



Influence of COVID-19 on the sustainability of livestock performance and welfare on a global scale

Md. Tanvir Rahman¹ · Md. Saiful Islam¹ · Awad A. Shehata^{2,3,4} · Shereen Basiouni⁵ · Hafez M. Hafez⁶ · Esam I. Azhar⁷ · Asmaa F. Khafaga⁸ · Fulvia Bovera⁹ · Youssef A. Attia^{10,11}

Received: 4 November 2021 / Accepted: 29 July 2022 / Published online: 17 September 2022
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Abstract

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is currently spreading worldwide. The pandemic has already had significant adverse effects on human civilization, the environment, and the ecosystem at national and global levels. Moreover, the various sectors of the food production chain, particularly agriculture and livestock, have also been significantly affected in terms of production sustainability and economic losses. The global pandemic has already resulted in a sharp drop in meat, milk, and egg production. Restrictions of movement at national and international levels, implemented as a part of control strategies by public health sectors, have negatively impacted business related to the supply of raw materials for livestock farmers and farm outputs, veterinary services, farmworkers, and animal welfare. This review highlights the significant impacts of COVID-19 on the sustainability of livestock performance, welfare on a global scale, and strategies for mitigating these adverse effects.

✉ Md. Tanvir Rahman
tanvirahman@bau.edu.bd

✉ Youssef A. Attia
yaattia@kau.edu.sa

Md. Saiful Islam
dvm41257@bau.edu.bd

Awad A. Shehata
dr_awadali_1@yahoo.com

Shereen Basiouni
shereenbh@yahoo.com

Hafez M. Hafez
hafez.mohamed@fu-berlin.de

Esam I. Azhar
eazhar@kau.edu.sa

Asmaa F. Khafaga
Asmaa.Khafaga@alexu.edu.eg

Fulvia Bovera
bovera@unina.it

⁴ Prophy-Institute for Applied Prophylaxis, 59159 Bonen, Germany

⁵ Clinical Pathology Department, Faculty of Veterinary Medicine, Benha University, Moshtohor, Toukh 13736, Egypt

⁶ Institute of Poultry Diseases, Faculty of Veterinary Medicine, Free University of Berlin, 14163 Berlin, Germany

⁷ Special Infectious Agents Unit - BSL3, King Fahd Medical Research Center and Medical Laboratory Sciences Department, Faculty of Applied Medical Sciences, King Abdulaziz University, Jeddah 21362, Saudi Arabia

⁸ Department of Pathology, Faculty of Veterinary Medicine, Alexandria University, Edfina 22758, Egypt

⁹ Sustainable Agriculture Research Group, Department of Veterinary Medicine and Animal Production, University of Napoli Federico II, Italy, via F. Delpino, 1, 80137 Napoli, Italy

¹⁰ The Strategic Center to Kingdom Vision Realization, King Abdulaziz University, P.O. Box 80200, Jeddah 21589, Saudi Arabia

¹¹ Sustainable Agriculture Research Group, Department of Agriculture, Faculty of Environmental Sciences, King Abdulaziz University, P.O. Box: 80208, 21589 Jeddah, Saudi Arabia

¹ Department of Microbiology and Hygiene, Faculty of Veterinary Science, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

² Birds and Rabbit Medicine Department, Faculty of Veterinary Medicine, University of Sadat City, Sadat City 32897, Egypt

³ Research and Development Section, PerNaturam GmbH, 56290 Godenroth, Germany

Keywords COVID-19 · SARS-CoV-2 · Sustainability · Livestock production · Economic loss · Supply chain · Animal welfare

