

Abstract

Trends of antimicrobial resistance rates of major clinical pathogens isolated from general hospitals in Korea in 2016-2019: results from Kor-GLASS

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The Korea Centers for Disease Control and Prevention (renamed the Korea Disease Control and Prevention Agency [KDCA]) established an antimicrobial resistance (AMR) surveillance system, compatible with the GLobal AMR Surveillance System (GLASS), called Kor-GLASS, in 2016. The aim of this report was to analyze the results of the AMR status of major resistant bacteria collected through the operation of Kor-GLASS from 2016 to 2019. Among 303,928 blood cultures, 15,116 target pathogens were recovered. The predominant bacterial species were *Escherichia coli* (n=6,547), *Klebsiella pneumoniae* (n=2,536), and *Staphylococcus aureus* (n=2,532). From 286,951 urine cultures, 26,873 *E. coli* and 4,673 *K. pneumoniae* were recovered. The rate of methicillin-resistant *S. aureus* (MRSA) decreased from 53.5% in 2016 to 48.6% in 2019, while the rate of vancomycin-resistant *Enterococcus faecium* (VRE) remained steadily high. The resistance rates to cefotaxime of *E. coli* isolated from blood increased from 35.4% in 2016 to 37.1% in 2019, and those of *E. coli* and *K. pneumoniae* isolated from urine also increased. The majority of these strains carried the CTX-M type extended-spectrum beta-lactamase (ESBL) gene. The rates of resistance to carbapenems, which is used for treatment of ESBL-producing gram-negative bacterial infections, were as low as 2% or less in *Enterobacteriales*. On the other hand, the carbapenem resistance rates in *Pseudomonas aeruginosa* and *Acinetobacter baumannii* in 2019 were relatively high at 23.6% and 90.3%, respectively. Kor-GLASS generated well-curated surveillance data devoid of collection bias or isolate duplication, including patient data associated with the bacterial cultures. The results of this surveillance can provide basic data for making management policies to overcome AMR.

