Management of infectious animal diseases: the Korean experience

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Abstract: Despite the efforts of stakeholders, infectious animal diseases, including foot and mouth disease and avian influenza, continue to afflict Korea during winter. The present research aims to examine how the nation can improve its management of infectious animal diseases toward the ultimate goal of emergency disease management. The main methodology applied is qualitative content analysis. The management of infectious animal diseases is compared between the normal and the emergency approach in terms of central government policy, local government strategy, farm efforts, scientific research, and visitor readiness. The key finding is that disease management in Korea has to shift from the current normal approach to an emergency approach. Neighbouring nations need to implement all four phases of the emergency management process toward achieving an emergency approach to management.

Keywords: foot and mouth disease; avian influenza; foreign animal diseases; public health; four phases of emergency management lifetime.

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1 Introduction

Multiple factors, including climate change, movement through globalisation, and bird migration, have caused outbreaks of infectious animal diseases in the international community (Wu et al., 2016, pp.15–18), which different nations have had to deal with individually. Korea has experienced outbreaks not only of foot and mouth disease (FMD) but also of avian influenza (AI). These two infectious animal diseases frequently afflict South Korea (hereinafter Korea) during winter, as shown in Table 1.

Table 1 Recent outbreak of infectious animal diseases in winter (V = applicable)

Years	*Outbreak of FMD*	*Outbreak of AI*
2020/2019		V (H5-typed)
2019/2018	V (O-typed, January 2019)	
2018/2017	V (A-typed, March 2018)	V (H5N1 & H5N6 in 2018 + H5N8, *summer 2017)
2017/2016	V (O-typed and A-typed)	V (H5N8 and H5N6)
2016/2015	V (O-typed)	
2015/2014	V (O-typed)	V (H5N8)
2014/2013	V (O-typed, *summer 2014)	
2013/2012		
2012/2011		
2011/2010	V (O-typed)	V (H5N1)
2010/2009	V (O-typed and A-typed)	
2009/2008		V (H5N1)

Source: MAFRA (2020)

Despite continued efforts to prevent the incidence of FMD and AI in Korea, these two animal diseases occur in the country each year. In a sense, many Koreans have become indifferent to the frequent outbreaks of these diseases (Hong, 2017). The fact that FMD and AI continue to plague the nation indicates that Korea's efforts at preventing these diseases are inadequate. A key research question, therefore, is how Korea can stop the repeated outbreaks of these two infectious animal diseases.

The present study aims to explore whether Korea needs to change its approach in dealing with outbreaks of FMD and AI. Two styles of the management of infectious animal diseases are rigorously compared, namely, the normal vs. the emergency approach.

The two management styles have different basic definitions. Under the normal approach, stakeholders try to manage the infectious animal diseases only during an outbreak. In short, it is a temporary approach to dealing with FMD and AI. Under the emergency approach, stakeholders continuously manage the diseases by all means possible before, during, and after an outbreak. This involves the systematic efforts of all stakeholders toward managing unexpected incidences of FMD and AI.

The two management styles are compared in terms of five factors, namely, central government policy, local government strategy, farm efforts, scientific research, and visitor readiness. The key finding is that Korea needs to shift from the current normal approach to the management of infectious animal diseases to an emergency approach. On the basis of international cooperation, neighbouring nations could elaborate on all phases of the emergency management lifetime by implementing a whole community approach, planning, and education and training.

2 Literature survey

Many researchers consider the outbreak of infectious animal diseases as a form of natural disaster, mainly because the occurrence of these diseases follows a pattern similar to that of a natural disaster (Ricciardi et al., 2011, pp.313–314). However, other researchers maintain that infectious animal diseases are a form of man-made emergency or a combination of a natural disaster and a man-made emergency, primarily because the diseases are closely linked to the behaviour of people or to human management of the biological environment (Rull, 2015, pp.5–9).

