Chapter 9
Animal Health and Food Security in Saudi Arabia

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Abstract While the human population keeps growing, our community has a tremendous challenge to provide enough, safe, and wholesome food for everyone, including foods of animal origin. Food security and food safety are closely linked. Unsafe food contributes to a vicious cycle of illness and hunger that mainly affects young children, the elderly and the sick. On the other hand, a secure food supply promotes national economies, trade, tourism and sustainable development. Thus, it is essential to have access to enough quantities of safe and nourishing food to sustain life and advance good health in our communities. Generally, food safety is affected by different factors such as an expanding global population, climate change, and animals diseases. With every meal we consume, we run the risk of contracting a sickness from either microbial or chemical contamination. More than 200 different diseases can be brought on by contaminated foods, which contain dangerous viruses, bacteria, parasites, or chemical substances. Public anxieties over food safety are elevated during outbreaks of any disease in animals used for food production. If any tissues from an infected animal, including meat or milk, are permitted to enter the food chain, they become a potential source of human infection. On the other hand, animal diseases also affect food availability due to animal death. Veterinary Practices, as well as Husbandry Practices, can play critical roles along the food chain (from farm to human consumption) to enhance the safety, availability, and accessibility of food of animal origin. These practices principally contribute to animal health and welfare.

Keywords Animal health · Animal welfare · Food safety · Food security

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1 Introduction

As the human population keeps increasing, our community meets a massive challenge to provide sufficient, safe and healthy food for everyone, including foods of animal and plant origin (Garcia et al. 2020). The Food and Agriculture Organization (FAO) assesses that to feed inhabitants of 9.1 billion people by 2050, total food production must increase by almost 70% (FAO et al. 2021; FAO 2017).

Raised demand for food has numerous negative impacts on our environment, such as soil erosion, environmental degradation and increased pollution. Moreover, natural catastrophes like floods, fires and diseases, particularly transboundary and zoonotic diseases, present a massive threat to food safety and sustainable food production (Andrade et al. 2018; Tilman et al. 2011; Watson et al. 2007; Otte et al. 2004). Therefore, optimising production systems that provide safe, nourishing and sustainable food must be a priority while maintaining natural and environmental resources for the benefit of forthcoming generations (Shariff 2019). To fulfil this task, multidisciplinary teams of experts from different sectors, including animal health and agriculture, must address these challenges (Garcia et al. 2020).

This chapter aims to expand writing on the impact of animal health on food safety and food security, with an emphasis on research done in Saudi Arabia.

In the first place, this chapter illustrates the value of animal-based foods in human nourishment, as well as their contribution to the global food supply. Secondly, it clarifies the fundamental idea of animal health and animal welfare. Thirdly, this chapter thoroughly discusses the direct and indirect effects of animal health and animal welfare on food safety and security and provides examples. Lastly, it briefly illustrates veterinary services contribute to the security and safety of food.

2 Animals and Human Diet

The principal food origin for the world's human population is agriculture, comprising crop production, orchards, livestock production, fisheries, and aquaculture (FAO 2021). Foods of animal origin (animal-based foods) include food items obtained from an animal like meat, milk, egg, fish, shellfish, the derivatives of meat and dairy (sausage, burger, yoghurt and cheese), and honey (Cabrera-Barjas et al. 2022). There are three central production systems in which the world's livestock (approximately 17 billion) occur: open grazing systems, mixed crop-livestock systems, and confined intensive systems. Calculations based on data between 2001 and 2003 suggest that grazing systems provide 2% of milk and 9% of the world's meat; mixed crop-livestock methods supply 88% of milk and 46% of meat; while intensive systems contribute 45% of meat (Thornton and Herrero 2009; Steinfeld et al. 2010).

Animal-based foods contain several vital nutrients in bioavailable forms essential for human growth, development, cognition and health throughout the life cycle. Some

micronutrients like vitamin A, iron, zinc, and calcium are inclined to be more bioavailable in foods of animal origin. While others, like vitamin B12, are naturally found only in animal-based foods. These foods supply several micronutrients concurrently, which can be essential in diets short of more than one nutrient. For example, riboflavin and vitamin A are required for iron mobilisation and haemoglobin synthesis; dietary supplements that contain iron alone may not successfully remedy anaemia if other nutrients are insufficient (Smith et al. 2013). Moreover, these foods are specifically important among nutrition-insecure and low-income communities where a modest amount of animal-based foods consumption can lead to more significant nutritional gains than a diet of plant-based foods alone (Eisler et al. 2014).

Generally, meat, milk and eggs are the primary source of nutrients and contribute significantly to the global food supply.

