Original Article

Assessment of the Economic Impact of Porcine Epidemic Diarrhea (PED) Epidemic in the Southern Kyushu, Japan

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Summary

Porcine epidemic diarrhea (PED) was detected for the first time in seven years in Japan in October 2013, and had spread into Miyazaki and Kagoshima Prefectures, Japan. The objective of the present study was to estimate the economic impact of PED outbreak in Japan in 2013 and 2014. Datasets from all pig farms were provided by Miyazaki (506 farms) and Kagoshima Prefectures (709 farms). A 1:1 case-control study using a postal questionnaire survey was conducted to collect the economic losses or costs attributed to PED outbreak in both PED infected farms and non-infected farms. Out of 250 farms infected with PED, farrow-to-finish and farrow-to-wean farms were 185, and the number of piglet mortality due to PED in these farms were 93,650. Total economic losses due to piglet mortality was 339,107 thousand Japanese Yen (JPY). Costs per farm due to implementation of enhanced biosecurity measures ranged from 159 to 2,585 thousand JPY. Costs of vaccination that newly started after PED outbreak per farm ranged from 4 to 289 thousand JPY. Total losses due to PED outbreak were 1,182 million JPY.

Keywords : Biosecurity, Economics, Porcine epidemic diarrhea, Swine

Introduction

Outbreaks due to porcine epidemic diarrhea (PED) virus were first recognized in the late 1980s in Japan[11,24]. Clinical signs of infected piglets showed high morbidity and high mortality, and if survived the infection animals had low growth rate[2,8,17]. By the middle 1990s, severe outbreaks were found around Japan, but there were no severe outbreaks in these regions until recently since a PED live vaccine was approved in 1996[22]. However, PED emerged after an interval of seven years in Okinawa in October 2013 and rapidly spread throughout Japan. The incidence was largest in 2014, and up to 2016 October 5th, 1,157 farms in 39 of 47 prefectures were infected and 523,310 piglets died[16]. The epidemic once declined, but is still persisting sporadically in 2017.

The most important aspect affected to economic losses due to PED outbreak is deaths of suckling piglets. In current PED epidemic in Japan, preweaning mortality rate of sows exposed to PED virus in the late pregnancy and during lactating were reportedly an increase of 66−77% and 34−57% compared to uninfected sows, respectively[5,6,19]. Labor costs would be increased in PED infected farms because they had to deal with piglet mortality or treat infected pigs and sows. Additionally, PED non-infected farms strengthened their biosecurity levels to prevent PED virus invasion to their farms. Furthermore, many farms started PED vaccination after the current epidemic from 2013. These aspects could have affected economic situation in commercial farms, but no study has estimated the economic impact of PED outbreak in Japan. Therefore, the objective of the present study was to estimate the economic impact of PED outbreak in Japan in 2013 and

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2014, when the epidemic grew very fast. The present study was conducted in Miyazaki and Kagoshima Prefectures, which are a major pork-producing region, with the first and second largest swine populations in the country (8.9% for Miyazaki and 12.1% for Kagoshima of the total Japanese herds[14]) and the highest density of swine farms.

Materials and Methods

Study area

The study population included all pig farms in Miyazaki (n=506) and Kagoshima (n=709) Prefectures, located in Kyushu, the southern island of Japan. In this region, the first case of PED was reported on December 3rd, 2013, in Kagoshima Prefecture. Consequently, the case was also found on December 13th, 2013, in Miyazaki Prefecture. Details of PED spread in this region were reported in a previous study[20]. Briefly, the strong spatio-temporal clustering of PED cases was found in this region which is consistent with the recent U.S. PED epidemic[1,3].

