



Antimicrobial Resistance Surveillance Program 2016 Data Summary Report

**Antimicrobial Resistance Surveillance
Reference Laboratory**

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Department of Health
Philippines*



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EXECUTIVE SUMMARY

Resistance data for **72,347 bacterial isolates** coming from 24 sentinel sites hospital bacteriology laboratories located in 16 regions of the Philippines and 2 gonorrhoeae surveillance sites were analyzed for 2016.

Streptococcus pneumoniae

- ◆ Cumulative resistance rate of *S. pneumoniae* isolates from all specimen types reported for 2016 against penicillin, using meningitis breakpoints, was at 6.1% (n=427). When the pneumococcal isolates were analyzed by specimen type, penicillin resistance was at 2.6% for invasive (blood and CSF) isolates when analyzed using meningitis breakpoints but only 1% penicillin resistance rate for non-invasive isolates (non-CSF and non-blood) when analyzed using non-meningitis breakpoints.
- ◆ There was 1 ceftriaxone-resistant *S. pneumoniae* respiratory isolate using non-meningitis breakpoints reported for 2016.

Haemophilus influenzae

- ◆ For 2016, 7.8% of *H. influenzae* isolates were resistant to ampicillin (n= 461) and 5.8% were resistant to amoxicillin-clavulanic acid (n=431).
- ◆ Resistance rates for 2016 isolates of *H. influenzae* are at 31.2% for co-trimoxazole (n= 407) and 5.3% for chloramphenicol (n=394).
- ◆ There were no reports of levofloxacin or azithromycin resistant *H. influenzae* for 2016.

Salmonella enterica serotype Typhi

- ◆ *S. enterica* ser. Typhi isolates have remained susceptible to first line antibiotics with no reported resistant isolates for ampicillin, co-trimoxazole and chloramphenicol for 2016 and with rates for the past 10 years remaining at less than 5% for all 3 drugs.
- ◆ Emerging resistance against fluoroquinolones is noted with resistance rates against nalidixic acid at 7.8% (n=128). Of these nalidixic acid resistant isolates, 90% tested as intermediate to ciprofloxacin.
- ◆ For 2016, 24% of these *S. Typhi* isolates had decreased susceptibility to ciprofloxacin (DSC).

Nontyphoidal *Salmonella*

- ◆ Increasing resistance of nontyphoid salmonella to ciprofloxacin (n= 187) is noted with rate at 12.8% for 2016.
- ◆ The commonest nontyphoidal *Salmonella* species serovar identified for 2016 are *S. enterica* serotype Enteritidis and *S. enterica* serotype Typhimurium.

Shigella species

- ◆ Combined 2014-2016 data reveals emerging resistance of *Shigella* species against the fluoroquinolones as seen with cumulative rate of resistance at 13.7% against ciprofloxacin (n=51).

Vibrio cholerae

- ◆ *Vibrio cholerae* isolates remain susceptible to first line agents: chloramphenicol, co-trimoxazole and tetracycline with no reported resistant isolates for 2016.

Neisseria gonorrhoeae

- ◆ The 2016 *Neisseria gonorrhoeae* isolates have high rates of resistance against penicillin at 93.9% (n=198); tetracycline at 44.9% (n=178); and ciprofloxacin at 72.2% (n=198).
- ◆ There was no reported streptomycin and cefixime non-susceptible isolates for the 2016 data.
- ◆ For 2016, there was 1 isolate reported as nonsusceptible to ceftriaxone (MIC > 0.25 ug/ml) out of the 198 tested.
- ◆ For 2016, there were 2 *N. gonorrhoeae* isolates with ceftriaxone reduced susceptibility (MIC ³ 0.15 ug/ml) out of the 198 isolates tested.

Staphylococcus aureus

- ◆ MRSA rate for 2016 is at 61.5% (n= 5,072). This did not differ statistically from the reported MRSA rate of 60.3% in 2015.
- ◆ Resistance rates for 2016 against antibiotics used for treatment of *S. aureus* infections are as follows: 24.6% for co-trimoxazole (n=4,146); 11.4% for clindamycin (n=5,250); 4.3% for rifampicin (n=4,495); 1.4% for linezolid (n=4,245); and 0.8% for vancomycin (n=3,885). None of these vancomycin resistant isolates were confirmed as resistant at the reference laboratory.

Enterococcus species

- ◆ For 2016, we continue to report higher rates of ampicillin resistance in enterococci with rates at 13.1% for *E. faecalis* (n=1,339) and 88.9% for *E. faecium* (n= 648).
- ◆ Rates of *Enterococcus faecalis* resistance is reported at 4.4% (n=1,1120) for linezolid and 0.9% (n=1,337) for vancomycin.
- ◆ Rates of *Enterococcus faecium* resistance is reported at 1.6% (n=616) for linezolid and 2.9% for vancomycin (n=624).

Escherichia coli

- ◆ *E. coli* rates of resistance against the fluoroquinolones and third generation cephalosporins have been increasing for the past years with resistance rates against ciprofloxacin at 43.7% (n=7,191) and ceftriaxone at 36.4% (n=6,437) for 2016.
- ◆ Emerging resistance against the carbapenems are also reported for 2016 with rates of resistance at 4.1% for ertapenem (n=3,954); 4.2% for imipenem (n=7,590); and 3.8% for meropenem (n=7,085).
- ◆ *E. coli* extended-spectrum β -lactamase suspect rates for 2016 is at 30% (n=5,578).
- ◆ Urinary *E. coli* isolates from outpatients remain susceptible to nitrofurantoin with rate of resistance at 4.4% (n= 614). Comparatively, urinary *E. coli* isolates from hospitalized patients show variable susceptibility to parenteral agents with rates of resistance ranging from 5.1% against ertapenem (n= 982) to as high as 44.8% against ceftriaxone (n= 1,824).

Klebsiella pneumoniae

- ◆ Resistance to the carbapenems are also rising with 2016 *Klebsiella pneumoniae* resistance rates as high as 9.1% for ertapenem (n=4,524); 11.8% for imipenem (n=9,033) and 11.4% for meropenem (n=9,298).
- ◆ *K. pneumoniae* extended-spectrum β -lactamase suspect rates for 2016 is at 40% (n=8,861).

Pseudomonas aeruginosa

- ◆ Resistance rates of 2016 *P. aeruginosa* isolates were 14.9% for ciprofloxacin (n=5,266), 17.7% for ceftazidime (n= 5,416); 8.6% against amikacin (n= 5,522) and 18.8% for imipenem (n=5,233). Blood culture isolates of *P. aeruginosa* have relatively higher resistance rates than that reported for all isolates combined.

Acinetobacter baumannii

- ◆ Rate of resistance of *A. baumannii* is reported at 47% for ampicillin/sulbactam (n= 2,651) for 2016.
- ◆ *A. baumannii* aminoglycoside resistance rates are at 38.4% for amikacin (n= 3,564) and 45.5% for gentamicin (n=4,064).
- ◆ Resistance of *A. baumannii* against imipenem for 2016 is at 52.1% (n=3,967).
- ◆ When blood culture *A. baumannii* isolates rates of resistance were compared from combined cumulative rates from all specimen types, rates were relatively lower except for that of amikacin.

Multidrug-resistant Pseudomonas aeruginosa & Acinetobacter baumannii

- ◆ *P. aeruginosa* MDR and possible XDR rates for all isolates were at 21% and 16%, respectively.
- ◆ *A. baumannii* MDR and possible XDR rates for all isolates were at 61% and 50%, respectively.

The 2016 Isolates

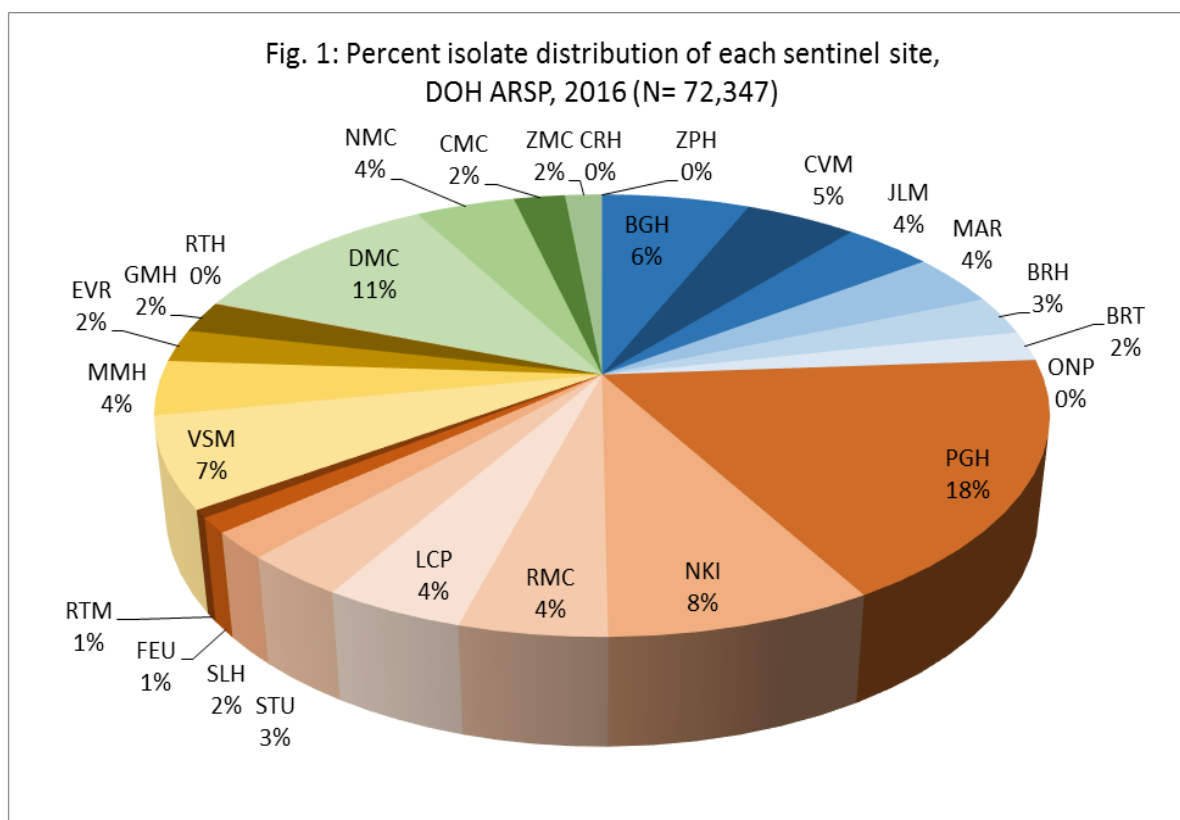
Resistance data for **72,347 isolates** were reported and analyzed for the year 2016. This was a 42% increase when compared to the reported **50,895** isolates for 2015.

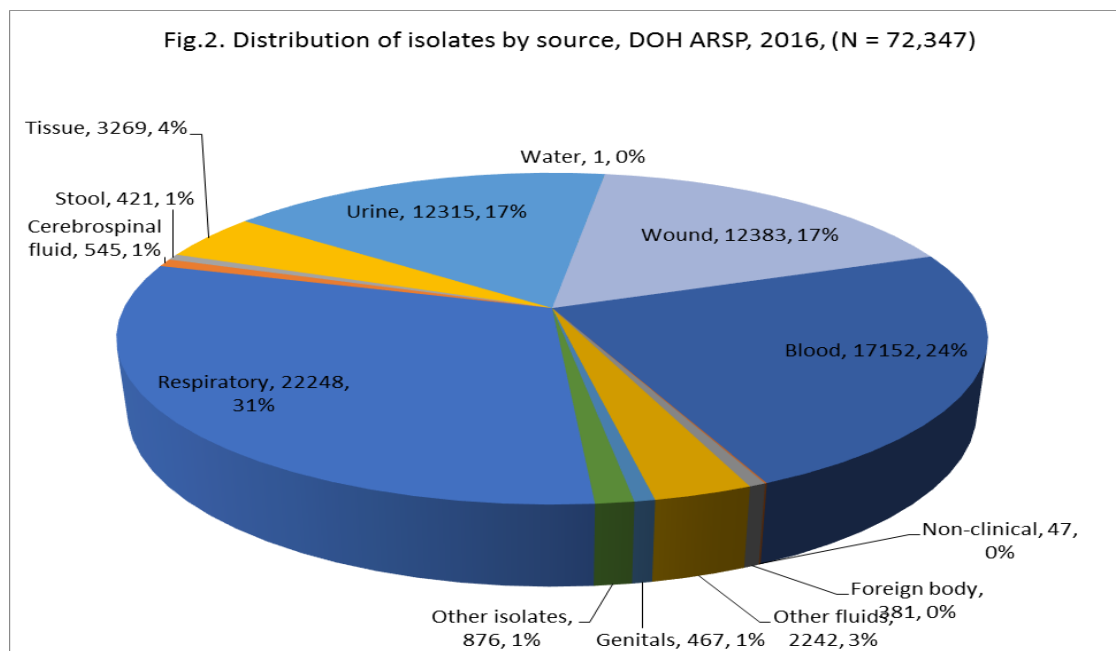
Sentinel Site Data Contribution

The 2016 ARSP data came from the **24 sentinel and 2 gonorrhoeae surveillance sites** of the program which represents **16 regions of the Philippines (Figure 1 and Table 10)**. Of the total number of isolates for 2016, 66% were from Luzon, 15% were from Visayas and 19% were from Mindanao. The 8 Metro Manila sentinel sites contributed 42% of the total 2016 annual data. Comparatively, contributions for the 2015 annual report data were 61% from Luzon (41% from NCR), 20% from Visayas and 19% from Mindanao sentinel sites.

Specimen Types

The most common specimen types comprising the 2016 ARSP data were respiratory (31%), blood (24%), wound (17%) and urine (17%) specimens. Other specimen types contributing to the 2016 data were: tissues, cerebrospinal fluid, other fluids, genital specimens and stool (**Figure 2**).





SENTINEL SITES	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Change %
PGH	-	-	-	-	-	-	7093	12471	11710	12860	9
RMC	757	757	878	962	845	942	1207	320	1054	3252	68
NKI	2996	3112	3345	3681	2726	2403	2179	2918	1455	5894	75
LCP	2548	2701	2694	2	1233	2083	2253	2921	2905	3115	7
RTM	361	335	280	348	328	383	303	303	336	410	18
SLH	461	662	468	615	409	318	1132	575	824	1410	42
GMH	886	826	1151	936	1119	1521	1307	1351	1807	1669	-8
ZMC	434	440	599	1060	686	721	822	819	841	1142	26
FEU	684	690	699	864	1064	931	1050	956	712	810	12
STU	1329	1180	1722	1470	752	1788	2050	2002	1923	2275	15
EVR	491	466	340	530	744	507	697	823	1514	1731	13
MMH	380	525	562	590	855	1153	1413	2289	2940	2886	-2
DMC	2161	2374	2523	2870	2439	3332	3456	4062	5109	8058	37
VSM	1063	1241	1447	1931	2142	2450	3171	3951	3834	4803	20
BGH	1041	1329	2129	2199	1916	1972	2583	2625	3214	4628	31
CMC	686	541	459	600	595	639	796	833	1300	1599	19
BRT	388	401	618	486	537	677	611	1047	1251	1584	21
RTH	32	19	-	-	-	-	-	-	-	25	
ZPH	67	53	38	11	-	-	-	9	8	4	-100
MAR			2275	1898	1851	1928	1773	1706	1849	2759	33
BRH			1008	791	304	38	-	1022	1294	2075	38
CVM			248	907	790	944	1100	1223	1512	3473	56
JLM			387	1024	643	655	502	638	1266	2768	54
NMC			814	1817	1776	1684	2131	2416	2237	3105	28
ONP										2	
CRH										10	
TOTAL	16765	17652	24684	25592	23754	27069	37629	47280	50895	72347	

Table 1. Sentinel site isolate contribution to the ARSP 2007-2016.

Most Common Isolates

For 2016, *Klebsiella pneumoniae*, followed by *Escherichia coli* and *Pseudomonas aeruginosa* were the most commonly isolated bacterial organisms from all specimen types reported. The most commonly isolated bacteria by specimen type is seen at **Table 2**.

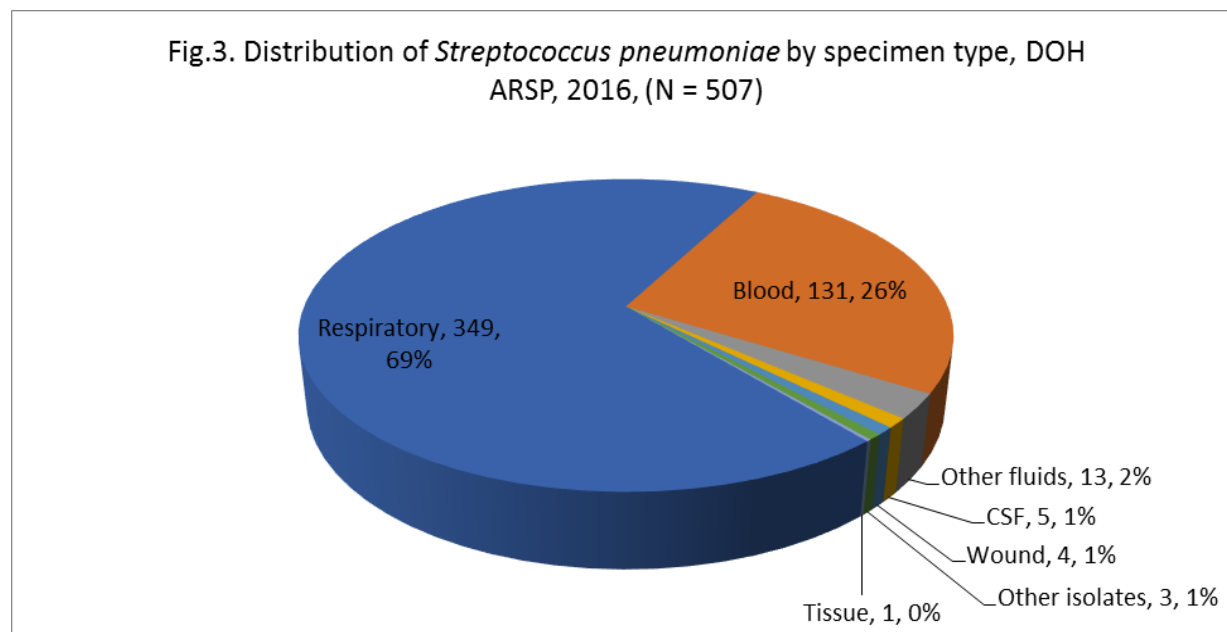
Table 2. Most common isolates by specimen type, all ARSP sites, 2016

Respiratory specimens		Blood	
1	<i>Klebsiella pneumoniae</i>	1	<i>Staphylococcus</i> , coagulase negative
2	<i>Pseudomonas aeruginosa</i>	2	<i>Staphylococcus aureus</i>
3	<i>Acinetobacter baumannii</i>	3	<i>Escherichia coli</i>
Cutaneous or Wound		Stool	
1	<i>Staphylococcus aureus</i>	1	<i>Vibrio cholerae</i>
2	<i>Escherichia coli</i>	2	<i>Salmonella sp.</i>
3	<i>Klebsiella pneumoniae</i>	3	<i>Aeromonas sp.</i>
Cerebrospinal Fluid		Urine	
1	<i>Staphylococcus</i> , coagulase negative	1	<i>Escherichia coli</i>
2	<i>Acinetobacter baumannii</i>	2	<i>Klebsiella pneumoniae</i>
3	<i>Staphylococcus aureus</i>	3	<i>Enterobacter sp.</i>

Streptococcus pneumoniae

Isolates

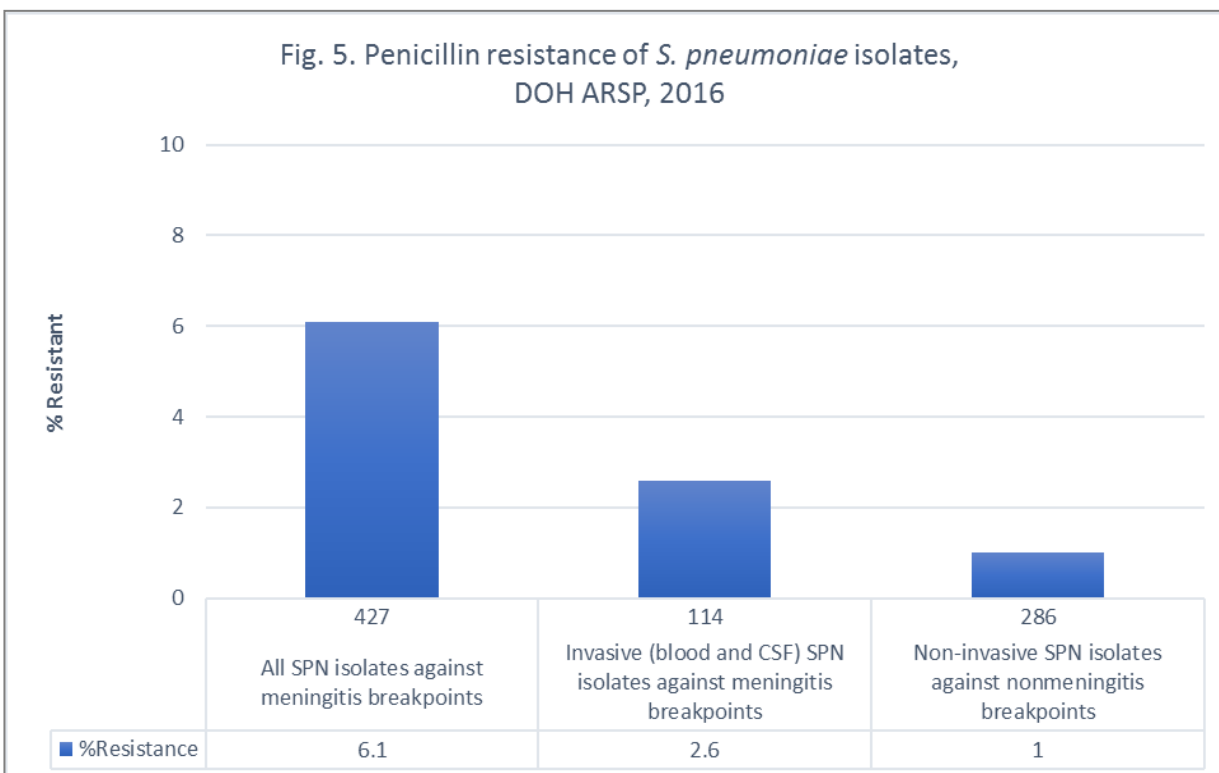
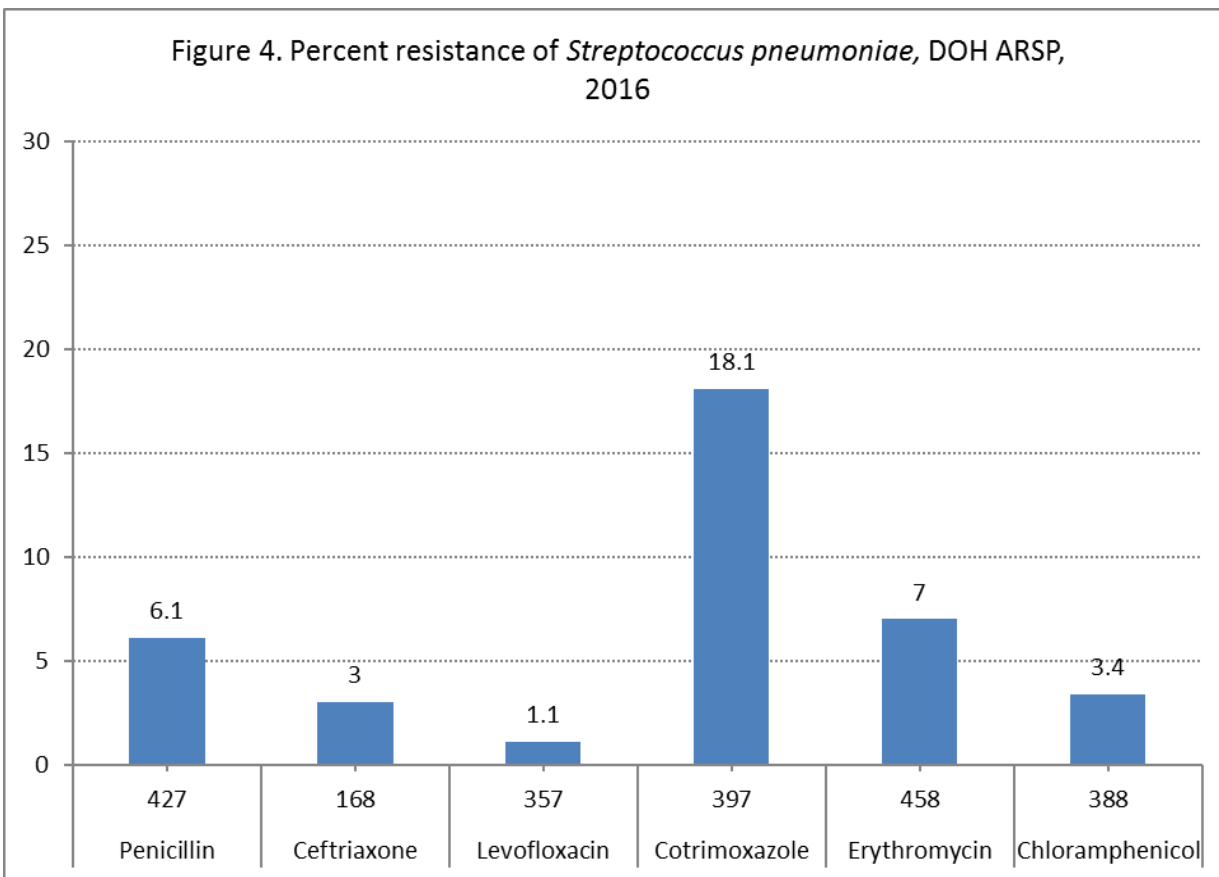
There were 507 reported *S. pneumoniae* isolates for 2016. This was 16% more than the 436 *S. pneumoniae* isolates reported for 2015. Major contributors making up 45% of the 2016 *S. pneumoniae* data were DMC (108 isolates), VSM (66 isolates) and PGH (54 isolates). Majority of the *S. pneumoniae* reported were respiratory isolates (69%) and invasive isolates (27%) from blood and cerebrospinal fluid cultures. The rest of the isolates were from wound, tissue and other body fluids (**Figure 3**).

