



Food and Agriculture Organization  
of the United Nations



# Guidelines to mitigate the impact of the COVID-19 pandemic on livestock production and animal health



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## ABBREVIATIONS AND ACRONYMS

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<b>COVID-19</b>	Coronavirus disease 2019
<b>FAO</b>	Food and Agriculture Organization of the United Nations
<b>ICT</b>	Information and communication technology
<b>MERS</b>	Middle East respiratory syndrome
<b>MERS-CoV</b>	Middle East respiratory syndrome coronavirus
<b>OIE</b>	World Organisation for Animal Health
<b>PCR</b>	Polymerase chain reaction
<b>PPE</b>	Personal protective equipment
<b>RNA</b>	Ribonucleic acid
<b>SARS</b>	Severe acute respiratory syndrome
<b>SARS-CoV</b>	Severe acute respiratory syndrome coronavirus
<b>SARS-CoV-2</b>	Severe acute respiratory syndrome coronavirus 2
<b>TAD</b>	Transboundary animal disease
<b>WHO</b>	World Health Organization
<b>NGO</b>	Non-governmental organization

## INTRODUCTION

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COVID-19 has had a substantial impact on many sectors at global, regional and national levels, including the livestock sector (FAO, 2020; G20, 2020). The actions taken in many countries, such as lockdown, travel restrictions and border controls, have resulted in unintended or negative consequences for the livestock sector, including but not limited to (i) difficulty moving live animals and animal products like milk, meat and eggs to markets, (ii) restrictions potentially limiting seasonal border crossings (transhumance) with ruminants, (iii) restricted capacity to purchase necessary production inputs, (iv) restricted access to labour and professional services. These difficulties have led to a decrease in processing capacity for animal products, as well as loss of sales and slowdown of market activity. Additionally, COVID-19 could undermine the capacities of countries to prevent and control animal diseases – as governments and households reallocate resources to respond to the pandemic and reduce its socio-economic impact. Of particular concern are current outbreaks of transboundary animal diseases such as African swine fever, foot and mouth disease, avian influenza and other infectious animal diseases whose prevention and control may have been severely compromised.

The purpose of these guidelines is to describe the impact of COVID-19 on livestock production and animal disease prevention and control, and to provide practical recommendations for actors along value chains to reduce this impact and ensure continuity of the livestock supply chain and animal health. The target beneficiaries of these guidelines are livestock value chain actors including livestock farmers, slaughterhouse workers, animal product processors, traders, animal health professionals and veterinary paraprofessionals, policy makers and other relevant stakeholders.

## 1. COVID-19 OVERVIEW

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### 1.1 COVID-19

Coronavirus disease 2019 (COVID-19) is an infectious disease of humans caused by a newly discovered coronavirus: severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The most common symptoms of COVID-19 are fever, tiredness, dry cough and shortness of breath or difficulty breathing (WHO, 17 April 2020; Centers for Disease Control and Prevention, 2020). According to available reports (WHO, 2020; Yang X. *et al*, 2020; Zhou F. *et al*, 2020), some patients may have aches and pains in joints or muscles, repeated shaking with chills, nasal congestion, runny nose, sore throat, diarrhea, and loss of smell and taste in some cases. In severe cases, COVID-19 can be complicated by acute respiratory disease syndrome, sepsis and multiple organ failure (Yang X. *et al*, 2020). Most COVID-19 patients (85 percent) experience mild or uncomplicated illness, approximately 14 percent develop severe disease requiring hospitalization and 5 percent will require intensive care (The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. 2020).

### 1.2 SARS-CoV-2

Coronaviruses are capable of surviving in multiple unrelated hosts due to ease of cross transmission between numerous animal species, including humans. SARS-CoV-2 is closely related to a group of coronaviruses in bat populations (the genus Betacoronavirus). Severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV), that appeared in 2002 and 2012 respectively, are also part of this group.

According to current evidence, even though this virus could have emerged from a spillover event after zoonotic exposure, the COVID-19 pandemic is due to human-to-human transmission where animals do not appear to play a role. The virus can be transmitted (i) directly from person to person, when an infected person coughs, sneezes or speaks and produces droplets of saliva or discharge, that reach the nose, mouth or eyes of another person, or (ii) when a person touches contaminated objects or surfaces and then touches their eyes, nose or mouth. The virus can be detected and isolated in faeces and the role of faecal-oral transmission is yet to be determined. Aerosol transmission of the virus – in which fine particles or droplet nuclei are suspended in the air – may be possible in specific circumstances and settings (e.g. associated with aerosol-generating procedures or treatment such as endotracheal intubation) (WHO, March 2020).

### 1.3 COVID-19 in animals

The SARS-CoV-2 is zoonotic – it affects humans and some animals (O'Connor *et al*, 2020; FAO, 2020). It is not a surprise to find that domestic animals living closely with COVID-19 positive human cases are exposed to the virus, either through environmental contamination, or through human-animal interactions. Positive findings by polymerase chain reaction (PCR) in household animals such as dogs (OIE, 16 March 2020; OIE, 21 March 2020; Zhang Q. *et al*, 2020; OIE, 28 March 2020) and cats from households of COVID-19 patients have been reported. Furthermore, some cat sera collected after the outbreak in Wuhan city, Hubei Province were positive for neutralizing antibodies (Zhang Q. *et al*, 2020). These findings, albeit preliminary, have raised concerns about the possibility of humans transmitting the virus to domestic animals, and the potential role that domestic animals could play in the spread of the virus between each other. Similar potential reverse zoonotic transmission has been seen in other settings such as tigers in Bronx Zoo (OIE, 6 April 2020) and minks in two farms in The Netherlands (De Rijksoverheid, 2020).

