

# Antimicrobial Resistance Surveillance in the South African Public Sector

Report | 2016

## Authors

Olga Perovic<sup>1,2</sup>, Husna Ismail<sup>1</sup>, Erika van Schalkwyk<sup>1</sup>,

## Affiliations

<sup>1</sup>Centre for Healthcare-Associated Infections (HAIs), Antimicrobial Resistance (AMR) and Mycoses, National Institute for Communicable Diseases, a division in the National Health Laboratory Service

<sup>2</sup>Faculty of Health Sciences, School of Pathology, Department of Clinical Microbiology and Infectious Diseases at University of Witwatersrand

## **INTRODUCTION**

Colonization and infection due to multidrug-resistant (MDR) bacteria has become a significant public health concern with both clinical and economic consequences.<sup>1,2</sup> Surveillance for antimicrobial resistance (AMR) is conducted not only to detect changes or variation in AMR either geographically or over time, but is a vital component of any antimicrobial stewardship programme.<sup>3</sup> Integrated health data on bacterial AMR was obtained from an electronic database of antimicrobial susceptibility testing (AST) results generated by public health laboratories in South Africa. This report was designed to provide information on AMR rates in bacterial pathogens causing both community-associated and healthcare-associated infections and was prepared by the Centre for HAIs, AMR and Mycoses (CHARM) and Surveillance Information Management Unit (SIMU) at the National Institute for Communicable Diseases (NICD) and Corporate Data Warehouse (CDW) at the National Health Laboratory Service (NHLS).

## **REPORT OBJECTIVES AND SCOPE**

1. To determine the number of cases for each of the following ESKAPE pathogens isolated from blood cultures in 2016: *Enterococcus faecalis*, *Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Enterobacter cloacae*, and *Escherichia coli*.
2. To compare AST patterns for each of the ESKAPE pathogens in 2016 to the previous year, 2015.
3. To describe the AST patterns for each of the ESKAPE pathogens by sentinel hospital in 2016.
4. To determine the number of laboratory-confirmed carbapenemase-producing Enterobacteriaceae (CPE) isolated from all specimen types in 2016.

## **METHODS**

### **Data collection and analysis**

Data for this report were sourced from the NHLS, CDW. The CDW exists as a national repository for all laboratory tests performed from public sector hospitals in South Africa and contained archived data (demographic and laboratory) from the laboratory information system (LIS), TrakCare. These data were mapped as national, provincial, district and sentinel hospitals by the SIMU at NICD and were available in a dashboard from the NICD website, <http://www.nicd.ac.za>.

AMR surveillance in the public sector, relied on submission of data from the NHLS laboratories that served academic tertiary hospitals.<sup>4</sup> Data containing routine AST results for the ESKAPE pathogens were extracted, from 1 January 2016 to 31 December 2016 for 16 sentinel hospitals across South Africa (Table 1).<sup>4</sup>

For the analysis of ESKAPE pathogens, AST results were interpreted in accordance with the Clinical and Laboratory Standards Institute (CLSI) 2016 guidelines and were categorised based on categorical data, susceptible (S) and non-susceptible including intermediate (I) and resistant (R).<sup>5</sup> Due to site-specific differences in testing methodologies and data capture on the LIS, extensive cleaning and recording of data were necessary, which was done within the CDW (Table 2).

For the analysis of carbapenemase producing Enterobacteriaceae (CPE), data were obtained from the Antimicrobial Resistance Laboratory (AMRL) in CHARM where carbapenem-resistant isolates were referred for phenotypic characterisation, AST and molecular characterisation.

Table 1 List of 16 sentinel hospitals participating in antimicrobial resistance surveillance.