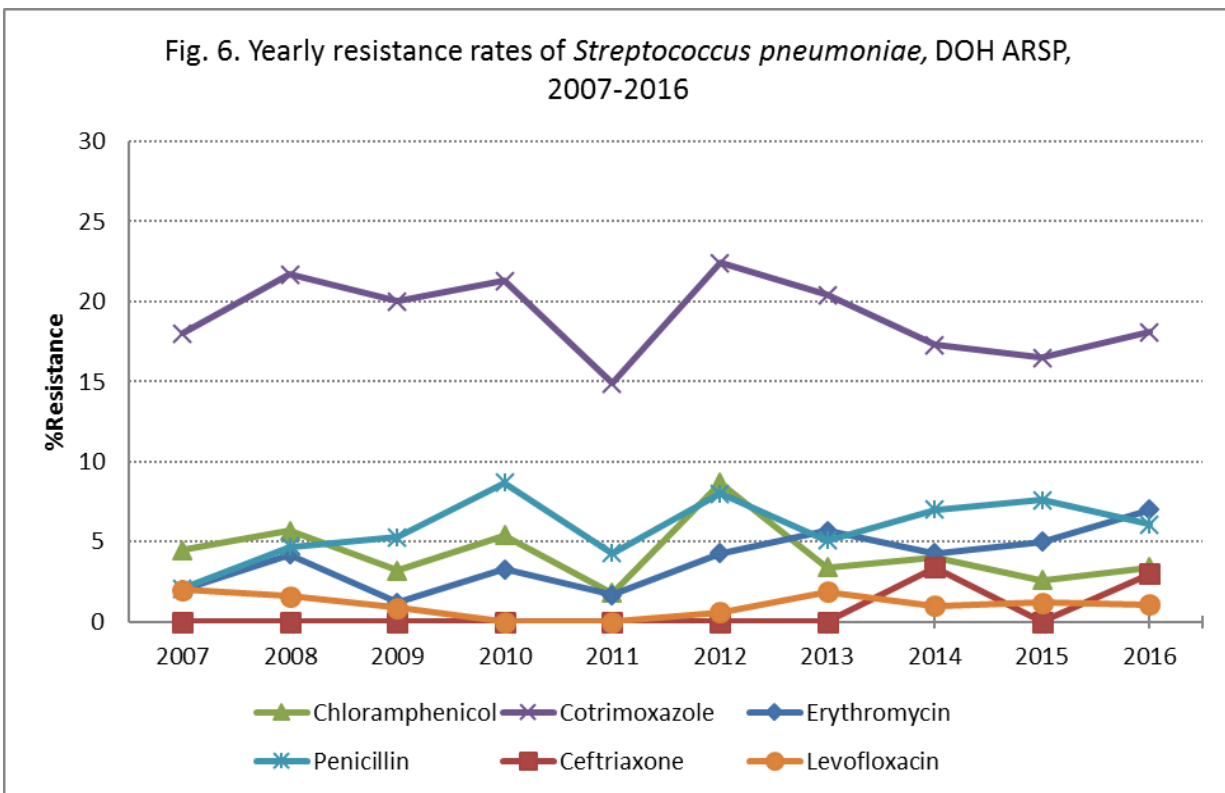


Antimicrobial Resistance

Since 2008, the Clinical and Laboratory Standards Institute (CLSI) recommends the use of different breakpoints for meningitis and non-meningitis pneumococcal infections when testing for penicillin. The recommended meningitis breakpoints are more stringent due to the poor penetration of penicillin thru the blood brain barrier.³ For 2016, penicillin resistance is at 6.1 (n=427; 95% CI: 10.1-16.8) when all *S. pneumoniae* isolates were analyzed using meningitis breakpoints. When analyzed by specimen type, penicillin resistance was higher for invasive isolates (114 blood and CSF isolates) using meningitis breakpoints at 2.6% while among noninvasive *S. pneumoniae* isolates, only 1% (n=286 non-invasive isolates) were reported as penicillin-resistant isolates using non-meningitis breakpoints for 2016. Of the 2 invasive isolates confirmed penicillin resistant at the reference laboratory using meningitis breakpoints, these were further identified as of serotypes 19 and 24; both were also susceptible to ceftriaxone and levofloxacin. The respiratory isolate confirmed as penicillin resistant using nonmeningitis breakpoints, this was further identified as of serotype 6 and was susceptible to both ceftriaxone and levofloxacin.

Resistance rates of *S. pneumoniae* isolates for 2016 were 18.1% for co-trimoxazole (n=397; 95% CI: 13.1-20.6); 7% for erythromycin (n=397; 95% CI: 3.2-7.7); 3.4% for chloramphenicol (n=388; 95% CI: 1.3-5.1); 1.1% for levofloxacin (n=357; 95% CI: 0.4-3.3); and 3% for ceftriaxone (n=168; 95% CI: 0-2.8). Among the levofloxacin- and ceftriaxone-resistant isolates, only 1 ceftriaxone-resistant respiratory isolate was sent to the reference laboratory and was confirmed as ceftriaxone-resistant using non-meningitis breakpoints. These rates did not differ significantly from that reported for 2015 (p value > 0.5). The 2016 resistance rates and 10 year trends of resistance is seen in **Figures 4, 5 and 6**.

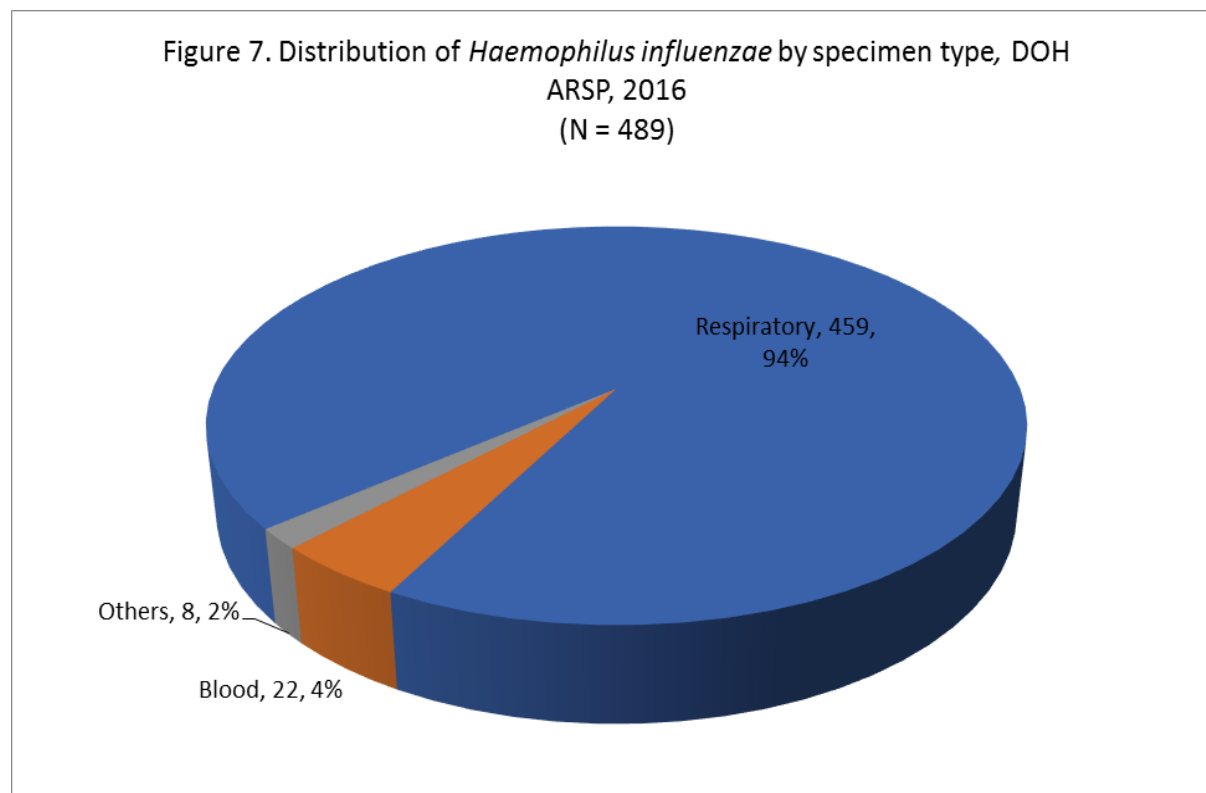




Haemophilus influenzae

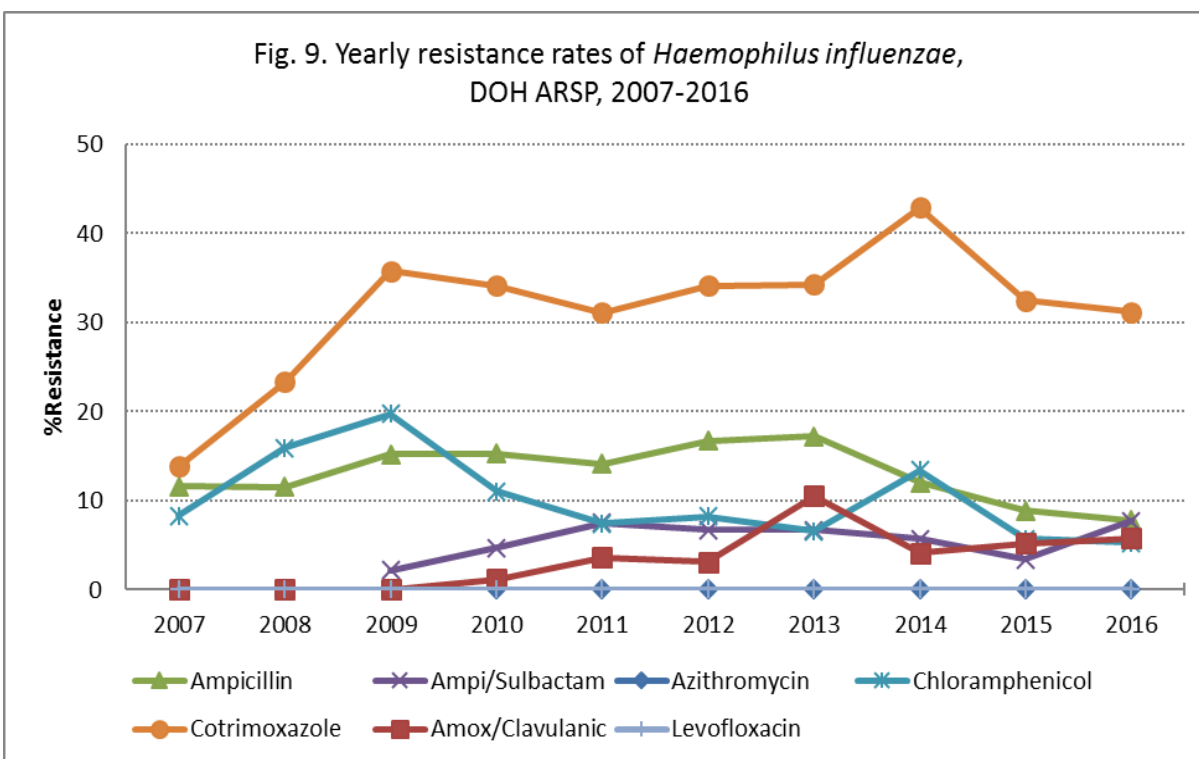
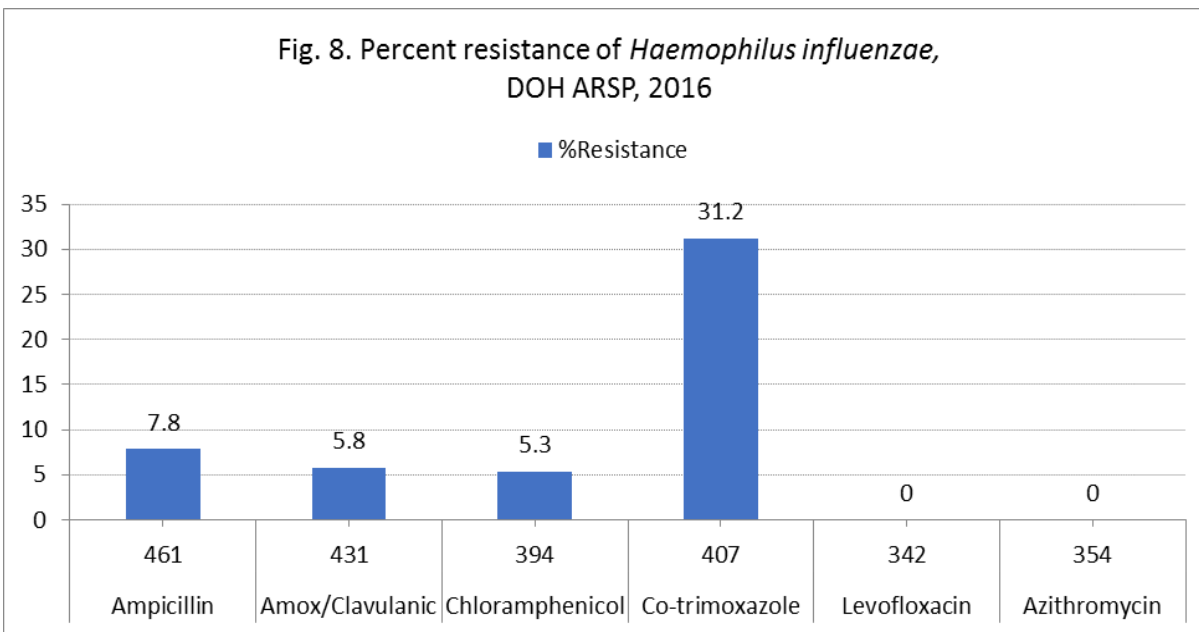
Isolates

There were 489 reported *H. influenzae* isolates for 2016. This was 29% more than the 379 isolates reported for 2015. Biggest contributors for the 2016 *H. influenzae* data were BGH (103 isolates), VSM (94 isolates) and DMC (75 isolates). Majority of the 2015 *H. influenzae* isolates were from respiratory specimens (94%) while there were 23 invasive isolates (22 blood and 1 CSF culture isolates). Distribution of specimen types contributing to the *H. influenzae* data for 2016 is illustrated in **Figure 7**.



Antimicrobial Resistance

Resistance rates among the isolates of *H. influenzae* for 2016 were: 7.8% for ampicillin (n=461; 95% CI: 5.6-10.7); 5.8% for amoxicillin-clavulanic acid (n=431; 95% CI: 3.8-8.6); 5.3% for chloramphenicol (n=394; 95% CI: 3.4-8.1); and 31.2% for co-trimoxazole (n=407; 95% CI: 26.8-36) as seen in **Figure 8**. When 2016 rates were compared to that reported for 2015, there were significant increase in resistance rates against ampicillin-sulbactam from 12% in 2015 to 33% in 2016 (p value 0.0129); while the rates of resistance for the other antibiotics tested did not differ significantly from that reported for 2015. There were no reported levofloxacin-resistant or azithromycin-resistant *H. influenzae* isolate for 2016 as in the past decade. Trends of resistance for *H. influenzae* is illustrated in **Figure 8 & 9**.



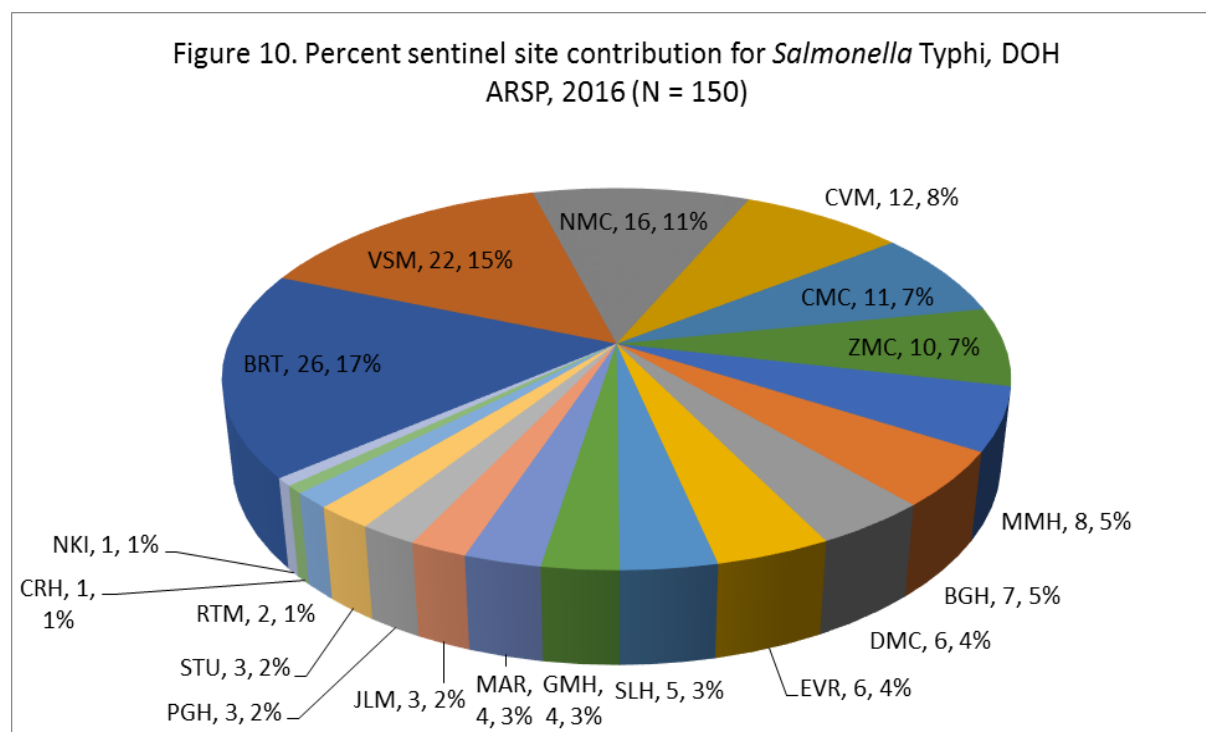
Salmonella enterica serotype Typhi

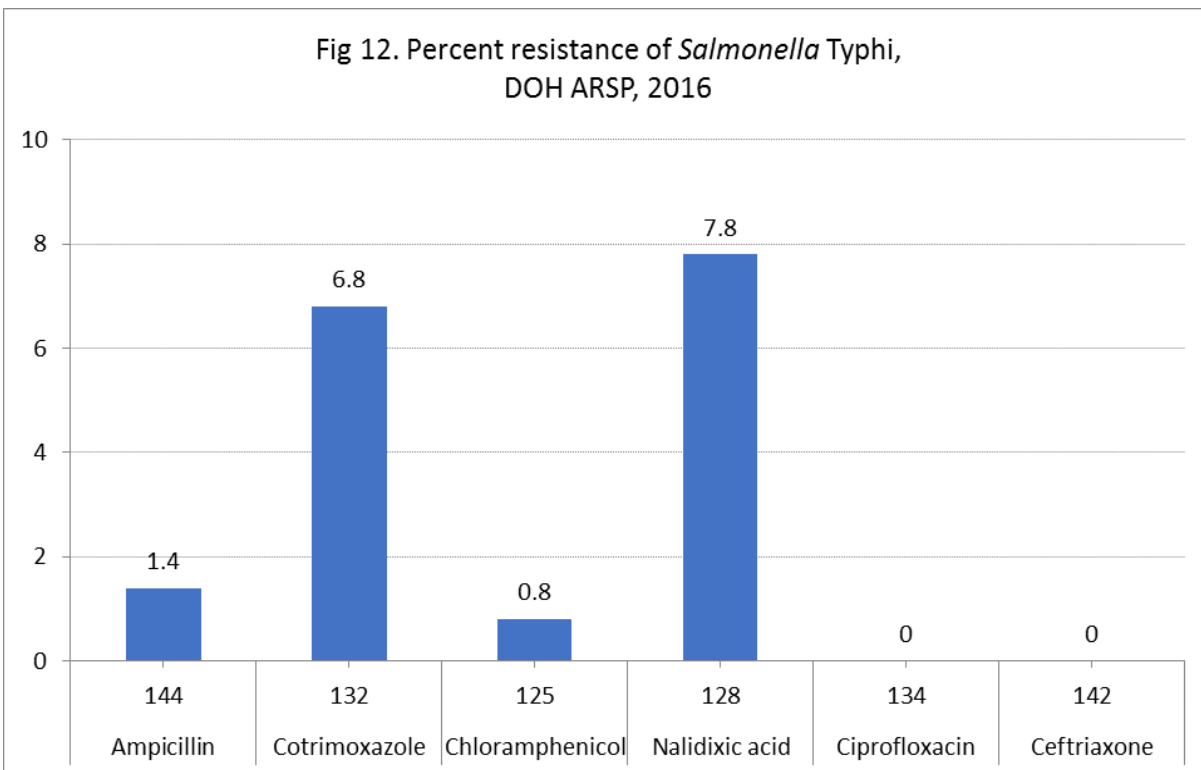
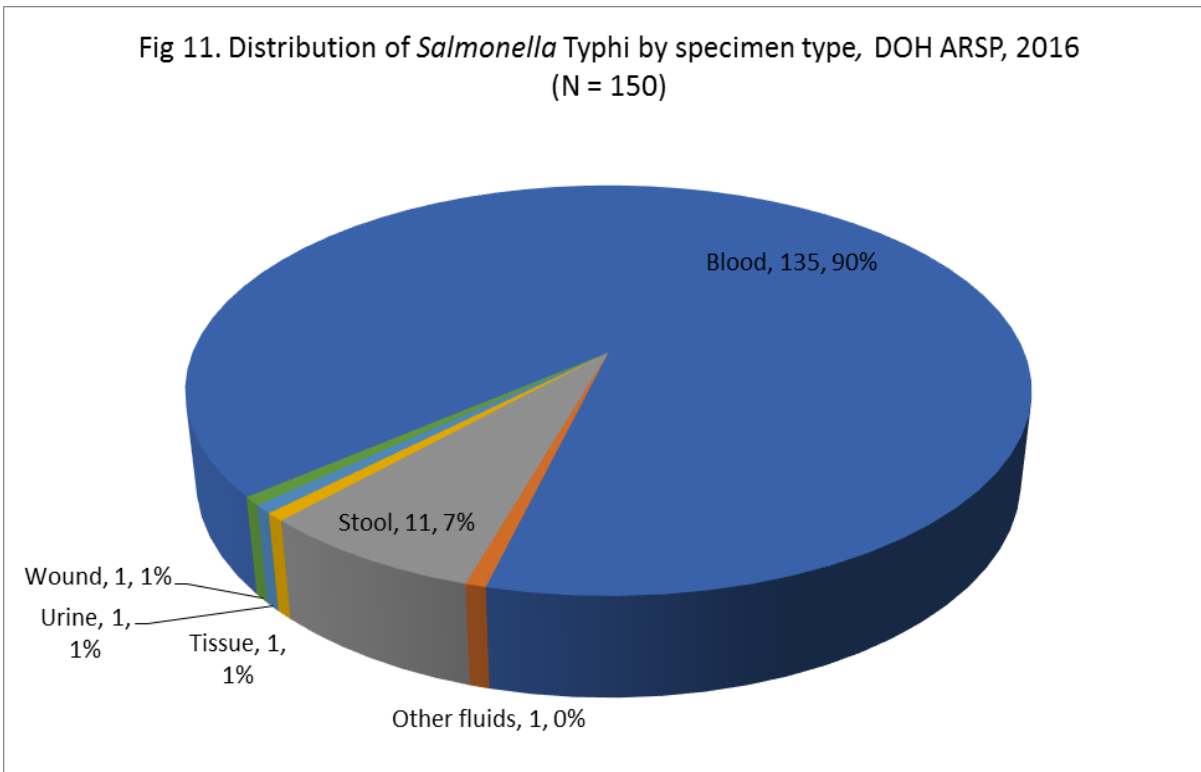
Isolates

