

The exploration of financial impacts among three stakeholders during the 2016 Foot-and-Mouth Disease Outbreak in a Dairy Cooperative, Chiang Mai province, Thailand

Wilasinee Jongthanachote¹ Manthita Poontrakulkeat¹ Kwankla Mungthisarn¹
Anuwat Wiratsudakul² Sineenard Jiemtaweewoon^{2*}

¹Sixth year student, Faculty of veterinary science, Mahidol University, Nakhon Pathom, Thailand

²Department of Clinical Sciences and Public Health, Faculty of veterinary science, Mahidol University, Nakhon Pathom, Thailand

*Corresponding author, E-mail address: sineenard.jie@mahidol.edu

Abstract

Foot-and-mouth disease (FMD) leads to a huge impact to dairy farmers as milk selling is not allowed during the outbreak. This study thus aimed to estimate the economic impact of FMD outbreaks in a dairy cooperative located in Chiang Mai province, Thailand. We explored economic losses in three different categories including farmers, dairy cooperative and governmental authority. A multiple linear regression model was employed to identify the key factors that contribute to the financial impacts. Our results reveal that farmer losses were resulted from milk selling prohibition, treatment service and their supplies. The loss per cow was approximated at 33.9 USD resulting in the total loss of 31,120.25 USD. During the outbreaks, the cooperative spent some expenses on farmer compensation, overtime wages, laboratory testing, together with the loss due to raw milk reduction and decline on selling goods. The impact on this sector was around 3,725.44 USD. At the provincial DLD office, veterinary authority needed to set up animal checkpoints during the outbreak and carried out laboratory testing for suspected samples. The cost of these control measures was 2,466.58 USD. In total, the financial impact of the 2016 FMD outbreak in this certain cooperative was estimated at 37,312.27 USD. According to our model, the key parameters that can predict the economic impact were milk income, fuel cost and feed cost ($R^2 = 0.88$). We anticipate that our model may help to raise awareness on these economic impacts and manage the identified factors during the course of the outbreaks.

Keywords: Dairy cattle, Economics, FMD, Modeling, Thailand

การสำรวจผลกระทบทางเศรษฐกิจของผู้มีส่วนเกี่ยวข้องในการระบาดของโรคปากและเท้าเปื่อยในปี พ.ศ. 2559 ณ สหกรณ์โคนมในจังหวัดเชียงใหม่ ประเทศไทย

วิลาสินี องชนโชติ¹ มณฑิตา พุนตระกูลเกียรติ¹ ขวัญกล้า มังธสาร¹
อนุวัฒน์ วิรัชสุดากุล² ลีนิภาณ เจียมทวิบุญ*

¹นักศึกษาระดับปริญญาโท คณะสัตวแพทยศาสตร์ มหาวิทยาลัยมหิดล จังหวัดนครปฐม ประเทศไทย
²ภาควิชาเวชศาสตร์คลินิกและการสาธารณสุข คณะสัตวแพทยศาสตร์ มหาวิทยาลัยมหิดล จังหวัดนครปฐม ประเทศไทย

