THE PREVALENCE OF SALMONELLA ANTIBODIES IN PIGS AT SLAUGHTER AND DETECTION OF *SALMONELLA ENTERICA* IN PORK

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The main objective of the nation-wide salmonella control program is to reduce the risk of human exposure of *Salmonella enterica* contaminated pork. The philosophy of the program is that a reduction in the salmonella occurrence in all links of the chain from stable to table is necessary for the reduction of the contamination of pork and thereby a decreased health risk for humans. Not only is it important to monitor the contamination of pork with *Salmonella enterica* but also to monitor the salmonella occurrence in the swine herds.

All Danish swine herds with an expected kill above 100 pigs per year are monitored serologically using meat juice samples from pigs at slaughter for the mix-ELISA (Mousing et al. 1997). The quality control of pork at Danish slaughter plants includes an ongoing monitoring of the contamination of the end-product — pork — with *Salmonella enterica*. The monitoring is based on culturing of samples for *Salmonella enterica* in an ongoing sampling program where a specified number of samples must be taken every 14 days at each slaughter plant. The sampled materials are: pigs (bone-in meatcuts); cuts (boneless meatcuts); by-products (offal excluding tongues); tongues; and pork (trimmings, minced meat, fresh meat).

There are indications that the prevalence is not constant over time. For example, the sero-prevalence was relatively low in the summer of 1995 (Carstensen and Christensen, 1996). The objective is to present the sero-prevalence of *Salmonella enterica* in meat juice samples from pigs at slaughter and the prevalence of contaminated pork over calendar time.

MATERIALS AND METHODS

Two sources of data were used in this work: (1) the data on the serological test results of meat juice samples from pigs at slaughter originated from the Official Zoonoses Register (PIG-data); and (2) the data on the contamination of pork originated from The Danish Veterinary Service via the Database of the Danish Zoonosis Centre (PORK-data).

Generally, no sampling took place on weekends, therefore the week of sampling was chosen as the unit of time. In both data sets, the number of positive samples, the number of negative samples, and the prevalence of positive samples (positive/(negative+positive)) per week was calculated and the identification variables were: key for the week, year, and the number of the week. The PIG- and PORK-data were restricted to the period from week 1 of 1995 to week 52 of 1996. The change-point analysis (Anderson-Darling test statistic (AD) with the Ornstein-Uhlenbeck approximation of the AD) was applied to detect change-points that divided the study period into periods where the prevalence was constant and to estimate the average prevalences in these periods (Christensen and Rudemo, 1996).

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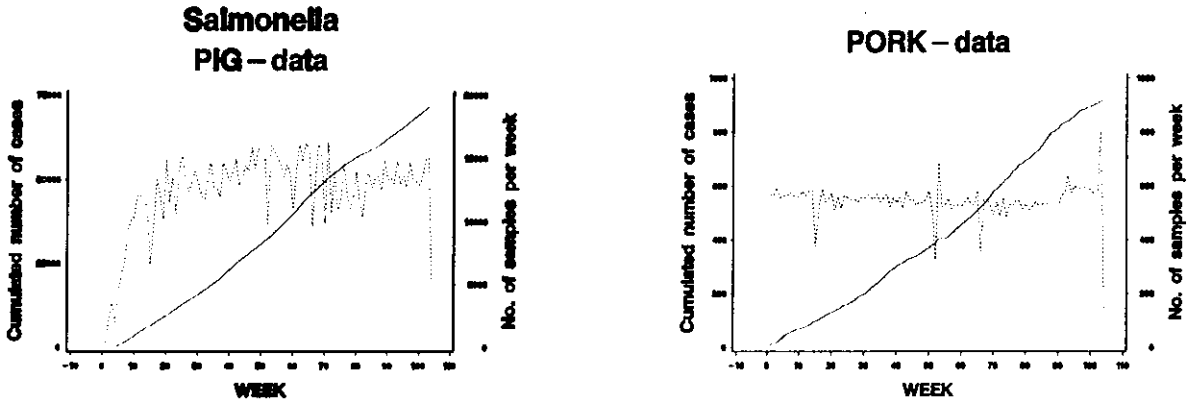
The number of samples in the PIG-data was high (approximately 14,000 per week) therefore, the significance level $\alpha = 0.001$ was applied. In the PORK-data, the number of samples was much lower (approximately 550 per week) and the significance level was set to $\alpha=0.05$.