FMD is a highly contagious viral disease that affects cloven hoofed animals, including livestock and wildlife (Aftosa, 2014, pp.1–9). Animals infected by the FMD virus experience distress and pain. As a result, they produce less milk, develop chronic mastitis, and suffer permanent damage to their hooves. FMD may be reintroduced to animals in any region through the rapid spread of the FMD virus. Extreme cases of FMD can result in the death of the animals. Thus far, FMD has not been found to infect people; thus, it is not considered as a zoonosis.

FMD is a seasonal disease occurring mostly in winter, although it can also break out during summer if the environment is compromised. The disease has thus far occurred in several nations in Asia and in a few countries in Africa, as well as in other regions. Outbreaks have ceased to occur in North America, Australia, and Western Europe, where the disease had been previously reported (OIE, 2020). However, under the right conditions, FMD can be reintroduced in any region, as in the case of the FMD outbreak in the UK in 2001.

AI is a type of influenza, which is a contagious respiratory disease (MedicineNet.com, 2017). Also known as avian flu, bird flu, or fowl plague, it is caused by the H5N1 influenza virus and has occurred in various parts of the world, particularly in cold temperature environments. AI can infect not only various birds, including chickens, ducks, quails, turkeys, and wild birds, but also mammals, such as cats, pigs, dogs, horses, moose, and whales.

AI viruses, such as H5N1 and H7N9, have been known to cause human deaths. For example, H5N1 was transmitted to more than 500 individuals worldwide and then killed about 60% of them. H7N9 hit China four times between March 2013 and June 2016, infecting 580 people, about 35% of whom died (Liu et al., 2017, pp. 118–120). The pattern of the AI epidemic has been nonlinear, which makes it difficult to explain how the zoonosis operates.

In some nations, such as US, both FMD and AI are classified under either foreign animal diseases or transboundary animal diseases (USAHA, 2008, pp.17–18). Foreign animal diseases originate from other areas but have been unexpectedly transmitted to many animals in US. The incidence of foreign animal diseases in a specific nation becomes less meaningful, however, considering that such diseases can rapidly spread around the world under a globalised arena (Lee et al., 2011, pp.233–235). The more relevant issue is how to efficiently manage these diseases.

Each nation defines the scope of pandemic viruses within its own context. According to the Federal Emergency Management Agency (FEMA), pandemic viruses have three common features (EMI, 2013b). First, they can reproduce quickly and then spread through individuals and individual contact. Second, they have the capacity to mutate rapidly; that is, they undergo natural mutation. Third, they can cause a second surge of victims, which include healthcare workers and emergency responders.

Because it is not a zoonosis, FMD cannot be transmitted to humans. The FMD virus has the ability to mutate rapidly, but it does not spread through humans and human contact. Initially, the FMD virus was not considered as a pandemic virus. Nonetheless, some researchers regard it as such because the virus can spread to many regions or globally within a short period of time (Knowles et al., 2005, pp.1887–1888).

On the other hand, the AI is a typical pandemic virus. Because it is a zoonosis, AI can be transmitted to humans from affected birds and can spread to different regions through humans or human contact, creating a second wave of victims. Furthermore, through natural mutation, the AI virus can reproduce rapidly and then infect not only birds and other mammals but also humans.

Three kinds of risks are discussed during an FMD or AI outbreak, namely, human losses, economic damages, and psychological impacts (Shortle, 2007, pp.1239–1240). Similarly to any emergency, infectious animal diseases can cause harm or death to humans. They also cause large economic damages by killing cattle, poultry, and other animals. Moreover, many individuals suffer psychological shock during outbreaks of FMD or AI. Previous studies have analysed the risks in specific research areas, such as medical science, emergency management, economics, and psychology.

Infectious animal diseases frequently give rise to public health concerns, particularly regarding human losses, given that the AI virus, which undergoes zoonosis, may directly affect or threaten human health through hydatidosis, vector-borne diseases, and visceral larva migrans (Heath et al., 1999, pp.262–268). Although the FMD virus is not known to undergo zoonosis, it can indirectly pose a threat to public health. There also remains the possibility that the FMD virus could undergo zoonosis in the near future.

