Antimicrobial Resistance Surveillance Program

DATA SUMMARY REPORT

2019

Department of Health
Research Institute for Tropical Medicine
Antimicrobial Resistance Surveillance Reference Laboratory

Antimicrobial Resistance Surveillance Program

2019 Data Summary Report

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ABBREVIATIONS

AMR	Antimicrobial Resistance
ANSORP	Asian Network for Surveillance of Resistant Pathogens
ARSP	Antimicrobial Resistance Surveillance Program
ARSRL	Antimicrobial Resistance Surveillance Reference Laboratory
AST	Antimicrobial Susceptibility Testing
CALABARZON	Cavite, Laguna, Batangas, Rizal, Quezon
CAR	Cordillera Administrative Region
CLSI	Clinical and Laboratory Standards Institute
DMU	Data Management Unit
DNA	Deoxyribonucleic acid
DOH	Department of Health
EQA	External Quality Assessment
ESBL	Extended-spectrum beta-lactamase
GLASS	Global Antimicrobial Resistance Surveillance System
GHRU	Global Health Research Unit
HFEP	Health Facilities Enhancement Program
MDR	Multidrug– resistant
MIC	Minimum Inhibitory Concentration
MIMAROPA	Mindoro, Marinduque, Romblon, Palawan
MRSA	Methicillin-resistant *Staphylococcus aureus*
NCR	National Capital Region
NIHR	National Institute for Health Research
PCHRD	Philippine Council for Health Research and Development
PhilHealth	Philippine Health Insurance Corporation
PNF	Philippine National Formulary
RMT	Registered Medical Technologist
SOCCSKSARGEN	South Cotabato, Cotabato, Sultan Kudarat, Sarangani, General Santos City
WHO	World Health Organization
XDR	Extensively drug-resistant

Surveillance Sites

BGH	Baguio General Hospital and Medical Center
BRH	Batangas Medical Center
BRT	Bicol Regional Training and Teaching Hospital
CRH	Caraga Regional Hospital
CMC	Cotabato Regional Hospital and Medical Center
CVM	Cagayan Valley Medical Center
DMC	Southern Philippines Medical Center
EVR	Eastern Visayas Regional Medical Center
FEU	Far Eastern University Hospital
GMH	Governor Celestino Gallares Memorial Hospital
JLM	Jose B. Lingad Memorial Regional Hospital
LCP	Lung Center of the Philippines
MAR	Mariano Marcos Memorial Hospital and Medical Center
MMH	Corazon Locsin Montelibano Memorial Regional Hospital
NKI	National Kidney and Transplant Institute
NMC	Northern Mindanao Medical Center
ONP	Ospital ng Palawan
PGH	Philippine General Hospital
RMC	Rizal Medical Center
RTH	Dr. Rafael S. Tumbokon Memorial Hospital
RTM	Research Institute for Tropical Medicine
SLH	San Lazaro Hospital
STU	University of Sto. Tomas Hospital
VSM	Vicente Sotto Memorial Medical Center
ZMC	Zamboanga City Medical Center
ZPH	Zamboanga del Norte Medical Center

Foreword

Celia C. Carlos, MD
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The 2019 Antimicrobial Resistance Surveillance Program (ARSP) Annual Report is a testament to the enduring commitment of the men and women involved in this surveillance program. It provides the most recent national estimate of antimicrobial resistance of bacteria of public health importance to the antibiotics commonly used against them. Such data is invaluable for policy development for the prevention and control of the emergence of AMR in the country as well as a useful guide in the treatment of patients.

The Methicillin Resistant *Staphylococcus aureus* (MRSA) rates in the country is shown in the 2019 ARSP report to be decreasing in the past several years albeit remaining above 50% which limits the use of an affordable previously effective antibiotic oxacillin in the treatment of infections against this common bacteria. Multi-drug resistance among pathogens such as *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Acinetobacter baumannii* persists in the country and continue to pose challenges in treatment. Aside from emerging penicillin resistance among *Streptococcus pneumoniae,* there appears likewise to be a distinct emergence of vancomycin and linezolid resistance among the enterococci. With the developing capacity of the Antimicrobial Resistance Surveillance Reference Laboratory (ARSRL) for whole genome sequencing and bioinformatics, more granular surveillance data may be utilized towards understanding the dynamics of the emergence and spread of resistant bacteria so that corresponding actions in their prevention and control can be crafted and implemented.

The COVID-19 pandemic has posed extreme challenges in the country and in the lives of the Filipino people. It has affected the lives of the men and women involved in the country's AMR surveillance and has posed limitations in the implementation of the surveillance. However, the main impact may come in the form of changes in the AMR rates of bacteria of public health importance in the Philippines which may become manifest in the coming days and can be documented through the surveillance. AMR surveillance at various level of health care thus will all the more be relevant for both patient care as well as policy implementation.

The continued significance of AMR surveillance has likewise been recognized in the Philippine Action Plan to Combat Antimicrobial Resistance 2019-2023 which cites surveillance as among the key strategies in the prevention and control of AMR in the country.

Given the fundamental need for AMR data in the country, ARSP is committed to continuously identify ways to improve its implementation and to contribute in the accomplishment of the country's national action plan to combat AMR.

Executive Summary

*Resistance data for **100,334 bacterial isolates** coming from 24 hospital-based bacteriology laboratories as sentinel sites, and 2 gonorrhoeae surveillance sites were analyzed for 2019.*

Streptococcus pneumoniae

Cumulative resistance rate of *S. pneumoniae* isolates from all specimen types reported for 2019 against penicillin, using meningitis breakpoints, was at 13.4% (n= 404) and 0.5% for non-meningitis breakpoint. When pneumococcal isolates were analyzed by specimen type, using meningitis breakpoints, penicillin resistance was at 10.6% for invasive (blood) and 15.0% for non-invasive isolates (respiratory). Using non-meningitis breakpoint, penicillin resistance was at 0.8% for non-invasive isolates (respiratory). The most common invasive *S. pneumoniae* serogroups/serotypes identified for 2019 were 3, 1, 10 and 5.

Haemophilus influenzae

Resistance rates against panel of antibiotics for 2019 isolates of *H. influenzae* are highest for ampicillin at 10.2% (n=432). There were no reports of cefuroxime or azithromycin resistant *H. influenzae* for 2019.

Salmonella enterica serotype Typhi

S. enterica serovar Typhi isolates have remained susceptible to first line antibiotics with reported resistance rates of 3.9% or less for cefotaxime, ampicillin, co-trimoxazole and chloramphenicol for 2019. There was no confirmed ciprofloxacin resistant isolate for 2019.

Nontyphoidal *Salmonella*

Resistance rates of nontyphoidal *Salmonella* is at 9.8% for ciprofloxacin (n=214) and 8.8% for ceftriaxone (n=226). The commonest nontyphoidal *Salmonella* identified for 2019 were *S. enterica* serotype Enteritidis and *S. enterica* serotype Typhimurium.

Shigella species

The 2019 data showed increased resistance to ampicillin (68.2%, n= 44) and co-trimoxazole (60.5%, n=43) compared to 2018 resistance rates. Resistance to ciprofloxacin and ceftriaxone were at 2.4%, and 9.3%, respectively.

Vibrio cholerae

Vibrio cholerae isolates remain susceptible to first line antibiotics: chloramphenicol, co-trimoxazole and tetracycline with 5% or less reported resistance rates for 2019.

Neisseria gonorrhoeae

Isolates were found to be resistant to ciprofloxacin (79.4%, n=131) and tetracycline (58%, n=131). There were 3 isolates reported to be non-susceptible to azithromycin one of which was confirmed to be non-susceptible to azithromycin in the ARSRL.

Staphylococcus aureus

Methicillin resistant *Staphylococcus aureus* (MRSA) rates for 2019 was at 52.1% (n=7,189). Although not statistically significant, the observed decrease in oxacillin resistance for 2019 is a continuation of the decrease in rates observed in the past two years. Resistance rates for 2019 against antibiotics used for treatment of *S. aureus* infections are as follows: 35.5% for co-trimoxazole (n=7,040); 10.4% for clindamycin (n=7,323); 3.2% for rifampicin (n=5,867); 0.6% for linezolid (n=6,512); and 0.8% for vancomycin (n=6,512).

Enterococcus species

Resistance rates of *E. faecalis* resistance is reported at 2% (n=1,900) for linezolid and 1.6% (n=2,094) for vancomycin. While resistance rates of *E. faecium* are reported at 1.6% (n=1,233) for linezolid and 12.1% for vancomycin (n=1,290).

Escherichia coli

E. coli rates of resistance against the fluoroquinolones and third generation cephalosporins were at 46.6% for ciprofloxacin (n=10,946) and 39.9% for ceftriaxone (n=11,081). However, resistance to carbapenems continue to rise with rates against ertapenem at 5.0% (n=9,833); imipenem at 6.0% (n=9,978), and meropenem at 6.4% (n=10,961). *E. coli* extended-spectrum beta-lactamase (ESBL) suspect rates for 2019 is at 53.25% (n=5,639).

Klebsiella pneumoniae

Resistance to the carbapenems continue to rise with 2019 *K. pneumoniae* resistance rates as high as 13.5% for meropenem (n=13,912), 12% for imipenem (n=13,394), and 10.2% for ertapenem (n=11,976). *K. pneumoniae* ESBL suspect rates for 2019 is at 55.2% (n=8,154).

Pseudomonas aeruginosa

For 2019, carbapenem resistance is reported at 16.9% for imipenem (n=7,041) and 14.2% for meropenem (n=7,702) for *P. aeruginosa*.

Acinetobacter baumannii

For the 2019 data, more than 50% of the reported *A. baumannii* isolates were resistant to the following antibiotics: cefepime at 58.1% (n=5,747); imipenem at 55.8% (n=5,128); meropenem at 56.8% (n=5,750); ciprofloxacin at 56% (n=5,696); and co-trimoxazole at 52.6% (n=5,247).

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

P. aeruginosa MDR and possible XDR rates for all isolates were at 18% and 14%, respectively. *A. baumannii* MDR and possible XDR rates for all isolates were at 58% and 47%, respectively.

Introduction

Antimicrobial resistance (AMR) is the ability of organisms that cause disease to withstand attack by antimicrobials.

- ***AMR is a serious public health threat*** because of its far reaching and serious implications in health care as well as economies. [1] Infections caused by resistant microorganisms often fail to respond to standard treatment, resulting in prolonged illness and greater risk of death.
- AMR hampers the control of infectious diseases because patients remain infectious for a longer time increasing the risk of spreading resistant microorganisms to others.
- AMR increases the cost of health care as more expensive therapies must be used when infections become resistant to first-line medicines. Infections due to resistant microorganisms increase economic burden to families and societies as it often results in longer duration of illness and treatment.

When we lose antimicrobials to resistance, the achievements of modern medicine such as organ transplant, cancer chemotherapy and major surgery would be compromised as these would not be possible without effective antimicrobials for prevention and treatment of infections. Losing antimicrobials to resistance can result in many infectious diseases becoming untreatable and uncontrollable. This can bring us back to the pre-antibiotic era.

AMR Surveillance

It is recognized that the issue of AMR must be addressed by concerted efforts of government agencies, health providers, drug industry, professional organizations, academe and civil society. ***Surveillance is a fundamental part of an effective response to AMR problem***.[2] It is needed to detect resistant microorganisms, enable correct decisions to be made about treatment options and guide policy recommendations.

As the country's response to the recommendation of the World Health Organization (WHO) Working Group on the Regional Information Network on Antimicrobial Resistance that a surveillance program be initiated among member states of the Western Pacific Region to contain and prevent resistance to antimicrobials, the ***Philippine Committee on Antimicrobial Resistance Surveillance Program was created in 1988 by the Department of Health's Department Order 339-J***.

The Antimicrobial Resistance Surveillance Program

The program aims to provide critical inputs to the Department of Health's effort to promote rational drug use by determining the status and developing trends of antimicrobial resistance of selected bacteria to specific antimicrobials.

The DOH-ARSP is a sentinel laboratory-based antimicrobial resistance surveillance on aerobic bacteria from clinical specimens. The surveillance collects culture and antimicrobial susceptibility data from its ***24 sentinel sites and 2 gonorrhoeae surveillance sites***. Case finding is based on priority specimens sent routinely to sentinel sites laboratories for clinical purposes.

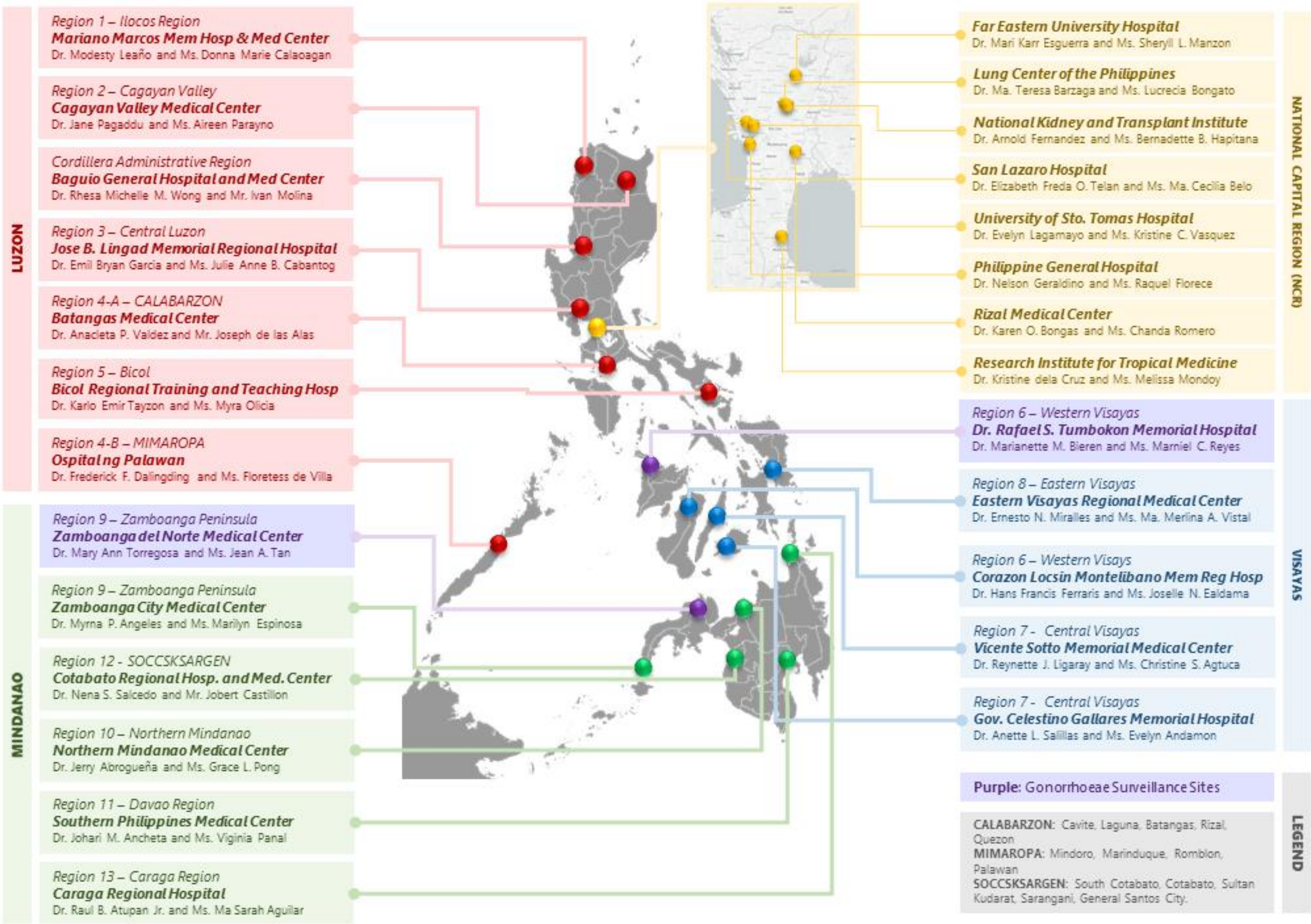

Figure 1. The Antimicrobial Resistance Surveillance Program Sentinel Sites

ARSP Surveillance Methods : Testing and Data Analysis

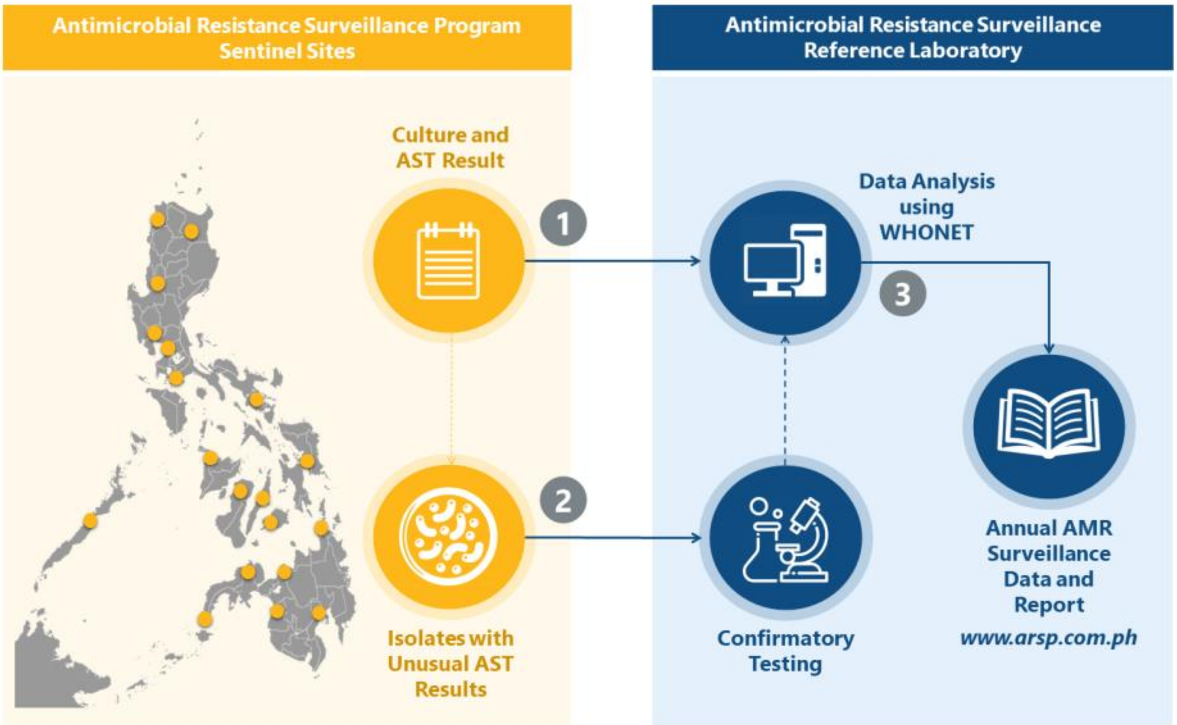

Figure 2. Schematic diagram of ARSP confirmatory testing and data analysis

1

All sentinel sites implement standard methods for culture and susceptibility testing based on the WHO Manual for the Laboratory Identification and Antimicrobial Susceptibility Testing of Bacterial Pathogens of Public Health Importance in the Developing World [3] and updated Clinical Laboratory Standards Institute (CLSI) references for antibiotic susceptibility testing and quality control [4] [5] [6] [7].

The culture and antimicrobial susceptibility test results are encoded, managed, and analyzed using a Windows-based database software called ***WHONET***.[8] These results are sent or automatically transmitted monthly to the reference laboratory's data management unit who manages the cleaning, analysis and storage of the program's surveillance data.

2

Sentinel sites likewise send isolates with unusual antimicrobial susceptibility patterns to ARSRL for phenotypic and genotypic confirmatory testing.

All referred isolates with unusual susceptibility patterns are re-identified using both automated and conventional methods. Both disk diffusion and minimum inhibitory concentration (MIC) are employed in antimicrobial susceptibility testing. Serotyping for *Streptococcus pneumoniae, Haemophilus influenzae*, *Salmonellae* and *Vibrio cholerae* was done for 2019.

The panel of antibiotics for inclusion in the surveillance is prescribed to the sentinel sites based on the latest CLSI recommendations, [4] the World Health Organization Global Antimicrobial Resistance Surveillance System (GLASS) Report Early Implementation [9] and the latest Philippine National Formulary [10]. In the analysis of AST, an isolate is considered resistant to an antimicrobial agent when tested and interpreted as resistant (R) in accordance with the clinical breakpoint criteria based on the most recent CLSI standards for AST.

3

Analysis is restricted to the first isolate received (per genus under surveillance) per patient in the calendar year. Data are expressed as a cumulative resistance percentage, i.e. the percentage of resistant isolates out of all isolates with antimicrobial susceptibility testing (AST) information on that specific organism–antimicrobial agent combination. For selected analyses, a 95% confidence interval is determined for the resistance percentage. Cumulative percentages of resistance rates are compared as proportions using either Chi-squared or Fisher's Exact Test, using a p value of <0.05 as statistically significant. Only species with testing data for 30 or more isolates are included in the analysis.

An annual report with a summary of the surveillance data focusing on aerobic bacterial pathogens of public health importance causing common infectious diseases with significant morbidity and mortality locally are disseminated to the program's stakeholders.

Limitations

Interpretation of data in this annual report should be undertaken with caution considering that there may be several factors that could influence and introduce bias to the data, resulting in over- or underestimation of resistance percentages. Potential sources of bias include population coverage, sampling, and laboratory capacity.

1. Most of the resistance data in the program came from regional hospitals which typically cater to patients from towns and cities within the vicinity of the hospital. Resistance variations in local areas not covered by regional hospitals are not represented in the program data.
2. Data for the National Capital Region came from 8 sentinel sites while data for other regions come from 1 or 2 sentinel sites.
3. Given that the program data are from routine clinical samples, differences in factors indicating need for microbiological cultures may introduce variations in the resistance data.
4. Performance of culture and susceptibility tests in the sentinel sites is dependent on the diagnostic habits of the clinicians as well as the financial capability of patients for such test. Differential sampling can occur if cultures are typically only performed after empirical treatment shows no adequate therapeutic response. Predictably, this will lead to a serious overestimation of the percentage resistance by not including susceptible isolates in the denominator.
5. Lastly, the ability of the laboratory to identify the microorganism and its associated antimicrobial susceptibility pattern may differ.

The Antimicrobial Resistance Surveillance Reference Laboratory

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Most Common Isolates

For 2019, *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 shown in Figure 3.

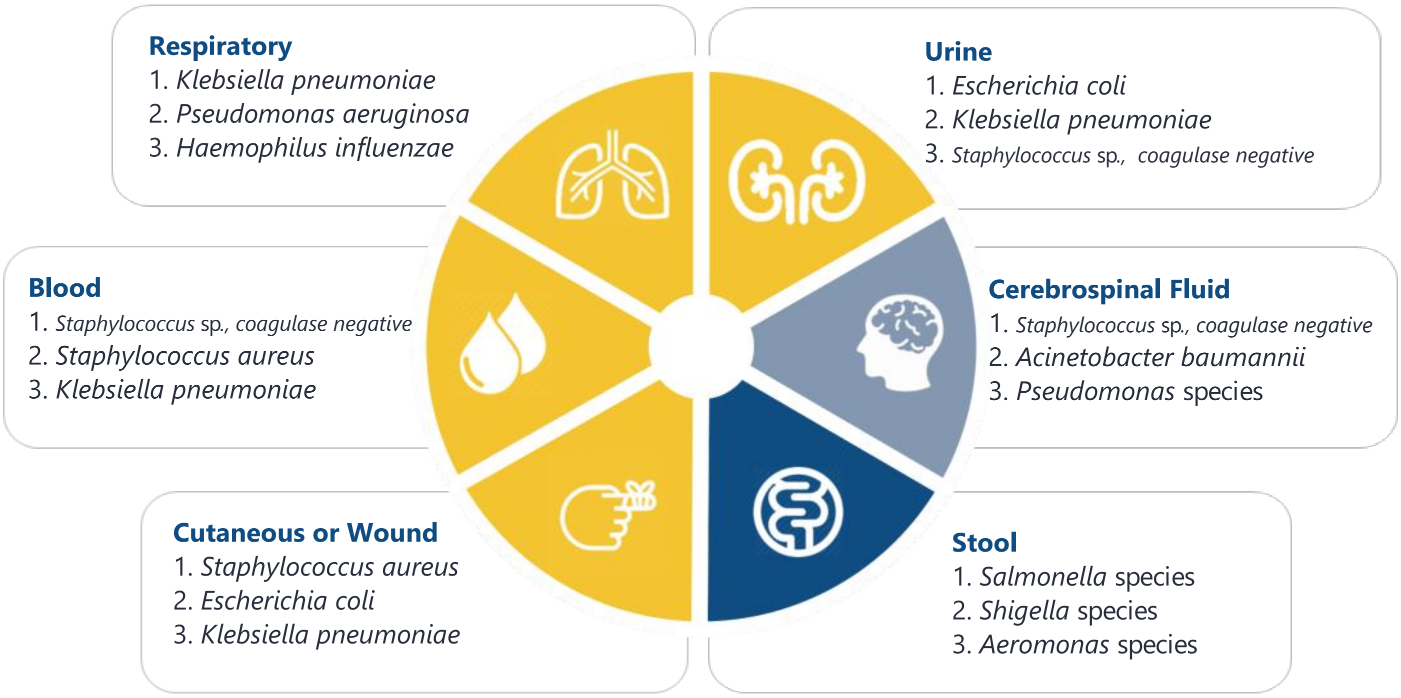


Figure 3. Most common isolates by specimen type, DOH-ARSP, 2019

The 2019 ARSP Data

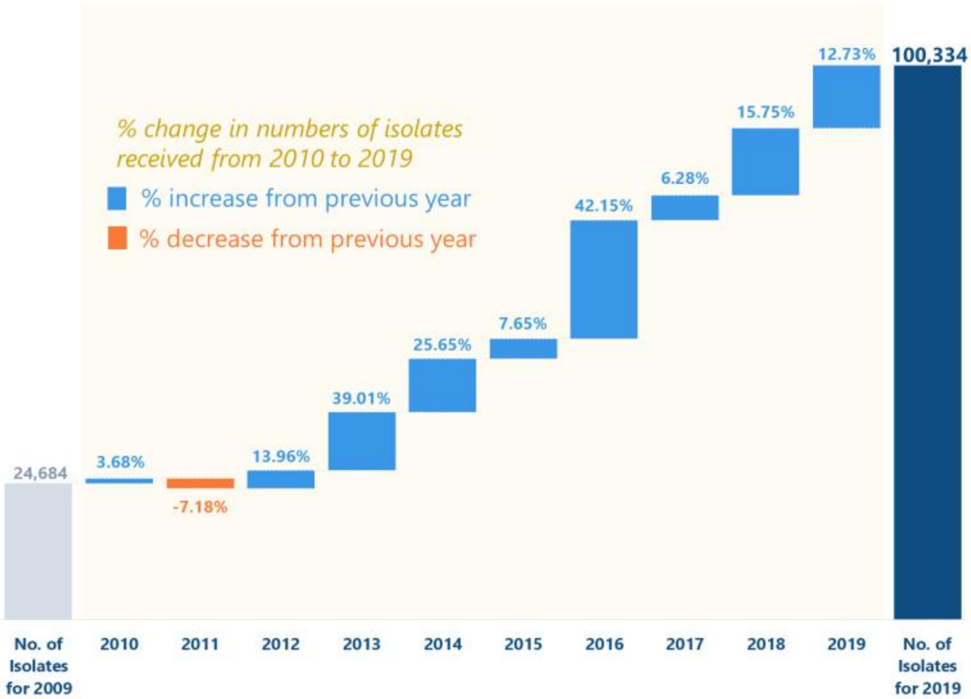


Figure 4. Number and the percentage difference of isolates received from 2009 to 2019

Resistance data for **100, 334 isolates** were reported and analyzed for the year 2019. This was a 12.73% increase when compared to the reported 89, 001 isolates for 2018 (Figure 4).

Table 1. Sentinel sites isolate contribution, DOH-ARSP, 2009-2019

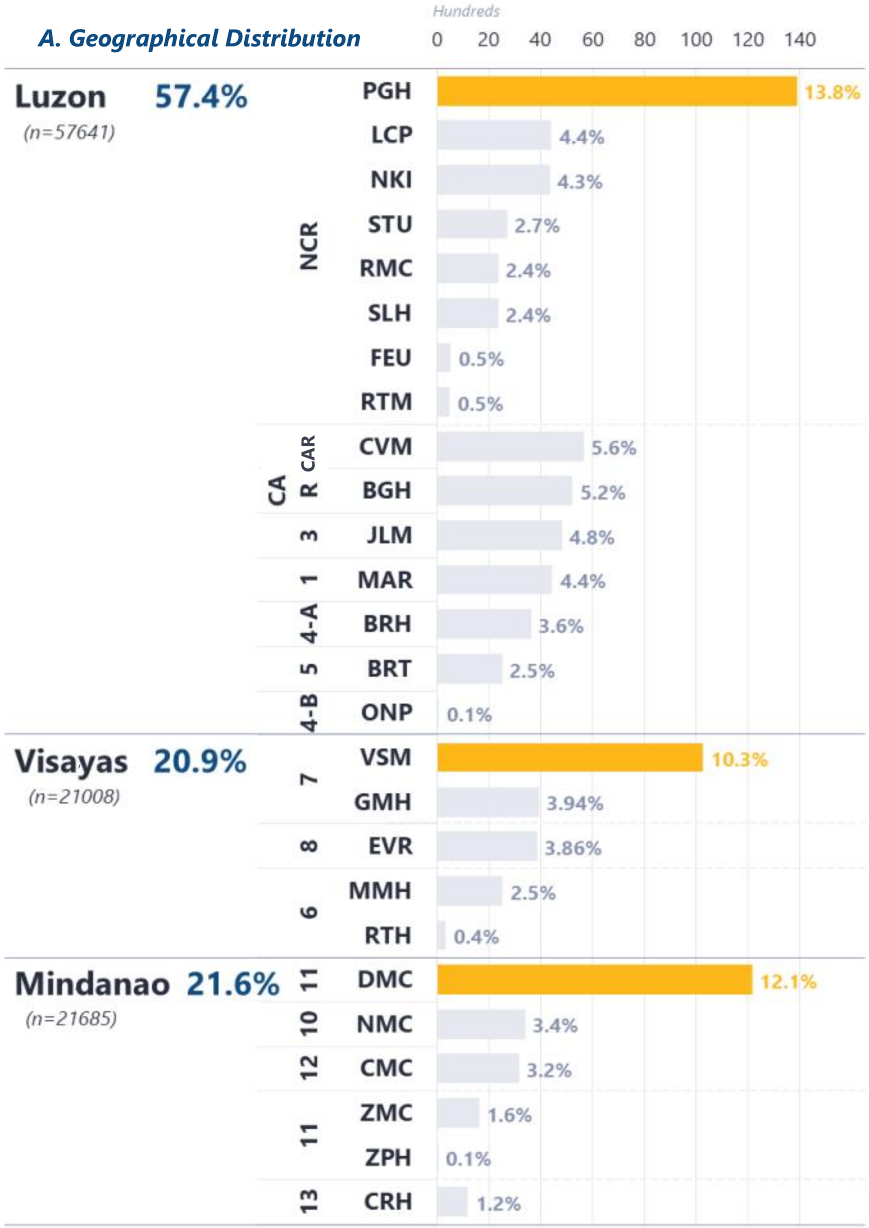
SENTINEL SITES	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Change %
PGH	-	-	-	-	7093	12471	11710	12860	14572	12808	13895	7.82
RMC	878	962	845	942	1207	320	1054	3252	3160	3241	2375	-36.46
NKI	3345	3681	2726	2403	2179	2918	1455	5894	627	2959	4358	32.10
LCP	2694	2	1233	2083	2253	2921	2905	3115	1367	3098	4433	30.12
RTM	280	348	328	383	303	303	336	410	513	598	507	-17.95
SLH	468	615	409	318	1132	575	824	1410	2460	2044	2371	13.79
GMH	1151	936	1119	1521	1307	1351	1807	1669	3153	3258	3957	17.66
ZMC	599	1060	686	721	822	819	841	1142	1222	1346	1644	18.13
FEU	699	864	1064	931	1050	956	712	810	1201	1173	548	-114.05
STU	1722	1470	752	1788	2050	2002	1923	2275	2088	2184	2722	19.76
EVR	340	530	744	507	697	823	1514	1731	3303	3879	3874	-0.13
MMH	562	590	855	1153	1413	2289	2940	2886	3133	3026	2539	-19.18
DMC	2523	2870	2439	3332	3456	4062	5109	8058	8680	10762	12177	11.62
VSM	1447	1931	2142	2450	3171	3951	3834	4803	6838	8714	10286	15.28
BGH	2129	2199	1916	1972	2583	2625	3214	4628	4842	5775	5234	-10.34
CMC	459	600	595	639	796	833	1300	1599	1704	2642	3181	16.94
BRT	618	486	537	677	611	1047	1251	1584	1640	1842	2521	26.93
RTH	-	-	-	-	-	-	-	25	69	159	352	54.83
ZPH	38	11	-	-	-	9	8	4	7	3	69	95.65
MAR	2275	1898	1851	1928	1773	1706	1849	2759	3565	4293	4462	3.79
BRH	1008	791	304	38	-	1022	1294	2075	2472	3133	3633	13.76
CVM	248	907	790	944	1100	1223	1512	3473	4141	4276	5668	24.56
JLM	387	1024	643	655	502	638	1266	2768	3261	3880	4824	19.57
NMC	814	1817	1776	1684	2131	2416	2237	3105	2245	2961	3409	13.14
ONP	-	-	-	-	-	-	-	2	5	68	90	24.44
CRH	-	-	-	-	-	-	-	10	624	879	1205	27.05
TOTAL	**24684**	**25592**	**23754**	**27069**	**37629**	**47280**	**50895**	**72347**	**76892**	**89001**	**100334**	

Isolate Distribution

The 2019 ARSP data came from the **24 sentinel and 2 *N. gonorrhoeae* surveillance sites** of the program (Table 1, Figure 5-A) which represents **16 out of 17 regions of the Philippines**.

