

Review

The health and management of poultry production

Charles L. Hofacre⁽¹⁾

The poultry industry in the USA is a fully integrated system of animal agriculture. Each company has control over the bird husbandry and health management aspects of production, including the use of antimicrobial agents. The three segments of the industry—broiler chickens, turkeys, and layer chickens—have few antibiotics available for the therapeutic treatment of bacterial diseases. Prior to approval of the fluoroquinolones, tetracyclines were the major antibiotics approved for the treatment of the most economically important disease in broiler chickens and turkeys, *Escherichia coli* airsacculitis. This resulted in levels of resistance to the tetracyclines in clinical *E. coli* isolates in excess of 90%. The integrated nature of the poultry industry lends itself well to preventive medicine utilizing the tools of biosecurity and vaccination. Therefore, very few flocks of birds require antibiotic therapy. When a flock must be treated, the poultry veterinarian will usually base the recommendation of the drug to use on culture and antibiogram results.

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The poultry industry in the USA is a fully integrated system of animal agriculture. Each poultry company has control over all fiscal and bird husbandry aspects of production, from the day-old parent breeders to the marketing and distribution of the final products to the retailer. The 'poultry industry' is actually three different industries, commercial layers, broilers, and turkeys. Commercial layers are chickens of the leghorn breed that lay table eggs for human consumption. There are approximately 275 million table egg layers in production in the USA.¹ When these birds begin laying eggs for human consumption at 18–19 weeks of age, they can only be treated with a small number of antibiotics that have been demonstrated to result in no antibiotic residue in the eggs.^{2,3}

The US turkey (272 million) and broiler chicken (8.5 billion) industries are similar to each other, with the company purchasing the parent breeders at 1 day of age or hatching eggs from a primary breeder or genetic selection company.¹ These birds are raised on farms contracted by the company under specific company guidelines for antibiotic usage. The offspring (broiler chickens or commercial turkeys) of these breeders are hatched in company-owned hatcheries, and placed on a contract or company-owned farm, where the farmer must follow strict company guidelines for antibiotic usage. All feed that is fed to the breeders, broiler chickens or commercial turkeys is manufactured in a company-owned feedmill under specific guidelines of

a company. The company nutritionist will specify the nutritional aspects of the feed, and the veterinarian will determine any antibiotic usage requirements. The birds will then be slaughtered in a company-owned processing plant.

The typical US broiler chicken farm will have approximately 100 000 chickens, divided equally into four houses. As in a city of 100 000 people, disease prevention becomes imperative for the poultry industry. Poultry veterinarians practice preventive medicine, utilizing two primary tools, biosecurity and vaccination. The US average level of death loss (mortality) in the typical 100 000-bird broiler farm is 4–5%.⁴ There is also loss of approximately 0.5–1.0% of the birds for human consumption in the processing plant, when birds are removed by the United States Department of Agriculture–Food Safety Inspection Service (USDA-FSIS) inspectors, primarily for visible signs of respiratory disease, most often due to an *Escherichia coli* infection.⁴

In those cases where a disease has been introduced onto a farm, the poultry veterinarian must decide whether the birds can be treated with an antibiotic, and, if so, which antibiotic and by what route of administration (in feed or drinking water). The choice of antibiotic is often limited by the cost of the drug versus level of disease, and also by the safe duration of withdrawal prior to slaughter to ensure that no drug residue is found in the meat. The vast majority of therapeutic treatments are given via the drinking water, because sick birds stop eating, but continue to consume water. As for layer chickens, the choice of antibiotics available to poultry veterinarians for the treatment of bacterial infections is limited (Table 1). Until the fluoroquinolones were approved for poultry, the primary antibiotic class available for *E. coli* infections comprised the tetracyclines. This limited choice of antibiotic therapy has led to a level of tetracycline resistance in poultry *E. coli* isolates exceeding 90%.⁵

⁽¹⁾Department of Avian Medicine, College of Veterinary Medicine, University of Georgia, Athens, Georgia, USA.

Address correspondence to Charles L. Hofacre, Department of Avian Medicine, College of Veterinary Medicine, University of Georgia, Athens, Georgia, USA.

