Chapter

Dairy Farms Biosecurity to Protect against Infectious Diseases and Antibiotics Overuse

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Abstract

Biosecurity is a key element in the battle against antibiotic resistance. The goals of biosecurity are focused not only on the reduction or prevention of the introduction of new diseases from outside sources but also on the reduction or prevention of the movement of infectious diseases on the farm. In this regard, the use of antibiotics can be reduced by simple actions such as physically inspecting animals, testing for bovine diseases, vaccination, or quarantine for at least 3 weeks before mixing with the herd of all new additions. All these examples reduce the risk of diseases with germs from outside. This chapter attempts to synthesize the best biosecurity solutions that can be applied in modern dairy farms.

Keywords: antibioresistance, biosecurity, dairy farm, cattle

1. Introduction

In dairy farms, biosecurity, surveillance, resilience/immunity, biocontainment, and control of disease spread within the herd are the pillars that need to be appropriately managed to ensure the healthy herd [1].

Biosecurity is focused to reduce and prevent the introduction of diseases or pests of animals on a farm, and to minimize the spread of diseases or pests within a farm. Biosecurity action plans need to be implemented mainly in large dairy farms where the disease agents can be introduced by various sources such as labor, advisers, replacement cattle, supplies, feedstuffs, and vehicles [2].

Surveillance programs are developed for early detection of emerging pathogens, to establish disease-free status or the prevalence of a specific disease in a herd [3].

Relation resilience immunity is based on the individuals' resistance to diseases that can be modulated by the ability of animals to adapt to adverse conditions (stress factor) and recover from them [4].

Biocontainment and control programs are important backup systems for biosecurity plans that will prevent the emerging disease spreading within the herd or the endemic diseases spreading between animals into the farm [2, 5].

The overall biosecurity of dairy farm uses different levels or shells of actions (national or supranational, regional, and local), linked with the epidemiological profile of the pathogen. For highly contagious infectious agent (e.g., foot-and-mouth disease), the most efficient biosecurity plan is at national or European Union level, while for infectious agents transmitted by close contact between animals (e.g., bovine tuberculosis), the regional biosecurity measures such as movement controls will protect the status of the region [1].

Biosecurity practices on livestock farms have been described and prioritized in various ways [1, 2, 5, 6]. In this chapter, we grouped biosecurity measures in the following categories: dairy farm sanitation, facility biosecurity, animal biosecurity, feed biosecurity, and manure biosecurity.

2. Dairy farm sanitation

2.1 Employees and visitors

Some infectious agents are specific for dairy cattle and others are zoonotic, affecting both bovine and human health. Employees and visitors can contribute to the spread of all these infectious agents on a dairy farm [7]. The transmission of pathogens by humans can be reduced or even stopped by providing on-farm laundry facilities for all protective clothing used on the farm, using only clean overalls during farm visits, providing disposable clean booties for visitors and cleaning of boots with disinfecting solution after scrubbing off any visible dirt at the end of the visit, and washing of hands before and after working with sick or young animals [7–9].

Milking parlor personnel should wear latex gloves while milking to reduce the spreading potential of the contagious mastitis pathogens [9]. Sometimes, these hired personnel can take care of other animals outside the dairy farm and carry pathogens on the farm. Employees should be regularly trained in good practices to prevent the spread of disease (the principles of hygiene and disease security). They need to know that calves are susceptible to diseases carried by adult animals, and daily activities should be organized so that employees work with younger animals before working with older animals. Prevention of the infectious agent's introduction and spreading from outside and inside sources should also be considered in the education of hired personnel in basic hygiene and disinfection [10]. The main actions included in the biosecurity plan for dairy farms should reduce the risk of infectious diseases to be introduced by employees and visitors (**Table 1**).

The access of visitors must be limited and recorded in a logbook; the farm touring must start from younger to older animal groups; barn doors are recommended to be locked and a warning sign must be posted to keep out unauthorized personnel [9].

Also, along the access road of the farm must be displayed signs directing visitors to the administrative area and to the visitor parking, as well as warning signs to limit direct contact of visitors with farm feed and animals [11].