Meat supplied 11% of the world's food energy, 21% of the protein and 29% of the dietary fat. It also was responsible for 32% of lysine and 16% of cystine of the worldwide availability of bioavailable essential amino acids. For other nutrients, meat delivered highly percentage of vitamins B12 (56%), A (24%), B1 and B2 (15% each), B6 (13%) and B5 (10%). Meat contributes poorly to vitamins C and E, fibres and magnesium. Also, it contributes to a significant portion of several elements such as copper (10%), phosphorous (11%), iron (13%), selenium (18%) and zinc (19%). Meat is an inferior contributor to vitamins C and E, fibers and magnesium (Smith et al. 2022; FAO 2022; Pighin et al. 2016; Mottet et al. 2017).

Milk and its derivative supplied 9.1% of the total energy supply, 54.7% of calcium, 28.1% of riboflavin, 26.1% of vitamin B12 and 24.6% of phosphorus. These foods also contributed significantly to several elements, including protein, zinc, fat, vitamin A, cholesterol, magnesium, potassium, and numerous amino acids (Górska-Warsewicz et al. 2019).

Eggs are one of the healthiest foods available, providing a balanced diet that benefits everyone's health, especially children. According to Kuang et al. (2018), a medium-sized cooked egg (50 g) has 78 kilocalories of energy, 6.29 g of protein, 0.56 g of carbohydrate, and 5.3 g of fat. Plenty of vital proteins, lipids, vitamins, and minerals may be found in eggs.

Insufficient consumption of animal-sourced foods leads to a critical deficiency of essential nutrients necessary for humans' physical and mental development, particularly for kiddies. Additionally, the demand for animal-based foods is anticipated to rise in the ensuing decades, with the largest increases anticipated in middle- and low-income nations (Alexandratos and Bruinsma 2012).

Since livestock is the major supplier of foods and vital nutrients, animal health and welfare are the keys to livestock production and productivity. It is well known that livestock needs a minimum level of care to be productive. Thus, improving animal welfare, which is connected intrinsically with farm animal husbandry practices and animal health, will boost the productivity of animals (Skaperda et al. 2019).

3 Animal Health and Animal Welfare

3.1 Animal Welfare

Animal welfare means "the physical and mental state of an animal concerning the conditions in which it lives and dies" (Hewson 2003). There are five pillars of animal welfare, including (a) liberty from starvation and thirst by providing a balanced diet and freshwater; (b) liberty from discomfort by equipping a proper environment such as a resting area and shelter; (c) liberty from pain, injuries and illness, by prevention, diagnosis and remedy; (d) liberty to express normal manners, by supplying adequate space, suited facilities and a group of the animal's kind; (e) liberty from anxiety and distress, by providing conditions and therapy which avoid mental suffering (Mellor 2016).

3.2 Animal Health

Generally, health is clarified as physical and psychological well-being. In the case of animals, health may be explained as the absence of disease or an animal's normal behaviour and functioning compared with other individuals that determine the standard and health (Ducrot et al. 2011). Based on both definitions, animal health is a crucial component of animal welfare. Although the concept of animal health in the literature reviews covers different approaches, it can simply divide into the following approaches; animal diseases, animal welfare, and animal productivity (Gunnarsson 2006).

Several pathogens, including viruses, bacteria and parasites, can cause animal diseases. These diseases were classified based on their transmissible, spreading and impact on society, economy and trade (Mcelwain and Thumbi 2017). Among these diseases, transboundary animal diseases, including zoonotic diseases, significantly impact livestock productivity, particularly in developing countries and can result in restrictions on the global commerce of livestock and livestock products (Cartn-Rojas 2012). Transboundary animal diseases (TADs) refer to those epidemic diseases which are highly contagious with the possibility to distribute rapidly across the world. At the same time, zoonotic diseases are defined as diseases that can transmit from animals to humans (Table 1) (OIE 2021).

In general, these illnesses can endanger the world's food supply by direct mortality of animals or production shortages due to the loss of animal power or reducing the availability of animal products, or, in the case of zoonotic diseases, reducing the supply of food or other animal products through the loss of human productivity (Clemmons et al. 2021).

