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Economic Losses Estimation of Pathogenic *Escherichia coli* Infection in Indonesian Poultry Farming

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ABSTRACT

This study aims to calculate the estimated economic losses in national poultry farming in Indonesia that are infected with pathogenic Escherichia coli. Poor management of chicken preservation is a major predisposing factor. *Escherichia coli* is a normal flora found in the gastrointestinal tract of chicken, but when the chicken stress or decrease immune system, *Escherichia coli* develops into a pathogenic agent. Pathogenic *Escherichia coli* appears as secondary infections that aggravate other disease infection. Cost of illness approach was divided into two main categories namely direct losses from disease and indirect losses from other related costs. Direct losses in broiler farms that were infected with pathogenic *Escherichia coli* through calculation of weight loss of harvest and total mortality, while in layer farms that were infected with pathogenic *Escherichia coli*, direct loss calculations included decreased chicken egg production and total mortality. Indirect losses on broiler and layer farms included calculation of other expenditure costs at the time of the occurrence of pathogenic *Escherichia coli* infections such as cleaning, disinfection and labor compensation costs. Based on the total calculation results obtained that the estimated economic losses incurred on national scale broiler farms reached IDR 14,167,792,041,150, - per harvest period of broiler, while estimated total loss of layer farms on national scale based on the calculation results reached IDR 13,391,996,617,850, - per month. The overall total loss due to this colibacillosis reached 13.10% of total poultry assets in Indonesia. The large proportion of losses incurred to total livestock assets can indicate how important the disease is to be controlled or overcome.

Keywords: Broiler, Cost of illness approach, Economic loss, *Escherichia coli*, Layer

Introduction

Poultry in Indonesia is one of the livestock industry that is able to develop rapidly and is ready to face the global market. The food industry of animal protein in Indonesia as a whole covers the poultry industry at 86.00%, far higher than the pig farming industry, cattle farms and other food industries of animal protein at 5.00%, 8.00% and 1.00% respectively (Lui, 2017). Chicken meat and eggs are sources of animal protein that are widely consumed by Indonesian people, because the price of chicken meat and eggs is more affordable than other livestock meat.

Broiler farm (broiler chicken) and layer (laying hens), are maintained in small and medium scale farms. The condition of poultry farms is generally in the form of open house with low biosecurity, limited availability of clean water, and inadequate facilities to control room temperature, so that poultry experience stress, heat, and poor health. Poor maintenance management can contribute to the high incidence of a disease. Disease in poultry is one of the obstacles that has an impact on decreasing economic value because poultry that have been attacked by disease can be a source of disease.

Poor maintenance management can cause various diseases in poultry, one of which is colibacillosis. Colibacillosis is a bacterial infectious disease caused by *Escherichia coli. Escherichia coli* is an opportunistic bacterium, which is a normal flora that is naturally present in the gastrointestinal system in a controlled amount, but when the immune condition of chicken decreases, *Escherichia coli* can develop into a pathogenic agent. Colibacillosis in broiler has a negative impact on health during the maintenance period because it can cause low weight and death (Wahyuwardani et al., 2014). Colibacillosis has been shown to have an effect on decreasing egg productivity in laying hens (Hastarinda, 2016). Colibacillosis appears as secondary infection in respiratory diseases (Infectious Bronchitis and

Mycoplasmosis - CRD complex), immunosuppressive disease (Infectious Bursal Disease - Gumboro), Newcastle Disease (ND) in chickens or Hemorrhagic enteritis in turkeys (Vandekerchove *et al*., 2004).

The value of colibacillosis morbidity and mortality varies between 5.00 - 20.00%. This infectious agent is quite resistant in the environment, but is susceptible to disinfectants and temperatures of 80°C. The distribution of *Escherichia coli* is very wide, can be found in litter (poultry house floor), chicken manure, dust in poultry house and the environment around the farm, feed, drink, and water sources. Inhalated dust by chicken will infect the respiratory tract with incubation period of 3-5 days. High level of ammonia, poor ventilation of poultry house, and overcrowded populations are also predisposing factors to the widespread *Escherichia coli* bacteria (McMullin, 2004). Colibacillosis can affect the poultry industry sector in Indonesia because it can cause economic losses (Figure 1).

Efforts to prevent disease can be done in two ways which are breaking the cycle of transmission and treatment. Efforts to break the transmission cycle are more efficient than treatment, because they are done before bird gets sick as a form of prevention. Economic losses due to medical expenses and decreased poultry productivity can be avoided. Efforts to control and overcome diseases require big enough budget. The size of losses due to infection with *Escherichia coli* pathogens can be determined by referring to the cost of illness approach, both direct and indirect losses. This study aims to calculate the estimated range of economic losses in poultry farms caused by pathogenic *Escherichia coli* infections in Indonesia. The calculation results are expected to be used as a basis for the importance of conducting efforts to control and overcome pathogenic *Escherichia coli* infections in Indonesia.

