Journal of Sustainability Science and Management
Volume 18 Number 5, May 2023: 143-150
eISSN: 2672-7226

IMPACT OF FOOT AND MOUTH DISEASE ON CATTLE PRODUCTION IN PENINSULAR MALAYSIA

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Submitted final draft: 19 March 2022 *Accepted: 27 March 2023* http://doi.org/10.46754/jssm.2023.05.010

Abstract: Foot and mouth disease is vital in Malaysia with increasing yearly cases. Quantitative information about the impact of the disease on the cattle in the country, however, is scarce. This study quantitatively assesses the direct economic impacts of foot and mouth disease outbreaks on cattle production in Peninsular Malaysia. The impacts were assessed based on the data obtained from case outbreaks of cattle in 2017 and 2018. Data were collected using a questionnaire administered to 349 cattle farmers in six states of Peninsular Malaysia from April to October 2018. Collected data were analyzed using a t-test (i.e., to compare between gender within the age of breed) and one-way ANOVA (i.e., to compare between breeds and between ages within the breed). Results demonstrate that the breed of Limousine, Charolaise and Kedah-Kelantan have been proven affected due to the FMD outbreak. The economic losses of foot and mouth disease outbreaks due to mortality and weight loss reached the figure of MYR390.24 per herd. To reduce the impact of the loss of cattle production and achieve Malaysia food security target, it is vital for the government to surveillance and eradicate the FMD outbreak.

Keywords: Cattle, foot and mouth disease, food security, economic loss, Malaysia.

Introduction

Foot and Mouth Disease (FMD) is a highly contagious disease causing widespread concern worldwide. FMD, however, has nothing to do with Hand, Foot, and Mouth Disease (HFMD). Viruses of different sorts carry both diseases. FMD is caused by the Aphthovirus from the Picornaviridae' family and affects exclusively cloven-hoofed animals (e.g., cow, buffalo, goat, and pig). Only serotypes O, A and ASIA 1 were detected in Peninsular Malaysia (World Organization for Animal Health, 2019). The animal movement has been a crucial contributor to the quick spread of the FMD virus (Ramanoon *et al*., 2013). However, the illegal animal movement contributed significantly to the FMD outbreak (Ramanoon *et al.*, 2013).

Previous studies have shown that the impact of FMD outbreak on cattle production differs by country (Knight-Jones & Rushton, 2013) farming systems (Jemberu *&*., 2014), breeds, gender, and age of animals (Şentürk & Yalçin, 2008). Knight-Jones and Rushton (2013) found that the impact of the FMD outbreak on cattle output is disproportionately great in developing countries because of the high dependence on livestock as the main source of income among people experiencing poverty. Although herds of animals experience a one-time shock, the impact of the FMD outbreak on cattle production is permanent and prolonged (Lyons *et al.*, 2015). Furthermore, the probability of recovery for production is usually not the same as before the outbreak (Kitching, 2002).

According to Alhaji *et al*. (2020) and Knight-Jones and Rushton (2013), the impact of an FMD outbreak on cattle can be divided into direct and indirect losses. The direct losses include losses due to the decline in production, mortality, weight loss, losses of draft power, milk loss, fertility problem, change in herd structure and delays in sale. The indirect losses include

additional costs incurred for the FMD control measures (e.g., vaccination and culling) and revenue forgone (e.g., denied market access).

In fact, loss in cattle production occurs more in the form of morbidity[1] than mortality (Bayissa *et al.*, 2011; Ferrari *et al.*, 2014). Despite the morbidity rate having a higher record, the impact of mortality is greater (Young, Suon, Andrews, Henry & Windsor, 2013). In monetary terms, on average, the total cattle production losses caused by the FMD outbreak can be as high as hundreds of dollars. For example, average losses of cattle production incurred by Cambodia farmers ranged between USD216.32 and USD370.54 per cattle (Young *et al.*, 2013), that of Turkish farmers ranged between USD152 and USD294 per cattle (Senturk & Yalcin, 2008) and the Ethiopian farmers' losses ranged between USD76 and USD174 per herd (Jemberu *et al.,* 2014). However, the adverse impact of disease on the cattle industry is not only limited to the FMD but also includes *E. Coli* (Moon & Tonsor, 2020), Johne's disease (Ott *et al.*, 1999), brucellosis (Singh *et al.,* 2015) and many more. As aforementioned, this paper aims to estimate the economic loss of cattle production (from mortality and weight loss of cattle) due to the FMD outbreak in Peninsular Malaysia by looking at the different types of cattle breeds, ages, and gender (i.e., Kedah-Kelantan, Charolaise and limousine).

