OVERVIEW OF ANTIMICROBIAL SUSCEPTIBILITY PATTERNS OF ESKAPE ORGANISMS ISOLATED FROM PATIENTS WITH BACTERAEMIA IN SOUTH AFRICA, 2016 – 2018

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Summary

Antimicrobial resistance (AMR) in Gram-positive and Gram-negative bacteria has increased in recent years. According to the World Health Organization (WHO), the ESKAPE group (*Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter* spp.) are listed amongst 12 bacterial species against which new antimicrobial agents are urgently needed. The aim of this project was to describe these ESKAPE organisms and *Escherichia coli* isolated from patients with bacteraemia as reported from two health sectors in South Africa, and to compare their antimicrobial susceptibility profiles over a three-year period. Antimicrobial susceptibility testing data were extracted from a web-based electronic platform created by the National Institute for Communicable Diseases. Specific 'drug-bug' combinations following the WHO's Global Antimicrobial Surveillance System guidelines were included in the analysis. A total of 106 300 ESAKPE plus *E. coli* isolates from both private and public health sectors was analysed. There was an increase in the number of pathogens identified from 31 369 in 2016 to 34 928 in 2017 to 40 003 in 2018, with a two-fold increase in non-susceptibility to carbapenems among *K. pneumoniae* in both health sectors. The relative proportion of *A. baumannii* drug susceptible isolates from the public sector remained stable during 2017 and 2018 (20% were susceptible). *Pseudomonas aeruginosa* isolates reported from the private sector showed an increase in susceptibility to piperacillin-tazobactam, from 64% in 2017 to 74% in 2018. In this surveillance period the key findings include an increase in the numbers of ESKAPE pathogens and resistance to carbapenems among Enterobacteriaceae. This analysis provides AMR surveillance data for healthcare guidance at national level.

Introduction

Bacteria in the ESKAPE group of pathogens includes six healthcare-associated multidrug-resistant organisms (*Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter* spp.).[1] In addition, *Escherichia coli* causes the majority of life-threatening bacterial infections in community and healthcare facilities worldwide. According to the World Health Organization (WHO), these organisms are listed amongst 12 bacterial species against which new antimicrobial agents are urgently needed.[1] Surveillance for antimicrobial resistance (AMR) is key to understanding the current extent of resistance. This is necessary to inform health programmes that generate guidelines for treatment, and assists in the prevention of AMR transmission.[2] In South Africa (SA), one of the strategic objectives of the Antimicrobial Resistance National Strategy Framework document, formulated by the National Department of Health, is to optimize surveillance and early detection of AMR.[2,3] This strategy includes AMR reporting from the list of organisms of the Global Antimicrobial Resistance Surveillance System of the WHO. In addition to the ESKAPE group of organisms, *E. coli* was added because it is one of the most common community and hospital pathogens of the Enterobacteriaceae family.

The aim of this project was to describe the ESKAPE organisms and *E. coli* isolated from patients with bacteraemia as reported from public and private health sectors in SA, and to compare their antimicrobial susceptibility profiles over a three-year period.

Methods

Study design, population and setting

A secondary data analysis of antimicrobial susceptibility testing (AST) in South Africa from January 2016 to December 2018 was conducted. AST data were extracted from a secure web-based electronic platform created by the Surveillance Information Management Unit (SIMU) at the National Institute for Communicable Diseases (NICD). These data were available on the AMR dashboard hosted by the NICD website (http://www.nicd.ac.za). The study population included all patients who had a blood culture submitted either to the public National Health Laboratory Service (NHLS) or to one of the four accredited private pathology laboratories (Ampath, Lancet Laboratories, PathCare and Vermaak and Partners). Positive blood cultures for any one of the ESKAPE organisms or *E. coli* were included in the analysis. The working group of the South African Society for Clinical Microbiology made a decision in 2015 to exclude

surveillance of *Enterobacter* spp. owing to concerns about the lack of standardisation in the testing and reporting of susceptibility profiles between different laboratories.