The interconnectivity of humans, animals and the environment is important in understanding and tackling any threats to food systems, agricultural production and livelihoods. This is particularly important in rural livestock farming communities where animals play an important role for society and food security – providing, income, transport, fuel and clothing as well as food. Embracing this challenge, FAO recommends a One Health approach, where animal, human and environmental health work together to achieve the best results.

## 2. THE IMPACT OF COVID-19 ON THE LIVESTOCK SUPPLY CHAIN AND ANIMAL HEALTH

The challenges posed by COVID-19 and the impacts experienced throughout livestock supply chains and regarding animal diseases have been observed around the world and are detailed in this section.

### 2.1 The impact of COVID-19 on the livestock supply chain

To stop the spread of COVID-19, countries introduced various restrictive measures. These had an impact on the supply chains of various products and sectors as well as reducing the availability of workers. In April 2020, FAO published the policy brief: "[Mitigating the impacts of COVID-19 on the livestock sector](#)", which discusses how to plan for and address the difficulties at policy level, regarding the production of livestock and livestock products. Based on examples, the policy brief proposes various options for action which national policy makers may take to mitigate the impact. In relation to these policy options, further examples are shown in the table below, followed by practical recommendations which can be implemented by different stakeholders.

TABLE 1 | The impact of COVID-19 on the livestock supply chain

AREA	IMPACT	EXAMPLES
<b>Production</b>	<p>Enforced closure of non-essential businesses, travel restrictions and border controls may:</p> <ul style="list-style-type: none"> <li>• <b>hinder farmers from accessing farming inputs, supplies and equipment</b>, such as feed, replacement stocks (chicks, piglets, gilts), breeding materials and milking machines;</li> <li>• cause a <b>temporary labour shortage</b>;</li> <li>• <b>result in animal and animal product loss/waste</b> - farmers may depopulate their animals to save costs, such as animal feed, and discard perishable animal products.</li> </ul>	<ul style="list-style-type: none"> <li>• The Enterprise Survey for Innovation and Entrepreneurship in China (ELSIC) looked at the operational situation and demands in small, medium, and micro-enterprises impacted by COVID-19. It shows that as of February 2020, logistical interruptions were the main issue agricultural enterprises faced: 38.5 percent of livestock operations listed this as the biggest challenge. The main reason for logistical interruptions is the shortage of raw materials, especially the insufficient supply of feed for livestock farmers (Zhang, X. 2020).</li> <li>• Some Chinese poultry farmers destroyed chicks, chickens and ducks to avoid further losses (刘畅, 2020; 苏杰德, 2020).</li> <li>• Pig farmers in the United States of America and Canada have culled or aborted their herds as they have not been able to sell and ship their animals due to closure of processing facilities (Vincent ter Beek, V. &amp; McCullough, C. 2020).</li> <li>• Farmers in Wisconsin, United States of America were asked to dump 25 000 gallons of fresh milk a day because there was no place for it to go (Barrett, R. 2020).</li> </ul>
<b>Processing and distribution</b>	<ul style="list-style-type: none"> <li>• <b>Delivery failure</b> of animals and animal products causes the overstocking or wasting of them.</li> <li>• Restricting animal movement can cause <b>overcrowding and overuse of natural resources</b> such as water and grazing land.</li> <li>• <b>Reduced slaughtering and processing capacity</b> can limit the meat output – notably for labour-intensive slaughterhouses and food processing plants.</li> <li>• Product distributors are <b>losing their routine customers</b> such as schools, local markets, restaurants, public gatherings and the travel industry.</li> </ul>	<ul style="list-style-type: none"> <li>• Trucking companies that haul dairy products are struggling to get enough drivers as some have stopped working due to fear of contagion (Huffstutter, P. J. 2020).</li> <li>• In the United States of America and Canada, there is rising concern regarding a labour shortage in meat processing plants and farms, while in the situation of lockdowns and/or suspension of foreign visas (Attwood, J. 2020; Hein, T. 2020).</li> <li>• About 25 percent of pork production and 10 percent of beef production in the United States of America have been closed due to COVID-19 outbreaks among staff (Good, K. 2020).</li> <li>• In several countries, food has lost its routine market due to the closure of school canteens, restaurants, etc (Ministry of Agriculture, Food and Rural Affairs, 2020; InEuropa Srl. 2020).</li> </ul>
<b>Markets and consumers</b>	<ul style="list-style-type: none"> <li>• Closure of local markets has <b>limited the ability of many smallholder farmers and suppliers</b> to sell their products.</li> <li>• The <b>misconception</b> regarding livestock or livestock products being hosts or vehicles of the virus may result in further decline of demand for meat and other animal products.</li> <li>• <b>Import and export</b> restrictions and reduction.</li> </ul>	<ul style="list-style-type: none"> <li>• FAO's Food Price Index decreased by 4.3 percent between February and April, largely driven by changes in demand (FAO. 2 April 2020).</li> <li>• World Bank estimates that agricultural production could potentially decrease between 2.6 percent and 7 percent if there are trade blockages. Food imports could decline substantially (between 13 percent and 25 percent) due to a combination of higher transaction costs and reduced domestic demand (World Bank. 2020).</li> </ul>

## 2.2 The impact of COVID-19 on animal disease prevention and control

COVID-19 directly or indirectly disrupts activities to keep livestock healthy, including the prevention and control of animal diseases. Some examples are shown below.