Introduction

The coronavirus disease 2019 (COVID-19) outbreak is wreaking havoc worldwide. The World Health Organization (WHO) declared the disease a pandemic due to its worldwide spread and devastating implications on the global health, economy, and social life (Rahman et al., 2020a; Zhou et al., 2020; Islam et al., 2020). COVID-19 has become more virulent due to its zoonotic nature (Rahman et al., 2020b; Tazerji et al., 2020). Within a few months, the pandemic had destroyed everyday life and disrupted all communities. Unfortunately, although the implementation of lockdown was a significant measure to decrease virus spread during the pandemic, it resulted in substantial collateral human and animal health damage and an unprecedented economic disaster (Shehata et al., 2021). Furthermore, the COVID-19 pandemic has significantly impacted the agriculture sectors globally (Rahman et al., 2021) and directly affected the sustainability of livestock production chains, particularly meat and milk, supply chain, trade, and even consumption

behavior (Maliszewska et al., 2020; Bekuma, 2020). In this review, we have focused on the impacts of COVID-19 on the sustainability of livestock production, animal health, and animal welfare on a global scale.

Impact of COVID-19 on livestock production systems

Livestock production systems are closely linked to human livelihoods, food supply chains, and the global economy (FAO, 2020a). However, the COVID-19 pandemic has adversely impacted all animal production sectors, such as processing, transport, sales, and consumption behavior (FAO, 2020b). The shutdown of the processing plants, movement restrictions, and quarantine and isolation protocols resulted in labor shortages and/or employees in the food chain industry losing their jobs. As a result, several countries worldwide have faced crisis conditions in the farming system (FAO, 2020b). For example, in Austria, the labor shortage has created backlogs in most livestock production systems; about 80% of the workforce in the meat processing industry is made up of migrants from Eastern European countries (Hashem et al., 2020). In February 2020, approximately 60–70% of Chinese dairy farms