*ผู้รับผิดชอบบทความ E-mail address: sineenard.jie@mahidol.edu

บทคัดย่อ

การระบาดของโรคปากและเท้าเปื่อยนำมาซึ่งผลกระทบที่รุนแรงต่อเกษตรกรผู้เลี้ยงโคนมจากการดส่งนมในช่วงของการระบาด เป้าหมายของการศึกษาในครั้งนี้คือ การประเมินค่าความเสียหายทางเศรษฐกิจ จากการระบาดของโรคปากและเท้าเปื่อยในพื้นที่สหกรณ์โคนมแห่งหนึ่ง ซึ่งตั้งอยู่ในจังหวัดเชียงใหม่ คณะผู้วิจัยได้แบ่งผู้ได้รับผลกระทบเป็น 3 กลุ่ม ได้แก่ เกษตรกรผู้เลี้ยงโคนม สหกรณ์โคนม และภาครัฐบาลที่เกี่ยวข้อง และใช้แบบจำลองการวิเคราะห์การถดถอยแบบพหุคูณ (multiple linear regression) เพื่อระบุปัจจัยหลักที่มีส่วนทำให้เกิดผลกระทบทางเศรษฐกิจ ผลของการศึกษาในครั้งนี้แสดงให้เห็นว่า ความสูญเสียในภาคเกษตรกรรมนั้นเกิดจากการดส่งนม และค่าใช้จ่ายในการรักษาโดยรวมถึงเวชภัณฑ์ที่เกี่ยวข้อง มูลค่าความเสียหายต่อตัวโคนมนั้นคิดเป็น 33.9 ดอลลาร์สหรัฐ มูลค่าความเสียหายรวมในส่วนของเกษตรกรคิดเป็น 31,120.25 ดอลลาร์สหรัฐ ในส่วนของสหกรณ์โคนม ความสูญเสียเกิดจากการจ่ายค่าชดเชยให้แก่เกษตรกรที่เป็นสมาชิก ค่าจ้างล่วงเวลาให้แก่พนักงาน และค่าใช้จ่ายในการตรวจทางห้องปฏิบัติการ รวมไปถึงปริมาณการขายน้ำนมดิบและสินค้าที่ลดลง ซึ่งประเมินความเสียหายได้ทั้งสิ้น 3,725.44 ดอลลาร์สหรัฐ และในส่วนของภาครัฐบาลที่เกี่ยวข้องซึ่งหมายถึงหน่วยงานของกรมปศุสัตว์ในพื้นที่นั้น มีการจัดตั้งจุดตรวจและควบคุมโรคระบาดและส่งตรวจตัวอย่างทางห้องปฏิบัติการซึ่งคิดเป็นค่าใช้จ่าย 2,466.58 ดอลลาร์สหรัฐ จึงสามารถสรุปผลเป็นมูลค่าความสูญเสียจากผู้ได้รับผลกระทบทั้งหมดได้ทั้งสิ้น 37,312.27 ดอลลาร์สหรัฐ จากแบบจำลองพบว่าปัจจัยที่สามารถนำมาคาดการณ์ความสูญเสียในภาคเกษตรกรรมได้ คือ รายได้จากการขายนม กำน้ำมัน และค่าอาหารสัตว์ โดยมีค่าสัมประสิทธิ์การตัดสินใจอยู่ที่ 0.88 ($R^2 = 0.88$) คณะผู้วิจัยคาดหวังว่าแบบจำลองที่แสดงให้เห็นมูลค่าความเสียหายทั้งหมดนี้จะสามารถสร้างความตระหนักให้เห็นถึงผลกระทบทางเศรษฐกิจที่สำคัญ และสามารถนำไปใช้วางแผนการจัดการกับปัจจัยต่าง ๆ ที่ก่อให้เกิดผลกระทบในช่วงของการระบาด

คำสำคัญ : โคนม เศรษฐศาสตร์ โรคปากและเท้าเปื่อย แบบจำลอง ประเทศไทย

Introduction

Foot-and-mouth disease virus (FMDV) is an icosahedral shape virus, classified in the family of Picornaviridae, Genus *Aphthovirus*. Seven serotypes of FMDV were recognized so far. Nevertheless, only three serotypes were observed in Thailand including serotype O, A and Asia1 (Yano 2013). The virus can infect most of Artiodactyla or Pair-hooves species, for examples, swine, bovine, sheep and Alpaca (Ashford 2015).

The outbreaks of FMD in livestock species may result in a huge economic impact. For examples, In Laos PDR, financial impact was assessed from number of villages with FMD outbreaks (414 villages in 14 provinces). During 2011 outbreaks, financial losses were 30,881 USD at the village level and 13,512,291 USD at the national level (Nampanya et al., 2016). In Thailand, FMD is an endemic disease, causing economic losses in different livestock species including dairy cattle. There were around 16,000 households raising 600,000 dairy cattle in 2016 (FIC 2016) nationwide. These cattle produced milk around 1.08 million ton per year. Therefore, the occurrence of foot and mouth disease in dairy cattle may affect the livelihood of dairy farmers especially small holders.