<b>Hospital Name</b>	<b>Academic</b>	<b>Number of Beds</b>	<b>Province</b>
Charlotte Maxeke Johannesburg Academic Hospital	Yes	1088	Gauteng
Chris Hani Baragwanath Hospital	Yes	3200	Gauteng
Dr George Mukhari Hospital	Yes	1200	Gauteng
Frere Hospital	No	916	Eastern Cape
Grey's Hospital	Yes	530	KwaZulu-Natal
Groote Schuur Hospital	Yes	893	Western Cape
Helen Joseph Hospital	Yes	700	Gauteng
Inkosi Albert Luthuli Central Hospital	Yes	846	KwaZulu-Natal
King Edward VIII Hospital	Yes	922	KwaZulu-Natal
Livingstone Hospital	Yes	616	Eastern Cape
Mahatma Gandhi Hospital	No	350	KwaZulu-Natal
Nelson Mandela Academic Hospital/Mthatha Tertiary	Yes	520	Eastern Cape
RK Khan Hospital	No	543	KwaZulu-Natal
Steve Biko Academic Hospital	Yes	832	Gauteng
Tygerberg Hospital	Yes	1310	Western Cape
Universitas Hospital	Yes	650	Free State

Table 2 Antimicrobial susceptibility testing methods performed at the 16 sentinel hospitals.

<b>NHLS Laboratories at Public Sector Hospitals</b>	<b>MicroScan</b>	<b>Vitek 2</b>	<b>Disk Diffusion Method</b>
Charlotte Maxeke Johannesburg Academic Hospital	√	√	√
Chris Hani Baragwanath Hospital	√		√
Dr George Mukhari Hospital		√	
Frere Hospital		√	
Grey's Hospital/Northdale Laboratory		√	
Groote Schuur Hospital		√	
Helen Joseph Hospital		√	√
Inkosi Albert Luthuli Central Hospital		√	
King Edward VIII Hospital		√	
Livingstone Hospital		√	
Mahatma Gandhi Hospital		√	
Nelson Mandela Academic Hospital/Mthatha Tertiary			√
RK Khan Hospital		√	
Steve Biko Academic Hospital		√	
Tygerberg Hospital		√	
Universitas Hospital		√	

## **RESULTS**

For the purpose of this report, ESKAPE pathogens were categorised as Enterobacteriaceae (*Klebsiella pneumoniae*, *Enterobacter cloacae*, and *Escherichia coli*), non-fermentative Gram-negative bacteria (*Acinetobacter baumannii* and *Pseudomonas aeruginosa*) and Gram-positive bacteria (*Enterococcus faecalis*, *Enterococcus faecium* and *Staphylococcus aureus*).

### **Enterobacteriaceae**

Of the 5 265 lactose-fermenting bacteria, 53% (2783/5265) were identified as *Klebsiella pneumoniae*, 35% (1850/5265) were identified as *Escherichia coli* and 12% (632/5265) were identified as *Enterobacter cloacae*. All three pathogens were reported from all 16 sentinel hospitals in South Africa. Twenty-one percent (1095/5265) of all three pathogens were reported from Chris Hani Baragwanath Hospital (Figure 1).

Of the panel of antimicrobial agents that were tested, more than 65% of *Klebsiella pneumoniae* isolates were non-susceptible to third and fourth generation cephalosporins, which is indicative of extended-spectrum beta-lactamase (ESBL) production. Thirty-six percent (952/2642) of *Klebsiella pneumoniae* isolates were non-susceptible to ciprofloxacin, 44% (1183/2686) of isolates were non-susceptible to piperacillin/tazobactam and 59% (1568/2676) were non-susceptible to gentamicin (Table 3). In comparison to 2015, *Klebsiella pneumoniae* isolates demonstrated higher susceptibility to cefepime ( $p=0.65$ ), piperacillin/tazobactam ( $p=0.26$ ) and gentamicin in 2016. Although, a higher susceptibility was observed for cefepime and piperacillin/tazobactam in 2016, this was not statistically significant. Overall, antimicrobial susceptibility to carbapenems remained constant over the two-year period (Figure 2). However, high proportions of *Klebsiella pneumoniae* isolates reported from King Edward VIII Hospital Grey's Hospital, Frere Hospital and Nelson Mandela Academic Hospital/Mthatha Tertiary were shown to display reduced susceptibility to cephalosporins (Table 4).