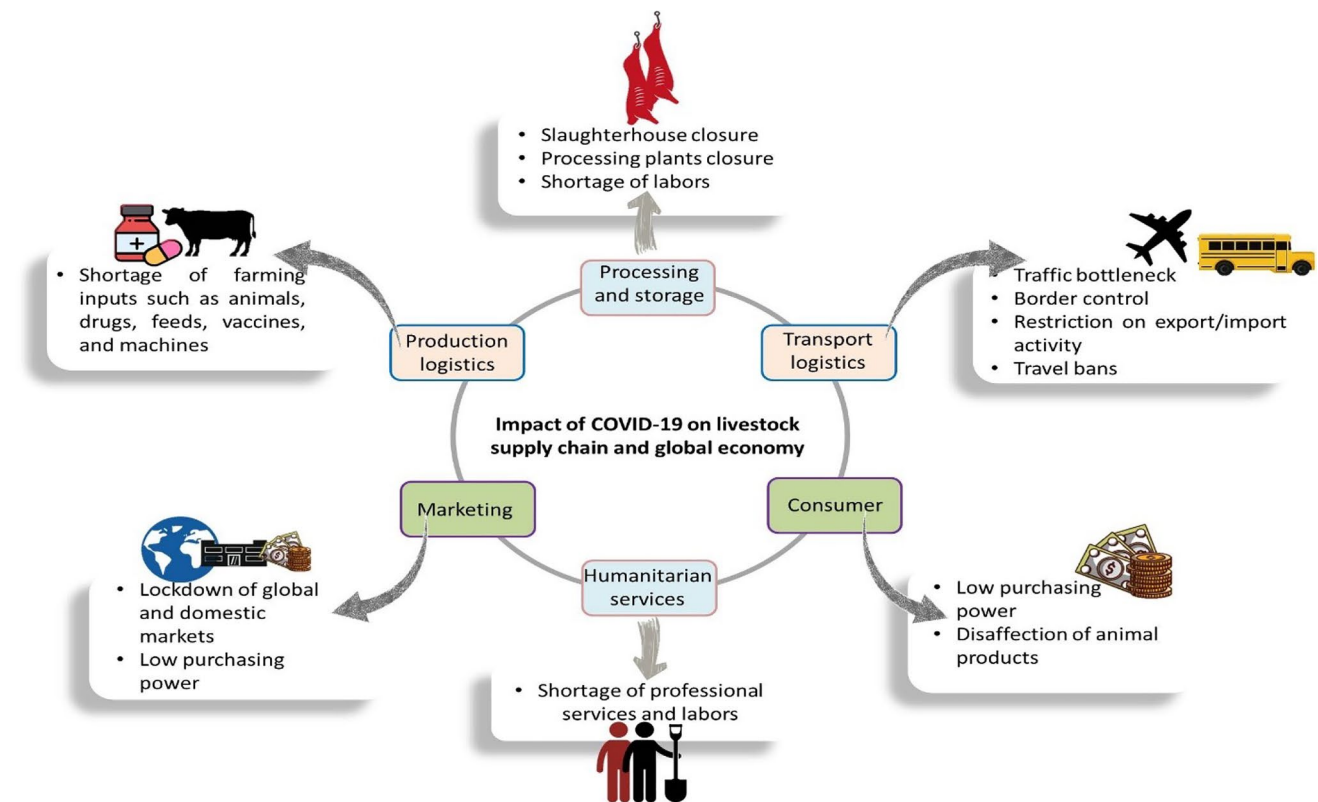


Fig. 1 Impact of COVID-19 on the sustainability of livestock supply chain and global economy

reported a labor shortage (Qingbin et al., 2020). Moreover, several countries have reported that imported feed and feed ingredients, such as soybeans, wheat, and corn, were unavailable at the farm level (Rahimi et al., 2022). Developing countries have also been severely affected as they rely on international trade (Galanakis, 2020; Seileman et al., 2020). Several countries also suffered from a shortage of the veterinary services, production equipment, vaccines, disinfectants, feed additives, and drugs at the farm level due to restrictions on the trade and movements (FAO, 2020b; Hashem et al., 2020; 2021), which negatively impacted animal health and welfare (Hashem et al., 2020; 2021). Furthermore, the global demand for animals and animal products has been negatively affected due to the closure of various outlets and restaurants, strict lockdown, and transport restrictions. In the USA, the demand for dairy products fell by 12–15% (Gibbens, 2020). During the COVID-19 outbreak, egg, meat, and milk sales in the USA, Southeast Asia, the Middle East, Arabian, and Latin America significantly declined (Galanakis, 2020). Additionally, the price of animal feed has increased globally due its shortage at the farm level (FAO, 2021a). Figure 1 depicts the impact of COVID-19 on the sustainability of livestock production systems. In the next sections, we will report the impacts of COVID-19 pandemic on animal products, animal production, and animal welfare.

Impacts of COVID-19 on animal products

Although lockdown and social distancing are essential measures to decrease the virus spread and slow it down, this pandemic caused substantial collateral health issues (for both humans and animals) and economic damage (Shehata et al., 2021). This section will shed light on the negative impacts of the lockdown, social distancing, panic situations, and workers' illness on animal production.

Meat

At the beginning of the pandemic, some experts speculated that SARS-CoV-2 might be transmitted from wild animals

like pangolins (*Manis javanica*) to humans in China (WHO, 2021). The global demand for food, especially meat, is increasing due to the rapid population growth (Sanchez-Sabate and Sabaté, 2019). The vast majority of meat consumed by humans is produced by intensive farms. Table 1 shows various aspects of animal production, imports, and meat exports (thousand tons of carcass weight equivalent) globally in 2019 and 2020 (before and during the COVID-19 pandemic). Bovine meat production, imports, and exports have decreased since the start of the pandemic in 2019, but pig meat has shown the opposite trend (FAO, 2021b). Production, imports, and meat exports declined in low-income food-deficit countries, whereas meat production increased and meat imports and exports decreased in developed countries. Overall, the results show that the effect of COVID-19 on meat production, imports, and exports varies depending on the type of meat, with poultry meat being unaffected compared to other animal meat. In addition, the changes in production, imports, and exports depend on the stage of development of the countries.