TABLE 2 | The impact of COVID-19 on animal disease prevention and control

AREA	IMPACT	EXAMPLES
Farm	<ul style="list-style-type: none"> <li>• <b>Due to labour shortages, there is reduced capacity to work on animal health activities</b> such as maintaining good biosecurity, vaccination, medical treatment of sick animals and prophylactic treatment.</li> <li>• The overstocking of animals at farms could <b>increase stress and the prevalence of animal diseases, and compromise animal welfare standards. This can lead to reduced production performance.</b></li> <li>• Movement restrictions and quarantine measures <b>limit farmers' ability to access basic veterinary services</b> and also pose challenges for veterinary and veterinary paraprofessionals to visit farms.</li> <li>• The impact on logistics and supply chains <b>affects farmers' access to animal health inputs</b>, such as veterinary drugs, vaccines, disinfectants and supplies.</li> <li>• Farmers are <b>less likely to reach out to their veterinarians</b> when animals were suspected to be sick, due to financial hardship.</li> <li>• The farmers and/or producers themselves can be affected by COVID-19, <b>preventing them from maintaining their normal routine work</b> during their own illness and convalescence period.</li> </ul>	<ul style="list-style-type: none"> <li>• According to the United States Food and Drug Administration (USFDA), 6 of the 32 animal drug companies that make finished drugs or source active pharmaceutical ingredients in China for the market of the United States of America, have indicated that the supply chain disruptions could soon lead to shortages (American Veterinary Medical Association. 2020).</li> </ul>
Laboratory: veterinary diagnostics and disease surveillance and reporting	<p><b>Reduced testing and diagnostic capacities</b></p> <ul style="list-style-type: none"> <li>• Shortage of commonly used ribonucleic acid (RNA) extraction kits, polymerases and specimen swabs will restrict the ability to test animal diseases.</li> <li>• Societal lockdowns and the closure of some veterinary laboratories and institutions have suspended animal disease testing and research.</li> </ul> <p><b>Disrupted animal disease surveillance and reporting</b></p> <ul style="list-style-type: none"> <li>• Disease surveillance activities such as outbreak investigation and disease reporting could be disrupted due to logistical issues including restrictions and constraints on: access to farms, transport of samples, access to equipment and personal protective equipment (PPE).</li> </ul>	<ul style="list-style-type: none"> <li>• The increased demand for COVID-19 testing has caused shortages of chemicals for extracting RNA, polymerase enzymes, specimen collection swabs, and PCR machines (Slabodkin, G. 2020; Herper, M. &amp; Branswell, H. 2020).</li> <li>• Limited or restricted access to PPE has been reported in most countries (WHO, 3 March 2020), making it more difficult to safely perform outbreak investigations and responses – this is a particular issue for animal diseases that are easily transmitted through fomites or that represent occupational risks.</li> </ul>



<p><b>National animal health activities</b></p>	<ul style="list-style-type: none"> <li>• National <b>animal disease control programmes</b> may be reduced or even <b>suspended</b>.</li> <li>• National activities on outbreak investigations, animal disease surveillance, and vaccination campaigns <b>cannot be implemented as planned</b>.</li> <li>• <b>Late or insufficient response</b> to the outbreak of transboundary animal diseases may occur.</li> </ul>	<ul style="list-style-type: none"> <li>• Australia’s Minister of Agriculture said that current COVID-19 restrictions would affect the way industry and government respond to an outbreak of African swine fever, regarding the early detection and reporting of the virus (Phelps, M. 2020).</li> <li>• African swine fever control efforts in Papua New Guinea are difficult to implement due to COVID-19 lockdown in the country.</li> </ul>
<p><b>International animal health activities</b></p>	<ul style="list-style-type: none"> <li>• <b>FAO, the World Organisation for Animal Health (OIE) and other international organizations’ global, regional and national animal health programmes and efforts might be delayed</b>.</li> <li>• Member countries and donors may switch priorities to manage the most relevant issues created by production and market disruption due to COVID-19, reducing funding and/or logistical support to other projects.</li> <li>• <b>Bilateral and multilateral</b> animal health projects and activities <b>cannot be implemented as planned</b>.</li> </ul>	<ul style="list-style-type: none"> <li>• The planned FAO conference: “African swine fever unprecedented global threat: a challenge to food security, wildlife management and conservation” has been postponed (FAO. 2020).</li> <li>• FAO project delivery is compromised and discussions with donors and veterinary services are ongoing to modify plans and deliver activities.</li> </ul>

### 3. RECOMMENDATIONS FOR THE LIVESTOCK SUPPLY CHAIN AND ANIMAL HEALTH

To reduce the impact of COVID-19 and ensure continuity of the livestock supply chain and animal health activities, practical recommendations and precautionary measures are given below. These are for livestock farmers, actors along value chains, animal health professionals and policy makers – aiming to protect people and animals, and to minimize the disruption of services.

To avoid human-to-human transmission and prevent surface contamination including animal surfaces, it is recommended to strengthen hygiene practices, including: washing hands with soap and water (WHO, 2020; WHO, 13 March 2020) or using hand sanitizers before and after entering farm areas and common places or having contact with animals; maintaining physical distancing; limiting physical interaction; wearing necessary PPE<sup>1</sup>; and avoiding overwork. Please refer to WHO advice on general personal hygiene practices.

Due to increased pressure and stress, physical and mental health issues are one of the main concerns for people working in the livestock value chain. Therefore, it is recommended to become familiar with early detection of signs of mental health difficulties and to identify existing mental health services in the community that understand the occupational stressors that farmers (and veterinary personnel) are facing. Early interventions should be made to provide practical and emotional support. See WHO's "Mental health and psychosocial considerations during the COVID-19 outbreak" for more information (WHO, 18 March 2020; UN, 13 May 2020).

#### 3.1 Recommendations for livestock farmers

- 1) Communicate with suppliers (e.g. feed, consumables) and professional service providers (e.g. veterinarians, mechanics, milk collectors) to find solutions to secure supplies, inputs and services.
- 2) Communicate through producer cooperatives or farmers associations – to reach out to decision makers regarding assistance, as well as obtaining necessary exemptions for mobilization of animals, products and personnel.
- 3) Explore alternative sales channels. These include online sales, e-commerce and direct sales using point-to-point transportation to deliver livestock and their products to buyers instead of via retailers or markets.
- 4) Obtain the latest information on the evolving COVID-19 situation from trusted sources e.g. official news releases, radio programmes provided by local governments, field livestock/veterinary officers, livestock market officers, livestock NGOs, veterinary pharmacies and farmers associations.
- 5) Implement practical biosafety and biosecurity measures to prevent human contamination with COVID-19 on the farm:
  - a. Install footbaths in between different areas if possible, and change the disinfectant frequently.
  - b. Maintain a designated area for all external visitors and restrict visitor interactions with farm workers and operations to essential activities only.