Less than 30% of *Escherichia coli* isolates were non-susceptible to third and fourth generation cephalosporins and 30% (530/1760) of isolates were non-susceptible to ciprofloxacin (Table 3). In comparison to 2015, *Escherichia coli* isolates, showed reduced susceptibility in almost all antimicrobial agents (Figure 2). Overall, high proportions of *Escherichia coli* isolates were shown to be susceptible to carbapenems across all 16 sentinel hospitals (Table 5).

Antimicrobial susceptibility patterns for *Enterobacter cloacae* were not reported as data were not available during the preparation of this report.

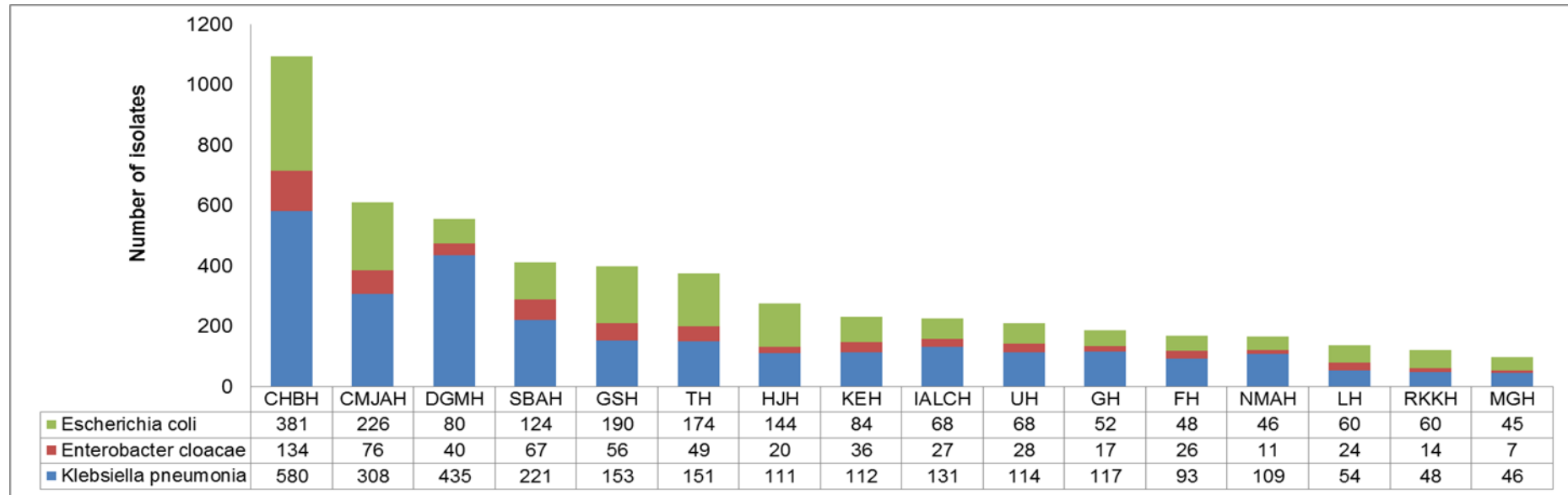


Figure 1 Number of Enterobacteriaceae: *Klebsiella pneumoniae* (n= 2783), *Escherichia coli* (n=1850) and *Enterobacter cloacae* (n=632) reported from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

**Abbreviations:** Chris Hani Baragwanath Hospital (CHBH), Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), Dr George Mukhari Hospital (DGMH), Steve Biko Academic Hospital (SBAH), Groote Schuur Hospital (GSH), Tygerberg Hospital (TH), Helen Joseph Hospital (HJH), King Edward VIII Hospital (KEH), Inkosi Albert Luthuli Central Hospital (IALCH), Universitas Hospital (UH), Grey's Hospital (GH), Frere Hospital (FH), Nelson Mandela Academic Hospital/Mthatha Tertiary (NMAH), Livingstone Hospital (LH), RK Khan Hospital (RKKH) and Mahatma Gandhi Hospital (MGH), number of isolates (n)

Table 3 Antimicrobial susceptibility patterns of Enterobacteriaceae isolated from blood cultures reported from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