Although no statistics about the impacts of the COVID-19 pandemic on small ruminant production are available, a short-term economic impact of COVID-19 on Spanish small ruminant flocks has been reported. In April 2020, milk prices for dairy goat flocks fell by about 4.5 cents per liter compared to the prices in March. On the other hand, monthly sheep milk prices remained nearly constant during this period, with some reports of increases of more than EUR 6 cents compared to the previous year. Additionally, according to the global data of 2750 Spanish flocks, a drop in lamb prices ranging from 16.8 to 26.9% was reported. Likewise, the goat kid meat prices dropped by 12.5% per kilogram (Vidaurreta et al., 2020).

Eggs

Currently, no evidence exists that SARS-CoV-2 can be transmitted to humans via poultry products, including eggs (Suárez-García et al., 2020). However, all segments of the chicken processing industry, from smallholder farmers to massive integrators, have been severely impacted

Table 1 World statistics of production, imports, and exports of meat (thousand tons, carcass weight equivalent) from 2019 to 2020 (before and during the COVID-19 pandemic) (FAO, 2021b)

Types of meat	Production		Imports		Exports	
	2019	2020	2019	2020	2019	2020
Bovine	72,410	71,408	10,627	10,560	11,335	11,193
Poultry	131,562	133,266	12,451	12,501	14,241	14,226
Ovine	16,214	16,276	1045	977	1049	981
Pigs	110,095	109,200	9101	11,574	9553	11,889
Total world meat production	337,209	337,182	33,630	35,999	36,611	38,694
Low-income food-deficit countries	27,272	26,558	2452	2134	1741	1579
Least developed countries	14,448	14,570	1483	1393	56	50

by COVID-19, far worse than by the 2006 avian influenza pandemic (Das and Samanta, 2021). Strict restrictions imposed during the COVID-19 pandemic disrupted egg marketing and forced market closures. Farmers could not sell eggs in local markets or restaurants, resulting in substantial financial losses (Hafez et al., 2021). Although egg production in 2020 was higher than that in 2019, restrictions on farmer mobility, disruptions in the food supply chain, and containment strategies during the COVID-19 pandemic resulted in modest declines in egg import and export supplies in value terms around the globe (IndexBox, 2020).

Processed food

SARS-CoV-2 could theoretically be introduced via food in two ways: (1) through the consumption of foodstuffs derived from infected animals or (2) through foods that have been cross-contaminated by foods of nonanimal origin, infected individuals involved in food preparation, or food contact materials (Oakenfull and Wilson, 2020). So far, the Centers for Disease Control and Prevention (CDC) have identified processed food, packaging, and handlers as risk factors for SARS-CoV-2 transmission (FAO, 2021c). The virus can survive on different surfaces (e.g., plastics, copper, and cardboard) from a few hours to a few days (Van Doremalen et al., 2020). Therefore, the CDC recommends washing and disinfecting various surfaces to avoid contracting any contamination (Seymour et al., 2020). Currently, no evidence highlights that SARS-CoV-2 disease can spread directly through food. Given that food is an essential human requirement, we should consider the possibility of food being a direct or indirect carrier of the virus (Duda-Chodak et al., 2020).

Economic impacts of COVID-19 on animal production

The COVID-19 infection has adversely affected the global economy, particularly animal production and related trade. As a result, global economic growth has declined from 2.9 to 2.4%. And if the pandemic continues, it is expected to further fall to 1.5% (Hussain et al., 2020; Yamin, 2020). In addition, the COVID-19 pandemic has affected the agricultural sectors (crop and animal production) drastically, ultimately harming those who rely on agriculture (about 60% of the total world populace) (Lenzen et al. 2020; Siche 2020). The influence of COVID-19 on the global economy is illustrated in Fig. 1.

