Preventive Veterinary Medicine 109 (2013) 25–36

Contents lists available at SciVerse ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

Bayesian network as an aid for Food Chain Information use for meat inspection

C. Lupo[a,*], S. Le Bouquin[a], L. Balaine[a], V. Michel[a], J. Péraste[a], I. Petetin[a], P. Colin[b], L. Jouffe[c], C. Chauvin[a]

[a] Anses, Ploufragan/Plouzané Laboratory, Epidemiology Research Unit – Zoopôle, BP 53, 22440 Ploufragan, France
[b] Université de Bretagne Occidentale – Technopôle Brest-Iroise, 29280 Plouzané, France
[c] Bayesia SA – 6, rue Léonard de Vinci, BP 119, 53001 Laval Cedex, France

ARTICLE INFO

Article history:
Received 30 September 2011
Received in revised form 6 September 2012
Accepted 8 September 2012

Keywords:
Bayesian network
Poultry
Condemnation
Declarative data
Decision support systems
Ante mortem inspection

ABSTRACT

Current *ante mortem* inspection involves a check of relevant Food Chain Information (FCI) transmitted by the farmer to the slaughterhouse on a regulatory FCI document. Since 2000, a farm sanitary form with FCI data has been used for all consignments of broiler chickens in France. However, the FCI needs to be standardized for the collection and interpretation of data. A study was conducted to develop an expert system, undertaken to elaborate on a simple decision support system capable of predicting whether the flocks will present a high condemnation risk, based on FCI. For this, 'optimal' (i.e. on-farm survey data) and 'worthy' (i.e. farmers' declaration on existing farm sanitary form) data quality conditions were considered to estimate the lower and upper reference bounds of the confidence that the decision-makers could have in such a tool.

Chicken broiler flocks (404) were randomly selected in 15 slaughterhouses located in Western France in 2005. Condemnation proportion and farm sanitary form were collected for each selected flock. Information about health history and technical performances were also specifically collected on farm. Condemnation risk category was modelled from the on-farm collected information, using a Bayesian network and assuming this represented the optimal data quality conditions. Corresponding information declared by the farmer on the existing farm sanitary form was secondly used in the network to evaluate the impact of the uncertainty of such information on the condemnation classification obtained with the expert system.

The learnt Bayesian network had 16 explanatory variables pertaining to technical characteristics and sanitary features of the flock. Using a threshold of 1% of condemned carcases to define high risk, the network sensitivity and specificity were 55% and 93%, respectively, corresponding to positive and negative predictive values of 70% and 87%. When declared existing information was used in the network, the sensitivity and specificity were 16% and 96%, respectively, corresponding to positive and negative predictive values of 57% and 80%.

Results suggested that the predictive network developed may be insufficient for correctly classifying chicken flocks for targeting of management procedures, and in its current form, the expert system may be unlikely to be implemented in the field. However, it could help to improve the standardization of both form design and FCI interpretation at a national level.

* Corresponding author. Present address: IFREMER, French Research Institute for Exploitation of the Sea, Genetic and Pathology of Molluscs Laboratory – Avenue Mus de Loup, 17390 La Tremblade, France. Tel.: +33 5 46 76 26 10; fax: +33 5 46 76 26 11.
E-mail address: clupo@ifremer.fr (C. Lupo).

0167-5877/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.prevetmed.2012.09.004

1. Introduction

In accordance with current EU regulations (European Commission, 2004a,b), official meat inspection of poultry involves *ante mortem* and *post mortem* inspections, which are conducted at the slaughterhouse and performed on a flock basis. *Post mortem* inspection leads to the withdrawal from the food chain of all carcasses that present macroscopic abnormalities, such as arthritis or bruises, and is quantified by the condemnation proportion for the flock. *Ante mortem* inspection consists of two investigations. On the one hand, the physical examination is to prevent obviously diseased or grossly dirty poultry entering into a slaughterhouse. On the other hand, the check of the Food Chain Information (FCI) is to help to evaluate the health status of the flock to be slaughtered. In particular, FCI can be used to classify poultry flocks intended for slaughter into food safety risk categories, so that slaughter procedures and/or decisions for fitness for consumption can be adapted to the risk category presented by the flock (European Food Safety Authority, 2012). FCI is reported on a regulatory document, which has to be provided to the slaughterhouse before the flock's arrival. This document gathers appropriate and relevant information from previous production stages, based on farmer's declaration. Although the content of FCI is described in EU regulation, it has not been yet fully detailed (European Food Safety Authority, 2012).