Data collection

Information on the characteristics of all farms in Miyazaki and Kagoshima Prefectures was extracted from Prefectural government databases containing demographic data for livestock producers. Since the databases were anonymized, approval was not required as per the local legislation. Data included location (coordinates), farm size, and production type (farrow-to-finish, farrow-to-wean, and wean-to-finish). In addition, data on PED detection between December 2013 (when the first case of the epidemic was detected in the prefecture) and September 2014 and number of piglet mortality due to PED were obtained from both Prefectural governments. In Japan, all farms in which PED-like symptoms are detected must report disease occurrence to its regional Livestock Hygiene Service Center (LHSC). In both prefectures, prefectural LHSC receive notice of the occurrence of a suspected case from either the farmer or a veterinarian, and veterinarians at the LHSC sample the diseased animals or feces. A diagnosis was made based on the combination of clinical symptoms, reverse transcription polymerase chain reaction (RT-PCR) analysis, and immunohistochemistry testing. For cases in which only feces were sampled, a diagnosis was made based on clinical symptoms and RT-PCR analysis. There was a possibility that some infected farms might have been misclassified as non-infected farms if not notified to the prefectures, particularly among farms with only low-susceptible grower pigs[12].

Questionnaire survey was conducted among PED infected farms and non-infected farms in Miyazaki and Kagoshima Prefectures to collect the economic losses or costs attributed to PED outbreak. The data used in the present study was a subset of a large dataset from a previous study[26]. Matching was performed for 1 : 1 in terms of ratio, and PED non-infected farms were matched with the same numbers of PED infected farms by prefecture, type of operation and farm size categories. PED non-infected farms were randomly selected within each category.

The questionnaires were sent to 81 PED infected farms in Miyazaki Prefecture and 169 PED infected farms in Kagoshima Prefecture, and to corresponding numbers of non-infected farms in September 2014. They were returned by 28 and 50 infected farms and 31 and 63 non-infected farms in Miyazaki and Kagoshima Prefectures, respectively (78 infected and 94 non-infected farms in total). The response rates to the questionnaire were 34% (172/500) overall, 36% (59/162) in Miyazaki Prefecture and 33% (113/338) in Kagoshima Prefecture. Among them, dataset that filled out the questions about the economic losses or costs attributed to PED outbreak were used in the present study.

Farms were classified into three groups based on size in each production type. In farrow-to-wean farms, small farms were defined as less than 100 sows, middle were 101 to 300 sows, and large were more than 301 sows. In farrow-to-finish and wean-to-finish farms, small farms were defined as less than 1000 pigs, middle were 1001 to 3000 pigs, and large were more than 3001 pigs.

Economic analysis

In the present study, the economic impact of PED outbreak between December 2013 (when the first case of the epidemic was detected in the studied regions) and September 2014 was estimated. Total losses due to PED outbreak were divided by three items : “Economic losses due to piglet mortality”, “Costs due to implementation of enhanced biosecurity measures” and “Costs of vaccination after PED outbreak”. Each calculation was separately performed by each category of PED status (infected or non-infected), production type (farrow-to-finish, farrow-to-wean or wean-to-finish) and farms size (small, middle or large). Economic unit used in this analysis was Japanese Yen (JPY). One US dollar is equivalent to 115 JPY, and one Euro is equivalent to 135 euro in 2017.

Economic losses due to piglet mortality

Economic losses due to piglet mortality were calculated by the value of a piglet multiplied by the number of piglet mortality due to PED. In this calculation, a piglet was assumed to be died at day 10 after birth and the value of a piglet at day 10 was calculated as follows:

The market value of a piglet at day 10 = the value of a piglet at birth + cost incurred for a piglet during 10 days after birth.

The value of a piglet at birth was 2,871 JPY, and cost incurred for a piglet, such as feed cost and labor cost, per day was 75 JPY/day. These values were obtained from the government database that estimated for compensation[15]. Thus, the value of a piglet that died at 10 days old was 3,621 JPY (2,871 JPY + [75 JPY/day × 10 days]). The number of piglet mortality due to PED was obtained from the Livestock Hygiene Service Center.