Keywords: Antimicrobial resistance, GLASS, Kor-GLASS, MRSA, VRE, CRE, ESBL

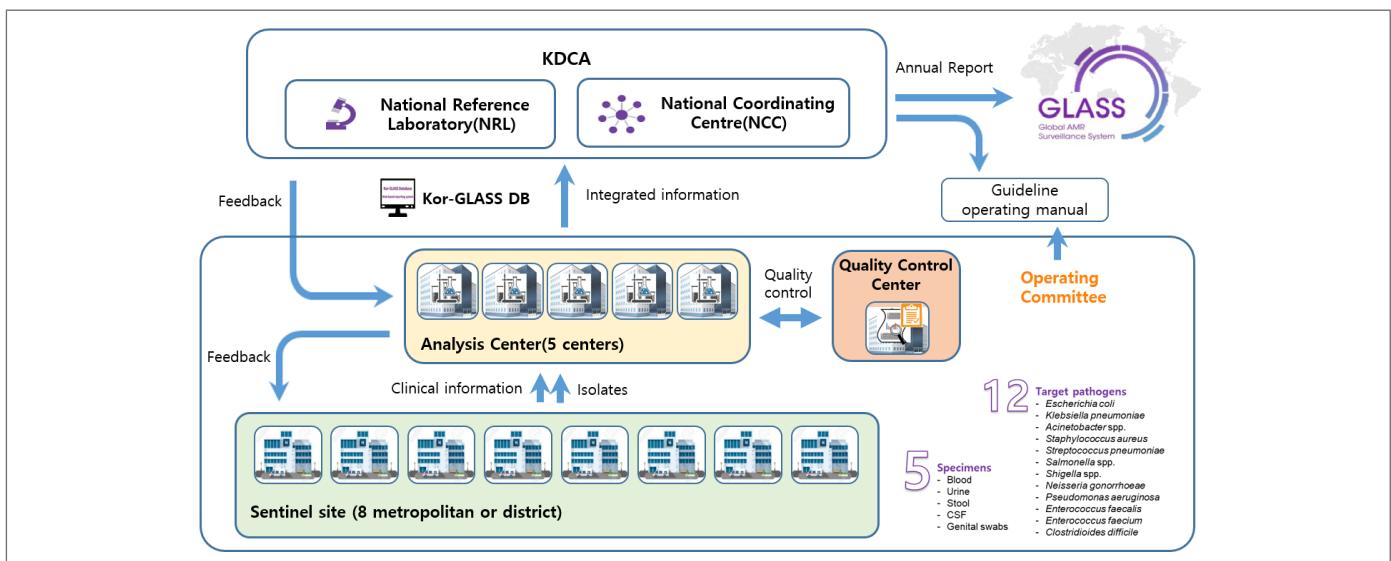


Figure 1. Global Antimicrobial Resistance Surveillance System in Korea (Kor-GLASS) system in 2019

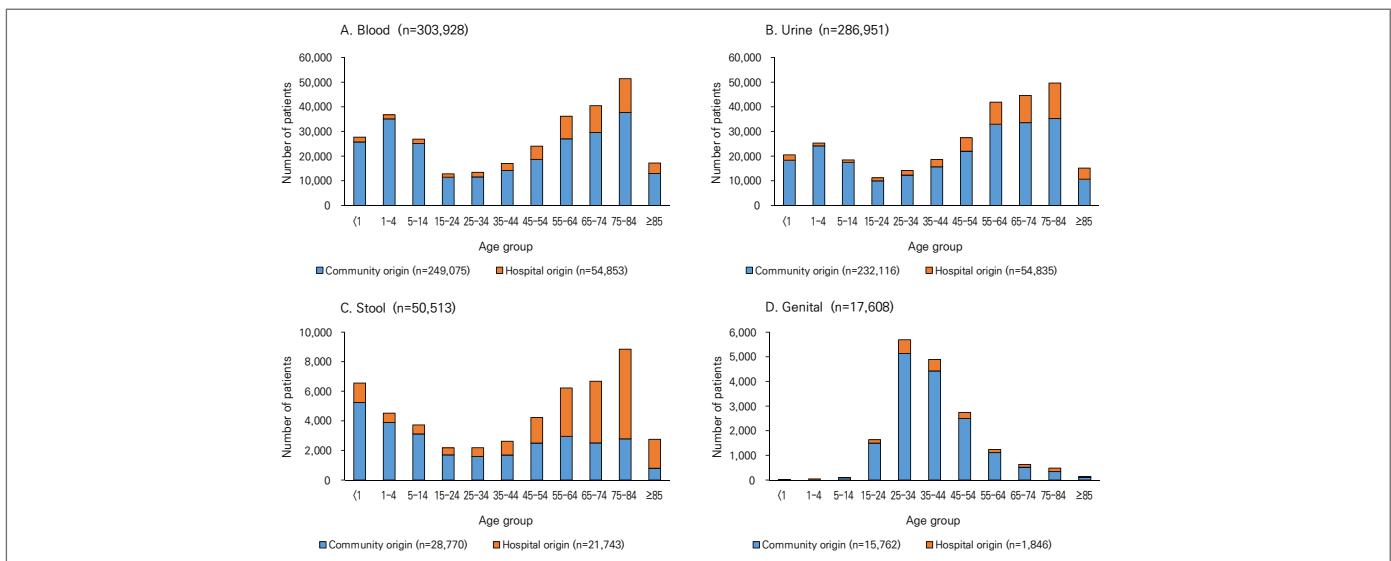


Figure 2. Number of patients samples for bacterial culture, by specimen and age group

