The impact of antibiotic-free production on broiler chicken health: an econometric analysis

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Introduction

Antibiotics are generally acknowledged to support good health and welfare in the production of broilers. Limited studies, however, have looked specifically at how antibiotic-free feeding programs impact bird disease states, an important component of overall bird welfare. Much of the prior literature on the impact of antibiotic-free programs on poultry production confine the analysis to growth-promotion uses only and narrowly focus on productivity impacts related to bird performance and grower financial outcomes (MacDonald and Wang 2011; Graham et al. 2007; Emborg et al. 2001; Engster et al. 2002).

More recent studies investigate the impact of the complete elimination of antibiotics across all uses which include the control, prevention, and treatment of disease. For example, Smith (2011) examines the impacts of a full drug-free program (no antibiotics or ionophores given at any levels) on overall bird performance and gut health. The author finds that in addition to being more expensive to produce, due to stricter and more expensive diet requirements, drug-free birds had a higher incidence of necrotic enteritis.[1] Smith (2011) highlighted several practices that were found to assist in the control of necrotic enteritis, which include geography, weather, looser density, and a vegetarian diet. Gaucher et al (2015) conducted a prospective study of 1.55 million birds and evaluated the impact of antibiotic-free conditions on both productivity and health indicators, including percent condemnations and cases of necrotic enteritis. Similarly to Smith (2011), the Gaucher et al (2015) find that the drug-free program was associated with an overall negative effect on key performance indicators and gut health, which is indicative of the potentially negative effects on the overall animal welfare. In particular, the drug-free program

[1] Necrotic enteritis is an acute infection of the intestines which can result in a sharp increase in mortality.

was associated both an increased incidence of necrotic enteritis, as well as, a significant increase in feed conversation ratio and a decrease in both daily weight gain and mean live weight at slaughter.

This study examines the impact of antibiotic-free broiler production on several key health conditions that are indicative of broiler welfare, due to disrupted biological functions and the negative experience of pain associated with certain disease states. Conditions evaluated in this study include, corneal ammonia burns, burned feet, mouth lesions, and body scratched.   Unlike other papers in the literature, a unique data set is utilized that track specific health condition beyond overall gut health. The next section of this paper explains the specific health conditions in more detail. Section three describes the data and methods used to examine the impact of antibiotic-free status on these health conditions. The final section discusses the results and conclusions.

Background

Ammonia burns in the cornea can lead to corneal ulcerations, a painful condition to the bird since ocular tissue is known to be highly innervated. The cornea burns are known to be a result of high ammonia levels, which also directly impact respiratory health. The pain associated with these conditions is associated with poor bird welfare and growth performance. High ammonia levels often serve as an indication of improper house ventilation or litter imbalance. The degree of pH imbalance and ammonia levels in the barn can be affected by bird litter, specifically if birds are ill and experiencing abnormal diarrhea.

Burned feet, again associated with ammonia burns from wet litter, also have direct effects on bird health and welfare since these can be the site of introduction of bacteria into the footpads and tendon sheaths of birds, causing lameness. The incidence of burned footpads is also used as an indication of animal welfare by many producers. Burned feet can lead to footpad lesions, which are a cause of significant downgrades and decreased economic returns in plants which harvest paws.

Mouth lesions are indicated by the presence of any erosion, ulceration, necrosis, scabbing or proliferation of tissue in the oral cavity, at the base of the tongue or anterior portion of the esophagus. Such ulcerations most likely result from exposure to toxins, such as mycotoxins, produced by molds growing on feedstuffs. These mycotoxins negatively impact all metabolic systems. Mycotoxins also affect production directly through tissue damage and feed-ingredient deterioration, as well as indirectly through reduced bird health and performance. Finally, mycotoxicosis is painful and at high levels can result in death and food adulteration.

Lastly, scratches are indicated by the presence of cuts or lacerations on the skin. Scratches are a portal for entry of bacteria and may result in inflammatory process or gangrenous dermatitis. Scratches may indicate competition at the feeder or drinker lines, or heightened activity within a flock. Downgrades and increased mortality are often an outcome.

The ability to control enteric diseases, like coccidiosis, with antibiotics is well-established in the veterinary science literature. Anecdotal evidence suggest that drug-free programs can result in poorer gut health, which causes increased diarrhea thus leading to poor litter conditions. In turn, poor litter conditions can lead to ammonia burns in the cornea, as well as, burned feet.