Of the total number of isolates for 2019, 57.4% were from Luzon, 20.9% were from Visayas and 21.6% were from Mindanao. The eight Metro Manila sentinel sites contributed 31% of the total 2019 annual data (Figure 5–A).

Majority of the isolates were from male patients (53.2%) and from 20-64 years of age (53.6%). The most common specimen types were respiratory (30.2%), blood (23.9%), urine (18.5%), and wound (16.4%). Other specimen types contributing to the 2019 data were: tissues, cerebrospinal fluid, other fluids, genital specimens and stool (Figure 5-B-F).



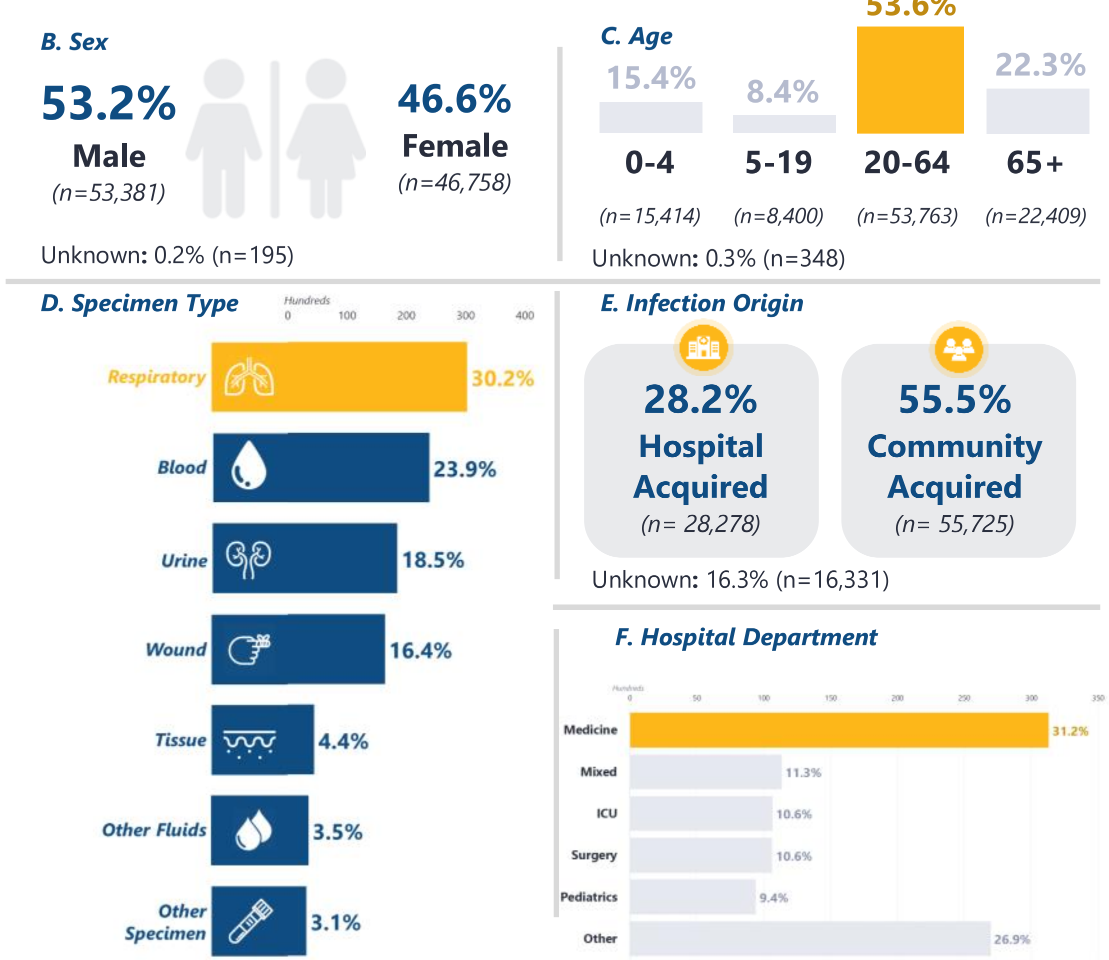


Figure 5. Isolate distribution and patient characteristics of the 2019 ARSP Isolates, DOH-ARSP, 2019 (N=100,334)

Streptococcus pneumoniae

Isolate Distribution and Characteristics

581
Isolates analyzed

There were 581 reported S. pneumoniae isolates for 2019. This was 18.81% higher than the reported number of isolates for 2018 (n=489).

For 2019, sentinel sites located in Luzon contributed most of the *S. pneumoniae* isolates (59.4%) with 32.1% coming from the National Capital Region (NCR); 27.2% came from Visayas and 13.4% were from Mindanao (Figure 6A).

Many of the isolates came from patients 20-64 years of age (53.5%), and majority were males (60.1%). Most patients were from the medicine department of the hospital (Figure 6-B, C, E).

Majority of the *S. pneumoniae* reported were from respiratory specimens (67%), 27.7% from blood and 0.5% from CSF (Figure 6-D).

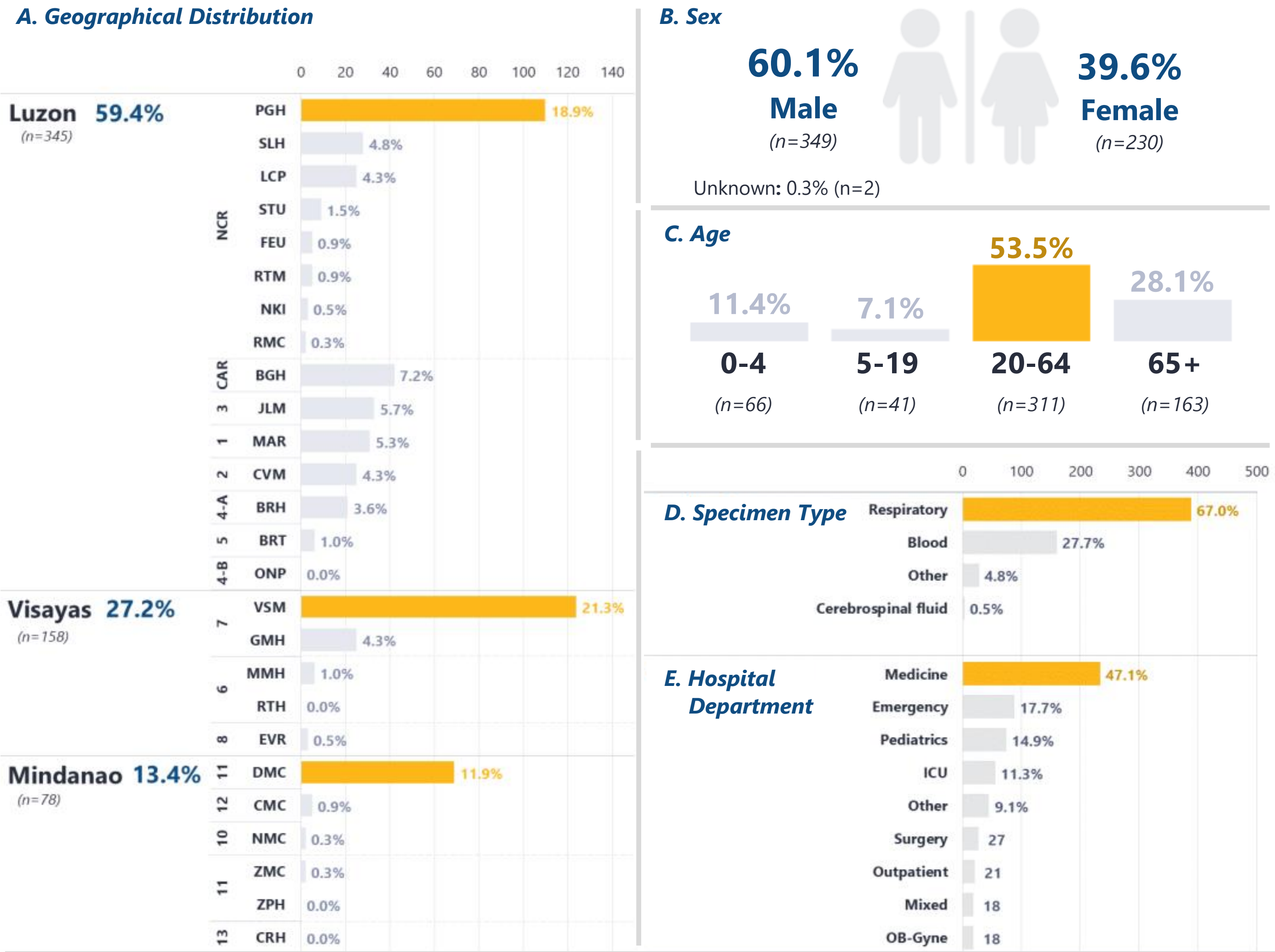
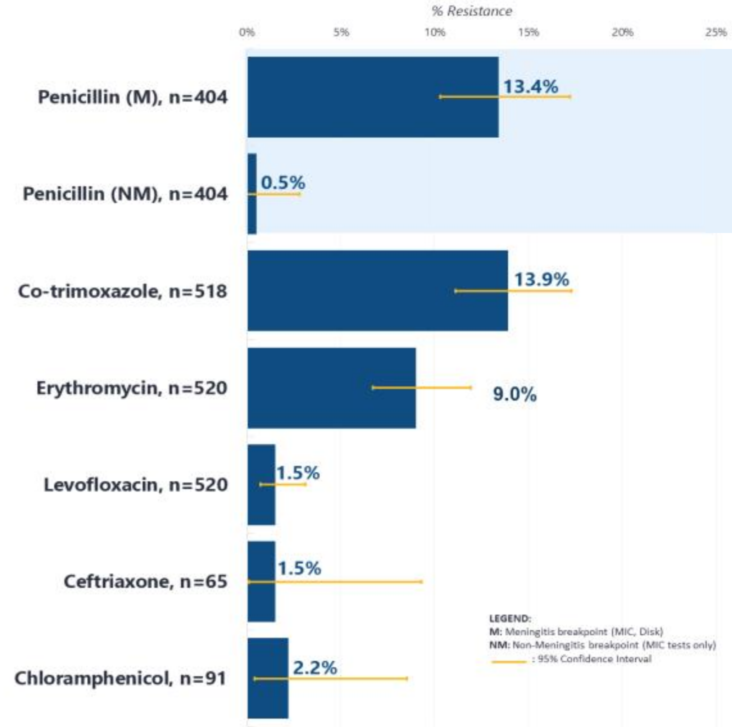


Figure 6. Isolate distribution and patient characteristics of ***Streptococcus pneumoniae*** isolates, DOH-ARSP, 2019 (N=581)

Antimicrobial Resistance Analysis

All Isolates



Penicillin Testing and Interpretation of Results for *S. pneumoniae*

The Clinical and Laboratory Standards Institute (CLSI) recommends the use of different breakpoints for meningitis (M) (MIC ≥ 0.12 ug/ml) and non-meningitis (NM) (MIC ≥ 8 ug/ml) pneumococcal isolates when testing for penicillin. The recommended meningitis breakpoints are more stringent due to the poor penetration of penicillin thru the blood brain barrier.

For 2019, penicillin resistance confirmed with MIC testing is at 0.5% (n=404 isolates) when all *S. pneumoniae* isolates were analyzed using non-meningitis (NM) breakpoints and 13.4% using meningitis (M) breakpoints.

Overall resistance rates of 2019 *S. pneumoniae* isolates against co-trimoxazole was at 13.9%, (n=518), and 9% (n=520) against erythromycin. Resistance to levofloxacin at 1.5% (n=520), and 2.2% (n=91) for chloramphenicol (Figure 7).

Figure 7. Percent resistance of *Streptococcus pneumoniae*, DOH-ARSP, 2019

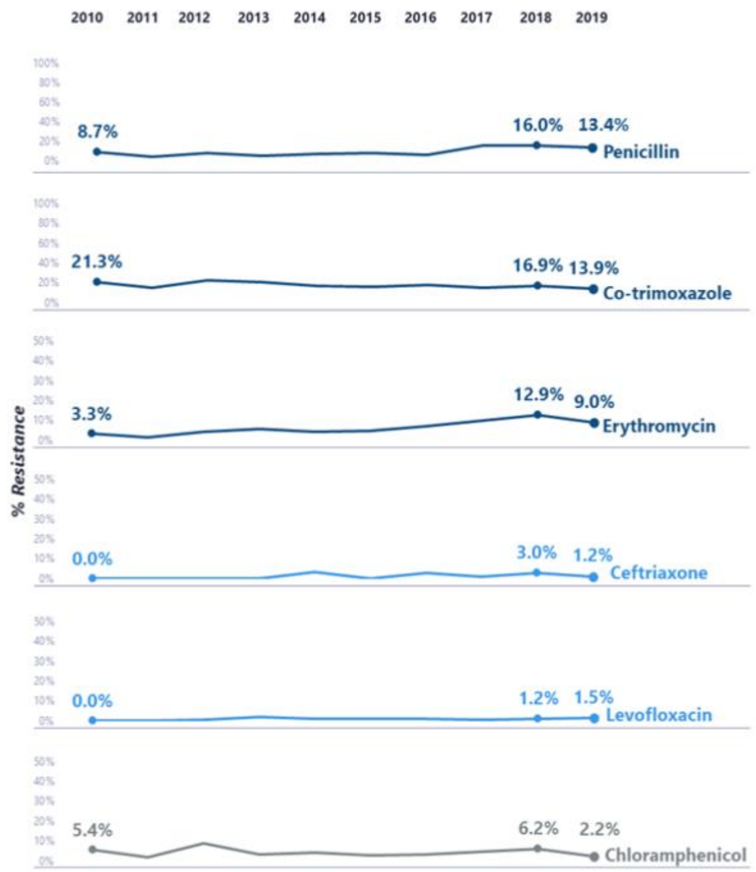


Figure 8. Yearly resistance rates of *S.pneumoniae*, DOH-ARSP, 2010-2019

The resistance to penicillin among *S. pneumoniae* isolates decreased in 2019 to 13.4% from 16% in 2018. This decrease is a deviation from the trend of increasing penicillin resistance observed in the past two years. However, this decrease in resistance, is not statistically significant.

It also was noted that resistance to co-trimoxazole had been decreasing over the past 10 years. Consistent with such trend is a decrease in resistance rate against co-trimoxazole from 16.9% in 2018 to 13.9% in 2019. This decrease is also not statistically significant (p =0.1977).

Although the resistance rate for levofloxacin remains low at 1.5% for 2019, there has been an observed increase, though not statistically significant, over the past two years.

Resistance to chloramphenicol had been increasing in the past 3 years. But for 2019, there was a decrease from 6.2% in 2018 to its current rate of 2.2% (p =0.1571) but is not statistically significant.

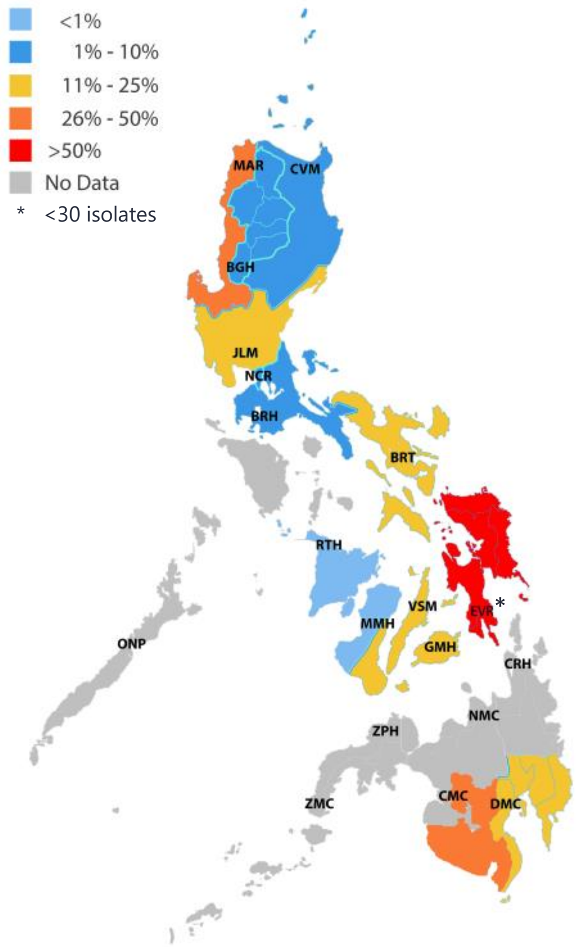


Figure 9. Geographic distribution of penicillin-resistant *S. pneumoniae* in the Philippines, DOH-ARSP, 2019

Figure 9 shows penicillin resistance of *S. pneumoniae* across the country. Penicillin resistant *S. pneumoniae* isolates were reported from almost all regions except for Regions IV-B, VI, IX, X, and XII.

Respiratory Isolates

The cumulative resistance rates of S. *pneumoniae* 2019 respiratory isolates are shown in Figure 10. Percent resistance against penicillin (meningitis breakpoint) was at 15.0% (n=260). There was 13.8% resistance against co-trimoxazole among the 354 isolates tested, while no resistance was recorded for ceftriaxone.

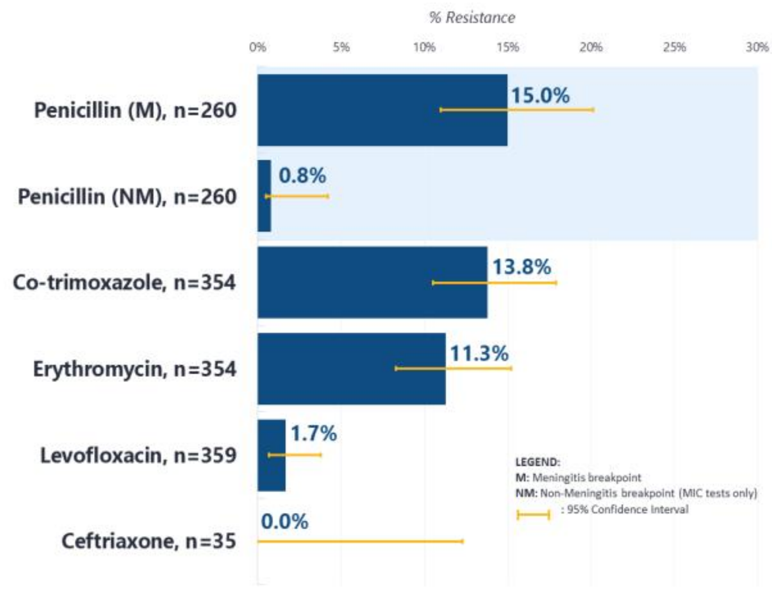


Figure 10. Percent resistance of *S. pneumoniae* respiratory isolates, DOH-ARSP, 2019

Penicillin Resistance

Among 30 confirmed penicillin-resistant (meningitis breakpoint) respiratory *S. pneumoniae* isolates, 50% (15) were from age group 20-64 years, 37% (11) were from age group 65-years and older, 6.67% (2) each for age groups 0-4 years and 5-19 years. These were mostly serotypes 19 and 23.

Blood Isolates

Cumulative resistance rates of invasive isolates are shown in Figure 11. Co-trimoxazole showed the highest resistance rate at 12.9% among 139 isolates tested followed by penicillin (meningitis breakpoint) at 10.6% (n=123) and ceftriaxone (3.3%, n=30.

Among the 11 confirmed penicillin-resistant (meningitis breakpoint) *S. pneumoniae* isolates from blood specimens, 73% (8) were from age group 20-64 years, 18% (2) were from 1-4 years and 9% (1) was from 65 years and older group. These were of sero-types 19, 10, 5, 14, 11, and 1.

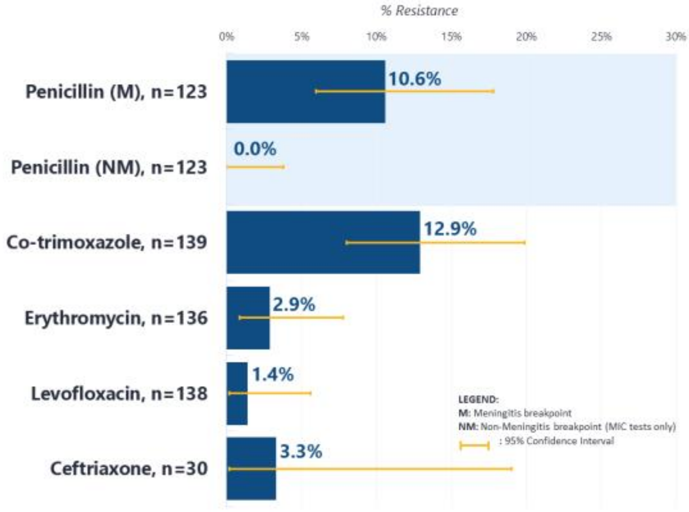


Figure 11. Percent resistance of *S. pneumoniae* blood isolates, DOH-ARSP, 2019

Serotyping

Following the Denka Seiken slide agglutination method, serotyping of *S. pneumoniae* isolates received at the reference laboratory was done to identify locally prevailing serotypes.

For 2019, there were 78 invasive (blood and CSF) pneumococci isolates that were received at the national reference laboratory for confirmatory testing and serotyping.

There were 25 different serotypes/serogroups identified with the most common being 3, 1, 10 and 5. Serotypes identified per age group is shown in Figure 12.

Vaccine

Percent pneumococcal vaccine conjugate (PCV) coverage of invasive *S. pneumoniae* isolates was determined by dividing the number of serotypes included in PCVs identified in this report over the total number of isolates with identified serotypes.

The overall PCV7 coverage of 2019 invasive *S. pneumoniae* isolates is 19.23%, 42.31% for PCV10 and 55.12% for PCV13.

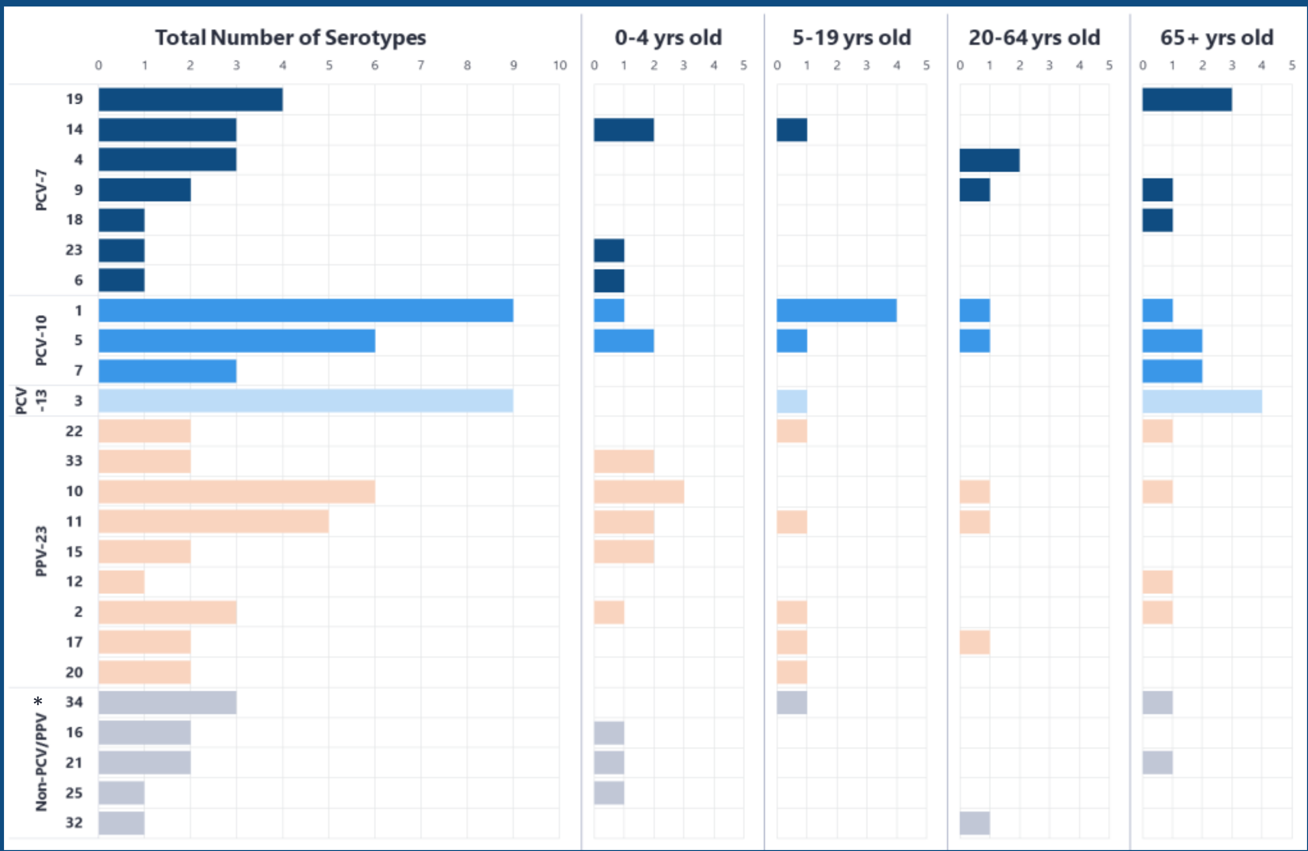


Figure 12. Invasive *S. pneumoniae* serotypes and PCV serotypes, DOH-ARSP, 2019

*Pneumococcal Polysaccharide Vaccine

Haemophilus influenzae

Isolate Distribution and Characteristics

482
Isolates analyzed

There were 482 reported H. influenzae isolates for 2019. This was 14.5% higher than the 421 isolates reported for 2018.

The biggest contributors for the 2019 *H. influenzae* data were VSM (22.8%, n=110), SLH (14.7%, n=71), and DMC (14.5%, n=70). Based on island group distribution, 57.7% came from Luzon (n=278), with 56.1% coming from the NCR, 27.8% from Visayas (n=134), and 14.5% from Mindanao (n=70) (Figure 13-A).

Majority (51.2%) of the isolates came from patients 20-64 years of age, and most were males (61.6%). Majority of the *H. influenzae* isolates reported were from respiratory specimens (89.8%), and 6% from blood.

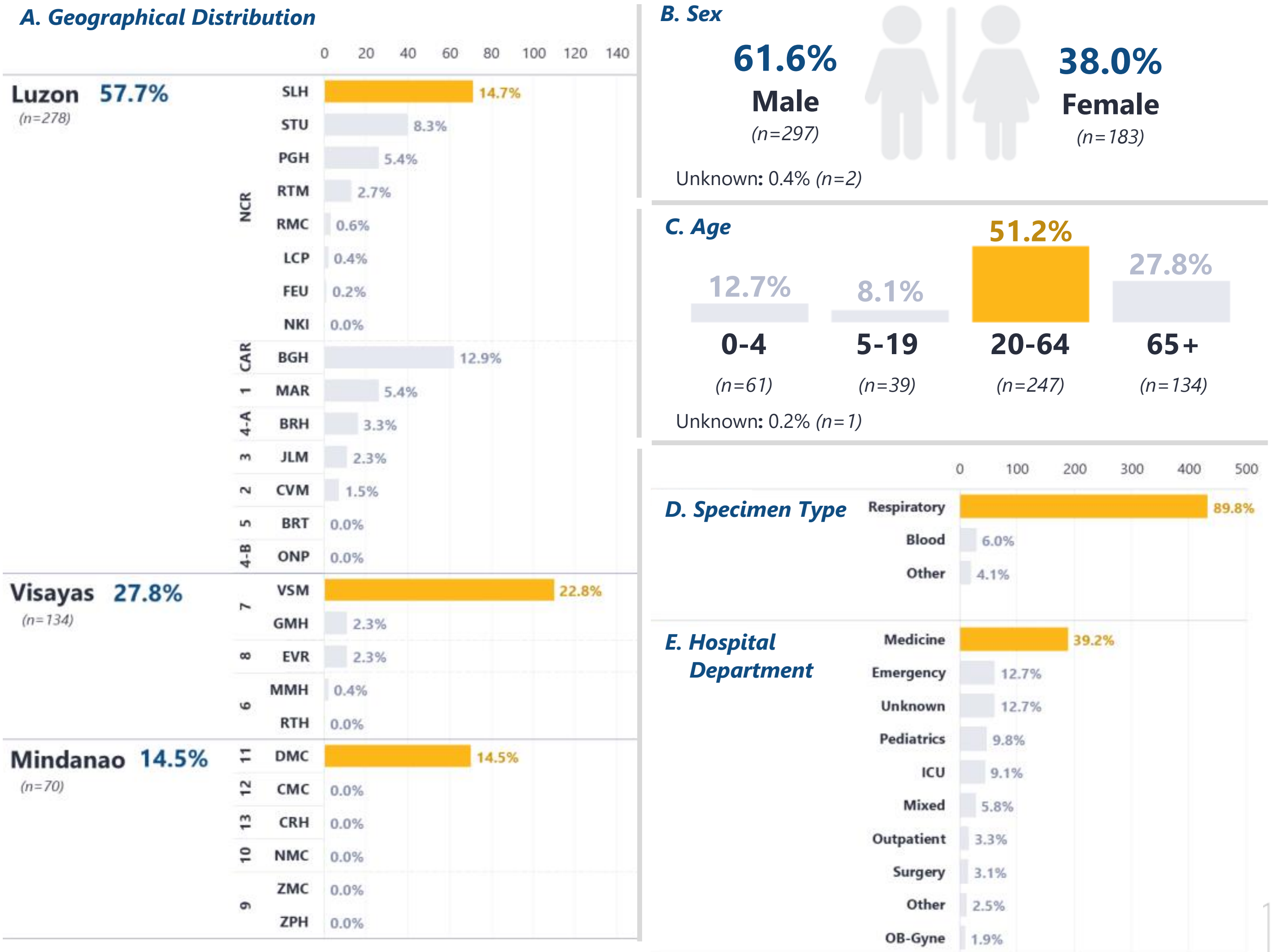


Figure 13. Isolate distribution and patient characteristics of *H. influenzae* isolates, DOH-ARSP 2019 (N=482)

All Isolates

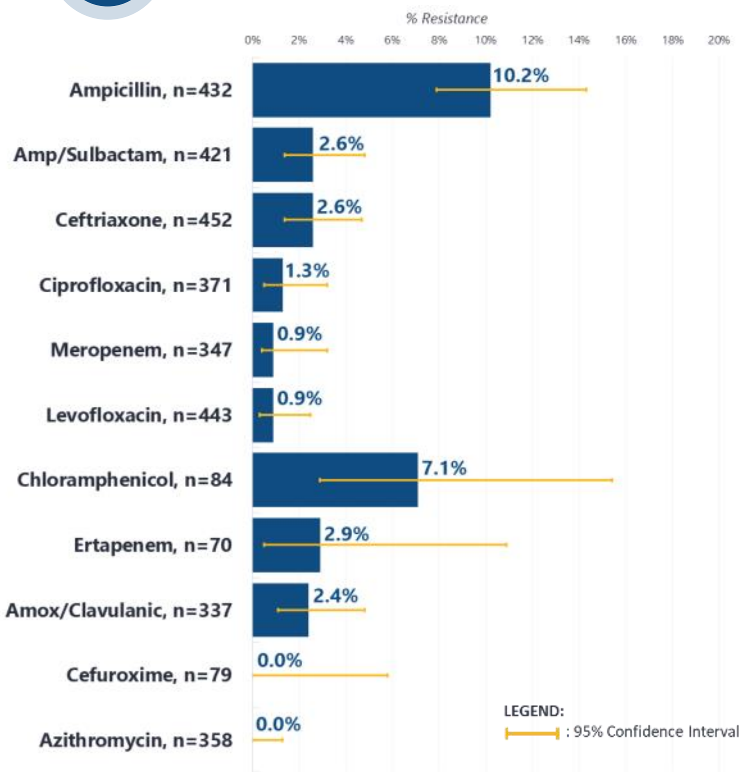


Figure 14. Percent resistance of *H. influenzae,* DOH-ARSP, 2019

Resistance rates of *H. influenzae* for 2019 ranged from zero for azithromycin (n=358) and cefuroxime (n=79) to 10.2% for ampicillin (n=432) (Figure 14).

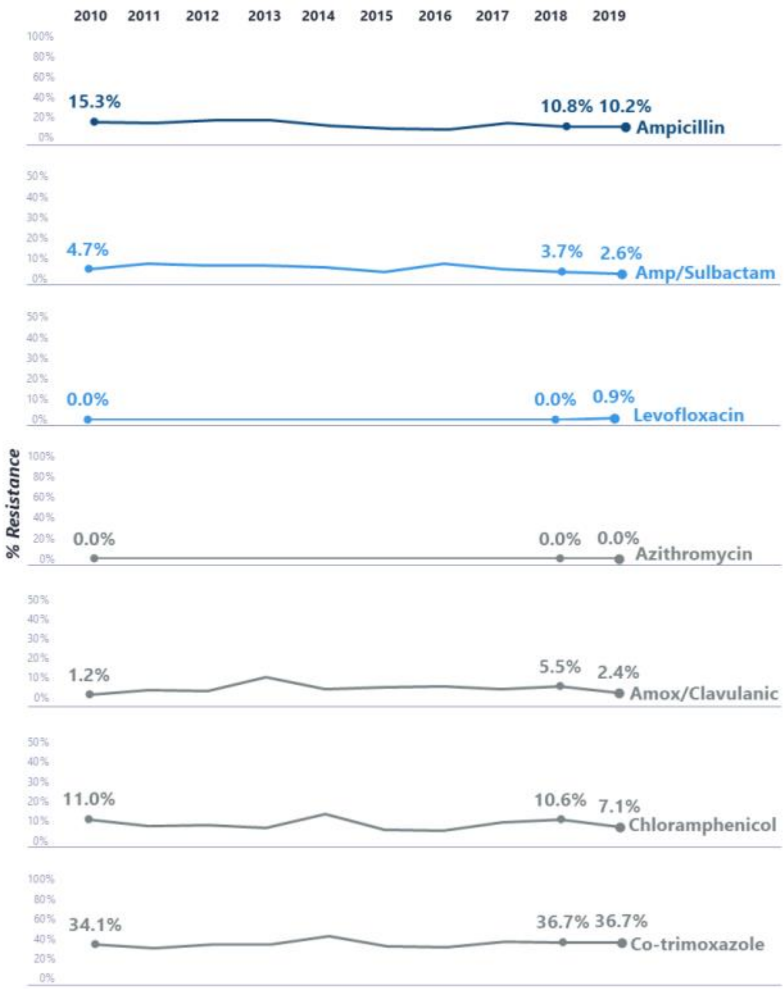


Figure 15. Yearly resistance rates of *Haemophilus influenzae,* DOH-ARSP, 2010-2019

When compared with the 2018 *H. influenzae* resistance rates for all specimens, there were decreases in the resistance rates for ampicillin from 11% to 10.2% in 2019 (p = 0.7150), chloramphenicol from 11% to 7.1% (p = 0.3472), ampicillin/sulbactam from 4% in 2018 to 2.6% (p = 0.2828) in 2019, and amoxicillin/ clavulanic acid from 6% to 2.4% showing a statistical significance with p value of 0.0195. (Figure 15).