Table 1. Therapeutic antibiotics for poultry^{2,3}

Antibiotic	Egg-layer chickens		Broiler chickens		Turkeys	
	Feed	Drinking water	Feed	Drinking water	Feed	Drinking water
Bacitracin	Yes	Yes	Yes	Yes	Yes	Yes
Chlortetracycline	Yes	No	Yes	Yes	Yes	Yes
Erythromycin	No	No	Yes	Yes	Yes	Yes
Enrofloxacin	No	No	No	Yes	No	Yes
Lincomycin	No	No	Yes	Yes	No	Yes
Neomycin	No	No	No	Yes	No	Yes
Novobiocin	No	No	Yes	No	Yes	No
Oxytetracycline	No	No	Yes	Yes	Yes	Yes
Penicillin	No	No	Yes	No	Yes	Yes
Streptomycin	No	No	No	Yes	No	No
Sulfadimethoxine and ormetoprim	No	No	Yes	Yes	Yes	Yes
Tylosin	Yes	No	Yes	No	No	No

Another factor relevant to the choice of antibiotic is the cost of the drug. It has been estimated by one particular broiler company that the mortality must exceed 1000 birds per farm before it is economically feasible to use a fluoroquinolone (personal communication). This is why fluoroquinolones are infrequently used in broilers. Most of the *E. coli* infections are secondary, and result from primary infections caused by Newcastle disease virus or infectious bronchitis virus (IBV). IBV is a coronavirus that undergoes genomic reassortment and homologous recombination in vivo. Therefore, over time, new genotypes arise to which large populations of birds may be susceptible. Infected, medicated flocks may lose uniformity of body weight if treatment is unable to restore normal body physiology.

The issue of antibiotic resistance in potential human foodborne pathogens such as *Salmonella* and *Campylobacter* also becomes an issue when selecting an antibiotic for treating an *E. coli* infection in broilers or turkeys. The FSIS issued the Pathogen Reduction; Hazard Analysis and Critical Control Point (HACCP) Systems regulations in 1996; these imposed on all poultry-processing plants a system of performance standards for *Salmonella* with regard to the final product.⁶ The results of this program have shown continued improvements in pathogen reduction by the broiler industry. Additionally, this began to raise the awareness of consumers about *Salmonella* and other foodborne pathogens that could be resistant to antibiotics used to treat human infections. Therefore, many food markets and restaurants began to require that the poultry products originate from farms with no history of usage of specific antibiotics such as the fluoroquinolones.

The fully integrated nature of the poultry industry allows the poultry-producing company to implement bird husbandry practices that impact on a large proportion of the meat supply for the US consumer. It is therefore imperative that preventive health programs as well as appropriate therapeutic strategies are practiced to avoid not only disease in the birds, but also pre-

vention of introduction of potential human foodborne pathogens. This means that, when birds must be treated with antibiotics, not only effectiveness against the disease-causing bacteria, but also the impact on foodborne pathogens, must enter into the decision-making process of the poultry veterinarian. The ever-increasing pressure on food retailers by consumers to limit the use of antibiotics in food-producing animals limits the choices for therapy by poultry veterinarians and the means by which they can ensure that healthy birds can be brought to processing.

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PANEL DISCUSSION

M. Ginevan: In your example of birds at 1 week to slaughter, could a third possible choice of handling that illness in that house be to send the birds in that house to slaughter early, not treat them, and confine your losses to that?

C. Hofacre: If you can. It depends on the marketing of the birds for that company—the sales department for the company. If you are selling a product of a smaller bird and a bird of 49 days, then you might be able to switch and process another farm later, and pull this one in earlier. In many instances when it gets that close to processing, this is like a very well-oiled machine; if one thing breaks down, it really becomes difficult. Everything starts to pile up behind.

R. Carnevale: If you were unable to use enrofloxacin because it was no longer on the market for this use, what antibiotic would you have used in this house?

C. Hofacre: I would have used tetracyclines, at as high a level as I could. Because *E. coli* is a secondary infection, very often in the isolation we will find that 90% of the isolates within this outbreak will be resistant, but there will be a few that will be sensitive. You will be able to slow the course of the disease but you won't be able to stop it.