Food-borne diseases are another category of animal diseases that significantly impact food safety. They are a disease commonly transmitted through ingested food and caused by bacteria, viruses, and parasites (Table 1). Many food-borne diseases

Table 1 A selection of animal diseases that affect the availability and safety of food

Disease	Causative agent	Species affected	Other
African swine fever	African swine fever virus (*Asfivirus*)	Domestic and wild pigs	Transboundary disease
Avian influenza	Avian influenza virus (Influenza A)	Domestic poultry; birds and mammals	Transboundary and Zoonotic disease
Bluetongue	Bluetongue virus (*Orbivirus*)	Domestic and wild ruminants; primarily sheep	Transboundary disease
Classical swine fever	Classical swine fever virus (Pestivirus)	Domestic and wild pigs	Transboundary disease
Contagious bovine pleuropneumonia	*Mycoplasma mycoides s*ubsp. Mycoides	Domestic and wild large ruminants; primarily cattle	Transboundary disease
Foot and mouth disease	Foot and mouth virus (*Aphthovirus*)	Cloven-hooved animals	Transboundary disease
Middle East respiratory syndrome	Coronavirus (*Betacoronavirus*)	Camels	Zoonotic disease
Newcastle disease	Newcastle disease virus (*Avulavirus*)	Primarily domestic chickens; reptiles, birds, and mammals possible	Zoonotic disease
Peste des petits ruminants	Peste des petits ruminants virus (*Morbillivirus*)	Domestic and wild ruminants; primarily goats and sheep	Transboundary disease
Rift Valley fever	Rift Valley fever virus (*Phlebovirus*)	Ruminants	Zoonotic disease
Sheep and goat pox	*Capripoxvirus*	Sheep and goats	Transboundary disease
Swine vesicular disease	Swine vesicular disease virus (*Enterovirus*)	Pigs	Transboundary disease
Vesicular stomatitis	Vesicular stomatitis virus (*Vesiculovirus*)	Horses, cattle and pigs; rarely sheep and goats	Transboundary disease
Salmonellosis	*Salmonella spp.*	Domestic and wild animals, including cattle, sheep, goats and pigs, chickens	Food-borne zoonotic disease
Campylobacteriosis	*Campylobacter spp.*	cattle, sheep, goats, pigs, chickens,	Food-borne zoonotic disease
Escherichia coli (E.coli)	*Escherichia coli*	Domestic and Farm animals including cattle, sheep, goats, pigs, chickens	Food-borne zoonotic disease

(continued)

Table 1 (continued)

Disease	Causative agent	Species affected	Other
Listeriosis	*Listeria monocytogenes*	Ruminants, such as cattle, goats, and sheep	Food-borne zoonotic disease
Brucellosis	*Brucella spp*	Sheep, cattle, and goats	Food-borne zoonotic disease
Norovirus	Norovirus *(Caliciviridae)*	Pigs	Food-borne zoonotic disease
Toxoplasmosis	*Toxoplasma gondii*	Cattle and pigs	Food-borne zoonotic disease

Source Clemmons et al. (2021), Villabruna et al. (2019), Bintsis (2017), Román et al. (2013)

are considered zoonotic diseases. The economic costs associated with these diseases come from the effect on food production, healthcare systems and trade (McLinden et al. 2014).

4 Food Safety and Food Security

4.1 Food Safety

Food safety is defined as the circumstances and procedures that are used in the production, storage, processing, distribution, and preparation of food to confirm that it is safe and suitable for human consumption (Farm-to-fork chain). Access to safe food results in promoting people's health and productivity. However, both developing and developed nations have faced severe health concerns related to food safety in the past ten years (Yemane and Tamene 2022).

Similar to other foods, safety issues of animal-based foods start at the initial production stage and persist till consumption (Fig. 1). Thus, it is necessary to have proper practices (Good Animal Husbandry Practices or Good Veterinary Practices) on every farm where livestock are raised for food (Fung et al. 2018; Attrey 2017).

Good Animal Husbandry practices contain animal welfare, animal feeding, and the control and treatment of animal diseases. These practices have been set to ensure buyers that foods that come from animals fulfil satisfactory levels of quality and safety (FAO 2004).

The food safety practices during food processing and distribution in retail shops aim to address the hazards that might occur to food during this chain. These practices include proper food handling, separating raw and cooked, cleaning and sanitation, the correct temperature for storing, use of safe water and the health status of workers (Tegegne and Phyo 2017; WHO 2006).

