THE CHANGING NATURE OF FOOD BORNE PATHOGENS – A BIRD’S EYE VIEW
OF HOW THESE MAY IMPACT ON FOOD SAFETY

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Food borne pathogens have always had a major impact on human health, but in the
late 19th Century and earlier 20th Century outbreaks of infection due to contaminated
foodstuffs tended to be localised. However, with the greater centralisation of food processing
there is now a greater opportunity for extensive spread of disease from a single source
(Salyers and Whitt, 2002). Food borne diseases, especially those associated with enteric
infection, are one of the most important public health issues affecting the developing
communities because the net effect is a major loss in productivity.

The expectation of the public is that food products are safe and do not constitute a
disease risk. Consequently around the world there are numerous quality assurance projects to
ensure food safety. However, as rapidly as food is monitored we are seeing the emergence of
“new” pathogens, or the changing nature of “older” pathogens.

From the poultry industry perspective, in the late 1980’s/1990’s the emergence of
Salmonella Enteritidis as a food borne pathogen in the USA and Europe had a major impact
on the poultry and egg industries. Likewise, the spread of E. coli 0157:H17 by undercooked
contaminated hamburger meat by a takeaway food chain in the USA, or through
contaminated salad products in Japan has impacted significantly on the public perception of
safe food.

Perhaps the most significant impact on the changing nature of food borne pathogens
has been the development of antibiotic resistance in food borne pathogens.

The development of antibiotic resistance in bacteria is of significant concern in
matters pertaining to public health matters. Of particular interest to food animal producers,
and the industry in general, is the development of resistance in enteric bacteria. These
bacteria, which are normal flora in the intestine of animals and people, are a key resource for
the maintenance and spread of resistance to like and related organisms.

There is presently enormous pressure on food producers to limit the use of
antibiotics in food production animals. This is because of the perception that the use of
growth promoting agents in food production animals has led to the selection of antibiotic
resistance (Phillips et al, 2003). Where there is an animal reservoir for the maintenance of
antibiotic resistant strains the resistance characteristics are even more important.

Since the widespread development and use of antibiotics has occurred only over the
past 60 years there is significant information on what resistance levels are like in organisms
such as Escherichia coli and Salmonella species before and after the introduction of
antibiotics.

The extent and types of antibiotics that bacteria are exposed to also influence
resistance. Antibiotic resistance is determined in two ways in bacteria. The first of these, and
the most important, is the characteristic that allows bacteria to resist significantly high levels
of an individual antibiotic. This resistance type is due to mutation in, or acquisition of, genes
(either plasmid or chromosomal) responsible for antibiotic uptake or destruction. The second
characteristic is the development of relatively non-specific genetic resistance to multiple
antibiotics (Houndt and Ochman, 2000).

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One key question to be determined in understanding antibiotic resistance is how resistance is acquired and transferred.

For the transfer of high level specific resistance DNA agents such as plasmids, transposons, integrons and gene cassettes are involved. All of these DNA transfer agents have the ability to transfer DNA between strains of the same species or between different species, enhancing the opportunity for acquisition and transfer of antibiotic resistance.

In recent years there has been considerable work undertaken to understand the level of antibiotic resistance in organisms that colonise food animals (Ruiz et al., 1999). The main driving force of these surveys has been to determine the relationship between animal flora and human pathogens. The key focus of the surveys has been enteric bacteria and in Europe there are a number of countries that routinely survey enteric bacteria from food animals to determine the level of antibiotic resistance.

Bywater et al. (2004) reported on slaughter samples from chickens, pigs and cattle from four European countries where 2118 isolates of E. coli, 271 isolates of Salmonella spp. and 1325 isolates of Campylobacter spp. were evaluated for resistance to 11 antibiotics.

In this study the isolation rate of E. coli was high. For isolates from chickens the level of antibiotic resistance was relatively low across the spectrum of antibiotics tested with the highest level of resistance being 75% for tetracyclines.

Multiple resistances, represented as resistance to 4 or more antibiotics, in E. coli isolates from chickens were 9.5% in chickens but only 2.5% in pigs and 1% in cattle. The most common multi-resistant phenotype in chickens was ampicillin/ streptomycin/ tetracycline/ trimethoprim and sulphamethoxazole.

In the same survey Salmonella isolates were also evaluated. The isolation rate for Salmonella spp. across the four countries was 4.9% in total, with species prevalence of 7.1% for chickens, 4.5% pigs and 0.6% cattle. (Bywater et al., 2004)

The majority of isolates from chickens were S. Heidelberg, S. Hadar, and S. Typhimurium. For Salmonella isolates from chickens there was a relatively high level of resistance to ampicillin and tetracycline. Multiple resistance in chicken isolates was relatively low at 5.8% with the most common resistance phenotype being ampicillin/ chloramphenicol/ streptomycin/ tetracycline/ trimethoprim plus sulphamethoxazole.

For campylobacter isolates the isolation rate varied from 3% (Sweden) to 70% (UK) with C. jejuni as the most common chicken isolate. Ciprofloxacin resistance was common in greater than 30% in Holland and France. Multiple antibiotic resistance was low in Campylobacter spp, only 1.8%, with the most frequent phenotype being ciprofloxacin/ nalidixic acid/ erythromycin/ tetracycline. Similar results for Campylobacter spp in chickens have been reported from Japan (Ishihara et al., 2004) with resistance to oxytetracycline, macrolides and fluoroquinolones the dominant feature.

A recent survey of food borne pathogens isolated from beef, pork and poultry in Austria (Mayrhofer et al., 2004) showed similar results to the work of Bywater et al. (2004). However, the Austrian samples had a higher rate of Salmonella isolation from chickens at 16.4%, with the variety of serovars indentified including S. Enteritidis, S. Heidelberg, S. Blockley, and S. Virchow as the main isolates.

Of these Salmonella isolates 57.7% exhibited a resistant phenotype, however the level of multi-resistance was low with only S. Blockley isolates and S. Hadar showing resistance to four or more antibiotics.

Of great concern internationally is the emergence of the Salmonella strain known as multi drug resistant (MDR) Salmonella enterica serovar Typhimurium DT104. This strain has been isolated in a number of countries, is commonly known as S. Typhimurium DT104, and is resistant to chloramphenicol, streptomycin, sulfonamides, and tetracycline. Some
isolates have been identified that are resistant to fluoroquinolones, trimethoprim and kanamycin (Boyd et al., 2001).

It has been suggested that MDR S. Typhimurium DT104 has increased virulence. This virulence is not necessarily because of enhanced invasion, but it appears to have enhanced invasion virulence factors (Boyd et al., 2001).

Recently we have been evaluating virulence characteristics of Salmonella and E. coli isolates from Australia and Vietnam.

In studies of Salmonella spp. and E. coli isolates from poultry meat from various retail sources in Vietnam screened against ampicillin, ciprofloxacin, tetracycline, gentamycin, chloramphenicol and sulphamethoxazole 96% of E. coli isolates were resistant to one or more antibiotics and 52% of isolates were resistant to four or more antibiotics. For salmonella the percentages were 77% resistant to one or more antibiotics and 17% resistant to four or more antibiotics.

Clearly this is a major concern from a public health perspective.

We have also shown that a wide variety of Salmonella enterica isolates have a novel fimbrial gene cluster that plays a key role in attachment and invasion, and which can be used to differentiate salmonella serotypes.

Food borne pathogens are a major concern for the poultry industry. Clearly over time we are seeing an evolution of resistance and virulence characteristics in the major enteric organisms associated with food poisoning that will impact both on disease management and food quality.

REFERENCES