Table 1. Number of target pathogen by specimen, 2016–2019

Specimen	Target pathogen	2016 (n=7,877)	2017 (n=13,440)	2018 (n=13,262)	2019 (n=13,327)	Total
Blood	<i>Staphylococcus aureus</i>	398	708	743	683	2,532
	<i>Enterococcus faecalis</i>	116	175	181	651	651
	<i>Enterococcus faecium</i>	137	288	277	308	1,010
	<i>Streptococcus pneumoniae</i>	15	54	48	36	153
	<i>Clostridioides difficile</i>	–	–	1	28	29
	<i>Escherichia coli</i>	1,112	1,772	1,724	1,939	6,547
	<i>Klebsiella pneumoniae</i>	426	693	701	716	2,536
	<i>Salmonella</i> spp.	35	56	55	47	192
	<i>Shigella</i> spp.	0	0	0	0	0
	<i>Pseudomonas aeruginosa</i>	102	149	157	182	590
	<i>Acinetobacter baumannii</i>	131	203	210	187	731
	<i>non-baumannii Acinetobacter</i>	38	32	37	38	145
Urine	<i>Escherichia coli</i>	4,474	7,874	7,255	7,270	26,873
	<i>Klebsiella pneumoniae</i>	823	1,256	1,299	1,295	4,673
Stool	<i>Salmonella</i> spp.	71	172	163	140	546
	<i>Shigella</i> spp.	0	1	2	0	3
	<i>Clostridioides difficile</i>	–	–	409	277	686
Genital	<i>Neisseria gonorrhoeae</i>	0	1	0	0	1
CSF	<i>Streptococcus pneumoniae</i>	0	6	2	0	8

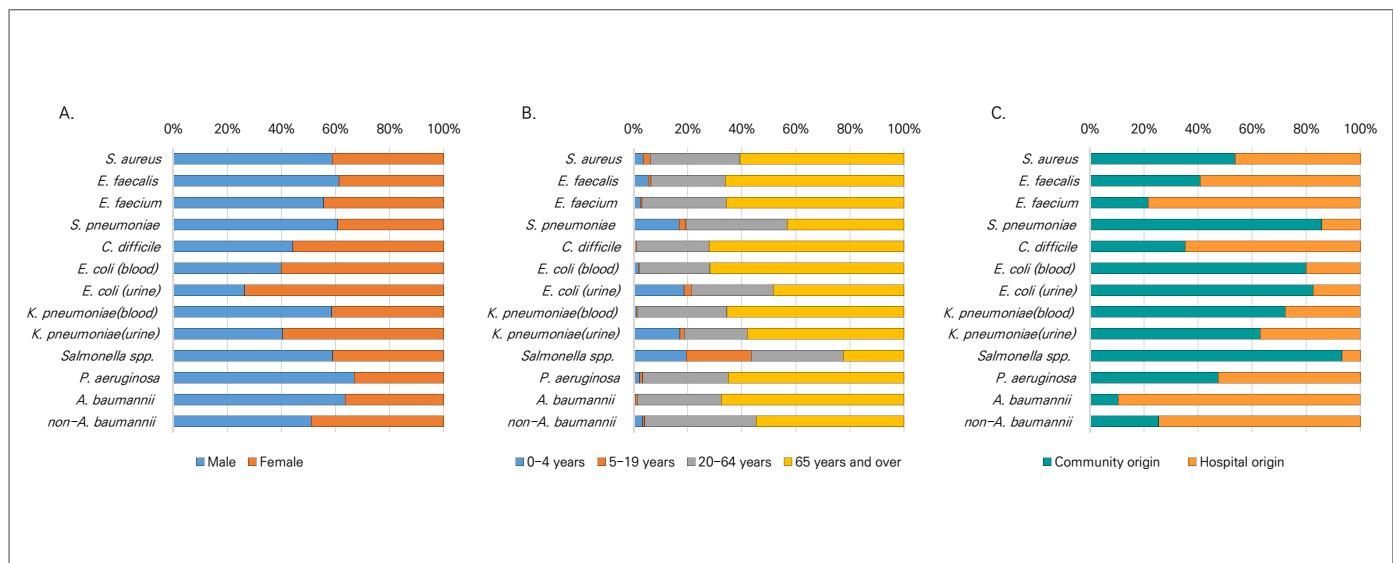


Figure 3. Distribution of (A) sex, (B) age group, (C) infection origin by specimen

Table 2. Antimicrobial resistance rates of major gram-positive pathogens, 2016–2019