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<sup>1</sup> PPE plays two roles in the COVID-19 pandemic: it protects wearers and prevents carrying contaminated material to other places. Different products have different protection capacity. Particular attention should be paid not to contaminate bare hands when removing PPE by touching outer surface of respirator or gloves. Follow instructions provided by WHO especially how to safely remove PPE (WHO, 2020).

- c. Limit visitors to minimum essential (e.g. animal health workers, feed truck drivers, milk collectors) and keep records. Ensure that visitors follow physical distancing and other hygiene recommendations.
  - d. Anyone (including farmers and farm workers) with fever and other symptoms of COVID-19 (whether confirmed or suspected), people who have tested positive for SARS-CoV-2 (including asymptomatic or recovering persons), and people in an isolation period due to close contact history with COVID-19 patients, should avoid or minimize close contact/work with animals, until recovered and cleared by medical providers.
  - e. Routinely clean and disinfect common areas e.g. resting areas, kitchens, changing rooms, bathrooms, sleeping quarters (see BOX 1).
  - f. Control interactions/socialization of people inside the farm, e.g. around the TV or resting areas, to ensure physical distancing and other recommendations are followed.
  - g. Disinfect equipment and other materials as they come onto the farm and at periodic intervals. Limit the introduction of personal items to the farm.
  - h. Change clothes and footwear between livestock areas and living areas, or at least put on work wear (e.g. coveralls) and change footwear to reduce cross contamination.
  - i. Maintain general hygiene of the premises where the animals are kept (e.g. prevent rodents and vermin) to avoid contamination.
  - j. Consult with animal health professionals to improve biosecurity and biosafety on the farm.
- 6) Adjust management measures on the farm:
- a. Raise awareness among farm workers about how COVID-19 spreads and how to prevent getting infected, and routinely remind them about biosafety and biosecurity measures against COVID-19 on the farm.
  - b. For large farms
    - Stagger arrival of workers to the farm, screen body temperature and typical clinical symptoms as described in 1.1 above, before entering the farm.
    - Frequently clean and disinfect common spaces including workers' break rooms, dining rooms, and bathrooms (see BOX 1).
    - Change the settings (e.g. add barriers) in common places (e.g. break rooms for farm workers) to maintain physical distancing. Stagger mealtimes to avoid large gatherings in the break rooms.
    - Prepare for shortage of workforce and develop a contingency plan.
  - c. For medium and smaller producers
    - Avoid contact or apply physical distancing outside the farm so you do not get sick and have to leave your animals alone.
    - Identify a substitute person/people that could take care of your animals at short notice in case you become indisposed (or to involve in finding the supplies and resources needed to maintain production).
- 7) Maintain animal disease prevention at farm level:
- a. Maintain good animal husbandry and production practices as much as possible (e.g. milking hygiene).
  - b. Make best efforts to ensure continuation of sanitary programmes for the farm animals as planned, including vaccination, vector control and deworming.
  - c. Implement good biosecurity practices, including routinely cleaning and disinfecting barns, pens, rooms, and other facilities to reduce the pathogen loads.
  - d. Seek advice from veterinarians and livestock husbandry specialists when needed.

**BOX 1 | Disinfectants known to be effective\*** against SARS-CoV-2 to date (Kampf G, *et al*, 2020; Günter Kampf, 2020; Chinese Center for Disease Control and Prevention. 2020; Centers for Disease Control and Prevention, 2 April 2020).

DISINFECTANTS	SOLUTION
Ethanol	at least 70 percent
Glutaraldehyde	0.5 – 2.5 percent
Povidone iodine	0.5 percent
Sodium hypochlorite	0.1 percent sodium hypochlorite, which can be made by 1:50 dilution of household bleach (5.25-6 – 6 percent sodium hypochlorite)
Hydrogen peroxide	3 percent

\*When fully covered/soaked after washing away dust and dirt with water.

### 3.2 Recommendations for animal health professionals (veterinarians, veterinary technicians and veterinary paraprofessionals)

- 1) Secure supplies, inputs and services:
  - a. Contact suppliers (of veterinary drugs and consumables) and professional services (diagnostic laboratories) regarding availability and possible delay in delivery.
  - b. Where lockdown or curfew is in place, apply for the exemption for essential businesses (many countries include animal health activities in the essential business category).
  - c. Manage the essential consumables you have in stock, including syringes, tubes, disinfectants and PPE. Be familiar with the correct disinfection procedure of reusable veterinary equipment such as needles, syringes and surgical instruments to help with limited supply.
  - d. Consider reviewing and refreshing existing management, preventive and diagnostic techniques, in order to substitute current practices that cannot be maintained due to the lack of supplies and/or reagents (Centers for Disease Control and Prevention. 2020; OIE, 2020).
- 2) Keep up to date with reliable information and sensitize farmers on required behaviour changes.
  - a. Help farmers to review and adjust production management with the supplies, equipment and personnel available to them.
  - b. Help farmers to review and adjust biosecurity practices, such as cleaning and disinfection, based on the need and the availability of resources.
  - c. Help farmers to identify the most relevant priorities and functions regarding prevention of diseases, that can be performed with minimum personnel.
- 3) Implement personal biosafety and biosecurity measures (along with general hygiene practices for COVID-19 recommended by WHO):
  - a. Do not visit farms, herds, markets or animal product processing facilities if you have any symptoms of COVID-19, or if you are confirmed positive and have not yet recovered/been cleared by medical providers following the isolation period.
  - b. Carry soap, alcohol-based hand sanitizer, disinfectant and PPE when visiting farms and other livestock related facilities without relying on availability at the farm.