The selection method for choosing change-points was a modified forward selection method. Briefly, the significance of previously detected change-points neighbouring the new change-point was tested given the new change-point. When more than four change-points were detected the data were divided into subsets according to change-points already detected (CP) and separate change-point analyses were performed on each subset.

As a test of the stability of the change-points CP, a subset overlapping the CP was tested for change-points. In the special case, where marginally significant change-points (p-values between 0.05 and 0.20) were added the change-points in the final model were tested individually by removing one at a time.

Figure 1. The monitoring of the occurrence of *Salmonella enterica* in pigs at slaughter (PIG-data) and the end-product — pork — (PORK-data) in Denmark, January 1995 to December 1996. Left diagram: the cumulated number of sero-positive meat juice samples (cases) and the number of samples per week. Right diagram: the cumulated number of culture positive pork samples (cases) and the number of samples per week



RESULTS

In the PIG-data, the number of samples per week ranged from 318 (week 1) to 16,397 (week 71). The number of samples per week was below 10,000 in the following periods: from week 1 to week 8 (implementation of the control program); around Easter 1995 and 1996 (week 15, 16, and 66); Christmas 1995 and 1996 (week 52 and 104); and "Bededag" 1996 (week 70) (Fig. 1). Similarly for the PORK-data, the number of samples per week ranged from 120 (week 104) to 809 (week 103). The number of samples was below 400 in the weeks 15, 52, 66, and 104. These weeks were Easter 1995, Christmas 1995, Easter 1996, and Christmas 1996, respectively (Fig. 1).

In the PIG-data, 12 change-points were found (Tab. 1) and the estimated prevalences between change-points were low in summer, (week 23-35 and 75-87) (Fig. 2). When the first four change points were detected the data were divided into three subsets by the change-points at week 54 and 81. The change-points already detected in the analyses on the total data set were detected again

in the analyses on the subsets (except the change-point between week 76 and 77) and subsequently additional change-points were detected. The test of the stability of the change-point around week 54 was tested by applying the change-point analysis to a subset of data from week 45 to week 57. The same change-points as before but no additional change-points detected. Likewise, the stability of the change-point between 81 and 82 was tested using a subset from week 75 to 86.

Table 1. The detected change-points and prevalences in intervals between change-points. The Anderson-Darling test statistic (AD) with the Ornstein-Uhlenbeck approximation of the AD was applied

PIG -data Significance level α=0.001		**PORK-data** Significance level α=0.20	
Interval	*Prevalence*	*Interval*	*Prevalence*
1 ≤week≤ 17	5.90 %	1 ≤week≤ 31	1.16 %
18 ≤week≤ 36	4.85 %		
37≤week≤ 44	6.23 %	32 ≤week≤ 53	1.63 %
45≤week≤ 49	4.92 %		
50≤week≤ 54	5.57 %		
55≤week≤ 57	6.32 %	54 ≤week≤ 56	0.55 %
58≤week≤ 67	7.13 %	57 ≤week≤ 91	2.27 %
68≤week≤ 74	6.34 %		
75≤week≤ 77	5.53 %		
78 ≤week≤ 81	4.74 %		
82 ≤week≤ 86	3.51 %		
87≤week≤ 88	4.48 %		
89≤week≤ 104	5.29 %	92 ≤week≤ 104	1.14 %