Antimicrobial Resistance Analysis

Respiratory Isolates

Resistance rates among respiratory isolates of *Haemophilus influenzae* are shown in Figure 16. Resistance to ampicillin was highest at 10.8% (n=390) followed by chloramphenicol at 8.2% (n=73), ceftriaxone (2.9%, n=410) and ampicillin-sulbactam (2.7%, n=376).

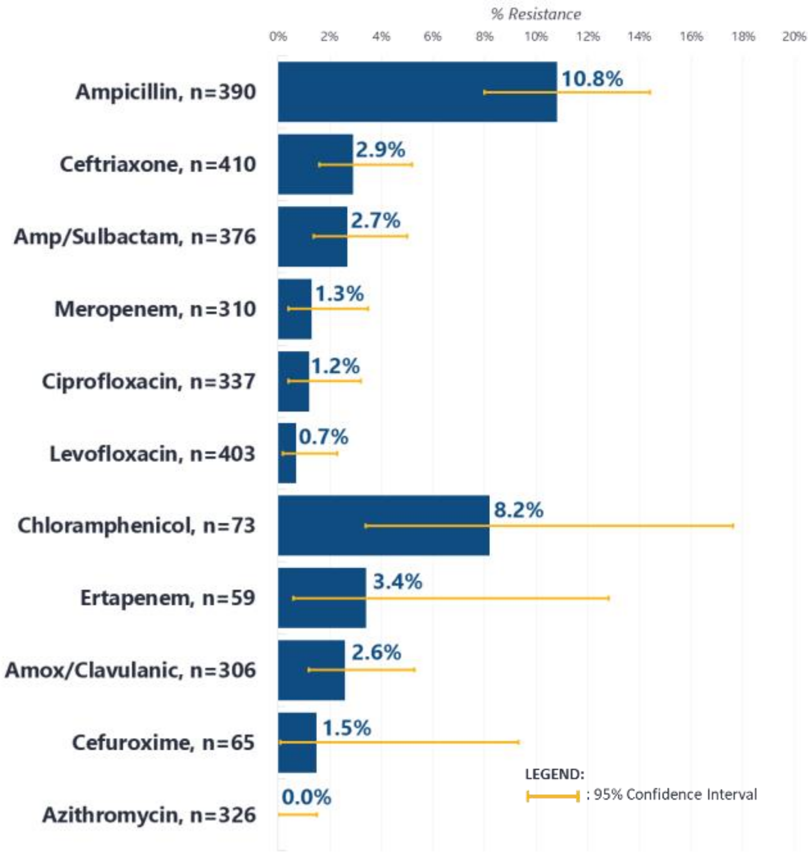


Figure 16. Percent resistance of *H. influenzae* respiratory isolates, DOH-ARSP, 2019

Amoxicillin-Clavulanic Acid Resistance

There were two isolates confirmed to be amoxicillin-clavulanic acid resistant, one isolate was from a 69-year old female from the Mindanao and one from a 70-year old male from Visayas.

Ampicillin-Sulbactam Resistance

Of the 9 reported *H. influenzae* isolates resistant to ampicillin/sulbactam, 3 were confirmed to be resistant by ARSRL while the rest were not referred for confirmation. Two of the isolates confirmed to be ampicillin/sulbactam resistant were from DMC and one was from VSM. The isolate from VSM was also resistant to amoxicillin-clavulanic acid and beta-lactamase-negative ampicillin-resistant (BLNAR) *H. influenzae* from a 70-year-old male.

For BLNAR H. influenza isolates, resistance to penicillin and ampicillin may be due to mechanisms other than beta-lactamase production such as alterations in penicillin binding proteins, particularly PBP3. BLNAR phenotypes are associated with increasing resistance to ampicillin, amoxicillin, amoxicillin-clavulanic acid, and many cephalosporins, limiting the efficacy of expanded-spectrum cephalosporins against meningitis and of many oral cephalosporins against other diseases.

Blood and Cerebrospinal fluid Isolates

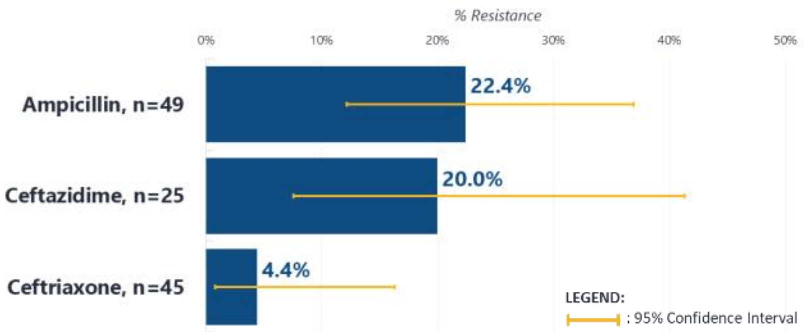


Figure 17. Percent resistance of *H. influenzae* blood and cerebrospinal fluid isolates, DOH-ARSP, 2018-2019

To obtain a reasonable statistical estimate of the cumulative percentage resistance for *H. influenzae* from blood and CSF, we combined the results of isolates from 2018 to 2019 (n=49). Resistance to ampicillin was at 22.4% (n=49), while no resistance were detected for both ceftriaxone and meropenem.

Salmonella enterica serovar Typhi

Isolate Distribution and Characteristics

There were 139 S. Typhi isolates reported and analyzed for 2019. This is 17.80% more than the 118 isolates reported for 2018.

139
Isolates analyzed

CMC contributed most to the number of *S.* Typhi isolates (18%). Based on island group distribution, 28.1% came from Luzon with 5.8% coming from the NCR and 36% from Visayas as well as Mindanao (Figure 18-A).

Many of the isolates came from patients 5-19 years of age (50.4%), and more than half were males (56.1%). Majority of the *S.* Typhi reported were from blood (92.8%), and 2.2% were from stool. The rest of the isolates were from wound, urine, tissue and other body fluids (Figure 18-B to D).

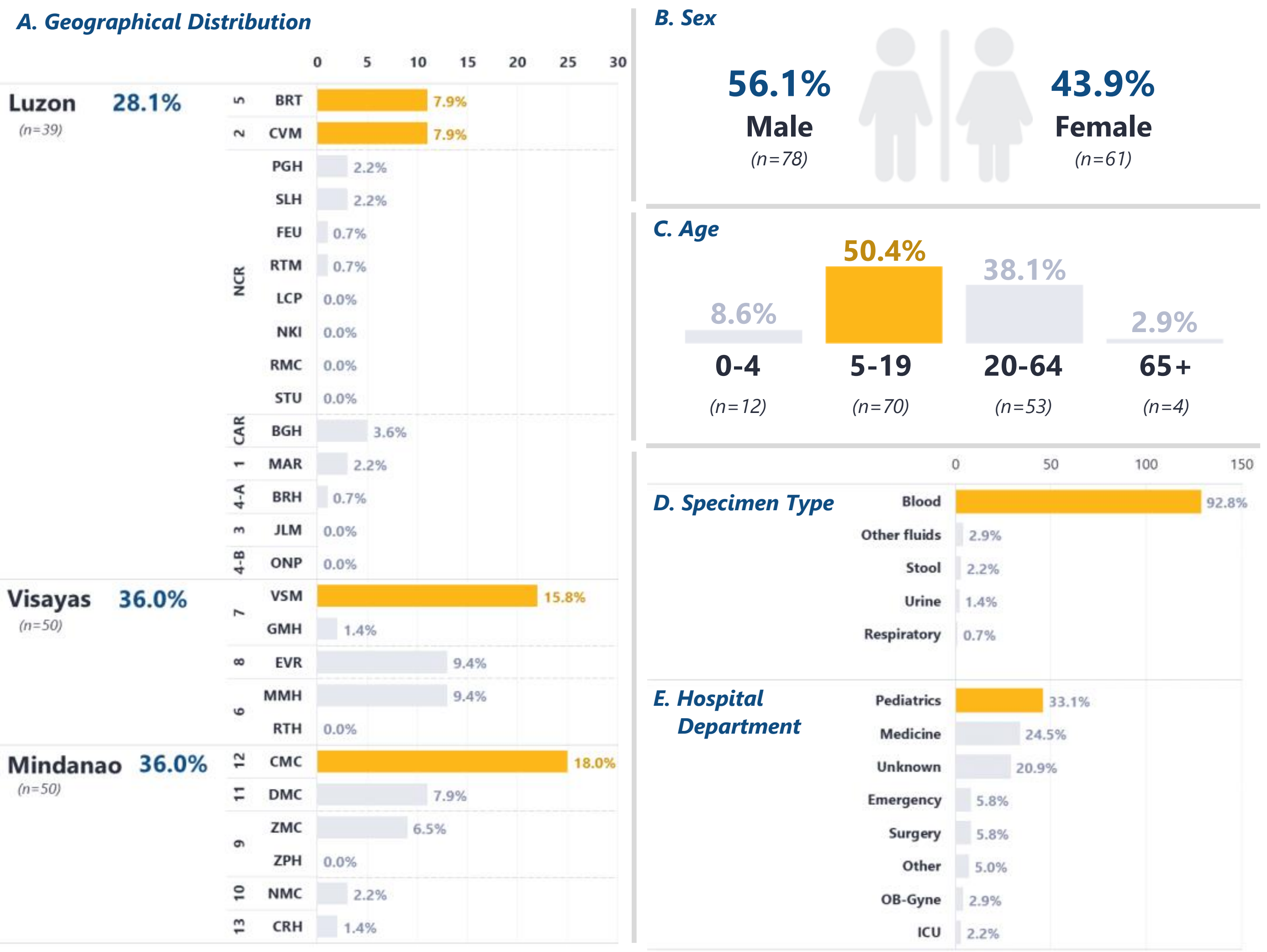


Figure 18. Isolate distribution and patient characteristics of *Salmonella enterica* serovar Typhi isolates, DOH-ARSP, 2019 (N=139)

All Isolates

The cumulative resistance rates of *S.* Typhi to antibiotics used against it remained at less than 5% (Figure 19).

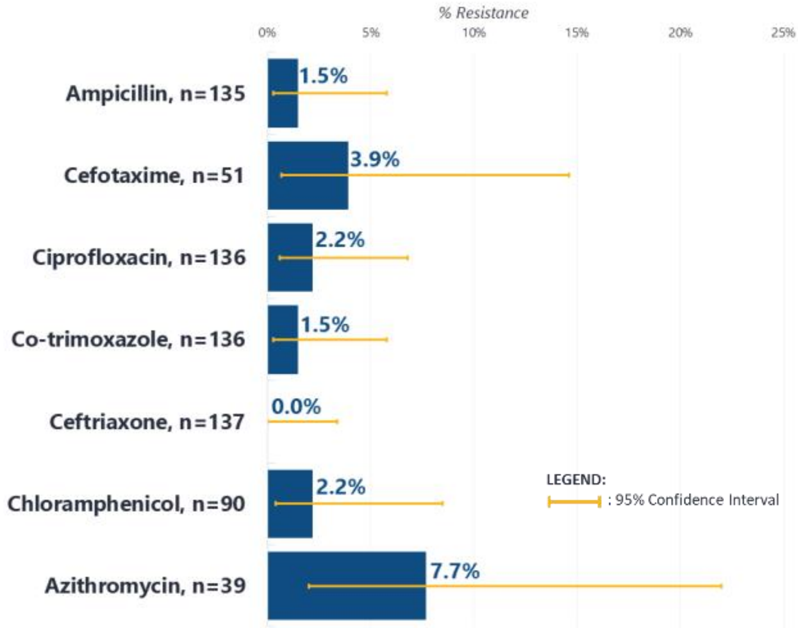


Figure 19. Percent resistance of *S.* Typhi, DOH-ARSP, 2019

Ciprofloxacin Resistance

There were 3 ciprofloxacin resistant *S.* Typhi isolates reported for 2019. The isolate from Visayas was from blood specimen of a 21 year old male. Of the two ciprofloxacin resistant isolates from Mindanao, one was from urine specimen of a 57 year old male while the other isolate was from fluid specimen of a 49 year old female. The second ciprofloxacin resistant *S.* Typhi from Mindanao was also resistant to levofloxacin but susceptible to cefotaxime and ceftriaxone. These isolates were not sent to ARSRL for confirmation.

The ten year trend of resistance for *S.* Typhi is shown in Figure 20. The decrease in resistance to ampicillin, co-trimoxazole, ceftriaxone and chloramphenicol were not statistically significant. There has been an increase in resistance to ciprofloxacin for the past two years, although not statistically significant.

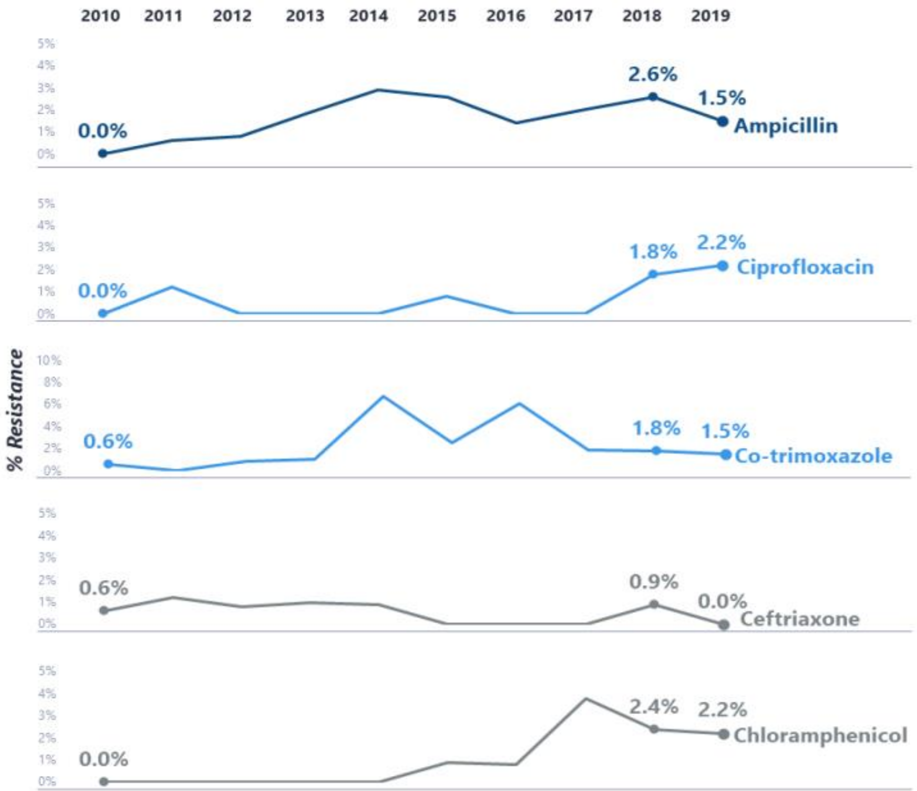


Figure 20. Yearly resistance rates of *S.* Typhi, DOH-ARSP, 2010-2019

Blood Isolates

Among the *Salmonella enterica* serotype Typhi blood isolates, it was noted that 1.6% of 127 isolates tested were resistant against ampicillin, 4.7% of 43 isolates tested were resistant to cefotaxime and 2.4% (n=85) for chloramphenicol. The detected resistance rate for ciprofloxacin was low at <1% while zero for ceftriaxone (Figure 21).

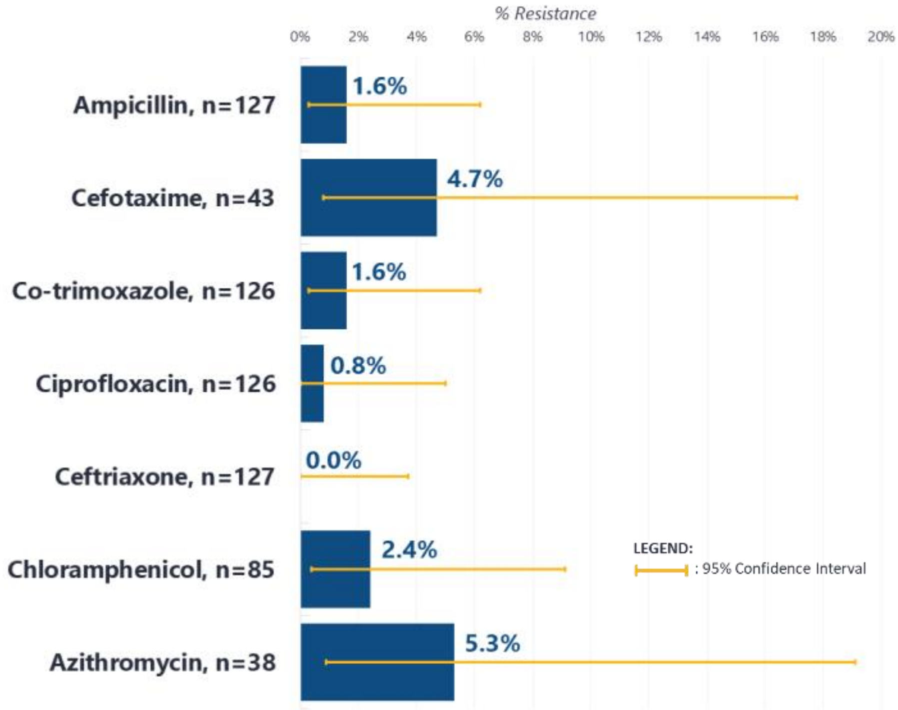


Figure 21. Percent resistance of *S.* Typhi blood isolates, DOH-ARSP, 2019

Non-typhoidal *Salmonella* species

Isolate Distribution and Characteristics

245
Isolates analyzed

There were 245 reported nontyphoidal Salmonella (NTS) isolates for 2019. This is 6.06% more than the 231 reported nontyphoidal Salmonella isolates for 2018.

PGH (20%) contributed most to the number of NTS isolates. Based on island group distribution, 67.3% came from Luzon with 61.21% coming from the NCR, 15.9% from Visayas and 16.7% from Mindanao (Figure 22-A).

Majority (50.6%) of the isolates came from patients 20-64 years of age, and most (63.3%) were males. Many of the NTS reported were from blood (47.8%), 16.7% from wound, 15.9% from stool and 9.4% from urine. The rest of the isolates were from respiratory specimens and other body fluids (Figure 22-B to D).

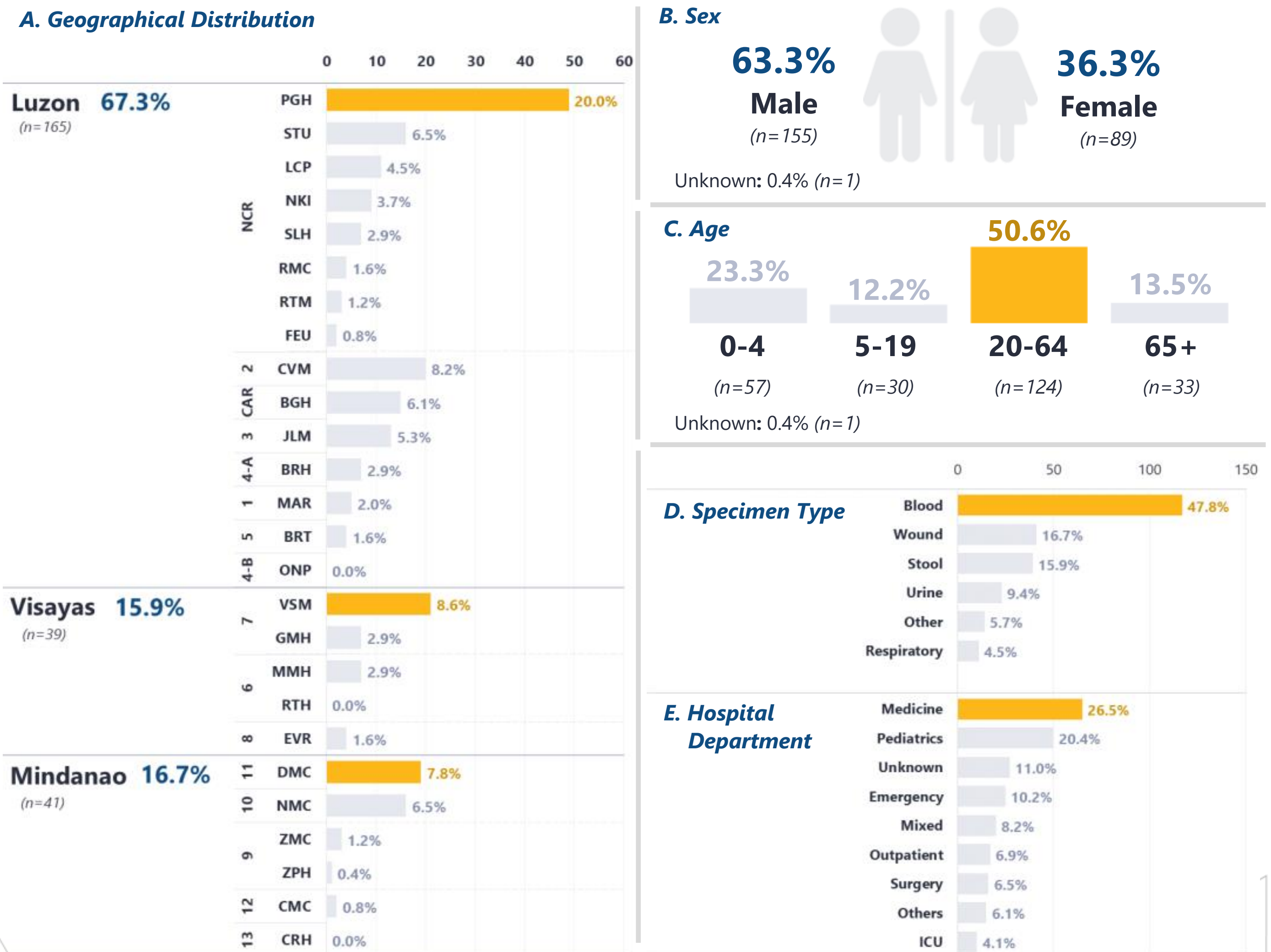


Figure 22. Isolate distribution and patient characteristics of Nontyphoidal *Salmonella* species isolates, DOH-ARSP, 2019 (N=245)

Antimicrobial Resistance Analysis

All Isolates

Figure 23 shows the antimicrobial resistance rates of NTS isolates for 2019. Resistance against ampicillin was 30% (n=213), which is lower from 2018 rate of 40% (*p*=0.036), while resistance to levofloxacin was 20.9% (n=43), which was higher than the rate of 5% reported in 2018 (*p*= 0.0375).

Yearly resistance rates for NTS are shown in Figure 24. Resistance rate against co-trimoxazole is seen to be decreasing for the past six years while increasing for chloramphenicol.

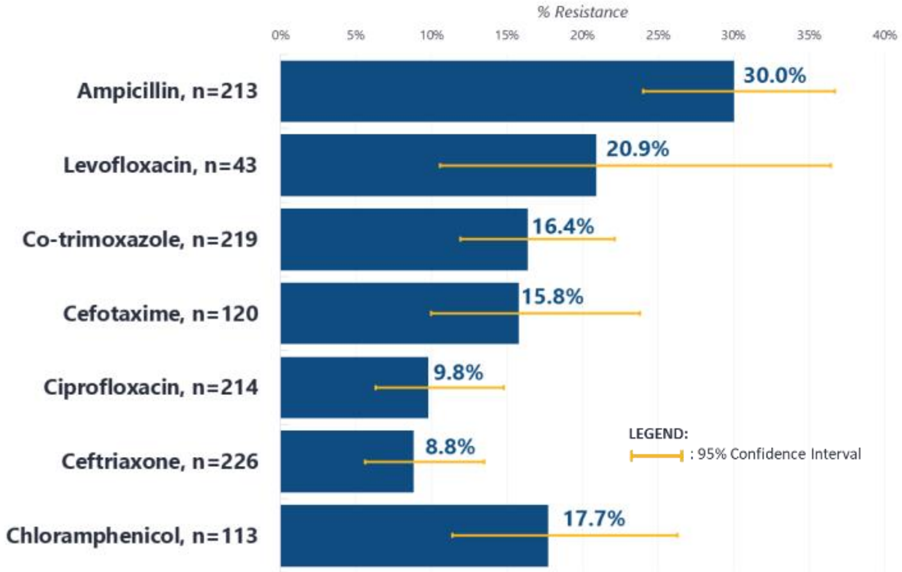


Figure 23. Percent resistance of Nontyphoidal *Salmonella,* DOH-ARSP, 2019

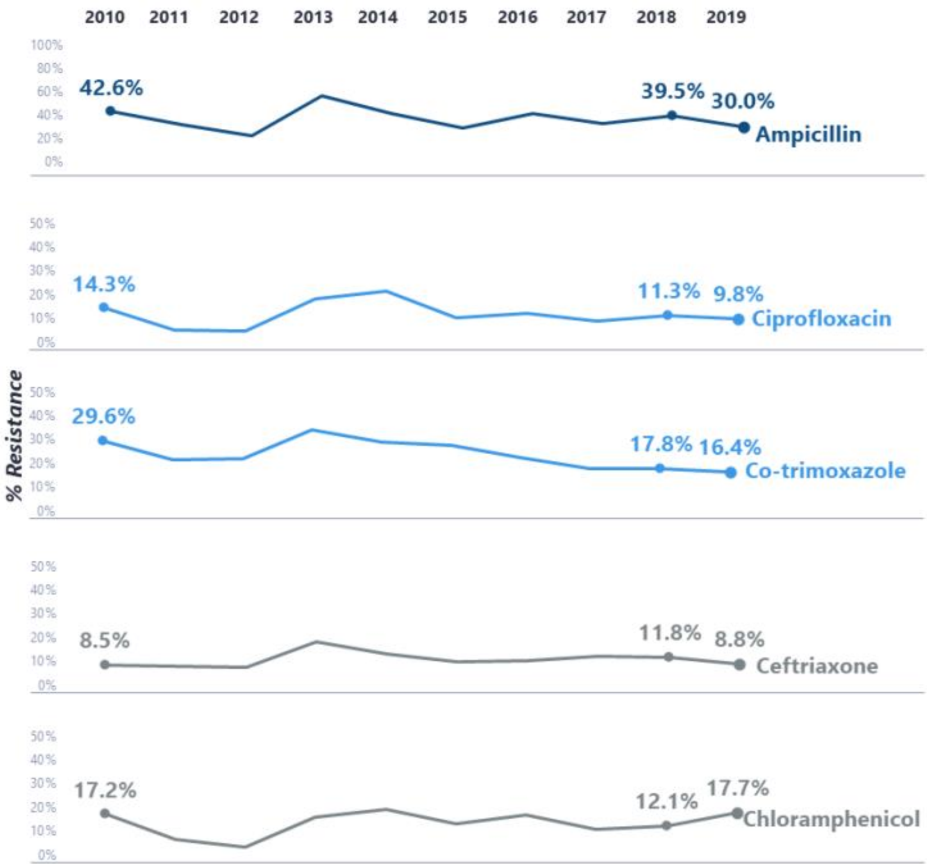


Figure 24. Yearly resistance rates of Nontyphoidal *Salmonella,* DOH-ARSP, 2010-2019

Blood Isolates

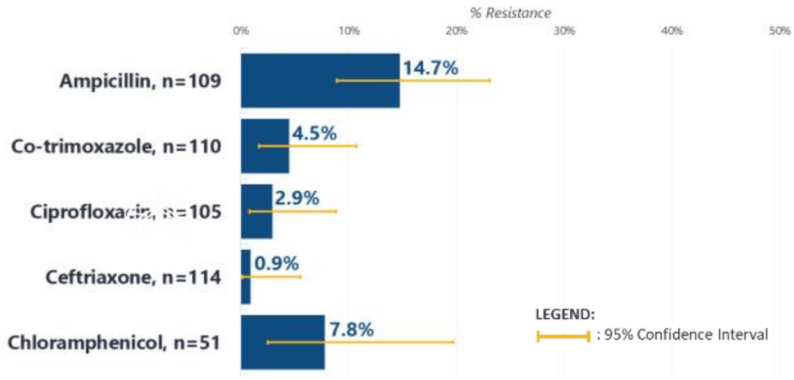


Figure 25. Percent resistance of Nontyphoidal *Salmonella* blood isolates, DOH-ARSP, 2019

Figure 25 shows the percent resistance rates of NTS blood isolates. Percent resistance rates of blood NTS isolates to ampicillin (n=109) is at 14.7% and chloramphenicol (n=51) at 7.8%, while the resistance rates for co-trimoxazole, ciprofloxacin, and ceftriaxone remains at less than 5%.

Serotyping

There were 193 confirmed *Salmonellae* at the reference laboratory. Most of these isolates were *Salmonella enterica* serovar Typhi (50.7%).

Among the 95 confirmed nontyphoidal *Salmonella*, the most common serotypes identified were *Salmonella enterica* serovar Enteritidis (42 isolates) and *Salmonella enterica* serovar Typhimurium (13 isolates) which were also the most commonly reported for the past five years. Antimicrobial resistance for NTS varies by serotype. Overall changes in resistance among NTS reflects variations in serotypes, its distribution, or both.

Table 2. List of confirmed *Salmonella* serotypes, DOH-ARSP, 2019

Serotype	No. of isolates
Salmonella Typhi	98
Salmonella Enteritidis	42
Salmonella Typhimurium	13
Salmonella Anatum	6
Salmonella Weltevreden	5
Salmonella Rissen	3
Salmonella Schwarzengrund	3
Salmonella Virchow	3
Salmonella London	2
Salmonella Agona	2
Salmonella Group B	2
Salmonella Group E	2
Salmonella Alachua	1
Salmonella Brunei	1
Salmonella Emek	1
Salmonella enterica ss. diarizonae	1
Salmonella Group C	1
Salmonella Aberdeen	1
Salmonella Group I	1
Salmonella Makiso	1
Salmonella Muenster	1
Salmonella Nesziona	1
Salmonella Newport	1
Salmonella Saintpaul	1
Total	**193**

Shigella species

Isolate Distribution and Characteristics

For 2019 there were 45 Shigella species isolates reported which is 45% higher in number than those reported in 2018 (31 isolates).

45

Isolates analyzed

Largest sentinel site contributors *Shigella* sp. in 2019 data were VSM (28.9%) and PGH (20%) as seen in Figure 26-A. Based on island group distribution, 51.1% were from Luzon with 82.61% coming from the NCR, 33.3% from Visayas and 15.6% from Mindanao (Figure 26-A).

Many of the isolates came from patients 5-19 years of age (40%). The number of samples from males is almost equal to those from females. Most of the reported *Shigella* sp. 2019 isolates were from stool (73.3%), 11.1% from urine and 8.9% from blood. The rest of the isolates were from genitals, wound and other body fluids (Figure 26-B to D).