Fundamentally, the issue of how to deal with FMD or AI is related to that of how to address critical challenges in human life (Nanavati, 2018). Thus, each individual or stakeholder has to build up its capacity to address FMD or AI. Also, stakeholders must not rely on a single method but instead adopt multiple ways to overcome life challenges under the changing environment. Hence, each stakeholder must think big, set appropriate goals, and maximise work performance while developing a positive attitude and self-motivational skills.

It is necessary for each stakeholder to take every precaution in dealing with FMD or Al (Government of the Netherlands, 2020). Given the critical impact of infectious animal diseases on human society, individuals or institutions need to apply all means possible to control outbreaks of FMD or AI. Thus, farmers regularly vaccinate their animals and comply with the legal requirements of the industry. Governments, with the cooperation of other organisations, also play a role in monitoring infectious animal diseases. Moreover, transporters must implement safety procedures in moving animals to and from other regions. Once an animal disease breaks out in a nearby region, stakeholders need to take extra measures to prevent the spread of infection, such as euthanasia, border control, and banning animal movement.

Considering the above-mentioned risks, dealing with FMD or AI can be regarded as related to risk-oriented management. However, the issue of infectious animal diseases is also related to politics (Smith et al., 2014, pp. 3906–3907). In the process of managing an outbreak of either FMD or AI, the various stakeholders may impose their own political interests by taking advantage of their networks, influencing the political leadership, or even allowing corruption. Hence, although a risk-oriented management approach is desirable, politics exerts considerable influence in addressing the issue of infectious animal diseases.

Several international researchers have studied infectious animal diseases from their own perspectives. In these studies, three variables have been frequently identified and examined, namely, the viral variable, the human variable, and the ecological variable (EMI, 2013c; Hui, 2006, pp.905–906; Schultz, 2014, pp.26–27). The viral variable includes the virus adaptation and evolution. The human variable considers human travel, unplanned mitigation, and other human social behaviour. The ecological variable addresses climate change and other environmental factors.

For example, some researchers tried using sniffing animals to diagnose FMD or AI, similarly to infectious human diseases (Cambau and Poljak, 2019). Sniffing animals, including dogs and elephants, use their olfactory acuity in this task, with elephants known to have a much better sniffing function compared with dogs. Other scientists used insects to diagnose FMD or AI. A number of insects are able to detect the scent of infectious animal diseases by using their receptors. Lizards, in comparison, use their tongue to detect such smell. Nonetheless, scientists face difficulties in providing appropriate training and housing for animals and insects.

Some Korean researchers have studied how to deal with infectious animal diseases in their specific areas of expertise, including veterinary medicine, infectious diseases, and infectious viruses. Most of them have focused on a single infectious animal disease, such as FMD or AI (Kim et al., 2016, pp.279–283; Park et al., 2013, pp.655–656; Park et al., 2016, pp.102–104). Few studies have rigorously examined series of infectious animal diseases, as the present research does. Moreover, in contrast to previous works, this study points to the significance of emergency management by including not only local viewpoints but also international perspectives on the outbreak of infectious animal diseases.

3 Research methodology

Qualitative content analysis was the main research method applied, given the considerable amount of qualitative data identified, collected, and then interpreted in support of the key finding. After the observation and selection of the relevant qualitative materials at the appropriate scales, the data were flexibly interpreted and then added into the right places.

The process of qualitative content analysis consisted of six steps. A research question was first formulated, as presented in the Introduction. Then, various text materials were selected. These materials were carefully reviewed, and units of analytical categories were defined. Next, the appropriate text materials were coded. Finally, the findings were flexibly interpreted and recorded (Hall, 2018).

