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Impact of technical and economic performance on costs of *campylobacter* spp. interventions on broiler farms in six European countries

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ABSTRACT

Campylobacter spp. is one of the leading causes of acute diarrheal disease in humans worldwide and human *Campylobacter* spp. infections can result in severe sequelae. Because broilers are an important reservoir for human *Campylobacter* spp. infections, it is relevant to control *Campylobacter* spp. on broiler farms. The costs of interventions to control *Campylobacter* spp. on broiler farms are important for acceptance and implementation by farmers. In comparing costs of *Campylobacter* spp. interventions on broiler farms between countries, differences in national economic factors, such as interest level and labour costs, are often considered, but differences in average technical and economic performance of broiler farms are not taken into account. This study used a farm calculation model based on the economic engineering-approach to estimate annual costs of eight interventions on a common commercial broiler farm in Denmark, the Netherlands, Norway, Poland, Spain, and United Kingdom, for the year 2009 considering differences in national economic factors and in technical and economic farm performance. Across countries, the interventions building an anteroom with hygiene barrier, applying designated tools and applying fly screens had the lowest estimated costs and replacing old houses with new houses, slaughter at 35 days and a ban on thinning (partial depopulation) the highest. Applying drink nipples without a cup and having a maximum downtime of ten days resulted in intermediate estimated costs. Across interventions, Poland and Spain had the lowest estimated costs, Denmark and Norway the highest. The estimated costs in the most expensive country were between 67% and 550% higher than in the cheapest country, depending on the intervention. The estimated costs of *Campylobacter* spp. interventions on broiler farms varied substantially between countries due to differences in average technical and economic farm performance and in national economic factors.

1. Introduction

Campylobacter spp. is one of the leading causes of acute diarrheal disease in humans worldwide. Human *Campylobacter* spp. infections can also result in severe sequelae, such as reactive arthritis, irritable bowel syndrome and Guillain-Barré Syndrome (Mangen et al., 2013). Broilers are an important reservoir for human *Campylobacter* spp. infections (Mangen et al., 2013, EFSA Panel on Biological Hazards 2011). Havelaar et al. (2008) estimated that 23% of human *Campylobacter* spp. infections in the Netherlands is attributable to chicken meat. Therefore, it is relevant to control *Campylobacter* spp. on broiler farms.

Several interventions to control *Campylobacter* spp. on broiler farms have been proposed (EFSA Panel on Biological Hazards 2011, Elliott et al., 2012). The costs of interventions are an important part in policies to control *Campylobacter* spp. on broiler farms, because they should be balanced against public health revenues. The costs of interventions to control *Campylobacter* spp. on broiler farms are also important for acceptance and implementation by farmers. *Campylobacter* spp. has long been considered commensal in chickens showing no pathological signs of infection (Hermans et al., 2012). Humphrey et al. (2014) recently showed an inflammatory response in broilers with a *Campylobacter jejuni* infection that can lead to diarrhoea in broilers, which, in turn, could lead to damage to the feet and legs on broilers due to standing on wet litter. However, currently the general opinion still is that *Campylobacter* spp. interventions do not result in direct production gains and related economic benefits for farmers. Several studies estimated the costs of on-farm *Campylobacter* spp. interventions in a single country, such as Fraser et al. (2010) in the United Kingdom, Lawson et al. (2009) in Denmark, Mangen et al. (2007) in the Netherlands and McDowell et al. (2008) in Ireland. Interventions differed between these studies, complicating extrapolation to other countries.

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Farm labour income	**=**	**revenue – feed costs – day-old-chick costs – other variable costs – fixed costs**
where		
revenue	=	number of broilers per cycle · number of cycles per year · final live weight · (1-mortality) · farm gate price
feed costs	=	number of broilers per cycle · number of cycles per year · final live weight · feed conversion · (1-mortality) · feed price
day-old-chick costs	=	number of day-old-chicks per cycle · number of cycles per year · day-old-chick price
other variable costs	=	number of broilers per cycle · number of cycles per year · other variable costs per broiler per cycle
manure disposal costs	=	manure production per broiler per year · number of broilers per cycle · manure disposal price
fixed costs	=	size of house in m^2 · (building investment per m^2 · (depreciation + maintenance + 0.5 · interest) + inventory investment per m^2 · (depreciation + maintenance + 0.5 · interest)) + overhead costs per farm per year

Fig. 1. Method and main input parameters to calculate farm labour income in a farm calculation model used to estimate the costs of *Campylobacter* interventions on a common commercial broiler farm in Poland, Spain, Netherlands, United Kingdom, Denmark, and Norway.