Species	Antimicrobial agents	2016		2017		2018		2019	
		No. of strains	R (%)						
<i>Staphylococcus aureus</i> (blood, n=2,532)	Cefoxitin		53.5		53.2		47.1		48.6
	Erythromycin		42.0		38.7		35.3		35.1
	Clindamycin		28.4		24.7		20.9		19.0
	Mupirocin		8.0		8.1		12.0		13.3
	Quin-Dalf	398	1.8	708	0.7	743	0.1	683	0.3
	Trim-Sulf		1.3		0.1		0.7		1.2
	Vancomycin		0		0		0		0
	Teicoplanin		0		0		0		0
	Linezolid		0		0		0		0
<i>Enterococcus faecalis</i> (blood, n=651)	Tigecycline		1.8		0.4		4.4		5.0
	Ampicillin		0		0.6		1.7		5.5
	Ciprofloxacin		33.6		41.1		39.7		35.4
	Gentamicin-HL		25.9		26.9		29.6		22.1
	Streptomycin-HL		7.8		6.3		5.6		6.6
	Tetracycline	116	70.7	175	73.7	179	74.9	181	68.5
	Vancomycin		0		0.6		0.6		1.7
	Teicoplanin		0		0.6		0.6		1.7
	Linezolid		0		1.1		0		1.7
<i>Enterococcus faecium</i> (blood, n=1,010)	Tigecycline		0		0		0		0
	Ampicillin		90.5		89.6		91.0		90.3
	Ciprofloxacin		90.5		89.9		90.3		90.8
	Gentamicin-HL		21.2		18.1		21.3		23.7
	Streptomycin-HL		3.6		1.0		0		0.6
	Tetracycline	137	11.7	288	14.9	277	15.9	308	12.0
	Quin-Dalf		8.8		3.1		6.1		8.4
	Vancomycin		29.9		34.0		39.4		40.9
	Teicoplanin		20.4		18.8		27.1		34.7
<i>Streptococcus pneumoniae</i> (blood, n=153)	Linezolid		0.7		0		0		0
	Tigecycline		0		0.3		0		0
	Penicillin		0		9.3		8.3		2.8
	Amox-Clav		6.7		18.5		25.0		27.8
	Cefotaxime		0		1.9		6.3		2.8
	Ceftriaxone	15	0	54	1.9	48	10.4	36	2.8
	Cefuroxime		60.0		68.5		66.7		72.2
	Erythromycin		80.0		75.9		77.1		83.3
	Levofloxacin		0		3.7		2.1		2.8
<i>Clostridioides difficile</i> (stool, n=715)	Trim-Sulf		26.7		31.5		27.1		25.0
	Ampicillin		—		—		11.5		20.0
	Cefotetan		—		—		33.2		25.9
	Imipenem		—		—		44.1		48.2
	Clindamycin		—		—		68.3		70.5
	Chloramphenicol	—	—	—	—	410	1.2	305	0.7
	Tetracycline	—	—	—	—		16.6		14.4
	Rifaximin	—	—	—	—		16.8		13.1
	Moxifloxacin	—	—	—	—		44.4		39.3
	Vancomycin	—	—	—	—		0		0
	Metronidazole	—	—	—	—		0		0

*Abbreviations: Quin-Dalf, quinupristin-dalfopristin; Trim-Sulf, trimethoprim-sulfamethoxazole; Gentamicin-HL, High-level gentamicin; Streptomycin-HL, High-level streptomycin; Amox-Clav, amoxicillin-clavulanic acid