2.2 Equipment biosecurity

Equipment can be contaminated with infectious secretions, excretions, and blood and the movement of equipment between stalls and farms may also transport pathogens [12].

All equipment used on the farm must be regularly cleaned and disinfected [11]. To prevent contamination of equipment, storage containers need to be used for all tools and feeding equipment. Also, all storage containers are regularly cleaned and disinfected. The storage containers must protect equipment from diseases, pests, or weeds [13]. Before use in healthy animals, equipment that has been used on sick animals must be cleaned and disinfected. However, it is better not to use clothing, shoes, and tools dedicated to the compartment of sick animals [14]. Dehorners, ear

Biosecurity measure	Action
Record in the logbook all farm visitors	Place the visitor logbook at the farm entrance
Restrict the access of visitors to the stable	Locking the stable doors
Inform unauthorized persons that they are not allowed to enter the stable	Post-warning signs asking visitors not to pass inside stable and several directing signs to the farm offices
The visitors can access the stable only with clean clothes and boots, which they have not used in other farms	Provide clean boots and overalls for all visitors
The visitors should use a footbath with disinfectant and clean their boots before entering the stable	Place a disinfectant footbath and brushes outside the stable
The dealer or transporter of the newly arrived animals is not allowed to enter in stable or in contact with the farm animals	The access of the cars is made on a route that avoids contact with the farm animals, directly toward the quarantine area located at a distance from the herd
The livestock renderer access in the stable or the contact with cattle is restricted	Store dead animals away from the stable and main roads

Table 1.
Biosecurity measures designed to reduce the risk of the infectious disease's introduction in dairy farms by employees and visitors.

taggers, hoof knives, clippers, and all shared and hired equipment will be cleaned and disinfected between uses [11, 14].

Nursing bottles and buckets must be sanitized before each feeding [14], calves kept indoors must have fresh clean dry bedding, and plastic calf hutches will be cleaned and disinfected after use [11].

The equipment used for manure disposal will not be used for transporting or delivering feed [13].

Disposable clothing and used veterinary equipment must be removed safely [11].

2.3 Vehicle biosecurity

Vehicles are considered fomites mainly for pathogenic robust organisms that can survive a long time in the environment [1]. Mainly external vehicles that collect milk, calves, and carcasses or deliver feedstuffs, pharmaceuticals, and semen can be involved in the transmission of infectious disease because they travel daily from farm to farm [2, 10]. A high biosecurity risk is associated with carcasses (dead stock) collectors because they are usually in contact with diseased animals [15, 16].

To prevent the introduction of infectious agents, vehicles must be kept clean and should not have access to the zones where the animals are housed [10, 11, 17].

External vehicles should not be allowed on the farm [18]. If vehicles are necessary on the farm, then ensure that vehicles and trailers are clean when entering the farm and disinfected before and after use [6, 11, 18, 19]. Cleaning and disinfection will cover both the exterior and the interior of the vehicles, with greater attention to areas where dirt may be hidden (e.g., wheel arches and tires) [11]. Because the transport by dealers may pose additional risks of infectious disease transmission between farms, it is recommended that the animal moving will use only farm-owned vehicles [20], with clean and ample bedding to prevent both injuries and disease [14].

Guidance indicators and warning and restricting access signs to unauthorized vehicles must be placed at the entrance to the farm road and along the road.

The farm must have a designated area for visitors' vehicles that are at the entrance of the farm and away from the animal and animal stalls [6, 10, 14]. Also, service vehicles should not drive over the routes of feed delivery or manure handling [14].

3. Buildings biosecurity

In a dairy farm, the building's design can help prevent the spread of pathogens to sick cows, periparturient cows, and newborns [2]. Buildings should have a well-established destination, in correlation with the categories of animals present on the farm. Dairy farms can secure their premises against domestic and wild animals by installing various types of fences (e.g., electric fence) around the buildings. Disinfectant footbaths should be at the entry of livestock housing. All farms should have isolation building (the quarantine facility) where the health status of the newly purchased cows will be observed before they join the rest of the herd [21]. To prevent direct and indirect contact between residents and new animals, the quarantine facility should be located in the farthest possible place on the dairy farm [10]. The farm must have a biosecurity plan that includes building maintenance activities (e.g., check and maintain fences, replace bird netting, and repair holes in buildings), which will reduce the contact of cattle with wild animals and the feed contamination with birds droppings or badger feces [14, 21].