Data and Methods

Data was sourced from the Elanco Health Tracking System™ (HTSi™), a unique and proprietary data management system that collects information on over 50 different indicators of general bird health globally since 1993. Data is collected via posting sessions (post-mortem examinations) conducted by a veterinarian, with a sub-sample of birds representing individual flocks in production. HTSi™ also collects information on the animal health products used during production within a defined feeding program, including antibiotics use. Broiler diets were defined as antibiotic-free if no antibiotics or ionophores are used in the diet at any point during the production cycle (ABF) or as antibiotic inclusive (ABI) if antibiotics or ionophores were used at least once during the production cycle[2]. A measure for vaccines was not included in this analysis.

The analysis was confined to 2014 bird-level data for the U.S. and focused on four health specific indicators: ammonia burns in the cornea, burned feet, mouth lesions, and scratches. Table 1 defines these conditions, their welfare implications, and the values used for quantification of assessment during post-mortem examinations. These specific conditions were selected due to the effect on bird welfare. Logistic regressions were utilized to estimate the association between antibiotic-free status and the occurrence of the aforementioned conditions. Ordered logit was used for the analysis of the effect of antibiotic-free (ABF) status on burned feet severity. The regression models include controls for the age of the bird and the date of placement which was defined as a quarterly variable.

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[2] Ionophores are an exclusive class of antibiotics uniquely designed only for use in animals. Because of their animal only designation, mode of action, and spectrum of activity, ionophores do not play a role in human health.

To help provide additional context to the regression estimates, which are difficult to interpret beyond directionality, both the marginal effects and odds ratios were computed. Each has a slightly different interpretation and meaning. Marginal effect measures discrete changes, which can be interpreted as measuring how the predicted probabilities change as the ABF indicator changes from 0 (non-ABF) to 1 (ABF), while the odds ratio represents the constant effect of ABF status on the likelihood that ammonia burns are present on a bird.

Results and Conclusions

A total of 19,237 birds observations and recorded for the U.S. in 2014. Not all observations, however, contained enough information with respect to the feeding program needed to define the birds as being ABF or conventional (i.e., raised with antibiotics). Table 3 provides summary statistics and the full sample size by health indicator, which varied with respect to the number of missing observations, but roughly between 11,000 – 12,000 birds. Overall, 412 birds were identified within the total sample as being ABF. Thus, ABF birds make up roughly about 3.5% of the total sample based on the number of birds with an identified feeding program.

In general, ABF birds appeared to have higher proportion of more severe health condition scores compared to when antibiotics were available at some point in their diets. For example, about 4.4% of ABF birds had some indication of ammonia burns compared to 0.9% of conventional birds. The average score for burned feet, which ranged from 0 (not present) to 2 (severe burns), was 0.77 for ABF birds and 0.58 for bird treated with antibiotics.

The regression estimates in Table 3 suggest that ABF status is positively associated with the presence of ammonia burns, but no significant difference was found for mouth lesions or scratches. Age was positively associated with all conditions, indicating that older birds are more likely to experience ammonia burns, mouth lesions, and scratches. The estimated effect of the quarterly variable was mixed, with birds in the first half of the year showing greater risk of ammonia burns but a lower risk of scratches.

The marginal effect for ABF of 0.014 means that, for two hypothetical birds that represent the average bird with their groups for age and date of placement, the model predicts that the probability of corneal ammonia burns will be 1.4% higher for the ABF-raised bird than for the bird treated with antibiotics. The estimated odds ratio of 3.148 suggests that ABF birds have a 215% increase in the odds of having an ammonia burn. In other words, for a bird that is ABF, the odds of having an ammonia burn are more than three times the odds of not having an ammonia burn for birds that are on an antibiotic program.

Table 4 presents results from the ordered logit regression on burned feet presence and severity. The coefficient estimate on ABF status was positive and significant indicating that ABF birds were associated with a greater presence and severity of burned feet. Marginal effects are estimated across the three levels of burned feet (0: not present, 1: mild lesion, 2: severe lesion). ABF birds are 5.5 percentage points less likely not to have burned feet, while ABF birds are 2.5 percentage points and 3.0 percentage points more likely to have mild and severe burned feet, respectively, compared to birds treated with antibiotics. The estimated odds ratio of 1.248 indicates that ABF birds have a 25% increase in the odds of having mild or severe burned feet. In other words, the odds of ABF birds having burned feet are 1.25 times more than the odds of not having burned feet for a bird on an antibiotic program.