Table 3. Antimicrobial resistance rates of major *Enterobacteriales*, 2016–2019

Species	Antimicrobial agents	2016		2017		2018		2019	
		No. of strains	R (%)						
<i>Escherichia coli</i> (blood, n=6,547)	Ampicillin		65.2		65.3		68.0		67.5
	Amp-Sulb		24.3		28.9		29.3		22.0
	Cefotaxime		35.4		32.4		38.6		37.1
	Ceftazidime		11.3		11.8		12.7		10.2
	Cefefime		21.4		20.3		24.8		20.2
	Aztreonam	1,112	21.2	1,772	20.8	1,724	24.6	1,939	20.0
	Imipenem		0.1		0.2		0.1		0.2
	Gentamicin		29.6		26.6		27.1		26.36
	Ciprofloxacin		39.4		35.8		42.7		41.1
	Tigecycline		0.2		0.1		0		0.1
<i>Escherichia coli</i> (urine, n=26,873)	Colistin		0.1		0.2		0.1		0
	Ampicillin		69.3		68.8		69.6		71.7
	Amp-Sulb		25.3		29.8		27.7		22.2
	Cefotaxime		31.6		31.3		33.2		37.5
	Ceftazidime		9.9		10.3		10.2		9.8
	Cefefime		17.7		17.6		18.1		18.3
	Aztreonam	4,474	17.4	7,874	17.9	7,255	18.4	7,270	17.9
	Imipenem		0		0		0.1		0.1
	Gentamicin		30.9		27.1		27.4		28.9
	Ciprofloxacin		44.5		40.9		40.7		45.0
<i>Klebsiella pneumoniae</i> (blood, n=2,536)	Tigecycline		0.1		0.1		0.1		0.02
	Colistin		0.2		0.2		0.1		0.03
	Piperacillin		29.8		28.9		31.0		29.6
	Amp-Sulb		24.2		27.0		26.1		20.5
	Cefotaxime		27.0		26.1		27.1		24.9
	Ceftazidime		20.0		21.2		20.7		16.8
	Cefefime		19.5		20.6		20.5		17.0
	Aztreonam	426	22.8	693	23.4	701	24.0	716	19.8
	Imipenem		1.6		0.7		1.4		1.0
	Gentamicin		13.8		12.0		14.8		12.8
<i>Klebsiella pneumoniae</i> (urine, n=4,673)	Ciprofloxacin		20.2		18.9		22.7		17.6
	Tigecycline		1.4		0.6		2.1		2.1
	Colistin		0.7		0.6		0.4		1.0
	Piperacillin		45.1		45.0		19.1		48.0
	Amp-Sulb		36.6		39.9		41.3		37.5
	Cefotaxime		39.7		39.0		41.8		41.8
	Ceftazidime		28.9		28.8		28.1		25.8
	Cefefime		27.5		26.6		27.9		26.9
	Aztreonam	823	31.5	1,256	32.1	1,299	9.9	1,295	9.0
	Imipenem		0.5		1.4		0.6		1.2
<i>Salmonella species</i> (stool, n=546)	Gentamicin		19.8		22.3		21.7		25.8
	Ciprofloxacin		32.8		31.9		32.5		31.9
	Tigecycline		2.6		1.4		2.2		4.6
	Colistin		0.9		0.7		0.9		1.0
	Cefotaxime		3.8		7.9		7.8		8.0
<i>Salmonella species</i> (stool, n=546)	Ceftazidime		2.9		6.1		6.9		7.5
	Imipenem	105	0	228	0	218	0	187	0
	Azithromycin		1.0		0.4		2.3		1.1
	Ciprofloxacin		0		3.0		3.2		4.3

*Abbreviations: Amp-Sulb, ampicillin-sulbactam

Table 4. Antimicrobial resistance rates of non-fermenting gram-negative bacilli, 2016–2019