4. Animal biosecurity

4.1 Live animal management

The introduction of new cattle is one of the most important biosecurity risks for dairy farms [10]. In modern dairy farming, the sale and movement of cattle is an intrinsic part of the business as a consequence of the increased herd replacement rate of adult milking cows, the forced culling, and the need to increase the size of the herd [1]. Therefore, keeping a closed herd is the most effective biosecurity measure but is the least practical [6]. To reduce the risk of diseases spreading between farms, the new animals are purchased only from herds with known health status and known vaccination protocols [9, 10].

The best solution to prevent the introduction of diseases through the acquisition of new animals is the hosting of the newly purchased cows in a quarantine facility with trained personnel to handle isolated animals [10, 21]. Quarantine is one of the most important biosecurity tools and consists of the separation of specific groups of animals to prevent the transmission of infectious diseases. Prophylactic quarantine is designed to separate the resident herd from newly acquired animals for 1 month or more. During the 30 days of isolation, the personnel from the quarantine facility will monitor cattle health status and prevent direct and indirect contact between new and resident animals [9, 10]. If the infections have short incubation times, then the animals will develop acute diseases during the quarantine period. In other cases, to prevent the diseases spreading from animals that might be hiding an infectious agent without exhibiting clinical signs to resident animals, the quarantined animals will be tested for various diseases such as bovine tuberculosis, Johne's disease, brucellosis, leptospirosis, salmonellosis, campylobacteriosis, leucosis, bovine viral diarrhea (BVD), infectious bovine rhinotracheitis (IBR), trichomoniasis, neosporosis, ringworm, liver fluke, lungworm, digital dermatitis, and contagious mastitis pathogens (*Streptococcus agalactiae* and *Staphylococcus aureus*) [10, 14]. The testing of animals in the prophylactic quarantine is a valuable biosecurity tool when properly applied.

To prevent the bovine tuberculosis introduction, the biosecurity plan should take into consideration all possibilities of *Mycobacterium bovis* transmission. Cattle are the main reservoir and spread microbes through aerosols (adults) or manure (calves) to many domestic and wild mammalian species. Sheep, goats, pigs, horses, and dogs are spillover hosts and spread *M. bovis* spread microbes in various ways (respiratory, digestive, by bites, or scratches). After infection, badgers, brush-tail opossums, wild boars, deer, and other wildlife species become wildlife reservoirs (maintenance host). Humans are susceptible and contract the infection mainly by drinking raw milk and raw milk products. People with pulmonary or urogenital tuberculosis can retransmit the infection to cattle [22].

Calves are more susceptible and should be kept in a separate area to minimize their exposure to infectious agents [14]. Calves can carry many infectious diseases without clinical signs and positive results on the laboratory tests (e.g., Johne's disease). This risk can be reduced by purchasing calves only from herds officially certified as disease-free [1].

Because one of the most common ways of the BVD virus introduction in a free farm is via a pregnant heifer ("Trojan cow") carrying a persistently infected fetus, all calves from purchased cattle should be tested at birth to detect persistently infected animals with BVD virus [1, 9, 10]. Persistently infected animals are the main route of the BVDV spreading between herds because they cannot be detected by serological tests (immunotolerant calves), but excrete massive amounts of virus [1, 23]. The risk of farm contamination can be reduced by purchasing animals only from herds officially certified as BVDV-free. If the BVDV status in the herd of origin is unknown, then pregnant females should be isolated on arrival (the contact with any animal of breeding age must be restricted), tested for BVD antibody and BVD antigen, and released from isolation only if they are negative results at both tests or antibody positive, antigen-negative, calved, and the calf was tested negative or removed from the herd [1]. To prevent BVDV introduction into a free farm, the following risk factors should be considered: trade with live animals, embryo transfer and semen recipients, return of animals from animal exhibitions, direct contacts between cattle on pasture or over fences, density and activity of arthropod vectors, vaccination, and employee and visitors contact with animals [9, 24].