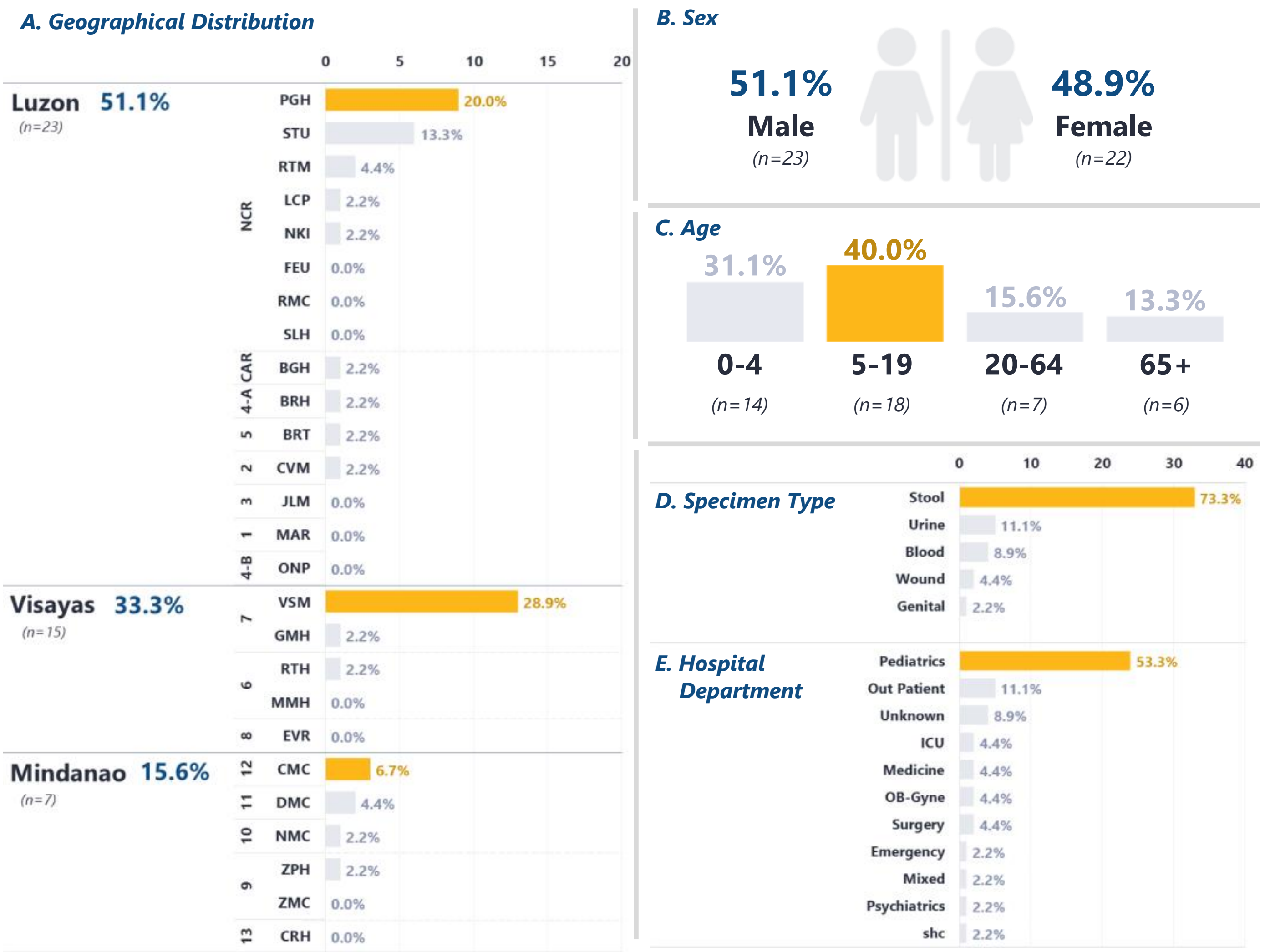


Figure 26. Isolate distribution and patient characteristics of *Shigella* species isolates, DOH-ARSP, 2019 (N=45)

All Isolates

Resistance rates of *Shigella* sp. for 2019 are shown in Figure 27. High resistance is seen for ampicillin at 68.2% (n=44) and for co-trimoxazole at 60.5% (n=43).

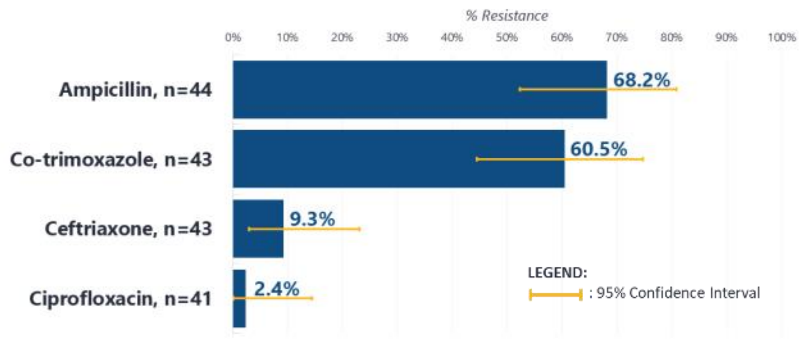


Figure 27. Percent resistance of *Shigella* species , DOH-ARSP, 2019

Ceftriaxone Resistance

There were 4 isolates reported to be resistant to ceftriaxone – 2 from Metro Manila and 1 each from Visayas and Mindanao. One of the ceftriaxone resistant isolate from Metro Manila was also resistant to ciprofloxacin. These isolates were not sent to the reference laboratory for confirmation.

Yearly resistance rates of *Shigella* sp. is shown in Figure 28. The decrease in resistance rates for co-trimoxazole from the resistance rate for combined 2017 and 2018 isolates compared with the rates in 2019 were not statistically significant. The increase in resistance rates of 2.1% and 2.4% in 2018 and 2019, respectively, for ciprofloxacin were also not significant.

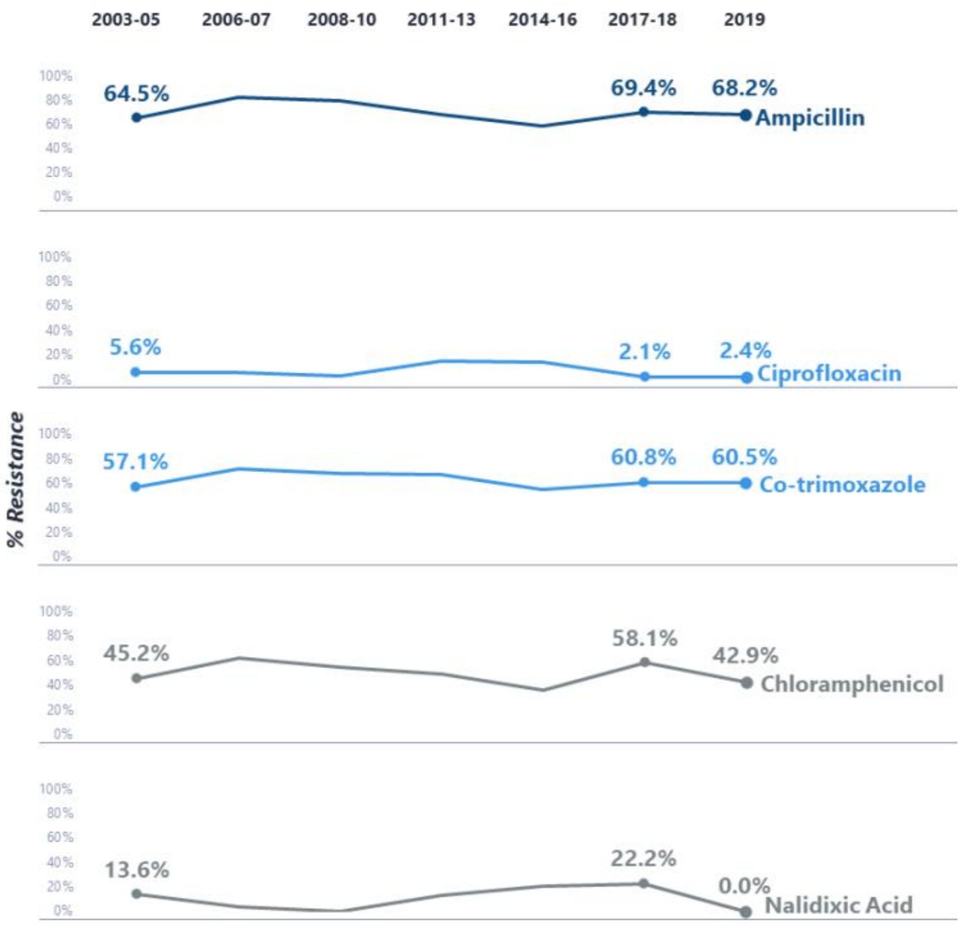


Figure 28. Yearly resistance rates of *Shigella* species, DOH-ARSP, 2003-2019

Stool Isolates

Among *Shigella* species from stool samples, resistance to co-trimoxazole was very high at a 63.6% while resistance to ceftriaxone was at 6.5% (Figure 29). There were no reports of resistance to ciprofloxacin.

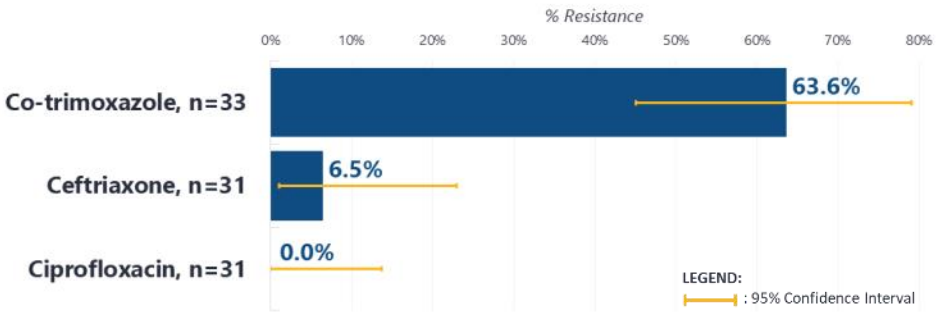


Figure 29. Percent resistance of *Shigella* species stool isolates, DOH-ARSP, 2019

Vibrio cholerae

Isolate Distribution and Characteristics

14
Isolates analyzed

There were only 14 isolates of Vibrio cholerae reported for 2019, which is the same number of isolates reported in 2018.

Half (50%) of *V. cholerae* isolates in 2019 is from BGH. Based on island group distribution, 78.6% came from Luzon, 21.4% from Mindanao and 0% from Visayas (Figure 30-A).

Fifty percent (50%, n=7) of *V. cholerae* isolates for 2019 came from the combined age group of 0-19 year and 50% were from adults 20-64 years old (50%, n=7). Most of the patients were males (85.7%). Majority of the isolates were from stool (12 out of 14 isolates) with two isolates from blood (Figure 30-B to D).

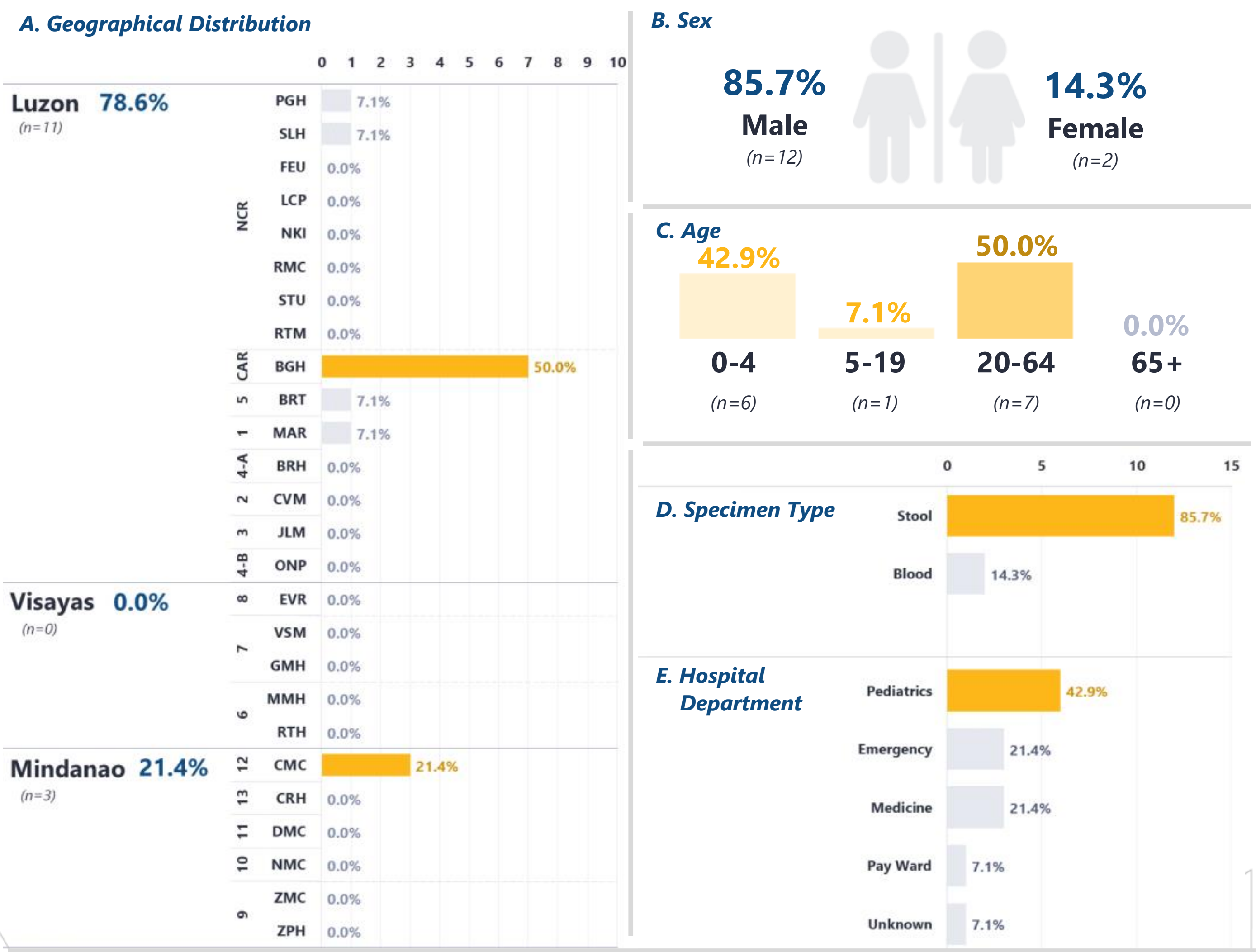


Figure 30. Isolate distribution and patient characteristics of *Vibrio cholerae* isolates, DOH-ARSP, 2019 (N=14)

Antimicrobial Resistance Analysis

All Isolates

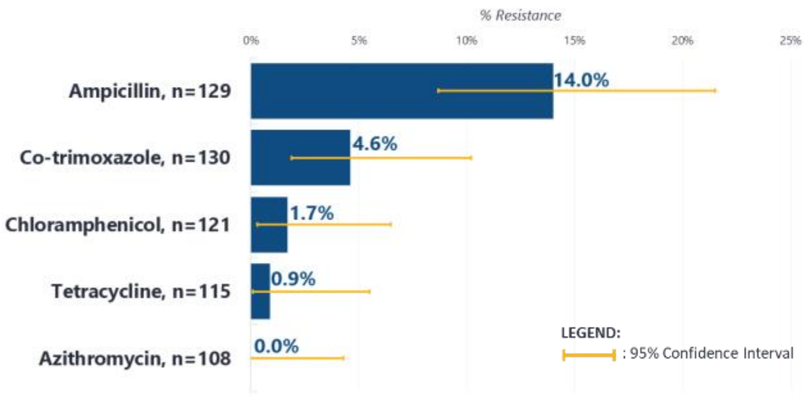


Figure 31. Percent resistance of *Vibrio cholerae,* DOH-ARSP, 2017-2019

As there were very few *V. cholerae* isolates for 2019, we combined the results of isolates from 2017 to 2019 (n= 131) to obtain a reasonable statistical estimate of the cumulative percentage resistance for *V. cholerae*.

Resistance rates to ampicillin was at 14% (n=129), 4.6% (n=130) for co-trimoxazole and 1.7% (n=121) for chloramphenicol. No resistance to azithromycin was reported for 2019 (Figure 31).

Yearly resistance rates of *V. cholerae* isolates are shown in Figure 32. The cumulative resistance rates of the three antibiotics tested against *V. cholerae* increased from 2016 to the rates for 2019.

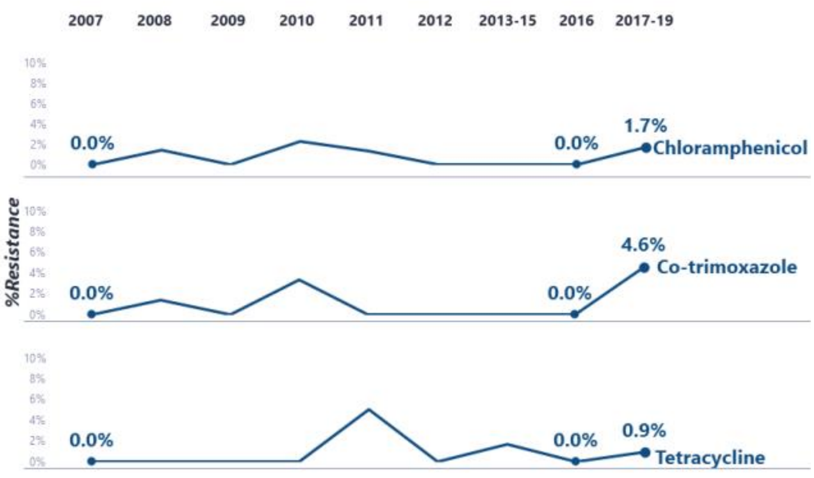


Figure 32. Yearly resistance rates of *Vibrio cholerae,* DOH-ARSP, 2007-2019

Stool Isolates

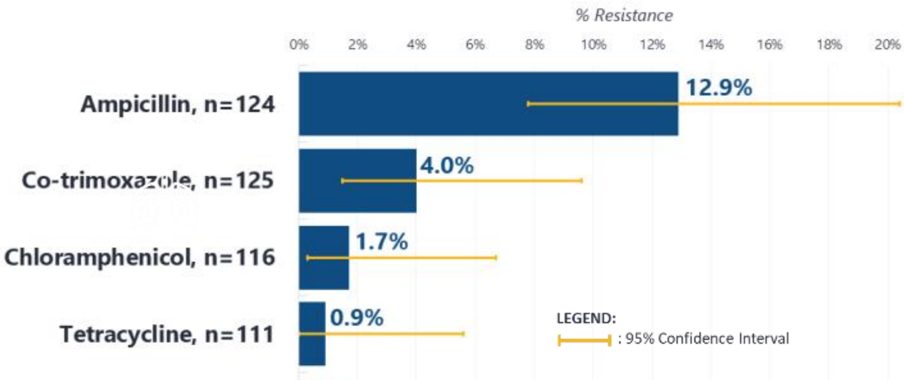


Figure 33. Percent resistance for *V. cholerae* stool isolates, DOH-ARSP, 2017-2019

Among *V. cholerae* isolates from stool specimens from 2017 to 2019, resistance rates for ampicillin was 12.9% (n=124), 4% (n=125) for co-trimoxazole, 1.7% (n=116) for chloramphenicol, and 0.9% (n=111) for tetracycline (Figure 33).

Neisseria gonorrhoeae

Isolate Distribution and Characteristics

142
Isolates analyzed

There were 142 Neisseria gonorrhoeae isolates reported for 2019. This is 27% more than those reported for 2018 (n=112).

The largest contributors of the 2019 *N. gonorrhoeae* data were VSM (33.8%, n=48), RTM (25.4%, n=36) and RTH (21.1%, n=30). Based on island group distribution, 41.5% of *N. gonorrhoeae* isolates reported for 2019 were from Luzon, 57% from the Visayas and 1.4% from Mindanao (Figure 34-A). Most of the 2019 isolates came from patients 20-64 years of age (63.4%) and majority were males (79.6%) (Figure 34 B-C).

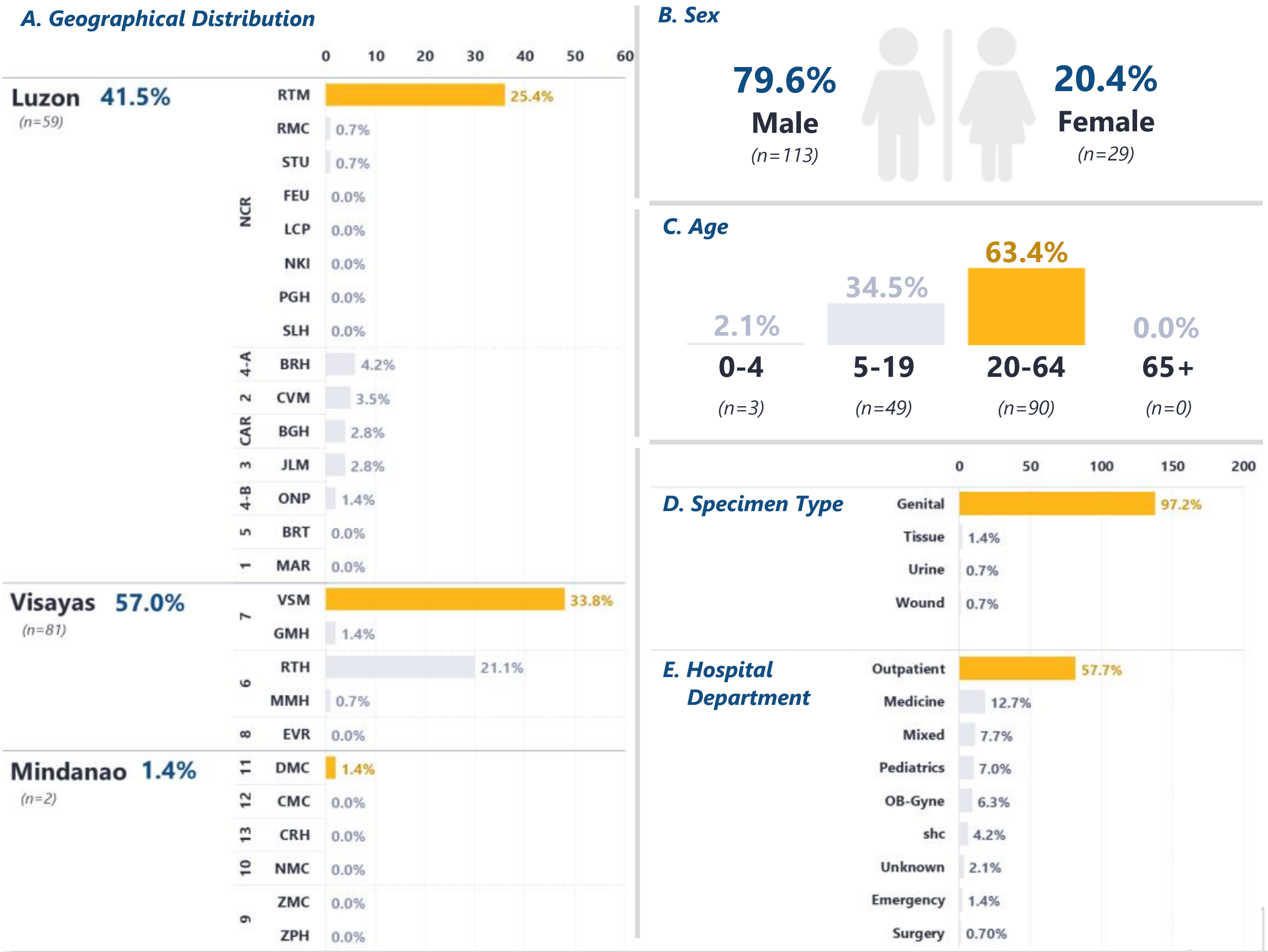


Figure 34. Isolate distribution and patient characteristics of *N. gonorrhoeae* isolates, DOH-ARSP, 2019 (N=142)

Antimicrobial Resistance Analysis

All Isolates

Cumulative resistance rates of *N. gonorrhoeae* isolates reported for 2019 are shown in Figure 35. Resistance to ciprofloxacin (79.4%) and tetracycline (58%) are both above 50%, no resistance was reported for cefixime.

Figure 36 showed the yearly resistance rates of *N. gonorrhoeae*. Ciprofloxacin and tetracycline resistance had been relatively at constant high levels for the past ten years while resistance to spectinomycin remained at zero for the last ten years.

Azithromycin Resistance

There were 3 isolates reported to be non-susceptible to azithromycin - from a female from Visayas and from 2 males from Metro Manila. The isolate from the Visayas was confirmed by ARSRL to be non-susceptible to azithromycin.

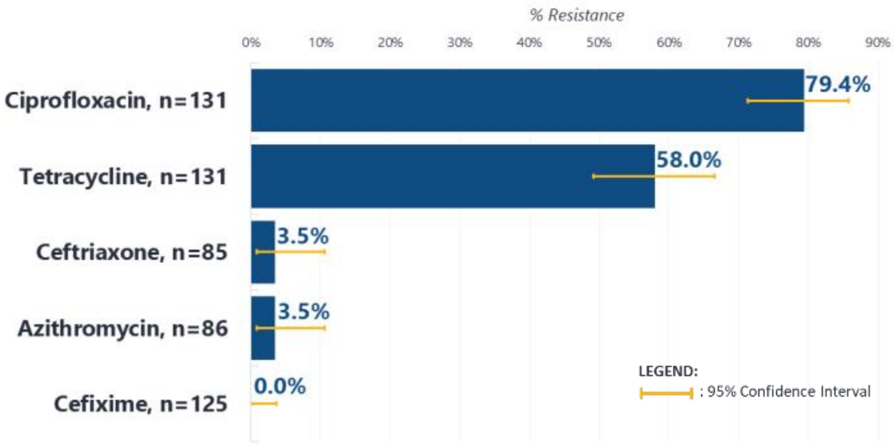


Figure 35. Percent resistance of ***N. gonorrhoeae*****, DOH-ARSP, 2019**

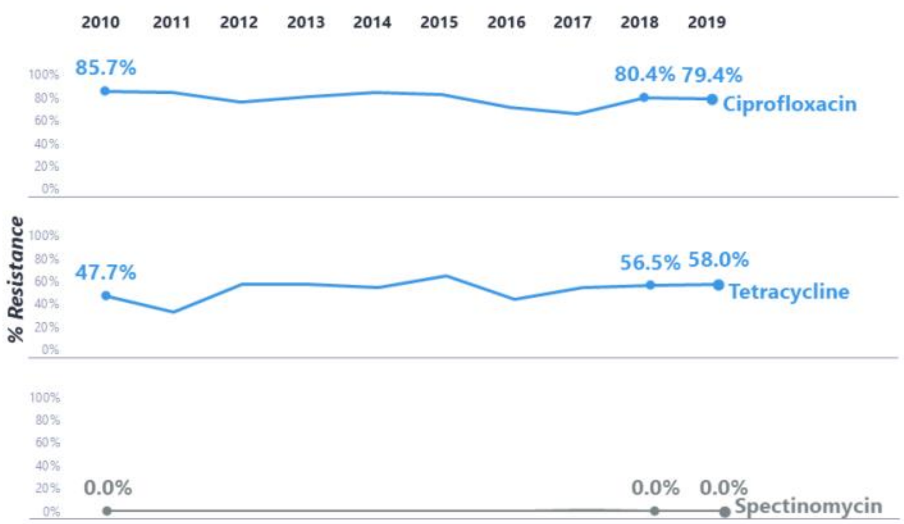


Figure 36. Yearly resistance rates of ***N. gonorrhoeae*****, DOH-ARSP, 2010-2019**

Staphylococcus aureus

Isolate Distribution and Characteristics

7,617
Isolates analyzed

For 2019, there were a total of 7,617 isolates of Staphylococcus aureus reported compared to 7,026 isolates in 2018 – an 8.41% increase.

Most of the *S. aureus* isolates were from Luzon (61.5%) with 47.7% coming from Metro Manila sites, 19.5% from the Visayas and 19% from Mindanao (Figure 37-A). Most of the isolates were from males (56.8%), and from age group 20-64 years old (56.9%). Most *S. aureus* were isolated from wound (40.8%) (Figure 37 B, D and F).

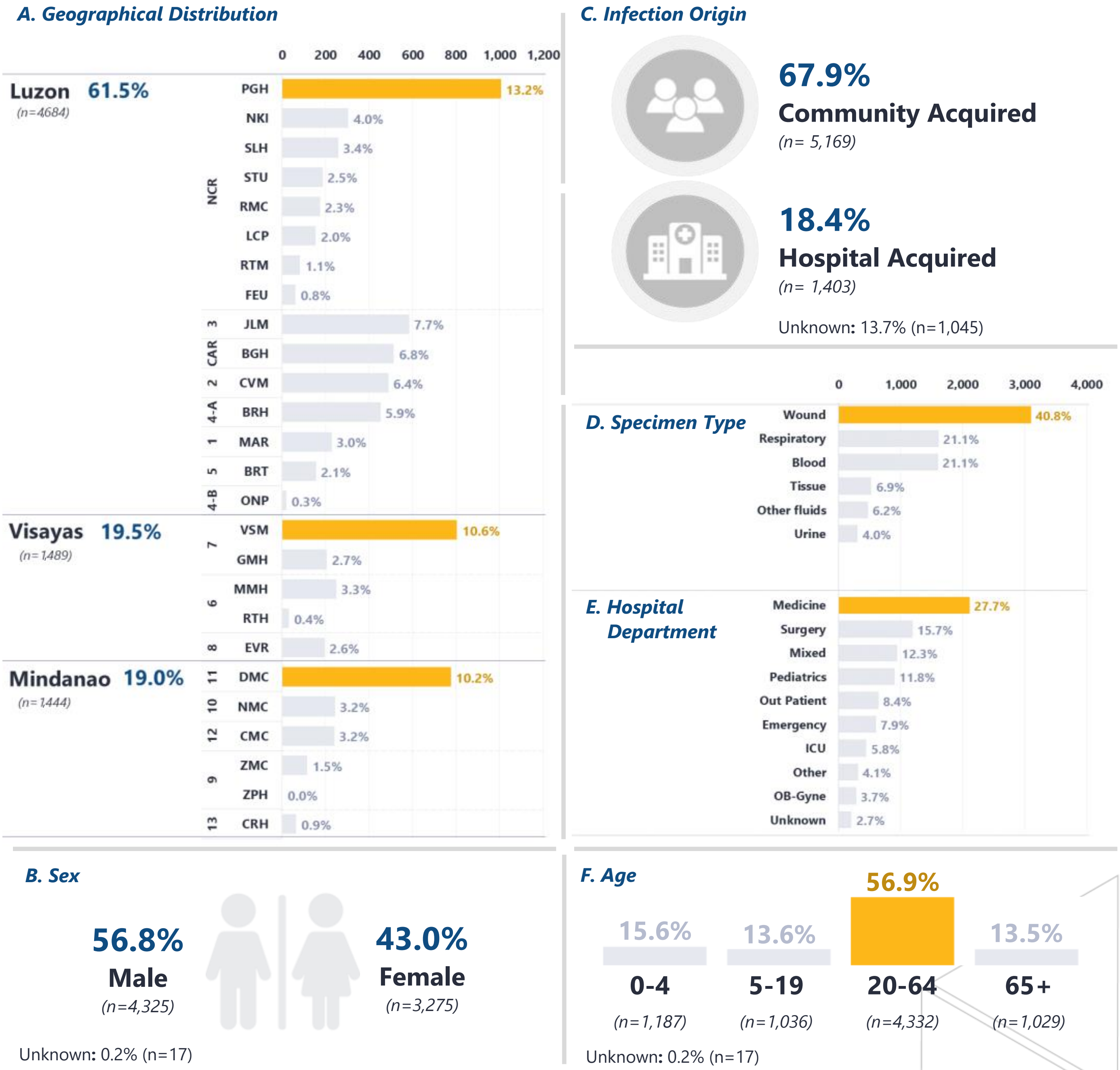


Figure 37. Isolate distribution and patient characteristics of *Staphylococcus aureus* isolates, DOH-ARSP, 2019 (N=7,617)

All Isolates

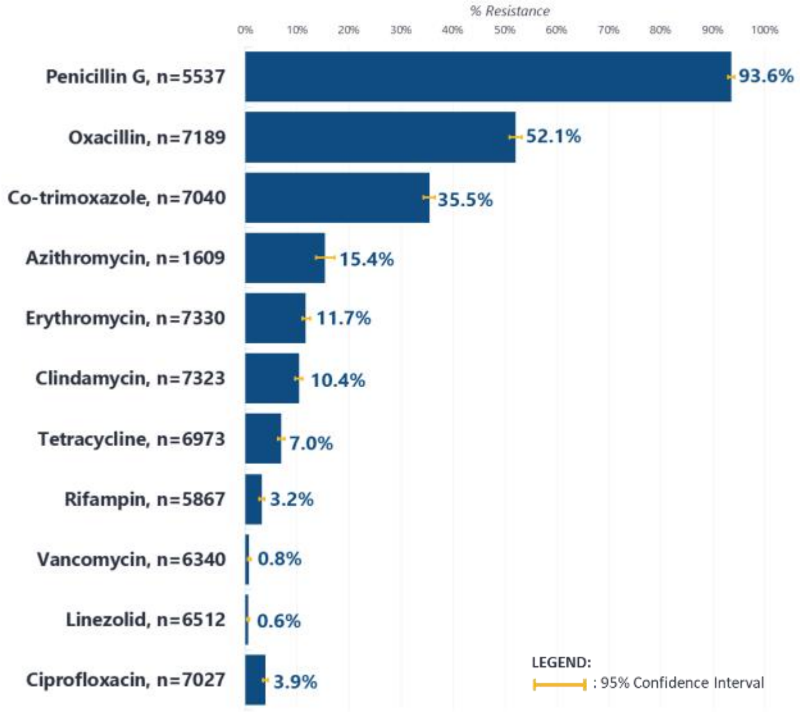


Figure 38. **Percent resistance of *Staphylococcus aureus*, DOH-ARSP, 2019**

The overall cumulative resistance rates of *S. aureus* isolates reported for 2019 are shown in Figure 38. Resistance to oxacillin was at 52.1% (n=7,189), 35.5% (n=7,040) for co-trimoxazole, 15.4% (n=1,609) for azithromycin, 11.7% (n=7,330) for erythromycin and 10.4% (n=7,323) for clindamycin. Resistance to vancomycin was at 0.8% (n=6,340) and linezolid was at 0.6% (n=6,512).