C. Thornsberry: What happens if you get back a report from the laboratory that says the bacterium is resistant to enrofloxacin?

C. Hofacre: If these were younger birds, say 3 weeks old, and we had an airsacculitis outbreak, and the report came back that it was resistant to the drug that we were using, then we would switch. If the report said that they were sensitive to the sulfas, then we might use one of the potentiated sulfas on a younger group of birds. On birds this close to slaughter, your options are limited. By the time you get the report, they are probably on the way to market.

C. Thornsberry: Do you really bother to re-treat?

C. Hofacre: No. For these birds in particular, you wouldn't have enough time.

E. Gonder: You might give them some idea of the rather tight weight ranges they are faced with in broiler processing. In the turkey industry, we would be more likely to try to ship a flock early, because we have some leeway on sizes. Mostly, the broiler industry, particularly if the birds are intended for a particular market, wants the weight in that flock to be within $\frac{1}{4}$ of a pound, so the options begin to drop fairly quickly on getting the bird into the plant. Those of you who aren't familiar with the poultry business may not realize how quickly the growth rate changes in these animals. I just did a brief calculation here, one that my major professor did some years ago; but in the turkey industry in particular, you start with a 50-g poult, and at the end of 20 weeks you have an 18-kg market turkey. If you translate that into human terms, it means that if you have a 7-pound baby, at the end of 20 weeks he weighs 2520 pounds. We are

acutely interested in maintaining that growth rate. That is where we make our money. That is one of the reasons why preventive medicine is so important to us.

C. Hofacre: We view disease as a failure. Treatment is a salvage option.

G. Tillotson: You demonstrated the economic significance of resorting to enrofloxacin, so, the cost and legal implications notwithstanding, I suppose that nobody would consider using a fluoroquinolone as a preventative, as prophylaxis, from the outset.

C. Hofacre: There is nobody in the USA who has, as far as I know, used fluoroquinolones in a prophylactic way.

Comment: *You emphasized the importance of this E. coli infection being secondary to something else. Unless I missed it, you didn't carry on with your case study and tell us what you might have found and what you would do if you found evidence of a virus infection. Can you elaborate on that?*

C. Hofacre: If it is an infectious bronchitis or a Newcastle virus—in most instances in broilers, it will be an infectious bronchitis—we will try to find out which serotype of infectious bronchitis it is (most commonly it will be a corona virus) and where it came from; if it is not part of our vaccination program, then we may decide to add that serotype to the vaccination program. The indication of a different serotype would come from serology, but confirmation will come with virus isolation and then determining through an RT-PCR which serotype of infectious bronchitis virus we are dealing with. If there is a vaccine available for that type, a commercial vaccine, then we use that the next time on that farm.

Question: *How often does the event you describe occur in an area over a given time period? Is it an isolated event or does it happen every day?*

C. Hofacre: When we talk about an area for a broiler industry, we are talking about what is termed a complex. A complex is a self-contained unit within an area. For example, a large complex in Athens, Georgia has a feedmill, a hatchery, broiler farms, breeder farms and all the personnel to go along with that in a processing plant. That complex places about 1.5 million broilers per week. Within that 1.5 million, there will probably be one or two farms per week that will have this airsacculitis problem, because it is fairly difficult with a high population density not to have these viruses circulating about. It is probably less than 1–2%, which would be an easier way to look at it. One of the things that I didn't show you in the table of poultry numbers from the economics is that 96% is the average proportion of birds that survive to go to the processing plant. Not a lot of birds die

during the growing period, and most of those that do die, do so as a result of physiologic or leg problems or other management issues, rather than from disease.

E. Gonder: One other thing that you might point out would be the effect a flock like that would have on the septicemia–toxemia condemnation figures. This is relevant to the question about incidence, because any of the birds that enter the processing plant with extensive fibrinous airsacculitis are going to be condemned, probably falling into either the septicemia–toxemia or airsacculitis categories. That brings us back to the figures shown on the national incidence of septicemia–toxemia and airsacculitis condemnations.