Definitions

In line with the GERMS-SA laboratory-based surveillance programmes, duplicate isolates of the same organism obtained from the same patient within 21 days were excluded, in order to avoid bias induced by multiple investigations of severely ill patients. AST and interpretation of results were performed by individual laboratories according to current Clinical and Laboratory Standards Institute (CLSI) guidelines, or the European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines (at one private laboratory). There were only a few minor changes in the breakpoint interpretation in EUCAST during the three-year study period (for instance, cefepime zone sizes were changed from 19 mm to 25 mm), and no changes in CLSI breakpoint interpretive criteria were used in the analysis of drug-bug combinations. AST results were grouped, based on categorical data as provided by the submitting laboratories. Results were reported as susceptible or non-susceptible, which includes the intermediate and resistant categories. The reporting format of susceptibility profiles for drug-bug combinations was based on the WHO Global Antimicrobial Surveillance System (GLASS) early implementation manual.[4]

Results

Over the three-year study period 106 300 ESKAPE organisms and *E. coli* were reported, of which 67% (n=71 661) were from the public sector and 33% (n=34 639) from the private sector. Gram-negative bacteria accounted for 61% (43 571/71 661) in the public sector and 72% (24 971/34 639) in the private sector. *Escherichia coli* accounted for 17% and 31%, *K. pneumoniae* 25% and 28%, *A. baumannii* 13% and 3%, *P. aeruginosa* 6% and 10%, *E. faecalis* 8% and 8%, *E. faecium* 7% and 3%, and *S. aureus* 24% and 17% in the public and private sectors respectively. In the private sector, there was a decrease in the relative proportion of *E. coli* isolates from 35% in 2017 to 28% in 2018, an increase in the relative proportion of *K. pneumoniae* isolates from 27% in 2017 to 29% in 2018, and an increase in the relative proportion of *S. aureus* isolates from 15% in 2017 to 20% in 2018 (Table 1).

Table 1. Bacterial profile for ESKAPE organisms and *Escherichia coli* identified from blood cultures obtained from the public and private health sectors in South Africa, 2016 to 2018.

Sector	Group	Organism	2016 (N=22340) n (%)	2017 (N=22892) n (%)	2018 (N=26429) n (%)
Public	Enterobacteriaceae	*Escherichia coli*	3981 (18)	4085 (18)	4441 (17)
		Klebsiella pneumoniae	5533 (25)	5440 (24)	6688 (25)
	Non-fermentative Gram-negative bacteria	*Acinetobacter baumannii*	2736 (12)	3139 (14)	3509 (13)
		Pseudomonas aeruginosa	1197 (5)	1471 (6)	1351 (5)
	Gram-positive bacteria	*Enterococcus faecalis*	1710 (8)	1768 (8)	2101 (8)
		Enterococcus faecium	1669 (7)	1565 (7)	1944 (7)
		Staphylococcus aureus	5514 (25)	5424 (24)	6395 (24)
			2016 (N=9029) n (%)	**2017 (N=12036) n (%)**	**2018 (N=13574) n (%)**
Private	Enterobacteriaceae	*Escherichia coli*	2781 (31)	4187 (35)	3863 (28)
		Klebsiella pneumoniae	2466 (27)	3204 (27)	3921 (29)
	Non-fermentative Gram-negative bacteria	*Acinetobacter baumannii*	304 (3)	458 (4)	403 (3)
		Pseudomonas aeruginosa	914 (10)	1256 (10)	1214 (9)
	Gram-positive bacteria	*Enterococcus faecalis*	739 (8)	867 (7)	1014 (7)
		Enterococcus faecium	311 (3)	315 (3)	389 (3)
		Staphylococcus aureus	1514 (17)	1749 (15)	2770 (20)

Enterobacteriaceae

Escherichia coli: Differences in susceptibilities were observed for the fluoroquinolone ciprofloxacin and third- and fourth-generation cephalosporins in both health sectors. In the public sector, there was an increase in non-susceptibility to ciprofloxacin from 26% in 2017 to 29% in 2018, and in the private sector from 31% in 2016 to 37% in 2018. In the public sector, non-susceptibility to cefotaxime/ceftriaxone increased from 25% in 2017 to 31% in 2018, ceftazidime from 25% in 2017 to 30% in 2018 and cefepime from 25% in 2017 to 30% in 2018. Isolates from the private sector showed greater susceptibility to the cephalosporins compared to those from the public sector. A high proportion of isolates reported from both health sectors were susceptible to the carbapenems (ertapenem, imipenem and meropenem). Although there was no difference in susceptibility to the beta-lactam and beta-lactamase inhibitor piperacillin-tazobactam in the public sector, there was an increase in non-susceptibility for isolates reported from the private sector from 20% in 2016 to 24% in 2018 (Table 2).