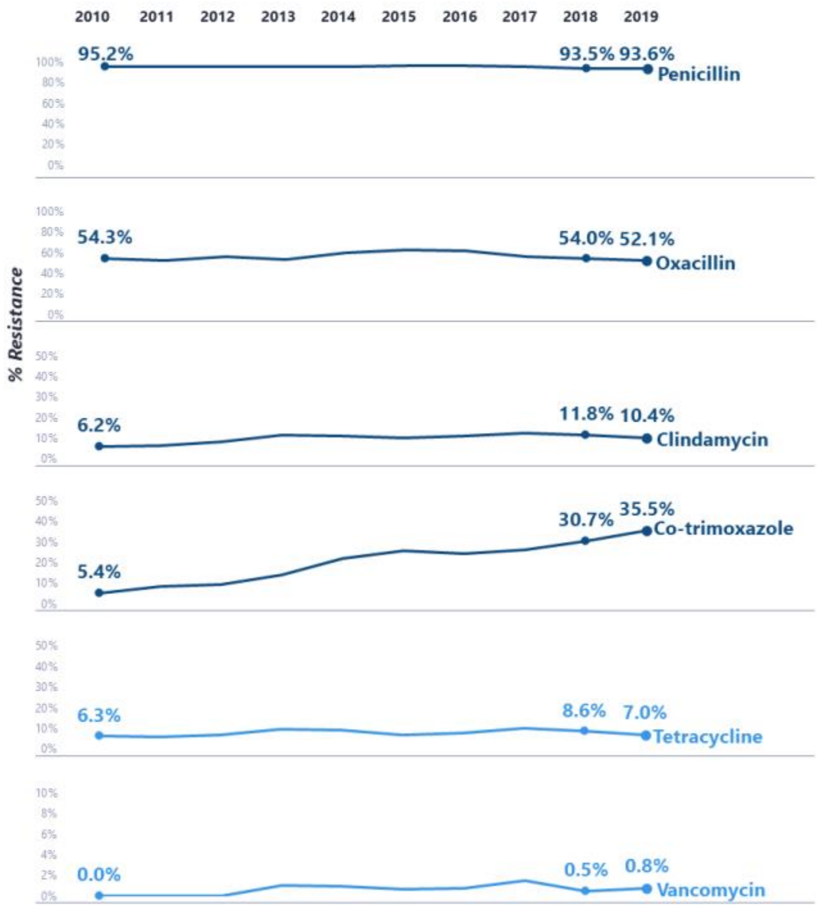


Figure 39. **Yearly resistance rates of *Staphylococcus aureus*, DOH-ARSP, 2010-2019**

Yearly resistance rates for *S. aureus* are shown in Figure 39. Oxacillin resistance rate continued to decrease to 52.1% from 54% in 2018; however this decrease was not statistically significant. There were also decreases in resistance rates for linezolid, and tetracycline from 2018 to 2019; however these changes were not statistically significant. On the other hand, resistance rate for co-trimoxazole increased from 31% in 2018 to 35.5% in 2019 (p=0.0000). Resistance to vancomycin increased from 0.5% in 2018 to 0.8% in 2019 (p-value 0.0436).

Figures 40-A and 40-B show the oxacillin resistance rates across the different regions in the country. It is apparent that there is much variability in oxacillin resistance rates across the different regions in the country.

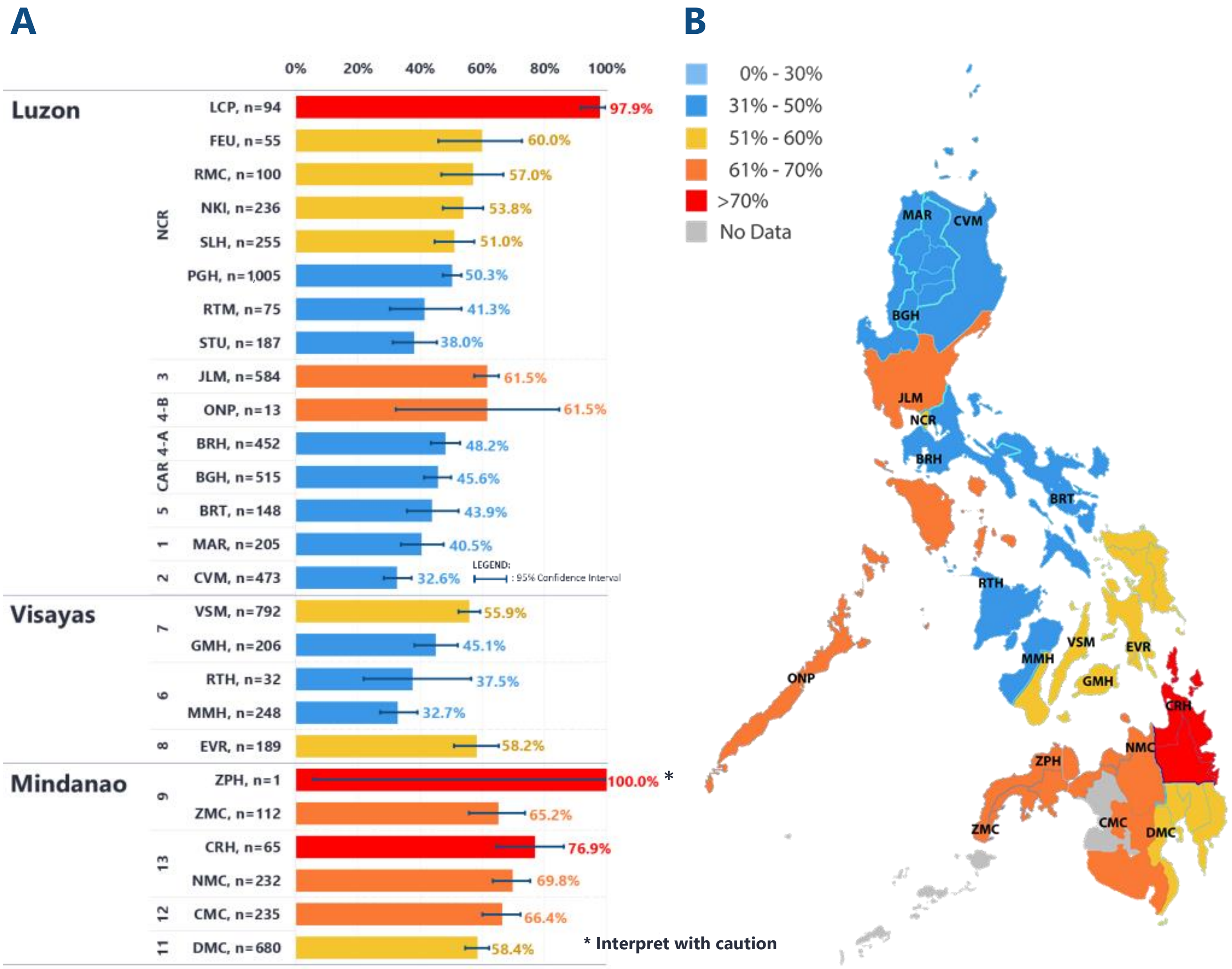


Figure 40. Geographic distribution of oxacillin resistant *S. aureus* in the Philippines, DOH-ARSP, 2019

Skin and Soft Tissue Isolates

Among skin and soft tissue isolates of *S. aureus*, resistance rates ranged from 0.4% for vancomycin and linezolid to 56% for oxacillin (Figure 41).

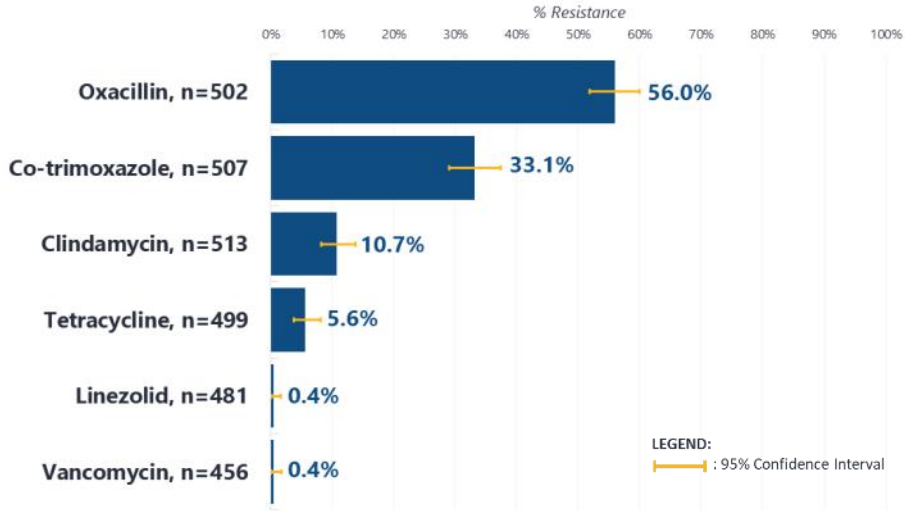


Figure 41. Percent resistance of *Staphylococcus aureus* skin and soft tissue isolates, DOH-ARSP, 2019

Blood Isolates

Among *S. aureus* blood isolates (Figure 42), oxacillin resistance was at 50.4% followed by co-trimoxazole at 35.4%. There were also reports of vancomycin resistance in 0.7% of the isolates. Moreover, from none in 2018, there were 6 isolates (0.5%) reported to show resistance to linezolid in 2019.

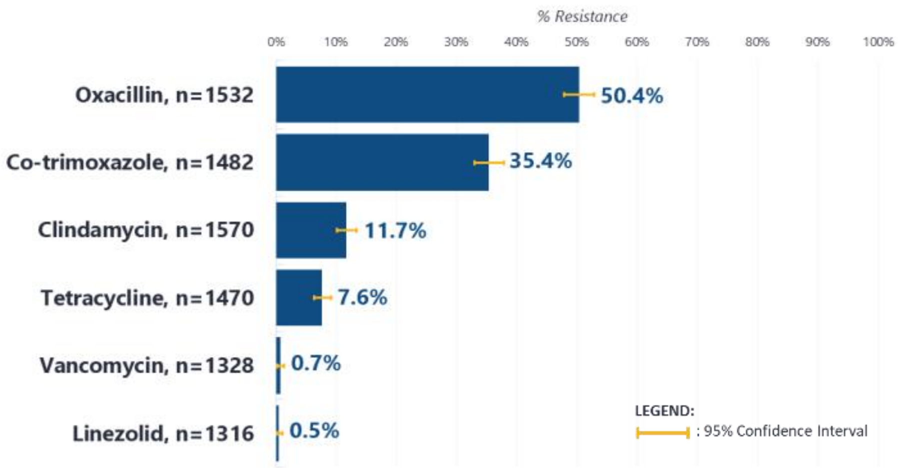


Figure 42. Percent resistance of *Staphylococcus aureus* blood isolates, DOH-ARSP, 2019

Methicillin Resistant *Staphylococcus aureus*

Isolate Distribution and Characteristics

3,640
Isolates analyzed

There were 3,640 MRSA isolates reported for 2019. Largest contributors for MRSA isolates include DMC (12.5%), VSM (12.3%), PGH and JLM (9.8%) (Figure 43). Many of these isolates were from wound (41.5%) and respiratory specimens (21.2%). Most are from males (57%) and from age group 20-64 years old (56.5%).

Figure 43. Isolate distribution and patient characteristics of Methicillin Resistant *Staphylococcus aureus* isolates, DOH-ARSP, 2019 (N=3,640)

Antimicrobial Resistance Analysis

All Isolates

Figure 44 shows the resistance rates of MRSA isolates from all specimens. Resistance ranged from less than 1% for linezolid and vancomycin to 39.5% for co-trimoxazole.

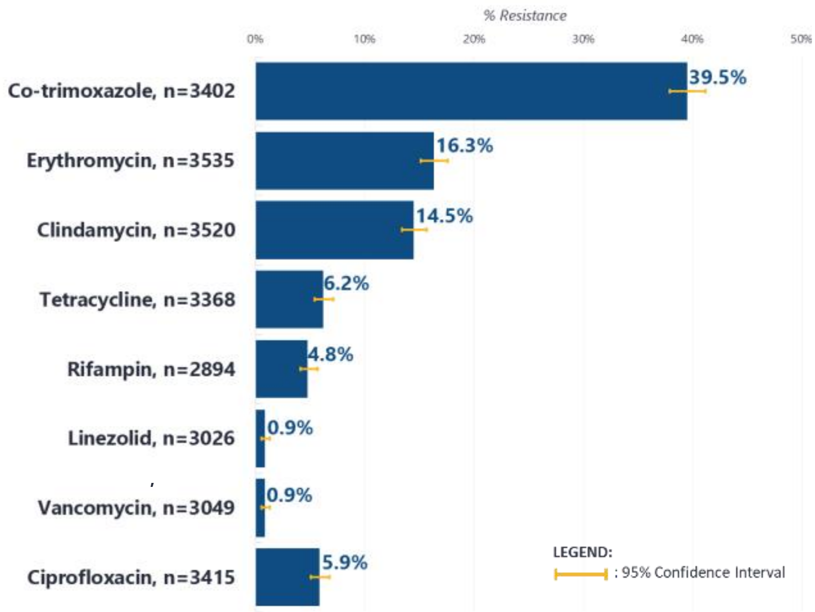


Figure 44. Percent resistance of MRSA isolates, DOH-ARSP, 2019

Skin and Soft Tissue Isolates

Among MRSA isolates from skin and soft tissue, resistance rates ranged from zero for vancomycin to 31.6% for co-trimoxazole (Figure 45).

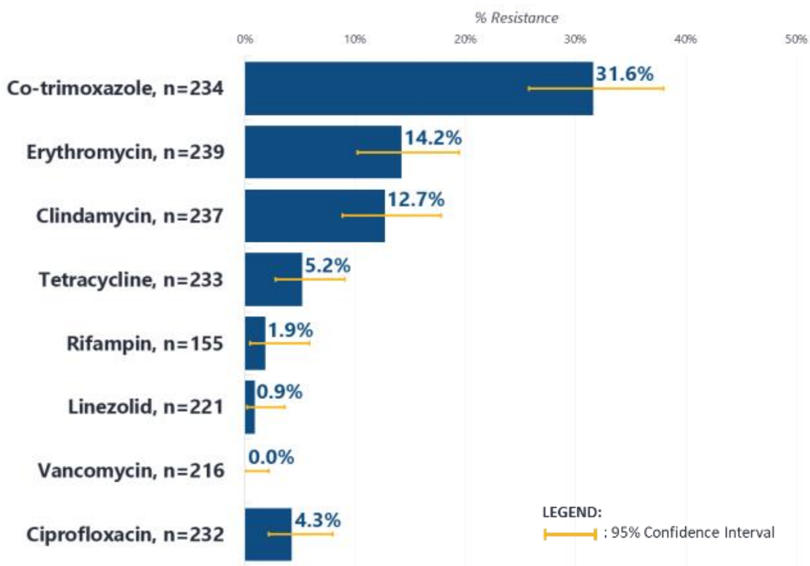


Figure 45. Percent resistance of MRSA skin and soft tissue isolates, DOH-ARSP, 2019

Enterococcus species

3,623

Isolates analyzed

For 2019, there were a total of 3,623 Enterococcus species reported of which the most common were Enterococcus faecalis (61.9%) and Enterococcus faecium (38.1%).

Enterococcus faecalis

2,242

Isolates analyzed

Isolate Distribution and Characteristics

PGH contributed most of the data on E. faecalis isolates (17.6%) followed by DMC at 17.3%. By island group distribution, 59.1% were from Luzon, 17.2% from the Visayas and 23.7% from Mindanao. Most of the isolates were from urine (46.7%), and more than half were from female patients (55.8%), and from age group 20-64 years (58.9%). (Figure 46)

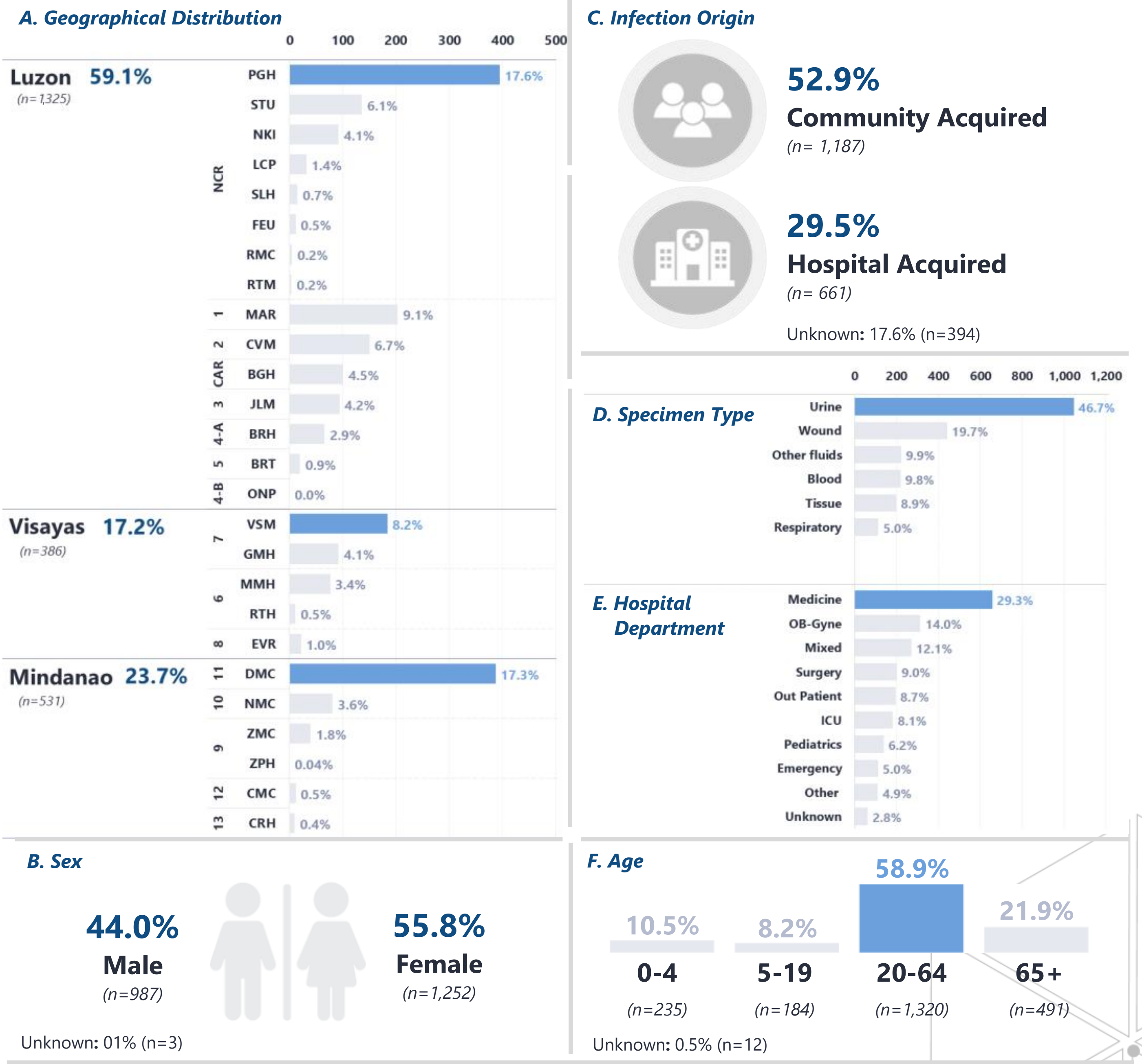


Figure 46. Isolate distribution and patient characteristics of *Enterococcus faecalis* isolates, DOH-ARSP, 2019 (N=2,242)

All Isolates

Figure 47 shows the cumulative resistance rates for *E. faecalis* for 2019. Resistance to linezolid and vancomycin were at 2% and 1.6%, respectively while high-level resistance to gentamicin and streptomycin were at 26.9% and 23.8%, respectively.

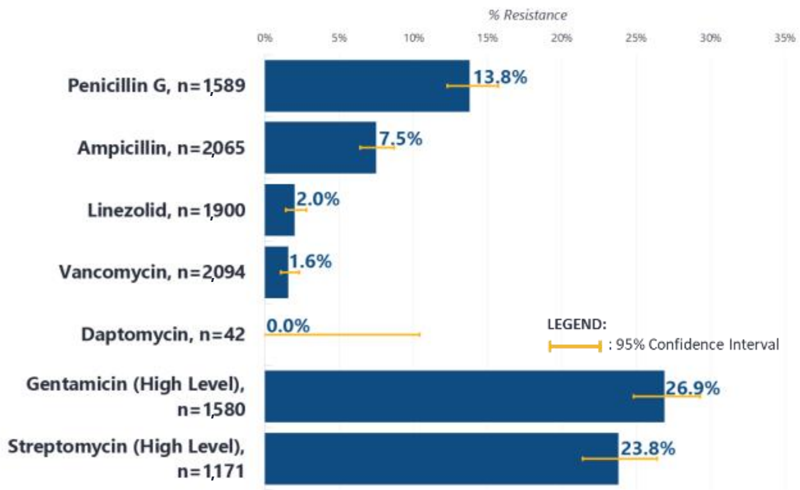


Figure 47. Percent resistance of *Enterococcus faecalis,* DOH-ARSP, 2019

Vancomycin and Linezolid Resistance

There were 3 confirmed vancomycin resistant *E. faecalis* for 2019 – 1 from urine specimen of a one-month old male from NCR, one from respiratory specimen of a 51-year-old female from Luzon and one from urine specimen of a 64 -year-old female from the Visayas. Furthermore, there were 6 confirmed linezolid resistant *E. faecalis* for 2019 – 4 were from Luzon, 1 from Mindanao and 1 from the Visayas. Three of the isolates were from 20-64 years old group and 3 from 65 years and older age group. The isolates were from wound, urine and respiratory samples.

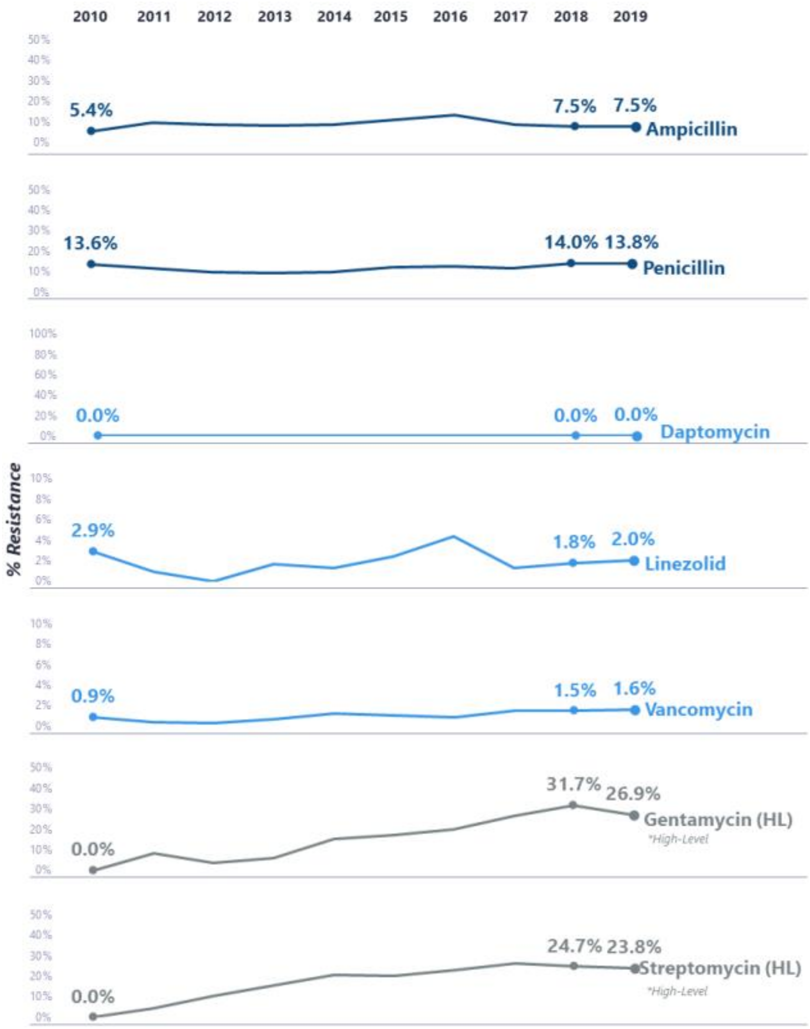


Figure 48. Yearly resistance rates of *Enterococcus faecalis,* DOH-ARSP, 2010-2019

Figure 48 shows the yearly resistance of *E. faecalis*. Resistance to ampicillin, penicillin and vancomycin were relatively constant over the past ten years. Despite increasing trend in the past 9 years, both high-level resistance to gentamicin and high-level resistance to streptomycin (HLAR) decreased in 2019 with only the decrease in HLAR-gentamicin being statistically significant.

Figures 49 and 50 show the geographical distribution of vancomycin and linezolid resistant *E. faecalis* across the country. NMC reported the isolates with the highest percent resistance to both vancomycin and linezolid ranging from 6% to 10%.

Vancomycin Resistance

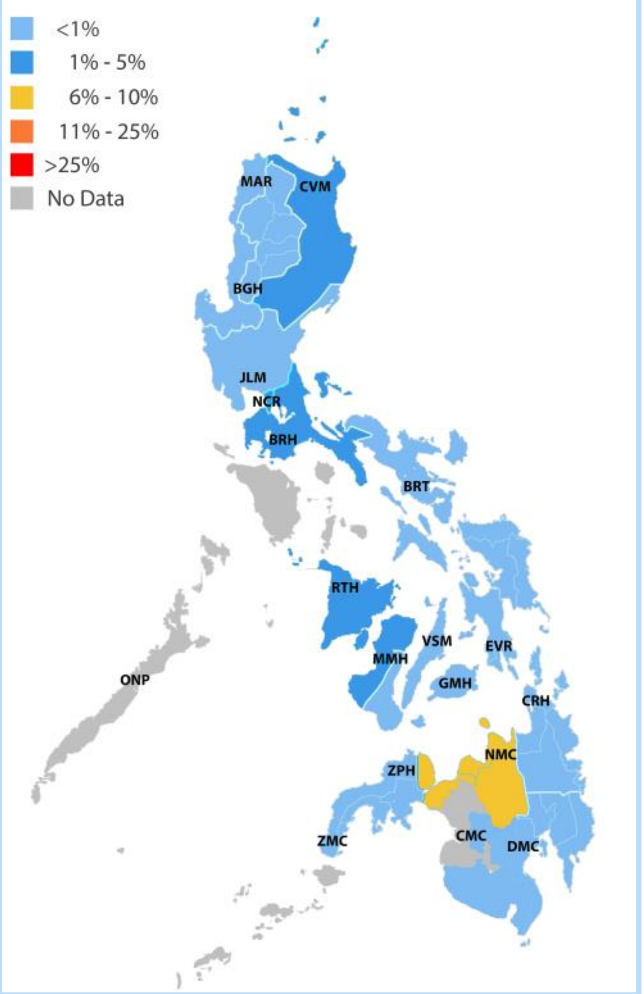


Figure 49. Geographic distribution of vancomycin resistant *E. faecalis* in the Philippines, DOH-ARSP, 2019

Linezolid Resistance

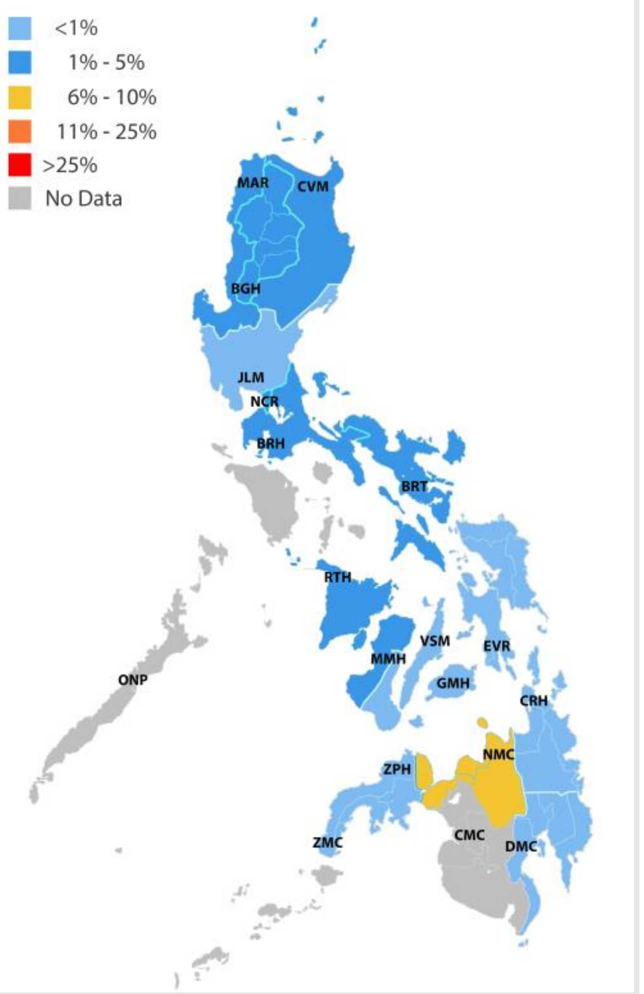


Figure 50. Geographic distribution of linezolid resistant *E. faecalis* in the Philippines, DOH-ARSP, 2019

Blood Isolates

Among *E. faecalis* isolates from blood, resistance to penicillin was at 12.1% and at 8.4% for ampicillin (Figure 51). Resistance to linezolid was at 2.2% and at 1.0% to vancomycin. High level resistance to gentamicin was at 23.3% and to streptomycin at 22.7%.

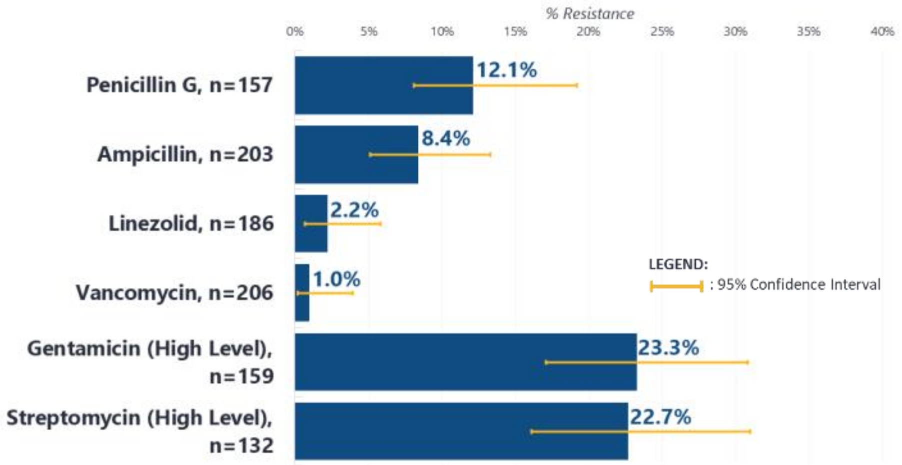


Figure 51. Percent resistance of *E. faecalis* blood isolates, DOH-ARSP, 2019

Urine Isolates

Among *E. faecalis* isolates from urine, linezolid and vancomycin resistance rates were at 1.6% and 1.4% respectively (Figure 52). Resistance to tetracycline was at 78.2%, 39.5% for ciprofloxacin, 37.9% for levofloxacin and 2.9% for nitrofurantoin.

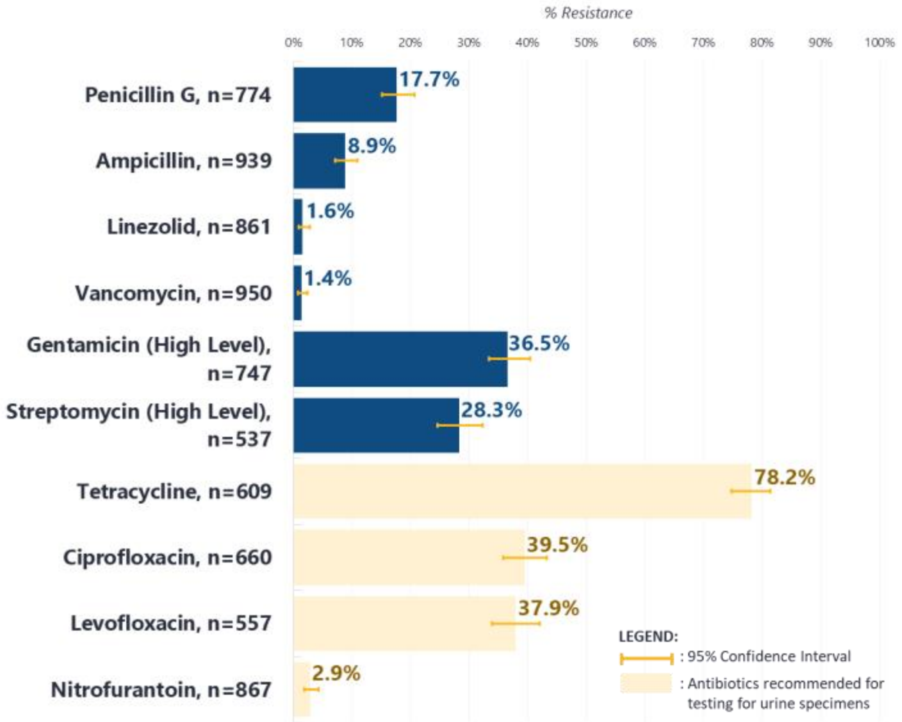


Figure 52. Percent resistance of *E. faecalis* urine isolates, DOH-ARSP, 2019

Enterococcus faecium

Isolate Distribution and Characteristics

1,381
Isolates analyzed

Highest contribution came from DMC (27%). Most of the E. faecium isolates were from urine (65.6%), most were from female patients (56.2%) and many were from age group 20-64 years (43.5%). By island group distribution, 55.2% were from Luzon with 60.55% of isolates from Luzon coming from Metro Manila, 13.3% from the Visayas and 31.5% from Mindanao (Figure 53).