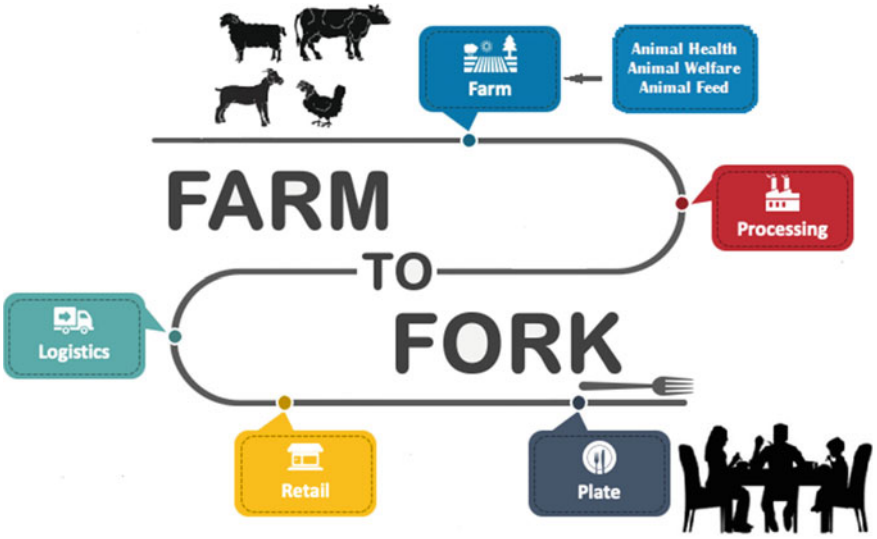

Fig. 1 Farm to fork model for food of animal origin (Modified from: https://www.sketchbubble.com/en/presentation-farm-to-fork.html)

4.2 Food Security

Food security is the availability and access of enough food to all people at any time, allowing them an active and healthy life (Campbell 1991).

Food security is multifaceted and characterized by four pillars: availability, access, utilization, and stability. These pillars are defined as follows:

Availability: means the availability of adequate amounts and appropriate qualities of food, which is provided through regional production or imports.

Access: implies the ability of the individual to acquire sufficient nutritious food.

Utilization: is the capacity of the human body to consume and metabolize food through a good diet, hygienic water, good sanitation and health care to reach a condition of nutritional well-being where all physiological necessities are fulfilled.

Stability: refers to a situation that exists when all populations, households or individuals have access to sufficient food at any time (food secure) and do not risk failing access as a result of economic or climatic crises such as drought (Guiné et al. 2021; FAO 1996).

In general, the safety and security of animal-based foods before harvest are influenced mainly by farm management systems, animal nutritional status, and animal diseases. Whereas after harvest, they are influenced by handling, processing, storage, industrial and commerce practices.

Since animal-based foods are nutritionally dense origins of protein, energy, and diverse vital micronutrients, the shortages in these foods will result in serious health problems (Fig. 2). For instance, the WHO counted that more than 250 million children

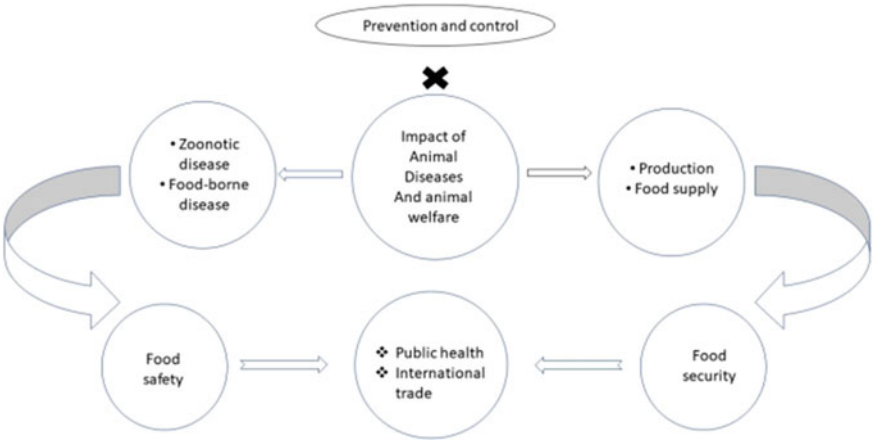

Fig. 2 Diagram shows the general impact of animal diseases and animal welfare in food safety and food security

develop blindness due to vitamin A deficiency (WHO 2009). Furthermore, around 56% of children's deaths in growing nations are due to protein-energy malnutrition, whereas 16.42% suffer from iron deficiency anaemia (Gedfie et al. 2022; Walker 1990). Even small quantities of animal-based foods have been shown to substantially secure dietary sufficiency, prevent malnourishment and have favourable effects on growth, physical activity, mental function and reduced morbidity from illness, especially in children and pregnant women. Besides, eating sufficient amounts of animal-based foods is linked with more capable immune systems and better immune reactions (Smith et al. 2013).

Animal-based foods could also contribute to food security indirectly through income generation. A good example is livestock-production households. Livestock production and marketing are estimated to be necessary for the living of more than one billion poverty-stricken in Asia and Africa (one-seventh of people) (Otte et al. 2012; Staal et al. 2009). Generally, the animal owners consume part of their products and sell the rest, which reflects positively on their income and a healthy household diet.