Table 2. Antimicrobial susceptibility patterns of *Escherichia coli* isolates identified from blood cultures in South Africa, 2016 to 2018.

		2016		2017		2018	
Health sector	**Drug**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**
Public	Amikacin	3842	3478 (91)	3885	3522 (91)	4275	4067 (95)
	Amoxicillin-clavulanic acid	3845	2462 (64)	3870	2456 (63)	4237	2509 (59)
	Ampicillin/amoxicillin	3834	614 (16)	3823	595 (16)	4191	607 (14)
	Cefepime	3668	2785 (76)	3750	2825 (75)	4232	2972 (70)
	Cefotaxime/ceftriaxone	3752	2798 (75)	3835	2874 (75)	4257	2941 (69)
	Ceftazidime	3780	2869 (76)	3791	2848 (75)	4253	2979 (70)
	Ciprofloxacin	3815	2818 (74)	3720	2756 (74)	4287	3056 (71)
	Cotrimoxazole	NR	NR	NR	NR	NR	NR
	Doripenem	NR	NR	NR	NR	NR	NR
	Ertapenem	3552	3518 (99)	3659	3645 (100)	4218	4198 (100)
	Gentamicin	3864	3168 (82)	3872	3175 (82)	4263	3470 (81)
	Imipenem	3727	3705 (99)	3774	3757 (100)	4267	4243 (99)
	Levofloxacin	9	7 (78)	19	16 (84)	17	13 (76)
	Meropenem	3716	3691 (99)	3810	3791 (100)	4247	4224 (99)
	Piperacillin-tazobactam	3485	3020 (87)	3736	3237 (87)	4259	3733 (88)
Private	Amikacin	2781	2598 (93)	4040	3725 (92)	3855	3724 (97)
	Amoxicillin-clavulanic acid	2780	1945 (70)	4171	2791 (67)	3859	2443 (63)
	Ampicillin/amoxicillin	1998	425 (21)	2310	466 (20)	3800	857 (23)
	Cefepime	2778	2283 (82)	4040	3254 (81)	3858	3018 (78)
	Cefotaxime/ceftriaxone	2777	2253 (81)	4171	3329 (80)	3623	2768 (76)
	Ceftazidime	2148	1755 (82)	2804	2231 (80)	3199	2489 (78)
	Ciprofloxacin	1997	1378 (69)	3534	2301 (65)	2713	1719 (63)
	Cotrimoxazole	1746	657 (38)	2298	839 (37)	2243	817 (36)
	Doripenem	2753	2748 (100)	4013	4007 (100)	3745	3731 (100)
	Ertapenem	2779	2769 (100)	4041	4026 (100)	3860	3836 (99)
	Gentamicin	2779	2368 (85)	4045	3448 (85)	3857	3280 (85)
	Imipenem	2777	2772 (100)	4043	4033 (100)	3862	3847 (100)
	Levofloxacin	792	593 (75)	1229	868 (71)	1152	859 75)
	Meropenem	2780	2777 (100)	4042	4034 (100)	3862	3849 (100)
	Piperacillin-tazobactam	2774	2212 (80)	3677	2868 (78)	3854	2923 (76)

NR = not reported

Klebsiella pneumoniae: Non-susceptibility to ciprofloxacin in both health sectors increased from 2016 to 2018: in the public sector from 34% to 37% and in the private sector from 40% to 51%. We also observed an increase in non-susceptibility to carbapenems over the three-year study period. In the public sector, non-susceptibility to ertapenem increased from 4% to 10%, imipenem from 5% to 12% and meropenem from 6% to 12%. In the private sector, non-susceptibility to ertapenem increased from 15% to 30%, imipenem from 10% to 18% and meropenem from 9% to 18%. No changes in susceptibility to piperacillin-tazobactam were noted for isolates reported from the public sector. Isolates reported from the private sector however showed an increase in non-susceptibility from 57% in 2016 to 64% in 2018 (Table 3).

Table 3. Antimicrobial susceptibility patterns of *Klebsiella pneumoniae* isolates identified from blood cultures in South Africa, 2016 to 2018.