- c. Make sure you and the farms are using disinfectants that are known to be effective against SARS-CoV-2 (see BOX 1).
  - d. Maintain physical distancing with farmers and workers when you interact with them and follow other hygiene recommendations.
- 4) Assist animal disease prevention and control at field level:
- a. Maintain open communication with livestock farmers and live animal markets (if the markets are open).
  - b. Request farmers and markets to continue reporting disease outbreaks and animal deaths of unknown reason to veterinary offices even when lockdown or curfew is in place.
  - c. Advise farmers on good livestock husbandry practices to mitigate the risk of disease outbreaks on farms.
  - d. Assist in contingency planning for livestock production, livestock markets and processing facilities.
- 5) Have a contingency plan:
- a. Maintain an inventory of medicines, drugs, disinfectants, PPE, diagnostic tests, supplies and equipment.
  - b. Ensure information and communication technology (ICT) is in place for giving animal health advice: e.g. telephone and messaging services.
  - c. Familiarise yourself with the latest laws and regulations regarding online veterinary consultation or telemedicine during the COVID-19 pandemic.

### **3.3 Recommendations for animal product processing plants, live animal markets and related supply chains**

- 1) Secure supplies, inputs and services (refer to 3.1.1).
- 2) Keep updated with reliable information (refer to 3.1.4).
- 3) Implement biosafety and biosecurity measures against COVID-19 to protect people working at the facility, including increasing air ventilation.
- 4) Following the measures for food processing facility workers, food delivery and transport, and food retail premises as detailed in the FAO and WHO Interim Guidance, COVID-19 and food safety: guidance for food businesses (FAO/WHO, 7 April 2020).
- 5) Follow biosafety and biosecurity measures to prevent contamination of the environment by COVID-19:
  - a. Disinfect reusable PPE items after every use using appropriate disinfectant (see BOX.1).
  - b. Maintain general cleanliness of the premises and periodically disinfect the facilities.
  - c. Limit visitors to the processing environment.
  - d. Keep records of movement of people including workers, visitors and suppliers.
- 6) Adjust management measures to decrease the risk of introduction and spread of COVID-19 in the facilities:
  - a. Stagger workers entering or leaving the premises.
  - b. Stagger mealtimes and break times to avoid large gatherings in break rooms and dining rooms.
  - c. Consider screening individual temperatures and typical COVID-19 symptoms before entering the facilities. When possible, provide access to medical personnel (e.g. nurse) for the workers.
  - d. Provide guidance to clean and disinfect the work environment before and after shifts, including shared spaces, employee break rooms, dining rooms, sleeping quarters, bathrooms and company transportation services.

- e. Prepare for shortages in the workforce. Develop an alternative plan to manage the facility with fewer workers – adjusting work arrangements in case some of the workers become infected or are isolating due to COVID-19. Implement cross-training as much as possible.
  - f. If possible, review and adjust the sick leave policy of employees and encourage self-reporting of illness.
- 7) Recommended actions for animal disease prevention at live animal markets and by traders:
- a. Keep market area clean and regularly disinfected (See BOX.1).
  - b. Try not to let animals stay overnight in live markets in the case that lockdown or curfew is imposed.
- 8) Have a contingency plan:
- a. Identify alternative suppliers or inputs in case the main supply-chain is disrupted.
  - b. If possible, seek exemption of movement restrictions to contribute to ensuring stable basic food supply for national food security and nutrition.
  - c. Review and adjust waste and litter management plans.
  - d. Strengthen control of movement of people including workers, visitors and suppliers.

### 3.4 Recommendations for policy makers at national level

- 1) Develop, endorse and implement policies to mitigate impact of COVID-19 on livestock production and value chains:
  - a. Ensure availability and flow of the normal inputs and outputs for livestock production, for example by releasing a list of exemptions to movement restrictions.
  - b. If possible, review and adapt existing biosafety and biosecurity measures to the COVID-19 situation and provide these as a checklist for farms, livestock product processing facilities, live animal markets, slaughterhouses and related value chains.
  - c. Include veterinary services as essential businesses.
  - d. Ensure a functioning supply chain of livestock and animal products:
    - Governments may release and broadly publicize a list of exemptions to movement restrictions to ensure the flow of food materials and production related services. The information on exemption should be shared with the relevant stakeholders using various channels such as mass media, interest groups or associations.
    - Governments may work with farmers and producer organizations to promote collective marketing which can maintain demand for products. Governments may promote e-commerce to help connect rural producers to urban consumers.
    - Governments may coordinate with NGOs and suppliers to purchase products and redistribute them, possibly through food banks, religious charitable organizations or international emergency and relief organizations (e.g. UNICEF, UNHCR, etc.).
  - e. Plan to strengthen resilience of the national food system.
- 2) Review, revise, endorse, and implement policies on animal disease prevention and control:
  - a. Prioritize animal diseases, in consultation with the field veterinarians and other key stakeholders to support maintenance of essential monitoring, prevention and control programmes.
  - b. Continue monitoring, prevention and control of transboundary animal diseases by maintaining surveillance, outbreak investigation, laboratory diagnosis and early response capacities.
  - c. Review and update biosecurity and biosafety requirements and disseminate them widely to farmers, livestock and live animal markets, slaughterhouses and animal health professionals.