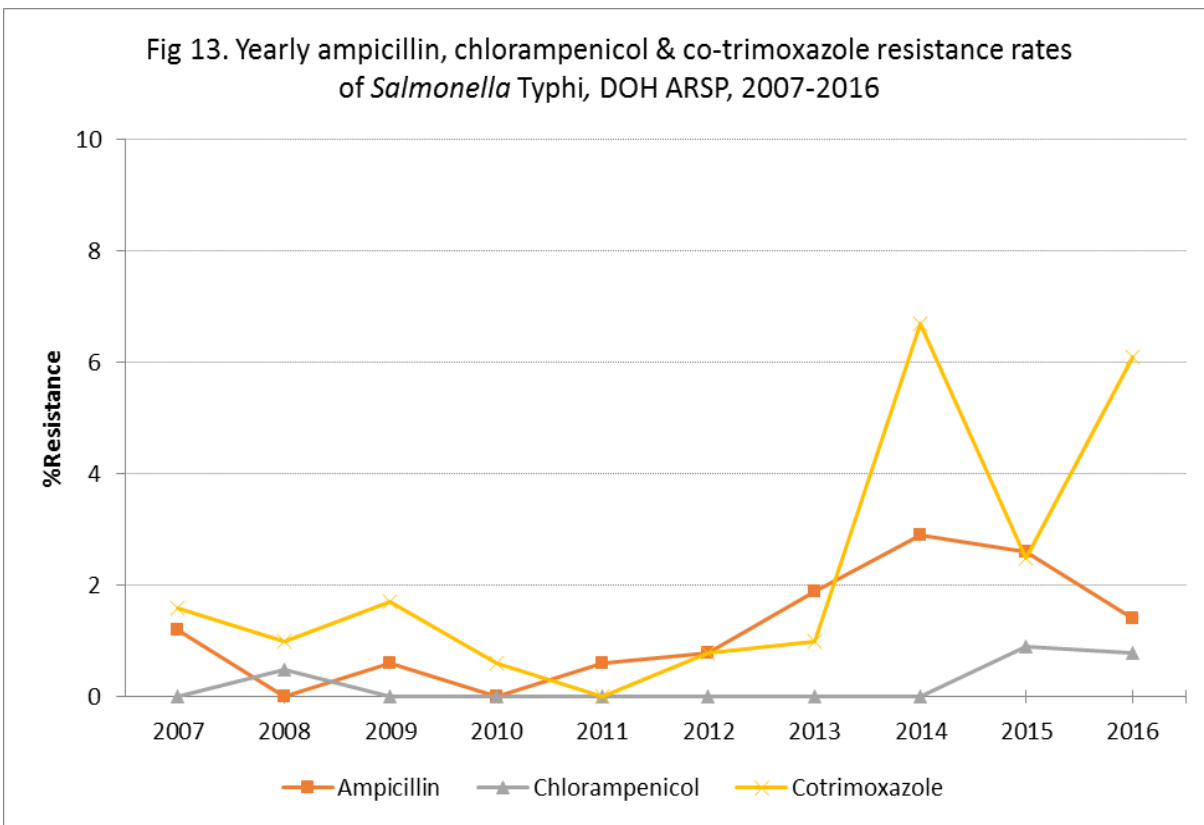
There were 150 *S. Typhi* isolates reported and analyzed for 2016. This is 18% more than the 127 total number of isolates reported for 2015. The largest sentinel site contributors making up 43% of the 2016 *S. Typhi* data were: BRT (26 isolates), VSM (22 isolates) and NMC (16 isolates) as seen in **Figure 10**. Most of the 2016 *S. Typhi* isolates were from blood specimens (90%). Others were isolated from stool, tissue, urine, wound and other body fluids (**Figure 11**).

Antimicrobial Resistance

S. Typhi isolates for 2016 reported rates of resistance to ampicillin at 1.4% (n=144; 95% CI: 0.2-5.5); co-trimoxazole at 6.8% (n=132; 95% CI: 3.4-12.9); and chloramphenicol at 0.8% (n=125; 95% CI: 0-5.0). These reported 2016 rates did not significantly differ statistically from reported rates for 2015 (p value > 0.05). Resistance rate was at 7.8% against nalidixic acid (n=128; 95% CI: 4-14.2). Of these nalidixic acid resistant isolates, 90% tested as intermediate to ciprofloxacin. Nalidixic acid-resistance in extra-intestinal *Salmonella* isolates predicts reduced susceptibility to fluoroquinolone and may signify poor fluoroquinolone treatment outcomes.³ There were no reports of ciprofloxacin or ceftriaxone-resistant *S. Typhi* for 2016. Although nalidixic acid susceptibility can predict poor outcomes with fluoroquinolones therapy, a subset of *S. Typhi* isolates may test susceptible against nalidixic acid but tests in vitro as intermediate or resistant to ciprofloxacin (decreased susceptibility to ciprofloxacin or DSC with MICs (≥ 0.12 $\mu\text{g/ml}$) for ciprofloxacin) often indicative of the presence of plasmid-related quinolone resistance.⁶ For 2016, of the 132 *S. Typhi* isolates tested against ciprofloxacin, 24% tested intermediate of which only 10 tested as nalidixic acid resistant. The 2016 percentage resistance and 10 year trends of resistance for *S. Typhi* are seen in **Figures 12-13**.







Nontyphoidal *Salmonella* (NTS) species

The Isolates

There were 263 reported nontyphoidal *Salmonella* for 2016. This is 47% more than the 179 reported nontyphoidal *Salmonella* isolates for 2015. The largest contributor of the 2016 isolates were BRT (36 isolates), PGH (36 isolates) and DMC (30 isolates) as seen in **Figure 14**. Most of the isolates were from blood specimens (53%). Other specimens from which nontyphoid *Salmonella* were isolated are: stool, wound, respiratory, urine, tissue and other body fluids (**Figure 15**).

Nontyphoidal *Salmonella* (NTS) Serotypes and Antimicrobial Resistance

There were 60 nontyphoidal *Salmonella* isolates referred for serotyping at the reference laboratory. The most common NTS serotypes identified were *Salmonella enterica* serotype Enteritidis (21 isolates) and *Salmonella enterica* serotype Typhimurium (13 isolates) which were also the most commonly reported for the past 3 years. **Table 3** summarizes the serotype data for *Salmonella* referred isolates for 2016. Antimicrobial resistance for NTS varies by serotype. Overall changes in resistance among NTS may reflect changes in resistance within serotypes, changes in serotype distribution, or both.

For 2016, cumulative rates of resistance of all reported nontyphoid *Salmonella* are at 41.5% for ampicillin (n=188; 95% CI: 34.4-49.9); 22.5% for co-trimoxazole (n=182; 95% CI:16.8-29.4); 16.7% for chloramphenicol (n=174; 95% CI: 11.6-23.3); 12.8% for ciprofloxacin (n=187; 95% CI: 8.5-18.7) and 9.8% to ceftriaxone (n=194; 95% CI: 6.2-15.1) as seen in **Figure 16**. These rates did not differ significantly except for the statistically significant increase in rate of resistance against ampicillin from 28.9% in 2015 to 41.5% in 2016 (**Figures 17 & 18**). Although nalidixic acid resistance usually correlates with decreased susceptibility to ciprofloxacin (DSC) and fluoroquinolone treatment failure, there are increasing reports of NTS isolates with DSC that are susceptible to nalidixic acid which often indicates plasmid-related quinolone resistance. For 2016, NTS with DSC (i.e. intermediate or resistant MICs ($\geq 0.12 \mu\text{g/ml}$) for ciprofloxacin) was 42%.

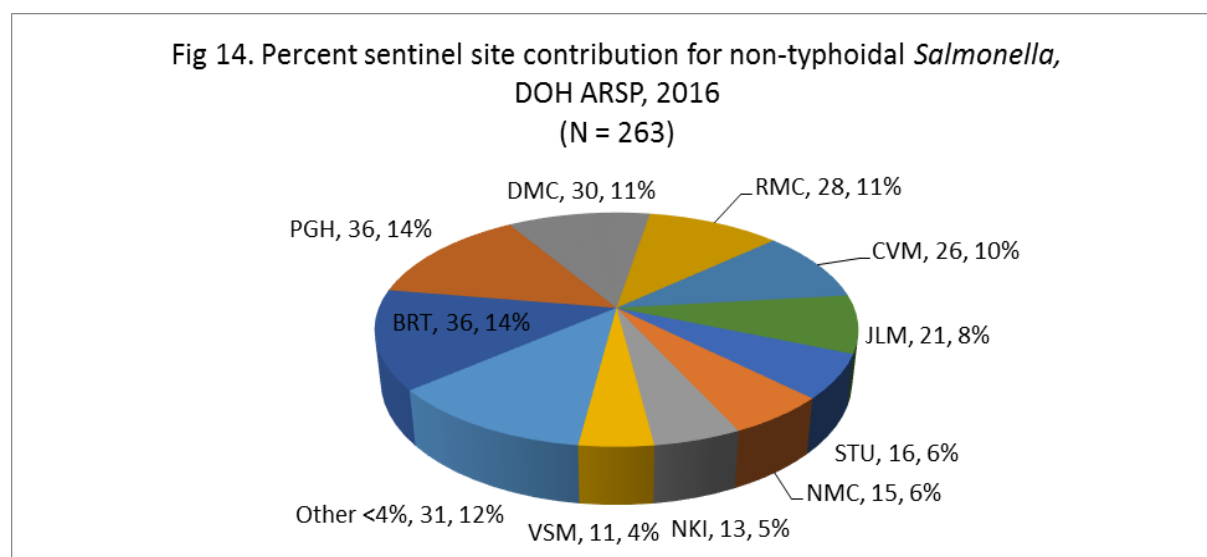


Fig 15. Distribution of non-typhoidal *Salmonella* by specimen type, DOH ARSP, 2016 (N = 263)

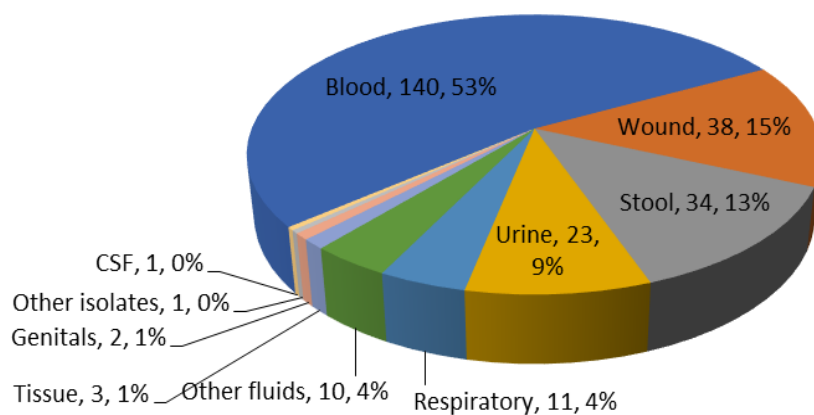
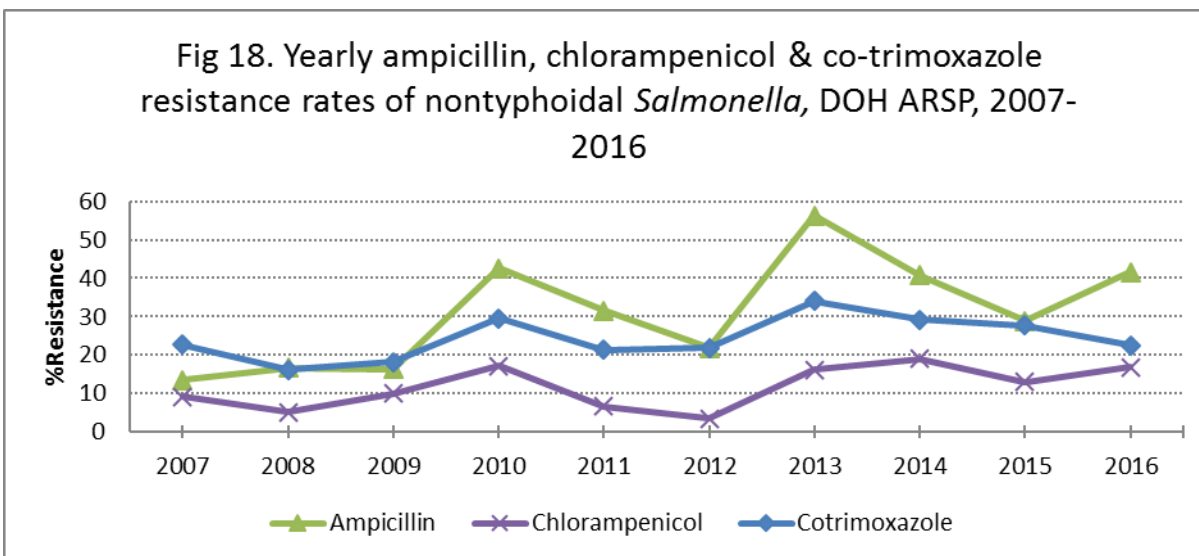
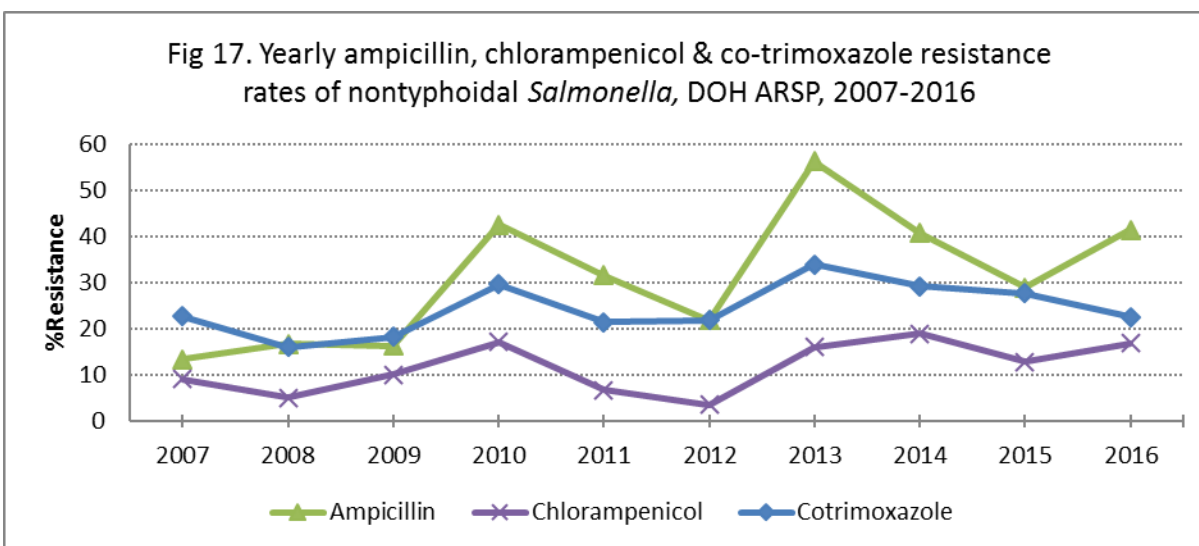
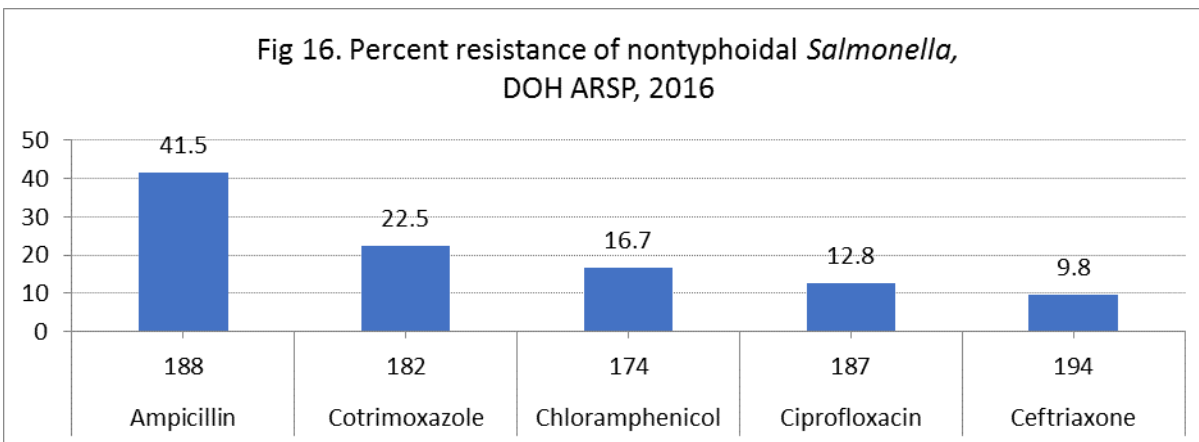


Table 3. Confirmed *Salmonellae* serotype, all ARSP sites, 2016

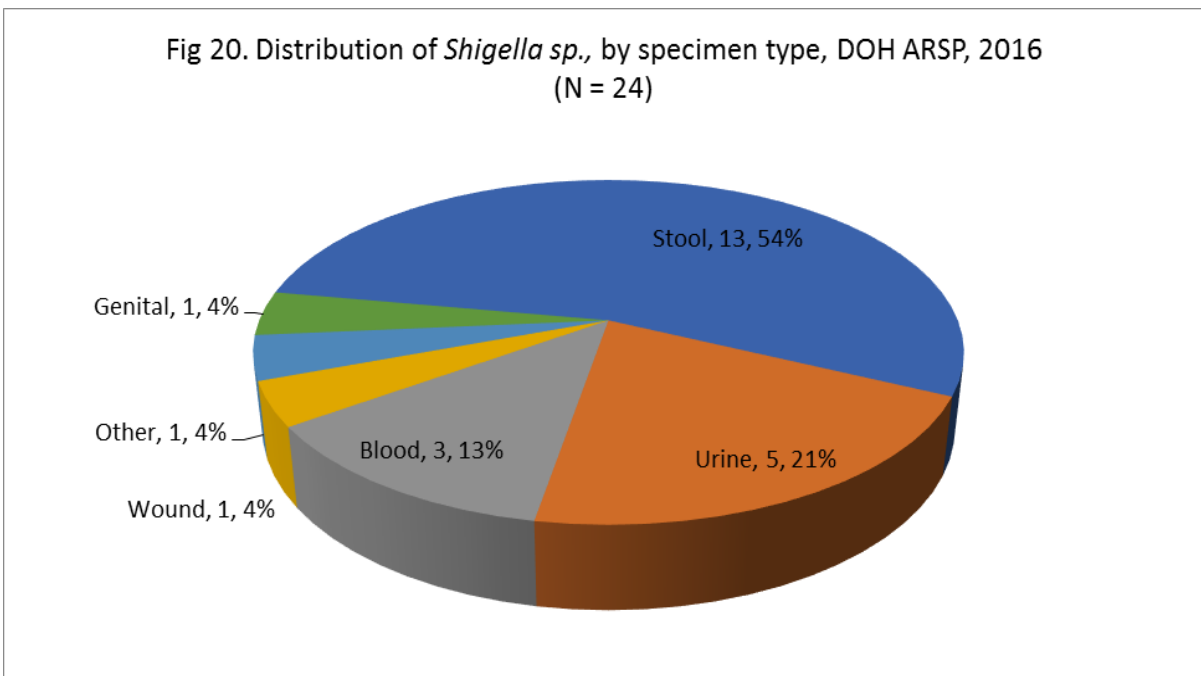
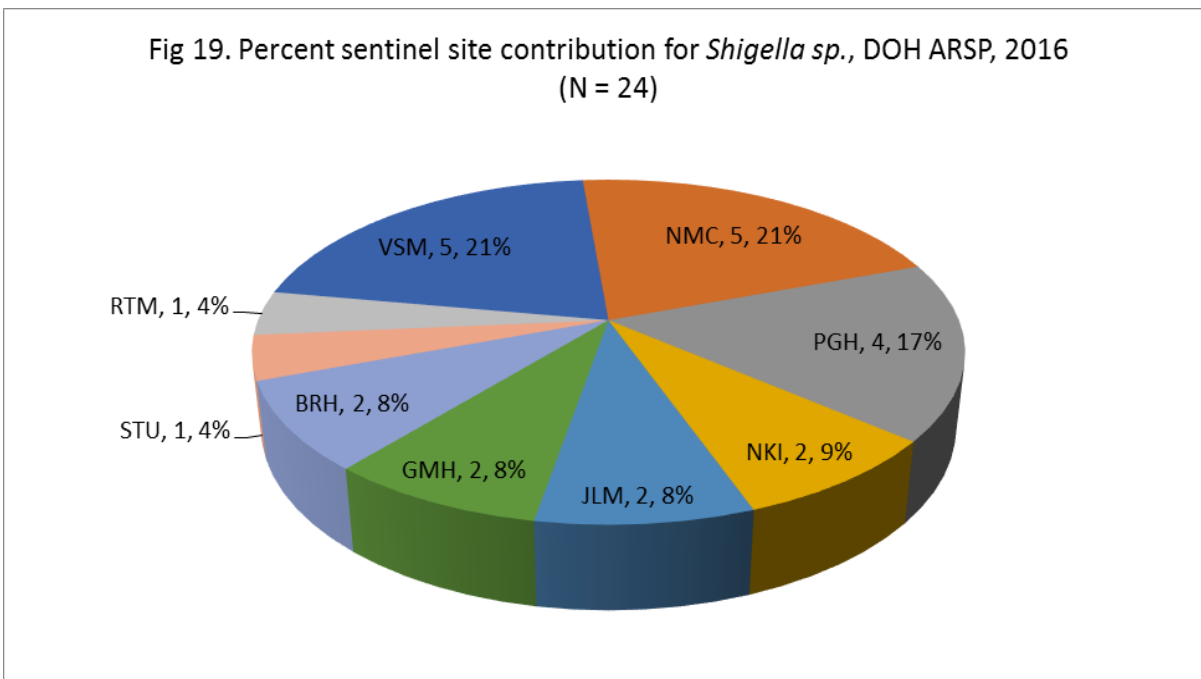
Organism	Number of isolates
<i>Salmonella</i> Typhi	119
<i>Salmonella</i> Enteritidis	21
<i>Salmonella</i> Typhimurium	13
<i>Salmonella</i> Anatum	4
<i>Salmonella</i> Virchow	4
<i>Salmonella</i> Heidelberg	2
<i>Salmonella</i> Weltevreden	2
<i>Salmonella</i> Bardo	1
<i>Salmonella</i> Bonn	1
<i>Salmonella</i> Choleraesuis var. Kunzendorf	1
<i>Salmonella</i> Group C	1
<i>Salmonella</i> Hillingdon	1
<i>Salmonella</i> Kentucky	1
<i>Salmonella</i> Lexington	1
<i>Salmonella</i> Mbandaka	1
<i>Salmonella</i> Newport	1
<i>Salmonella</i> Ohio	1
<i>Salmonella</i> Paratyphi A	1
<i>Salmonella</i> Paratyphi B	1
<i>Salmonella</i> Rissen	1
<i>Salmonella</i> Schwarzengrund	1
<i>Salmonella</i> species	1
<i>Salmonella</i> Stanley	1
Total	181