Antimicrobial agent	<i>Klebsiella pneumoniae</i>				<i>Escherichia coli</i>			
	Non-susceptible		Susceptible		Non-susceptible		Susceptible	
	n	%	n	%	n	%	n	%
Amikacin	442	16.4	2251	83.6	160	8.8	1651	91.2
Amoxicillin-clavulanic acid	1785	66.3	909	33.7	708	39.2	1096	60.8
Ampicillin/amoxicillin	-	-	-	-	1539	86.3	244	13.7
Cefepime	1748	65.0	941	35.0	470	26.5	1305	73.5
Cefotaxime/ceftriaxone	1779	66.0	916	34.0	500	27.8	1297	72.2
Ceftazidime	1768	65.7	921	34.3	483	26.8	1317	73.2
Ciprofloxacin	952	36.0	1690	64.0	530	30.1	1230	69.9
Ertapenem	137	5.2	2476	94.8	23	1.3	1754	98.7
Gentamicin	1568	58.6	1108	41.4	348	19.5	1441	80.5
Imipenem	168	6.2	2541	93.8	14	0.8	1797	99.2
Meropenem	178	6.6	2535	93.4	15	0.8	1797	99.2
Piperacillin/tazobactam	1183	44.0	1503	56.0	257	14.5	1513	85.5

**Abbreviations:** number of isolates (n), percentage (%), not reported (-)

Colistin was not reported as no reference method was applied at routine laboratories.



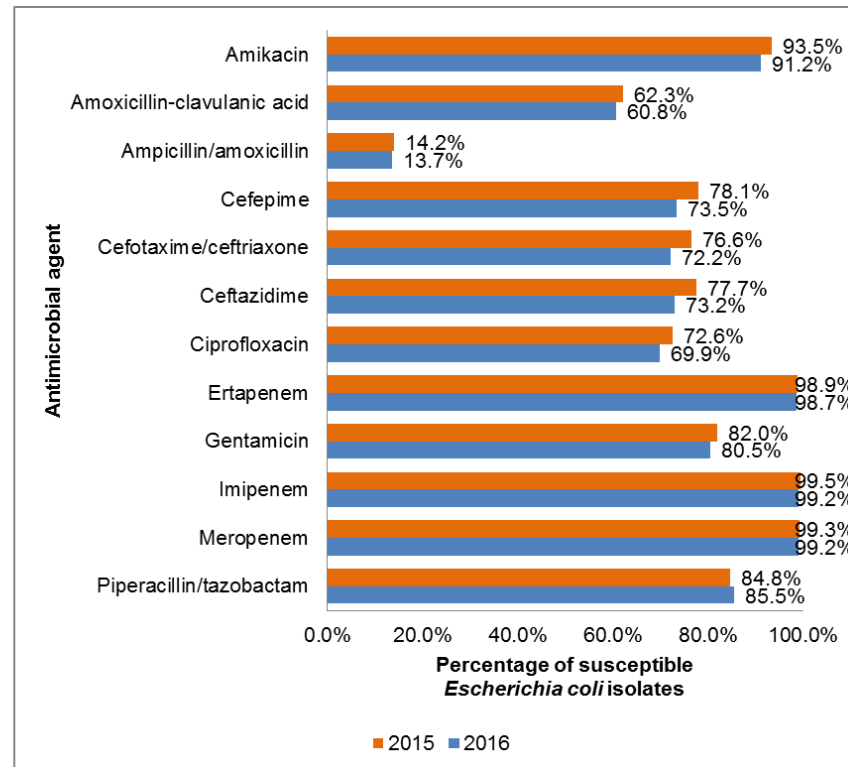
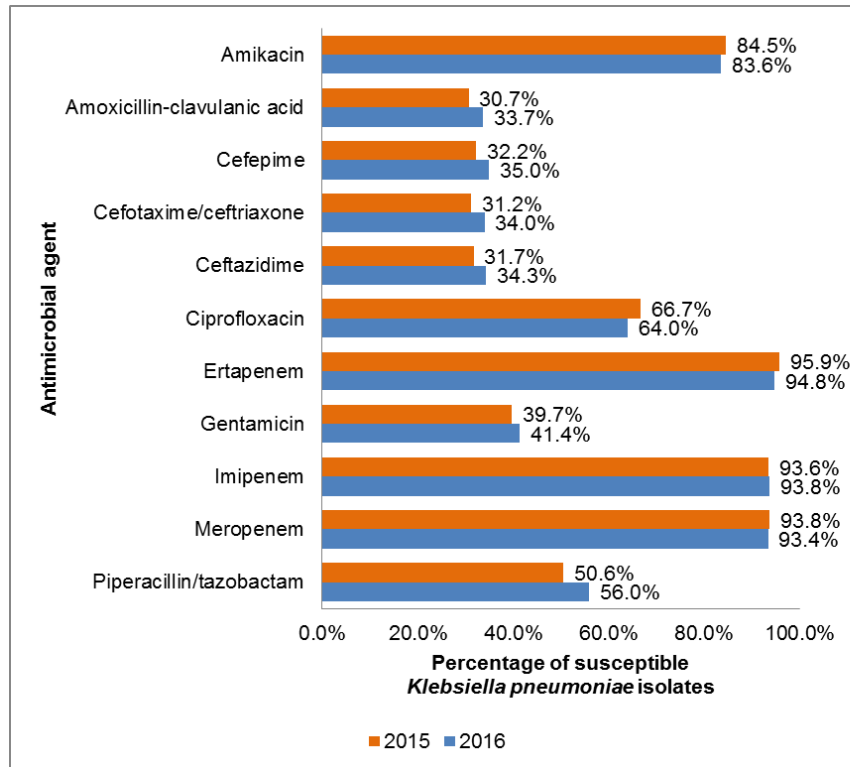