- d. Maintain the capacity of national reference laboratories to support surveillance, diagnosis, early detection and response to outbreaks.
  - e. In case veterinary laboratories are needed to support the public health sector in testing human specimens for COVID-19, the additional activities should not disrupt any surveillance and routine diagnosis of animal diseases. Please refer to OIE Guidance on Veterinary Laboratory Support to the Public Health Response for COVID-19 (OIE, 1 April 2020) for further information.
  - f. If possible, develop a specific contingency plan for access to veterinary services for remote or rural smallholders.
  - g. Introduce/maintain ICT including online platforms, to facilitate livestock farmers contacting veterinarians and livestock husbandry consultants in order to obtain advice.
  - h. Encourage veterinary services to continue supporting farmers, including real-time communication using technologies such as short messaging services (SMS), social networking services (SNS), etc.
- 3) Develop and disseminate information materials and collaborate with partners to organize outreach activities, in order to sensitize livestock production and animal health stakeholders, including relevant recommendations in this document:
- a. Develop a series of communication materials and widely distribute through media, field staff and other communication channels, with the advice of stakeholders. Materials also can be made available through smartphone-friendly graphics and apps.
  - b. Strengthen coordination and collaboration among all relevant sectors including transport industry, markets and media, to assist flow of information from reliable sources. This will help stabilize availability and price of basic food and reduce disruption of livestock production and animal disease control and prevention, in the context of the COVID-19 pandemic.

## REFERENCES

- American Veterinary Medical Association. 2020. COVID-19: Drug and medical supply impacts. *AVMA*, 12 April 2020. [online]. <https://www.avma.org/resources-tools/animal-health-and-welfare/covid-19/covid-19-drug-medical-supply-impacts>
- Attwood, J. 2020. World's Top Pork Company Closes More Plants in Domino Effect. *Blomberg*, 15 April 2020. [online]. <https://www.bloomberg.com/news/articles/2020-04-15/smithfield-foods-to-close-two-added-meat-processing-facilities>
- Barrett, R. 2020. Wisconsin farmers forced to dump milk as coronavirus slams a fragile dairy economy. *Milwaukee Journal Sentinel*, 2 April 2020. [online]. <https://eu.jonline.com/story/money/2020/04/01/coronavirus-forces-dairy-farmers-dump-milk-wisconsin-covid-19/5108609002/>
- Centers for Disease Control and Prevention. 2020. Watch for symptoms. In: *Coronavirus Disease 2019 (COVID-19) - Symptoms*. [online]. Atlanta. [Cited 30 April 2020]. <https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html>
- Centers for Disease Control and Prevention. 2 April 2020. Everyday Steps and Extra Steps When Someone Is Sick. In: *Coronavirus Disease 2019 (COVID-19) - Cleaning Your Home*. [online]. Atlanta. [Cited 30 April 2020]. <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/disinfecting-your-home.html>
- Centers for Disease Control and Prevention. 2020. Interim Infection Prevention and Control Guidance for Veterinary Clinics During the COVID-19 Response. In: *Coronavirus Disease 2019 (COVID-19) - Veterinarians & Veterinary Staff*. [online]. Atlanta. [Cited 30 April 2020]. <https://www.cdc.gov/coronavirus/2019-ncov/community/veterinarians.html>
- Chinese Center for Disease Control and Prevention. 2020. Guidelines for Personal Protection of Specific Groups from COVID-19. [online]. Beijing. [Cited 30 April 2020]. <http://weekly.chinacdc.cn/en/article/id/65577621-f02e-4c47-b883-f70659c300b3>
- De Rijksoverheid. Voor Nederland. 2020. COVID-19 geconstateerd op twee nertsenbedrijven. In: *Nieuwsbericht*, 26 April 2020. [online]. <https://www.rijksoverheid.nl/actueel/nieuws/2020/04/26/covid-19-geconstateerd-op-twee-nertsenbedrijven>
- FAO. 2020. Q&A: COVID-19 pandemic – impact on food and agriculture. In: *Novel Coronavirus (COVID-19)*. [online]. Rome. [Cited 30 April 2020]. <http://www.fao.org/2019-ncov/q-and-a/impact-on-food-and-agriculture/en/>
- FAO. 2020. Qualitative Risk Assessment on Exposure to SARS-CoV-2 from Domestic Mammals, Wildlife, Birds and Aquatic Species. [online]. Rome. [in preparation].
- FAO. 2020. African swine fever unprecedented global threat: a challenge to food security, wildlife management and conservation. In: *Emergency Prevention System for Animal Health (EMPRES-AH)*. [online]. Rome. [Cited 30 April 2020]. <http://www.fao.org/ag/againfo/programmes/en/empres/FAO ASF call for action.html>
- FAO. 2 April 2020. World food prices drop in March. In: *FAO - News Article*, 2 April 2020. [online]. Rome. [Cited 30 April 2020]. <http://www.fao.org/news/story/en/item/1269050/icode/>
- FAO & WHO. 7 April 2020. COVID-19 and food safety: guidance for food businesses, Interim guidance [online]. Geneva. [Cited 30 April 2020]. [https://apps.who.int/iris/bitstream/handle/10665/331705/WHO-2019-nCoV-Food\\_Safety-2020.1-eng.pdf](https://apps.who.int/iris/bitstream/handle/10665/331705/WHO-2019-nCoV-Food_Safety-2020.1-eng.pdf)



