Reducing liver lesion incidence in the Dutch pork supply chain

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Abstract

Livers with lesions are an important quality aspect among slaughter pig producers and slaughterhouses. Total losses of non-marketable livers with lesions, lower growth and higher feed intake of pigs in the Netherlands in 2003 were estimated at €3.5 million. The major cause of liver lesions is the roundworm *Ascaris suum*. Worm treatment on the farm can be effective in reducing liver lesions. Before July 2004 an insurance with a fixed premium for each slaughtered pig was in place in the Netherlands to compensate slaughterhouses for pathological lesions. Individual pig producers had low incentives to take control measures. In July 2004 a new incentive mechanism was introduced: a reduction in the payment of €1 for each pig with a liver lesion. This placed the financial burden of livers with lesions on the producer, thereby increasing incentives to treat roundworm infections. We analysed the data of 1,104 farms with 55,802 deliveries from 2003 to 2006. The mean liver lesion incidence decreased from 8% in 2003 when a collective insurance was in place to 5% in 2006, after the change to the price reduction. Of the producers, 68% reduced liver lesion incidence. Of the producers with an increased incidence, 83% showed a low increase (less than 5%). We conclude that the price reduction was effective in reducing the mean incidence of liver lesions, although large differences between individual producers exist. Further research is needed to determine what causes these large differences.

Introduction

Livers with lesions are an important quality aspect among pig producers and slaughterhouses. Since the late 1990s the mean liver lesion incidence in slaughter pigs in the Netherlands was high, fluctuating between 8 and 12%. The majority of liver defections are caused by an infection with the roundworm *Ascaris suum*. Application of anthelmentica (worm medicines) on group level through injection, feed or water is generally sufficient to reduce the incidence to 2-4%, although effectiveness depends on the active ingredient and the extent of implementation of the treatment in the producers' management. Treatment costs are around €0.85 per delivered pig when medicine is applied three times. Since pathologically deformed livers are unfit for human consumption, slaughterhouses must dispose of livers with lesions. Further financial losses include a lower growth, higher feed intake, and lower meat percentage as a result of an infection with *Ascaris suum*. Loss estimates vary from €0.85 to €4.50 for an infected pig, depending on the infection level. Total losses in the Netherlands in 2003 were estimated at €3.5 million (Bondt *et al.* 2004).
EU legislation (EG/854/2004) prescribes that all pigs delivered for slaughter must be assessed individually for pathological lesions directly after slaughter. This was already prescribed by Dutch legislation. The procedure is documented in the handbook for IKB-encoding developed by the National Inspection Service for Livestock and Meat (RVV) in the early 1990s. The inspection of the carcasses is conducted by official assistants, under the supervision of veterinarians from the Food and Consumer Product Safety Authority (VWA). This guarantees the independency of the assessment. The assessment of livers is based on the degree of infection with the roundworm *Ascaris suum*. When larvae have migrated through the liver the immune response leads to inflammatory tissue in the liver that shows as white spots. A liver has minor lesions if it has one or

two white spots on the front side of the liver and declared unfit for human consumption - and consequently rejected - if it has three or more white spots.
To compensate slaughterhouses for the resulting economic losses of slaughter lesions a mandatory collective insurance was in place. A pig producer paid a fixed insurance premium per pig delivered to a Dutch slaughterhouse. Until July 2004 rejected livers were part of the insurance. Since a lower rejected liver incidence did not directly result in a lower premium - and thus in lower costs - insufficient incentives for an individual producer existed to implement control measures to reduce liver lesion incidence.
To reduce the financial losses caused by liver lesions, in 2004 the Dutch pig sector created a new financial incentive mechanism to induce individual pig producers to control liver lesion incidence. Such incentives are commonly used in agricultural supply chains to induce growers to provide processors with the correct amount of raw materials of the desired quality at the correct time (e.g. Hueth and Ligon 2002; Martinez and Zering 2004). According to incentive theory increasing the financial consequences of production risks should induce producers to take action to control the risks (Prendergast 1999). On 5 July 2004 - the first Monday in July - a new incentive mechanism was introduced in the Netherlands aimed at putting the costs where they originate: a direct price reduction in the payment to a pig producer of €1 for each delivered pig with a liver lesion. This price reduction places the financial consequences of liver lesions on the producers, theoretically increasing the incentives for them to treat roundworm infections. This paper describes the effect of the introduction of the price reduction on liver lesion incidence.