Materials and Methods

Source of Data

Although the study was conducted in Peninsular Malaysia, not all states were included in the data collection. The only sample of cattle farmers was chosen to participate in this study because as data provided by DVS Malaysia, the number of cattle farmers (i.e., over 15,000 in six states) is significant enough for the study. The respondent then was picked using the snowball sampling method, and respondents were chosen based on their recent experience with the FMD outbreak between 2017 and 2018 and their accessibility for study. The data were collected in six states of Peninsular Malaysia (i.e., Kelantan, Pahang, Selangor, Melaka, Negeri Sembilan and Johor) from April until October 2018. As a result, 349 farmers from six states were involved in the FMD outbreak study. A questionnaire was used to collect data and then administered via interview. Before the researcher starts with the interview, each respondent has explained the purpose, risks, and benefits of the study. Respondents voluntarily can refuse to participate in the study and have their answers presented confidential.

Data Analysis

This section is divided into two: Estimation and statistical sections. The estimation section estimates cattle production loss due to the FMD outbreak. The statistical analysis was used to examine the cattle distribution and test for any significant differences of loss in cattle production between and within the breed. IBM-SPSS software was used to analyze the data.

Estimation of Cattle Production Losses

Although draught power[2] loss captures cattle production losses, in Peninsular Malaysia, usually, the cattle farmers no longer use the cattle for agricultural activities (e.g., ploughing and threshing). Therefore, it is no longer relevant to estimate drought power loss. On the other hand, despite the efforts made to estimate milk loss in this study, the number of dairy farmer respondents is too small to be reported (i.e., 2 farmers). Thus, after considering this issue, only the loss of cattle production from mortality and weight loss were estimated. Adapting Jemberu *et al.* (2014) model, the estimation of loss of cattle production from mortality was expressed in equation (1).

[1] Morbidity refers to a situation where animal is dying due to the disease. It is an opposite word of mortality.

[2] Draught power loss refers to the loss of day use of animal in agriculture (e.g., plowing and threshing). This estimation is normally conducted at smallholder or farm level.

$$LM_{ij} = (NCM_i \times CP) + (NYM_i \times YP) + (NAM_i \times AP) \quad (1)$$

where LM_{ij} refers to loss of cattle production due to mortality for herd in farming system j, NCM_i is the number of calf[3] that died in herd i, CP is the price of a healthy calf, NYM_i is the number of young[4] cattle that died in herd i, YP is the price of healthy young, NAM_i is a number of adult[5] cattle that died in herds, i and AP is the price of a healthy adult. Meanwhile, based on Young *et al*. (2013), loss of cattle production due to weight loss can be calculated by multiplying the average weight of healthy livestock by the average weight loss percentage and the value of live weight per kg. Thus, adopting this equation, the loss of cattle production due to the weight loss is expressed in equation (2):

$$LW_{ij} = NI_i \times AWL_i \times MP \quad (2)$$

where LW_{ij} refers to loss of cattle production due to weight loss of herd in farming system j, NI_i is the number of infected cattle by FMD outbreak for herd i, AWL_i is the average weight loss per cattle for herd i, and MP is the average meat price per kg in Peninsular Malaysia.

Statistical Analysis

A statistical analysis was done to test if there are significant differences in total cattle production loss between breed, age, and gender within the breed. Two tests were carried out to test the result: Independent t-test and one-way ANOVA. Specifically, the independent sample t-test was used to determine if there were any significant differences between the gender of the breed; while one-way ANOVA, on the other hand, was used to determine any significant differences between breed and age within the breed. Multiple comparisons or post-hoc tests were applied after one-way ANOVA to determine where the differences lie.

Results and Discussion

Farm Size

Three groups of cattle breeds were identified from a total of 349 affected cattle farmers surveyed (i.e., Kedah-Kelantan, Charolaise, and Limousine). Kedah-Kelantan has the highest number of herds and cattle (197 herds and 1630 cattle), followed by Charolaise (100 herds and 604 cattle) and Limousine (52 herds and 245 cattle), as shown in Table 1.