Figure 2 Percentage of susceptible *Klebsiella pneumoniae* and *Escherichia coli* isolates, 2015 to 2016.

Table 4 Number and percentage of susceptible *Klebsiella pneumoniae* isolates per antimicrobial agent from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

	CHBH	CMJAH	DGMH	SBAH	GSH	TH	HJH	KEH*	IALCH*	UH	GH*	FH	NMAH	LH	RKKH*	MGH*
	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Antimicrobial agent	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Amikacin	560	288	416	220	151	149	106	106	130	112	113	91	106	54	47	44
	<b>94.8</b>	<b>93.8</b>	<b>89.2</b>	<b>64.1</b>	<b>94.7</b>	<b>81.2</b>	<b>98.1</b>	<b>60.4</b>	<b>67.7</b>	<b>87.5</b>	<b>88.5</b>	<b>64.8</b>	<b>45.3</b>	<b>87.0</b>	<b>76.6</b>	<b>68.2</b>
Amoxicillin-clavulanic acid	556	292	413	221	152	150	107	109	128	111	113	90	106	54	48	44
	<b>27.0</b>	<b>32.9</b>	<b>56.4</b>	<b>29.9</b>	<b>38.2</b>	<b>38.7</b>	<b>36.4</b>	<b>21.1</b>	<b>27.3</b>	<b>33.3</b>	<b>15.9</b>	<b>15.6</b>	<b>20.8</b>	<b>40.7</b>	<b>43.8</b>	<b>38.6</b>
Cefepime	566	297	413	221	152	150	110	100	120	111	111	90	105	53	45	45
	<b>32.5</b>	<b>38.0</b>	<b>58.1</b>	<b>33.0</b>	<b>41.1</b>	<b>40.0</b>	<b>44.5</b>	<b>15.0</b>	<b>25.0</b>	<b>35.1</b>	<b>14.4</b>	<b>13.3</b>	<b>4.8</b>	<b>32.1</b>	<b>31.1</b>	<b>24.4</b>
Cefotaxime/ceftriaxone	556	296	414	221	150	151	107	104	129	111	113	92	105	54	47	45
	<b>31.7</b>	<b>35.8</b>	<b>56.3</b>	<b>33.0</b>	<b>41.3</b>	<b>39.7</b>	<b>40.2</b>	<b>15.4</b>	<b>24.8</b>	<b>35.1</b>	<b>14.2</b>	<b>12.0</b>	<b>5.7</b>	<b>31.5</b>	<b>29.8</b>	<b>26.7</b>
Ceftazidime	563	290	412	221	149	150	109	105	128	111	113	89	105	54	46	44
	<b>32.5</b>	<b>36.9</b>	<b>55.8</b>	<b>33.0</b>	<b>41.6</b>	<b>40.0</b>	<b>39.4</b>	<b>16.2</b>	<b>25.0</b>	<b>35.1</b>	<b>14.2</b>	<b>12.4</b>	<b>3.8</b>	<b>33.3</b>	<b>30.4</b>	<b>27.3</b>
Ciprofloxacin	553	244	416	221	151	151	107	107	129	111	112	90	105	54	46	45