Costs due to implementation of enhanced biosecurity measures

Costs due to implementation of enhanced biosecurity measures

were estimated by the data obtained by questionnaire survey. This cost consists of "costs for sterilizing equipment that was purchased after PED outbreak (such as high-pressure cleaner or vehicle disinfecting gate)", "the other expense except for above (such as additional purchase of disinfectant or new employment)", and "costs per month due to changes of biosecurity practice before and after PED outbreak". The costs per month due to changes of biosecurity practice was multiplied by 6, assuming that the farm enhanced biosecurity measures for 6 months after PED outbreak. In this region, PED outbreak was mainly observed from December 2013 to May 2014.

Costs of vaccination that newly started after PED outbreak

Costs of vaccination after PED outbreak were calculated in the following calculation. At first, percentage of farms that newly started PED vaccine was calculated by the questionnaire survey. Second, estimated number of sows that newly vaccinated after PED outbreak was calculated as the percentage of farms that newly started PED vaccine multiplied by actual number of sows in each category, which obtained from Prefectural government databases. Then, the estimated number of sows that newly vaccinated after PED outbreak was divided by actual number of farms in each category, which obtained from Prefectural government databases. This is estimated number of sows that newly vaccinated after PED outbreak per farm. Finally, costs of vaccination that newly started after PED outbreak per farm was calculated as the estimated number of sows that newly vaccinated after PED outbreak per farm multiplied by price for PED vaccine per sow. The price for PED vaccine per sow was 1,000 JPY, which was calculated as price for PED vaccine per dose (500 JPY) multiplied by recommended doses that are 2 doses per sow. The price was the market price of the vaccine without service charge and was obtained from commercial company in 2015.

Results

Economic losses due to piglet mortality

In the studied period, the number of farms infected PED virus was 250. Out of 250 farms, farrow-to-finish and farrow-to-wean farms were 185, and the number of piglet mortality due to PED in these farms were 93,650 (Table 1). Total economic losses due to piglet mortality were 339,106.7 thousand JPY (total number of piglet mortality x the value of a piglet: 93,650 piglets x 3,621 JPY). There was no difference of economic losses due to piglet mortality between production types, but large difference was found between farm sizes. Large farms had almost five times higher economic losses due to piglet mortality than middle farms.

Costs due to implementation of enhanced biosecurity measures

Costs due to implementation of enhanced biosecurity measures were estimated by the data obtained by questionnaire survey. Table 2 shows costs for sterilizing equipment that purchased after PED outbreak and the other expense except for above in each production type and farm size categories. The costs per farm for sterilizing equipment that purchased after PED outbreak increased as farm size increased. Both PED infected and non-infected farms had similar costs. In addition, the other expense per farm except for above costs also increased as farm size increased.

Table 3 shows costs per month due to changes of biosecurity practice before and after PED outbreak and total costs due to im-

Table 1 Number of piglet mortality due to PED outbreak and economic losses due to piglet mortality in each category of production type and farm size

Production type and farm size	Number of farms infected to PED	Total number of piglet mortality	Piglet mortality per farm	Economic losses per farm[1], thousand JPY
Farrow-to-finish farms				
Large farms	42	48,913	1,164.6	4,217.0
Middle farms	38	10,499	276.3	1,000,4
Small farms	62	4,335	69.9	253.2
Farrow-to-wean farms				
Large farms	17	22,784	1,340.2	4,853.0
Middle farms	10	3,024	302.4	1,095.0
Small farms	16	4,095	255.9	926.8
Total	185	93,650	506.2	1,833.0
Total economic losses due to piglet mortality[2] : 339,106.7 thousand JPY				

[1] Economic losses per farm was calculated as the value of a piglet that assumed to be died at 10 days old (3,621 JPY) multiplied by the number of piglet mortality per farm.

[2] Total economic losses due to piglet mortality was calculated as the value of a piglet that assumed to be died at 10 days old (3,621 JPY) multiplied by the total number of piglet mortality (93,650 piglets).