Economic impacts on the dairy sector

Globally, the economy of the dairy sector has been affected by COVID-19. The demand for milk grows day by day, but the supply has been reduced during the pandemic. Thus, there was an enormous gap between the market and prospective supply chain. In the USA, dairy animal producers had to discard about 4 million gallons of fresh milk during the first week of April 2020 due to failure to access markets, resulting in millions of US dollars in losses (Newman and Bunge, 2020). In Canada, dairy farmers had to dump their fresh milk due to the closure of retailing shops, the inability to store milk in their houses for many days, and a lack of processing facilities (Weersink et al., 2020). In Bangladesh, dairy producers faced dire financial problems and could not sell the milk in marketplaces due to the lockdown during the COVID-19 pandemic (Zabir et al., 2020). Also, milk prices have drastically declined during COVID-19. Moreover, due to COVID, Bangladesh has lost about 67 million US dollars as a result of discarding fresh milk (Begum et al., 2020). Nepal has suffered 17 million US dollars in losses in dairy products (Poudel et al., 2020). In Pakistan, dairy farmers

Table 2 The significant reasons for the economic losses in China's dairy sector due to the COVID-19 pandemic, adapted from Qingbin et al. (2020)

Contributing factors	Effect	Ultimate impact
Insufficient supply of farm inputs	Production and transportation problem	Economic loss
Increased price of farm inputs		
Lack of sufficient labor		
Difficulty in product transport		
Refused dairy products	Reduced sales of milk to processors	
Reduced product quantity		
Reduced product price		
Milk dumping	Financial problems	
Insufficient operating capital		
Difficulty in paying salaries and other bills		
Increase in accounts receivable		
Difficulty in borrowing capital		

were unable to sell approximately 57.3 billion liters of milk and other dairy products (butter, yogurt, ghee, etc.) due to the COVID-19 pandemic (Ghafar et al., 2020). A significant decline in milk demand (25–30%) and milk sales or price (50%) was noticed in India (Bajwa, 2020; Shashidhar, 2020).

In China, the main reasons behind economic losses in the dairy sector were production and transportation issues, an insufficient supply of inputs, and an increase in their price. About 27.34% of farms could not sell their entire milk production, and 6.25% of the farms had their milk rejected by factories. In addition, approximately 12.50% of the farms had to dump some of their milk during the disease outbreak (Qingbin et al., 2020). The primary causes of the dairy sector's economic loss due to the COVID-19 pandemic are listed in Table 2.

Economic impacts on the meat sector

Under the influence of COVID-19, the global meat industries have faced negative consequences due to import and export restrictions, market failure, and processing industry disruption (Ijaz et al., 2021). As a result, the global meat production dropped to 333 million tons in 2020 compared to 338.9 million tons in 2019, resulting in a 1.7% fall in meat production due to the neglected animal diseases and decimated market systems (FAO, 2020a). Pig industries in the USA have been hit the hardest, with a drop of 8.9 million tons of pork production (8%) in 2020 compared to that in 2019 (Hess, 2020).

Beef production fell by 1% in 2020 (72.0 million tons) vs. that in 2019 (72.6 million tons) (FAO, 2020a). In addition, the removal of 10 million hogs from the pig market chain (between April and September 2020) has led to an economic crisis (loss of 2 billion pounds of pork), which, compared to 2019, resulted in a 7% decline in pork from markets (Ijaz et al., 2021).

In the USA, the closure of farms and beef slaughterhouses resulted in 25% and 43% of losses in beef industry production, respectively (Hashem et al., 2020). In addition, USA has suffered from economic losses of more than 13.6 billion US dollars in the beef industry (Peel et al., 2020).

During the COVID-19 pandemic, the price of ovine meat has declined the most (8.6%) globally, followed by the other kinds of meat (poultry > pork > beef) (Pal and Kerorsa, 2020; Phelps, 2020).

Economic impacts on the poultry sector

The poultry sector was also affected by the COVID-19 pandemic, especially due to the marketing policy implemented during the pandemic (Sattar et al., 2021). In India, the poultry sector must deal with the unprecedented impacts

of COVID-19, resulting in 370 million US dollars in losses (estimated) by the end of April 2020 (Biswal et al., 2020). Similar situations have been observed in other South Asian countries, such as Bangladesh and Pakistan. Moreover, China has experienced a severe economic crisis in the international trade of poultry and poultry products. Turkey imposed a temporary ban on importing poultry products from China (Pan et al., 2020). Most countries, including the USA, India, and Russia, tightened livestock import restrictions, including poultry and poultry products (Pan et al., 2020).