Overall, the risk of ammonia burns in the cornea and burned feet were significantly higher in antibiotic-free birds than birds raised with antibiotics. These results are consistent with the negative effect of ABF diets reported by Gaucher et al. (2015). Policies aimed at eliminating or banning the use of antibiotics in broiler production may come with potentially negative consequences with respect to good animal welfare, and should consider comprehensive animal care plans that incorporate good housing, management, and responsible antibiotic use.

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Table 1. Health Conditions

Condition/ Value	Ammonia Burns in the Cornea	Mouth Lesions	Scratches	Burned Feet
0	Normal cornea	Absence of the condition	No cuts or lacerations on skin	No lesions. No or very small superficial lesions, slight discoloration on a limited area, mild hyperkeratosis
1	Damage to the eye characterized by cloudiness and/or ulceration of cornea	Erosion, ulceration, necrosis, scabbing or proliferation of tissue in the oral cavity, base of tongue or anterior esophagus	Cuts or lacerations on skin	Mild lesion. Discoloration of the foot pad, superficial lesions, dark papillae
2	N/A	N/A	N/A	Severe lesion. Ulcers or scabs, signs of hemorrhages or swollen foot pads

Table 2. Summary Statistics

Variable		Full Sample			Antibiotic-Free Only			Antibiotics-Used		
	Range	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD
Ammonia Burns	[0,1]	11,403	0.010	0.100	412	0.044	0.205	10,991	0.009	0.094
Burned Feet	[0 – 2]	11,353	0.588	0.736	412	0.765	0.823	10,941	0.582	0.732
Mouth Lesions	[0,1]	11,496	0.049	0.216	412	0.051	0.220	11,084	0.049	0.216
Scratches	[0,1]	11,505	0.173	0.378	412	0.141	0.348	11,093	0.174	0.379

Table 3. Logistic Model Results (standard errors in parentheses)

	Ammonia Burns			Mouth Lesions			Scratches		
	Regression Estimates	Marginal Effects	Odds Ratios	Regression Estimates	Marginal Effects	Odds Ratios	Regression Estimates	Marginal Effects	Odds Ratios
Intercept	-6.134***	--	--	-5.269***	--	--	-3.062***	--	--
	(0.343)			(0.153)			(0.083)		
ABF	1.147***	0.014**	3.148***	0.181	0.007	1.198	-0.108	-0.014	0.898
	(0.269)	(.005)	(0.808)	(0.234)	(0.011)	(0.293)	(0.148)	(0.018)	(0.130)
Age	0.015*	0.000*	1.016*	0.070***	0.003***	1.072***	0.052***	0.007***	1.053***
	(0.009)	(0.000)	(0.009)	(0.004)	(0.000)	(0.004)	(0.002)	(0.000)	(0.002)
Q1	1.912***	0.026***	6.767***	-0.107	-0.004	0.898	-0.335***	-0.042***	0.715***
	(0.247)	(0.005)	(1.627)	(0.121)	(0.004)	(0.111)	(0.070)	(0.008)	(0.050)
Q2	1.217***	0.012***	3.378***	-0.013	-0.000	0.987	-0.310***	-0.039***	0.733***
	(0.273)	(0.004)	(0.929)	(0.109)	(0.004)	(0.108)	(0.065)	(0.008)	(0.049)
Observations	11,403			11,496			11,505		
Log Likelihood	-593.119			-2,085.854			-5.039.764		

* p<0.1; ** p<0.05; ***p<0.01

Table 4. Ordered Logit Results

	Burned Feet				
	Regression Estimates	Marginal Effect 0	Marginal Effect 1	Marginal Effect 2	Odds Ratios
ABF	0.221**	-0.055**	0.025**	0.030**	1.248***
	(0.099)	(0.025)	(0.010)	(0.014)	(0.291)
Age	-0.002	0.001	0.000	0.000	0.998
	(0.002)	(0.000)	(0.000)	(0.000)	(0.002)
Q1	0.673***	-0.167***	0.070***	0.097***	1.960***
	(0.047)	(0.001)	(0.004)	(0.008)	(0.093)
Q2	0.139***	-0.034***	0.016***	0.018***	1.149***
	(0.046)	(0.001)	(0.005)	(0.006)	(0.053)
Observations	11,353				
Log Likelihood	-10,889.020				

* p<0.1; ** p<0.05; ***p<0.01