The assistance of livestock to household revenue varies widely, between 2 to 33% in several developing countries (Staal et al. 2009). For instance, the production and marketing of beef support around 70 million individuals in West Africa, whereas dairy production supports 24 million in East Africa and 124 million individuals in South Asia. The small ruminants aid 28 million in Southern Africa and an extra 81 million individuals in West Africa (Herrero et al. 2013; FAO 2009; Staal et al. 2009).

5 The Impact of Animal Welfare and Animal Health in Food

5.1 Safety and Security

Most people know that food safety and food security are the key elements that sustain the food system to establish a healthy population, and both issues are everyone's business. As the main idea of food security is sufficient, safe and nutritious food for all people, the contribution of food safety emerges here, safe food. Thus, to have healthy, sustainable food production, food safety and food security must come into action together. On the other hand, due to this interrelationship between food safety and food security, any harmful factor can negatively impact food safety and food security simultaneously (Chattu 2015; Hanning et al. 2012).

5.2 Animal Diseases

The World Organization for Animal Health (OIE) lists around 118 notifiable diseases that infect different species of animals (i.e. cattle, sheep, goats, swine, equines and poultry). This list includes diseases that threaten trade in animals and animal products (Mcelwain and Thumbi 2017).

Food deterioration and food-borne diseases are brought on by pathogens that may be found in food, such as bacteria, viruses, and certain parasites. These pathogens are significant issues concerning food safety and security and result in human diseases when consumed through animal products that have been infected with them (Heredia and Garcia 2018). According to reports, approximately 600 million individuals globally get sick after eating tainted food (Guerra et al. 2016).

Although food-borne illnesses are a health concern in both rich and developing nations, the impact of these illnesses is often greater in poorer countries. According to WHO estimation, food-borne diseases are estimated to cause illness to 30% of the population and up to 2 million deaths yearly (Abunna et al. 2016). The majority of food-borne microorganisms have a zoonotic origin, and food items of animal-based are thought to be a major source of food-borne diseases (Ejo et al. 2016).

Zoonotic pathogens can contaminate food in several ways. If an animal is affected by a disease, the tissues of this animal, such as meat or milk, become a source of human infection if allowed to enter the food chain. In addition, many of these pathogens live in the digestive system of healthy animals naturally and can spoil raw meat during slaughtering, milk during milking, or eggs during laying. Cross-contamination can occur of other foods if they come into contact with a contaminated product either directly, during preparation or storage or indirectly via workers, work surfaces, utensils or other objects (Hemalata and Virupakshaiah 2016; Aklilu et al. 2015). Approximately 60% of human illnesses are zoonotic diseases, and around

75% of new emerging human infections are transmitted from animals to people (Bidaisee and Macpherson 2014).

During the last decade, the outbreak of Highly pathogenic avian influenza (HPIA) between 2014 and 2015 was one of the most numerous animal diseases that impacted food security in the USA. Over 42 million egg layers and 7.5 million turkeys were eradicated to control the spread of the disease. Furthermore, the US Department of Agriculture paid around US$ 879 million for detection, reaction and rescue activities. This amount is comparable to 1.82% of the whole poultry production worth in the US (Johnson et al. 2016; Hagerman and Marsh 2016). Although there is no precise data, we can assume that during that time, there was an increase in egg prices which may reflect in the accessibility of this product.

In Africa, HPIA had an adverse effect on pricing for poultry and eggs due to consumer fear and decreased availability of poultry and poultry products as a result of culling and mortality (Birol et al. 2013). In Nigeria, for example, HPAI resulted in 900,000 birds on business farms have died or being slaughtered in 2006, with an evaluated cost of US$ 4.82 million (Mcelwain and Thumbi 2017). The consumer panic and scare in Nigeria led to an extreme decline (around 80%) in poultry meat and egg consumption at restaurants and households (Obayelu 2007). A similar scenario happened in Kenya, as the public panic led to a sharp drop in egg and poultry meat consumption and a loss of revenue for the 65% of countryside farmers who raised poultry (Mcelwain and Thumbi 2017). These are examples of where a food safety concern could lead to food insecurity.

Foot and mouth disease (FMD) is an endemic disease in most of Africa, except a few areas in southern Africa that are deemed free of this disease. Although FMD generally has a short-term impact on an animal's health, the chronic form of the disease can reduce milk yields by 80%, affecting both humans, particularly children, and calves that depend on it (Bayissa et al. 2011). Also, the growth rates of livestock are suppressed due to FMA, and the mortality rate among young animals is typically between 2 and 3% (Rufael et al. 2008).

FMD can result in abortion, which considers a cost as the farmer will have to keep the cows without producing anything for another period.