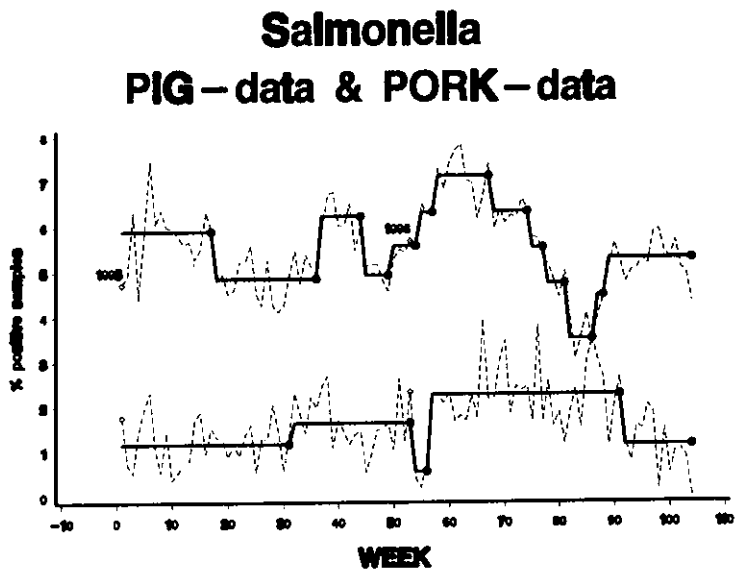
The estimated prevalences in PORK-data were lower than the prevalences in the PIG-data (Fig. 2). In the PORK-data four change-points (week 31, 53, 56, and 91) were detected using the α=0.2 significance level (Tab.1 and Fig. 2). The change-point between week 53 and 54 was marginally significant (p-value 19%). All four change-points that were found when using α=0.2 were removed one by one to test their significance given the three other change-points. For the change-points 31, 53, 56, and 91 the p-values were 0.06, 0.05, 0.0006, and 0.000001, respectively.

DISCUSSION

The difference in sero-prevalence and prevalence in pork may be explained by the different materials sampled in combination with the different laboratory tests. Antibody detection in meat juice evaluates if the tested animal has been exposed to *Salmonella enterica* in a way that it has

produced antibodies up until slaughter. The bacteriological test examines if *Salmonella enterica* is present in pork at the time of sampling.

Figure 2. The monitoring of the occurrence of *Salmonella enterica* in the meat juice screening (PIG-data) and the end-product (PORK-data) in Denmark, 1995 and 1996. Weekly prevalences of positive samples (dashed lines), the change-points and the end-points (●), the average prevalences (solid line) and the first week of the years 1995 and 1996 (◊). The upper graph represents the PIG-data and the lower graph the PORK-data



The factors affecting the sero-prevalence and the prevalence in PORK differ. The sero-prevalence is affected by feeding and management factors related to the rearing of pigs while the prevalence in PORK is affected by hygiene management of the slaughter plant and pigs being exposed to *Salmonella enterica* immediately before slaughter. Contamination of tongues (and to some extend by-products) may be a result of the pigs being exposed to *Salmonella enterica* at the slaughter plant, during transport or close to departure from the herd. Whereas, contamination of pigs, cuts and pork is a more direct measurement of hygiene at the slaughter plant.

When the prevalence in PORK between 0.55% and 2.27% is compared to other studies it must be appreciated that the material pork here includes tongues and by-products.

REFERENCES

Carstensen B., Christensen J., 1996. Fitting a random effects model for a very large data set with censored data. Statistical modelling. Proceedings of the 11th International Workshop on Statistical Moddelling, Orvieto, Italy 15-19 July 1996.

Christensen J., Rudemo M., 1996. Multiple change-point analysis of disease incidence rates. Prev. Vet. Med. 26, 53-76

Mousing J., Jensen P.T., Halgaard C., Bager F., Feld N., Nielsen B., Nielsen J.P., Bech-Nelsen S., 1997. Nation-wide *Salmonella enterica* surveillance and control in Danish slaughter swine herds. Prev. Vet. 29:247-261