Sick and suspicious animals should be isolated in a specific area and always handled at the end. In the control of contagious mastitis, the latter are milked cows suspected of the disease [9].

Implementing effective biosecurity programs will bring long-term economic benefits. Dutch studies have shown that the main benefits of a closed dairy herd with good biosecurity are better fertility and lower slaughter rates. The USA comparative studies in Johne's disease-positive herds and Johne's disease-negative herds revealed an economic loss of almost US$ 100 per cow in positive herds. Spread of an infectious disease onto a farm can lead to large economic losses. An outbreak of BVD in an Australian farm with 320 milking cows caused losses of $AUD 144,700 [25].

Vaccination is another important biosecurity tool designed to protect resident cattle from infectious agents that could have been brought in by the newly purchased cows [26]. In dairy cattle, immunization mainly targets common infectious agents such as BVD virus, IBR virus, parainfluenza-3 (PI3) virus, bovine respiratory syncytial virus (BRSV), leptospirosis, and clostridial infections [27]. Vaccination programs should be established in collaboration with the herd veterinarian and adapted to the risk of the disease spreading on the farm, including infectious agents that evolve in the area [25, 28]. Vaccination should not be considered the primary or single biosecurity tool because no vaccine provides 100% immunity [26, 28].

Dairy herd vaccination programs are affected by various factors such as age and category of production, disease history, housing, type of vaccine (killed or modified live), and costs [28]. Vaccination programs are designed by age categories and are applied continuously to maximize herd immunity and minimize the spread of the infectious agent [27, 28].

Vaccination schedule for dairy heifers from birth to 6 months of age can be started with an oral modified live vaccine (MLV) for bovine rotavirus and bovine coronavirus given 30 minutes before the ingestion of colostrum to prevent the inactivation [28]. In the first hour of life, calves must receive 2.8 L of colostrum, and in the next 23 hours, the rest of 2.8 L [27]. Depending on the epidemiological situation, an intranasal vaccination of neonatal calves with respiratory vaccines (IBR/PI-3/BRSV) can be started at 3 days of age or older [28]. At 6 weeks old, dairy heifers can receive an injectable modified-live IBR/PI3/BRSV/BVD vaccine and a seven-way clostridial bacterin-toxoid [27]. The immunity of injectable vaccines is longer than the immunity of intranasal vaccines [28]. Following national and international regulations on brucellosis prophylaxis, at 4–6 months age replacement heifers should receive brucellosis RB51 vaccine. Also, depending on the epidemiological situation, calves can receive the appropriate vaccination for leptospirosis clostridial diseases and/or *Histophilus somnus*. At 6 months of age, heifers should be revaccinated with modified live IBR/PI3/BRSV/BVD virus vaccine, seven-way clostridial vaccine, and five-way leptospirosis bacterin [27, 28].

Pre-breeding heifers (10–12 months of age) should be revaccinated with killed or modified live IBR/PI3/BRSV/BVD virus vaccine, five-way leptospirosis bacterin, and seven- or eight-way clostridial bacterin-toxoid [28]. Optionally, it can be done with vibriosis bacterin [27].

Pre-calving heifers should be revaccinated 40–60 days before calving with killed IBR/PI3/BRSV/BVD virus vaccine, five-way leptospirosis bacterin, killed rotavirus and coronavirus vaccine, and *Escherichia coli* + *Clostridium perfringens* types C and D bacterin/toxoid. Three weeks before to calving, heifers should be revaccinated with killed rotavirus and coronavirus vaccine, and *Escherichia coli* + *Clostridium perfringens* types C and D bacterin/toxoid [27, 28]. Also, pre-calving heifers should be vaccinated with coliform mastitis bacterin [27].