Reducing milk production, decreasing growth rate and abortion all these effects can reduce the availability and accessibility of animal-source foods. Additionally, FMD can influence food accessibility through quarantine measures, which are applied by most nations in case of FMD outbreak. It is well-known that countries, where FMD are endemic, cannot sell live animals to FMD-free countries (Knight-Jones and Rushton 2013). Even if a country is FMD-free and has commerce with FMD-infected countries, it will experience trade restrictions, which may also affect the trade of vegetables and fruit (Knight-Jones and Rushton 2013).

In 2000, a massive epidemic of Rift Valley fever (RVF) devastated the southern region of Saudi Arabia and neighbouring Yemeni areas. This outbreak was the first ever documented outside of Africa. During this epidemic, approximately 40,000 animals, predominantly sheep and goats, died or were aborted. Whereas 883 cases, with 124 deaths, were confirmed among people in Saudi Arabia. In northeastern

Yemen, 1328 new human cases were reported, including 166 deaths (Al-Afaleq and Hussein 2011).

Analogous to FMD, HPIA and RVF the other transboundary animal diseases, such as rinderpest, classical swine fever and peste des petits ruminants (Table 1), pose a severe risk to the food supply by lessening the availableness of animal products due to restriction of the international trade, which caused a significant socioeconomic and health consequences (OIE 2021). In the 1980s, for example, Africa lost over 2.5 million cattle due to rinderpest (Barrett and Rossiter 1999). In contrast, Rift Valley fever caused more than 100,000 domestic animal deaths in Africa during the 1950s and 1960s (Linthicum et al. 2016). What is more, the economic impact of Rift Valley fever between 2006 and 2007 ranged between 0.01% of the gross domestic product in Tanzania (6.7 million US$) to 5.5% of the gross domestic product in Somalia (471 million US$) (Bron et al. 2021).

Another illustrative example of the impact of animal illnesses on food safety and security is brucellosis, caused by *Brucella* species. Although brucellosis has been eradicated in first world countries, it remains endemic in many African countries. In endemic areas, brucellosis can cause a notable decrease in milk production, weight loss and abortion. All these effects cause harm to food security and the livelihood of farmers who rely on the trade of dairy, meat, and offspring from their animals (Franc et al. 2018). In Mexico, as an illustration, a decrease ranging between 20–30% in milk production has been calculated in brucellosis-affected farmsteads (Herrera et al. 2008). Brucellosis also threatens food safety as the disease can be transmitted from animal to human. Globally, WHO estimated around 393,239 brucellosis cases in humans and 1957 deaths (WHO 2015). Generally, humans get the disease through eating or drinking contaminated animal products (Wainaina et al. 2020). For instance, 62–94% of human brucellosis infections in Turkey are caused by the use of milk products that are contaminated. In contrast, intake of tainted raw milk was to blame for 57% of brucellosis cases in Iran, 69% of cases in Kuwait, and 63% of cases in Oman (Moosazadeh et al. 2016; Buzgan et al. 2010; El-Amin et al. 2001; Mousa et al. 1988).

Similar to Brucellosis, Bovine tuberculosis substantially impacts fertility, milk and meat productivity in cattle, which means a decrease in the availability and accessibility of food. It also affects food safety as a man can get the infection from contaminated milk or meat. Globally, *Mycobacterium bovis*, the causative agent of Bovine tuberculosis (TB), caused 121,268 tuberculosis cases and 10,545 deaths in humans (WHO 2015). According to Hernandez and Baca (1998), tuberculosis was linked to a 4% decrease in milk production. Likewise, Bovine tuberculosis results in declining meat production due to the condemnation of organs and carcasses that are contaminated with TB lesions (Alembrhan and Haylegebriel 2013).

African Animal Trypanosomiasis, caused by the genus *Trypanosoma*, is an example of a parasitic zoonotic disease that has a major impact on food security in Africa. Countries, where the disease is endemic, have persisted to suffer from financial losses of millions of dollars (Mulenga et al. 2021). According to the FAO, this illness causes 3 million cow fatalities annually, and 50 million head of cattle are thought to be in danger of this disease. Loss in cow output alone was evaluated as

US$1.0–1.2 billion annually, which is considered as seriously threatening to food security (FAO 2018).

Food safety is influenced by the variety of microorganisms, including *Listeria monocytogenes*, *Salmonella species*, *Campylobacter*, *E. coli*, and *Toxoplasma gondii,* which are broadly prevalent and pose a considerable hazard to human health in developing societies (Food-borne disease) (Akhtar et al. 2014). Globally, the consumption of unsafe food resulted in 600 million cases of food-borne infections (approximately 7.69% of the world's population) and 420,000 deaths every year (approximately 7.5% of the world population) (WHO 2015).

Although food-borne diseases could happen due to plant-based food consumption, foods manufactured from animal products are considered the primary cause of food-borne illnesses (Table 2) (Heredia and García 2018).