In 2016, FMD outbreaks were mostly notified in the fifth livestock region. Within this region, Chiang Mai province possessed the most frequent outbreaks (DLD 2016). There were eight dairy cooperatives in the

province. We purposively selected Mae-jo dairy cooperative in San Sai district as our study site with the following reasons. First, San Sai was the second densely populated area in Chiang Mai (NSO 2010). Second, the FMD outbreaks had been reported in this district around twice a year during 2013-2016. Third, Mae-jo dairy cooperative had a computerized data collection system in which data input was quite completed and the cooperative previously faced the FMD outbreaks.

The objective of this study was to evaluate the financial loss due to the FMD outbreaks in Mae-Jo cooperative, Chiang Mai province, Thailand and further identify key factors that contribute to the economic impact.

Materials and Methods

Field data exploration

We examined records relevant to the FMD outbreaks reporting between June to September 2016. These records were available at the fifth regional livestock office and Mae-jo dairy cooperative. We explored data on financial loss during the FMD outbreaks (June to September 2016) and in the year after (June to September 2017) at the same period. To assess economic impact in different levels, we divided our financial loss data into three sectors including provincial DLD, cooperative and farmer. Data recorded in each sector were detailed in Fig. 1.

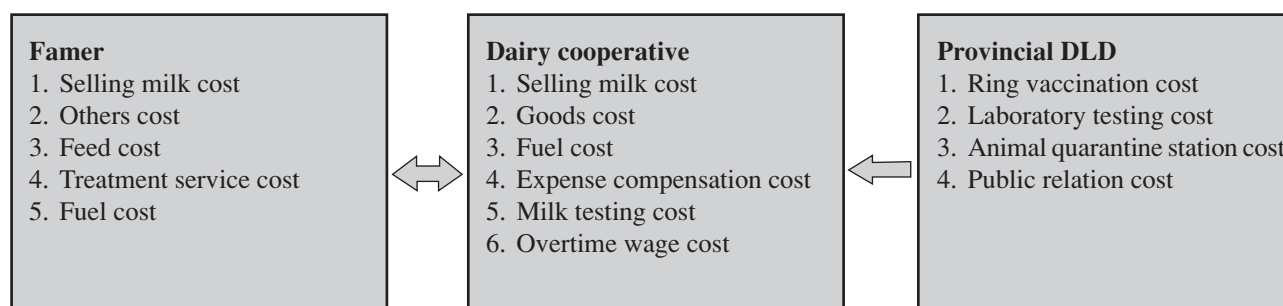


Fig. 1 Factors related to the financial losses from FMD outbreaks in the sectors of farmer, dairy cooperative and provincial DLD

Evaluation of financial losses

Farm level

At farm level, we included factors namely cost due to milk selling, feed, treatment service, fuel and others miscellaneous cost. Milk Selling was a farmer's income whereas other factors including costs of feed, treatment service, fuel and others miscellaneous cost were classified as outcome. Others miscellaneous cost was consisted of medical supplies, medicine and disinfectant. We collected data from 43 members of the cooperative in which the FMD was reported. The income per cow was summarized from milk selling revenue divided by the number of all cows. The outcome per cow were calculated from the summation of feed, treatment service, fuel and others (medical supplies, medicine and disinfectant) divided by the number of all cows in the farm. The calculation framework of the economic impact at the farm level was summarized in equation 1 and 2.

$$\text{Income} = \frac{\sum (MN1, MN2, MN3, \dots, MNn)}{\sum (CN1, CN2, CN3, \dots, CNn)} \quad (1)$$

$$\text{Outcome} = \quad (2)$$

$$\frac{\sum (FN1, FN2, FN3, \dots, FNn) + \sum (TN1, TN2, TN3, \dots, TNn) + \sum (fN1, fN2, fN3, \dots, fNn) + \sum (ON1, ON2, ON3, \dots, ONn)}{\sum (CN1, CN2, CN3, \dots, CNn)}$$

; where

MN_n = Milk selling revenue in each farm

CN_n = Number of cows in each farm

FN_n = Feed cost in each farm

TN_n = Treatment service cost in each farm

fN_n = Fuel in each farm

ON_n = Other cost in each farm

Cooperative level

We used data related to the cooperative payment, which includes expenses on farmer compensation, milk laboratory testing and overtime wages for the veterinary officers together with cooperative income from selling fuel and raw milk.