Shigella species

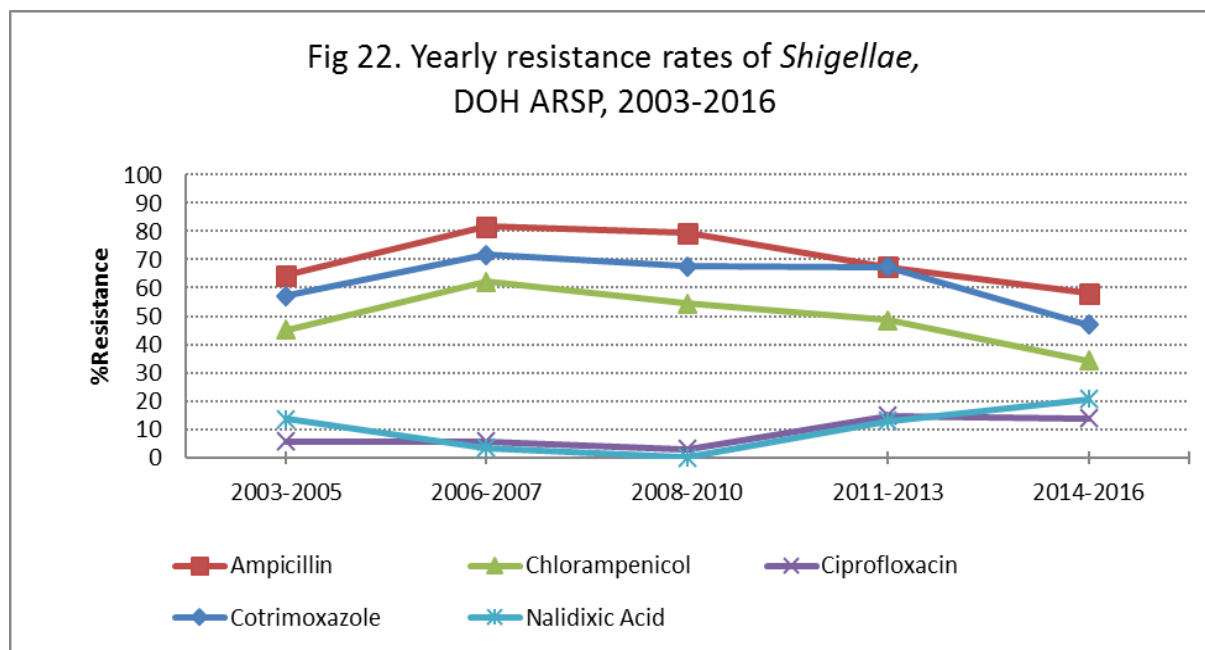
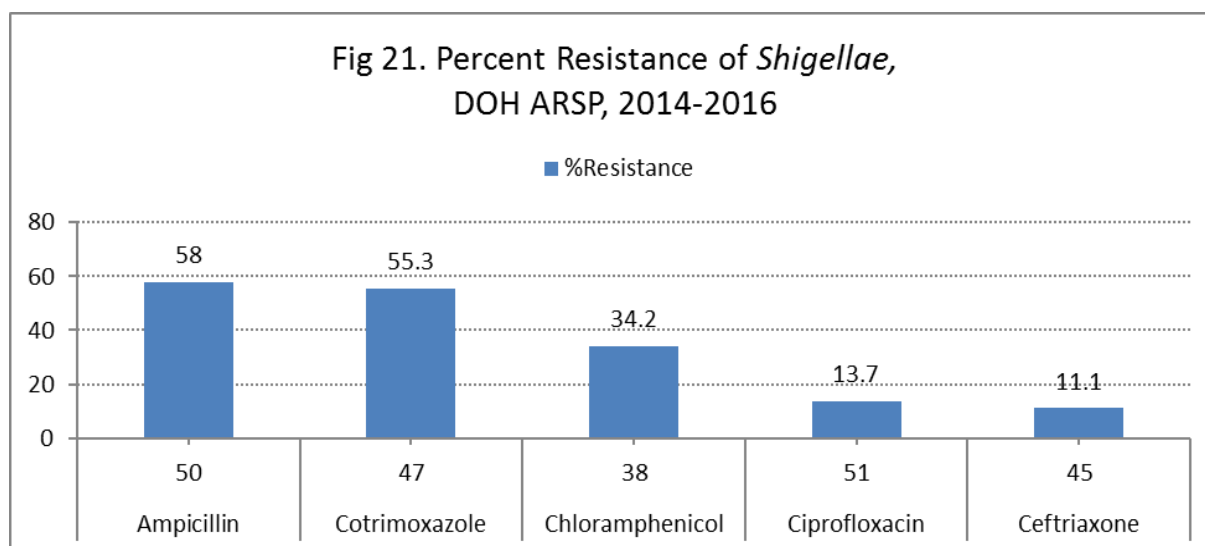
Isolates

For 2016, there were only 24 *Shigella* species isolates reported. Largest sentinel site contributors of the 2016 data were: VSM and NMC (5 isolates each) as seen in **Figure 19**. Most of the isolates were from stool specimens (**Figure 20**).



Antimicrobial Resistance

As there were very few *Shigella* isolates reported for 2016, we combined the results of isolates from 2014 to 2016 to obtain a reasonable statistical estimate of the cumulative percentage resistance for *Shigella* species. High rates of resistance to the previous first line agents against Shigellosis: ampicillin, cotrimoxazole and chloramphenicol is reported with cumulative 2014-2016 rates at 58% (n=50; 95% CI: 43.3-71.5); 55.3% (n=47; 95% CI: 40.2-69.5); and 34.2% (n=38; 95% CI: 20.1-51.4), respectively (**Figure 21**). Similarly, emerging resistance to newer agents is noted at 13.7% for ciprofloxacin (n=51, 95% CI: 6.1-26.8) and 11.1% for ceftriaxone (n=45; 95% CI: 4.2-24.8). When these cumulative 2014-2016 data are compared to that of the 2011-2013 reports, rates did not differ significantly (p value >0.05) as seen in **Figure 22**.



Vibrio cholerae

Isolates

There were only 39 (19 for 2015) isolates of *Vibrio cholerae* reported for 2016. The sentinel site MMH contributed majority (58%) of the *V. cholerae* 2016 isolates (**Figure 23**). Most of the isolates were from stool specimens (**Figure 24**).

Fig 23. Percent sentinel site contribution for *Vibrio cholerae*, DOH ARSP, 2016 (N = 39)

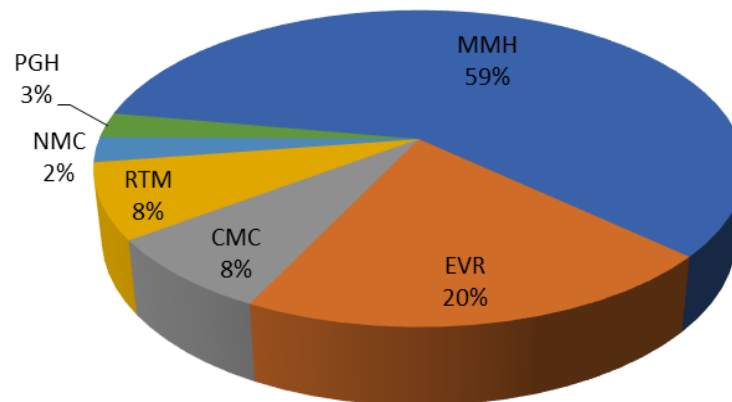
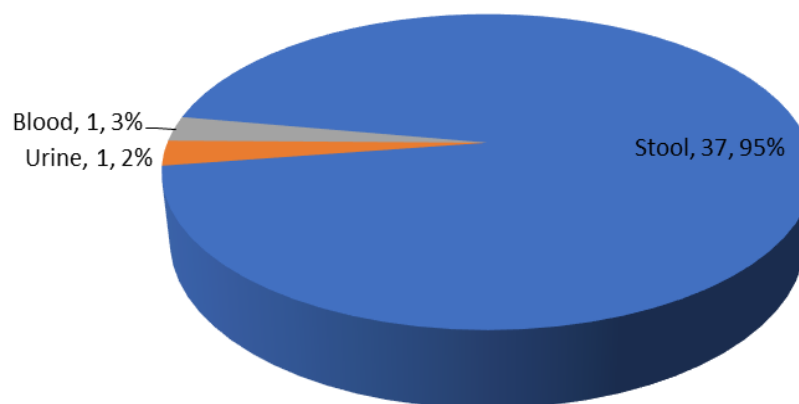
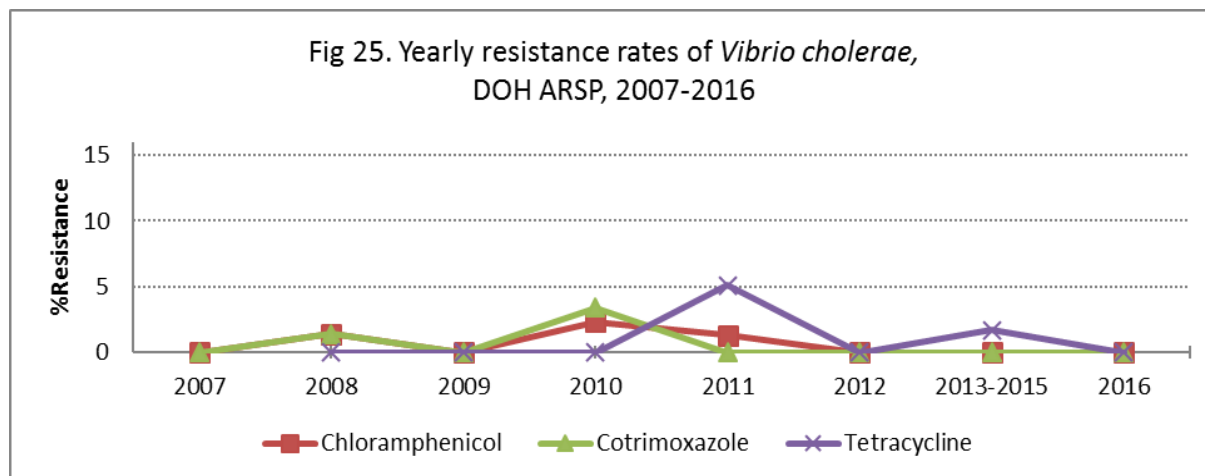


Figure 24. Distribution of *Vibrio cholerae* by specimen type, DOH ARSP, 2016 (N = 39)



Antimicrobial Resistance

As in the past years, *V. cholerae* isolates have remained susceptible to co-trimoxazole, chloramphenicol and tetracycline with no reported chloramphenicol, co-trimoxazole and tetracycline resistant isolate for 2016. These rates have remained stable for the past 10 years, with reported rates against each of these 3 antibiotics at 5% or less since 2007 (**Figure 25**).



*Neisseria gonorrhoeae***Isolates**

There were 200 (2015= 84) *Neisseria gonorrhoeae* isolates reported for 2016. This was more than twice of that reported in 2015. The largest contributors of the 2016 *N. gonorrhoeae* data were BGH (105 isolates), RTM (31 isolates) and RTH (25 isolates). Percent sentinel site contribution of 2016 *N. gonorrhoeae* data and specimen type distribution are depicted in **Figures 26 and 27**.

Antimicrobial Resistance

Rates of resistance against penicillin have been at least 80% for the past decade with 2016 resistance rate at 93.9% (n=198; 95% CI:89.4-96.7). Similarly, resistance of gonococci against ciprofloxacin and tetracycline remain high at 72.2% (n=198; 95% CI: 65.3-78.2) and 44.9% (n=178; 95% CI: 37.5-52.5), respectively as seen in **Figure 28**. These rates do not differ significantly from the 2013-2014 combined data except for the statistically significant decrease in resistance rate for tetracycline from 65% in 2015 (n=80) to 44.9% in 2016 (n=178) (**Figure 29**). There was no reported spectinomycin-resistant gonococcal isolate for the 2016 data, as in the past years.

For 2016, there were no cefixime non-susceptible isolates reported (100% of the 193 isolates tested as susceptible). Comparatively, for ceftriaxone there was 1 isolate reported as ceftriaxone non-susceptible (MIC > 0.25 ug/ml) and 2 more isolates qualified as ceftriaxone reduced susceptibility (MIC ³ 0.15 ug/ml) *N. gonorrhoeae* out of the 198 isolates tested.

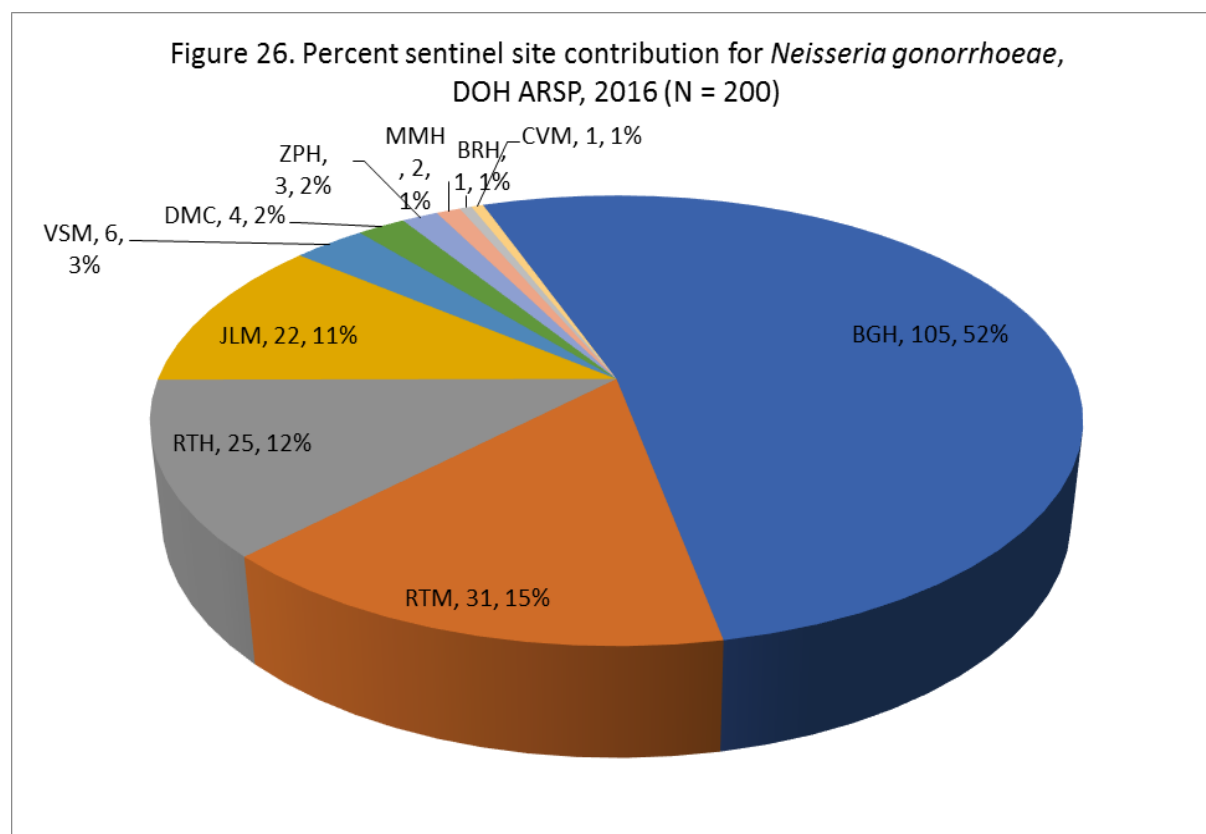


Figure 27. Distribution of *Neisseria gonorrhoeae* by specimen type, DOH ARSP, 2016 (N = 200)

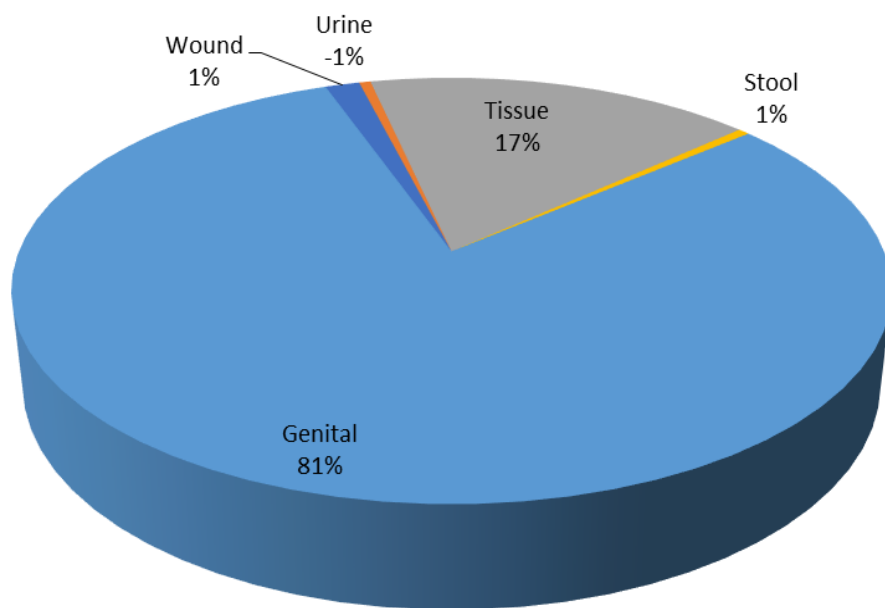
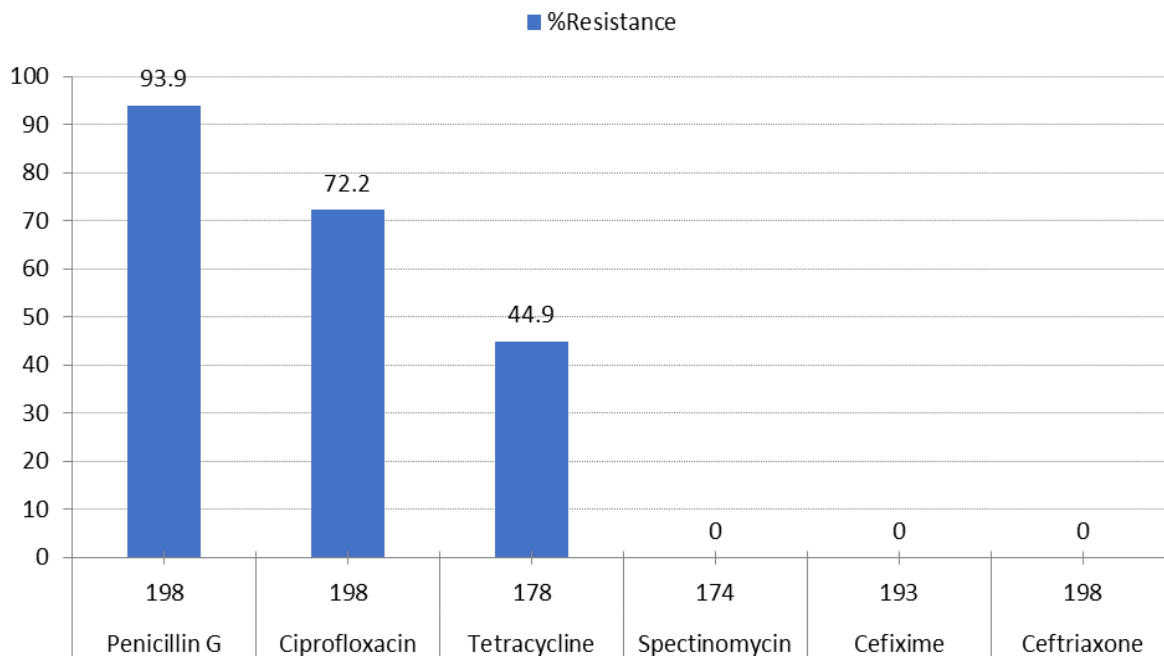
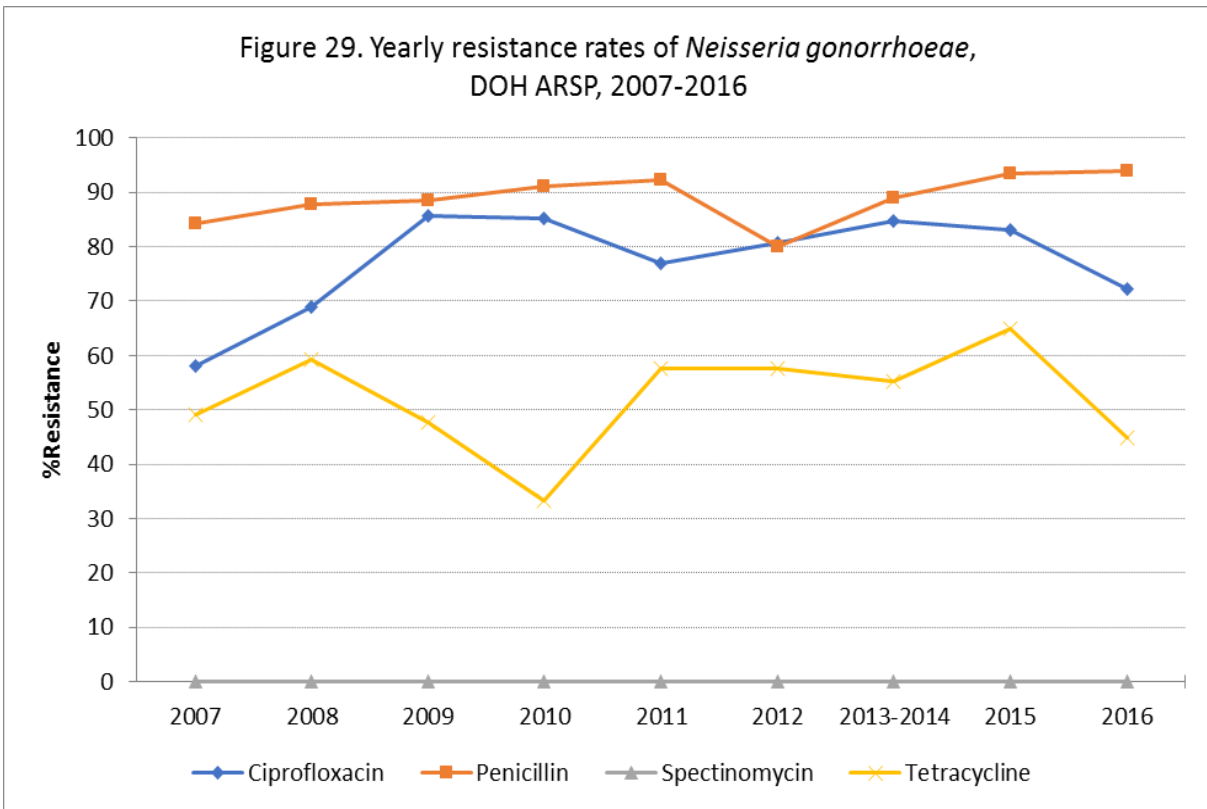