Material and methods

To show the effects of the change from the insurance to the price reduction we used a dataset with slaughter data of individual pigs of a pig slaughter company with multiple locations in the Netherlands. In the analysis we used livers with lesions, the sum of rejected livers and livers with minor lesions, as 1) both are caused by *Ascaris suum* and 2) coding problems made it impossible to identify rejected livers from livers with minor lesions in time.
The data included 213,398 deliveries of herds of 7,532 different producers from January 2003 to September 2006, including internal deliveries and imports. Deliveries from the analysis that could not be traced directly to a specific producer, such as internal deliveries and imports, were excluded. We also excluded small producers (less than 500 slaughter pigs a year), since often pigs are a - possibly less commercial - side activity on these farms and these producers might therefore be influenced less by a financial incentive. This resulted in 1,104 producers with 55,802 deliveries to be used in the analysis. We tested if the distribution of liver lesion incidence over producers in the sample correctly represented the whole dataset. A Kolmogorov-Smirnov test-statistic of 0.05 indicated that his indeed is the case.
We estimated the effects of the price reduction by comparing the weighted mean of the liver lesion incidence before with the weighted mean after 5 July 2004. The unit of analysis was a delivery and weighing factors were the delivery size. Because pig producers in the Netherlands are free to choose between slaughter companies, a decrease in the mean incidence of livers with lesions measured at a slaughterhouse could be caused by producers switching slaughterhouses. Therefore we used producers that that did not change slaughterhouses and delivered before and after the change. The literature is not clear on whether the current intensive pig husbandry systems as used in the Netherlands have a seasonal influence on liver lesion incidence. By using the same period before and after the change we overcame possible seasonal influences. We defined 1 July 1 2003 to 30 June 2004 as the insurance period (sample X1) and 1 July 2005 to 30 June 2006 as the price reduction period (sample X2). To determine the impact of the price reduction we tested if the weighted mean liver lesion incidence in the insurance period was significantly higher than in the price reduction period using the paired data from X1 and X2. The null hypothesis was H0: $\mu(X2-X1) \geq 0$, with $\mu(X2-X1)$ the weighted mean of X2-X1. The data were analysed with SAS 9.1.

Results

Figure 1 provides the development of weighted (with delivery size) mean of liver lesion incidence from 2003 to 2006 for the 1,104 selected producers. The bold line marks 5 July 2004, the introduction date of the price reduction. The intervals marked by the dashed lines indicate the insurance period X1 and the price reduction period X2. The incidence of livers with lesions in the insurance period was around 7-9% with a standard deviation (not in figure 1) of 8-10%. The incidence remained at this level until April 2005. Then the incidence of livers with lesions decreased in a few months to 4-5% in August 2005, where it remained. The standard deviation decreased to around 5-6%. The decline in liver lesion incidence started ten months after the introduction of the price reduction. This can be explained by producers only starting to apply worm treatment in new groups after 5 July 2004 and by the time it takes for the treatment to become effective. After implementation of the treatment it takes 6 to 18 months to sufficiently decrease infection pressure in the housing to actually reduce liver lesion incidence.

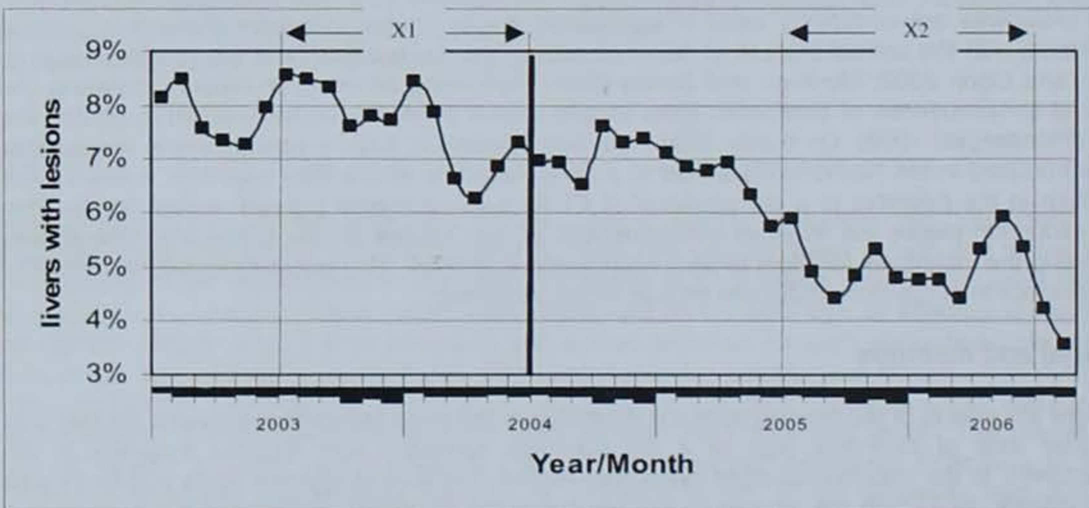

Figure 1: With delivery size weighted calculated mean liver lesion incidence in 2003-2006