		2016		2017		2018	
Health sector	**Drug**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**
Public	Amikacin	5288	4278 (81)	5130	4164 (81)	6344	5109 (81)
	Amoxicillin-clavulanic acid	5284	1763 (33)	5085	1542 (30)	6283	1861 (30)
	Cefepime	5164	1687 (33)	5012	1548 (31)	6279	1595 (25)
	Cefotaxime/ceftriaxone	5192	1631 (31)	5008	1483 (30)	6314	1506 (24)
	Ceftazidime	5201	1661 (32)	5042	1523 (30)	6275	1534 (24)
	Ciprofloxacin	5280	3479 (66)	4893	3128 (64)	6315	3990 (63)
	Cotrimoxazole	NR	NR	NR	NR	NR	NR
	Doripenem	NR	NR	NR	NR	NR	NR
	Ertapenem	4769	4562 (96)	4696	4333 (92)	5924	5310 (90)
	Gentamicin	5308	2083 (39)	5125	1992 (39)	6306	2124 (34)
	Imipenem	5071	4800 (95)	4929	4492 (91)	6200	5442 (88)
	Levofloxacin	48	35 (73)	38	22 (58)	63	33 (52)
	Meropenem	5068	4772 (94)	4967	4537 (91)	6200	5466 (88)
	Piperacillin-tazobactam	4967	2799 (56)	4951	2718 (55)	6267	3408 (54)
Private	Amikacin	2444	1964 (80)	3162	2392 (76)	3895	3346 (86)
	Amoxicillin-clavulanic acid	2450	975 (40)	3175	1133 (36)	3902	1283 (33)
	Cefepime	2435	1070 (44)	3167	1231 (39)	3899	1471 (38)
	Cefotaxime/ceftriaxone	2442	1052 (43)	3169	1203 (38)	3625	1334 (37)
	Ceftazidime	1760	789 (45)	2307	895 (39)	3131	1182 (38)
	Ciprofloxacin	2068	1231 (60)	2824	1528 (54)	3341	1638 (49)
	Cotrimoxazole	1853	789 (43)	2625	1027 (39)	2819	1061 (38)
	Doripenem	2376	2185 (92)	3047	2683 (88)	3630	3071 (85)
	Ertapenem	2419	2056 (85)	3124	2403 (77)	3829	2672 (70)
	Gentamicin	2442	1405 (58)	3169	1727 (54)	3896	2061 (53)
	Imipenem	2410	2175 (90)	3121	2647 (85)	3802	3113 (82)
	Levofloxacin	509	382 (75)	551	378 (69)	899	634 (71)
	Meropenem	2431	2206 (91)	3123	2679 (86)	3816	3140 (82)
	Piperacillin-tazobactam	2443	1050 (43)	3169	1184 (37)	3896	1402 (36)

NR = not reported

Non-fermentative Gram-negative bacteria

Acinetobacter baumannii: There were differences in susceptibilities to the aminoglycosides (amikacin and gentamicin) in data both health sectors. In the public sector, non-susceptibility to amikacin increased from 56% to 67% and gentamicin from 68% to 77% between 2016 and 2017 (no change was noted in susceptibility to gentamicin between 2017 and 2018). In the private sector, non-susceptibility to amikacin increased from 37% to 49% and gentamicin from 47% to 59%. Although there were differences in susceptibilities for the carbapenems reported from the public sector between 2016 and 2017, the proportion of susceptible isolates remained stable in 2018 (~20% were susceptible). In the private sector, an increase in non-susceptibility was noted over the three-year period i.e. resistance to imipenem increased from 54% to 64% and to meropenem from 56% to 65%. In addition, non-susceptibility to tigecycline increased from 10% of isolates in 2016 to 29% in 2018 (Table 4).

Table 4. Antimicrobial susceptibility patterns of *Acinetobacter baumannii* isolates identified from blood cultures in South Africa, 2016 to 2018.

		2016		2017		2018	
Health sector	**Drug**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**
Public	Amikacin	2064	913 (44)	2052	765 (37)	2050	671 (33)
	Doripenem	NR	NR	NR	NR	NR	NR
	Gentamicin	2629	837 (32)	2955	668 (23)	3315	749 (23)
	Imipenem	2581	684 (27)	2865	558 (19)	3322	663 (20)
	Meropenem	2602	654 (25)	2928	549 (19)	3322	661 (20)
	Minocycline	30	6 (20)	33	9 (27)	38	5 (13)
	Tetracycline	16	7 (44)	8	3 (38)	12	4 (33)
	Tigecycline	1279	1176 (92)	1745	1585 (91)	2356	2171 (92)
Private	Amikacin	288	182 (63)	439	249 (57)	390	197 (51)
	Doripenem	275	120 (44)	435	172 (40)	367	135 (37)
	Gentamicin	303	161 (53)	458	212 (46)	402	166 (41)
	Imipenem	304	139 (46)	458	174 (38)	380	137 (36)
	Meropenem	303	133 (44)	458	173 (38)	402	139 (35)
	Minocycline	NR	NR	NR	NR	NR	NR
	Tetracycline	NR	NR	NR	NR	NR	NR
	Tigecycline	212	190 (90)	326	285 (87)	271	192 (71)