Adult cows should be annually vaccinated, 40–60 days before calving for IBR, PI3, BRSV, and BVDV [27]. Depending on the history of diseases in the region and the associated epidemiological risks, the farm veterinarian should choose vaccines that immunologically protect dairy cows during the lactation period and the dry period for leptospirosis, vibriosis, *Rotavirus, Coronavirus, Clostridium perfringens* types C and D, and *Escherichia coli* mastitis. Types of vaccines recommended are killed or bacterin/toxoid and modified-live vaccines (MLV) [27, 28]. Adult dairy cattle should receive a booster vaccination at 3 weeks before calving with killed rotavirus and coronavirus vaccine and *Escherichia coli* + *Clostridium perfringens* types C and D bacterin/toxoid vaccine [27]. MLV vaccines should be used with prudence in pregnant cows and only after consultation with the veterinarian [28]. The annual vaccination for vibriosis should be performed in dairy herds where the artificial insemination is not practiced [27].

The annual vaccination of adult dairy cattle for calf scours (rotavirus and coronavirus, *Escherichia coli*, and *Clostridium perfringens* types C and D) should be considered in all herds with recent history as a part of the preventative management practices [27].

Mastitis is one of the most important diseases in dairy cows that affects the welfare, production, and duration of the economic life of the animals [29]. Economic losses are due to direct milk production losses (reduction of quantity, unsalable, or poor quality), culling or removal from the herd of animals with unsatisfactory treatment results, cost of veterinary care, cost of excessive use of antimicrobials and other medicines, and the risk of antibiotic resistance [30].

The main pathogens targeted by mastitis vaccines are *Staphylococcus aureus, Streptococcus agalactiae,* and *Escherichia coli* [29]. Reduction in the incidence and duration of intramammary infections can be obtained by applying the combination of vaccination with high milking hygiene procedures, treatment of clinical cases, segregation, and culling of known infected cows [29]. The following preventive measures were proved to have a positive result in the management of mastitis in dairy herds: the use of milkers' gloves, blanket use of dry-cow therapy, washing unclean udders, maintaining cows upright after milking, back-flushing of the milking cluster after milking an animal with clinical mastitis, and application of a treatment protocol [30] Also, to maximize the success of immunization, within 5 days of mastitis vaccines, dairy cows must not receive any other Gram-negative bacterin vaccines (e.g., *Escherichia coli*, *Salmonella* spp., *Pasteurella* spp., *Campylobacter* sp., and *Moraxella bovis*) [27].

To evaluate the effects of mastitis vaccines in dairy cows, the following monitoring parameters are most commonly used:

1. Clinical and subclinical mastitis incidence and severity

2. Somatic cell count

3. Serum and/or milk immunoglobulin G concentrations

4. Milk bacterial culture or *Staphylococcus aureus* count in milk

5. Milk production

6. Cure or cull rate [29]

Newly acquired dairy herd bulls should be 30–60 days in prophylactic quarantine and tested with negative results for persistent BVDV infection, brucellosis, and tuberculosis. Recommended vaccination schedule for dairy herd bulls is an annual vaccination at the breeding soundness examination with IBR/PI3/BVD killed vaccine, five-way leptospirosis bacterin, and vibriosis bacterin [27].

If there are animal species other than cattle, then the vaccination actions must take into account for these species as well. Farm dogs and cats should be vaccinated at least against rabies to protect humans and other animals [14].

Antibiotic overuse can be reduced by using a proper mixture of natural antibacterial peptides, biological response modifiers, prebiotics, probiotics, and correct development of the gut microbiome [31].

The limited use of bacterial culture and sensitivity testing by veterinarians are other causes of the persistence of the multidrug resistance (MDR) isolates in dairy farms. The findings of the last decades highlight the necessity of using antimicrobial susceptibility testing each time before prescribing an antibiotic [32].

4.2 Dead animal management

To reduce the risk of pathogens spreading in farm animals, dead animals should be disposed of in the shortest time. Depending on the national regulations and farm's possibilities, the disposal of carcasses can be done by a licensed dead stock collector, burial, or composting [14].

Studies designed to investigate what motivates and withholds farmers to implement biosecurity measures placed the carcass storage away from the stables on the second rank for feasibility, but with a lower score for efficacy [33].

Rendering trucks have a particular risk for farm biosecurity because they are at high risk for carrying animals killed by infectious diseases [26]. To prevent farm contamination, mortality pick-up should be located away from the stable and feed storage bin and silo [34].