Materials and Methods

This study estimated economic losses on poultry farms in Indonesia. The calculation of economic losses in this study focused on losses due to *Escherichia coli* pathogens, so that the direct losses calculated included weight loss, decreased egg production, and increased numbers of mortality. The indirect losses calculated included other expenses used which were disinfection and disposal costs as well as labor compensation costs, while other costs and consequences due to high antibiotic treatment and high antibiotic resistance were not included in the calculation due to limited supporting data.

Data source

Analysis calculation of economic losses on chicken farms infected with pathogenic *Escherichia coli* required adequate data support. Data needed included chicken population data, data on the spread of pathogenic *Escherichia coli* infections in Indonesia, epidemiological parameter data on pathogenic *Escherichia coli* infections, and market price assumption data from goods/services related to chicken farming. This loss calculation used census data of chicken population in the year of 2017 (Figure 2).

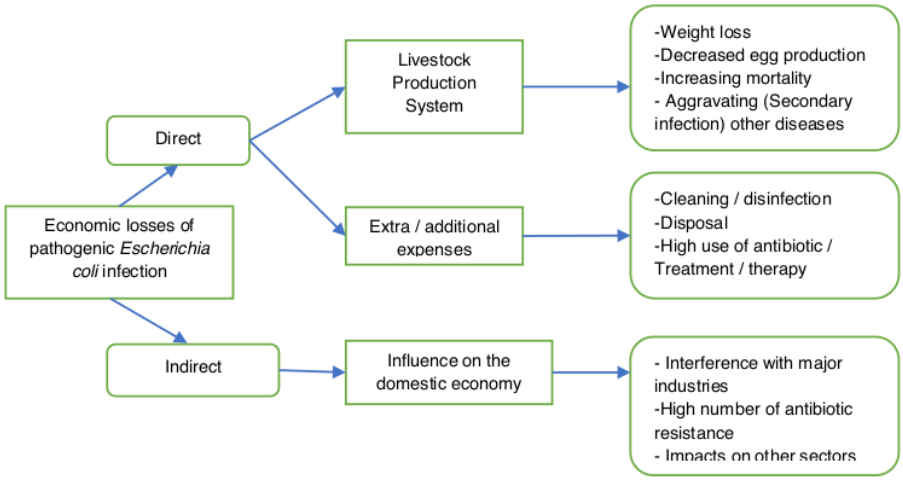

Figure 1. Chart a model of economic losses due to infected with pathogenic *Escherichia coli*.

Provinsi	Populasi Ayam (N) menurut Provinsi (Ekor) * Ras Peterlur (Nl)	Ras Pedaging (Nb)
ACEH	439.878	5.475.266
SUMATERA UTARA	15.861.489	54.968.161
SUMATERA BARAT	8.390.233	18.750.432
RIAU	165.531	47.192.122
JAMBI	764.598	13.499.528
SUMATERA SELATAN	6.599.130	28.712.380
BENGKULU	211.207	5.349.264
LAMPUNG	5.760.029	32.993.652
KEP. BANGKA BELITUNG	133.692	11.689.090
KEP. RIAU	932.502	9.778.102
DKI JAKARTA	0	0
JAWA BARAT	15.476.462	686.058.761
JAWA TENGAH	22.453.270	180.791.433
DI YOGYAKARTA	3.692.806	7.190.865
JAWA TIMUR	46.431.226	203.306.274
BANTEN	4.917.932	61.934.093
BALI	5.566.760	9.126.303
NUSA TENGGARA BARAT	511.620	7.800.535
NUSA TENGGARA TIMUR	202.622	4.947.992
KALIMANTAN BARAT	2.526.367	54.939.395
KALIMANTAN TENGAH	164.000	8.430.983
KALIMANTAN SELATAN	6.272.924	83.700.826
KALIMANTAN TIMUR	859.020	61.962.404
KALIMANTAN UTARA	29.305	10.729.050
SULAWESI UTARA	1.538.013	8.270.671
SULAWESI TENGAH	2.528.477	11.009.953
SULAWESI SELATAN	12.621.460	50.613.823
SULAWESI TENGGARA	372.453	4.087.184
GORONTALO	371.472	4.344.839
SULAWESI BARAT	168.482	1.603.221
MALUKU	21.825	75.533
MALUKU UTARA	37.360	463.200
PAPUA BARAT	70.908	1.772.627
PAPUA	629.594	6.800.779
INDONESIA (total)	166.722.647	1.698.368.741

* Angka sementara

Figure 2. Population of poultry in Indonesia (Dirjennak keswan, 2018).