Figure 28. Percent resistance of *Neisseria gonorrhoeae*, DOH ARSP, 2016

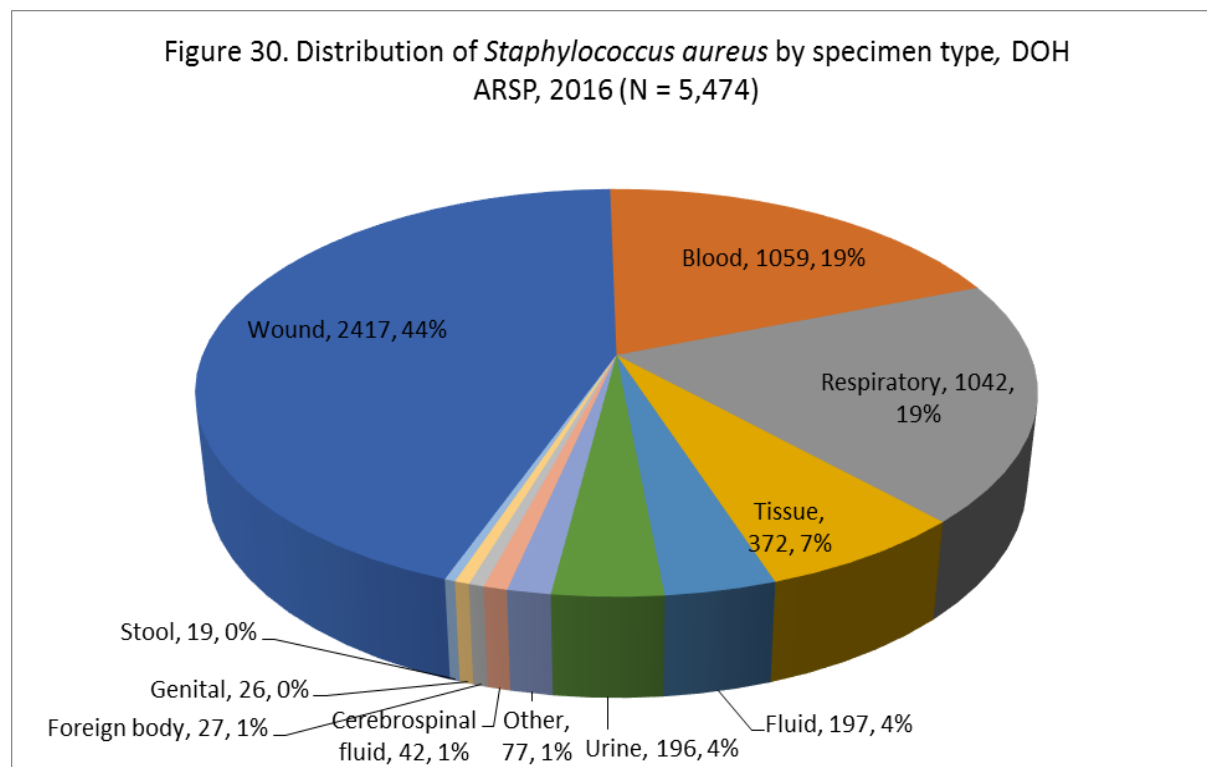




Staphylococcus aureus

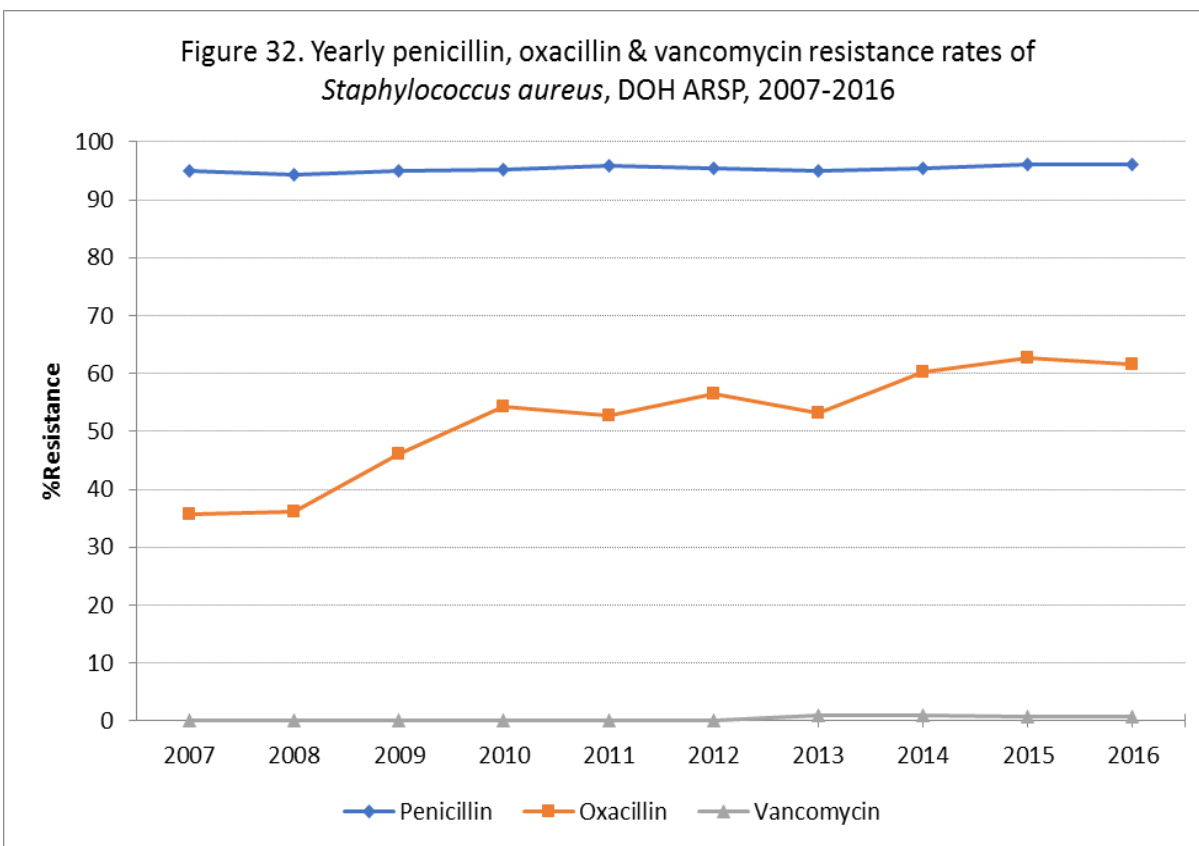
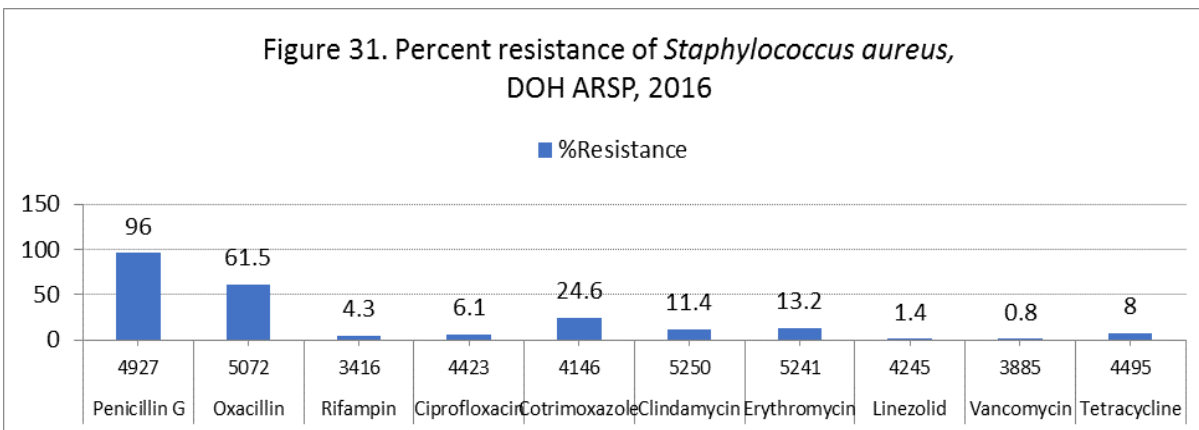
The Isolates

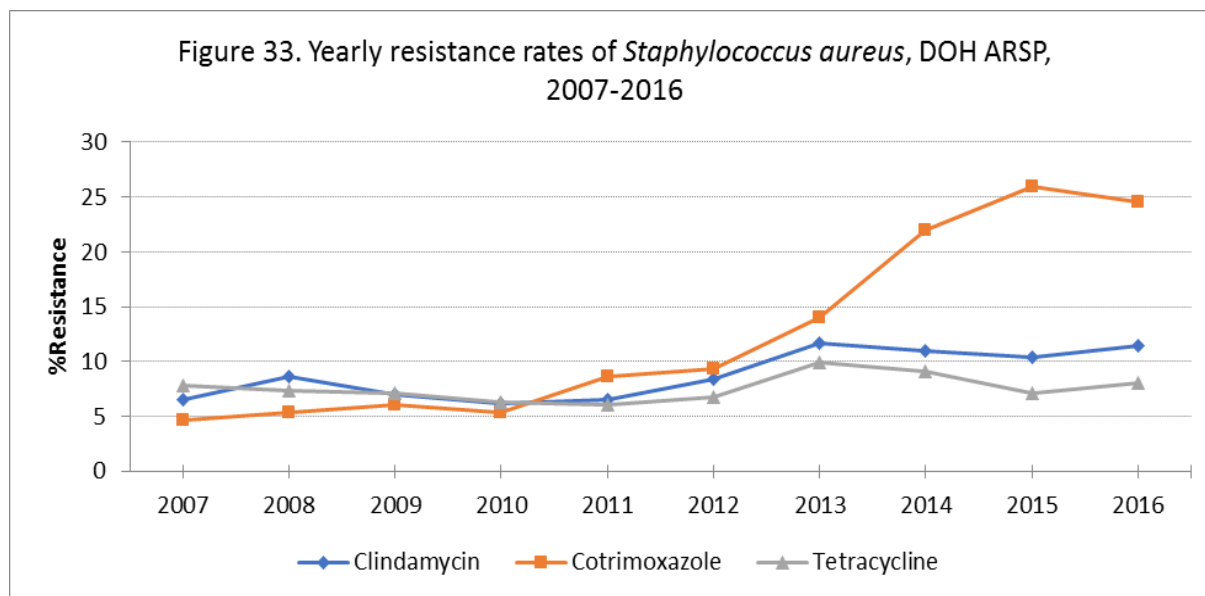
For 2016, there were a total of 5,474 isolates of *Staphylococcus aureus* reported. These were most commonly isolated from cutaneous/wound, blood and respiratory specimens (**Figure 30**). *S. aureus* was the most common isolate from cutaneous or wound specimens for 2016.



Antimicrobial Resistance

The 2016 cumulative methicillin-resistant *S. aureus* rate is at 61.5% (n=5,072; 95% CI: 61-64.2). This reported MRSA rate for 2016 did not differ significantly from the 2015 MRSA rate of 62.6%. *S. aureus* rates of resistance against the other antibiotics tested are as follows: 96% for penicillin (n=4,927; 95% CI: 95.3-96.6); 24.6% for co-trimoxazole (n=4,146; 95% CI: 24.4-27.4); 11.4% for clindamycin (n=5,250; 95% CI: 9.5-11.4); 13.2% for erythromycin (n=5,241; 95% CI: 10-12.1); 4.3% for rifampicin (n=3,416; 95% CI: 4.1-5.8); and 8% for tetracycline (n=4,495; 95% CI: 6.3-8). Although there were also several isolates reported as either linezolid (1.4% resistant; n=4,245; 95% CI: 1.3-2.3); or vancomycin resistant (0.8% resistant; n=3,885; 95% CI: 0.4-1.1). Only 1 linezolid resistant isolate from the sentinel sites was sent to the reference laboratory for confirmatory testing where it was confirmed as both oxacillin and linezolid resistant and tested intermediate against vancomycin. None of the reported vancomycin resistant *S. aureus* isolates were sent for confirmatory testing at the reference laboratory. Resistance rates for *S. aureus* isolates against commonly used antibiotics for 2016 and for the past 10 years are illustrated in **Figures 31 to 33**.

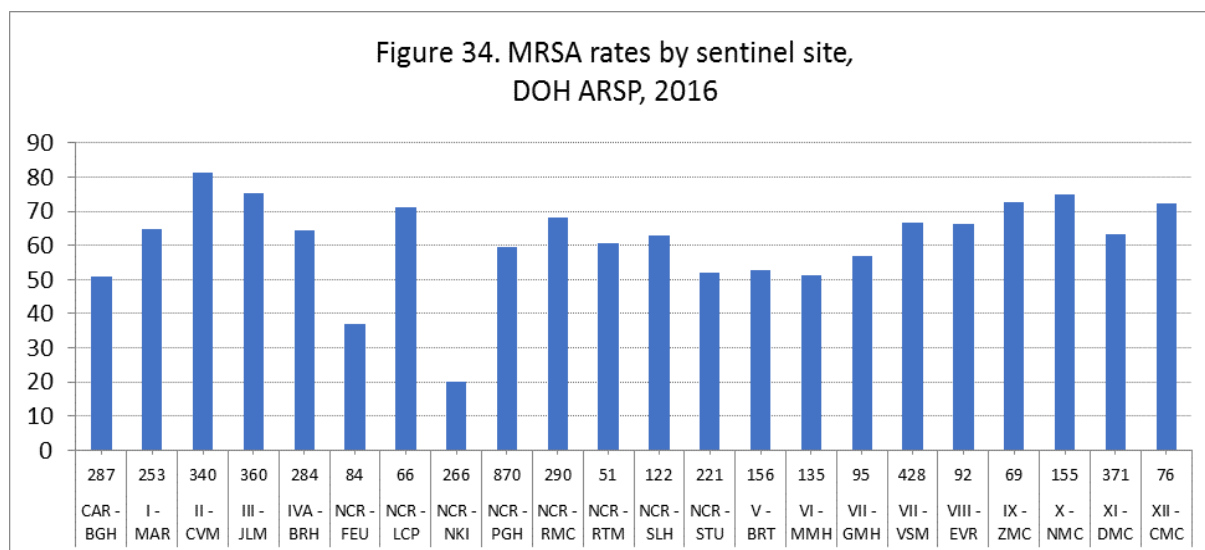


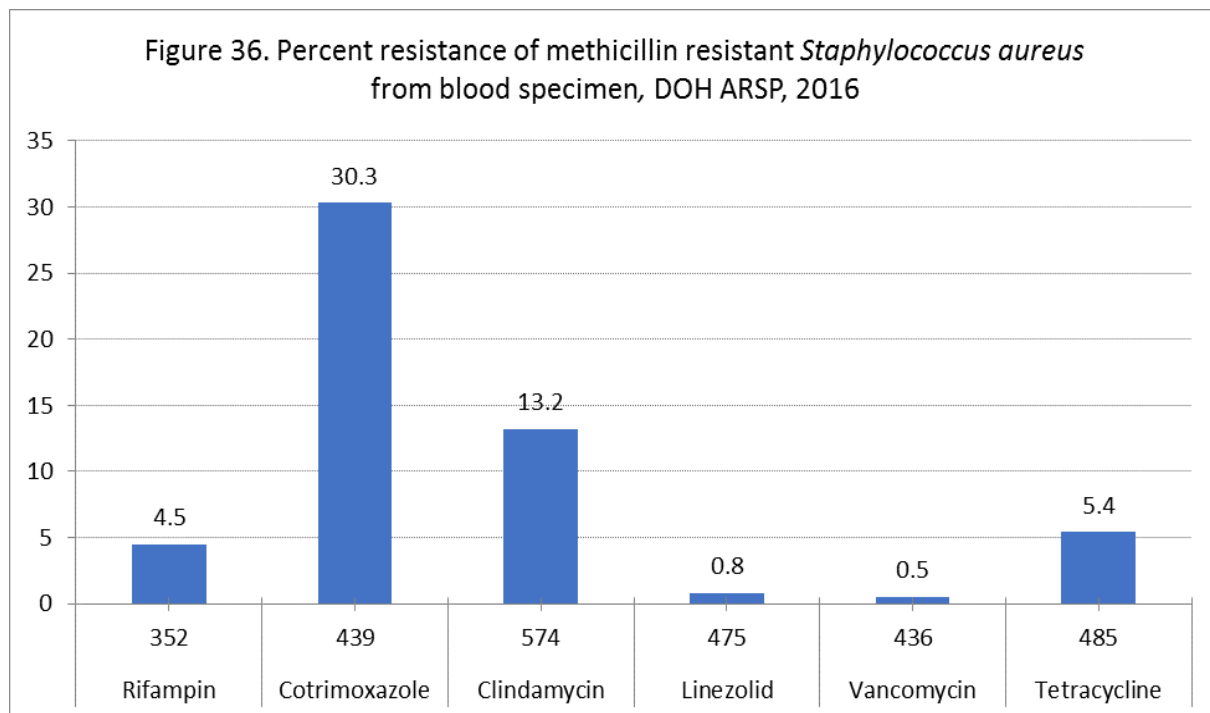
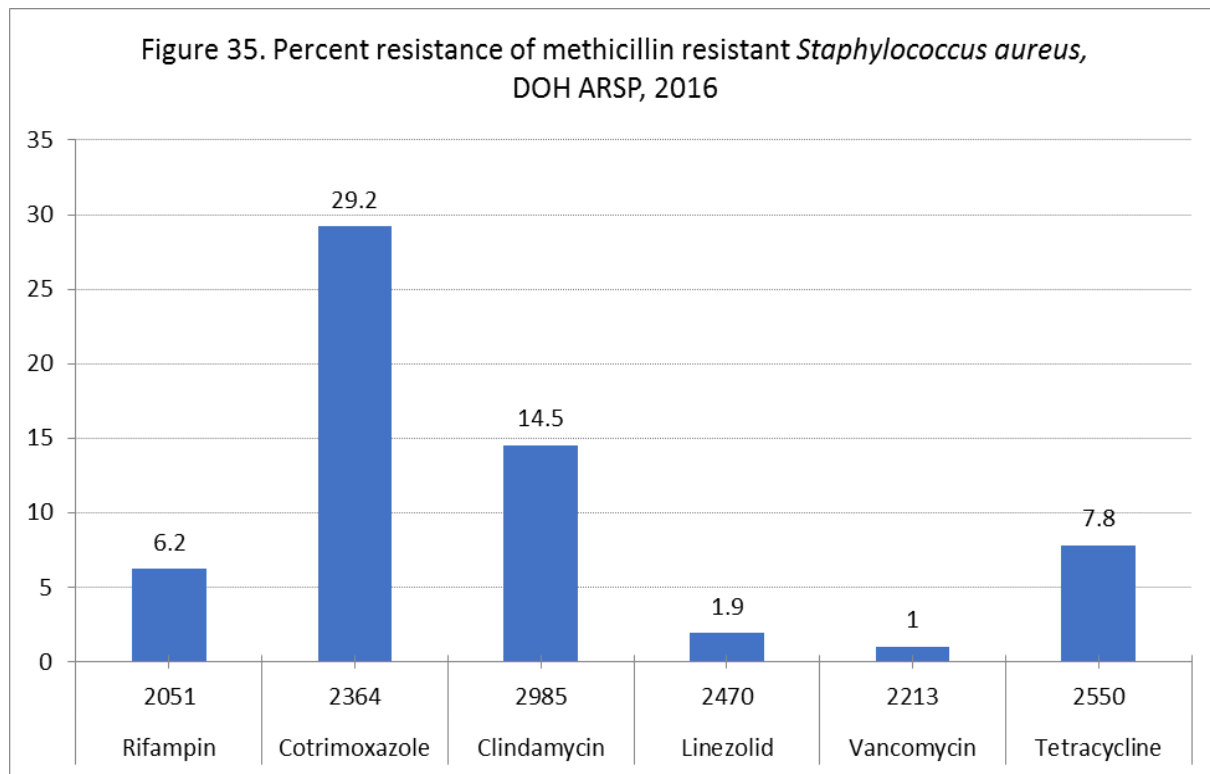


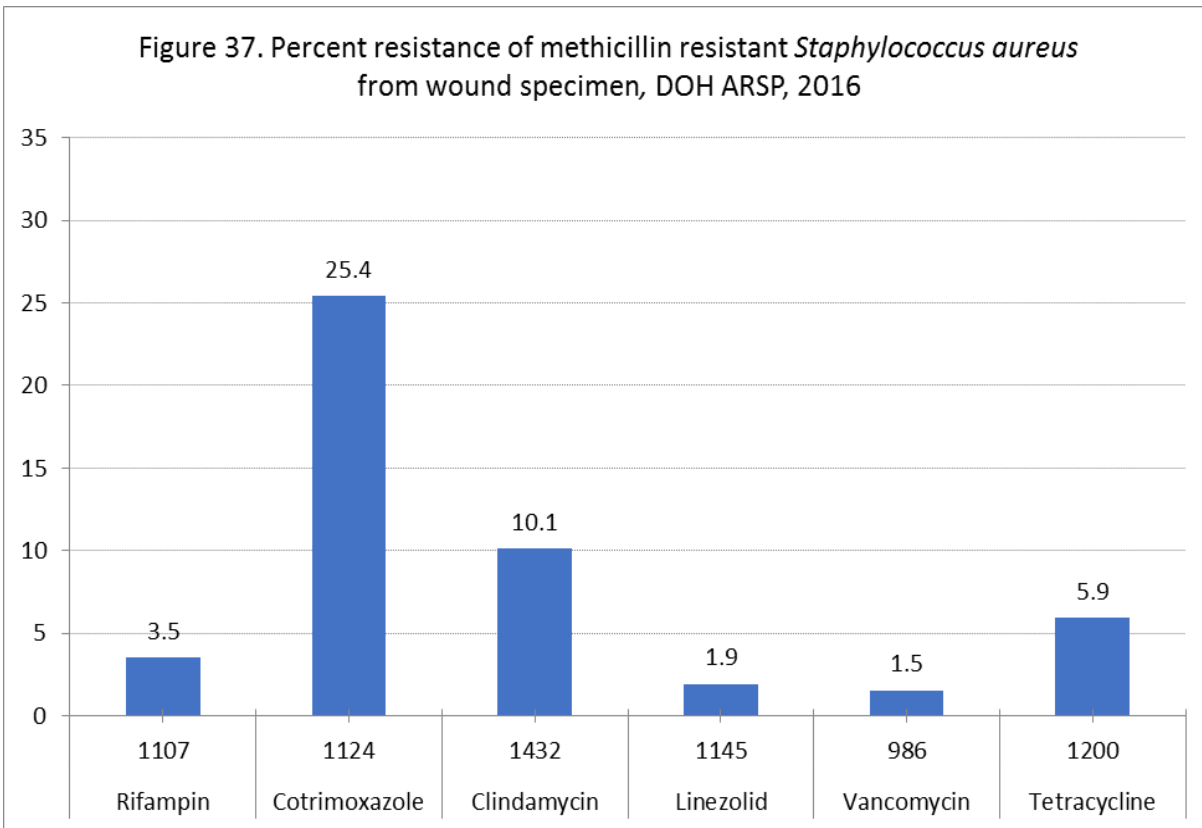
Methicillin resistant *Staphylococcus aureus*

There were 3,119 MRSA isolates reported from the ARSP sentinel sites for 2016. Most of these isolates were isolated from cutaneous and blood culture isolates. The overall cumulative MRSA rate for 2016 was at 61.5% with variations by sentinel site MRSA rates ranging from as low as 19.9% (NKI, n=266) to as high as 81.5% (CVM, n=340) as depicted in **Figure 34**.

MRSA rates for 2016 were also analyzed by specimen type with 60% MRSA rates in the subset of invasive (blood culture) isolates (n=1,129) and 67% MRSA rates in the subset collected from skin and wound specimens (n=2,495). Most of these MRSA isolates (58%) were also presumptively community-acquired or isolated from specimens taken from patients in the outpatient department, emergency room and admission within their 1st 2 hospital days. Rates of resistance of these subsets of MRSA isolates as seen in **Figure 35-37**.