Cattle Production Losses

Table 2 presents the mean total cattle production loss from mortality and weight loss due to FMD outbreak per herd by breeds. Between breed, Charolaise and Limousine experience higher production losses than Kedah-Kelantan. This occurred due to Charolaise and Limousine greater body size than the Kedah-Kelantan. Charolaise and Limousine, mature body size, can reach up to 1100 kg and 1200 kg for males and 900 kg and 700 kg for females, respectively. Kedah-Kelantan comprises only 250 kg for males and 175 kg for females. Therefore, this explains why Charolaise and Limousine experience higher production losses than Kedah-Kelantan. Using one-way ANOVA accompanied by multiple comparisons test, the mean total cattle production losses are statistically significantly higher for Limousine

Table 1: Farm size by breeds

Breeds	No. of Farm or Herd	No. of Cattle	Average Farm Size
Kedah - Kelantan	197	1630	8
Charolaise	100	604	6
Limousine	52	245	5

[3] Calf refers to cattle age ≤ 1 year.
[4] Young refers to cattle age range between >1 < 2 years.
[5] Adult refers to cattle age ≥ 2 years.

Table 2: Mean total cattle production losses per herd by breed

Breeds	Mortality Loss	Weight Loss	Total Production Losses	F-statistic
Kedah-Kelantan	15.99	219.03	235.01	
Charolaise	50.84	277.75	328.60	9.00***
Limousine	67.18	323.06	390.24	

Note: *, **, *** denote 10%, 5% and 1% significance levels, respectively.

(MYR390.24) and Charolaise (MYR328.60) than Kedah-Kelantan (MYR235.01) ($p < 0.001$). However, between Limousine and Charolaise, there is no statistically significant difference.

By comparing between ages within the breed, the adults have statistically significantly higher mean total production losses than the young and calf ($P < 0.001$). The mean total production losses for Kedah-Kelantan are MYR447.80 (adult), MYR214.29 (young), and MYR42.96 (calf). Charolaise has a mean total production loss of MYR696.67 (adult), MYR247.92 (young) and MYR41.19 (calf), while Limousine has a mean total production loss of MYR750.13 (adult), MYR291.65 (young) and MYR128.94 (calf) as shown in Table 3.

Using an independent t-test, each gender within the age of breed shows a different result. Table 4 shows mean total production loss between the gender of Kedah-Kelantan is only statistically significant for the calf and adult, while young cattle is not statistically significant. The mean total production losses for male calf (MYR53.83) is statistically significantly higher than for female calf (MYR32,10). In contrast, male adult (MYR228.75) has statistically significantly lower mean total production loss than female adult (MYR666.84). For the Charolaise it is only statistically significant for young and adults, while the calf is not statistically significant. Young (MYR71.78) and adult (MYR316.61) males have statistically significantly lower mean total production loss than young (MYR424.07) and adult (MYR1076.74) females. While for the Limousine, unfortunately, the differences in all mean total production losses between genders within the age are not statistically significant, as shown in Table 4.

Table 3: Mean total cattle production losses per herd by age

Breeds	Age of Cattle (year)	Mortality Loss	Weight Loss	Total Production Losses	F-statistic
Kedah-Kelantan	Calf	21.51	21.45	42.96	51.59***
	Young	7.66	206.63	214.29	
	Adult	18.80	429.00	447.80	
Charolaise	Calf	27.51	13.68	41.19	33.00***
	Young	27.96	219.96	247.92	
	Adult	97.05	599.62	696.67	
Limousine	Calf	67.67	61.27	128.94	10.89***
	Young	0	291.65	291.65	
	Adult	133.87	616.26	750.13	

Note: *, **, *** denote 10%, 5% and 1% significance levels, respectively.

Improving the hygiene procedure in the production system is not limited to reducing the impact of contaminated or animal disease on production (Mohamad & Hamzah, 2020) but is also capable of increasing consumer demand locally or internationally and reducing cost (Tansor & Schroeder, 2015). Therefore, an effort to develop a strategy to mitigate, increase surveillance and eradicate FMD is needed. However, to enhance the acceptance of farmers to the adaption of new knowledge on technologies or farm management, education, age, and gender should also be considered (Gillespie *et al.,* 2014; Sodjinou *et al.,* 2015; Awotide *et al.,* 2016).