Table 2 Costs for sterilizing equipment that purchased after PED outbreak (such as high-pressure cleaner or vehicle disinfecting gate; Cost A) and the other expense except for above (such as additional purchase of disinfectant or new employment; Cost B) in each category of PED status, production type and farm size

Production type and farm size	Cost A, thousand JPY						Cost B, thousand JPY					
	PED infected farms			PED non-infected farms			PED infected farms			PED non-infected farms		
	N[1]	Sum of Cost A	Cost A per farm	N[1]	Sum of Cost A	Cost A per farm	N[1]	Sum of Cost B	Cost B per farm	N[1]	Sum of Cost B	Cost B per farm
Farrow-to-finish farms												
Large farms	4	3,040	760.0	4	2,000	500.0	5	460	92.0	5	612	122.4
Middle farms	6	1,600	266.7	4	665	166.3	5	470	94.0	7	487	69.6
Small farms	7	1,091	155.9	7	1,330	190.0	4	95	23.8	1	20	20.0
Farrow-to-wean farms												
Large farms	3	750	250.0	2	220	110.0	7	1,350	192.9	4	850	212.5
Middle farms	0	NA	NA	2	42	21.0	0	NA	NA	0	NA	NA
Small farms	0	NA	NA	2	125	62.5	0	NA	NA	1	150	150.0
Wean-to-finish farms												
Large farms	0	NA	NA	2	1,000	500.0	0	NA	NA	2	200	100.0
Middle farms	0	NA	NA	1	300	300.0	1	100	100.0	1	48	48.0
Small farms	2	480	240.0	1	170	170.0	3	1,210	403.3	1	10	10.0

[1] Number of farms responded to each question

NA: Not available

plementation of enhanced biosecurity measures in each production type and farm size category. The costs per farm ranged from 159 to 2,224 thousand JPY in PED infected farms and from 134 to 1,635 thousand JPY in PED non-infected farms. Total costs due to implementation of enhanced biosecurity measures were calculated as the sum of costs for sterilizing equipment that purchased after PED outbreak (Table 2), the other expense except for above (Table 2), and costs due to changes of biosecurity practice before and after PED outbreak (Table 3). The total costs per farm ranged from 159 to 2,585 thousand JPY in PED infected farms and from 180 to 2,257 thousand JPY in PED non-infected farms.

Costs of vaccination that newly started after PED outbreak

Table 4 shows costs of vaccination against PED virus that newly started after PED outbreak in each production type and farm size. The percentage of farms that newly vaccinated after PED outbreak in PED infected farms was 42.4% with ranging from 25 to 71%, and that in PED non-infected farms was 40.9% with ranging from 20 to 64%. There was no apparent difference of the percentage between PED infected farms and non-infected farms. Costs of vaccination that newly started after PED outbreak per farm ranged from 13 to 289 thousand JPY in PED infected farms and from 4 to 411 thousand JPY in PED non-infected farms.

Total losses due to PED outbreak

Table 5 shows total losses due to PED outbreak in each production type and farm size. Total losses per farm were calculated as the sum of the three items : economic losses per farm due to piglet mortality (Table 1), costs per farm due to implementation of enhanced biosecurity measures (Table 3) and costs of vaccination that newly started after PED outbreak per farm (Table 4). Large farms had high economic losses per farm than small farms in each category except for wean-to-finish farms in PED infected farms. Total losses in each category were calculated as the total losses per farm multiplied by actual number of farms in each category. Total losses in PED infected farms in each production type were 433,007.2 thousand JPY in farrow-to-finish farms, 151,435.4 thousand JPY in farrow-to-wean farms, and 42,035.4 thousand JPY in wean-to-finish farms, and those in PED non-infected farms in each production type were 322,219.8 thousand JPY in farrow-to-finish farms, 91,675.9 thousand JPY in farrow-to-wean farms, and 141,200.5 thousand JPY in wean-to-finish farms. Total losses due to PED outbreak, calculated as the sum of total losses in all categories, in PED infected and non-infected farms were 626,478.0 thousand JPY and 555,096.2 thousand JPY, respectively, and total losses due to PED outbreak in all farms located in southern Kyusyu was 1,181,574.2 thousand JPY.