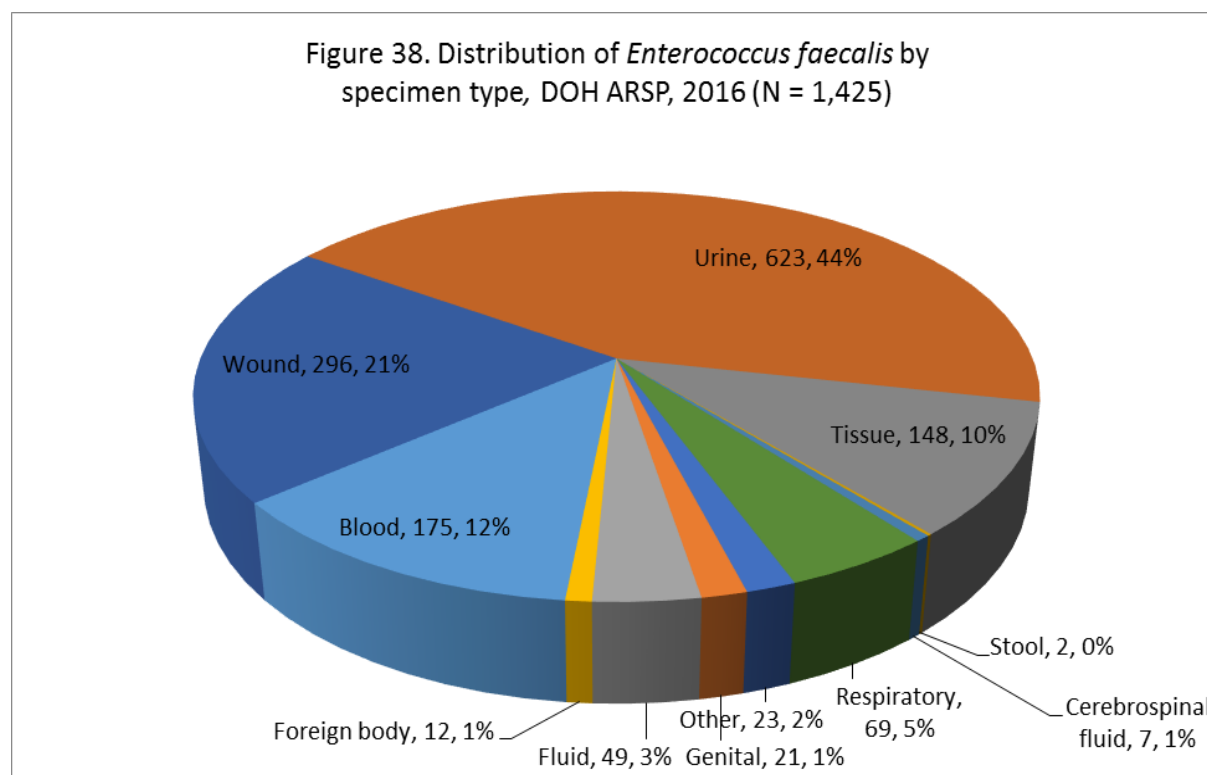
Enterococci

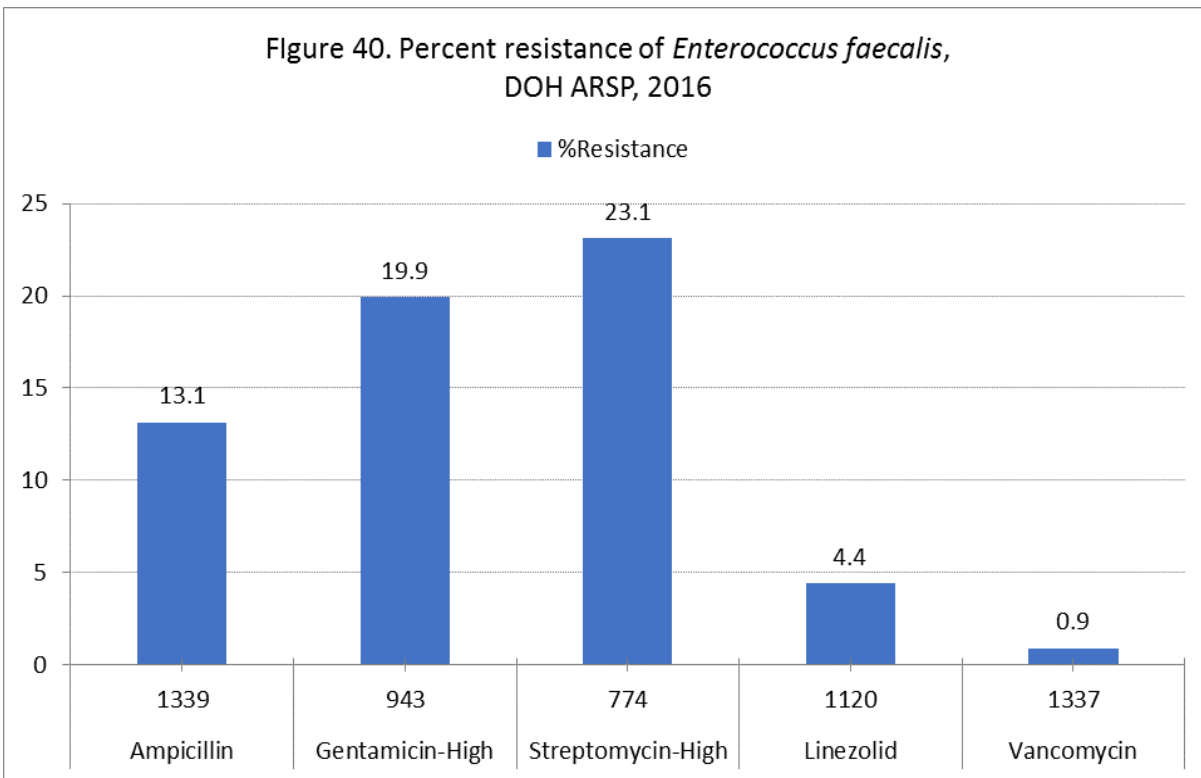
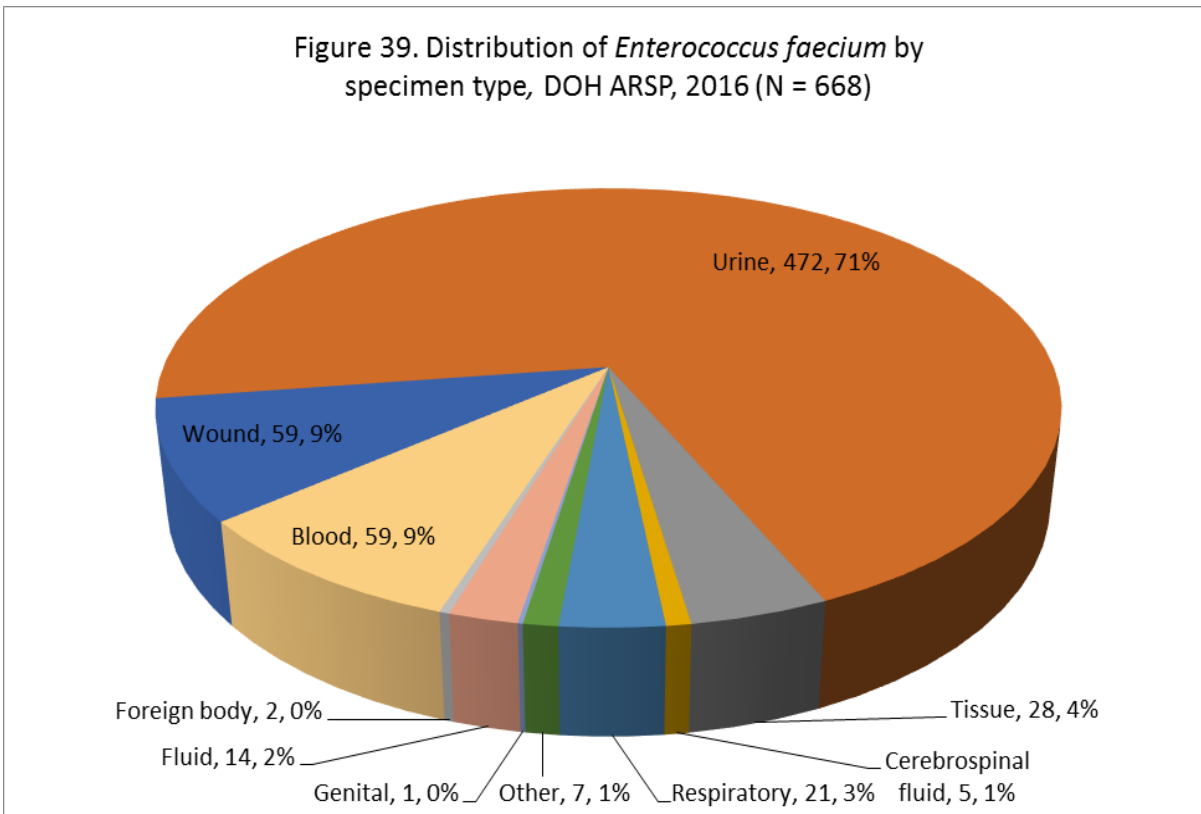
The Isolates

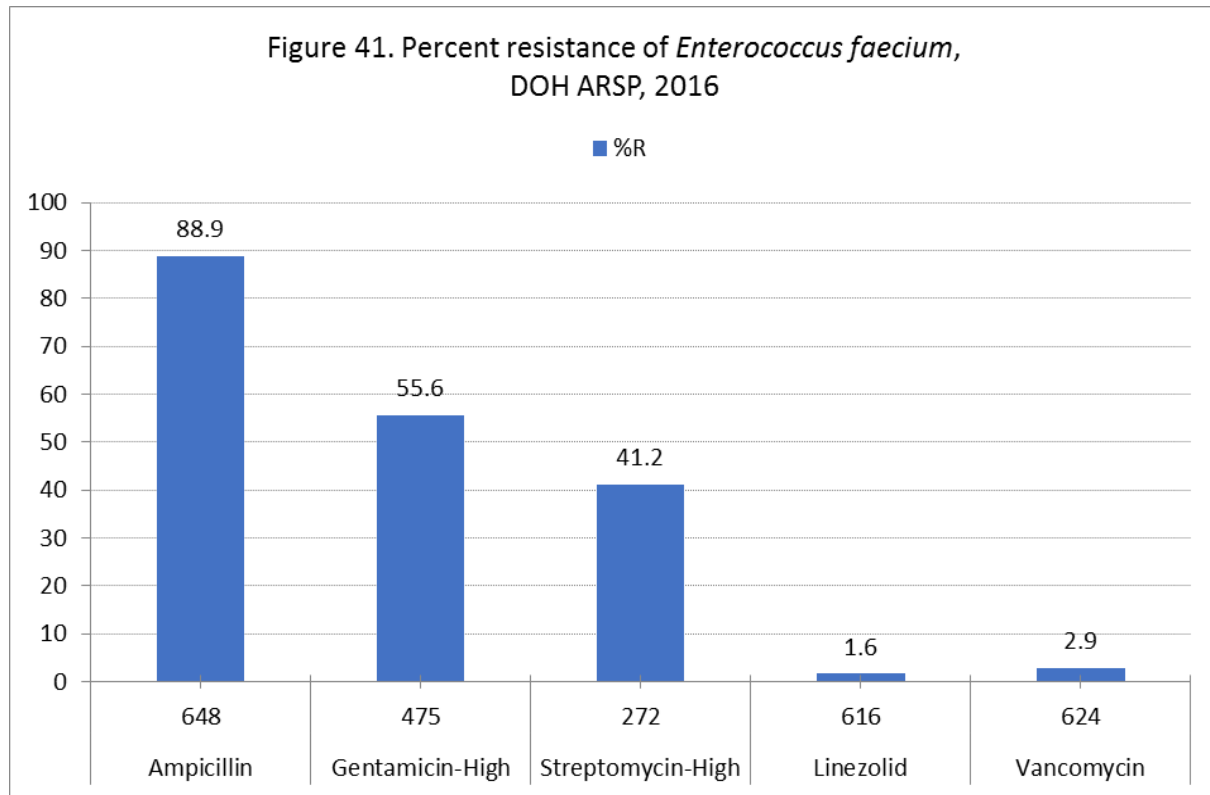
For 2016, there were a total of 2,554 *Enterococcus* species reported of which the commonest were *Enterococcus faecalis* (1,425 isolates) and *Enterococcus faecium* (668 isolates). Most of the 2016 *E. faecalis* were isolated from urine (623 isolates), wound (296 isolates) and blood (175 isolates) specimens. Similarly, 2016 *E. faecium* was most commonly isolated from urine (472 isolates), wound (59 isolates) and blood (59 isolates) specimens (**Figures 38-39**).

Antimicrobial Resistance

For 2016, ampicillin resistance among *E. faecalis* was at 13.1% (n=1,339; 95% CI: 11.4-15.1). Comparatively, ampicillin-resistance against *E. faecium* was reported higher at 88.9% (n=648; 95% CI: 86.2-91.2). Testing for high-level aminoglycoside resistance identifies loss of the synergistic effect of aminoglycosides with β -lactams and glycopeptides when treating enterococcal infections. For 2016, high level gentamicin and streptomycin resistance for *E. faecalis* was at 19.9% (n=943; 95% CI: 17.4-22.6); and 23.1% (n=774; 95% CI: 20.5-26.6), respectively. Similarly, higher high-level gentamicin and streptomycin rates of resistance were seen with *E. faecium* with reports at 55.6% (n=475; 95% CI: 51-60.1) and 41.2% (n=272; 95% CI: 35.3-47.3), respectively. Resistance rates against linezolid and vancomycin were reported at 4.4% (n=1,120; 95% CI: 3.3-5.8) and 0.9% (n=1,337; 95% CI: 0.5-1.6) respectively for *E. faecalis*; and 1.6% (n=616; 95% CI: 0.8-3.0) and 2.9% (n=624; 95% CI: 1.8-4.6) respectively for *E. faecium*. The 2016 rates of resistance of *E. faecalis* and *E. faecium* are seen in **Figures 40 and 41**, respectively.







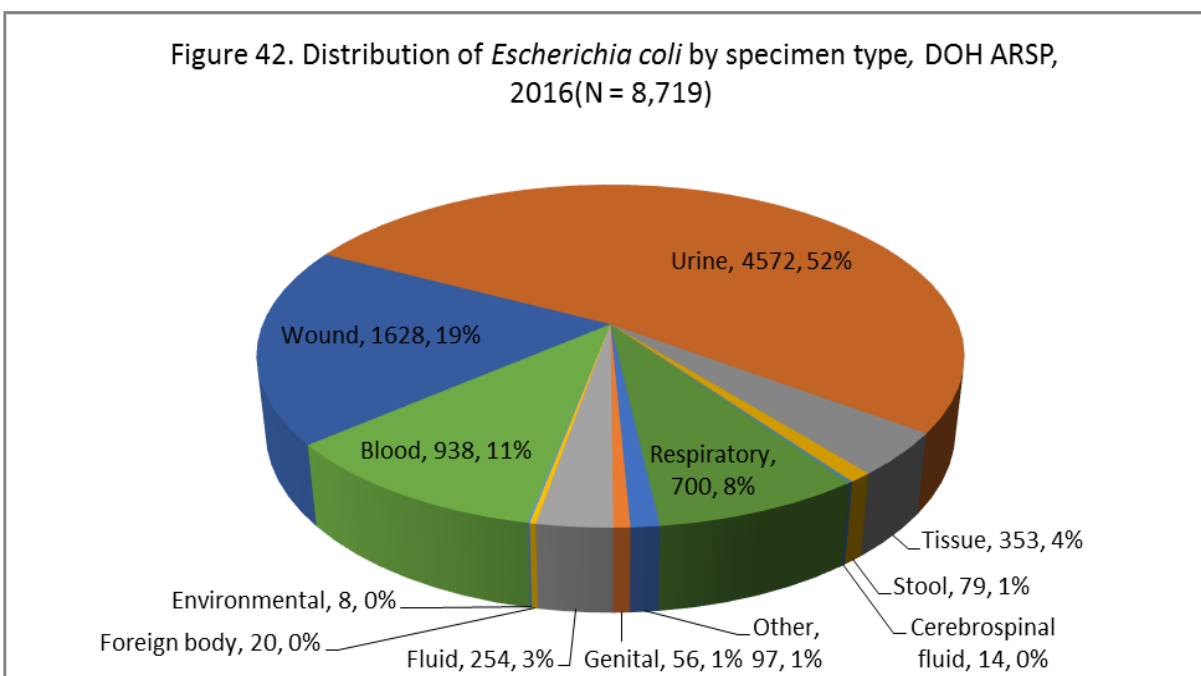
Escherichia coli

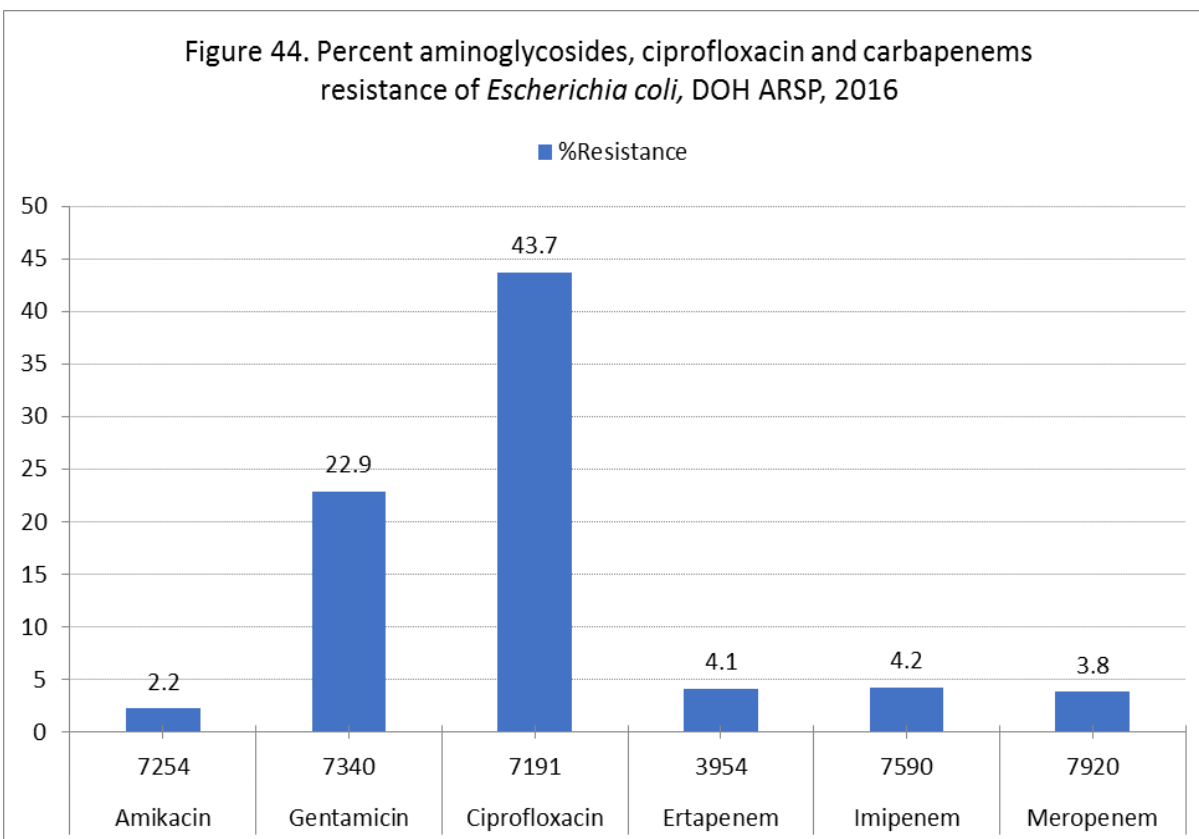
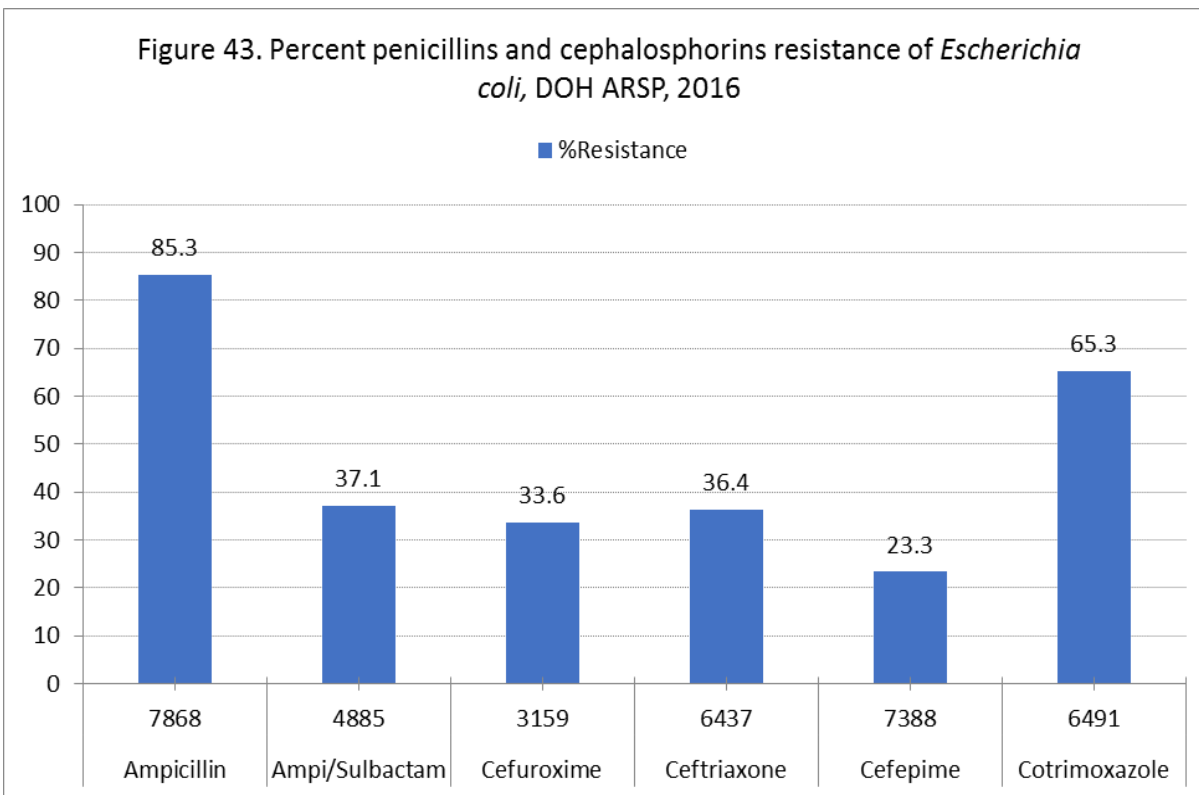
The Isolates

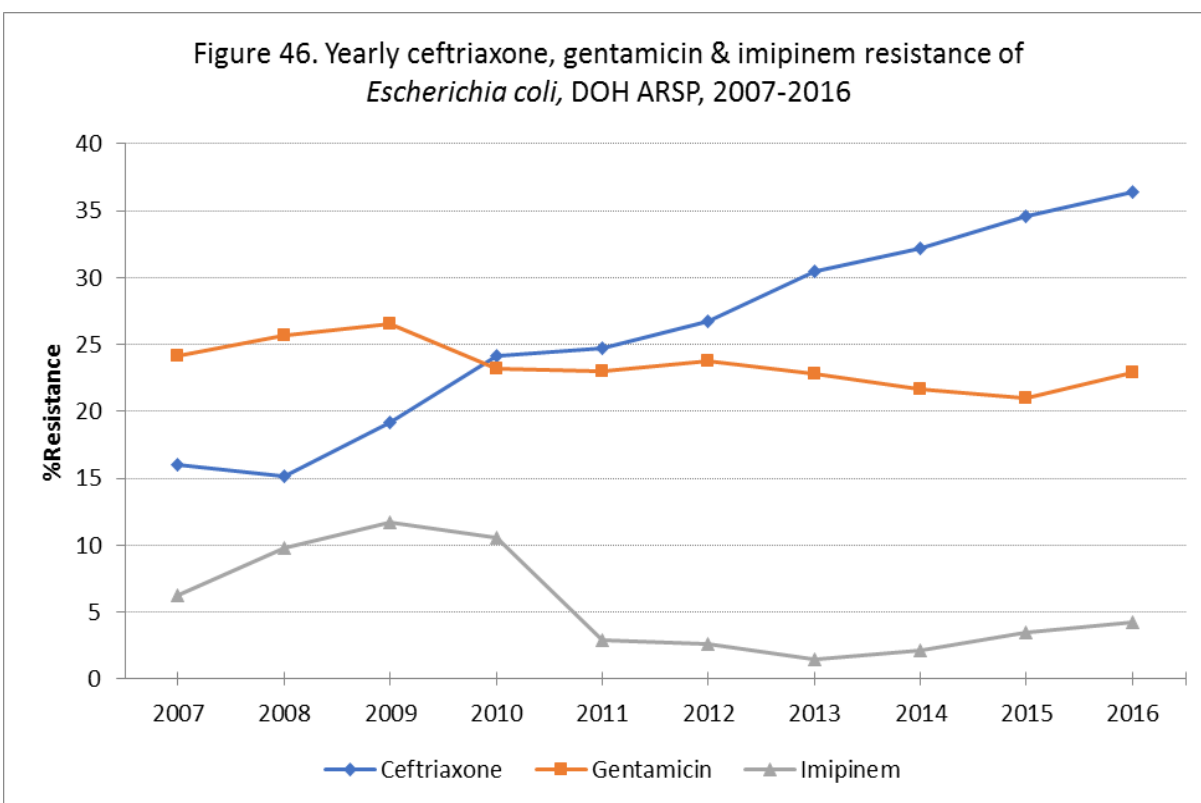
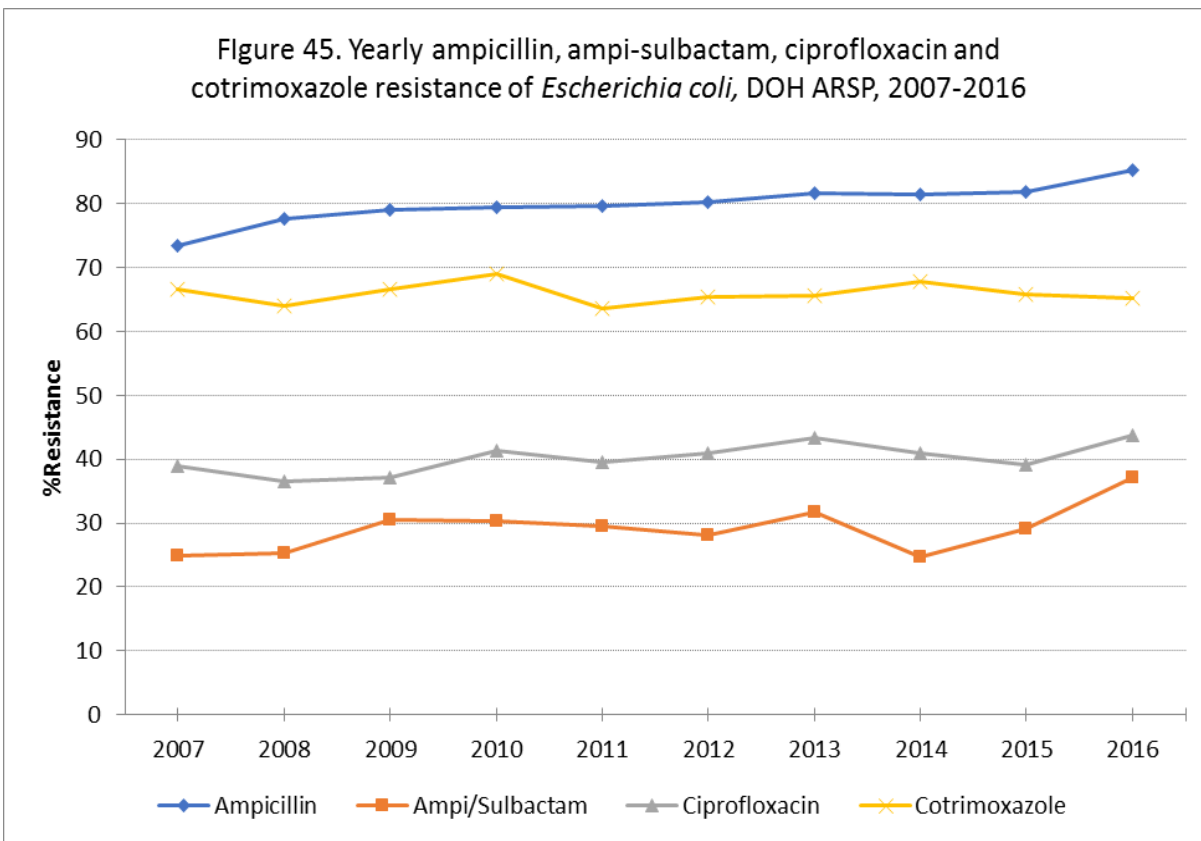
A total of 8,719 *Escherichia coli* isolates were reported for 2016. Majority of the isolates were from urine specimens (52%). Others were isolated from wound, respiratory, blood, tissue and other body fluids (Figure 42).