Research of broiler disease showed that the diseases identified in a farm were colibacillosis (22.20%), ascites (12.50%), gumboro (12.50%), Newcastle disease (ND) (10.00%), *Salmonella pullorum* (10.00%), and necrotic enteritis (7.50%). The disease mainly occurred in chickens aged 11-21 days (57.50%) and occurred in the rainy season (60.00%) (Wiedosari and Wahyuwardani, 2015). Various assumptions of epidemiological parameters from pathogenic *Escherichia coli* infections useful in calculating economic losses were presented in Table 1. Economic parameter assumption about market price associated with economic losses due to pathogenic *Escherichia coli* infections were presented in Table 2. The assumptions used came from scientific articles, market prices, and experience of experts.

Calculation method

Colibacillosis could affect the poultry industry in Indonesia because it could cause considerable economic losses. Research on the economic consequences of diseases based on the disease study approach was divided into two main categories: main costs generated directly from diseases and other related costs, including the costs of non-health diseases (Rice, 1994).

Direct loss

Productivity losses

1. Losses due to weight loss in broiler (KrPBB)
   KrPBB = Apbb x Nb x Hkb x Pcb
2. Losses due to decreased egg production in laying hen (KrPPT)
   KrPPT = Aphdp x Nl x Htl x 30 days

Explanation:

KrPBB = Losses due to weight loss in broiler
Apbb = Average body weight loss per broiler
Nb = Broiler population
Hkb = Price of broiler carcass per kg of broiler chicken
Pcb = The proportion of animals exposed to colibacillosis in broiler
KrPPT = Losses due to decreased egg production in laying hens
Aphdp = Average decrease hen day production of laying hen
Nl = Laying hen population
Htl = Price of chicken eggs per kg

Livestock mortality

1. Livestock mortality in broiler (KmTB)
   KmTB = Abb x Nb x Hkb x Mcb
2. Livestock mortality in laying hens (KmTL)
   KmTL = Nl x Hkl x Mcl

Explanation:

KmTB = Livestock mortality in broiler
Abb = Average body weight broiler at harvest (35 days)

Table 1. Epidemiological parameters as the basis for calculations due to infected with pathogenic *Escherichia coli*

Epidemiological parameters	Symbol	Broiler	Layer
The proportion of animals exposed to colibacillosis (%)	Pc	22.2	10
Average body weight of broiler at harvest (35 days)(kg)	Abb	2	-
Average body weight loss per head (kg)	Apbb	0.5	-
Average hen day production (%)	Ahdp	-	80
Average decreased hen day production (%)	Aphdp	-	12
Mortality of colibacillosis (%)	Mc	7.25	3

Data source: (Wiedosari and Wahyuwardani, 2015).

Table 2. Economic parameters as the basis for calculating losses due to infected with pathogenic *Escherichia coli*

Economic parameters	Symbol	Broiler	Layer
Price of chicken eggs per kg (IDR)	Htl	-	22,000
Price of broiler carcass per kg (IDR)	Hkb	32,000	-
Price of culled laying hen per head (IDR)	Hkl	-	32,500
Price of DOC (IDR)	Hd	6,800	7,000
Prices of feed per kg (IDR)	Hpb	6,400	-
Price of layer concentrate per kg (IDR)	Hpl	-	5,250
Rental fee for livestock labor (IDR / month / head)	Btk	700	700
Compensation cost of labor per head (IDR)	Bktk	50	50
Cleaning and disinfection costs per head (IDR)	Bd	100	100

Data source: (Disnak, 2018).

Nb = Broiler population
Hkb = Price of broiler carcass per kg of broiler chicken
Mcb = Mortality of broiler by colibacillosis disease
KmTL = Livestock mortality in laying hens
Nl = Laying hen population
Hkl = Price of culled laying hen per head
Mcl = Mortality of laying hen by colibacillosis disease

Indirect loss
Estimated loss of cleaning and disinfectant (EkPdD)
EkPdD = Bd x N
Estimated loss of labor compensation (EkKTK)
EkKTK = Bktk x N

Explanation:
EkPdD = Estimated loss of cleaning and disinfectant
Bd = Cost of cleaning and disinfection per head
EkKTK = Estimated loss of labor compensation
Bktk = Compensation cost of labor per head
N = Chicken population.