Discussion

In the present study, various costs due to PED outbreak were collected from both PED infected and non-infected farms to derive the costs attributable to PED for farrow-to-finish, farrow-to-wean, and wean-to-finish phases of production. The costs attributable to PED were calculated as the sum of three items: economic losses due to piglet mortality per farm, costs due to implementation of enhanced biosecurity measures per farm and

Table 3 Costs due to changes of biosecurity practice before and after PED outbreak and total costs due to implementation of enhanced biosecurity measures in each category of PED status, production type and farm size (thousand JPY)

Production type and farm size	Costs due to changes of biosecurity practice before and after PED outbreak								Total costs per farm due to implementation of enhanced biosecurity measures[2]	
	PED infected farms				PED non-infected farms				PED infected farms	PED non-infected farms
	N[1]	Sum of costs	Costs multiplied by 6 months	Costs per farm	N[1]	Sum of costs	Costs multiplied by 6 months	Costs per farm	Costs per farm	Costs per farm
Farrow-to-finish farms										
Large farms	7	1,914	11,484	1,640.6	6	1,635	9,810	1,635.0	2,492.6	2,257.4
Middle farms	3	1,112	6,672	2,224.0	3	243	1,458	486.0	2,584.7	721.9
Small farms	7	221	1,326	189.4	3	98	588	196.0	369.1	406.0
Farrow-to-wean farms										
Large farms	5	1,370	8,220	1,644.0	3	284	1,704	568.0	2,086.9	890.5
Middle farms	0	NA	NA	NA	1	70	420	420.0	NA	441.0
Small farms	2	53	318	159.0	1	30	180	180.0	159.0	392.5
Wean-to-finish farms										
Large farms	1	45	270	270.0	3	634	3,804	1,268.0	270.0	1,868.0
Middle farms	1	70	420	420.0	4	89	534	133.5	520.0	481.5
Small farms	2	204	1,224	612.0	0	NA	NA	NA	1,255.3	180.0

[1] Number of farms responded to each question

[2] Total costs per farm due to implementation of enhanced biosecurity measures were calculated as the sum of costs per farm for sterilizing equipment that purchased after PED outbreak, the other expense per farm except for above and costs per farm due to changes of biosecurity practice before and after PED outbreak for 6 months in each category of PED status, production type and farm size

NA : Not available

costs of vaccination that newly started after PED outbreak. Total losses due to PED outbreak estimated in the preset study were approximately 1.2 billion JPY, indicating that current PED outbreak in Japan resulted in severe economic losses in swine production. In addition, since the economic losses estimated in the present study did not include the other factors not incurred by most producers, such as economic losses in livestock-related company, labor costs for regional hygiene program, losses of markets for seed stock herds, boar studs after an outbreak of PED at their facility and effect of PED on reproductive and growth performance, the actual economic losses could be higher than the estimated value. It is important to prevent the invasion of infectious diseases by strengthened herd biosecurity.

Among three items of the economics losses, economic losses due to piglet mortality had a huge impact on total economic losses. In PED infected large farms, approximately 65% of the total losses were derived from the number of piglet mortality. Deaths due to PED infection mainly occurred in newborn piglet, and preweaning mortality rate of sows exposed to PED virus in the late pregnancy and during lactating were reportedly very high[5, 7]. Although there was no difference of the economic losses due to piglet mortality per farm between production type, large difference of the economic losses was found between farm sizes. This is simply due to the difference of piglet inventory: large farms had more piglet inventory than middle or small farms, which resulting in severe economic losses in large farms.