	<b>56.6</b>	<b>65.2</b>	<b>79.6</b>	<b>55.2</b>	<b>72.8</b>	<b>74.2</b>	<b>50.5</b>	<b>43.0</b>	<b>57.4</b>	<b>61.3</b>	<b>63.4</b>	<b>62.2</b>	<b>85.7</b>	<b>59.3</b>	<b>56.5</b>	<b>57.8</b>
Ertapenem	559	287	426	205	151	150	110	79	103	112	112	88	104	50	42	35
	<b>86.8</b>	<b>93.7</b>	<b>99.1</b>	<b>92.2</b>	<b>99.3</b>	<b>96.7</b>	<b>90.0</b>	<b>97.5</b>	<b>100.0</b>	<b>98.2</b>	<b>97.3</b>	<b>100.0</b>	<b>99.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
Gentamicin	550	289	415	221	151	151	108	105	120	111	113	91	105	54	47	45
	<b>32.2</b>	<b>47.8</b>	<b>62.7</b>	<b>43.4</b>	<b>49.7</b>	<b>53.0</b>	<b>55.6</b>	<b>27.6</b>	<b>27.5</b>	<b>37.8</b>	<b>18.6</b>	<b>25.3</b>	<b>7.6</b>	<b>55.6</b>	<b>40.4</b>	<b>37.8</b>
Imipenem	564	298	422	218	148	151	110	109	130	111	112	87	105	53	46	45
	<b>91.5</b>	<b>92.3</b>	<b>99.8</b>	<b>86.2</b>	<b>99.3</b>	<b>98.0</b>	<b>96.4</b>	<b>79.8</b>	<b>86.9</b>	<b>99.1</b>	<b>95.5</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>93.5</b>	<b>77.8</b>
Meropenem	558	298	426	220	153	149	109	105	130	112	113	90	106	52	46	46
	<b>91.9</b>	<b>92.6</b>	<b>99.3</b>	<b>85.0</b>	<b>99.3</b>	<b>97.3</b>	<b>96.3</b>	<b>80.0</b>	<b>86.2</b>	<b>97.3</b>	<b>94.7</b>	<b>98.9</b>	<b>97.2</b>	<b>100.0</b>	<b>91.3</b>	<b>78.3</b>
Piperacillin/tazobactam	564	296	423	220	152	151	109	108	130	110	111	63	103	54	47	45
	<b>57.8</b>	<b>60.8</b>	<b>66.7</b>	<b>27.3</b>	<b>75.7</b>	<b>78.8</b>	<b>49.5</b>	<b>45.4</b>	<b>45.4</b>	<b>33.6</b>	<b>43.2</b>	<b>74.6</b>	<b>34.0</b>	<b>50.0</b>	<b>78.7</b>	<b>62.2</b>

\*AST patterns for carbapenems varied for sentinel hospitals located in KwaZulu-Natal: KEH, IALCH, GH, RKKH and MGH

Table 5 Number and percentage of susceptible *Escherichia coli* isolates per antimicrobial agent from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