- Good, K. 2020. As COVID-19 Slows Meat Processing, Meat Shortages a Growing Concern; Livestock Producers Face Tough Choices. *Farm Policy News*, 23 April 2020. [online]. <https://farmpolicynews.illinois.edu/2020/04/as-covid-19-slows-meat-processing-livestock-producers-may-face-tough-choices/>
- Günter Kampf, G. 2020. Potential role of inanimate surfaces for the spread of coronaviruses and their inactivation with disinfectant agents. *Infection Prevention in Practice*, Volume 2, Issue 2: 100044 [online]. [Cited 30 April 2020]. <https://www.sciencedirect.com/science/article/pii/S2590088920300081>
- G20. 2020. G-20 Surveillance Note. G-20 Finance Ministers and Central Bank Governors' Meetings. [online]. [Cited 30 April 2020]. <https://www.imf.org/external/np/g20/pdf/2020/041520.pdf>
- Hein, T. 2020. Covid-19 may cause shortage of labour in NA pork sector. *Pig Progress*, 31 March 2020. [online]. <https://www.pigprogress.net/World-of-Pigs1/Articles/2020/3/Covid-19-may-cause-shortage-of-labour-in-NA-pork-sector-563355E/>
- Herper, M. & Branswell, H. 2020. Shortage of crucial chemicals creates new obstacle to U.S. coronavirus testing. *STAT*, 10 March 2020. [online]. <https://www.statnews.com/2020/03/10/shortage-crucial-chemicals-us-coronavirus-testing/>
- Huffstutter, P. J. 2020. U.S. dairy farmers dump milk as pandemic upends food markets. *World Economic Forum*, 7 April 2020. [online]. <https://www.weforum.org/agenda/2020/04/dairy-milk-pandemic-supply-chains-coronavirus-covid19-pandemic/>
- InEuropa Srl. 2020. FoodTalks: coronavirus and food waste. *InEuropa*, 3 March 2020. [online]. <http://www.progettareineuropa.com/en/2020/03/foodtalks-coronavirus-and-food-waste/>
- Kampf, G., Todt, D., Pfaender, S., & Steinmann, E. 2020. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. *J Hosp Infect.* 104(3): 246-251. (also available at [https://www.journalofhospitalinfection.com/article/S0195-6701\(20\)30046-3/pdf](https://www.journalofhospitalinfection.com/article/S0195-6701(20)30046-3/pdf))
- Ministry of Agriculture, Food and Rural Affairs. 2020. 농식품부, 코로나 19 로 판로 잃은 친환경농가를 돕는 '착한 소비' 적극 지원. *농업생명정책관*, 12 April 2020. (also available at <https://www.mafra.go.kr/bbs/mafra/68/323512/artclView.do>)
- Phelps, M. 2020. COVID-19: African swine fever response challenge. *Queensland Country Life*, 8 April 2020. [online]. <https://www.queenslandcountrylife.com.au/story/6715906/covid-19-creates-african-swine-fever-response-challenges/>
- O'Connor, A. M., Totton, S. C. & Sargeant, J. M. 2020. A rapid review of evidence of infection of pets and livestock with human associated coronavirus diseases, SARS, MERS, and COVID-19, and evidence of the fomite potential of pets and livestock. In: *Systematic Reviews for Animals & Food (SYREAF)* [online]. [Cited 30 April 2020]. [http://www.syreaf.org/wp-content/uploads/2020/04/Rapid-Review-of-pets-as-fomites\\_3.pdf](http://www.syreaf.org/wp-content/uploads/2020/04/Rapid-Review-of-pets-as-fomites_3.pdf)
- OIE. 16 March 2020. COVID-19 (SARS-COV-2), Hong Kong (SAR - PRC), Follow-up report No. 2. [online]. Paris. [Cited 30 April 2020]. [https://www.oie.int/wahis\\_2/public/wahid.php/Reviewreport/Review?page\\_refer=MapFullEventReport&reportid=33629](https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=33629)
- OIE. 2020. Questions and Answers on the 2019 Coronavirus Disease (COVID-19). [online]. Paris. [Cited 30 April 2020]. <https://www.oie.int/en/scientific-expertise/specific-information-and-recommendations/questions-and-answers-on-2019novel-coronavirus/>

- OIE. 21 March 2020. COVID-19 (SARS-COV-2), Hong Kong (SAR - PRC), Immediate notification. [online]. Paris. [Cited 30 April 2020]. [https://www.oie.int/wahis\\_2/public/wahid.php/Reviewreport/Review?page\\_refer=MapFullEventReport&reportid=33684](https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=33684)
- OIE. 28 March 2020. Information provided by the National Veterinary Services of Belgium (28/03/20). A case of a Belgian cat positive for Covid-19. [online]. Paris. [Cited 30 April 2020]. [https://www.oie.int/fileadmin/Home/eng/Our\\_scientific\\_expertise/docs/pdf/COVID-19/Belgium\\_28.03.20.pdf](https://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/COVID-19/Belgium_28.03.20.pdf)
- OIE. 1 April 2020. Veterinary Laboratory Support to the Public Health Response for COVID-19. Testing of human diagnostic specimens in veterinary laboratories. Version 1 [online]. Paris. [Cited 30 April 2020]. [https://www.oie.int/fileadmin/Home/eng/Our\\_scientific\\_expertise/docs/pdf/COVID-19/A\\_Guidance\\_for\\_animal\\_health\\_laboratories\\_1April2020.pdf](https://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/COVID-19/A_Guidance_for_animal_health_laboratories_1April2020.pdf)
- OIE. 6 April 2020. SARS-CoV-2/COVID-19, United States of America, Immediate notification. [online]. Paris. [Cited 30 April 2020]. [https://www.oie.int/wahis\\_2/public/wahid.php/Reviewreport/Review?page\\_refer=MapFullEventReport&reportid=33885](https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=33885)
- Patel, P., Sanghvi, S., Malik, K. & Khachemoune, A. 2020. Back to the Basics: Diluted Bleach for COVID-19. *J Am Acad Dermatol*: S0190-9622(20)30609-5 [online]. [Cited 30 April 2020]. [https://www.jaad.org/article/S0190-9622\(20\)30609-5/pdf](https://www.jaad.org/article/S0190-9622(20)30609-5/pdf)
- Slabodkin, G. 2020. FDA chief warns of supply 'pressure' on reagents for coronavirus tests. *MEDTECHDIVE*, 12 March 2020. [online]. <https://www.medtechdive.com/news/fda-chief-warns-of-supply-pressure-on-reagents-for-coronavirus-tests/573999/>
- The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. 2020. The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) — China, 2020. *China CDC Weekly*, 2(8): 113-122. (also available at <http://weekly.chinacdc.cn/fileCCDCW/journal/article/ccdcw/2020/8/PDF/COVID-19.pdf>)
- United Nations. 2020. Policy Brief: COVID-19 and the Need for Action on Mental Health. [online]. Geneva. [Cited 18 May 2020]. [https://www.un.org/sites/un2.un.org/files/un\\_policy\\_brief-covid\\_and\\_mental\\_health\\_final.pdf](https://www.un.org/sites/un2.un.org/files/un_policy_brief-covid_and_mental_health_final.pdf)
- Vincent ter Beek, V. & McCullough, C. 2020. Covid-19 crisis hits US pig production hard. *Pig Progress*, 28 April 2020. [online]. <https://www.pigprogress.net/World-of-Pigs1/Articles/2020/4/Covid-19-crisis-hits-US-pig-production-hard-576238E/>
- WHO. 3 March 2020. Shortage of personal protective equipment endangering health workers worldwide. [online]. Geneva. [Cited 30 April 2020]. <https://www.who.int/news-room/detail/03-03-2020-shortage-of-personal-protective-equipment-endangering-health-workers-worldwide>
- WHO. 13 March 2020. The Safe Hand Challenge [video]. [Cited 30 April 2020]. <https://youtu.be/y7e8nM0JAz0>
- WHO. 2020. SAVE LIVES: Clean Your Hands. [online]. Geneva. [Cited 30 April 2020]. <https://www.who.int/infection-prevention/campaigns/clean-hands/en/>
- WHO. March 2020. Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations. [online]. Geneva. [Cited 30 April 2020]. <https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations>

