IV. Data Analysis

A. *Salmonella*

1. Recovery of isolates by serotype within commodity

The total number of *Salmonella* isolates tested by year since 1997 is shown in Table 1A.

The top serotypes by commodity for 2009 are shown in Table 2A. Overall, Kentucky, Hadar, Montevideo and Derby ranked as the most prevalent serotype for chickens, turkeys, cattle and swine, respectively. Using 2009 as the baseline, the relative distributions for the top five serotypes per commodity are shown in Figures 1A-4A. While Kentucky was the most frequently recovered serotype for chickens, the upward trend observed beginning in 1997 halted in 2006 at 48.8%, declined in 2007 and 2008, and increased again in 2009 to 38.8% of isolates. From 1997 through 2002 Heidelberg frequency remained between 20.7% and 26.9%; however a decline was observed in 2003 and has remained below 15.1% of isolates since 2004. Since 2002, recovery of Enteritidis has increased to 21.4% of isolates in 2009. Conversely, recovery of Typhimurium variant 5- and I 4,5,12:i:- has remained below 10.0% for all years (Figure 1A).

Among isolates recovered from turkeys (Figure 2A) Hadar remained below 18.5% through 2004, increased in 2007 to 43.5%, and declined in 2009 to 26.4%. The recovery of Saintpaul fluctuated between 0.9% in 1997 and 14.9% in 2009. Both Schwarzengrund and Senftenberg remained at or below 11.4% of isolates since 1997.

From 2005 to 2009, recovery of Montevideo increased among cattle isolates from 13.1% to 29.5%. Dublin also showed an upward trend from 2005 to 2008 (from 3.6% to 12.0%) but decreased in 2009 to 10.5% of isolates. The recovery of the other top serotypes remained below 11.2% (Figure 3A).

Recovery of Derby among swine has fluctuated within the years tested from a high of 34.3% in 2002 to a low of 12.3% in 2007 (Figure 4A). Variations were noted for recovery of Anatum, Infantis, Johannesburg and Typhimurium variant 5- from 1997-2009, but overall remained below 16.2%.

2. MIC distributions

The 2009 MIC distributions by antimicrobial and commodity for all *Salmonella* serotypes combined (macro analysis) are shown in Table 3A. Since it is not unusual for resistance to be driven by only a few serotypes and because the distribution of serotypes between commodities varies greatly, it is important to determine resistance at the serotype and commodity level (micro analysis). However, a macro analysis is often useful to quickly determine any overt change between years prior to conducting a micro analysis of the data.

The overall percent resistance by year, antimicrobial and commodity of all *Salmonella* serotypes combined is shown in Table 4A. Resistance to amikacin has only been observed once in a single isolate from swine in 2007. Similarly, with the exception of one isolate from chicken in 2003, resistance has yet to emerge to ciprofloxacin; resistance to nalidixic acid remained $\leq$ 1.0% for all commodities in 2009. Additionally, resistance to gentamicin appears to remain stable among chickens, cattle and swine. While gentamicin resistance remains higher among turkeys when compared to the other animal sources, a decline was observed in this commodity from 16.9% in 2008 to 14.9% in 2009. In 2009, resistance to the cephems class remained highest among cattle isolates (13.5%, 14.5% and 14.5% for cefoxitin, ceftiofur and ceftriaxone, respectively); however, these numbers show a decline from 2008. Conversely, an increase in resistance to the cephems class was observed in chickens and turkeys from 2008 to 2009 but remained stable in swine. An increase in resistance to ampicillin was observed in all commodities from 2008 to 2009. Ampicillin resistance among turkeys in 2009 (38.8%) has been the highest observed among all commodities and years. In 2009, resistance to trimethoprim/sulfamethoxazole remained below 2.5% among all commodities. An increase was observed in resistance to sulfisoxazole among turkeys from 2008 to 2009 (24.3% to 28.9%) while a decrease was observed among chickens (13.3% to 10.0%, respectively). Resistance to sulfisoxazole remained stable in cattle and swine (24.5% and 30.8%, respectively). Resistance to the other antimicrobials varied by commodity.

A micro analysis of the 2009 data is presented in Tables 5A through 8A which shows total percent resistance and MIC distribution by commodity and serotypes. Data is only presented for those serotypes with greater than ten isolates in a particular commodity. Among serotypes from *Salmonella* isolates recovered from chickens (Table 5A), Enteritidis (n=118) exhibited $\leq$ 2.5% resistance to five antimicrobials (amoxicillin/clavulanic acid, ampicillin, ceftiofur, ceftriaxone, and tetracycline) and was susceptible to the remaining ten antimicrobials. Conversely, Kentucky (n=214) exhibited varying levels and combinations of resistance to 11 antimicrobials (amoxicillin/clavulanic acid, ampicillin, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, gentamicin, kanamycin, streptomycin, sulfisoxazole and tetracycline) and showed no resistance to four antimicrobials (amikacin, ciprofloxacin, nalidixic acid and trimethoprim/sulfamethoxazole).