The technique of description was applied in the qualitative content analysis. Whereas prescription involves proposing a main topic, description entails accounting, sketching, or describing a key theme in words. It is the description of something that has happened. Namely, this paper has made efforts to explain the key tenet as what it actually is or describes how things are done by utilising descriptive content analysis.

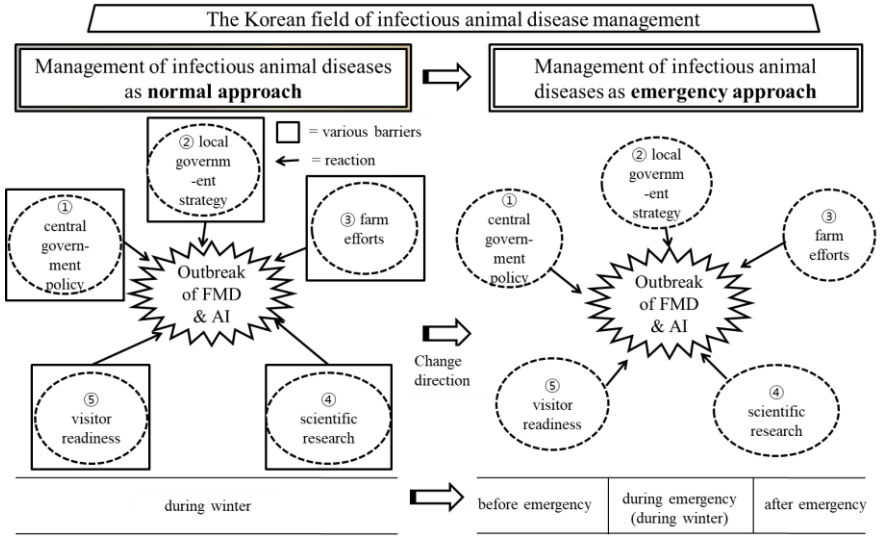
The technique of inference was used to condense the raw materials into themes or categories. Inference involves reaching a conclusion based on inductive or deductive reasoning (Gondim and Bendassolli, 2014, pp.194–195). To obtain valid inferences, efforts were made to ensure that the classification procedure was fairly consistent in

linking concepts, theories, and results. The analysis applied the method of inference to varying extents, depending on the presence or absence of themes or categories.

To obtain the qualitative data, internationally known search engines were used, including Oxford University Press, ScienceDirect, EBSCOhost, Google Scholar, and Yahoo.com. Among the keywords used were 'infectious animal diseases', 'foreign animal diseases', 'foot and mouth disease in Korea', 'avian influenza in Korea', and 'livestock and disaster management'. Korean search engines were also used, such as KISS, DBpia, and several government websites.

As shown in Figure 1, the findings of the present research indicate that Korea needs to change its strategy of managing FMD and AI, shifting from a normal to an emergency approach. Scientifically speaking, the outbreak of infectious animal diseases is a type of emergency in the human society, considering that these diseases can be rapidly transmitted and can affect human lives or influence human behaviours through numerous channels (Prueksakorn et al., 2014, pp.101–103). Although it is extremely difficult to completely manage each of these channels, Koreans have to take reasonable measures (or without square in Figure 1) to address them not just during winter but before, during, and after an outbreak.

Figure 1 Research framework



The normal approach to the management of FMD and AI was compared with the emergency approach in terms of several initially identified analytical variables. Among them, five major variables were chosen based on their role in managing infectious animal diseases in Korea. Considering that the emergency management of FMD and AI requires government efforts, with the support of close partners, for the benefit of the people as well as of animals, both the central government and local governments were regarded as two major players.

Farmers, scientists, and visitors can be classified as three close partners in this field. Because many infectious animals are found in farms, farmers as the owners of infectious animals are key players in emergency management. Scientists and veterinarians, being involved in the prevention and treatment of infectious animal diseases, also play very

important roles. Visitors and local residents who are situated close to infected animals or farms are also major players because they can come in contact with infectious animal diseases either directly or indirectly.