Since 2000, a farm sanitary form with FCI data is used for all consignments of broiler chickens to the slaughterhouse in France (French Ministry of Agriculture, 2000). This existing regulatory document is filled in and signed by the farmer. The reported information is based on common sense rather than on truly scientific criteria and its interpretation is not defined by regulation. Thus, the effective use of the farm sanitary form is not always consistent between slaughterhouses.

FCI needs to be standardized for the collection and interpretation of data, so that a warning system could be set at the slaughterhouse, based on flock classification into risk categories (Stark, 2000). Then, subsequent sanitary inspection could be suitably adapted to the particular category. Flocks could be classified in high or low risk categories on the basis of the results of meat inspection (i.e. the *post mortem* condemnation proportion). An expert system could therefore be undertaken to elaborate on a simple decision support system capable of predicting whether the flocks will present a high condemnation risk, based on FCI. The FCI items should be easily and routinely retrieved before birds were processed. But as the farmer declares them, FCI items may be inaccurate. Their reliability and the impact of a potential declaration bias on the risk of condemnation classification would therefore have to be evaluated (Lupo et al., 2009).

Recent studies have been carried out to determine indicators, which might be useful to design FCI in pigs (Blaha et al., 2007; Windhaus et al., 2007) and in poultry (Habtemariam and Cho, 1983; Lupo et al., 2009). A study was therefore conducted to develop an expert system tool, using a Bayesian network, to predict a chicken flock condemnation risk category, based on FCI. This network was then applied to information collected from the existing farm sanitary form to evaluate the impact of declaration uncertainty (i.e. missing data and potential declaration bias) on the condemnation classification obtained with the expert system.

2. Materials and methods

2.1. Study sample

The study population consisted of broiler chicken flocks slaughtered during 2005, from all the European Union-licensed slaughterhouses in the main French regions of production (i.e. Bretagne and Pays de la Loire), which represent 60% of the national production of broiler chickens (Agreste, 2005). Only confined production types were included as these are the major types produced in France (Agreste, 2005).

The study was of two-step cohort design and the epidemiological unit was the slaughtered flock. A flock was defined as a group of birds placed in the same house, shipped to the same slaughterhouse and processed together on the same day. Flocks were randomly selected (by lottery) by two-stage sampling, stratified by slaughterhouse. The first sampling stage was the day of slaughter and the second stage was the flock sequence number in the slaughtering schedule of that day.

Study population details, sampling design, flock random selection and sample size calculation have been fully described previously (Lupo et al., 2008, 2009).

2.2. Data collection

The first step in the study was prospective. Each flock was followed from its arrival at the slaughterhouse to completion of the *post mortem* meat inspection. Condemnation proportion and farm sanitary form were collected by Official Veterinary meat inspectors during the mandatory meat inspection.

The farm sanitary form is an existing regulatory document (French Ministry of Agriculture, 2000), which was not specifically designed to collect the variables for our study purpose. This regulatory document is a pre-tabulated paper form, which is filled in (usually by hand-writing) by the farmer. This form is then transmitted, usually by fax, to the slaughterhouse at least 48 h before the flock's arrival. The following information has to be provided (French Ministry of Agriculture, 2000):

- the origin of the animals, i.e. farm details (name, address, telephone and fax numbers), number of animals in the flock, date of departure from the farm;
- the destination, i.e. slaughterhouse details, number of animals to be slaughtered, date of arrival at the slaughterhouse;
- the technical characteristics of the flock, i.e. production type, genetic strain, hatchery details, date of placement, number of animals at placement, average live weight at slaughter date;