Antimicrobial Resistance

2016 *E. coli* rates of resistance are as follows: 85.3% for ampicillin (n=7,868; 95% CI: 84.5-86.1); 37.1% for ampicillin-sulbactam (n=4,885; 95% CI: 35.7-38.5); 33.6% for cefuroxime (n=3,157; 95% CI: 32.0-35.3); 36.4% for ceftriaxone (n=6,437; 95% CI: 35.2-37.6); 23.3% for cefepime (n=7,388; 95% CI: 22.3-24.3); 65.3% for co-trimoxazole (n=6,491; 95% CI: 64.1-66.5); 2.2% for amikacin (n=7,254; 95% CI: 1.9-2.6); 22.9% for gentamicin (n=7,340; 95% CI: 21.9-23.9); 43.7% for ciprofloxacin (n=7,191; 95% CI: 42.6-44.9); 4.1% for ertapenem (n=3,954; 95% CI: 3.5-4.8); 4.2% for imipenem (n=7,590; 95% CI: 3.8-4.7); and 3.8% for meropenem (n=7,920; 95% CI: 3.4-4.3). These rates when compared to that of 2015 showed statistically significant increase in resistance from 81.8% in 2015 to 85.3% in 2016 for ampicillin (p= 0.0001); from 29.1% in 2015 to 37.1% in 2016 for ampicillin-sulbactam (p= 0.0001); 39.2% in 2015 to 43.7% in 2016 for ciprofloxacin (p=0.0001); 21% in 2015 to 22.9% in 2016 for gentamicin (p=0.0094); and from 3.5% in 2015 to 4.2% in 2016 for imipenem (p= 0.0398). In contrast, 2015 and 2016 resistance rates for co-trimoxazole and ceftriaxone when compared did not differ significant (p value >0.05). Resistance rates for 2016 and the past 10 years to the antimicrobial agents tested against *E. coli* are seen in Figures 43-46.

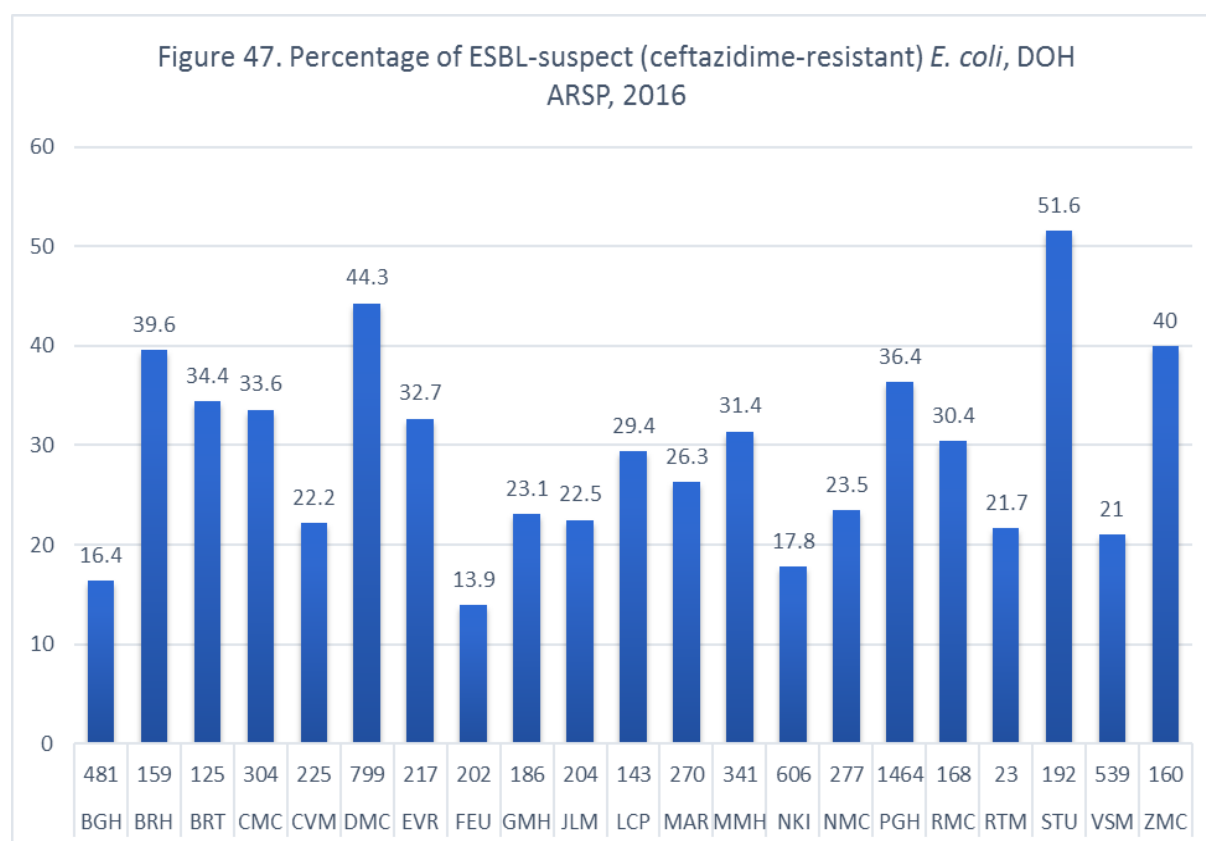






Extended-spectrum β -lactamase-producing *Escherichia coli*

Extended-spectrum β -lactamases (ESBLs) are enzymes that mediate resistance to extended-spectrum cephalosporins and monobactams but do not affect cephamycins or carbapenems.⁷ Using ceftazidime disk diffusion as initial screening for ESBL production, out of 7,085 *E. coli* isolates tested, 30% screened positive (ESBL suspect). ESBL-suspect *E. coli* rates varied by sentinel sites from as low as 13.9% (FEU) to as high as 51.6% (STU) as seen in **Figure 47**.



Urinary *Escherichia coli*

There were 4,572 urinary *Escherichia coli* isolates reported for 2016 making this organism the most common bacterial isolate from urine specimens. Resistance data of outpatient urinary *E. coli* isolates against commonly used oral antibiotics for urinary tract infections showed lowest resistance rate against nitrofurantoin at 4.4% (n=614 urinary isolates tested). In the subset of urinary *E. coli* isolated from admitted or hospitalized patients, rates of resistance against commonly used parenteral antibiotics for urinary tract infection was lowest against ertapenem at 5.1% (n=982 urinary isolates tested) and amikacin at 2.4% (n=2,293 urinary isolates tested). Percentage resistance of 2016 urinary *E. coli* isolates against the panel of antimicrobials are summarized in **Table 4**.

Table 4. Percentage of urinary *Escherichia coli*, all ARSP sites, Jan-Dec 2016

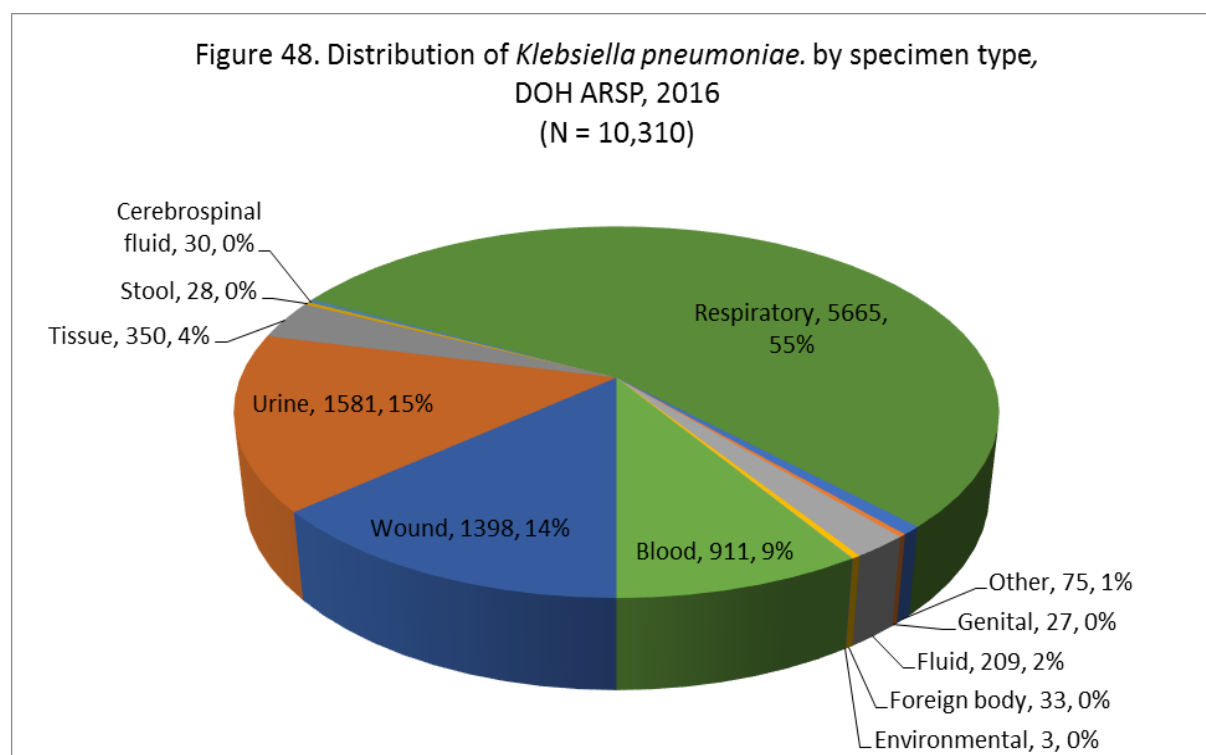
Antimicrobial	Outpatient			Inpatient		
	N	%R	95%C.I.	N	%R	95%C.I.
Oral Agents						
Ampicillin	879	84.4	81.8-86.7	2446	86.1	84.7-87.4
Co-amoxiclav	880	28.8	25.9-31.9	2388	39.6	37.6-41.6
Cefuroxime	359	39.3	34.3-44.6	803	41.7	38.3-45.2
Ciprofloxacin	809	52.2	48.7-55.7	2310	45.5	43.5-47.6
Co-trimoxazole	762	63.5	60.0-66.9	2148	68.7	66.7-70.6
Nitrofurantoin	614	4.4	3.1-6.7	1297	4.1	3.2-5.5
Intravenous Agents						
Piperacillin/Tazobactam	888	7.4	5.8-9.4	2337	12.5	11.2-13.9
Ceftriaxone	778	38.7	35.3-42.2	1824	44.8	42.5-47.1
Ertapenem	421	2.9	1.6-5.1	982	5.1	3.8-6.7
Amikacin	742	1.5	0.8-2.7	2293	2.4	1.8-3.1

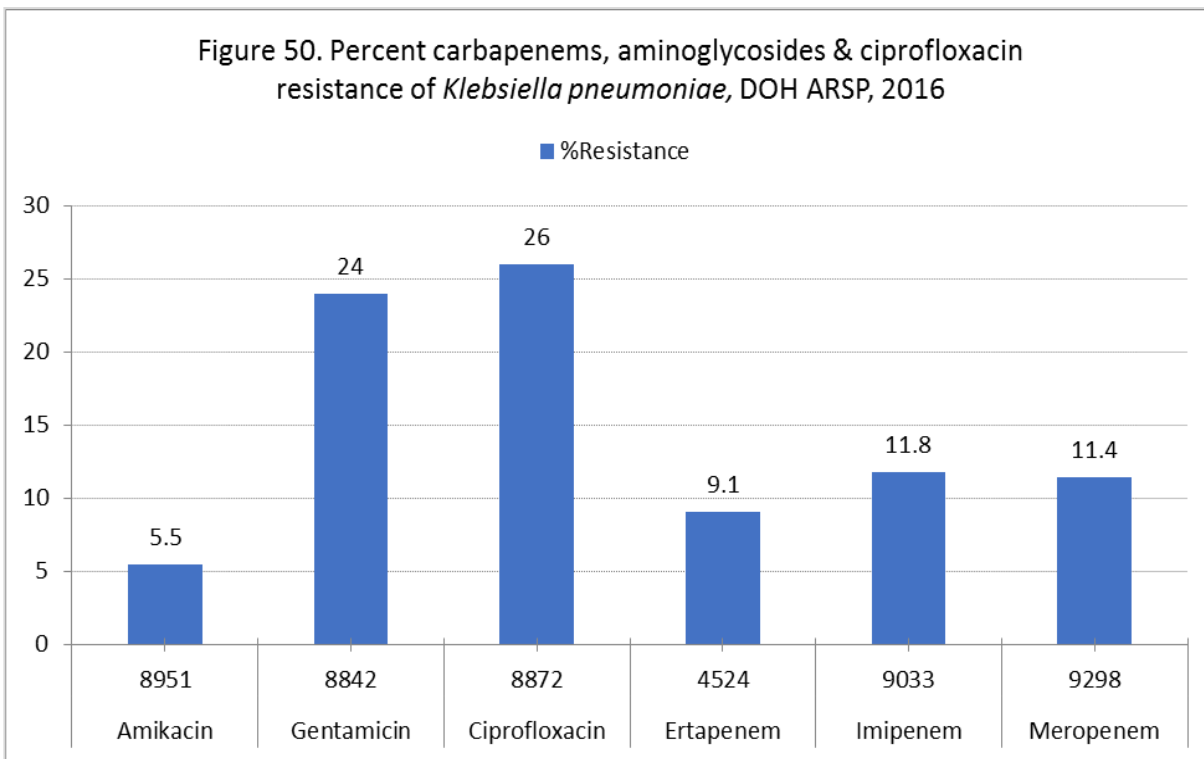
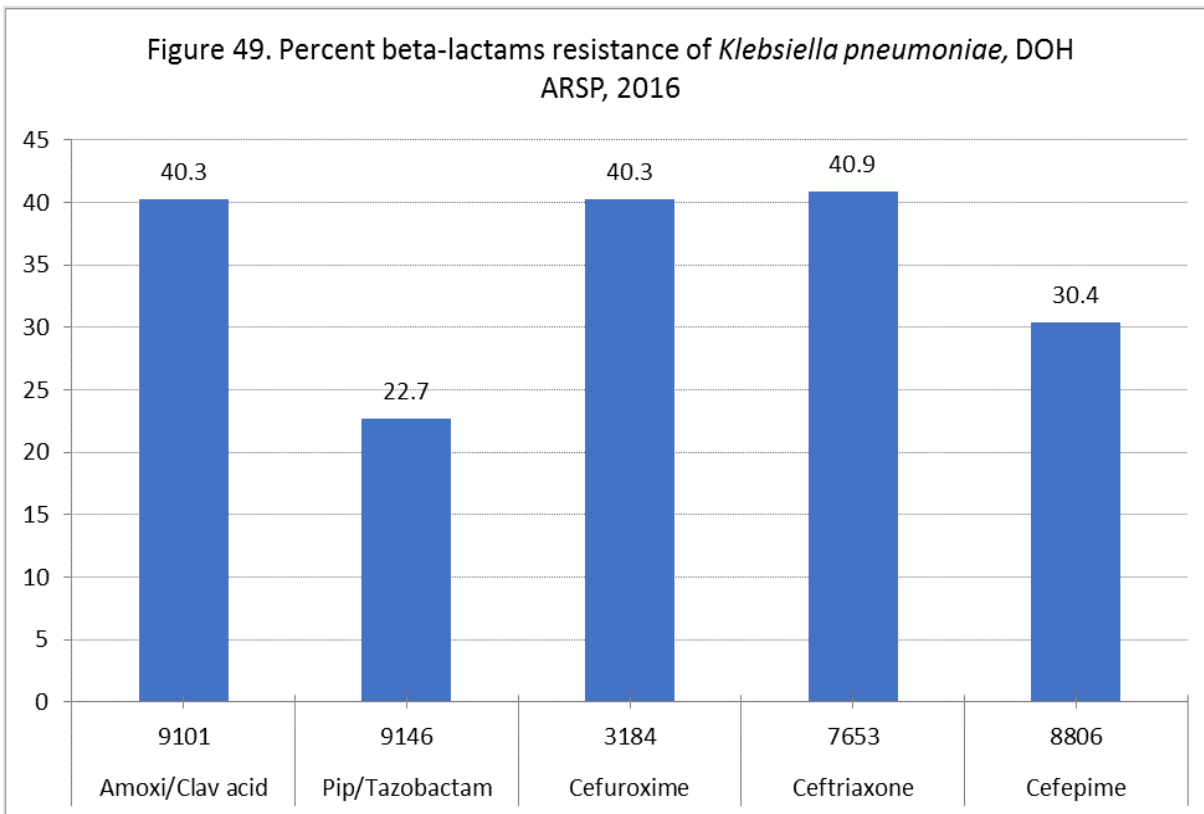
*Klebsiella pneumoniae***The Isolates**

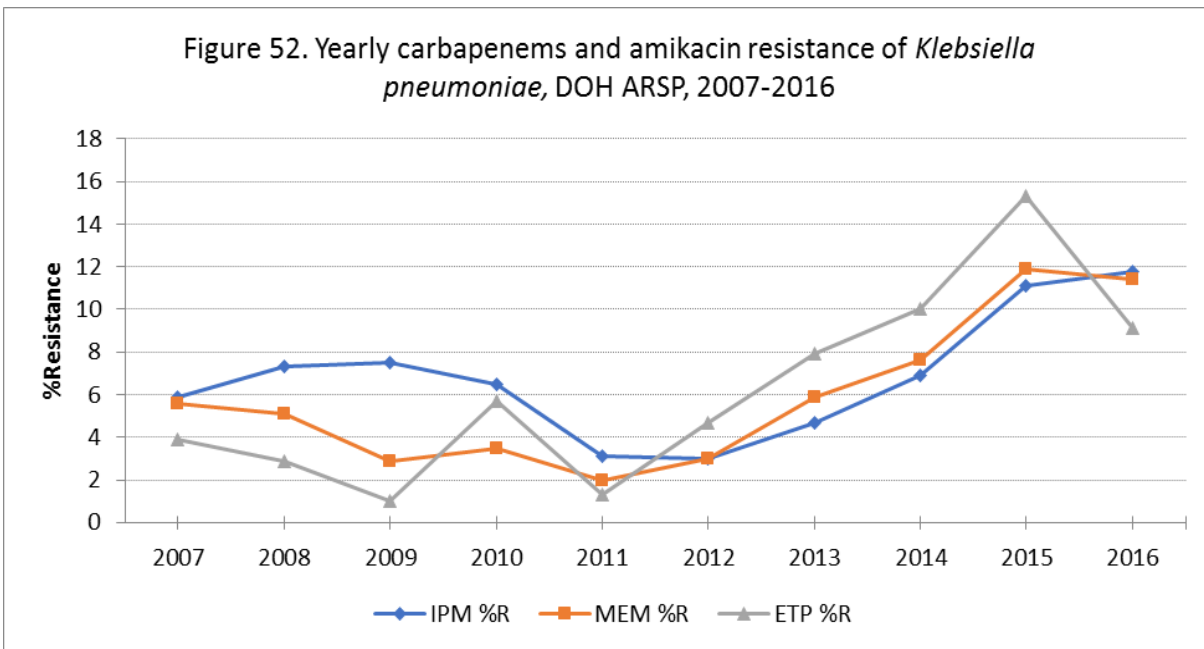
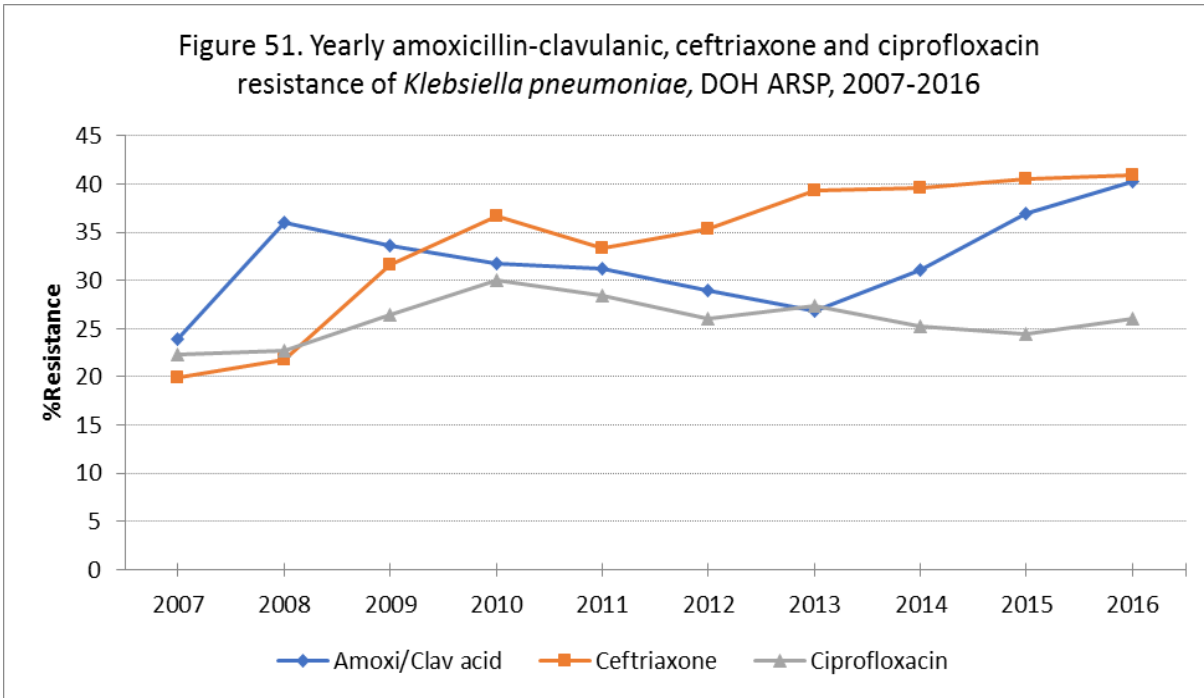
A total of 10,310 *Klebsiella pneumoniae* isolates was reported for 2016. Majority of the isolates were from respiratory specimens (55%). Others were isolated from urine, wound or cutaneous and blood specimens (**Figure 48**).

Antimicrobial Resistance

Klebsiella pneumoniae rates of resistance for commonly used antimicrobials for 2016 are: 40.3% for amoxicillin-clavulanic acid (n=9,101; 95% CI:39.3-41.3); 22.7% for piperacillin-tazobactam (n=9,146; 95% CI: 21.8-23.6); 40.3% for cefuroxime (n=3,184; 95% CI: 38.6-42); 40.9% for ceftriaxone (n=7,653; 95% CI: 39.8-42); 30.4% for cefepime (n=8,806; 95% CI: 29.3-31.4); 24% for gentamicin (n=8,842; 95% CI: 23.1-24.9); amikacin at 5.5% (n=8,951; 95% CI: 5.0-6.0); 9.1% for ertapenem (n=4,524; 95% CI: 8.3-10); 11.8% for imipenem (n=9,033; 95% CI: 11.1-12.5); and 11.4% for meropenem (n=9,298; 95% CI: 10.8-12.1). These 2016 resistance rates did not differ significantly from reported rates from the previous year except for the statistically significant increase in resistance rates of amoxicillin-clavulanic acid from 37% in 2015 to 40.3% in 2016 (p value 0.0001) and a significant decrease in resistance rates for ertapenem from 15.3% in 2015 to 9.1% in 2016 ertapenem (p value 0.0001) (**Figures 49-52**).