Provincial DLD level

We used official records on period and area of the outbreaks, policy and budgets spent by the fifth regional livestock office and provincial DLD office to control the outbreaks including the cost of ring vaccination, sample collection and laboratory test to confirm the subtype of virus, animal checkpoint (quarantine station) to restrict the spread of the disease and public relation.

Data analysis

All data collected from the three levels were then summarized as shown in equation 3.

$$C = Yf + Yg + Yc \quad (3)$$

; where

C = total financial impact of FMD

Yf = farmer's financial impact

Yg = government's financial impact

Yc = dairy cooperative's financial impact

Subsequently, multiple linear regression model was employed to identify key factors that significantly (P-value < 0.05) contribute to the financial impacts. IBM Statistical Package for the Social Sciences (SPSS) Software ver. 22.0 (IBM Corporation, New York, USA.) was used in this analysis.

Results

Observed financial losses

We compared the financial data between outbreak period (July to October 2016) and non-outbreak period (June to September 2017). During the outbreak period, the FMD outbreaks were recorded in 53.1% (43/81) of the Mae-jo dairy cooperative farm members. The epidemic curve of the FMD occurrence in that period is depicted in Fig. 2.

At farm level, average incomes per cow in August and September in 2016 were less than 2017 whereas incomes in June and July in 2016 were higher than 2017. Average outcome in 2016 was higher than 2017 (Fig. 3). Noted that number of farm members in the cooperative

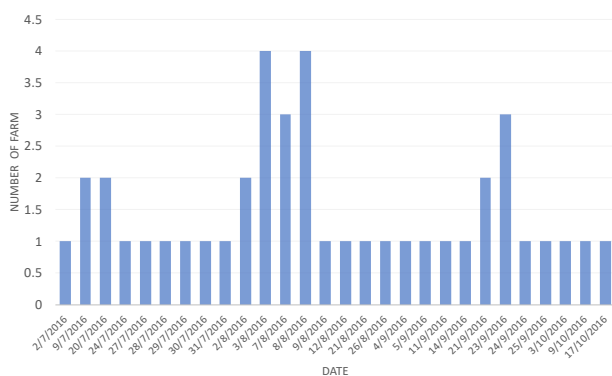


Fig. 2 Epidemic curve of FMD outbreak at farm level in Mae-jo dairy cooperative, Chiang Mai province in July - October 2016

keeps changing year by year. We thus included only the farms with FMD outbreak history and presented in both years in our analysis.

At the cooperative, total income in goods, fuel and raw milk in 2016 was less than 2017 (Fig. 4). This observation comes from the fact that technical supports, from veterinarians and relevant alliances, were highly required during the outbreaks. Consequently, overtime wages and related expenses must be paid. Besides, a certain amount of budget was wired to FMD affected farmers in that period to compensate their loss in milk selling. The laboratory related expenses also added into the overall expenses during the outbreaks as shown in Fig. 4.

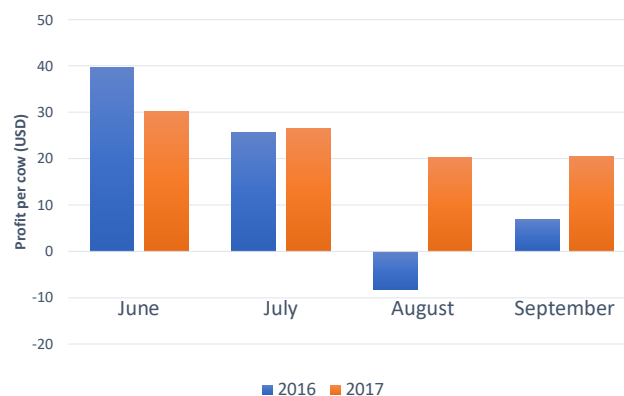


Fig. 3 Average profit per cow of the farmers at Mae-jo dairy cooperative, Chiang Mai, 2016 - 2017