As the Department of Veterinary Services (DVS) Malaysia deals with animal health, policies such as vaccination, quarantine, movement control, disinfection and culling may be the relevant strategies to mitigate FMD outbreaks. In this regard, we suggest that further enforcement of FMD control would be worthwhile. For example, enforcing vaccination saved production by USD5.70 for every US dollar spent (Ferrari *et al.,* 2014). By evaluating the alternative control strategies, Garner and Lack (1995) and Roche *et al*. (2014) demonstrated that stamping out, ring vaccination and slaughtering dangerous contact herds are some of the most effective ways to eradicate FMD outbreak, other than control movement (Velthuis & Mourits, 2007). While by applying animal tracking system to cattle producers, Elbakidze (2007) point out that information from animal tracking system can provide faster action to surveillance the spread of disease. In

Table 4: Total cattle production losses per herd by gender

Breeds	Age (year)	Gender	Mortality Loss	Weight Loss	Total production Losses (TPL)	t-statistic
Kedah-Kelantan	Calf	Male	36.62	17.21	53.83	1.11**
		Female	6.40	25.70	32.10	
	Young	Male	15.31	166.39	181.70	-1.20
		Female	0	246.87	246.87	
	Adult	Male	20.75	208.00	228.75	-5.99**
		Female	16.85	649.99	666.84	
Charolaise	Calf	Male	26.33	7.30	33.63	-0.37
		Female	28.69	20.06	48.75	
	Young	Male	0	71.78	71.78	-3.58***
		Female	55.93	368.14	424.07	
	Adult	Male	125.67	190.94	316.61	-4.53***
		Female	68.43	1,008.31	1,076.74	
Limousine	Calf	Male	68.59	25.25	93.84	-0.68
		Female	66.76	97.28	164.04	
	Young	Male	0	280.27	280.27	-0.24
		Female	0	303.02	303.02	
	Adult	Male	136.68	396.86	533.54	-1.31
		Female	131.07	835.67	966.74	

Note: *, **, *** denote 10%, 5% and 1% significance levels, respectively.

other words, it will reduce the time used to trace the previous history of the movement of animals apart from reducing the risk of losses that could be bear by the farmers. More interestingly, improving management practices has proven to increase profit via increases in sale prices (Zimmerman, 2010).

In this study, other cattle production losses were not considered (e.g., fertility problem, denied market access) as the main purpose was to provide evidence from the weight, drought power, milk, and mortality perspective. The calculation formula was based on the study by Jemberu *et al*. (2014) and Young *et al*. (2013). Although drought power and milk loss are categorized as loss in cattle production, both were not included in this study since cattle in Peninsular Malaysia are no longer used for agricultural purposes, coupled with the extremely low number of respondents. Indeed, to gain better insight into the overall impact of FMD on cattle production, future studies need to address other types of cattle production losses. Cattle production losses are likely higher than estimated in this study if other forms of cattle production losses were included in the analysis.

Further research is required to determine meat consumption during the high peak of the FMD outbreak, especially during the festive season among consumers and the economic loss bear by small cattle in Malaysia because the demand and supply of meat may be uncertain. In the widespread uncertainty created by the outbreak, it is perhaps natural for consumers to seek reassurance that their food supply is secure and for some to equate food security with (domestic or regional) self-sufficiency.

Conclusion

From the results obtained, there is an indication that cattle production loss in terms of weight and mortality is higher. Findings show that the mean value for total economic loss for each breed is MYR235.01 (Kedah-Kelantan), MYR328.60 (Charolaise) and MYR390.24 (Limousine) per farm or herd. By comparing mortality and morbidity rates, this result parallels the previous studies (e.g. Şentürk & Yalçin, 2008; Young *et al*., 2013) which also found that despite that morbidity rate is higher than the mortality rate, the loss due to mortality is much greater. These are crude estimates based on the survey at the farm level.

Acknowledgements

We thank the State Department of Veterinary Services (DVS) Malaysia for their valuable help.