In Saudi Arabia, the major food outbreaks caused by microbial food poisoning and food-borne pathogens have been documented in Mekka during the Hajj and Umrah seasons due to the flourishing of the street food trade during these seasons (Dablool et al. 2014). Bakri et al. (2017) reported that *Salmonella enteritidis* group D, *Staphylococcus aureus*, *Bacillus cereus, Clostridium perfringen*s, and *E. coli* were the most common pathogens in Saudi cities during the previous ten years (Table 3). However, many incidents go unreported because people are less likely to attend health facilities or because food inspection and analysis are incorrect (Alsubaie and Berekaa 2020).

Another report showed that Staphylococci are involved in 41% of bacterial food poisoning cases, and milk and dairy products are the main sources of the infection (Sheikha 2015).

In a study performed in Jeddah, the PCR analysis revealed that both E. coli and Salmonella species were found at higher rates in meat samples from butcher shops. Whereas in small butcher shops, *Salmonella was* found at an incidence of 45% and *E. coli* at 65% (Iyer et al. 2013).

Table 2 Examples of the number of human cases and deaths globally due to food-borne diseases, 2010

Pathogen	Total number of cases (mean)	Total number of death (mean)
Norovirus	124,803,946	34,929
Hepatitis A virus	13,709,836	27,731
Campylobacter spp.	95,613,970	21,374
E. coli	23,797,284	37,077
Shigella spp	51,014,050	15,156
Listeria monocytogenes	14,169	3175
Salmonella spp.	9,311,207	64,541
Toxoplasma gondii	10,280,089	684

Modified from WHO (2015)

Table 3 Outbreaks occurred in Saudi Arabian between 2006 and 2011

Pathogen	Area of outbreak (year)	The morbidity rate
Bacillus cereus and *Clostridium perfringens*	Makkah (2006)	39%
Salmonella spp and *Staphylococcus aureus*	Qassim (2006)	64.5%
Salmonella spp and *Amoeba*	Ahad Rafidah (2009)	77.1%
Escherichia coli	Taif (2006)	60.9%
Salmonella enteritidis	Bisha (2007)	100%
	AI-Hofuf (2009)	56%
	Khaiber (2009)	100%
	Riyadh (2009)	200 cases
	Abha (2011)	26 cases
Salmonella enteritidis group D	Riyadh (2007)	62%
	Najran (2008)	80%
	Al-Ahsa (2010)	33 cases
	Hail (2011)	100%
Salmonella spp	Sulyyel (2010)	64.5%
Staphylococcus aureus	Hail (2011)	39 cases

Modified from Bakri et al. (2017)

Another outbreak was reported in Taif City in 2006 when an extended family registered to the clinic with gastroenteritis signs. This epidemic was attributed to E. coli, which was isolated from raw milk (Al Mazroua and Al Hamadan 2006).

5.3 Animal Welfare

As we mentioned earlier, the main pillars of animal welfare are proper feeding, a suitable environment, treatment and freedom from stress factors such as crowdedness and pain (Mellor 2016). Proper animal welfare correlates to good food safety, in other words, improving animal welfare practices will reflect in the quality and safety of food.

Generally, stress reduces an animal's fitness by impairing its immune system, which can be described as a failure to meet production performance goals or illness and mortality. Consequently, the stress factors in farm animals could harm the quality of food products (Rostagno 2009).

Heat is an example of the stress effect on immunity status. It has been proven that heat stress hurts the immune system through cell-mediated and humoral immune reactions. The release of blood cortisol is triggered by heat stress. Interleukin-4 (IL-4), IL-5, IL-6, IL-12, interferon (IFN), and tumour necrosis factor (TNF) production have all been found to be suppressed by rising blood cortisol levels (Bagath et al.

2019). Immune system deterioration increases an animal's vulnerability to infectious illnesses, which in turn decreases the productivity of animals.

Heat stress often has a negative effect on production and animal well-being. However, fatalities will also happen in extreme or protracted circumstances. One of heat stress's first and most significant effects is reduced feed intake, which lowers growth rates and milk or egg production. Heat stress similarly impacts animal output due to changes in fertility and disease susceptibility (St-Pierre et al. 2003). Heat stress can also affect the quality of animal products, like changing the colour and water-holding ability of both white and red meat, reducing the protein and fat content of milk and decreasing the size of eggs and the thickness of eggshells (Godde et al. 2021).