In Bangladesh, six million people are directly or indirectly involved in the poultry business (Hamid et al., 2016; The Financial Express, 2017). The commercial poultry sector in Bangladesh is growing at a rate of 15% per year (Mahmud, 2020). The industry also contributes significantly to the country's economic development (Hamid et al., 2016). However, during the COVID-19 pandemic, poultry farmers suffered significant economic losses. The COVID-19 pandemic has resulted in a 35% drop in commercial day-old chick, egg, and meat production in Bangladesh, resulting in financial losses of approximately (BPICC, 2020). In addition, the industry has experienced nearly 29% losses per egg at the farm level (production cost of US\$0.07 vs. selling price of US\$0.046–0.065), even though the price per farm egg was US\$0.08–0.09 before the pandemic. For broiler meat, poultry farmers had to sell broiler meat for US\$0.77–0.80 per kilogram, even though production costs were US\$1.17–1.18, resulting in 32–34% in losses (Mahmud, 2020).

Impacts of COVID-19 on animal health and animal welfare

During COVID-19, restrictions on farming and veterinary services have negatively influenced animal health and welfare worldwide. Furthermore, confinement of people during the COVID-19 pandemic may impede regular zoonotic disease surveillance. These movement restrictions have also halted the surveillance and control strategies of wild animals and surveillance of different critical diseases, for example, animal tuberculosis, foot-and-mouth disease, African swine fever, and exotic transboundary diseases (lumpy skin disease, peste des petits ruminants, goat, and sheep pox, Japanese encephalitis, and Rift Valley fever) (Gortázar and de la Fuente, 2020).

As a result of the COVID-19 pandemic, severe adverse effects on animal health and welfare were observed worldwide. The risk of contracting other diseases has increased due to the long-term confinement of animals on farms. Moreover, animal health has been drastically affected by

the halted farming operations and services of veterinary professionals due to the unexpected restriction on human movement and procedures and the global economic crisis (Hashem et al., 2020; 2021). With the limited access to animals (especially cattle, sheep, and goats) and animal products, animal producers have to cull their animals and slaughter them or induce abortions to limit animal populations and overproduction.

In pig farming, the fall in demand of consumers and the disruption in the marketing system have forced the producers to abort sows and kill them using inhumane methods (ventilation shutdown, rising temperature to burn, and suffocation) (Jones, 2020; Vincent terBeek and McCullough, 2020).

Unfortunately, the foreboding implications of COVID-19 have been observed in animal healthcare systems at the farm, local, and global levels. In addition, budget constraints have resulted in suspending and postponing the efforts, programs, and projects of national and international organizations, which ultimately reduced the rate of progress in preventing, controlling, and eradicating different animal and zoonotic diseases (FAO, 2020a). The following effects on animal health and welfare were observed on a global scale as a result of the COVID-19 pandemic (Deeh et al., 2020).

1. Farming activities:

- (a) Failure to maintain pivotal animal health activities, e.g., diagnosing diseases, regular vaccination, and adequately treating diseased animals, is one of the adverse effects of COVID-19
- (b) Housing the animals on farms for a longer time resulted in stress, immunosuppression, increased stocking density, and multifactorial diseases because of decreased movement, increased mortality, reduced production, and declining economic profits.
- (c) Animal producers were unable to get advice due to the limited regular visits and restriction of veterinary professionals, which ultimately prevented animal producers from getting treatment for their animals from veterinary experts.
- (d) Due to import and export restrictions, illnesses increased due to insufficient and irregular input supply such as animal feed additives (vitamins, minerals, antibiotics, and others).

For example, the animal pharmaceutical supply chain between China (several drug companies) and USA has been disrupted due to the COVID-19 pandemic (Hashem et al. 2020; 2021). The impact of the COVID-19 pandemic on the sustainability of farming activity is illustrated in Fig. 2.