Elliott et al. (2012) estimated national costs of the same on-farm *Campylobacter* spp. interventions in 27 EU member states, considering differences between countries in national economic factors, such as interest rate, labour costs and prices for electricity and water. They showed that this resulted in different intervention costs in each country. To our knowledge, no studies exist that estimated costs of the same interventions in different countries, while also considering differences between the countries in technical and economic farm performance. As part of the CamCon project (EU Seventh Framework Programme (FP7/2007–2013) under grant agreement no. 244,547), this study estimated the costs of the same *Campylobacter* spp. interventions on broiler farms in the six European countries Poland, Spain, Netherlands, United Kingdom, Denmark and Norway, considering differences in national economic factors and in technical and economic farm performance. The interventions considered in our study were those that were associated with significant risk factors in these six countries retrieved from a questionnaire survey performed by Høg et al. (2011) in 2011. Interventions were identified in Sommer et al. (2016): building an *anteroom with hygiene barrier* in each individual broiler houses on farms at which the newest house is not older than 15 years, using *designated tools* in each individual broiler houses on farms at which the newest house is not older than 15 years, establishing a *maximum downtime of ten days* between flocks including improved consistent rodent control to minimum six times per year and disinfection between flocks, applying *drink nipples without cup*, and replacing all broiler houses by *new houses* on farms with all houses older than 15 years. Additionally, we included three interventions that could not be studied by Sommer et al. (2016), but have previously been identified as promising: a ban on partial depopulation (*stop thinning*) (Elliott et al., 2012, Adkin et al., 2006, Hald et al., 2000, Katsma et al., 2007), *slaughter at 35 days* (Elliott et al., 2012, McDowell et al., 2008), and the application of *fly screens* (Hald et al., 2007, Rosef and Kapperud, 1983).

2. Materials and methods

2.1. Farm calculation model

A deterministic farm calculation model based on the economic engineering-approach (Antle, 1999) was developed to estimate the costs of *Campylobacter* spp. interventions in each country. In the economic-engineering approach detailed engineering and costs data are combined in a quantitative model of the production process. Estimations were performed for a common commercial broiler in that country. Annual costs of interventions were estimated using Eq. (1) as the difference between annual farm labour income, revenue minus all costs excluding labour of the farmer and his family (Fig. 1), in the situation without and with the intervention:

$$Costs\ of\ intervention_i = FLI\ without\ intervention_i - FLI\ with\ intervention_i, \quad (1)$$

where FLI stands for annual farm labour income and *i* is an index for the interventions. The model was programmed in Microsoft Excel 2010.

2.2. General input data

The mean number of broilers on a typical farm in Poland, Spain, Netherlands, United Kingdom, Denmark and Norway was based on the average size of farms with more than 10,000 broilers from Eurostat in 2010 (Table 1). The mean number of poultry houses per farm was based on the broiler house size retrieved from Høg et al. (2011).

The base year for the technical and economic farm performance data was 2009, the same year as for the data from Høg et al. (2011). Baseline data for each country were received from local institutes participating in the Camcon project. In all six countries, annual depreciation costs were assumed to be 4.0% of investment for housing and 8.0% for inventory, and annual maintenance costs 1.0% of the investment for housing and 2.0% for inventory (Vermeij et al., 2009). Manure production was assumed to be 10.9 kg per broiler per year, water costs €0.80 per 100 broilers per cycle, and levies and dead animal removal costs €0.61 per 100 broilers per cycle (Vermeij et al., 2009). A distinction was made between farms that practice thinning and that did not, because technical and economic performance differed between these farming systems, which had an impact on the costs of interventions. Farms that practice thinning delivered 30% of the broilers in the first delivery and the remaining 70% in the second delivery. Litter costs for farms that practice thinning were assumed to be €0.90 per 100 broilers per cycle (Vermeij et al., 2009). Technical and economic farm