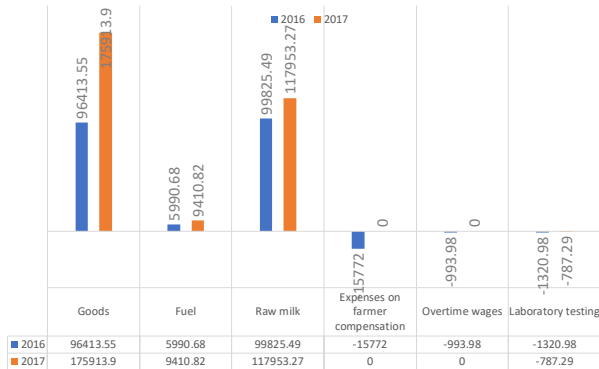


Fig. 4 Income and outcome of Mae-jo dairy cooperative, Chiang Mai, 2016 - 2017. The currency unit in this figure is USD.

At the provincial DLD office, veterinary authorities had to allocate budgets to set animal checkpoints around the outbreak areas and perform laboratory testing in order to halt the spread of the disease. For the animal checkpoint setting, the expenses included officer wages, fuel and disinfectant. The Liquid phase Enzyme-linked immunosorbent assay (LP-ELISA) was used for the laboratory testing. The budgets spent on these two categories were 2,125.93 USD and 340.65 USD, respectively.

In overall, each farmer was financially affected by the FMD outbreak at 354.03 USD per month. To compensate and control the outbreaks, cooperative and provincial DLD office spent around 20,845.32 USD (Fig. 5).

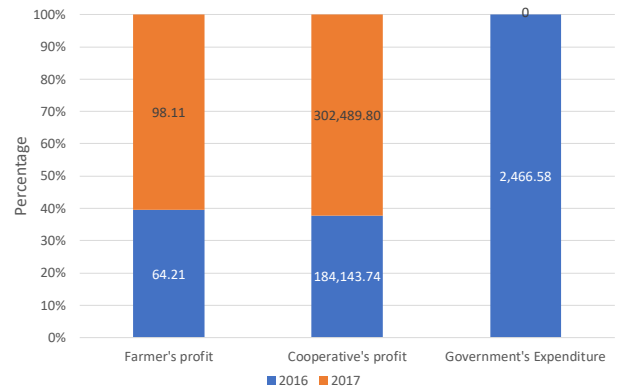


Fig. 5 Overall financial losses at farmer, cooperative and governmental levels. The currency unit in this figure is USD.

Key factor identification

As shown in Table 1, three independent variables in the model can significantly predict the financial loss due to FMD outbreaks at farmer level (P-value <0.001) including milk income, fuel cost and feed cost. In our regression analysis, the model degree of predicting the dependent variable was found to be R = 0.938. The model degree of explaining the variance in the dependent variable was R² = 0.88. The obtained regression equation is shown in equation 4.

$$Y = 11893.311 + 1.809X_1 - 1.815X_2 - 0.834X_3 \quad (4)$$

; where

Y = Total Financial impact of FMD at farmer level

X₁ = Milk income

X₂ = Fuel cost

X₃ = Feed cost

X₄ = Other cost

Table 1 Results from multiple linear regression analysis relate to total financial impact of FMD at farmer level in 2016

Model	Unstandardized Coefficients		Standardized Coefficients	Sig.
	β	Std.Error	β	
1				
Constant	-7115.252	12674.777	0.704	0.578
Milk income	0.944	0.166		0.000
2				
Constant	-4360.823	9722.588	0.826	0.657
Milk income	1.108	0.131	-0.482	0.000
Fuel cost	-1.855	0.377		
3				
Constant	11893.311	6863.13		0.038
Milk income	1.809	0.138	1.349	0.000
Fuel cost	-1.815	0.248	-0.472	0.000
Feed cost	-0.834	0.127	-0.665	0.000

Discussion

The present study explored the financial impacts of FMD outbreaks in dairy cattle settings in different levels involved including farms, cooperative and the related governmental authorities. We collected observed data related to incomes and expenses in all sectors in two consecutive years to compare the years with and without the FMD epidemics. Subsequently, we used a statistical model to identify key factors contributed to the financial impact.