Species	Antimicrobial agents	2016		2017		2018		2019	
		No. of strains	R (%)						
<i>Pseudomonas aeruginosa</i> (blood, n=590)	Piperacillin		11.8		14.1		12.1		11.0
	Pip-Tazob		9.8		12.1		8.9		9.9
	Ceftazidime		9.8		14.1		12.7		12.6
	Cefepime		11.8		10.7		13.4		14.3
	Imipenem	102	17.6	149	19.5	157	17.8	182	25.8
	Meropenem		14.7		18.1		24.2		23.6
	Amikacin		6.9		5.4		7.6		14.8
	Gentamicin		10.8		8.7		12.1		17.0
	Ciprofloxacin		15.7		15.4		20.4		20.3
<i>Acinetobacter baumannii</i> (blood, n=731)	Colistin		0		0		0		0
	Piperacillin		88.5		93.1		89.5		90.8
	Amp-Sulb		71.0		81.3		76.2		77.8
	Cefazidime		84.7		87.7		86.7		90.8
	Cefepime		87.8		92.6		90.5		91.4
	Imipenem		87.8		92.1		89.0		90.3
	Meropenem	131	87.8	203	92.1	210	89.0	187	90.3
	Gentamicin		69.5		75.9		66.7		76.2
	Ciprofloxacin		88.5		92.1		90.5		90.8
<i>non-baumannii</i> <i>Acinetobacter</i> (blood, n=145)	Minocycline		1.5		2.0		0.5		12.2
	Tigecycline		3.8		5.4		2.9		16.8
	Colisin		0.8		0		0		0.5
	Piperacillin		10.5		9.4		24.3		8.1
	Amp-Sulb		2.6		9.4		5.4		2.7
	Cefazidime		5.3		3.1		13.5		10.8
	Cefepime		7.9		3.1		10.8		13.5
	Imipenem		5.3		3.1		13.5		8.1
	Meropenem	38	5.3	32	3.1	37	13.5	38	8.1
<i>non-baumannii</i> <i>Acinetobacter</i> (blood, n=145)	Gentamicin		15.8		6.3		8.1		5.4
	Ciprofloxacin		10.5		6.3		13.5		18.9
	Minocycline		0		0		0		0
	Tigecycline		0		0		0		2.7
	Colisin		0		0		0		0

*Abbreviations: Pip-Tazob, piperacillin-tazobactam; Amp-Sulb, ampicillin-sulbactam

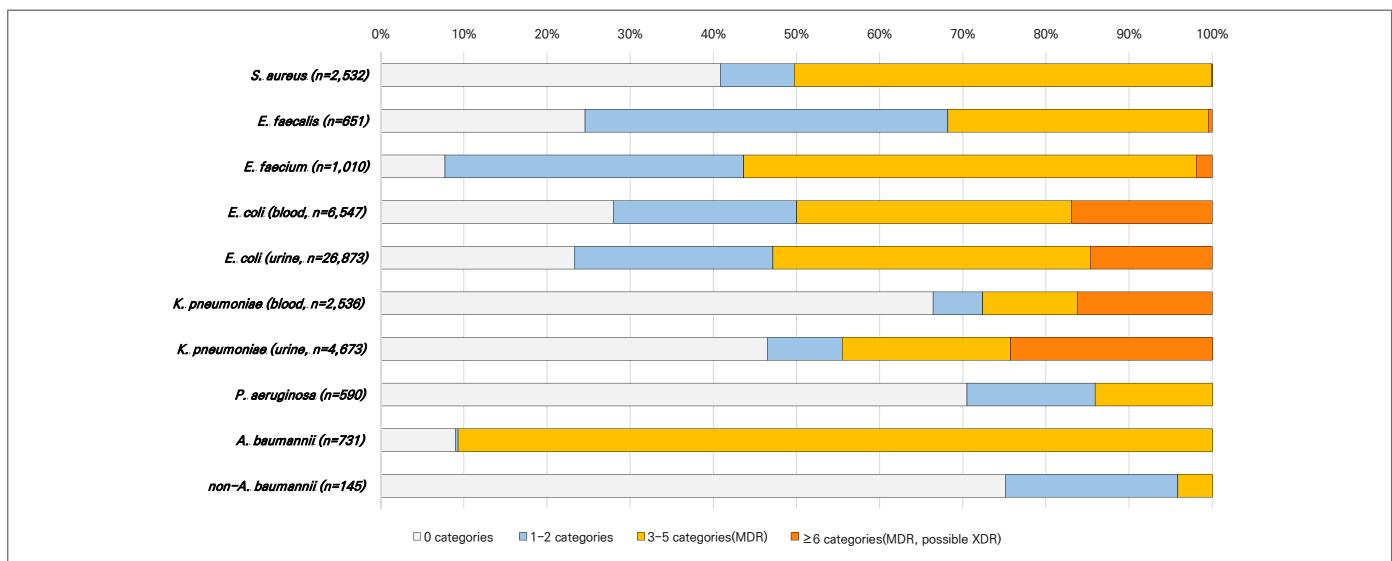


Figure 4. The rates of multi-drug resistance (MDR) of major pathogen