M. Pasternack: I have a couple of questions about *E. coli* infection. Is that a particular strain of *E. coli*, or is this a common bug in your average chicken house?

C. Hofacre: Most of the time it is normal floral *E. coli* that are opportunistic: 01, 02 and 078 are the most common serotypes. There are pathogenic *E. coli* serotypes that are found everywhere in the intestinal track, just as normal flora.

E. Rubinstein: Do you think that it is feasible to develop a vaccine to protect chickens from *E. coli* infections?

C. Hofacre: There has been some work with some live vaccines, but because the bacteria are opportunists and there are so many *E. coli* serotypes, you may vaccinate against one type, but others will take their place.

C. Thornsberry: Has the rate of quinolone resistance among the *E. coli* isolates risen over the time frame that enrofloxacin has been available?

C. Hofacre: Yes. There has been, as with the introduction of any antibiotic, the selection of resistant bacteria. We saw virtually no fluoroquinolone-resistant *E. coli* isolates in the USA to begin with, but, with use, we have started to see a few.

Question: *What happens to the birds if you have an outbreak and they die? What do you do with the carcasses?*

C. Hofacre: There are various methods of disposal used in the USA. There is burial. There is incineration. Those would probably be the two most common. There is also composting, where the carcasses are mixed in with used bedding material, allowing heat and decomposition within that bin.

C. Thornsberry: I would like to go back to the resistant *E. coli*. In my experience and opinion, the resistance of *E. coli* to fluoroquinolones is not a problem. In human medicine, in this country alone, we use over \$2 billion

worth. I know we don't measure antibiotics in dollars, but \$2 billion is a lot of fluoroquinolones; the amount of resistance that we see in *E. coli* is somewhere in the neighborhood of 2–4%, and doesn't change much. What you have in your situation, if you are looking at one house, is an infection control problem, not a measurement of the amount of resistance you are likely to see in *E. coli*.

C. Hofacre: You are correct in that we are selecting for a population of bacteria. We are not inducing resistance, but selecting for bacteria that are resistant. There are almost no treatment failures. I don't know of anyone who has mentioned a treatment failure with a fluoroquinolone for an airsacculitis infection in chickens or in turkeys.

D. Newell: Would your clinical decision be influenced at all if you were aware that the flock was positive or negative for *Campylobacter*?

C. Hofacre: I wouldn't have prior knowledge, but no. We really don't understand enough about *Campylobacter*. In my opinion, the actual epidemiology or ecology of *Campylobacter* in the poultry industry is not well enough understood for me to say that if I treated with this I am going to have some sort of problem at the processing plant with resistant *Campylobacter* in the birds.

T. Wassenaar: Are you going to refer to the incidence of *Campylobacter* in poultry and what the different species are in the different species of birds?

C. Hofacre: *Campylobacter jejuni* is the primary species in broilers, and *C. coli* is the primary one in turkeys. The incidence of both is quite high. We are probably looking at 80–90% of the birds having *Campylobacter* when they are processed.

Question: *Would you expect any impact on processing, other than the live weight disparities, to occur if you chose not to treat that flock?*

C. Hofacre: If we chose not to treat that flock, a lot of the birds would have fibrinous pericarditis, and the Food Safety Inspection Service would condemn them. I don't know if it has ever been clinically demonstrated or published, but one of the things that we have noticed is that broiler flocks that have had airsacculitis and have higher airsacculitis or septicemia–toxemia condemnation rates tend to have higher bacterial counts on the carcasses as well. If we can cure them or decrease the disease incidence, we may actually have a more wholesome carcass.

Question: *Would that be mostly re-processed birds?*

C. Hofacre: Most of those would go into re-processing. If the problem is septicemia–toxemia, they won't be re-processed. With airsacculitis, they can be re-processed at some plants.

E. Gonder: You didn't mention the effect that the all-in, all-out production method used in the poultry industry has on antimicrobial-resistant bacteria. This must be one of our strengths.

C. Hofacre: It helps to break these disease cycles, having all-in, all-out. It allows us to completely clean and disinfect. We don't start totally anew, but it helps to minimize the impact of any of those bacteria.