Result and Discussion

Chicken population in Indonesia

The population of broiler and laying hen in Indonesia from the year 2013 to 2017 had increased (Table 3). The population of broilers in Indonesia in 2017 reached 1,698,368,741 heads while the population of laying hens reached 166,722,647 heads. The average increase in broiler population in the past 5 years (2013 - 2017) was 65,800,902 heads or around 6.03% per year, while the average increase in laying hen population was around 5,372,841 heads or 3.39% per year. The broiler population in 2014 experienced quite high increase of around 7.37% compared to the increase in laying hen population which only increased by around 0.03%. In 2015, the percentage of increase in population of broiler and laying hens was almost the same, which was around 5.89% and 5.69% respectively. In 2016 the increase in broiler population reached 6.82% while in laying hens by 4.09%. In 2017 there was an increase in the population of broiler as well as in the laying hen population of 4.03% and 3.33%. The population size in 2017 is a temporary number issued by the Directorate General of Livestock and Animal Health (Dirjennak Keswan, 2018), this population was then used to calculate the estimated economic losses in the poultry industry in Indonesia infected with pathogenic *Escherichia coli*.

Estimated economic losses in broiler

Economic losses as a result of the infection of pathogenic *Escherichia coli* in chicken farms could cause losses in the form of direct losses from diseases and indirect losses. Direct losses in broiler could be through the calculation of body weight loss on harvest period and total mortality. Based on the results of the calculation, it was found that the estimated direct losses caused by pathogenic *Escherichia coli* infection on the national scale production system of broiler farm reached IDR 13,913,036,730,000,- per harvest period and indirect losses due to extra costs for prevention and control the disease reached IDR. 254,755,311,150 (Table 4). Based on these two results, then with this calculation method the total losses incurred reached IDR.14,167,792,041,150, - (fourteen trillion one hundred and sixty seven billion seven hundred ninety two million forty one thousand one hundred and fifty rupiahs) per harvest period of broiler.

Estimated economic losses in laying hen

Economic losses as a result of pathogenic *Escherichia coli* infection in direct losses calculation of laying hen included a decrease in

Table 3. Chicken populations in Indonesian in 2013 - 2017 (Dirjennak keswan, 2018)

Year	Broiler			Layer		
	Chicken population (head)	Increase		Chicken population (head)	Increase	
		head	%		Head	%
2013	1,344,191,104	-	-	146,621,514	-	-
2014	1,443,349,118	99,158,014	7.37	146,660,415	38,901	0.03
2015	1,528,329,183	84,980,065	5.89	155,007,388	8,346,073	5.69
2016	1,632,567,839	104,238,656	6.82	161,349,806	6,342,418	4.09
2017 *	1,698,368,741	65,800,902	4.03	166,722,647	5,372,841	3.33
Rata rata	1,529,361,197	88,544,409	6.03	155,272,354	5,025,058	3.39

* temporary number
Data source: (Dirjennak Keswan, 2018).

Table 4. Calculation of economic losses in the production system of broiler farms

Type of loss	Total loss (IDR)
Direct losses	
Weight loss (KrPBB)	6,032,605,768,000
Mortality of broiler (KmTB)	7,880,430,958,000
Total direct losses on livestock production systems	**13,913,036,730,000**
Indirect loss	
Treatment and disinfection (EkPdB)	169,836,874,100
Labor Compensation (EkKTK)	84,918,437,050
Total indirect losses on livestock production systems	**254,755,311,150**
Total loss (direct + indirect)	**14.167,792,041,150**

Data source: processed secondary data.

egg production and total mortality of chicken. Estimated direct losses caused by the presence of pathogenic *Escherichia coli* infections on laying hen production systems on a national scale based on the calculation results reached IDR. 13,366,988,220,800 per month and indirect losses due to extra costs for prevention and control efforts reached IDR. 25,008,397,050, - (Table 5). Based on these two results, then with this calculation method the total losses incurred reached IDR 13,391,996,617,850 - (thirteen trillion three hundred ninety one billion nine hundred ninety six million six hundred seventeen thousand eight hundred fifty rupiahs) per month.

The assumption of an exchange rate of US $ 1 = IDR. 13,500, - then the value of losses in broiler chickens was equivalent to 1,049 million US dollars or around 833 million euros (assuming 1 euro = IDR. 17,000, -) per harvest period of broiler, while losses on laying hen equals 992 million US dollars, or around 788 million euros per month. Economic losses due to decrease in carcass quality and meat removal in the US and Canada related to the problem of colibacillosis were estimated to reach more than 30 million dollars to 40 million dollars each year (Norton, 1997). Economic impact of *Escherichia coli* peritonitis syndrome (EPS), in the Netherlands in 2013. Total losses in broiler farms reached € 3.30 million (per farm) and € 3.70 (per farmer) million for the poultry layer sector (Landman and van Eck, 2015). Economic losses caused by coccidiosis in Romania with an average of € 3,162,40 per farmer (Györke *et al.*, 2016), and of course economic losses caused by colibacillosis were much higher.