The welfare of animals during transportation is one of the concerns we must address. Animals must be transported in a means of transport and under conditions that are suitable for that animal, such as sufficient floor area and height, water and feed available if necessary, the animal handler received training, the length of the journey should be minimized, and the convey must not cause any injury (Nielsen et al. 2011). Shipping fever, caused mainly by Mannheimia haemolytica, is a well-known example of transportation's effect on animal health. Shipping fever is a transport-associated disease that occurs in animals several days or weeks after shipment (Maeda and Oikawa 2019). In cattle, the illness is described by severe fibrinous bronchopneumonia, which may lead to death at an early stage. Clinically, cattle often exhibit anorexia, depression, and fever between 40 and 41 degrees Celsius. They may also exhibit a productive cough, an encrusted nose, mucopurulent nasal discharge, shallow breathing, or an expiratory grunt (Gershwin et al. 2015). Based on that, improper transportation could cause significant economic losses to the food supply by reducing the average daily gain and overall performance of animals due to illness.

Animal forages also play an important part in food safety and security. These feeds can be a source of several pathogens for animals that can lead to human illness. These diseases are caused by a proteinaceous infectious pathogen, sometimes known as a "prion." Prion diseases have been observed in a variety of different animals. Different names were given to each of the diseases based on the affected species: Creutzfeldt-Jacob disease (CJD) in humans, Scrapie in sheep, bovine spongiform encephalopathy (BSE) in cattle, and chronic wasting disease (CWD) in cervids. While these diseases appear to have a similar mechanism, they differ in symptoms, pathophysiology, and transmissibility among species (Hedlin et al. 2012).

Bovine Spongiform Encephalopathy is a well-known illustration of the impact of animal feed on food safety. This disease is conveyed to humans by ingesting food contaminated with infected animal tissue (Dealler and Lacey 1991). Cattle get the infection by consumption of forages containing ruminant-derived protein.

What is more, it's necessary to guarantee that the feed for animals is free of any hazardous substances that can harm the animals' health. The poison in the animal feed can occasionally be absorbed by the animal body and then given to the consumer in the form of milk, meat, or eggs.

The safety of our food is also affected by the misuse of veterinary medicines. These substances may leave residues in milk or meat. Thus, some procedures should be

followed strictly during animal treatment, such as using suitable therapy for the proper species and at an accurate dose. The medicines records must be kept maintained for each animal to guarantee that any animals or their products shipped to the market have no drug residues or these residues below the allowed limit. The time they demand between administering the last dose of medication and the production of animal-derived products is known as the withdrawal period. This period permits the concentration of drug residue in milk or meat to drop into acceptable levels, which is considered non-threatening to human health (Beyene 2016). Among all animal-based foods, milk is at high risk of drug residues. As an illustration, studies performed in Iran, Pakistan and Bangladesh found that 19.78%, 36.5% and 18% of the milk specimens were polluted with drugs residues, respectively (Rahman et al. 2021; Aalipour et al. 2015; Khaskheli et al. 2008).

6 The Roles of Veterinary Services in Food Safety and Security

The professionals of Animal Health and Welfare are critical in optimising physical health, behavioural health and the animal's welfare. Further, veterinarians and co-workers contribute significantly to preventing, treating and controlling animal diseases at the individual level or even the whole animal population (Carag et al. 2021). Minimising losses due to health problems and improving animal production are among the most essential goals for society. Such improvement necessarily translates into an augmentation of food security and the standards of our lives in all communities across the globe.

Although improvement of animal health can be performed in different ways, prevention and control are the best strategies that can be applied to reach the goal. Biosecurity, farm husbandry, vaccination and treatment are the main pillars to prevent and control animal diseases.

Biosecurity refers to practices that prevent the introduction and spread of disease within a farm (Dargatz et al. 2002), such as isolation of new animals, quarantine procedures, disease testing and treatment if they are sick. By doing these, we prevent introducing a new disease into a group of animals (Barrington 2014).

Good farm husbandry practices can aid in protecting the health of the animals, accordingly decreasing antibiotic usage and the risk of drug residue. These practices include; ensuring a balanced diet, minimising animal stress, and minimising exposure to pathogens. In these ways, we help to build the animal's resistance to disease (Ventura et al. 2021).

Vaccination is a tool for stimulating immunity to specific pathogens and prompting the animal body to produce antibodies or another defence mechanism against infection. Vaccinations not only strengthen a herd's immunity but also recede disease and prevent or decrease the shedding of disease by infected animals (Roth 2011). Knueppel et al. (2010) found that a boost in the vaccination of chicken Newcastle

disease leads to a growth in ownership of chickens and egg consumption and also has an effect on decreasing family food insecurity. In another study, Marsh and co-workers reported that a 1% increase in the number of cattle vaccinated against East Coast fever, a tick-borne protozoal disease, is linked with a statistically significant increase (0.08%) in the average reported milk production per herd (Marsh et al. 2016).

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