References

Abdul-Hamid, N. F., Hussein, N. M., Wadsworth, J., Radford, A. D., Knowles, N. J., & King, D. P. (2011). Phylogeography of foot-and-mouth disease virus types O and A in Malaysia and surrounding countries. *Infection, Genetics, and Evolution*, *11*(2), 320-328. https://doi.org/10.1016/j.meegid.2010.11.003

Alhaji, N. B., Amin, J., Aliyu, M. B., Mohammad, B., Babalobi, O. O., Wungak, Y., & Odetokun, I. A. (2020). Economic impact assessment of foot-and-mouth disease burden and control in pastoral local dairy cattle production systems in northern Nigeria: A cross-sectional survey. *Preventive Veterinary Medicine*, *177*, 104974.

Awotide, B. A., Karimov, A. A., & Diagne, A. (2016). Agricultural technology adoption, commercialization, and smallholder rice farmers' welfare in rural Nigeria. *Agricultural and Food Economics*, *4*(1), 1-24.

Bayissa, B., Ayelet, G., Kyule, M., Jibril, Y., & Gelaye, E. (2011). Study on seroprevalence, risk factors, and economic impact of foot-and-mouth disease in Borena pastoral and agro-pastoral system, southern Ethiopia. *Tropical Animal Health and Production*, *43*(4), 759-766. https://doi.org/10.1007/s11250-010-9728-6

Cleland, P. C., Baldock, F. C., Chamnanpood, P., & Gleeson, L. J. (1996). Village level risk factors for foot-and-mouth disease in northern Thailand. *Preventive Veterinary Medicine*, *26*(3-4), 253-261. https://doi.org/10.1016/0167-5877(95)00552-8

Department of Veterinanry Services Malaysia. (2011). *Malaysian Veterinary Protocol for foot and mouth disease*. https://www.dvs.gov.my/dvs/resources/user_1/2021/BKPBV/KAWALAN%20PENYAKIT%20&%20ZOONOTIK/PVM_FMD-ver2.pdf

Elbakidze, L. (2007). Economic benefits of animal tracing in the cattle production sector. *Journal of Agricultural and Resource Economics*, *32*(1), 169-180. http://www.jstor.org/stable/40987357

Elnekave, E., Zamir, L., Hamd, F., Tov, B. E., & Klement, E. (2015). Risk factors for foot and mouth disease outbreaks in grazing beef cattle herds. *Preventive Veterinary Medicine*, *120*(2), 236-240. https://doi.org/10.1016/j.prevetmed.2015.03.011

Ferrari, G., Tasciotti, L., Khan, E., & Kiani, A. (2014). Foot-and-mouth disease and its effect on milk yield: An economic analysis on livestock holders in Pakistan. *Transboundary and Emerging Diseases*, *61*(6), e52-e59. https://doi.org/10.1111/tbed.12072

Fourichon, C., Seegers, H., Bareille, N., & Beaudeau, F. (1999). Effects of disease on milk production in the dairy cow: A review. *Preventive Veterinary Medicine*, *41*(1), 1-35. https://doi.org/10.1016/S0167-5877(99)00035-5

Garner, M. G., & Lack, M. B. (1995). An evaluation of alternate control strategies for foot-and-mouth disease in Australia: A regional approach. *Preventive Veterinary Medicine*, *23*(1-2), 9-32.

Gillespie, J., Nehring, R., & Sitienei, I. (2014). The adoption of technologies, management practices, and production systems in US milk production. *Agricultural and Food Economics*, *2*(1), 1-24.

Hobbs, J. E. (2021). The COVID-19 pandemic and meat supply chains. *Meat Science*, *181*, 108459. https://doi.org/10.1016/j.meatsci.2021.108459

Jemberu, W. T., Mourits, M. C., Woldehanna, T., & Hogeveen, H. (2014). Economic impact of foot and mouth disease outbreaks on smallholder farmers in Ethiopia. *Preventive Veterinary Medicine*, *116*(1-2), 26-36. https://doi.org/10.1016/j.prevetmed.2014.06.004

Kitching, R. P. (2002). Clinical variation in foot and mouth disease: Cattle. *Revue Scientifique et Technique-Office International Des Epizooties*, *21*(3), 499-504.