4 Normal approach to the management of infectious animal diseases

4.1 Central government policy

The Ministry of Agriculture, Food and Rural Affairs (MAFRA) plays a major role in dealing with FMD or AI in Korea because the diseases occur in livestock. The MAFRA has provided general guidelines on how to fight against these diseases in terms of budget allocation, quarantine measures, and damage compensation, among others. However, these efforts have been shown to be inadequate because they deal with the infectious animal diseases only during an outbreak. For example, MAFRA authorities issue public warnings against the impact of infectious animal diseases only during winter but do not discuss the dangers of FMD or AI during other seasons.

Other organisations at the central government level do not play any significant role in dealing with infectious animal diseases. The Ministry of the Interior and Safety (MOIS) as a single, comprehensive emergency management agency is supposed to deal with all kinds of hazards, including FMD and AI, according to its website (MOIS, 2020). However, the MOIS has not systematically approached the issue of infectious animal diseases at all, although it recently expanded its function of increasing related awareness.

4.2 Local government strategy

Korea does not have federal government systems but rather unitary government structures (Kalinowski et al., 2016, pp.38–41). Hence, local governments in Korea have less extensive local autonomy compared with those under federalism. Given this context, Korean local governments mainly follow the MAFRA guidelines on dealing with infectious animal diseases, despite taking all measures possible to control the two diseases as the first line of emergency defense.

Of the three risks discussed–human losses, economic damages, and psychological impacts–local governments have paid more attention to the economic damages resulting from the outbreak of infectious animal diseases, without expressing equal concern regarding the human losses or psychological impacts of the diseases. Whereas the physical impact of an emergency includes not only economic damages but also human losses, the social impact of an emergency includes the psychological impacts. In summary, local governments adopt a normal approach to managing FMD and AI.

4.3 Farm efforts

Many farms in Korea raise cows, pigs, and chickens, but others also have horses, ducks, quails, and peacocks. Some farms have only one species, whereas others raise several species together. Because there is usually not enough space in farms, the majority of livestock do not enjoy sufficient raising grounds, with cows and chickens often kept inside small cages. A chicken may be kept within a tiny area of 0.03–0.04 m^2, which is

smaller than a sheet of A4 paper (0.06 m^2) (Choi, 2017). Hence, the animals end up stressed and trapped in a dirty environment.

During winter, many farm owners worry about the impact of infectious animal diseases (Lee, 2013, pp.535–541) and feel psychologically threatened by the potential human losses and economic damages of an outbreak. Moreover, the culling of huge numbers of infected livestock causes tremendous psychological distress to farmers, who generally have no way of addressing this psychological impact of infectious animal diseases except by talking to their peers.

4.4 Scientific research

In 2005, scientists at Seoul National University claimed that the traditional Korean dish kimchi, or pickled cabbage, could prevent or treat infection by the AI virus. Others have maintained that not only kimchi but also ginseng and garlic could help chickens recover from AI infection. Hence, many infected chickens are not clubbed (Kim et al., 2016, pp.310–311). However, no scientific evidence of how these traditional foods operate in disease prevention has thus far been provided.

Developing appropriate prevention and treatment methods for FMD and AI has proven to be a difficult task for scientists. Due to genetic or antigenic virus diversity, lack of research funds, and other factors, researchers have yet to find a way to easily diagnose infectious animal diseases. In particular, research has failed to produce appropriate vaccines because some strains inadequately grow their properties (Okamatsu et al., 2016, pp.82–83; Song et al., 2008, pp.274–275).

4.5 Visitor readiness

Outbreaks of FMD or AI frequently occur in local communities. Thus, visitors and local residents already know what to do in livestock farms during winter. Over the last decade, for example, many Koreans have refrained from making the traditional visit to their agricultural hometowns during the lunar New Year's Day, as a precaution against the spread of infection from livestock farms.