Table 2 gives basic with delivery size weighted statistics of the liver lesion incidence in the two periods. The mean decreased from 7.5 to 5.1% and the 95% percentile decreased from 26.8 to 15.5%. The differences between producers reduced as indicated by the decreased standard deviation from 8.5% in period 1 to 5.5% in period 2. We tested H0: $\mu(X2-X1) \geq 0$. Because X2-X1 was not distributed normally - Kolmogorov-Smirnov test statistic for goodness of fit for a normal distribution equals 0.19 - we used bootstrapping (1,000 iterations with seed 0) to test for this difference. The results showed that the difference was significantly different from 0 at $P < 0.001$. Alternatively, interpreting the data as a time series, we performed a prediction test. We forecast liver lesion incidence in the period of the price reduction using the data of the insurance period on a weekly basis. The actual observed weekly incidences from July 2005 onwards lay outside the 95% confidence interval of the forecast, indicating a significant decrease at the 5% level.

Table 2: With delivery size weighted statistics of liver lesion incidence in period 1 and 2

Period	P5[1]	Mean	P95[1]	Standard deviation
Insurance period 1	0.017	0.075	0.268	0.085
Price reduction period 2	0.012	0.051	0.155	0.055

[1] P5: 5% percentile and P95: 95% percentile

We observed differences between individual producer's liver lesion incidence developments from the insurance period to the price reduction period. Table 3 gives weighted (with delivery size) statistics of the distribution of producer developments. The mean development was -2.4% and the median development -0.9%. The standard deviation was 7.3%, indicating a spread between the developments of individual producers. Of the 1,104 producers 753 showed a decrease in liver lesion incidence ranging from 0% to -46.1%. Of the 352 producers with an increase 295 showed an increase less than 5.0%. The maximum increase was 30.9%.

Table3: Weighted statistics of the distribution of producer developments (X2-X1) of liver lesion incidence

Number of farms used in analysis	1,104	Mean development	- 0.024
- with $\mu(X2–X1) < 0$	753	Median development	- 0.009
- with $0 \leq \mu(X2–X1)$	352	St. dev development	0.073
- with $0 \leq \mu(X2–X1) \leq 5.0\%$	295	Minimum development	- 0.461
		Maximum development	0.309

Discussion

Because of the use of empirical data, non-observed external factors such as climate, housing or the assessment procedure could have contributed to the decrease in liver lesion incidence. Available data from a German slaughterhouse showed that the liver lesion incidence remained around 9% from 2001 to 2006. This suggests that housing systems and climate did not cause the decrease seen in these Dutch slaughterhouses. As the meat inspection assessment procedure did not change since 2003 it is not expected that this caused the decrease.

A specialised pig veterinarian indicated in an interview that, although communication towards pig producers about the financial consequences of roundworm infections started before 2004, pig producers started to actually take control measures only after the introduction of the price reduction. He argued that the direct negative financial consequences for the producers lead to them taking control measures to reduce liver lesion incidence.

Increased efforts to control liver lesions should show through an increase in the amount of purchased and used anthelmentica. LEI's Farm Accountancy Data Network dataset includes the medicine use of around 70 individual pig producers in the Netherlands. These data showed that the amount of anthelmentica bought increased with 15% from 2004 to 2005. This indicated that Dutch pig producers were more inclined to administer a worm treatment in 2005, confirming our hypothesis of the price reduction effect.

This research showed the effect of a change in incentive mechanism. It did not show why producers changed their management and therefore cannot indicate what leads to different reactions between farmers. To better understand farm decision making and to more effectively design new incentive mechanisms on an individual producer level we need an understanding of the reasons why individual producers reacted the way they did to this change.

Conclusion and further research

The introduction of an individual financial incentive mechanism for livers with lesions, a price reduction in the payment to pig producers, effectively put the financial burden on individual producers, leading to increased activities to control the causes. The mean liver lesion incidence decreased from 8% in 2003 - when a collective insurance was in place - to 5% in 2006, after the change to the price reduction. Of the producers, 68% reduced liver lesion incidence. Of the producers with an increase 83% showed only a low increase (less than 5%). We conclude that the price reduction of €1 was effective in reducing the mean liver lesion incidence, although large differences between individual producers exist. Further research is needed to determine what causes these differences.

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