- WHO. 17 April 2020. Q&A on coronaviruses (COVID-19). [online]. Geneva. [Cited 30 April 2020]. <https://www.who.int/news-room/q-a-detail/q-a-coronaviruses>
- WHO. 2020. Steps to take off personal protective equipment (PPE) including coverall. [online]. Geneva. [Cited 30 April 2020]. [https://apps.who.int/iris/bitstream/handle/10665/150118/WHO\\_HIS\\_SDS\\_2015.4\\_eng.pdf?sequence=1](https://apps.who.int/iris/bitstream/handle/10665/150118/WHO_HIS_SDS_2015.4_eng.pdf?sequence=1)
- WHO. 2020. Mental health and psychosocial considerations during the COVID-19 outbreak. [online]. Geneva. [Cited 30 April 2020]. <https://www.who.int/docs/default-source/coronaviruse/mental-health-considerations.pdf>
- WHO. 2020. Naming the coronavirus disease (COVID-19) and the virus that causes it. [online]. Geneva. [Cited 30 April 2020]. [https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-\(covid-2019\)-and-the-virus-that-causes-it](https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it)
- World Bank. 2020. COVID-19 (Coronavirus) Drives Sub-Saharan Africa Toward First Recession in 25 Years. Press release N. 2020/099/AFR, 9 April 2020. [online]. <https://www.worldbank.org/en/news/press-release/2020/04/09/covid-19-coronavirus-drives-sub-saharan-africa-toward-first-recession-in-25-years>
- Yang, X., Yu, Y., Xu, J., Shu, H., Xia, J., Liu, H., Wu, Y., Zhang, L., Yu, Z., Fang, M., Yu, T., Wang, Y., Pan, S., Zou, X., Yuan, S. and Shang, Y. 2020. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med*. S2213-2600(20)30079-5 [online]. [Cited 30 April 2020]. [https://www.thelancet.com/journals/lanres/article/PIIS2213-2600\(20\)30079-5/fulltext](https://www.thelancet.com/journals/lanres/article/PIIS2213-2600(20)30079-5/fulltext)
- Zhang, Q., Zhang, H., Huang K., Yang, Y., Hui, X., Gao, J., He, X., Li, C., Gong, W., Zhang, Y., Peng, C., Gao, X., Chen, H., Zou, Z., Shi, Z. and Jin, M. 2020 . SARS-CoV-2 neutralizing serum antibodies in cats: a serological investigation. *BioRxiv*, 1 April 2020 [online]. [Cited 30 April 2020]. <https://www.biorxiv.org/content/10.1101/2020.04.01.021196v1.full.pdf>
- Zhang, X. 2020. Chinese livestock farms struggle under COVID-19 restrictions. *IFORI Blog : Research Post*, 26 March 2020. [online]. <https://www.ifpri.org/blog/chinese-livestock-farms-struggle-under-covid-19-restrictions>
- Zhou, F., Yu, T., Du, R., Fan, G., Liu, Y., Liu, Z., Xiang, J., Wang, Y., Song, B., Gu, X., Guan, L., Wei, Y., Li, H., Wu, X., Xu, J., Tu, S., Zhang, Y., Chen, H. and Cao, B. 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet*, 395(10229) :1054-1062. (also available at [https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736\(20\)30566-3.pdf](https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(20)30566-3.pdf))
- 刘畅, 薛志伟 & 陈发明. 2020. 早春已至！疫情下的早春农事怎么样？. *经济日报*, 6 March 2020. (also available at <https://proapi.jingjiribao.cn/detail.html?id=234842> ; [http://www.xinhuanet.com/fortune/2020-03/06/c\\_1125669768.htm](http://www.xinhuanet.com/fortune/2020-03/06/c_1125669768.htm)).
- 苏杰德. 2020. 疫情“黑天鹅”袭击养鸡业:下半年的吃鸡难题 中国新闻周刊, 第 940 期, 23 March 2020. (also available at <https://cj.sina.com.cn/articles/view/5617046716/14ecd54bc00100nqcb?from=finance&subch=futures>).

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