2. Activities in the laboratory and veterinary services

- (a) Inputs of laboratory tools and agents with financial support were disrupted by import and export restrictions.

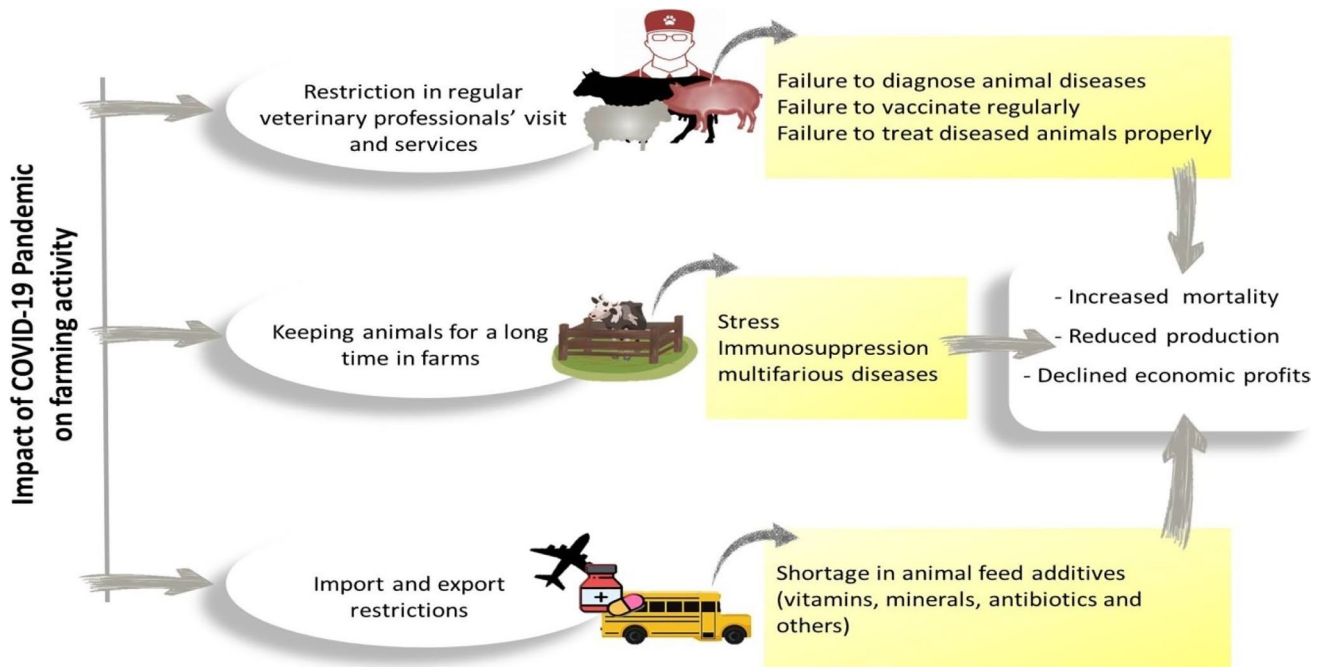


Fig. 2 The impact of the COVID-19 pandemic on the sustainability of the farming activity

(b) The veterinary professionals in the laboratory were unavailable due to movement restrictions, and the societal lockdown has reduced diagnostic and testing resources.

(c) Problems in sample transportation from animal farms to laboratories and deficiency of PPE (personal protective equipment) were also present.

(d) In some areas, laboratories were closed and veterinarians were not present.

Other effects were also observed as follows: (1) increment of animal disease transmission due to lack of safety measures and deprivation of PPE; (2) shortage of equipment to collect samples; (3) shortage of laboratory agents and PCR materials.

3. Local activities on animal health

(a) Control strategies for many animal diseases have been severely affected by economic emergencies that evolved during the COVID-19 pandemic.

(b) Limitations of movement adversely affected different animals and animal diseases, e.g., diagnosis and treatment campaigns and vaccination campaigns. For example, in Papua New Guinea, measures implemented to address COVID-19 directly affected the control activities taken by National Agriculture Quarantine and Inspection Authority (NAQIA) to address diseases like African swine fever as it was difficult to reach the infected areas due to the lockdown (FAO, 2020a).