NR = not reported

Pseudomonas aeruginosa: An increase in susceptibility to ceftazidime from 79% to 83% was noted for isolates reported from the public sector. In 2018, there was an increase in susceptibility for isolates reported from the private sector from 71% in 2017 to 75%. Isolates reported from the public sector showed no changes in susceptibilities to imipenem and meropenem. There was an increase in susceptibility for isolates reported from the private sector between 2017 and 2018. Susceptibility to imipenem increased from 58% to 66% and meropenem from 60% to 67%. Isolates reported from the private sector showed an increase in susceptibility to piperacillin-tazobactam from 64% in 2017 to 74% in 2018 (Table 5).

Table 5. Antimicrobial susceptibility patterns of *Pseudomonas aeruginosa* isolates identified from blood cultures in South Africa, 2016 to 2018.

		2016		2017		2018	
Health sector	**Drug**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**
Public	Cefepime	1076	884 (82)	1324	1119 (85)	1247	994 (80)
	Ceftazidime	1150	906 (79)	1404	1173 (84)	1279	1060 (83)
	Doripenem	NR	NR	NR	NR	NR	NR
	Imipenem	1102	845 (77)	1362	1040 (76)	1263	956 (76)
	Meropenem	1123	873 (78)	1372	1063 (77)	1258	950 (76)
	Piperacillin/tazobactam	1118	812 (73)	1369	1112 (81)	1263	1011 (80)
Private	Cefepime	908	652 (72)	1240	862 (70)	1205	888 (74)
	Ceftazidime	892	657 (74)	1228	876 (71)	1203	903 (75)
	Doripenem	883	601 (68)	1208	762 (63)	1144	809 (71)
	Imipenem	911	567 (62)	1243	719 (58)	1208	793 (66)
	Meropenem	912	588 (64)	1244	745 (60)	1206	805 (67)
	Piperacillin/tazobactam	902	582 (65)	1226	780 (64)	1196	889 (74)

NR = not reported

Gram-positive bacteria

Enterococcus faecalis: No differences in susceptibilities to the various antimicrobial agents were observed (Table 6).

Enterococcus faecium: Less than 5% of isolates reported from both health sectors were non-susceptible to both vancomycin and teicoplanin. Isolates from both sectors showed an increase in susceptibility to teicoplanin from 2017 to 2018. No changes in susceptibility patterns were noted for linezolid during the three-year surveillance period (Table 7).

Staphylococcus aureus: Although there was an increase in susceptibility to the penicillinase-stable penicillin cloxacillin from 2016 to 2017, an increase in non-susceptibility from 2017 to 2018 was evident in both sectors i.e. public from 23% to 25% and private from 15% to 18%. A greater percentage of non-susceptible isolates were reported from the public sector compared to the private sector during the three-year surveillance period (Table 8).

Table 6. Antimicrobial susceptibility patterns of *Enterococcus faecalis* isolates identified from blood cultures in South Africa, 2016 to 2018.

		2016		2017		2018	
Health sector	**Drug**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**
Public	Daptomycin	4	4 (100)	18	18 (100)	4	4 (100)
	Linezolid	1302	1292 (99)	1317	1306 (99)	1663	1644 (99)
	Penicillin/ampicillin	757	679 (90)	892	816 (91)	1292	1178 (91)
	Teicoplanin	947	933 (99)	978	966 (99)	1367	1334 (98)
	Vancomycin	1655	1632 (99)	1670	1643 (98)	1982	1955 (99)
Private	Daptomycin	168	168 (100)	263	263 (100)	244	244 (100)
	Linezolid	511	508 (99)	595	591 (99)	690	688 (100)
	Penicillin/ampicillin	88	66 (75)	82	67 (82)	58	46 (79)
	Teicoplanin	695	692 (100)	816	814 (100)	940	940 (100)
	Vancomycin	726	724 (100)	861	859 (100)	1011	1011 (100)

Table 7. Antimicrobial susceptibility patterns of *Enterococcus faecium* isolates identified from blood cultures in South Africa, 2016 to 2018.