We found that milk-selling loss contributed the greatest impact to the farmers, as milk was not allowed to sell from the FMD affected farms. Interestingly, we also pointed out other costs that were still a part of expenses in the subsequent non-outbreak year including medical supplies, medicine and disinfectant. Noticeably, number of newly FMD infected farms was at the peak in August

which is in line with the lowest profit of farmers compared to other months in 2016 (Fig. 3). We found that the FMD infected cows needed some consecutive treatments as the infected animals may take a while to recover. We can observe abortion cows, reductions in milk yields and lameness (Rushton 2009). Moreover, FMD infection causes immune suppression and the animals may, later on, infect with other infectious agents resulting in other diseases such as mastitis (Summerfield et al., 2009). This might be a hidden impact of the outbreak that is generally overlooked. A more elaborated study on this aspect is suggested in the future work.

In the cooperative sector, majority of the losses was spent on farmer compensation. This compensation system is widely used in different livestock species when outbreaks of infectious disease occurs especially

in low to middle income countries. For example, the compensation to the owners of chickens in case of Avian Influenza outbreaks in Thailand (Tiensin et al., 2005). The purpose of the system is to diminish the economic impacts of the farmers. The organization that pays the compensation can be greatly impacted. Nonetheless, we still support the idea of farmer compensation, as the agricultural practices of small holders may be collapsed without this system. Moreover, the farmer compensation policy is still widely used in many countries such as France, Canada, Brazil, United Kingdom, Australia, Morocco and Botswana. Mostly, the budget was spent on animals slaughtering in the eradication program (OECD 2012).

In the governmental sector, the DLD needed to strengthen the prevention and control program during the epidemic period. The animal checkpoints are not routinely set up unless the epidemics of important diseases occur. It is one of the inevitable costs paid to contain the outbreaks. Similarly, laboratory testing to confirm the occurrence of the disease is needed. However, we did not involve public relation and animal vaccination as additional costs. These are part of the routine practices, which are generally performed, even in the non-outbreak period.

In this study, we used multiple linear regression model that provides an accurate and precise understanding of the association between each factor and the outcome (Matsuyama et al., 2019). This model has also been applied in the assessment of economic impact of infectious diseases in other studies such as the economic impact of Lyme disease in five counties of the Maryland Eastern Shore from 1997 to 2000 (Zhang et al., 2006). Indeed, different methods have been previously applied in the economic impact assessment

of FMD outbreaks. For examples, an epidemiological model was used to estimate the direct and indirect costs to livestock and related industries in Japan (Hayama et al., 2017). In the Republic of Korea, a general linear regression was exploited to examine the effect of pig herd size and Wilcoxon rank-sum test was used to access the association between different farm types (Yoon et al., 2018). The selection of the model, basically, depends on research questions, study designs and the availability of the field data. In our case, we wanted to identify the key factors. We thus employed multiple linear regression model. However, we could only use this model in the farmer sector as we have enough number of samples to fit the model. In contrast, the model was not applicable in case of cooperative and governmental sectors as we assessed only one cooperative and one provincial DLD office. To conduct a similar model in these two higher levels, we needed to include many more cooperatives and DLD offices in the study. It was not feasible in our case due to our financial and time constraints. A future study on this approach is recommended.

We acknowledged some limitations in our study. The farmers did not have any written records for any incomes and expenses in their farms. We had to use records for the farmers prepared by officers at the cooperative. This may not cover all expenditures as farmers also bought agriculture goods, medical supplies and drugs from other sources. Besides, some farmers sold their milk to multiple cooperatives. This data may not be recorded. We hence encourage farmers to implement a computer recording system for their farm management. The benefit of the system is not only for better data analysis but also for their better income once other management problems emerge.

In the future study, a real-time data recording system should be developed to provide a prompt data sources for data analysis especially at the time of outbreaks. To work with retrospective data is not fully practical as we often face missing data problem or recall bias.

In conclusion, we found that milk income, fuel cost and feed cost are the main predictive variable for the economic losses in dairy farms of Mae-jo cooperative. Concurrently, the cooperative needed to spend a huge budget for the compensation of FMD affected farms. The compensation for FMD outbreak that the cooperative paid to each farm during the epidemic was estimated at 366.79 USD. In addition, veterinary authority had to allocate some budget for animal checkpoint setting. The present study primarily identified economic factors involved in the three study levels and quantified relevant losses. Our results are helpful to foresee and manage the budget in advance before the outbreak occurs.

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