Conditions in Indonesia, with an estimated population of broiler, around 1,698,368,741 chicken, and the average assumption per chicken reached a normal weight of 2 kg (harvest time of 35 days) and the assumption of price per kg of meat was IDR. 32,000, then the total assets of broiler chickens as a whole reached around 109 trillion rupiah. The amount of losses that was caused reached 14.20 trillion rupiah, so that the overall total loss due to this pathogenic *Escherichia coli* infection reached 13.10% from the total assets of broiler in Indonesia. The amount of loss proportion incurred on the total assets of these livestock could show how important this disease was to be controlled or overcome.

The high loss due to the infection of pathogen *Escherichia coli* in poultry in Indonesia was inseparable from the high assumption of the incidence or prevalence of colibacillosis in Indonesia. Many factors that could trigger the occurrence of pathogenic *Escherichia coli* infections, including weather factors and maintenance management. Wet weather also aggravated the incidence of pathogenic Escherichia coli infections, where a lot of water inundations was possible contaminated by all types of pathogenic bacteria including *Escherichia coli* so that poultry had peritonitis and caused a higher mortality rate. Pathogenic *Escherichia coli* infection as a primary or secondary infection, this disease attacked broilers and layers, at all ages, but more often at a younger age than the elderly. This outbreak often occurred in groups of chickens that were kept in a less clean environment and below standard sanitation or after a disease attack caused immunosuppression or respiratory disease (Tarmudji, 2003).

Death in the first week that occurred in broiler farms was caused by poor chicken quality and infections caused by *Escherichia coli* starting from chicken hatching. The main symptom of this infection was an infection of the yolk sac. *Escherichia coli* bacteria were secondary opportunistic bacteria which could play a role in several infections of bones and joints that affect poultry. Colibacillosis or infection due to the bacterium *Escherichia coli* could cause inflammation in the yolk sac (omphalitis) in the body of chicks (Santosa, 2016). Lange (2006) explained that omphalitis was the main cause of the increase in chicks death (DOC) in the first week. Omphalitis or infection of egg yolk through the navel, commonly known as mushy chick disease or navel disease (Lange, 2006; Ortega, 2012).

Cost estimation of disease or economic losses with approach of direct and indirect loss method required complete data support and long time so that the results obtained were more detailed. In this study, estimated total economic losses in chickens infected with pathogenic *Escherichia coli* in Indonesia produced very large numbers. Determination of the amount of the loss made the consideration of colibacillosis as one of the diseases that got priority to be controlled or overcome was still not enough. Information regarding the estimated economic losses caused

Table 5. Calculation of economic losses in the production system of laying hen farm

Type of loss	Total loss (IDR)
Direct losses	
Decrease in egg production per month (KrPPT)	13,204,433,640,000
Death of laying hen (KmTL)	162,554,580,800
Total direct losses on livestock production systems	**13,366,988,220,800**
Indirect loss	
Treatment and disinfection (EkPdB)	16,672,264,700
Labor Compensation (EkKTK)	8,336,132,350
Total indirect losses on livestock production systems	**25,008,397,050**
Total loss (direct + indirect)	**13,391,996,617,850**

Data source: processed secondary data.

by other diseases in chickens needed to be calculated as a comparison. Calculation of estimated losses due to other diseases should also be done using the same method so that the information produced could be compared with each other.

Veterinary economics is a relatively new discipline, which progressively develops conceptual frameworks, procedures and data that are solid to support the decision-making process in optimizing animal health management. Research in this field is primarily concerned with three interrelated aspects: (1) measuring the financial effects of animal diseases, (2) developing methods to optimize decisions when individual animals, groups or populations are affected, and (3) determining the costs and benefits of disease control. The importance of the close relationship between economics and epidemiology is emphasized for future development, as well as the need and possibility for the exchange of international models and procedures (Dijkhuizen et al., 1995).

Conclusions

Estimation of economic losses in the poultry industry in Indonesia infected with pathogenic *Escherichia coli* were estimated to reach IDR 14.20 trillion per harvest period of broiler and reached IDR 13.40 trillion rupiah per month laying hen, or worth 13.10% of total poultry assets in Indonesia. Based on the value of economic losses caused, colibacillosis needs to be considered as very important disease to be controlled or overcome.

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