Visitors also pay close attention to important issues, such as environmental concerns, food supply, and food safety. One such concern is the contamination of drinking water, which occurred in Icheon City in 2011 and in Anseong City in 2017 after leachate or contaminants from animal carcass seeped into groundwater sources (Ko et al., 2017, p. 463). Because prices of beef, chicken, and eggs increase sharply during winter, the Korean government tries to import these products from other countries. In 2017, due to an outbreak of AI, the government tried to import eggs from Thailand. However, the importation was not properly carried out, and the price of eggs soared, causing economic panic in the region.

5 Emergency management of infectious animal diseases

5.1 Central government policy

A single government organisation may not be able to deal efficiently with any hazards, including infectious animal diseases, regardless of the national boundaries (Basak et al.,

2011, pp.344–355). The US National Response Framework (NRF) has shown the importance of cooperation and coordination among all government organisations at the federal level toward an effective national emergency response. The management of an emergency is complicated and involves constantly evolving processes, which a single government organisation may not be able to fully address. Therefore, the Korean central government should change its focus on the superiority of a single organisation.

With the strong support of the MOIS, the MAFRA needs to set up a new multi-organisational coordination system among the 18 Korean ministries. The MAFRA has to seriously and consistently deal with FMD and AI throughout each year, whereas the MOIS should help coordinate the efforts among government institutions. In addition, the Ministry of Education (MOE) could extensively educate the public regarding animal diseases.

5.2 Local government strategy

All local governments should implement the guidelines of MAFRA on the issue of FMD or AI. However, this does not mean that local governments have to implement only these guidelines. Considering that some areas experience more frequent outbreaks of FMD or AI, such as Boeun-Gun in Chungbuk province and the northern part of Gyeonggi province, the local governments in these areas must try to deal with animal diseases more comprehensively (Boeun-Gun Government, 2020).

To equally address the three risks, local governments should consider not only the economic damages but also human health, the methods applied (e.g., burial, landfill, incineration, rendering, and euthanasia), the psychological impacts, and environmental concerns (e.g., effects on soil and water) in implementing strategies of carcass disposal. They also have to consider the local politics, culture, and emergency management history. In particular, mitigation of the above risks cannot be achieved without advanced planning.

5.3 Farm efforts

Fundamentally, farms have to provide enough space for livestock, though farmers face many difficulties in terms of economic growth. According to the MAFRA, each chicken should be kept in an area 0.075 m^2 or bigger in size (Lee, 2018). Furthermore, biosensors should be used, such as sound analysis and salivary and sweat sensing, to extensively improve animal well-being in terms of health status, health management, and livestock development (Neethirajan, 2017, pp.20–23).

The economic damages caused by outbreaks of animal diseases have been heavily discussed in Korea. However, farmers must strongly express their concerns not only regarding the potential human losses of such outbreaks but also their psychological impacts, even citing the human losses in China, Bangladesh, Indonesia, Egypt, and other nations. At the same time, they have to ask local governments to implement countermeasures against the psychological impacts, such as psychological first aid and crisis counselling.

5.4 Scientific research

A number of researchers have made significant progress in their investigations on infectious animal diseases in Korea. One study found that intensive clinical inspection could play a role in the rapid detection of the FMD virus (Yoon et al., 2013, pp.129–131). Another work confirmed that the H5N1 AI virus came to infect domestic poultry in Korea through the migration of seasonal birds from China (Lee et al., 2014, pp.251–253).

Nonetheless, further studies on FMD and AI are necessary. The fact that an outbreak of African swine fever also occurred during winter in Korea further complicates the issue of how to deal with FMD or AI. The AI virus has caused the death of some Chinese and foreigners and thus may cause similar deaths in Korea, regardless of the consumption of Korean traditional foods. In addition, there is a need to collect sufficient funds for research and development from among governments, industries, and other stakeholders.