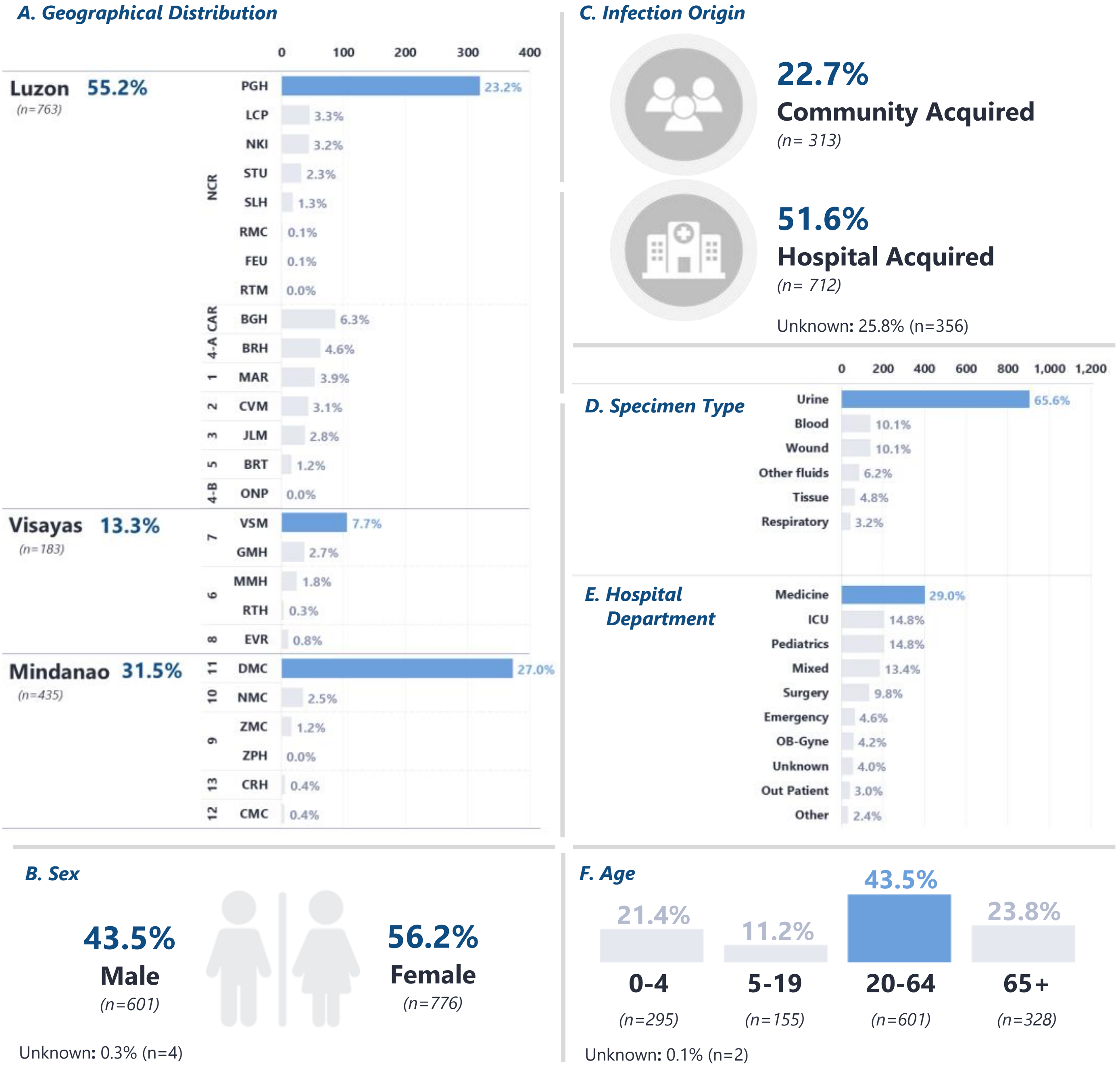


Figure 53. Isolate distribution and patient characteristics of ***Enterococcus faecium*** isolates, DOH-ARSP, 2019 (N= 1,381)

All Isolates

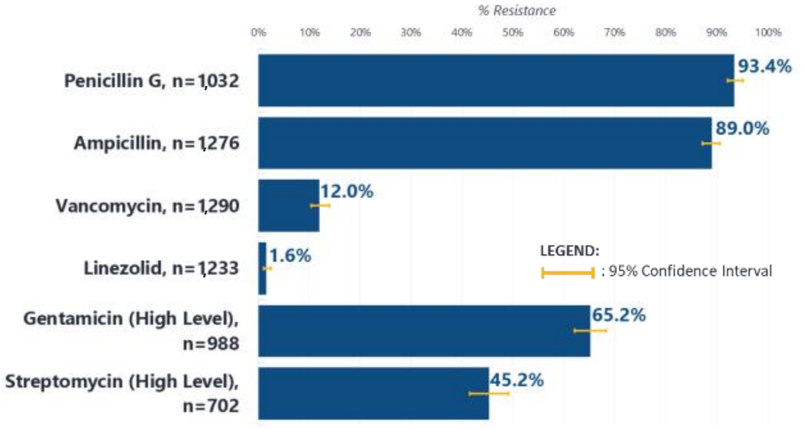


Figure 54. **Percent resistance of *Enterococcus faecium,* DOH-ARSP, 2019**

Resistance rates of *E. faecium* to vancomycin and linezolid were at 12% and 1.6% respectively. High level resistance to gentamicin was at 65.2% and high level resistance to streptomycin was at 45.2%.

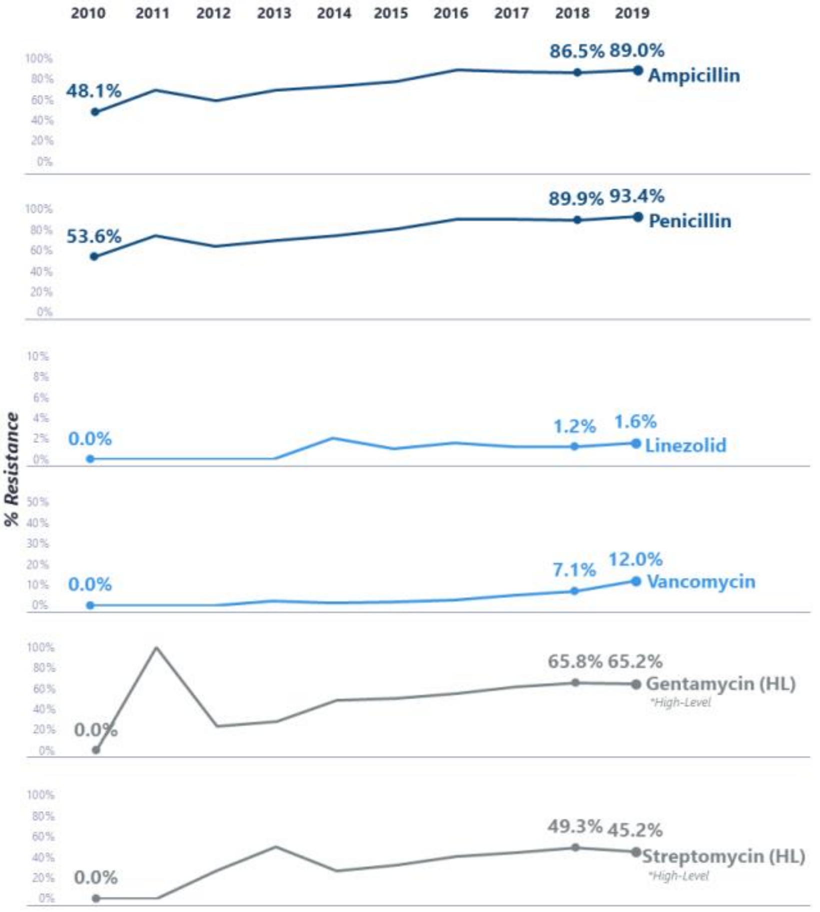


Figure 55. **Yearly resistance rates of *Enterococcus faecium,* DOH-ARSP, 2010-2019**

Yearly resistance rates of *E. faecium* is shown in Figure 55. Resistance to vancomycin increased from 7.1% in 2018 to 12% in 2019 and the increase was statistically significant. It can be seen that vancomycin resistance has been progressively increasing in the past 5 years.

Figure 56 shows the distribution across the country of vancomycin resistant *E. faecium* while Figure 57 shows the occurrence of linezolid resistant *E. faecalis* across the country.

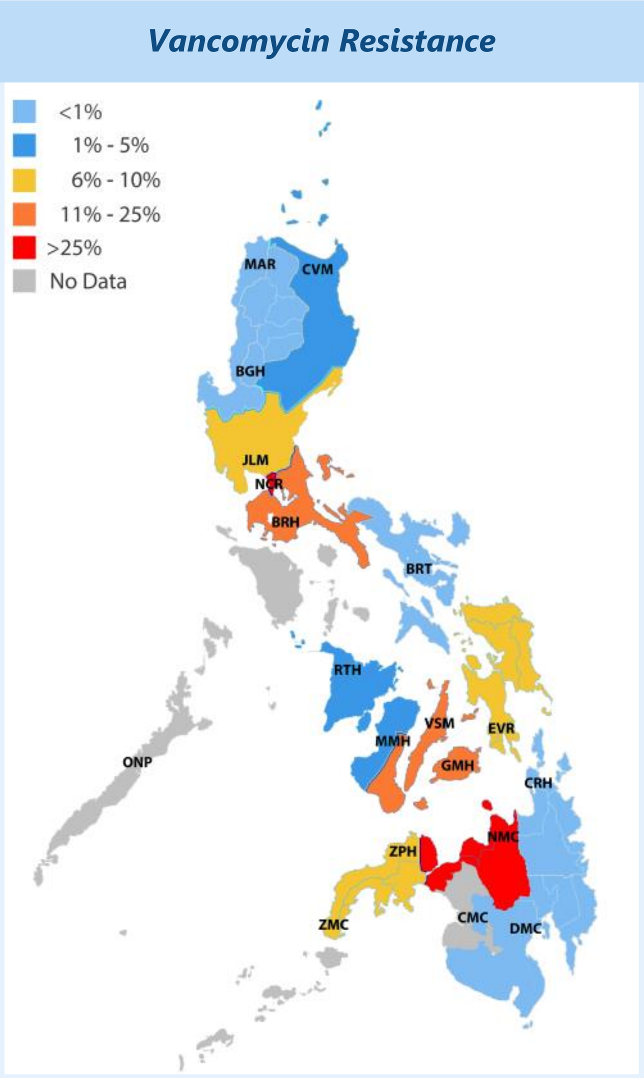


Figure 56. Geographic distribution of vancomycin resistant *E. faecium* in the Philippines, DOH-ARSP, 2019

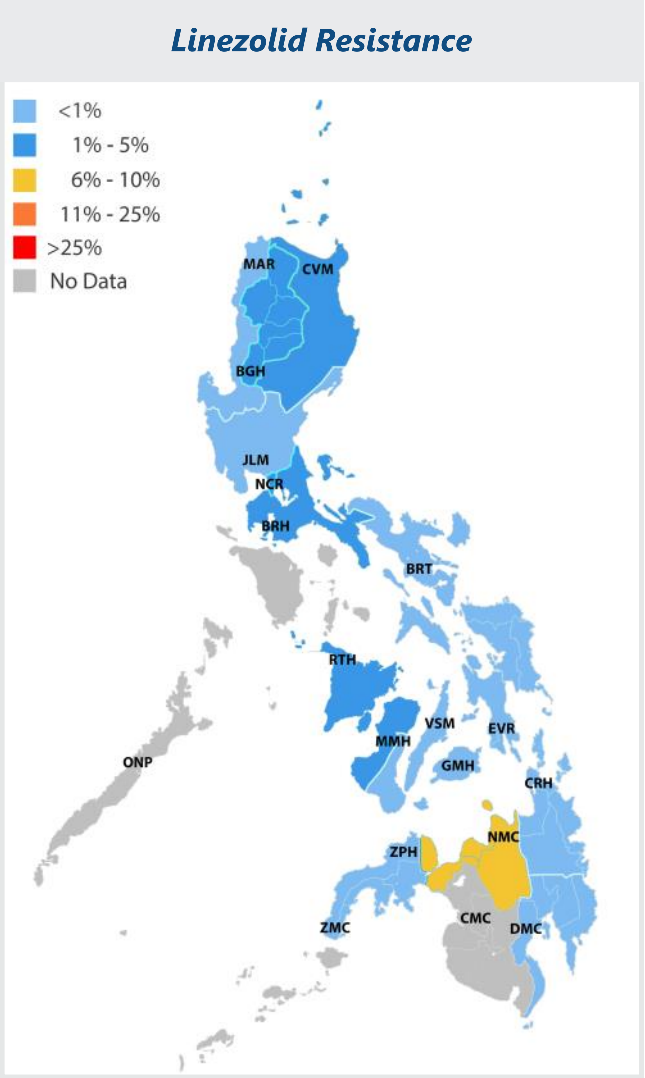


Figure 57. Geographic distribution of linezolid resistant *E. faecium* in the Philippines, DOH-ARSP, 2019

Blood Isolates

Among *E. faecium* isolates from blood, resistance to linezolid was at 1.6% and 20.8% for vancomycin (Figure 58). High level resistance to gentamicin was at 57.8% and to streptomycin at 46.9%.

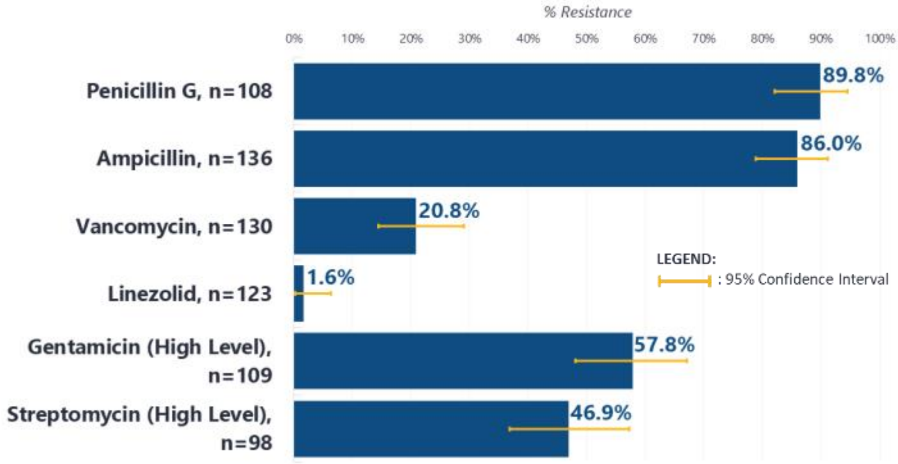


Figure 58. Percent resistance of *E. faecium* blood isolates, DOH-ARSP, 2019

Urine Isolates

Resistance of *E. faecium* isolates from urine were high to ciprofloxacin (86%), levofloxacin (85.1%) and tetracycline (42.9%) (Figure 59). Resistance to nitrofurantoin was at 26.7%, 11.3% to vancomycin and 1.2% to linezolid.

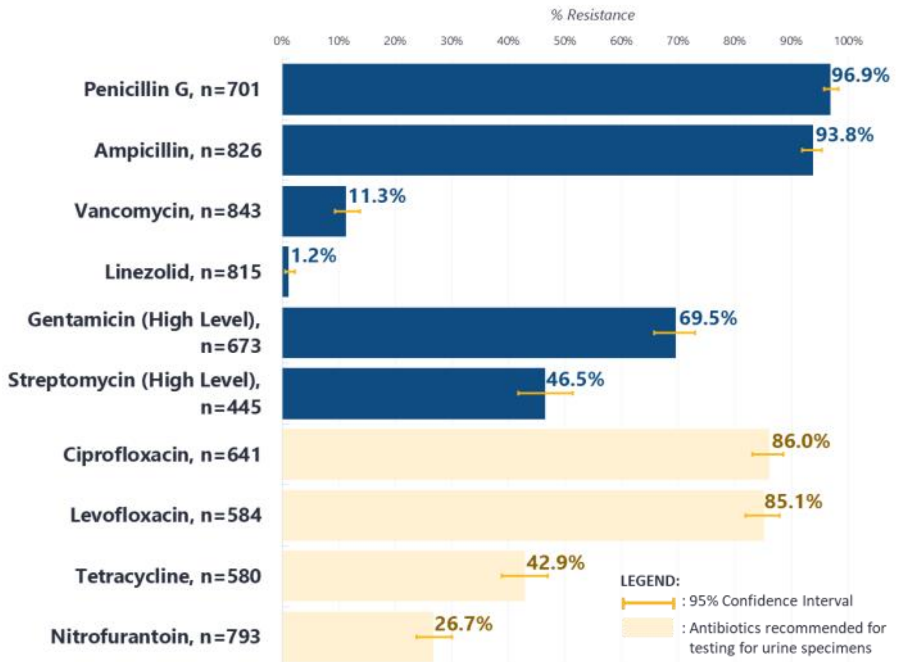


Figure 59. Percent resistance of *E. faecium* urine isolates, DOH-ARSP, 2019

Escherichia coli

Isolate Distribution and Characteristics

12,113
Isolates analyzed

A total of 12,113 Escherichia coli isolates were reported for 2019.

PGH contributed most to the number of *E. coli* isolates (16.1%) followed by DMC at 10.6%. Based on island group distribution, 59.6% were from Luzon with 58.4% from Metro Manila, 20.2% from Visayas and 20.3% from Mindanao. Most of the isolates were from urine specimens (50.5%). Majority of the patients were female (60%) and from age group 20-64 years old (56.3%) (Figure 60).

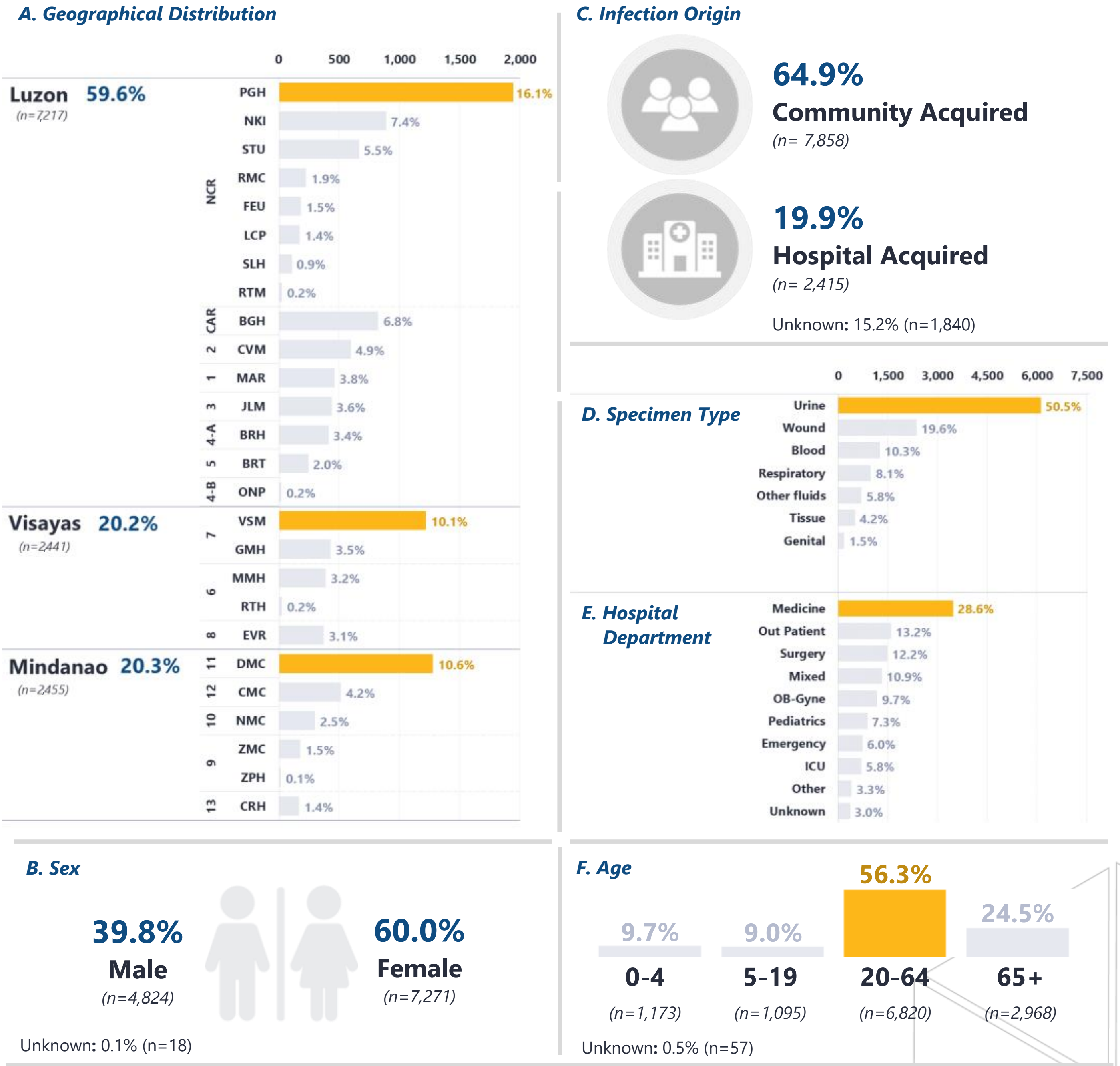


Figure 60. Isolate distribution and patient characteristics of *Escherichia coli* isolates, DOH-ARSP,2019 (N=12,113)

All Isolates

Cumulative antimicrobial resistance rates of 2019 *E. coli* isolates are shown in Figure 61. As in the past years, resistance rates of *E. coli* to most of the antibiotics are above 20%. Among the antibiotics for which resistance were relatively low were amikacin (3.7%), and the carbapenems (ertapenem - 5%, imipenem – 6%, meropenem – 6.4%, doripenem – 9.7%). Resistance against piperacillin-tazobactam and tobramycin were both at 11.7%.

Yearly resistance rates of *E. coli* for the past 10 years are shown in Figure 62. Resistance to ampicillin, ampicillin/sulbactam and co-trimoxazole were seen to be decreasing. The decline in the resistance rates observed from 2018 as compared to the reported values for 2019 are noted to be statistically significant for ampicillin/sulbactam and co-trimoxazole. Increasing resistance rates in 2019 were seen for ciprofloxacin, meropenem, imipinem and ceftriaxone, all of which are statistically significant except for imipenem.

Figures 63 shows the distribution of carbapenem resistant *E. coli* isolates of 2019 in the Philippines.

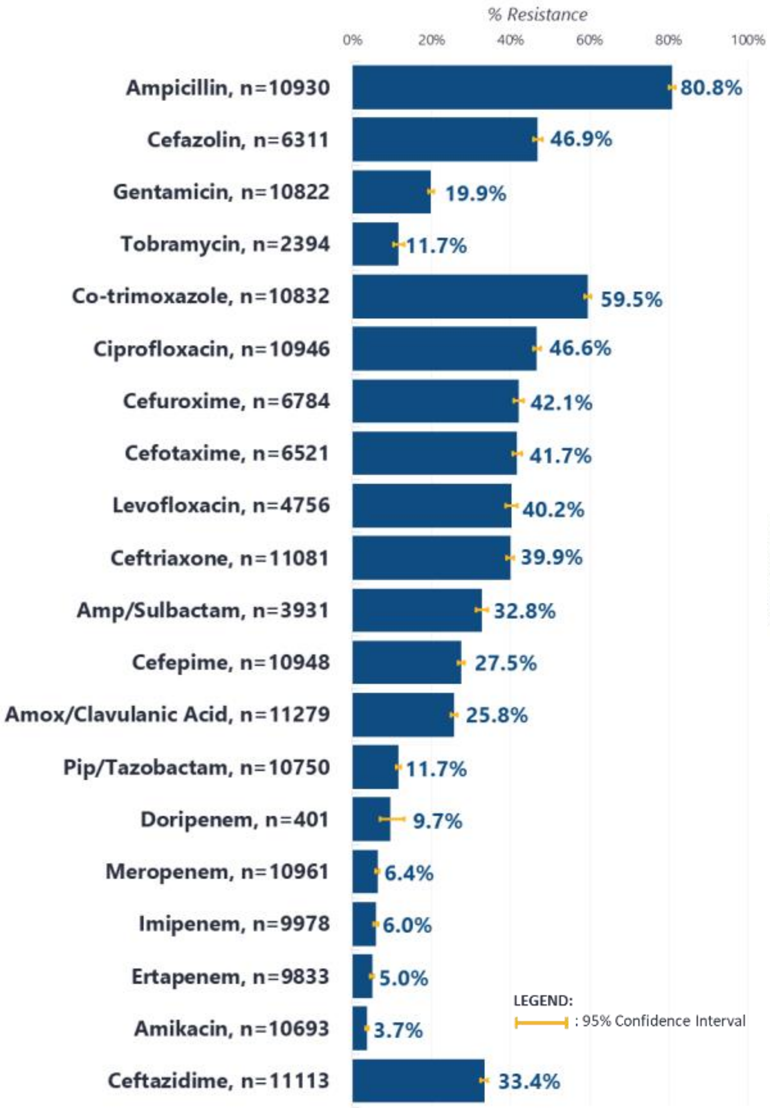


Figure 61. Percent resistance of *Escherichia coli,* DOH-ARSP, 2019

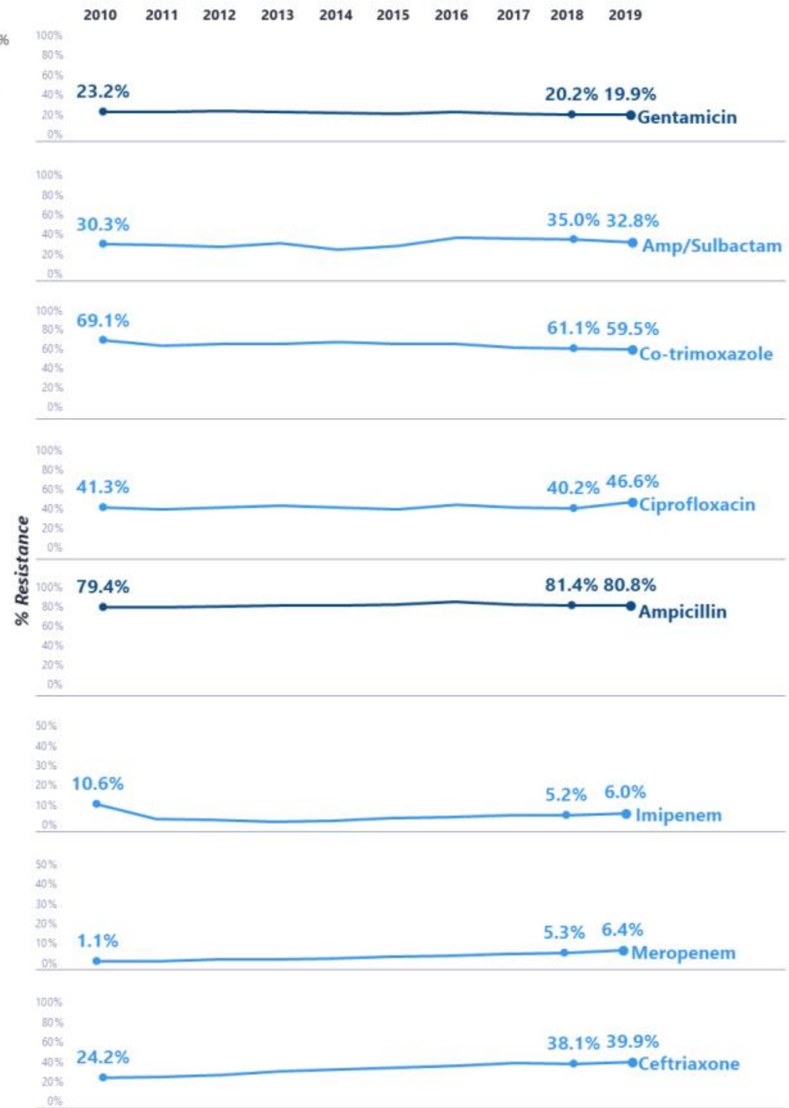
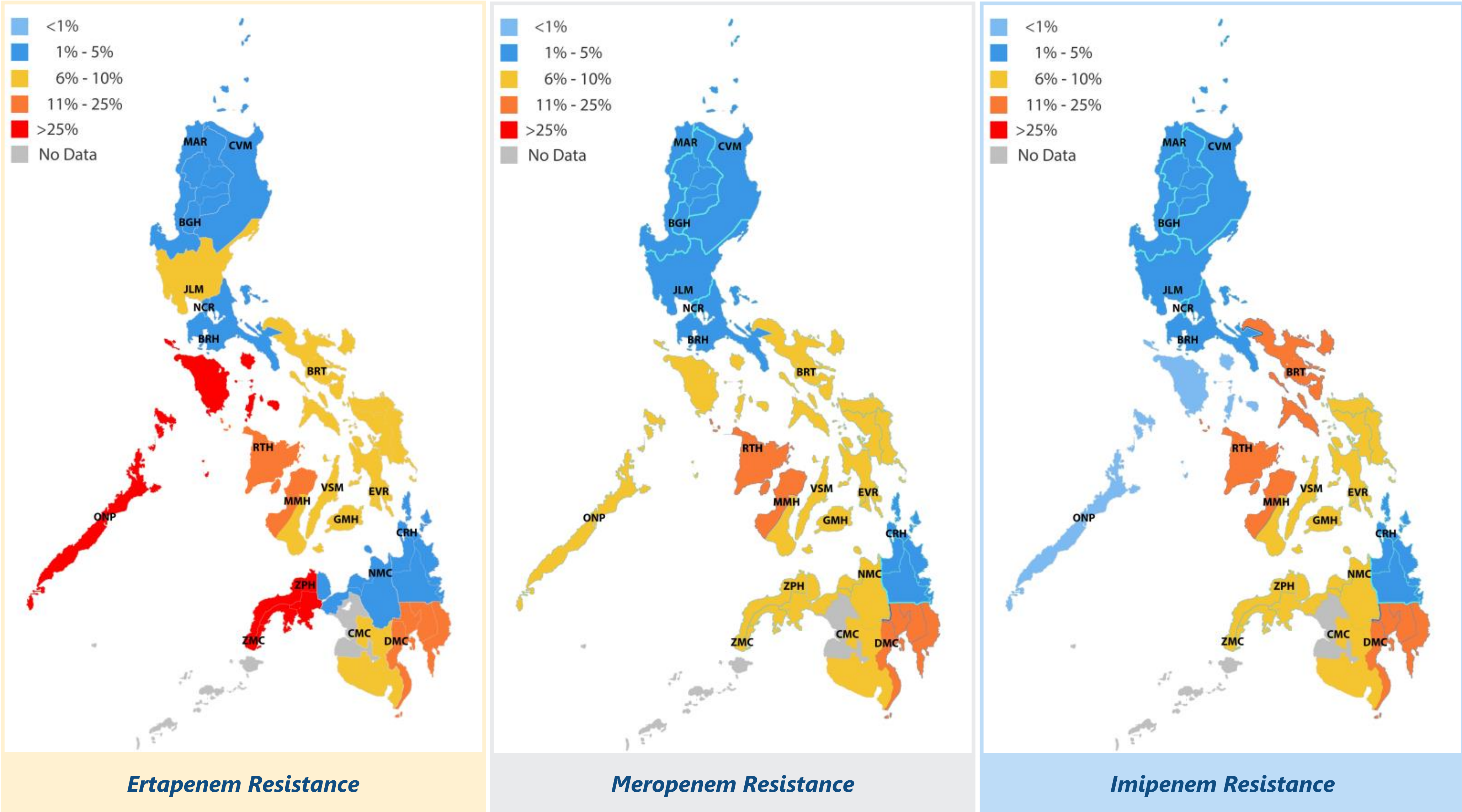


Figure 62. Yearly resistance rates of *E. coli,* DOH- ARSP, 2010-2019

Figure 63. Resistance maps of *Escherichia coli* for imipenem, meropenem and ertapenem , DOH-ARSP, 2019



Blood Isolates

For *E. coli* isolates from blood specimens, resistance to most antibiotics were likewise higher than 20% (Figure 64). Among the antibiotics for which resistance were relatively low were amikacin (3.1%), and the carbapenems (ertapenem – 4.7%, imipenem – 5.4%, and meropenem – 5.9%). Resistance against piperacillin-tazobactam was at 9.6% and 14.1% for tobramycin.

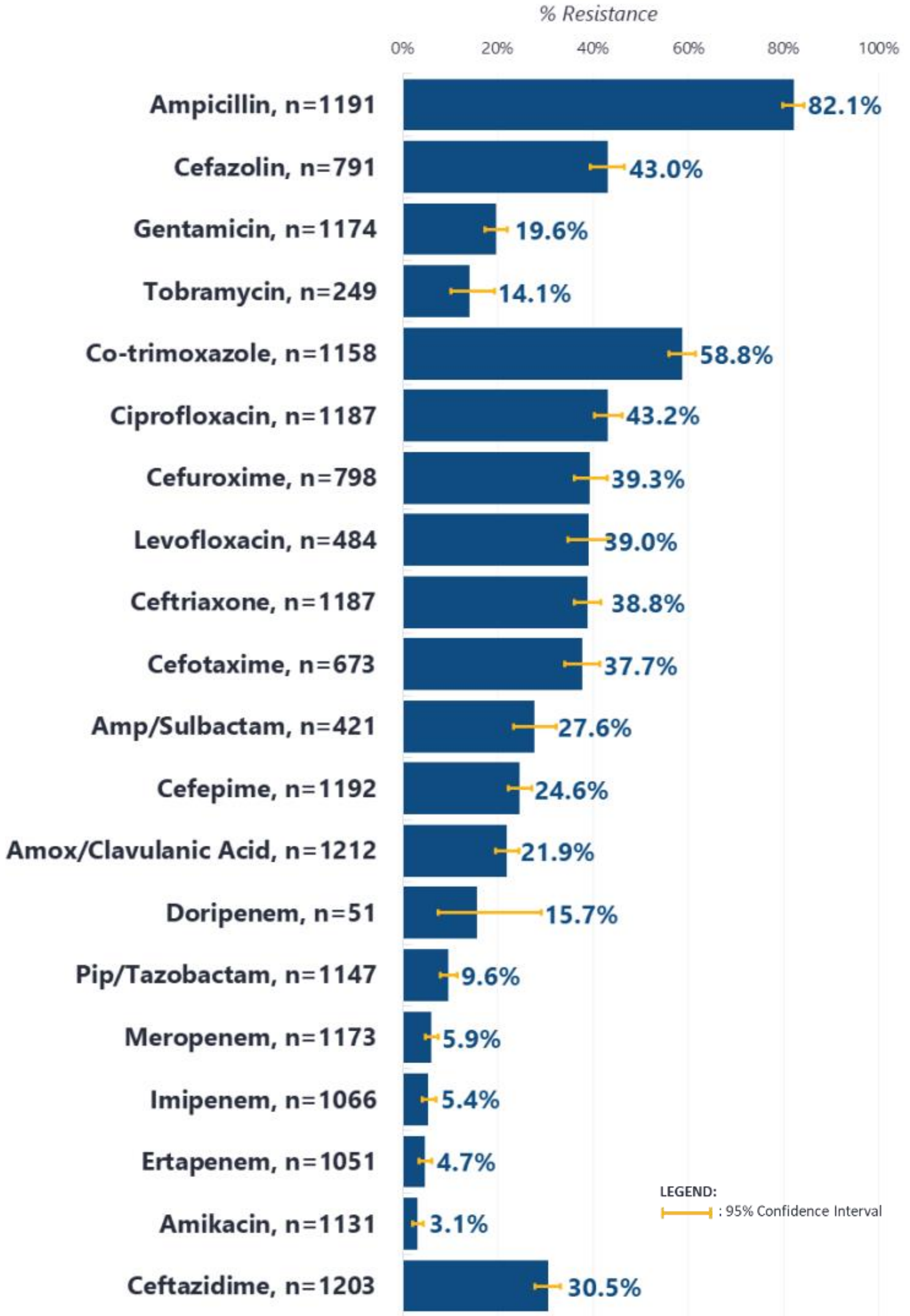


Figure 64. **Percent resistance of *E. coli* blood isolates, DOH-ARSP, 2019**

Urine Isolates

E. coli is the most common bacteria isolated from urine specimens reported for 2019 with 6,115 isolates.

Resistance rates of outpatient and inpatient urinary *E. coli* isolates against commonly used antibiotics are shown in Figure 65. Among outpatients, lowest resistance was observed against nitrofurantoin at 4.7% while the highest was against co-trimoxazole at 57.3%. As for the urinary isolates from in-patients, reported resistance rates against commonly used parenteral antibiotics was lowest for amikacin at 4.2% and highest for ceftriaxone at 46.9%.