In the present study, costs due to implementation of enhanced biosecurity measures were divided into three groups : “costs for sterilizing equipment that purchased after PED outbreak”, “the other expense except for above”, and “costs per month due to changes of biosecurity practice before and after PED outbreak”. Results of “the costs for sterilizing equipment that purchased after PED outbreak” revealed that both PED infected and non-infected farms newly purchased sterilizing equipment such as high-pressure cleaner or vehicle disinfecting gate in an effort to prevent or control PED. As well as this cost, the costs per month due to

Table 4 Costs of vaccination against PED virus that newly started after PED outbreak in each category of PED status, production type and farm size

Production type and farm size	N[1]	Farms newly Started vaccine	Farm % that newly started vaccine	Number of total sows[2]	Estimated number of sows newly vaccinated[3]	Number of total farms[2]	Estimated number of sows newly vaccinated per farm	Costs per farm[4], thousand JPY
PED infected farms								
Farrow-to-finish farms								
Large farms	15	6	40.0%	28,628	11,451.2	42	272.6	272.6
Middle farms	12	3	25.0%	4,227	1,056.8	38	27.8	27.8
Small farms	17	12	70.6%	2,685	1,895.6	62	30.6	30.6
Farrow-to-wean farms								
Large farms	11	3	27.3%	18,025	4,920.8	17	289.5	289.5
Middle farms	0	0	NA	1,557	NA	10	NA	NA
Small farms	4	1	25.0%	852	213.0	16	13.3	13.3
PED non-infected farms								
Farrow-to-finish farms								
Large farms	20	8	40.0%	39,897	15,958.8	45	354.6	354.6
Middle farms	11	7	63.6%	10,086	6,414.7	108	59.4	59.4
Small farms	16	4	25.0%	8,650	2,162.5	291	7.4	7.4
Farrow-to-wean farms								
Large farms	9	5	55.6%	17,730	9,857.9	24	410.7	410.7
Middle farms	5	2	40.0%	2,676	1,070.4	15	71.4	71.4
Small farms	5	1	20.0%	2,769	553.8	133	4.2	4.2

[1] Number of farms responded to each question

[2] Number of total sows and farms in each category was actual number obtained from Prefectural government databases

[3] Estimated number of sows that newly vaccinated after PED outbreak was calculated as total sows multiplied by percentage of farm that newly vaccinated after PED outbreak.

[4] Cost of vaccination against PED after PED outbreak per farm was calculated as estimated number of sows that newly vaccinated after PED outbreak per farm multiplied by total price of PED vaccine per sow, which is 1,000 JPY (500 JPY x 2 times per sow).

NA : Not available

changes of biosecurity practice before and after PED outbreak was high. Although it is costly to purchase new equipment or devise, keeping high biosecurity level would be more expensive than it, and be also a burden to producers or staff because it is additional management compared to ordinary condition. In addition, even though there was a farm size-scale difference of the costs due to implementation of enhanced biosecurity measures, no difference of the costs between PED infected and non-infected farms indicates that both farms performed similar biosecurity practices for reducing virus amount within the barn in PED infected farms or for preventing virus invasion in PED non-infected farms.

Regarding PED vaccine, approximately 50% farms, including both PED infected and non-infected farms, had newly started administration of PED vaccines after PED outbreak. In Japan, PED was first reported in the 1990s, and a PED live vaccine was approved in 1996[22]. Since then, only isolated and relatively unimportant outbreaks have been recorded and thus very few farms practiced PED vaccination before the current PED outbreak in Japan. Therefore, many farms purchased PED vaccine that led to additional costs due to PED outbreak. The sudden demand increase made the vaccine out of stock for a while, and some producers could not purchase it. Therefore, this percentage of the farms might be underestimated. On the other hand, some farms did not get started PED vaccine because the effect of the PED vaccine was not good enough to protect the virus infection to pigs. Current PED vaccine on sale in Japan was made based on strain that outbreak in 1990s, and the strain is totally different from the strain in the current epidemic[23, 27].