5.5 Visitor readiness

The field of infectious animal diseases may be more substantially managed if visitors have a high level of emergency awareness, which cannot be achieved without a high level of public information (Wee et al., 2008, pp.366–367). Thus, visitors should be allowed access to relevant and timely information on local communities, such as the specific farms affected by the outbreak, the degree of danger, and the amount of vaccine needed.

Contamination of underground sources of drinking water has previously occurred because local governments allowed farmers and quarantine officers to bury dead animals wrapped in plastic bags, which resulted in leachate. To prevent such contamination, local communities, including not only residents and visitors but also other professionals, need to discuss the problem and come up with a plan of action before another outbreak occurs.

6 Implications and recommendations for neighbouring nations

This study compared the management of infectious animal diseases between the normal and the emergency approach, as shown in Table 2. Climate change, which covers the variation of weather conditions, affects not only human beings but also animals (Khasnis and Nettleman, 2005, pp.690–691), in particular by directly or indirectly increasing the hosts, transmission, and pathogens that cause infectious animal diseases. This can in turn cause variations in the seasonal patterns and geographical trends of the incidence of infectious animal diseases in different nations.

In the arena of globalisation, infectious animal diseases pose a threat to both animals and people across regions, thus necessitating international cooperation among neighbouring nations (GHSA Preparation Task Force Team, 2015, pp.S25–S26). In other words, nations need to further strengthen the global infrastructure against infectious animal diseases, in particular with the support of the World Health Organization.

Regardless of their location, each nation should understand the flow of the emergency management of infectious animal diseases (Rubin and Saidel, 2016, pp.294–295; Webb, 2007, pp.40–41). Without such understanding of how an emergency would unfold, nations may not be able to achieve early detection of infectious animal diseases and efficiently deal with their impacts. Thus, it would fail to provide an effective emergency response.

Table 2 Summary of the comparison between normal and emergency management of infectious animal diseases

Units	*Normal approach*	*Emergency approach*
① Central government policy	• MAFRA has mainly dealt with FMD/AI only during winter	• MAFRA should establish a coordination system among the 18 government ministries
② Local government strategy	• Local governments without much autonomy have focused on the economic damages resulting from FMD/AI	• Local governments must consider not only the physical impacts but also the social impacts of infectious animal diseases
③ Farm efforts	• Farm animals have not been given enough physical space, and the psychological impacts on farmers have been overlooked	• The psychological impacts on farmers should be mitigated, and animal welfare should be improved
④ Scientific research	• No innovative research results have been produced due to lack of research funds, virus diversity, and other factors	• Scientists should further study FMD/AI and find ways to increase research funds
⑤ Visitor readiness	• Visitors have refrained from visiting farms during outbreaks of FMD/AI	• Visitors should raise their own level of emergency awareness by accessing public information and other tools

The emergency management of infectious animal diseases requires actions from neighbouring nations before, during, and after an outbreak of FMD and AI, not just during winter but throughout the year. These nations must follow the four phases of the emergency management lifetime (or cycle), namely, emergency prevention/mitigation, preparedness, response, and recovery (Lindsay, 2012, pp.2–3).

Table 3 shows the timelines of the four phases, which include the periods before, during, and after the outbreak of an emergency. Because the timelines form a continuous process, the four phases of the emergency management lifetime cannot be considered separately. Rather, the four phases occur continuously and indefinitely and should be prioritised at the national level toward the ultimate goal of emergency management of infectious animal diseases (Benabdouallah et al., 2018, pp.15–19).

Each phase of the emergency management lifetime has specific elements. The emergency prevention phase includes legalisation on animal diseases and livestock inspection, whereas the emergency mitigation phase involves weather forecasts and livestock conferences. The emergency preparedness phase encompasses emergency planning as well as training and exercise. Culling and quarantine fall under the emergency response phase, whereas insurance and rebuilding of cattle stalls belong to the emergency recovery phase.

The national-level implementation of the four phases of the management of infectious animal diseases involves a high degree of interdependence, considering that the stakeholders, service providers, and suppliers are interrelated under a whole community

approach. Hence, when one stakeholder lacks related resources or services, the other stakeholders are accordingly affected, leading to potentially large impacts.