4. Global activities on animal health during the COVID-19 pandemic

(a) Lack of funding and logistic support has delayed and suspended renowned international organizations' global animal health operations.

(b) Banned import and export international movement and trades have hampered animal health programs around the globe.

Suggestions to improve animal husbandry during the COVID-19 pandemic

Improving animal husbandry practices during and after the COVID-19 pandemic is critical. The health of people responsible for animal care must be maintained. This includes preventive measures such as boosting immunity through stress reduction, promoting healthier lifestyles, and vaccinations when proven effective and safe. Despite this, there is widespread public apprehension about vaccination due to concerns about the safety of the currently available COVID-19 vaccines. Significant misconceptions related to COVID-19 among people have been reported: for example, vaccines are not protective and have severe side effects, vaccine material could be integrated into human chromosomes, fetal tissue is used

in the development of the vaccine, and vaccines might introduce a microchip or nano-transducer into the body (Shehata et al., 2021). It is recommended to motivate workers to achieve high vaccination levels and reduce fear and anxiety. Health professionals have the leading role in explaining the urgent need for vaccination, communicating positive expectations to the public, and using motivational skills to correct the misunderstanding about the vaccinations (VandenBos, 2021; Verger et al., 2021).

Although poultry and cattle are classified as resistant and low susceptible to SARS-CoV-2, respectively, natural infection with SARS-CoV-2 has been stated in several domestic and wild animals such as dogs, cats, mink, ferrets, lions, tigers, pumas, snow leopards, and gorillas, which might contribute to complicating the epidemiology of the virus and have an impact on virus evolution (Shehata et al., 2022). Therefore, the One Health concept must be implemented. The following measures are recommended to improve the sustainability of live-stock production: (i) adequate management and strict hygienic processing of animal products during marketing and handling; (ii) improvement of social distancing and hand washing hygiene practices in manufacturing plants; (iii) imposing strict regulation of animal farms biosecurity, isolation, care, visitors, and animal workers; (iv) improvement of animal housing and hygienic conditions and protection against pests, rodents, cats, dogs, foxes, and other animals that can transmit zoonotic diseases by direct and indirect contact; (v) monitoring and active surveillance of animal and wildlife diseases using the geographical information system (GIS) in hotspot areas.

Conclusions

Livestock and poultry play a significant role in fulfilling the nutritional requirement of human beings. They are vital in achieving global food security, the Sustainable Development Goals (SDG), and many agricultural countries' economic prosperity and GDP. The COVID-19 pandemic has adversely influenced human civilization, ecosystems, and the economy significantly. The impact of the pandemic has also threatened the sustainability of livestock and poultry-related business, resulting in workers losing their jobs in those industries. Given the current pandemic's impact and the lessons learned, it is time to reconsider existing animal infectious disease and pandemic control strategies, particularly those with important zoonotic infectious agents. Smart agriculture and livestock production systems with animal welfare aspects need to be adopted. We recommend focusing more on coordinated solid activities toward a One Health

approach-based disease surveillance and monitoring system to detect new emerging diseases and pandemics. A strong network at the local, national, and international levels is crucial for effective preparedness to prevent further pandemic outbreaks.

Acknowledgements This research work was funded by Institutional Fund projects under grant no. (IFPDP-157-22). Therefore, the authors gratefully acknowledged technical and financial support from Ministry of Education and Deanship of Scientific Research (DSR), King Abdulaziz University (KAU), Jeddah, Saudi Arabia.

Author contribution MTR, HMH, and YA conceived and designed the study. MTR, MSI, SAA, SB, HMH, EIA, AFK, and YA conducted the literature search and prepared the manuscript draft. MTR, MSI, HMH, FB, and YA revised and edited the manuscript before submission. All the authors read and approved the manuscript.

Data availability Not applicable.

Code availability Not applicable.

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

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