Compared to PED infected farms, PED non-infected farms had lower economic losses due to PED outbreak. However, the PED non-infected farms still had high economic losses, which are

Table 5 Total losses due to PED outbreak in each category of PED status, production type and farm size, thousand JPY

Production type and farm size	Economic losses due to piglet mortality per farm	Costs due to implementation of enhanced biosecurity measures per farm	Costs of vaccination that newly started after PED outbreak	Total losses per farm[1]	Total farm[2]	Total losses[3]
PED infected farms						
Farrow-to-finish farms						
Large farms	4,217.0	2,492.6	272.6	6,982.2	42	293,252.4
Middle farms	1,000,4	2,584.7	27.8	2,612.5	38	99,275.0
Small farms	253.2	369.1	30.6	652.9	62	40,479.8
Farrow-to-wean farms						
Large farms	4,853.0	2,086.9	289.5	7,229.4	17	122,899.8
Middle farms	1,095.0	NA	NA	1,095.0	10	10,950.0
Small farms	926.8	159.0	13.3	1,099.1	16	17,585.6
Wean-to-finish farms						
Large farms	NA	270.0	NA	270.0	20	5,400.0
Middle farms	NA	520.0	NA	520.0	27	14,040.0
Small farms	NA	1,255.3	NA	1,255.3	18	22,595.4
PED non-infected farms						
Farrow-to-finish farms						
Large farms	NA	2,257.4	354.6	2,612.0	45	117,540.0
Middle farms	NA	721.9	59.4	781.3	108	84,380.4
Small farms	NA	406.0	7.4	413.4	291	120,299.4
Farrow-to-wean farms						
Large farms	NA	890.5	410.7	1,301.2	24	31,228.8
Middle farms	NA	441.0	71.4	512.4	15	7,686.0
Small farms	NA	392.5	4.2	396.7	133	52,761.1
Wean-to-finish farms						
Large farms	NA	1,868.0	NA	1,868.0	26	48,568.0
Middle farms	NA	481.5	NA	481.5	115	55,372.5
Small farms	NA	180.0	NA	180.0	207	37,260.0

[1] Total losses per farm was the sum of economic losses due to piglet mortality per farm, costs due to implementation of enhanced biosecurity measures per farm and costs of vaccination that newly started after PED outbreak

[2] Number of total farms in each category was actual number obtained from Prefectural government databases

[3] Total losses in each category was calculated as the total losses per farm multiplied by number of total farms in each category

mainly due to costs due to implementation of enhanced biosecurity measures per farm. These results indicate that an occurrence of infectious disease makes a burden in both infected farms and non-infected farms, and the calculation of economic losses due to infectious diseases should include the costs in non-infected farms.

Higher economic losses in farrow-to-finish and farrow-to-wean farms than wean-to-finish farms in PED infected farms could be due to the exist of newborn piglet. Newborn piglets are more prone to severe symptoms or vulnerable to infectious diseases, sometimes they get died, which enhanced economic losses in farrow-to-finish and farrow-to-wean farms. Additionally, they had to strength their biosecurity practices, including both internal and external biosecurity, in order to eliminate the virus from the farm and to break the chain of infection to newborn piglets. Median time to be stable in current PED outbreak was reportedly 43 days[6], and the costs for biosecurity practices increase as time to stable increases. Thus, management practice to shorten the time to stable can be minimized economic losses in farrow-to-finish and farrow-to-wean PED infected farms. In current epidemic in Japan, some unauthorized or insecure management was performed to shorten the within farm epidemic in PED infected farms, such as herd immunization by feedback to sows and culling of susceptible piglets. On the other hand, wean-to-finish farms had low economic losses because they did not have losses

due to piglet mortality and PED vaccination. However, PED infected farms were imposed a restriction about their shipping to the slaughter plant to prevent cross-contamination which decreased fattening efficiency and caused economic losses[10]. Thus, actual economic losses in wean-to-finish farms would be higher than estimated.