Table 3 Timelines of four phases of emergency management lifetime (… =)

Timelines / *Four phases*		*Before the emergency*	*During the emergency*	*After the emergency*
①	Emergency prevention	……		
	Emergency mitigation	……		
②	Emergency preparedness	……		
③	Emergency response		……...	
④	Emergency recovery		……	

Source: Ha and Ahn (2009, pp.1–11)

One of the key factors for a successful whole community approach against FMD and AI is the engagement of the central government (Saylors et al., 2015, pp.34–37). However, although the leadership of the national government is very important, the other players play equally significant roles in the disease management.

Toward the implementation of the four phases, all the stakeholders in each nation should discuss the different aspects of infectious animal diseases and formulate their management plans before an outbreak of FMD or AI occurs, unlike in the case of Korea (Kim et al., 2013, pp.336–337; Westergaard, 2008, pp.43–47). Otherwise, there would not be enough time and space for implementation during the short period of emergency response. Without appropriate planning, nations would not be able to respond adequately to an outbreak of FMD or AI.

The field of national emergency management should include outbreaks of infectious animal diseases in its emergency operations plans (EOPs), which must address the integration of diverse plans, the roles of multiple institutions, and proposals for difficult issues, among others. The implementation of EOPs could decrease the duplication of related efforts and materials. Thus, each nation should create, evaluate, and regularly revise their EOPs.

Appropriate education and training are necessary to implement the four phases of the emergency management cycle (EMI, 2013a). Primarily because the four phases cover so many topics, systematic education and training of the public is necessary. Thus, through educational curricula and training materials, neighbouring nations can disseminate the definition of the four phases, as well as relevant information for each phase, including personal hygiene checklists and possible disruption of services and supplies.

Similarly, the field of emergency management in each nation should provide educational curricula and training materials in multidisciplinary studies (Tago et al., 2016, p. e0157450). Professionals in various fields should participate in related emergency management. One single discipline may not be able to respond to the

complicated process of managing infectious animal diseases; thus, multiple disciplines have to be integrated into educational curricula and training materials.

7 Conclusion

This research aimed to explore how to improve the management of infectious animal diseases, including FMD and AI, in Korea and then draw lessons from the experiences of neighbouring nations. The management of infectious animal diseases was compared between the normal approach and the emergency approach in terms of five factors, namely, central government policy, local government strategies, farm efforts, scientific research, and visitor readiness. The four phases of the emergency management lifetime–emergency prevention/mitigation, preparedness, response, and recovery–were discussed.

The key finding is that Korea needs to shift from its current normal approach to the management of FMD and AI to an emergency management approach. To achieve this transition, all five stakeholders need to carry out their assigned roles and responsibilities. Thus, while the central government must facilitate cooperation/coordination among the 18 Korean ministries, local governments must consider the local risks, politics, culture, and emergency management history. Farms should address the psychological impact of infectious diseases by providing a bigger space for raising cows and chickens. Scientists must find ways to increase research and development funds as well as efforts, while visitors should obtain information on disease outbreaks, the degree of danger they pose, and the amount of vaccine needed, as well as address the issue of leachate in a timely manner.

Further, neighbouring nations, such as China, Japan, Taiwan, and others in Southeast Asia, should take away significant lessons from the case of Korea and flexibly apply these lessons in their own environment. Moreover, the four phases of the emergency management cycle must be implemented by neighbouring nations based on international cooperation, while relying on a whole community approach, the use of EOPs, the provision of education and training, and other measures.

Korean researchers need to further explore the emergency management of infectious animal diseases to come up with concrete proposals, in particular from a combination of various perspectives, including emergency management and medical science. Researchers in neighboring nations could focus on how to address each of the four phases of the emergency management lifetime within their own contexts while considering the lessons learned from Korea, toward the goal of achieving transnational emergency management.

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