		2016		2017		2018	
Health sector	**Drug**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**
Public	Daptomycin	8	8 (100)	1	0 (0)	3	3 (100)
	Linezolid	1380	1369 (99)	1236	1224 (99)	1638	1632 (100)
	Penicillin/ampicillin	837	30 (4)	813	46 (6)	1165	64 (5)
	Teicoplanin	1033	1001 (97)	908	853 (94)	1277	1234 (97)
	Vancomycin	1636	1560 (95)	1509	1436 (95)	1878	1819 (97)
Private	Daptomycin	65	63 (97)	104	102 (98)	117	116 (99)
	Linezolid	215	210 (98)	191	190 (99)	241	239 (99)
	Penicillin/ampicillin	38	3 (8)	27	0 (0)	22	0 (0)
	Teicoplanin	295	283 (96)	299	282 (94)	361	350 (97)
	Vancomycin	309	295 (95)	312	294 (94)	389	379 (97)

Table 8. Antimicrobial susceptibility patterns of *Staphylococcus aureus* isolates identified from blood cultures in South Africa, 2016 to 2018.

		2016		2017		2018	
Health sector	**Drug**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**	**Total isolates tested (N)**	**Susceptible (%)**
Public	Cloxacillin	5118	3705 (72)	5108	3951 (77)	6167	4640 (75)
Private	Cloxacillin	1283	950 (74)	1508	1283 (85)	2094	1713 (82)

Discussion & conclusions

Two-thirds of blood culture isolates were reported from the public sector. Gram-negative bacteria were more commonly reported and the relative proportion was higher in the private sector. *Klebsiella pneumoniae* and *S. aureus* were the most common organisms reported from the ESKAPE group. The relative proportions for organisms within each sector were similar over the study period. However, differences were observed between the two sectors. These findings show that higher proportions of *A. baumannii*, *E. faecium* and *S. aureus* were reported from the public sector, while higher proportions of *E. coli* and *P. aeruginosa* were reported in the private sector. Proportions for *K. pneumoniae* and *E. faecalis* were similar between both sectors.

There were notable differences for the Enterobacteriaceae. Compared to 2017, *E. coli* isolates from both sectors displayed lower susceptibilities to ciprofloxacin, amoxicillin-clavulanic acid and the cephalosporins in 2018. In addition, almost 25% of *E. coli* isolates were non-susceptible to piperacillin-tazobactam in the private sector. *Klebsiella pneumoniae* showed a worrisome continuous decrease in susceptibility to the carbapenems in both health sectors. There were substantial differences in the susceptibility profile for *A. baumannii* between 2017 to 2018. Isolates showed a decrease in susceptibility to the aminoglycosides and carbapenems in both health sectors. Of note, there was a 20% drop in susceptibility against tigecycline. *Pseudomonas aeruginosa* isolates reported from the public sector showed no noteworthy differences in susceptibility profiles. However, isolates from the private sector showed increases in susceptibility to ceftazidime and piperacillin/tazobactam. Susceptibility to the traditional antimicrobial agents may suggest that these can be used for longer durations.

Several limitations are highlighted in this report. The retrospective design of the study was based on obtainable data but some information was missing. Confirmatory AST methods were not recorded due to capturing AST only from primary screening testing on the laboratory information system. Data may have been incomplete owing to missing information not captured on the laboratory information system; for instance, susceptibility to ertapenem for *K. pneumoniae* was higher compared to meropenem in the public sector. The converse was observed in the private sector, which is expected. Colistin testing was not standardised across the both public and private sectors and therefore it was omitted from this report. No

demographic, epidemiological, clinical or molecular data were available to distinguish between healthcare-associated and community-associated infections.

Surveillance during this period confirms that resistance rates are increasing for carbapenems among Enterobacteriaceae in both health sectors, and in *A. baumannii,* particularly in the public sector. The carbapenem resistance is of concern as this stimulates the use of colistin in SA as a treatment option for these multidrug-resistant organisms. *Staphylococcus aureus* showed a slight increase in cloxacillin susceptibility (i.e. decrease in MRSA) over this period. Evidence of increasing antimicrobial resistance shows that monitoring these trends is of critical importance for public health interventions in community and hospital settings.

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