The frequency of isolates exhibiting the ACSSuT (ampicillin, chloramphenicol, streptomycin, sulfisoxazole and tetracycline) penta-resistant pattern or the ACSuT quad-resistant pattern is reported separately for *S.* Typhimurium and Typhimurium variant 5- (Table 9A). Although not streptomycin resistant, ACSuT isolates are often confirmed as DT104 and have been included in previous reports (streptomycin is typically intermediate [one dilution from resistant]). In 2009, only one *S*. Typhimurium variant 5- exhibited this quad-resistant pattern.

Table 10A shows the prevalence of confirmed DT104 or DT104 complex (a closely related definitive type) isolates. However, it is important to note that presentation of the ACSSuT pattern does not always result in confirmation of the isolate as DT104 (Table 11A). Therefore, analysis of isolates by phage type enables a more accurate assessment of the prevalence and importance of DT104 or DT104 complex isolates. In 2009, a total of 11 isolates were confirmed as DT104 or DT104 complex which accounted for 14.5% of all *S*. Typhimurium and *S*. Typhimurium variant 5- isolates tested and for 1.1% of all *Salmonella* tested in 2009.

The frequency and percentage of confirmed *S.* Typhimurium DT104 isolates is reported separately by food animal source from 1997 through 2009 (Table 12A). In 2009, DT104 isolates were found in swine (n=7) and cattle (n=4). From 1997 through 2009, DT104 prevalence was highest in swine followed by cattle, chickens and turkeys.

Specific MDR patterns by commodity are presented in Tables 13A through 16A. Data is presented by CLSI class as well as by phenotype(s) thought to be of clinical importance in humans [at least ACSSuT, ACT/S (ampicillin, chloramphenicol, trimethoprim/sulfamethoxazole), ACSSuTAuCx [ACSSuT, amoxicillin/clavulanic acid and ceftriaxone] or ceftriaxone and nalidixic acid resistance]. Overall, pan-susceptible isolates most often originated (in order of decreasing frequency) from cattle, chickens, swine and turkeys as observed in previous years. Among the clinically important phenotypes reported, resistance was least often observed to ACT/S and to ceftriaxone plus nalidixic acid for all animal sources.

B. *Campylobacter*

The number of *Campylobacter* isolates tested from chicken rinsates is shown in Table 1B. *Campylobacter jejuni* were more frequently recovered than *C. coli*. The distribution of *Campylobacter* species recovered from chicken remained stable from 1998 to 2008. In 2009, a decrease was observed in *C. jejuni* (73.6% to 59.1%) while an increase was observed in *C. coli* (26.4% to 40.9%) (Figure 1B).

MIC distributions by antimicrobial and species are shown in Table 2B. No resistance to florfenicol or clindamicin was observed for either species. In 2009, resistance was higher for *C. coli* than *C. jejuni* for all drugs with the exception of tetracycline.

Percent resistance by year, antimicrobial, and species are shown in Table 3B. In 2009, a decrease in resistance from 2008 was observed in both *C. coli* and *C. jejuni* to gentamicin, azithromycin, erythromycin and tetracycline. Following two consecutive years of increased resistance in *C. jejuni* to the quinolones, a decrease was observed in 2009 to 19.7% for both ciprofloxacin and nalidixic acid. However, in *C. coli* an increase in resistance to the quinolones was observed for the first time since 2004. Tetracycline resistance decreased from 2008 to 2009 in both *C. jejuni* and *C. coli;* however, resistance to tetracycline in *C. jejuni* (49.6%) was higher than *C. coli* (44.4%) which is opposite of what was observed in 2008.

MDR by CLSI class is presented in Tables 4B and 5B. Overall, MDR has been more frequently observed in *C. coli* than *C. jejuni.*

C. *Escherichia coli* (generic)

The number of *E. coli* isolates tested from chicken rinsates is shown in Table 1C. MIC distribution by antimicrobial is shown in Table 2C.

Percent resistance by year is shown in Table 3C. No resistance has been observed to amikacin from 1997 through 2009. Resistance to ciprofloxacin has remained below 0.6% since 1997. A decrease in percent resistance was observed to all antimicrobials in 2009 except tetracyline. Resistance in *E. coli* was highest to sulfisoxazole (52.6%), followed by streptomycin (49.8%) and tetracycline (49.1%). MDR by CLSI class is presented in Table 4C. The percent of isolates that were pan-susceptible increased in 2009 to 21.9% while resistance to multiple CLSI classes either decreased or remained stable.