5. Feed and water biosecurity

The biosecurity of feed and water must start from the source, respectively, from the fields where crops are grown and from the water capture source. Manure used as a natural fertilizer can contaminate the soil, crop, and water used for irrigation and groundwater sources [2]. The quality and potability of water should be tested regularly, and samples from each feedstuff batch or lot should be stored for possible laboratory analyses (e.g., bacteria, toxins, molds, and mycotoxins) until that batch is consumed without incidents [2, 10].

To reduce the risk of the diseases being introduced by contaminated feed, the dairy producer should record and monitor the manure application on its pastures and fields cultivated with feedstuffs [2]. The risk of a feed-related disease outbreak is increased when feedstuffs are purchased from multiple locations or the crops were fertilized with manure from other dairy farms [2, 10].

To prevent feedstuffs to be contaminated through fecal material and urine from rodents, birds, dogs, cats, and any wildlife, dairy farmers should design food storage areas in a way to be inaccessible (e.g., opened bags can be placed into containers with tight lids; barns can have welded wire fence) [2, 14].

The biosecurity plan of the dairy farm should include the frequency of storage areas cleaning, the way of feed bags storage off the floor on pallets, removing and disposing of the not consumed feed within 24 hours, rotation of feed inventory for the purpose to reduce the possible presence of detrimental organisms or toxins in stored feeds, and periodically checking of silos, bins, and bunks to detect and remove as soon as possible moldy or spoiled feedstuff [14].

Although not recommended, some cattle herds are still using surface water (e.g., lakes, ponds, and rivers) as a water source. Drinking water can be contaminated by animal carcasses (e.g., dead wild animals), manure from other livestock, bird droppings, urine and feces of wildlife, and human waste [2, 10, 14]. Water biosecurity programs should include several measures designed to prevent contamination with toxins and infectious agents such as restriction of the birds and wildlife access to farm water sources, filtration and chemical sterilization of water, and regular testing of water quality and potability [2]. Waterers should be cleaned once a week [14].

6. Manure biosecurity

In dairy farms, manure is the most problematic waste and should be treated as a biological risk material because it has a huge bacterial load [2]. Manure should be stored in an area inaccessible to cattle [14]. Contact with manure from infected cattle is the main means of spread for rotavirus, coronavirus, *Escherichia coli*, *Salmonellosis*, and Johne's disease to other receptive animals. Manure handling should prevent environmental contamination and should not violate the legislation in force [14].

Manure is rich in nutrients that could be recycled as fertilizer [35]. However, the use of this natural fertilizer should be done with caution to prevent contamination of crops, pastures, and groundwater sources [2]. *Salmonella* spp., *Escherichia coli*, *Listeria* spp., and *Mycobacterium avium* subsp. *paratuberculosis* can be killed by the process of manure composting but the process must be controlled before the use of compost in agriculture [2, 36, 37]. In the process of composting should not be used the manure from the hospital pen, where de infectious agents can be in a high concentration. Also, the temperature and microbial activity should be checked to confirm the complete sterilization [2, 14]. Also, manure can be recycled for bedding and to produce methane [2].

Manure biosecurity programs should include measures to prevent the manure equipment used to handle feed, the environment infestation with files and intestinal parasites (manure must be removed frequently to prevent the pest life cycles completion), manure run-off or transfer from adults to calves, and feed contamination by manure-covered wheels of farm vehicles [14].

Manure spreaders and slurry handling equipment are high-risk equipment and should be brought to the farm after proper cleaning or disinfection [1].

The manure cleaning of vehicles and equipment must be done in areas specially designed for this purpose, where water or disinfectants would not splash onto feed or into drinking water. Throughout the entire cleaning and disinfection process, the equipment will be inspected visually to dispel any suspicion of cross-contamination [2].

7. Conclusions

The development and implementation of biosecurity programs in dairy farms improve cattle health, welfare, and productivity. These programs must be monitored and evaluated continuously to identify new methods of control and new effective critical control points and to further improve the program to prevent the introduction and spread of infectious agents on the farm. The biosecurity program should be focused on the decision and adapted to the specific situations of each dairy farm. Many of the problems encountered can be prevented or minimized with the support of veterinary services. Staff and visitors should be trained on biosecurity measures applied on the farm.

Conflict of interest

The authors declare no conflict of interest.

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