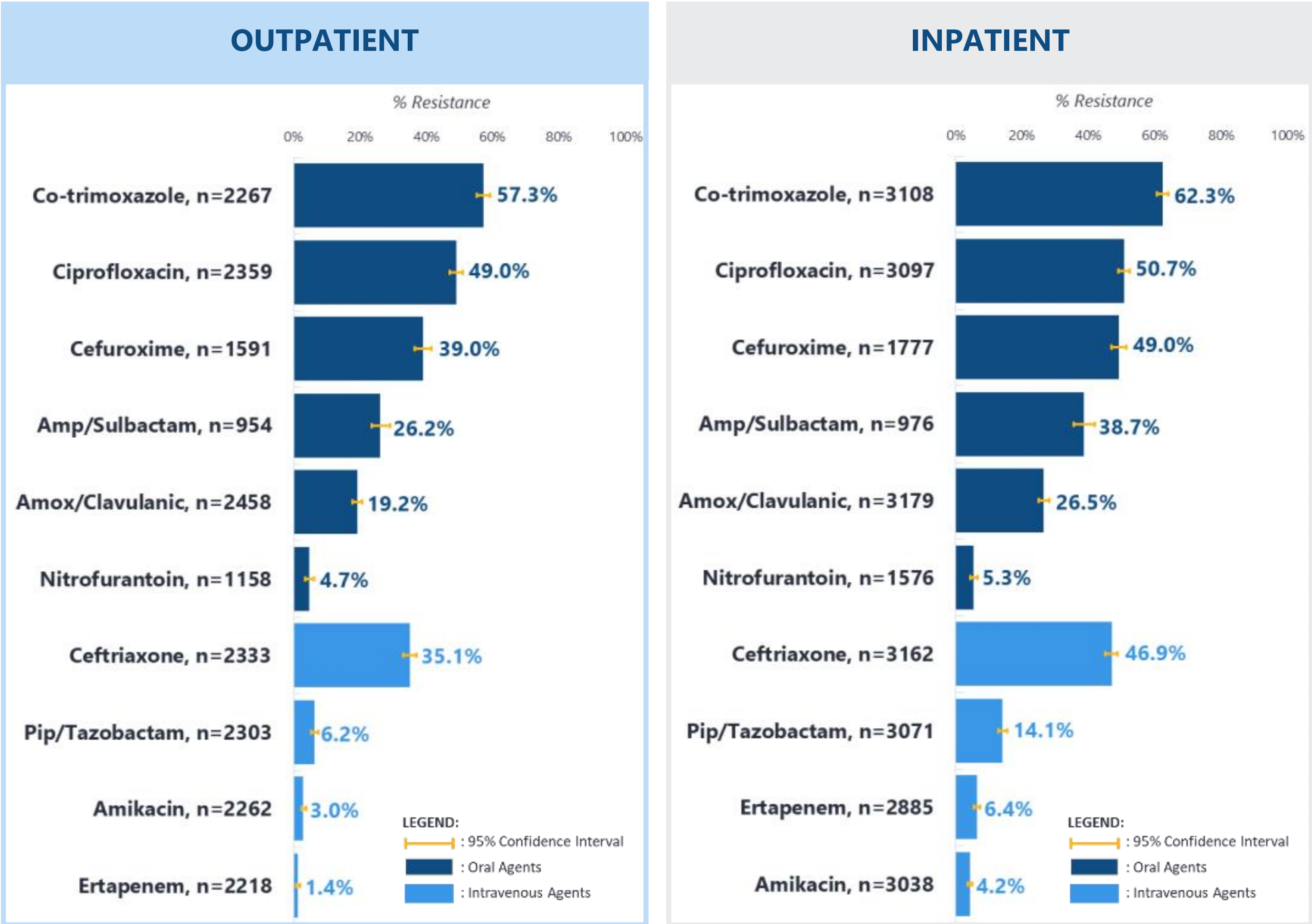


Figure 65. Percent resistance of *E. coli* urine isolates from outpatients and inpatients, DOH-ARSP, 2019

Extended Spectrum Beta-lactamase - producing *Escherichia coli*

From the subset of the 2019 isolates screened phenotypically (Figure 66) for ESBL production, cumulative rate is at 53.25% (n=5,639).

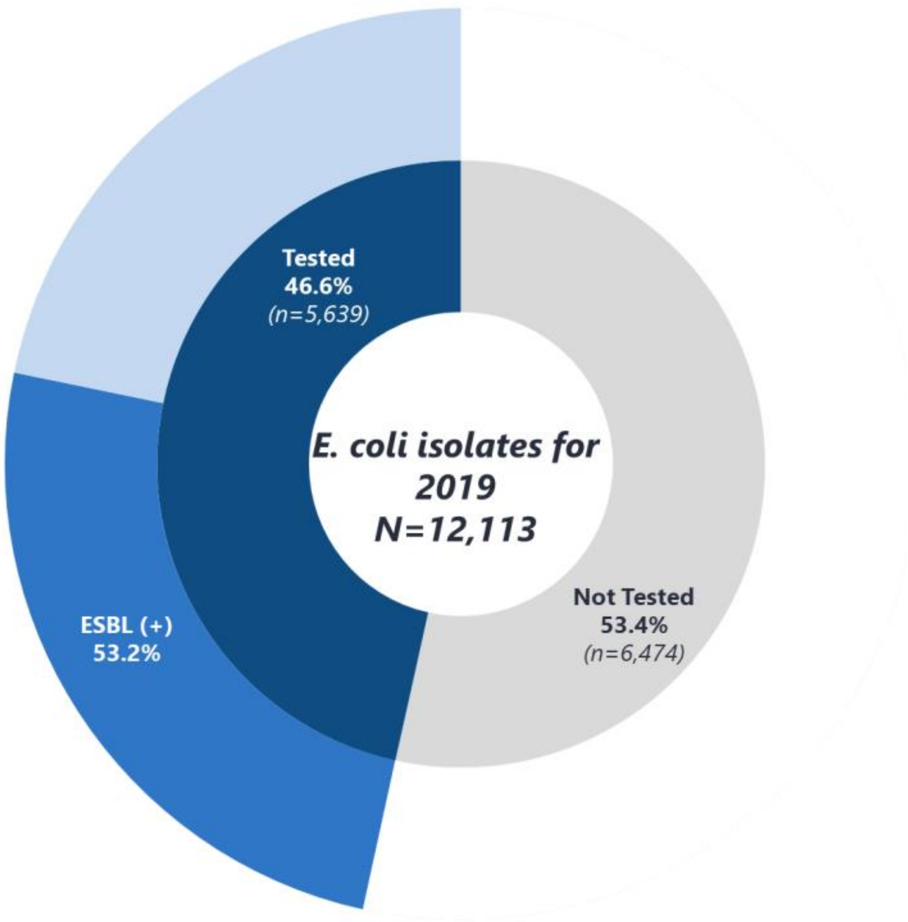


Figure 66. Percentage of ESBL-producing *E. coli* in the Philippines, DOH-ARSP, 2019

Klebsiella pneumoniae

Isolate Distribution and Characteristics

15,295
Isolates analyzed

A total of 15,295 Klebsiella pneumoniae were reported for 2019.

PGH contributed most to the number of *K. pneumoniae* with 13.6% of the total isolates. Based on island group distribution, 54.2% were from Luzon with 54.51% of those from Luzon coming from Metro Manila, 27.4% were from Visayas and 18.4% were from Mindanao. Majority of the isolates were from respiratory specimens (54.2%) and most were from male patients (55.9%) and were from 20-64 years age group (57.3%) (Figure 67).

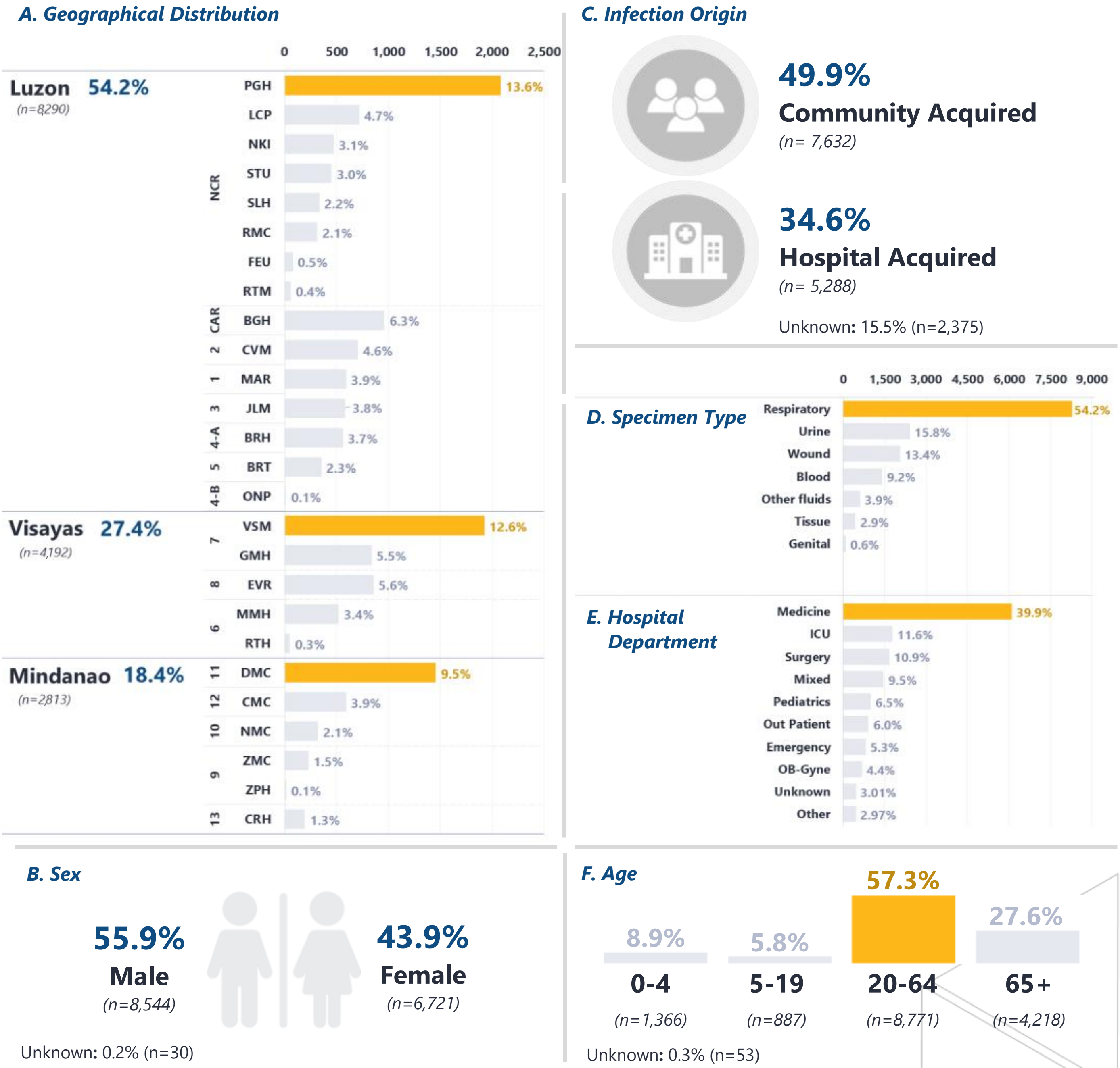


Figure 67. Isolate distribution and patient characteristics of ***Klebsiella pneumoniae*** isolates, DOH-ARSP, 2019 (N=15,295)

All Isolates

Cumulative resistance rates of *K. pneumoniae* from all specimens are shown in Figure 68. As known to be commonly resistant to multiple classes of antibiotics, *K. pneumoniae* antimicrobial resistance rates to most of the antibiotics in 2019 are above 20%. Among the antibiotics for which *K. pneumoniae* resistance were relatively low were amikacin (4.9%), ertapenem (10.2%), imipenem (12%) and meropenem (13.5%).

Figure 69 shows that resistance rates to gentamicin, amoxicillin/clavulanic acid, and ceftriaxone were relatively stable for the past ten years. The increase in resistance rates to cefuroxime and ciprofloxacin in 2019 compared to the rates in 2018 were statistically significant. Trends also showed resistance to carbapenem antibiotics were increasing in the last four to five years (imipenem and meropenem: p value= 0.0000, ertapenem: p value= 0.0042).

Figure 70 shows the distribution of carbapenem resistant *K. pneumoniae* isolates in 2019.

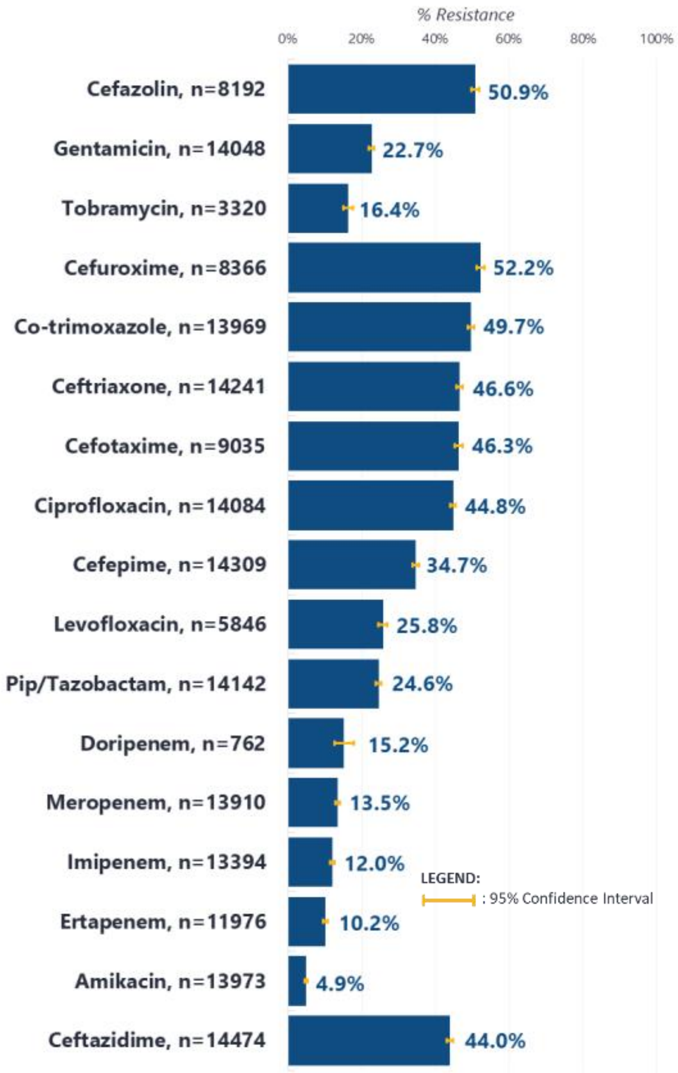


Figure 68. Percent resistance of ***K. pneumoniae*****, DOH-ARSP, 2019**

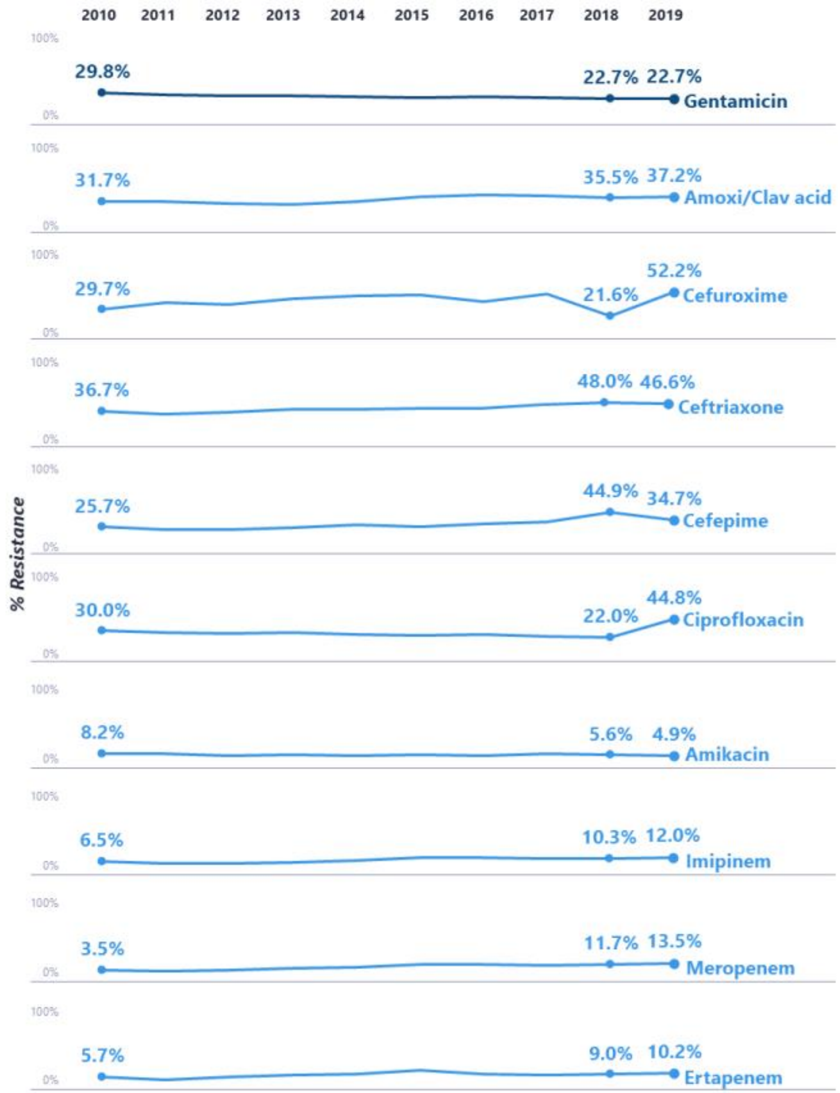
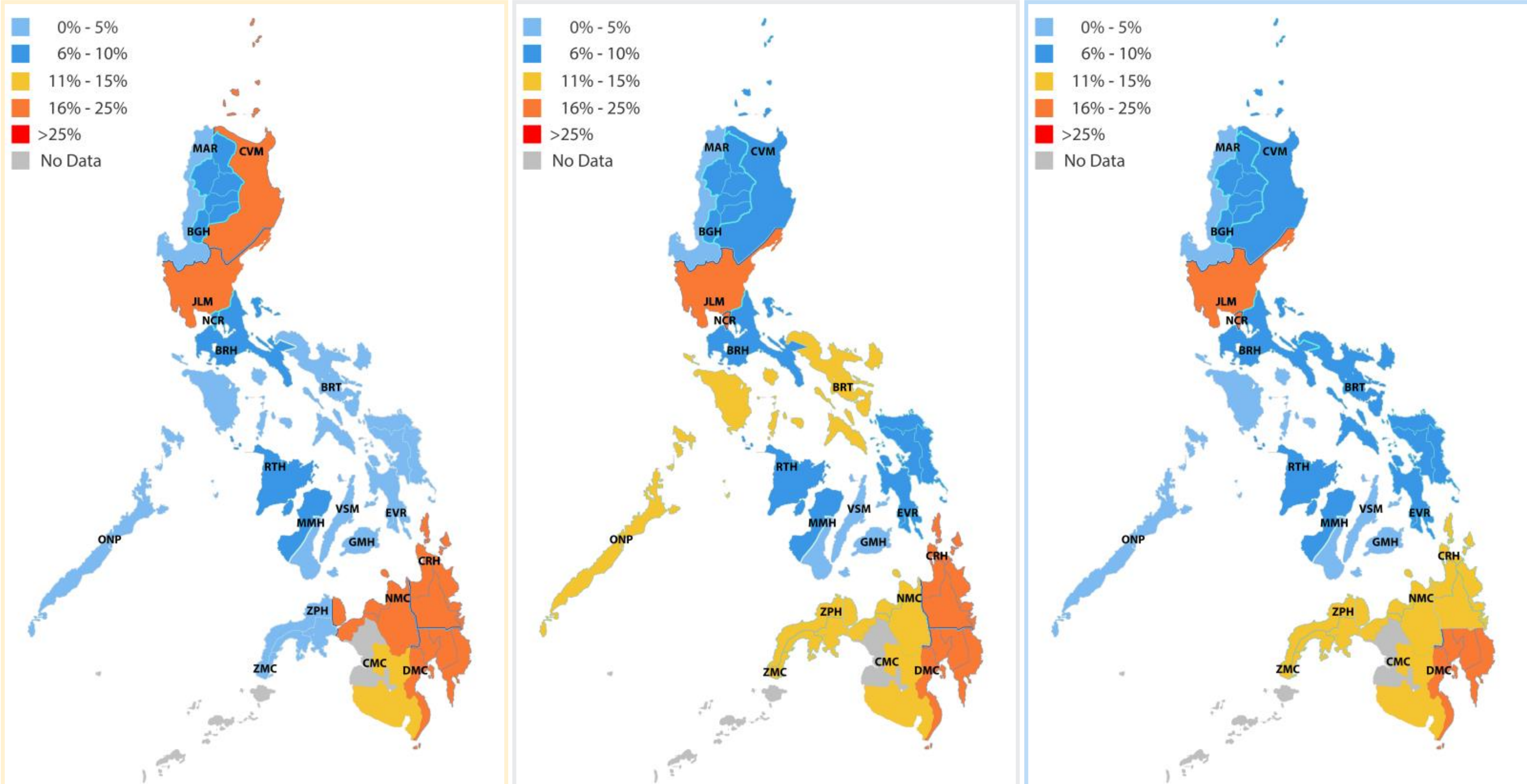


Figure 69. Yearly resistance rates of ***K. pneumoniae*****, DOH-ARSP, 2010-2019**

Figure 70. Resistance maps of ***Klebsiella pneumoniae*** for imipenem, meropenem and ertapenem, DOH-ARSP, 2019



Ertapenem Resistance | Meropenem Resistance | Imipenem Resistance

Blood Isolates

Resistance rates of *K. pneumoniae* isolates from blood (Figure 71) are notably higher compared to the overall cumulative resistance rates from all specimens (Figure 68). Resistance to cefuroxime was at 54.0%, ceftriaxone at 54.1%, co-trimoxazole at 52.9% and 41.0% for cefepime.

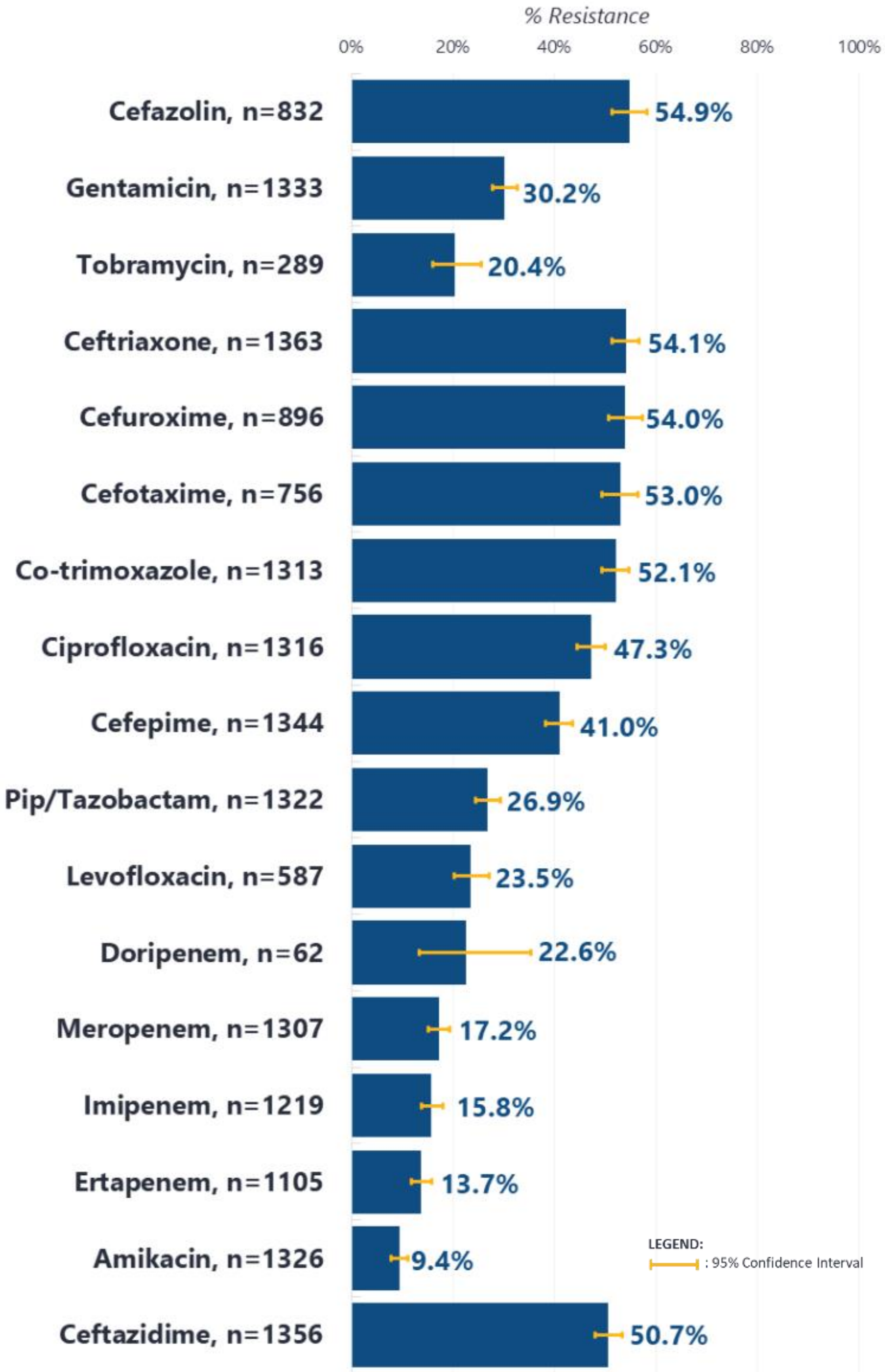


Figure 71. Percent resistance of *K. pneumoniae* blood isolates, DOH-ARSP, 2019

Urine Isolates

Resistance of *K. pneumoniae* from urine specimens were higher than 50% for cefazolin, co-trimoxazole, cefuroxime, ciprofloxacin, cefotaxime and ceftriaxone. Lowest resistance was for amikacin (7.0%) (Figure 72).

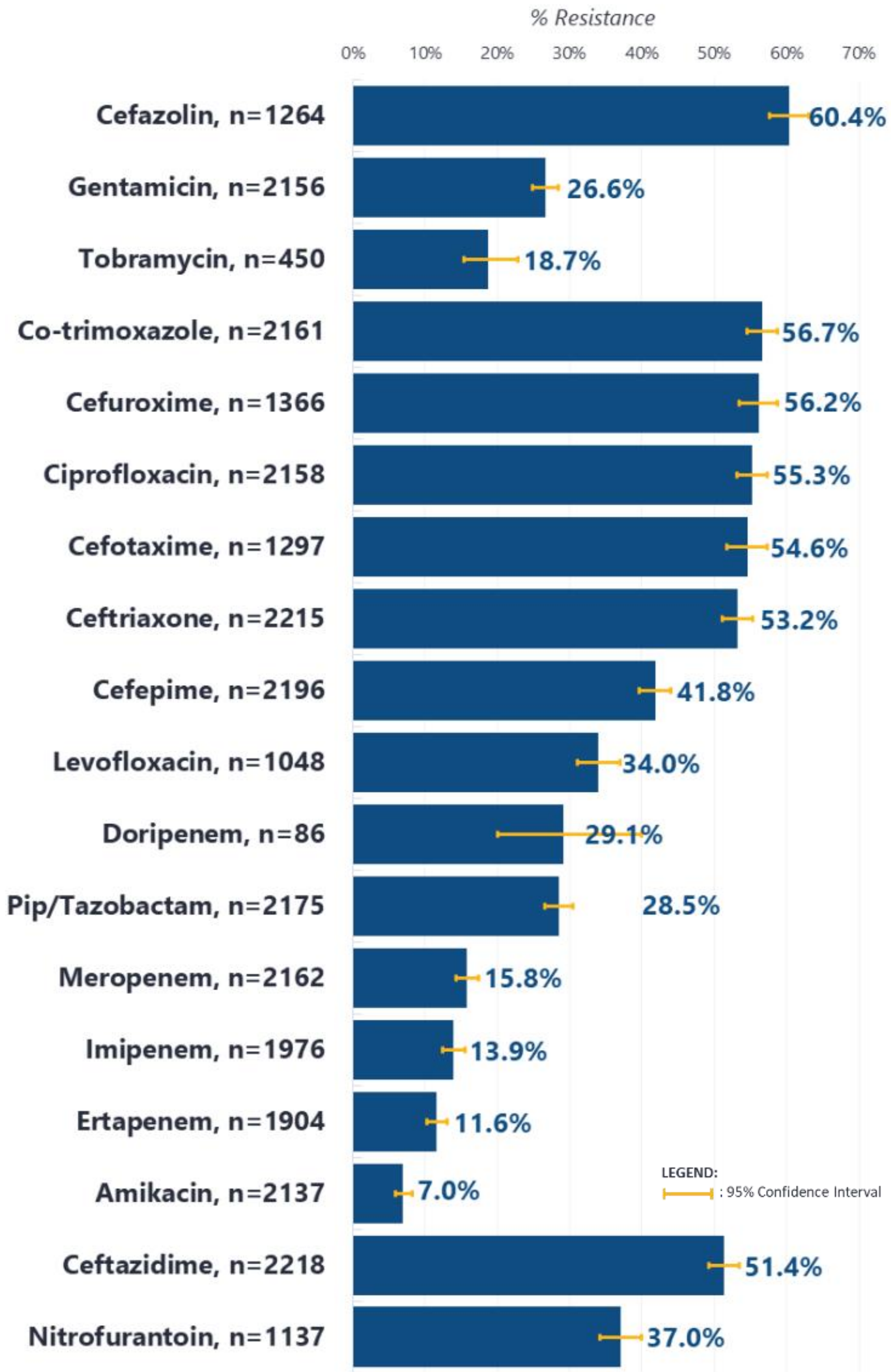


Figure 72. Percent resistance of *K. pneumoniae* urine isolates, DOH-ARSP, 2019

Extended Spectrum Beta-lactamase - producing *Klebsiella pneumoniae*

From the subset of the 2019 *K. pneumoniae* isolates screened phenotypically for ESBL production, cumulative rate is at 55.1% (n=8,153) (Figure 73).

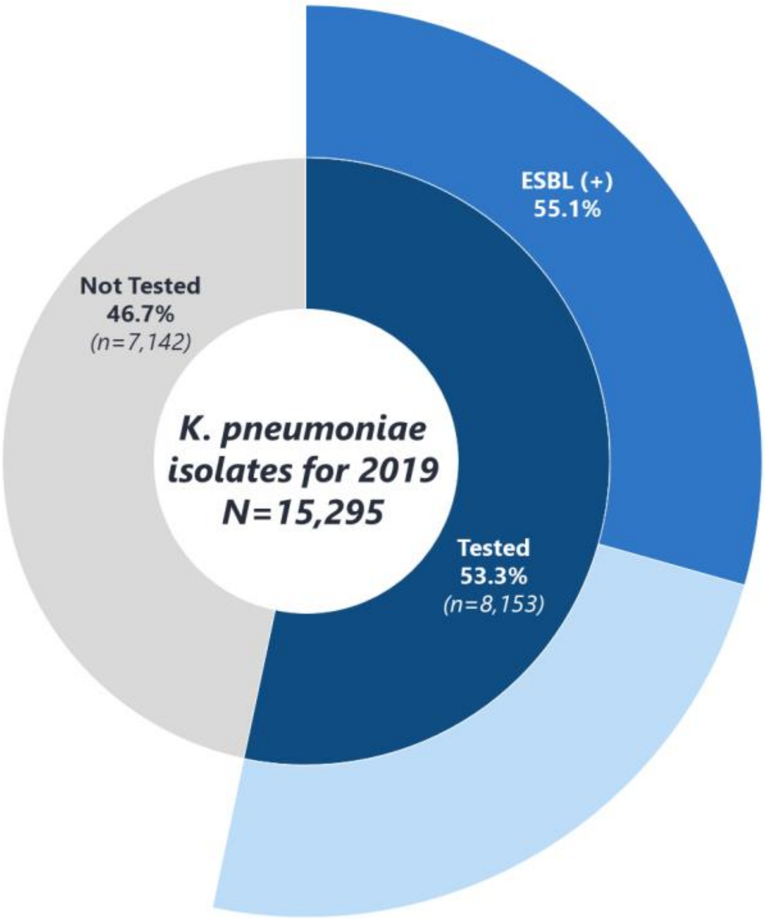


Figure 73. Percentage of ESBL-producing *K. pneumoniae* in the Philippines, DOH-ARSP, 2019

Pseudomonas aeruginosa

Isolate Distribution and Characteristics

8,253 Isolates analyzed

A total of 8,253 Pseudomonas aeruginosa isolates were reported for 2019.