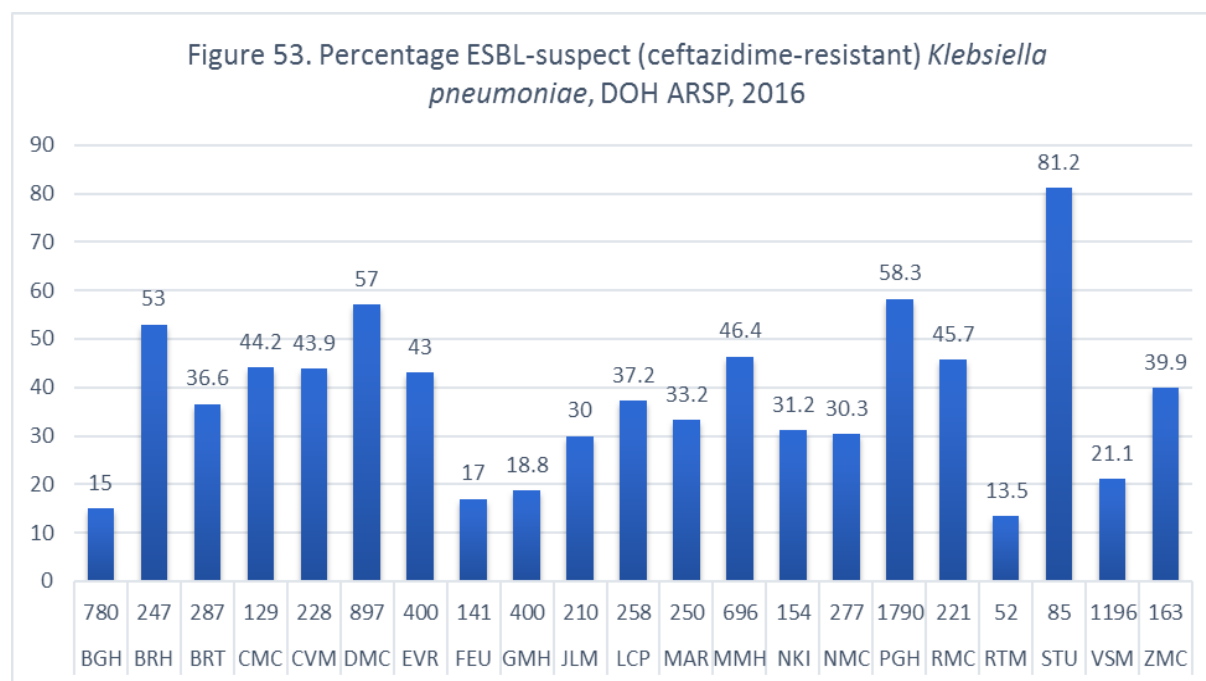






Extended-spectrum β -lactamase-producing *Klebsiella pneumoniae*

Extended-spectrum β -lactamases (ESBLs) are enzymes that mediate resistance to extended-spectrum cephalosporins and monobactams but do not affect cephamycins or carbapenems.⁷ Using ceftazidime disk diffusion as initial screening for ESBL production, out of 8,861 *K. pneumoniae* isolates tested, 40% screened positive (ESBL suspect). ESBL-suspect *K. pneumoniae* rates varied by sentinel sites from as low as 13.5% (RTM) to as high as 81.2% (STU) as seen in **Figure 53**.



Pseudomonas aeruginosa

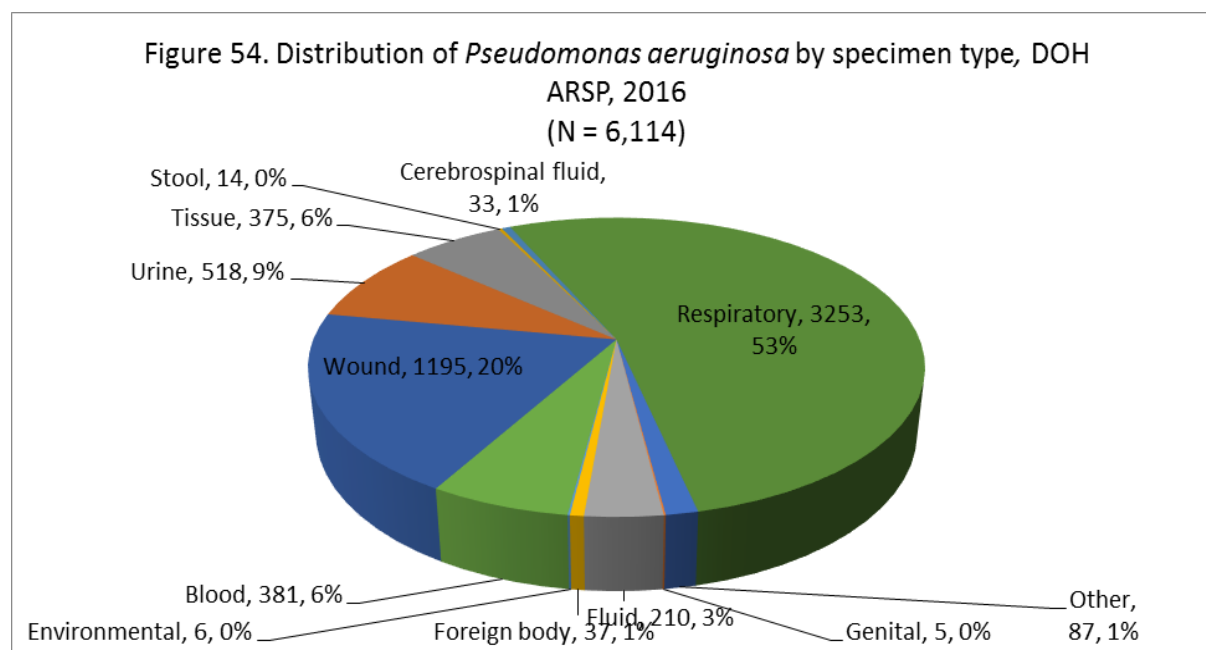
The Isolates

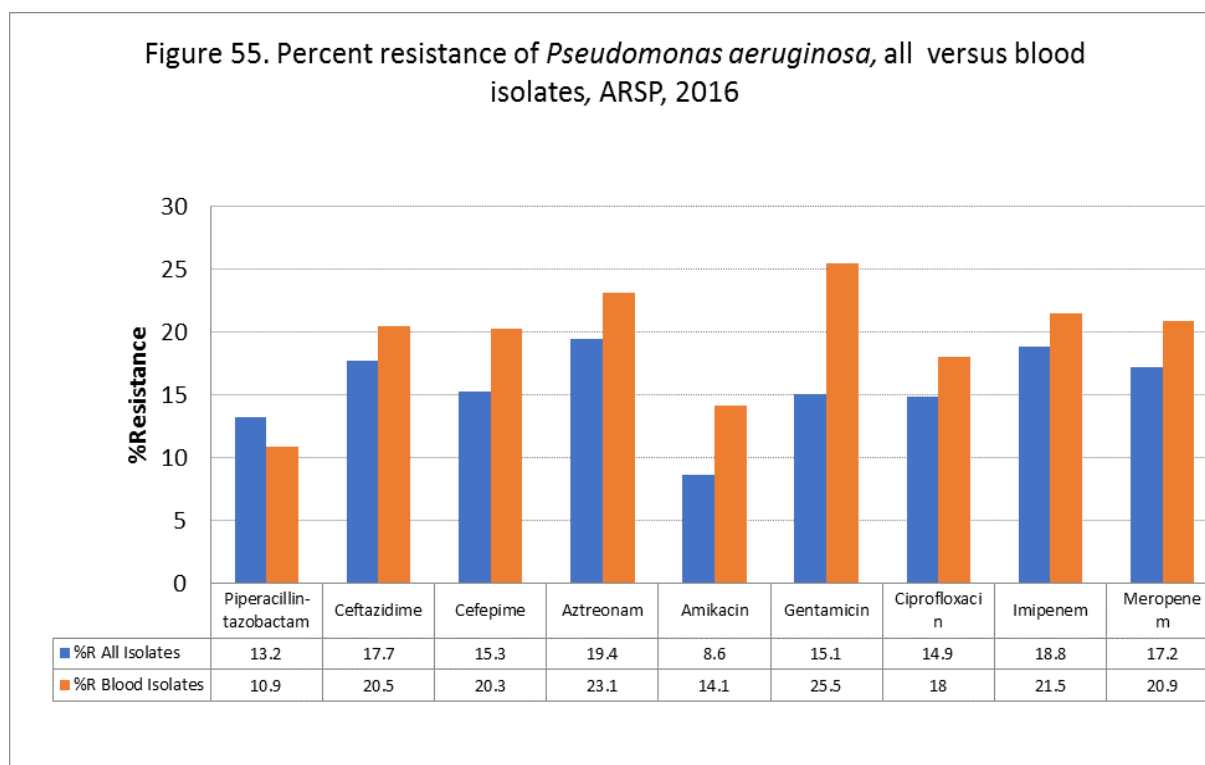
For 2016, there were 6,114 *P. aeruginosa* isolates which were most commonly isolated from respiratory, wound, urine, tissue and blood specimens (**Figure 54**).

Antimicrobial Resistance

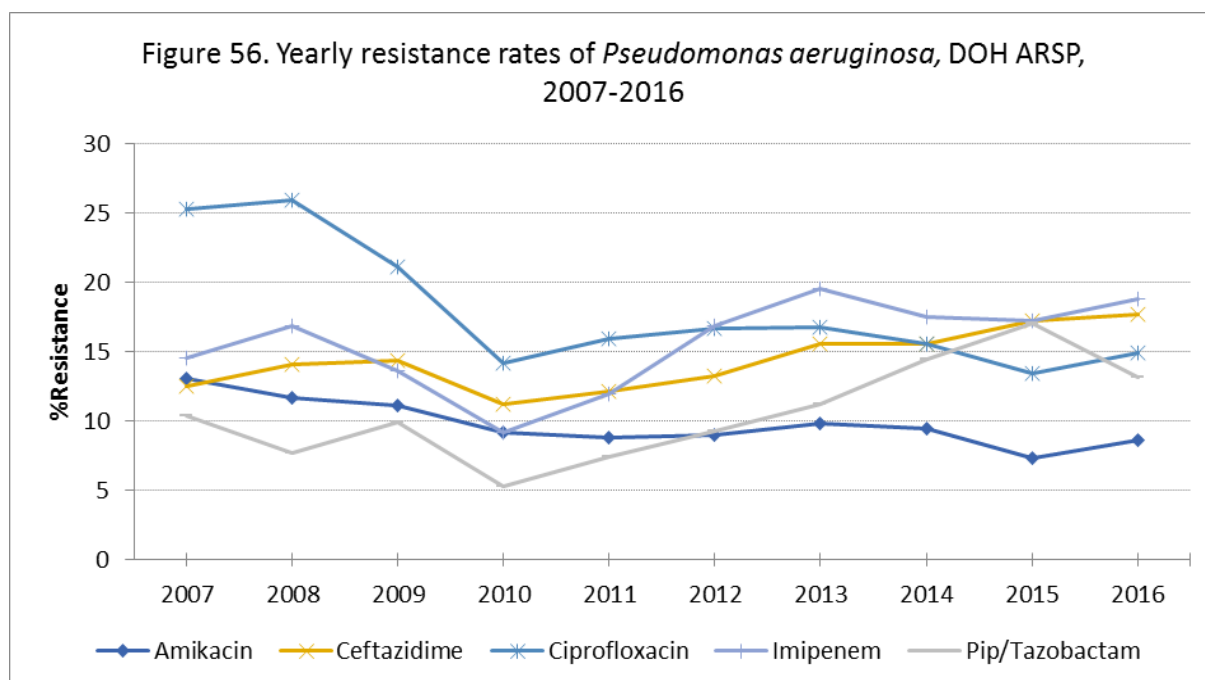
The 2016 resistance rates of *P. aeruginosa* isolates to antimicrobials for treatment were as follows: 13.2% for piperacillin-tazobactam (n=5,149; 95% CI: 12.4-14.3); 17.7% for ceftazidime (n=5,416; 95% CI: 16.7-18.7); 15.3% for cefepime (n=5,308; 95% CI: 14.3-16.3); 19.4% for aztreonam (n=3,608; 95% CI: 18.1-20.7); 8.6% for amikacin (n=85,522; 95% CI: 7.9-9.4); 15.1% for gentamicin (n=5,146; 95% CI: 14.1-16.1); 14.9 for ciprofloxacin (n=5,266; 95% CI: 14-15.9); 18.8% for imipenem (n=5,233; 95% CI: 17.8-19.9); and 17.2% for meropenem (n=5,377; 95% CI: 16.2-18.2). When the subgroup of blood culture isolates (invasive) were analyzed and compared to cumulative rates of resistance when all isolates were combined, invasive *P. aeruginosa* had relatively higher rates of resistance (**Figure 55**).

When the 2016 reported resistance data to agents used for treating *P. aeruginosa* infections were compared to those from 2015, statistically significant increase in rates were noted for amikacin from the reported 7.3% in 2015 to the 8.6% reported for 2016 (p value 0.0211); ciprofloxacin from the 13.4% reported in 2015 to the 14.9% rate for 2016 (p value 0.0395); imipenem from 17.2% in 2015 to 18.8% in 2016 (p value 0.044); and meropenem from 15.5% in 2015 to 17.2% in 2016 (p value 0.0279). In contrast resistance rates for piperacillin-tazobactam decreased significantly from 17.1% in 2015 to 13.2% in 2016 (p value 0.0001). The rest of the antimicrobial resistance rates for 2016 differed statistically from those reported the year prior. Resistance rates of *P. aeruginosa* to antimicrobials for treatment for 2016 and the past 10 years are illustrated on **Figures 56**.





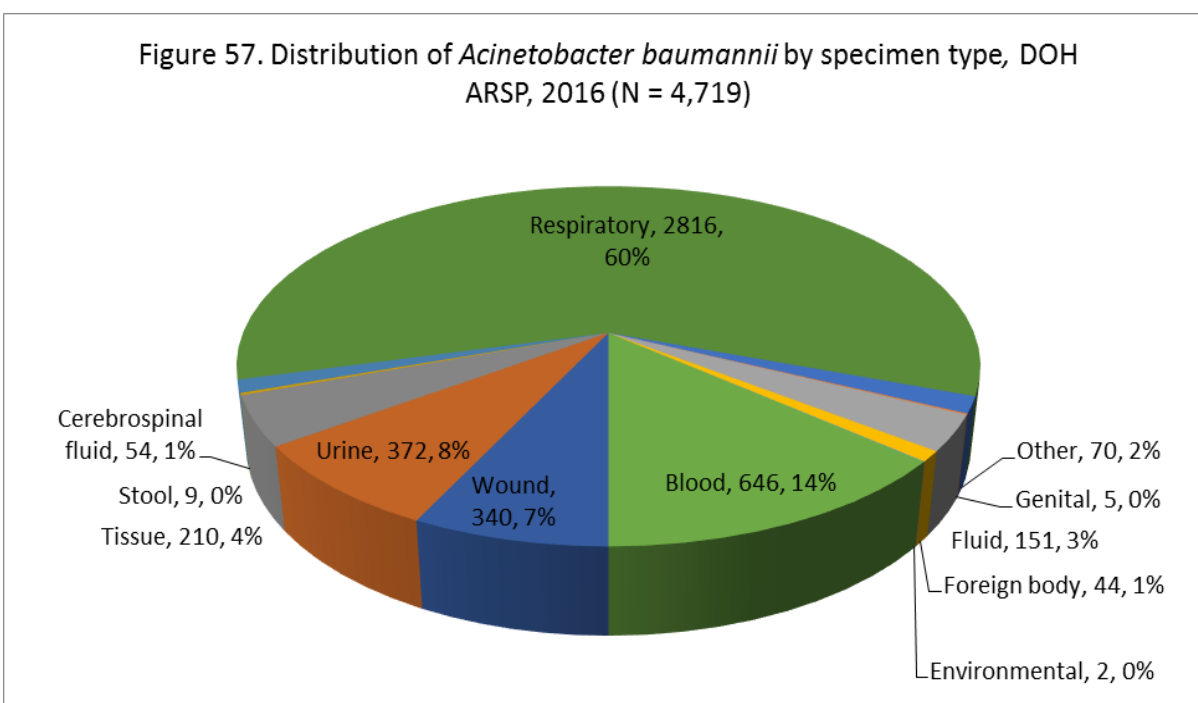
Number of isolates tested: All isolates against piperacillin-tazobactam 5,149; ceftazidime 5,416; cefepime 5,308; aztreonam 3,608; amikacin 5,522; gentamicin 5,146; ciprofloxacin 5,266; imipenem 5,233 and meropenem 5,377; Blood culture isolates against piperacillin-tazobactam 350; ceftazidime 356; cefepime 374; aztreonam 268; amikacin 362; gentamicin 345; ciprofloxacin 361; imipenem 330 and meropenem 359.



Acinetobacter baumannii

The Isolates

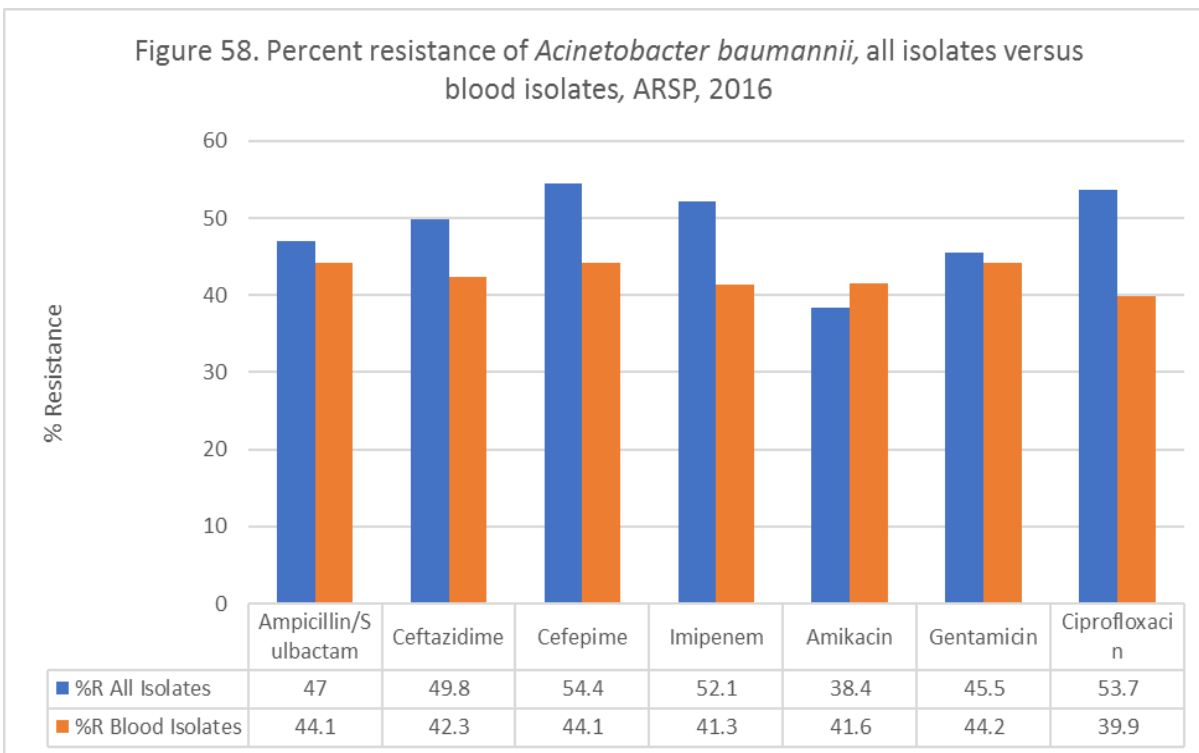
For 2016, there were 4,719 *A. baumannii* isolates which were higher than the total number reported for 2015 (3,575 isolates). As in the previous year, these were most commonly isolated from respiratory, blood, urine and cutaneous/wound specimens (**Figure 57**).



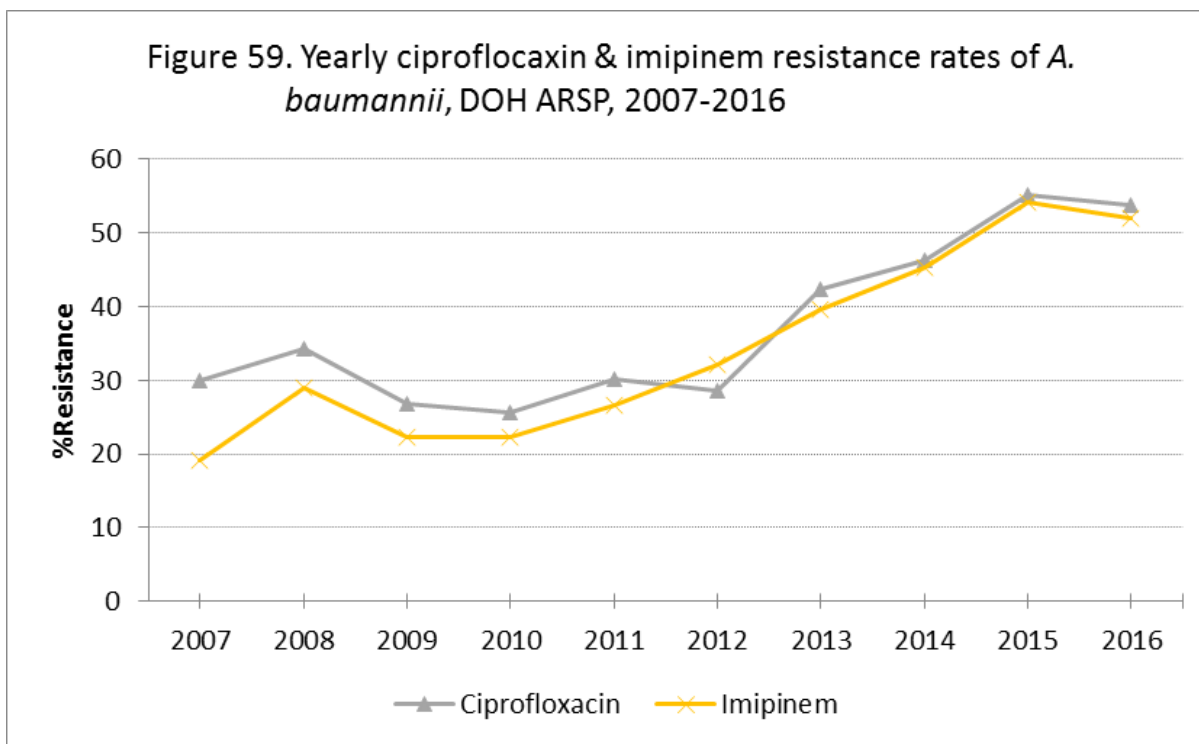
Antimicrobial Resistance

For the 2016 data, *A. baumannii* rates of resistance against the following antibiotics are as follows: 47% for ampicillin-sulbactam (n=2,651; 95% CI: 45.1-48.9); 49.8% for ceftazidime (n=4,159); 54.4% for cefepime (n=4,102; 95% CI: 52.9-55.9); 52.1% for imipenem (n=3,967; 95% CI: 50.3-53.7); 38.4% for amikacin (n=3,564; 95% CI: 37-40.2); 45.5% for gentamicin (n= 4,064; 95% CI: 44-47); and 53.7% for ciprofloxacin (n=3,93; 95% CI: 52.1-55.3) as seen in **Figure 58**. These rates were mostly higher than rates for the subset of blood isolates for 2016.

When 2016 data were compared to reported rates for 2015, statistically significant increase in resistance rates were noted for both aminoglycosides tested: amikacin from 31% in 2015 to 38.4% in 2016 (p value 0.0001) and gentamicin from 36.4% in 2015 to 45.5% in 2016 (p value 0.0001). The rest of the other antibiotics tested did not differ significantly from that of 2015. Resistance rates of *A. baumannii* to antimicrobials for treatment for 2016 and the past 10 years are illustrated on **Figures 59-60**.



Number tested: All isolates against ampicillin-sulbactam 2,651; ceftazidime 4,159; cefepime 4,102; imipenem 3,967; amikacin 3,564; gentamicin 4,064; ciprofloxacin 3,939 and co-trimoxazole 3,553; Blood culture isolates against ampicillin-sulbactam 347; ceftazidime 610; cefepime 614; imipenem 593; amikacin 462; gentamicin 591; ciprofloxacin 569 and co-trimoxazole 480



Multidrug-resistant *Pseudomonas aeruginosa* and *Acinetobacter baumannii*

Multidrug-resistant pathogens are increasingly recognized globally. Terminologies are summarized in **Table 5**. *P. aeruginosa* MDR and possible-XDR rates are noticeably higher in the subset of invasive (blood culture) isolates as in the previous year. *P. aeruginosa* and *A. baumannii* MDR and possible-XDR rates are shown in **Table 16**.

Table 5. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance⁸

Term	Definition
MDR (Multidrug-resistant)	Acquired non-susceptibility to at least one agent in three or more antimicrobial categories
XDR (Extensively drug-resistant)	Non-susceptibility to at least one agent in all but two or fewer antimicrobial categories (i.e. bacterial isolates remain susceptible to only one or two cate-
PDR (Pandrug-resistant)	Non-susceptibility to all agents in all antimicrobial categories.

Table 6. MDR and Possible XDR *Pseudomonas aeruginosa* and *Acinetobacter baumannii*, all ARSP sites, Jan- Dec 2016

Organism	Number of isolates tested	Percentage MDR	Percentage Possible XDR
<i>Pseudomonas aeruginosa</i>			
All isolates	4430	21%	16%
Blood isolates	213	43%	20%
<i>Acinetobacter baumannii</i>			
All isolates	3575	61%	50%
Blood isolates	435	52%	38%

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