The present study found large difference of economic losses between different farm size categories. Large farms had many pigs and therefore the impact of PED outbreak on their economic was high. In the current epidemic, farm sizes were considered a significant risk factor for PED outbreak because the number of contacts with the farm and the associated risk such as number of personnel on the farm or number of visits of loading trucks are expected to increase with the size of the farm[18]. Transport vehicles for swine and feed have been previously reported as potential vehicles for PED virus[4, 13]. Consequently, large farms should increase their biosecurity measures, such as the proper use of disinfectants or allowing disinfectant a contact time of more than 20 min[18, 21].

There were several limitations in the present study. At first, some subjects that could be associated with economic losses were included into the calculation. For example, sow productivity would impair due to loss of suckling stimulate: low number of pigs weaned extended weaning-to-first mating interval and decreased farrowing rate[25]. Piglet mortality also affected overall pig flow within farm that forced farm staff to extra management. In addition, herd closure during PED endemic period became impossible to enter the replacement gilt into farms and then break parity distribution which significantly decrease herd productivity[10]. In finishing barn, growing pigs were not able to ship to slaughter plant during PED endemic period, which made them overweighed and their carcass price would be impaired. The present study assumed that the farm enhanced biosecurity measures for 6 months after PED outbreak, but some farms may strength their biosecurity level more than 6 months. Additionally, the analysis did not include possible positive effects on carcass prices that would be attributable to the fact that fewer marketed pigs were produced as a result of PED related deaths. Indirect economic loss would be affected to total economic loss due to PED outbreak. Secondly, the present study was conducted questionnaire to obtain the costs of each subject, but we obtained a relatively small number of response, and the value in some categories would be underestimated or overestimated because of low number of response. The low recovery rate of a questionnaire survey might be due to that farmers were generally not cooperative because several different questionnaires already requested by different investigators. Therefore, the data may over represent the views of farmers with positive attitude towards public service. Finally, the present study was conducted in Miyazaki and Kagoshima Prefectures, which are a major pork-producing region, with the first and second largest swine population in the country. This region has a high farm density and thus the result obtained in the present study would be different from the other regions in Japan. Besides these limitations, strengths of the calculation of economic losses due to piglet mortality in the present study are including all farms infected with PED and all information located in the studied region. Therefore, the present study accurately calculated actual economic losses due to the number of piglet mortality and estimated economic losses.

In conclusion, the present study estimated economic losses due to PED outbreak in the southern Kyusyu, Japan and revealed that PED imposed a substantial financial burden on swine producers and caused approximately 1.2 billion JPY in losses. Although the PED non-infected farms had losses that mainly due to implementation of enhanced biosecurity measures, the economic total losses due to PED outbreak was higher in PED infected farms than PED non-infected farms. In order to prevent or control PED, it is important to design effective control and prevention strategies by performing adequate biosecurity practices and making an action plan if a virus entered into the farm.

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原 著

南九州において発生した豚流行性下痢（PED）に伴う経済損失の評価

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要旨

日本では，豚流行性下痢（PED）の発生が 2013 年 10 月に 7 年ぶりに発生し，宮崎県および鹿児島県に伝播した。本研究では，2013 年から 2014 年に同地域において発生した PED に伴う経済損失を推定することを目的とした。宮崎県（506 農場）および鹿児島県（709 農場）に所在する全ての養豚生産農場に関するデータセットを収集し，症例対照研究として，PED 発生農場および PED 非発生農場において同数の農場を対象としたアンケート調査を実施した。アンケート調査では，PED 発生に伴う経済損失やコストの増加に関する調査を実施した。PED 発生 250 農場の内，185 農場が一貫および繁殖農場であり，これらの農場における哺乳子豚の死亡頭数は 93,650 頭であった。哺乳子豚の死亡に伴う経済損失は 33,911 万円であった。PED 発生に伴う防疫体制の強化によって増加したコストは一農場当たり 16 から 259 万円であった。また，PED 発生後に新規で摂取を開始した PED ワクチンに伴うコストは 一農場当たり 0.4 から 29 万円であった。本研究では，PED 発生に伴う経済損失の総額は約 12 億円と推定された。

キーワード : 経済性，豚流行性下痢，防疫体制，養豚

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