Most of the *P. aeruginosa* isolates were from Luzon (57.7%) with 55.86% of these coming from NCR sites, 20.6% from Visayas and 21.8% from Mindanao (Figure 74-A). More than half of the isolates were from respiratory specimens (52.3%), and majority of the patients were males (59.3%) and from the age group 20-64 years (58.8%) (Figure 74).

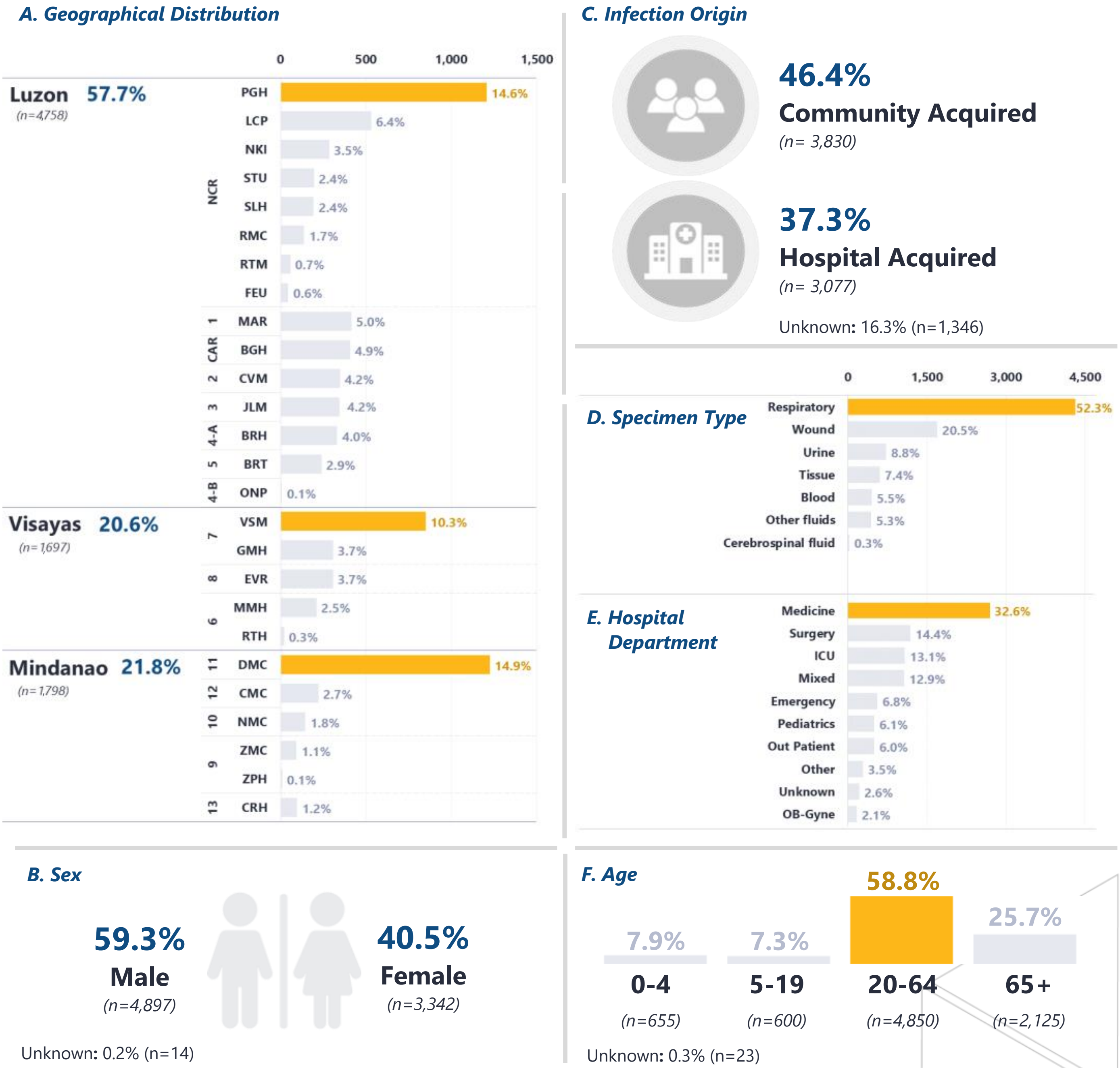


Figure 74. Isolate distribution and patient characteristics of *Pseudomonas aeruginosa* isolates, DOH-ARSP, 2019 (N=8,253)

All Isolates

P. aeruginosa is known to be resistant to a wide range of antibiotics. For 2019, cumulative resistance rates of *P. aeruginosa* ranged from 2.4% for colistin to 18.9% for piperacillin (Figure 75).

Antimicrobial resistance rates of *P. aeruginosa* isolates in 2019 mostly showed lower rates from 2018. Gentamicin (11.5% to 10.3%, p=0.0014), imipenem (18.8% to 16.9%, p= 0.0019), meropenem (16.1% to 14.2, p=0.0026) and amikacin (7.2% to 6.0%, p=0.0158) showed statistically significant decrease in antimicrobial resistance rates from 2018 to 2019. Aztreonam (13.5% to 14.6%, p=0.4944) and ciprofloxacin (12.7% to 14.2%, p=0.0379) significantly increased in percent resistance rates. Figure 76 showed that ceftazidime and cefepime were at relatively constant resistance rates while gentamicin and amikacin decreased in values for the last three years. On the other hand, aztreonam, imipenem and meropenem showed fluctuating AMR rates.

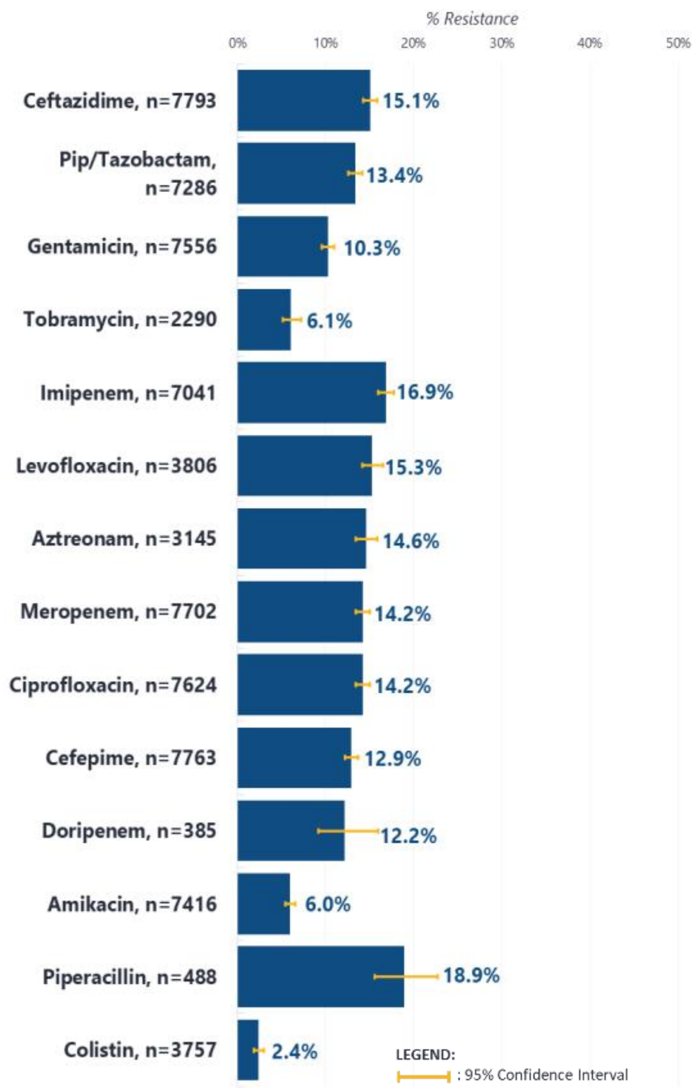


Figure 75. Percent resistance of *P. aeruginosa*, DOH-ARSP, 2019

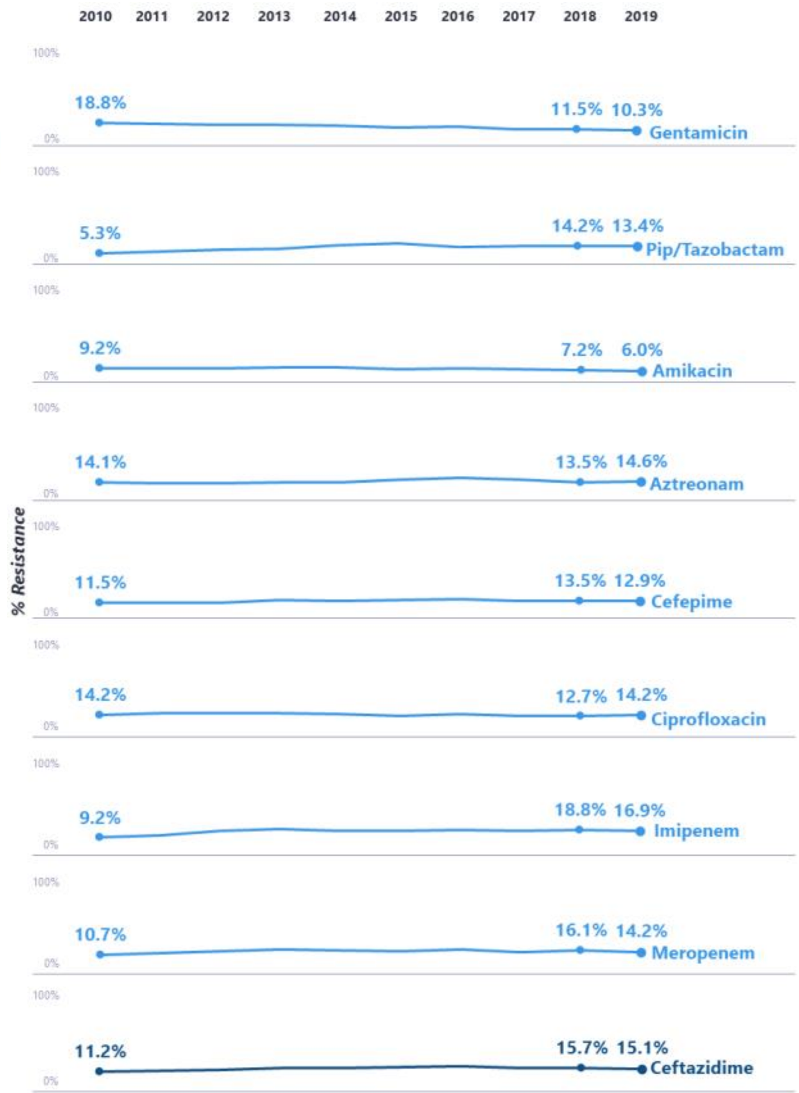


Figure 76. Yearly resistance rates of *P. aeruginosa*, DOH-ARSP, 2010-2019

Antimicrobial Resistance Analysis

Blood Isolates

Among isolates from blood, resistance rates to piperacillin, imipenem, meropenem and levofloxacin (Figure 77) were lower compared to overall (all specimens) cumulative resistance rates. Resistance ranged from 1% for colistin to 19.2% for tobramycin.

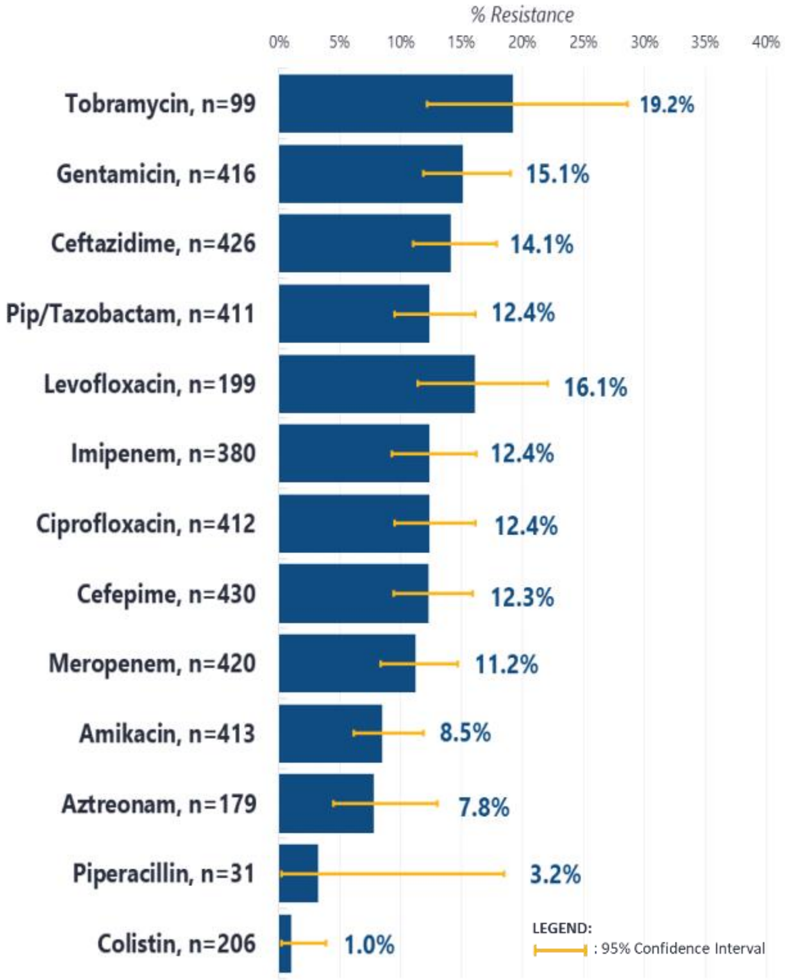


Figure 77. Percent resistance of *P. aeruginosa* blood isolates, DOH-ARSP, 2019

Acinetobacter baumannii

Isolate Distribution and Characteristics

For 2019, there were 6,250 isolates of A. baumannii.

6,250
Isolates analyzed

PGH contributed most to the total number of *A. baumannii* isolates at 19.1% followed by DMC at 13.5%. Most isolates were from Luzon (58.1%) (Figure 78-A).

As in the previous year, majority of the *A. baumannii* isolates were from respiratory specimens (62.6%) and were presumptively hospital acquired (43.7%). Most of the patients were males (57.1%) and were from 20-64 years age group (55.3%) (Figure 78-B to F).

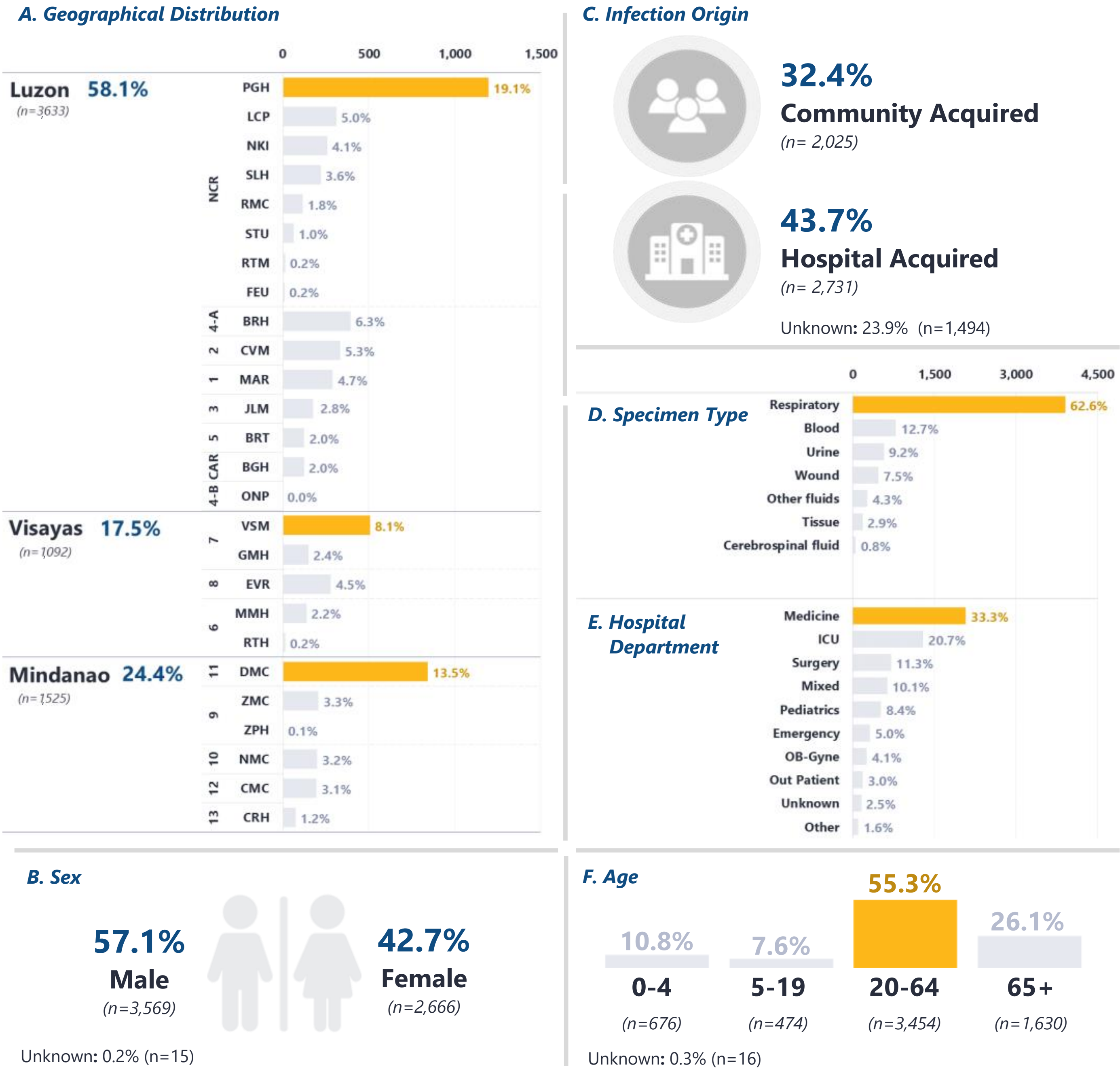


Figure 78. Isolate distribution and patient characteristics of ***Acinetobacter baumannii*** **isolates, DOH-ARSP, 2019 (N=6,250)**

All Isolates

Overall cumulative resistance of *A. baumannii* for 2019 is shown in Figure 79. Lowest resistance was observed against colistin at 0.5% while *A. baumannii* has the highest resistance against cefotaxime at 67.5%.

Yearly resistance rates of *A. baumannii* are shown in Figure 80. The reported resistance rate increase from 2018 to 2019 were found to be statistically significant for ampicillin/ sulbactam, and ceftazidime but not for meropenem and ciprofloxacin.

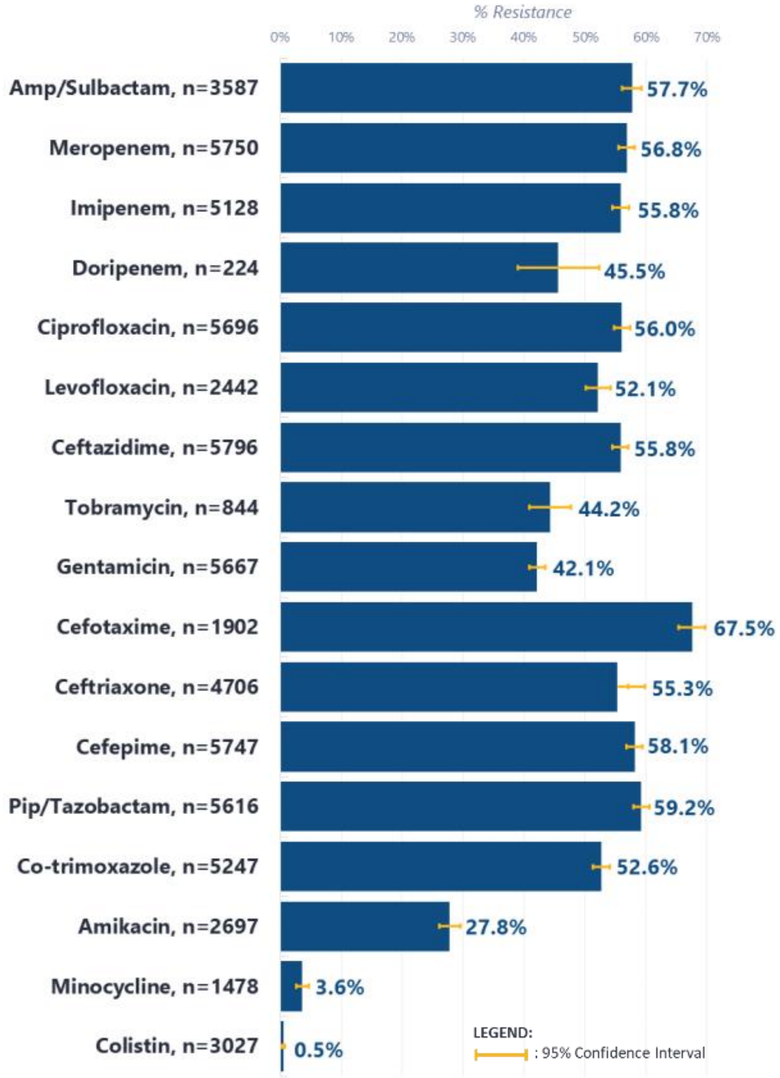


Figure 79. Percent resistance of *A. baumannii,* DOH-ARSP, 2019

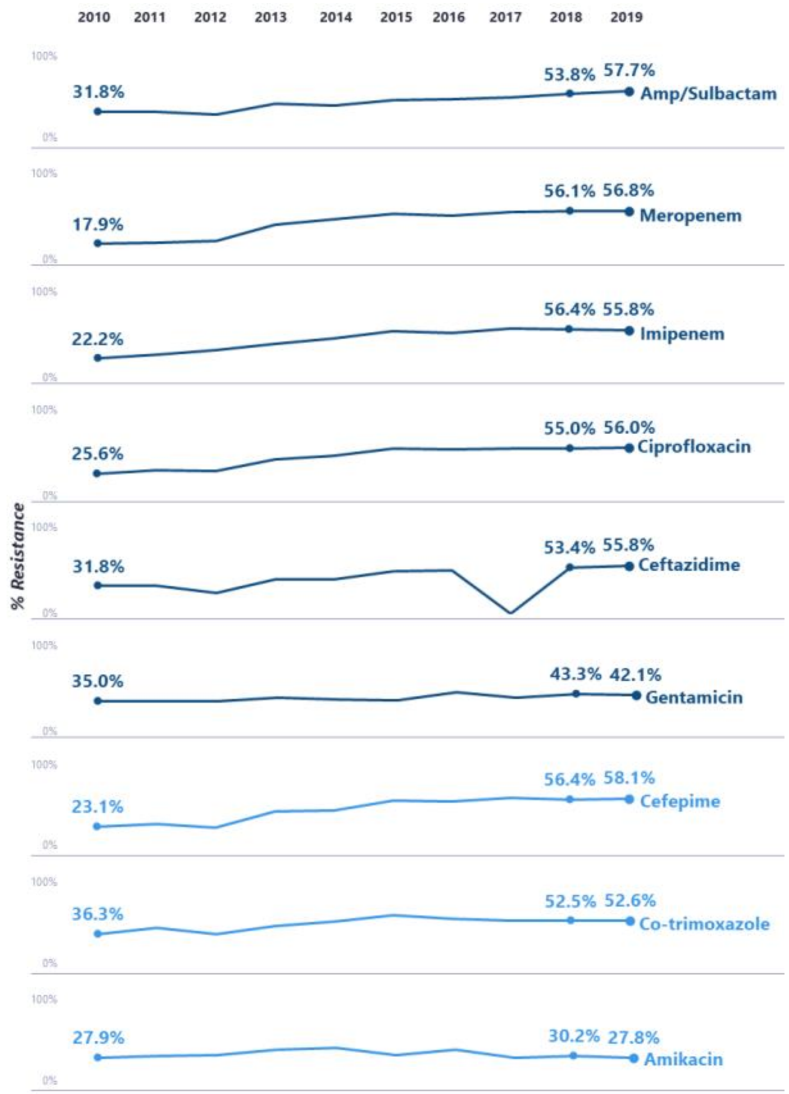


Figure 80. Yearly resistance rates of *A. baumannii,*

Blood Isolates

Among isolates from blood, most of the resistance rates were lower compared to the overall (all specimens) cumulative resistance rates (Figure 79 and 81). Resistance rates reported for *A. baumannii* isolated from blood specimens ranged from 1% for colistin to 45.2% for doripenem.

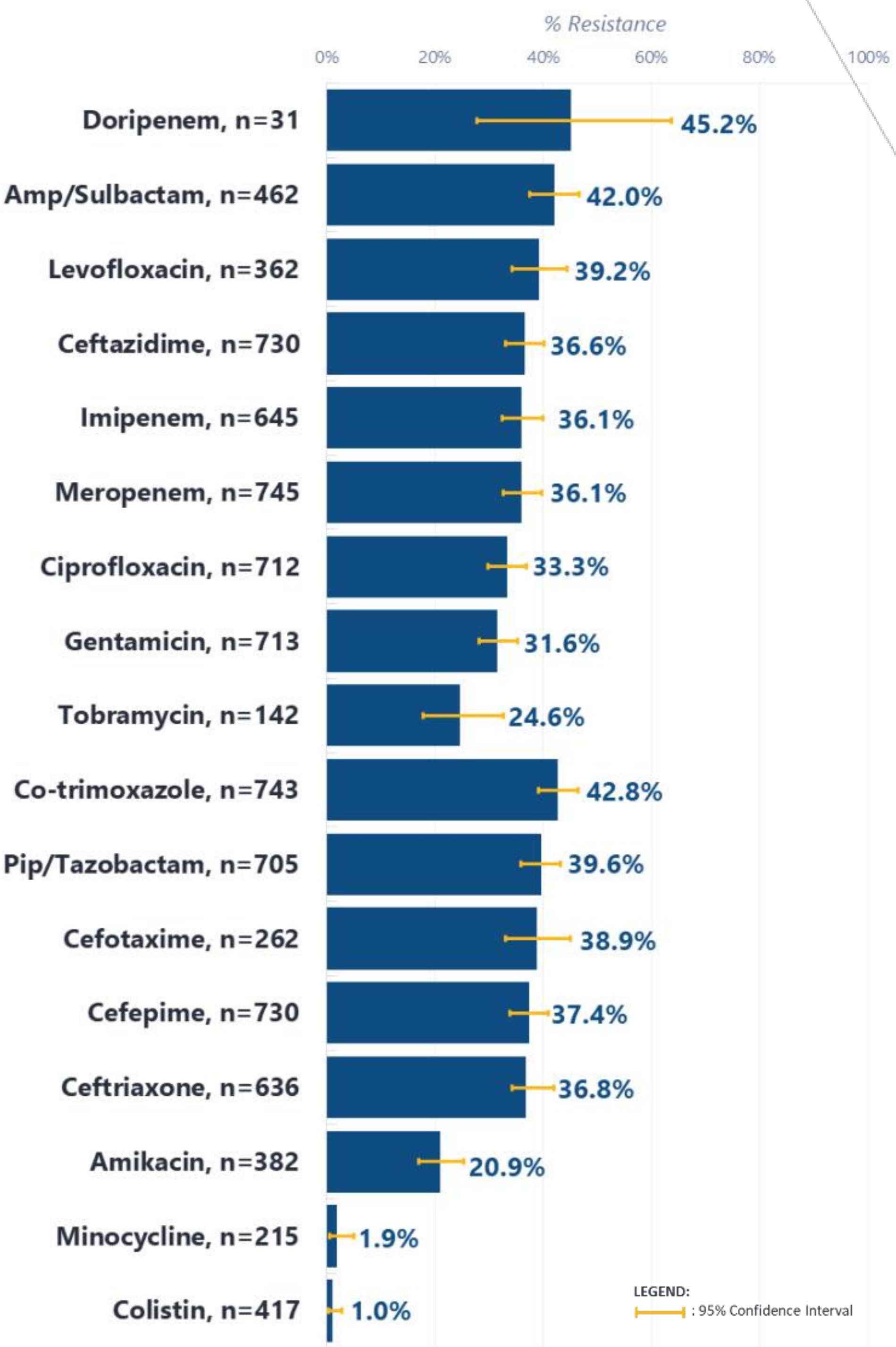


Figure 81. **Percent resistance of *A. baumannii* blood isolates, DOH-ARSP, 2019**

Multidrug-Resistant *Pseudomonas aeruginosa* & *Acinetobacter baumannii*

Multidrug-resistant pathogens are increasingly recognized globally. Terminologies are summarized in Table 3. P. aeruginosa Multidrug-resistant (MDR) and possible-extensively drug resistant (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 summarized in Table 4.

Table 3. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria - an international expert proposal for interim standard definitions for acquired resistance [11]

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 categories)
PDR **Pandrug-resistant**	Non-susceptibility to all agents in all antimicrobial categories.

Table 4. MDR and Possible XDR *P. aeruginosa* and *A. baumannii*, DOH-ARSP, 2019

	Number of isolates tested	Percentage MDR	Percentage Possible XDR
Pseudomonas aeruginosa			
All isolates	8,253	18%	14%
Blood isolates	494	18%	15%
Acinetobacter baumannii			
All isolates	6,250	58%	47%
Blood isolates	869	45%	35%

Conclusions, Recommendations and Future Directions

Antimicrobial resistance has been increasing for most of the bacterial pathogens considered of public health importance included in this surveillance. Hence we recommend the following based on the reported 2019 antimicrobial resistance surveillance data:

- *Infections secondary to Streptococcus pneumoniae can still be covered with penicillin, although there is a need to closely monitor the changing trends of resistance among pneumococci. Improving the surveillance to include clinical outcomes data for invasive isolates as well as routine pneumococcal serotyping will allow for better monitoring and evaluation of the government's vaccination strategy for this vaccine preventable pathogen.*

- *In view of high resistance rate of Haemophilus influenzae to ampicillin, recommended empiric treatment for suspected H. influenzae infections may consist of beta-lactam/beta-lactamase inhibitor combinations and extended spectrum oral cephalosporins.*

- *Empiric treatment for suspected uncomplicated typhoid fever could still consist of either chloramphenicol or co-trimoxazole or amoxicillin/ampicillin. Antimicrobial susceptibility data is recommended to aid in pathogen directed therapy.*

- *Increasing rates of ciprofloxacin resistance should remind clinicians to use antibiotics judiciously in Salmonella gastroenteritis, as this is usually a self-limited disease.*

- *In view of the emerging resistance of Shigella to the quinolones and limited data available, more vigilant surveillance of the resistance pattern of this organism should be pursued by encouraging clinicians to send specimens for culture.*

- *Tetracycline, chloramphenicol and co-trimoxazole remain good treatment options for cholera cases.*

- *For Neisseria gonorrhoeae, based on the 2019 reported isolates, ceftriaxone remains as empiric antibiotic of choice for gonococcal infections. More vigilant surveillance of the resistance patterns of this organism should be pursued by encouraging clinicians to send specimens for culture and confirmatory testing at the reference laboratory. Enhanced clinical data could also provide evidence for recommendations on possible stratified therapy.*

- *Decrease in MRSA rates are noted for 2019. Linking laboratory information with clinical data as well as genotyping to identify strains of prevalent MRSA isolates will allow for targeted and comprehensive strategies in MRSA containment.*

- *Multidrug resistance among the bacterial organisms Pseudomonas aeruginosa and Acinetobacter baumannii continues to be a public health concern because of the limited treatment options and infection control challenge in containment. Real time data analysis, genotyping to establish linkages will allow for timely isolation and infection control interventions. Stratified, institute specific antibiograms will allow clinicians to identify the best empiric antibiotic options for suspected infections.*

Program's Future Direction

- *Sustain vigilance in antimicrobial resistance surveillance among aerobic bacteria of public health significance in the light of the COVID-19 pandemic.*
- *Continue efforts to improve the quality of ARSP data through capacity building programs for the sentinel sites and the reference laboratory e.g training, improvement of facilities and provision of up-to-date equipment.*
- *Revive and expand the Gonorrhoeae surveillance network and harmonize with available clinical data by working with the Bureau of Epidemiology.*
- *Harmonize the national antibiotic use data and antimicrobial resistance surveillance data on animal specimens with ARSP data by collaborating with the Pharmaceutical Division of the Department of Health and the Department of Agriculture to enhance the relevance and significance of the surveillance information generated and present a more cohesive picture of the local state of AMR.*
- *Integrate a community-based and/or environmental antimicrobial resistance surveillance into the program.*
- *Enhance reference laboratory capacity by enhancing technical staff expertise and skills in molecular diagnostics and molecular epidemiology.*
- *Improve data management, security and sharing by personnel capacity building of the reference laboratory data management unit and equipment upgrade.*
- *Incorporate the technology of geographic information system and mapping in the surveillance.*
- *Work with Epidemiology Bureau to develop a protocol for notification of reportable drug-resistant pathogens.*
- *Pursue initiatives for case-based AMR surveillance.*
- *Pursue ISO 15189 accreditation for the reference laboratory.*
- *Generate more relevant collaborative and investigator initiated researches.*

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