Knight-Jones, T. J. D., & Rushton, J. (2013). The economic impacts of foot and mouth disease - What are they, how big are they and where do they occur? *Preventive Veterinary Medicine*, *112*(3-4), 162-173. https://doi.org/10.1016/j.prevetmed.2013.07.013

Lyons, N. A., Alexander, N., Stärk, K. D., Dulu, T. D., Sumption, K. J., James, A. D., Rushton, J., & Fine, P. E. (2015). Impact of foot-and-mouth disease on milk production on a large-scale dairy farm in Kenya. *Preventive Veterinary Medicine*, *120*(2), 177-186. https://doi.org/10.1016/j.prevetmed.2015.04.004

Moghadam, A. K., Schmidt, C., & Grier, K. (2013). The impact of *E. coli* O157: H7 recalls on live cattle futures prices: Revisited. *Food Policy*, *42*, 81-87.

Mohamad, A., & Hamzah, H. Z. (2020). Impact of good agricultural practices on Malaysian cattle industry: A case of Foot and Mouth Disease (FMD). *International Journal of Social Science Research*, *2*(2), 39-45.

Moon, D., & Tonsor, G. T. (2020). How Do *E. coli* recalls impact cattle and beef prices? *Journal of Agricultural and Resource Economics*, *45*(1), 92-106.

Ott, S. L., Seitzinger, A. H., & Hueston, W. D. (1995). Measuring the national economic

benefits of reducing livestock mortality. *Preventive Veterinary Medicine*, *24*(3), 203-211. https://doi.org/10.1016/0167-5877(95)00477-E

Ott, S. L., Wells, S. J., & Wagner, B. A. (1999). Herd-level economic losses associated with Johne's disease on US dairy operations. *Preventive Veterinary Medicine*, *40*(3-4), 179-192.

Ramanoon, S. Z., Robertson, I. D., Edwards, J., Hassan, L., & Isa, K. M. (2013). Outbreaks of foot-and-mouth disease in Peninsular Malaysia from 2001 to 2007. *Tropical Animal Health and Production*, *45*(2), 373-377. https://doi.org/10.1007/s11250-012-0226-x

Roche, S. E., Garner, M. G., Wicks, R. M., East, I. J., & de Witte, K. (2014). How do resources influence control measures during a simulated outbreak of foot and mouth disease in Australia? *Preventive Veterinary Medicine*, *113*(4), 436-446.

Singh, B. B., Dhand, N. K., & Gill, J. P. S. (2015). Economic losses occurring due to brucellosis in Indian livestock populations. *Preventive veterinary medicine*, *119*(3-4), 211-215.

Şentürk, B., & Yalçin, C. (2008). Production losses due to endemic foot-and-mouth disease in cattle in Turkey. *Journal of Veterinary and Animal Sciences*, *32*(6), 433-440.

Sodjinou, E., Glin, L. C., Nicolay, G., Tovignan, S., & Hinvi, J. (2015). Socioeconomic determinants of organic cotton adoption in Benin, West Africa. *Agricultural and Food Economics*, *3*(1), 1-22.

Tonsor, G. T., & Schroeder, T. C. (2015). Market impacts of *E. coli* vaccination in US Feedlot cattle. *Agricultural and Food Economics*, *3*(1), 1-15.

Velthuis, A. G. J., & Mourits, M. C. M. (2007). Effectiveness of movement-prevention regulations to reduce the spread of foot-and-mouth disease in the Netherlands. *Preventive Veterinary Medicine*, *82*(3-4), 262-281.

World Organization for Animal Health (2019). *World animal health information database*. WHO.

Young, J. R., Suon, S., Andrews, C. J., Henry, L. A., & Windsor, P. A. (2013). Assessment of financial impact of foot and mouth disease on smallholder cattle farmers in Southern Cambodia. *Transboundary and Emerging Diseases*, *60*(2), 166-174. https://doi.org/10.1111/j.1865-1682.2012.01330.

Zimmerman, L. C., Schroeder, T. C., Dhuyvetter, K. C., Olson, K. C., Stokka, G. L., Seeger, J. T., & Grotelueschen, D. M. (2012). The effect of value-added management on calf prices at superior livestock auction video markets. *Journal of Agricultural and Resource Economics*, *37*(1), 128-143. http://dx.doi.org/10.22004/ag.econ.122317