	CHBH	CMJAH	DGMH	SBAH	GSH	TH	HJH	KEH	IALCH	UH	GH	FH	NMAH	LH	RKKH	MGH
	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Antimicrobial agent	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Amikacin	373	221	79	124	186	171	138	83	68	67	51	47	43	59	57	44
	<b>98.7</b>	<b>98.2</b>	<b>81.0</b>	<b>74.2</b>	<b>98.9</b>	<b>91.8</b>	<b>99.3</b>	<b>71.1</b>	<b>69.1</b>	<b>89.6</b>	<b>84.3</b>	<b>91.5</b>	<b>86.0</b>	<b>86.4</b>	<b>89.5</b>	<b>93.2</b>
Amoxicillin-clavulanic acid	372	220	78	124	185	173	137	81	67	66	52	46	45	58	57	43
	<b>52.4</b>	<b>68.2</b>	<b>56.4</b>	<b>54.8</b>	<b>73.0</b>	<b>71.1</b>	<b>63.5</b>	<b>42.0</b>	<b>47.8</b>	<b>74.2</b>	<b>40.4</b>	<b>82.6</b>	<b>46.7</b>	<b>67.2</b>	<b>56.1</b>	<b>65.1</b>
Ampicillin/amoxicillin	363	215	74	123	185	171	134	81	67	67	52	48	43	59	57	44
	<b>4.4</b>	<b>16.7</b>	<b>10.8</b>	<b>21.1</b>	<b>22.7</b>	<b>21.6</b>	<b>10.4</b>	<b>4.9</b>	<b>7.5</b>	<b>22.4</b>	<b>3.8</b>	<b>18.8</b>	<b>14.0</b>	<b>23.7</b>	<b>14.0</b>	<b>4.5</b>
Cefepime	368	221	75	123	185	172	143	79	56	67	52	47	43	59	52	33
	<b>74.2</b>	<b>89.6</b>	<b>58.7</b>	<b>71.5</b>	<b>73.5</b>	<b>77.9</b>	<b>83.2</b>	<b>48.1</b>	<b>48.2</b>	<b>91.0</b>	<b>55.8</b>	<b>83.0</b>	<b>46.5</b>	<b>78.0</b>	<b>63.5</b>	<b>60.6</b>
Cefotaxime/ceftriaxone	369	218	78	124	185	171	141	82	66	66	52	45	40	59	57	44
	<b>72.9</b>	<b>81.7</b>	<b>59.0</b>	<b>71.8</b>	<b>74.1</b>	<b>78.4</b>	<b>80.9</b>	<b>48.8</b>	<b>51.5</b>	<b>90.9</b>	<b>57.7</b>	<b>82.2</b>	<b>50.0</b>	<b>78.0</b>	<b>63.2</b>	<b>61.4</b>
Ceftazidime	365	221	76	123	187	172	142	81	65	67	52	46	44	59	56	44
	<b>73.7</b>	<b>87.8</b>	<b>57.9</b>	<b>71.5</b>	<b>73.3</b>	<b>77.9</b>	<b>82.4</b>	<b>51.9</b>	<b>50.8</b>	<b>91.0</b>	<b>57.7</b>	<b>84.8</b>	<b>47.7</b>	<b>78.0</b>	<b>62.5</b>	<b>61.4</b>
Ciprofloxacin	364	185	77	122	184	169	141	82	67	67	51	47	44	58	57	45
	<b>70.9</b>	<b>79.5</b>	<b>61.0</b>	<b>69.7</b>	<b>65.8</b>	<b>72.2</b>	<b>80.1</b>	<b>54.9</b>	<b>47.8</b>	<b>83.6</b>	<b>52.9</b>	<b>78.7</b>	<b>75.0</b>	<b>79.3</b>	<b>64.9</b>	<b>53.3</b>
Ertapenem	375	222	77	122	184	173	140	77	58	66	52	45	42	54	51	34
	<b>94.9</b>	<b>99.5</b>	<b>100.0</b>	<b>99.2</b>	<b>100.0</b>	<b>100.0</b>	<b>99.3</b>	<b>98.7</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
Gentamicin	367	220	77	123	185	170	141	81	59	66	52	47	43	59	56	43
	<b>79.6</b>	<b>83.6</b>	<b>76.6</b>	<b>86.2</b>	<b>81.1</b>	<b>86.5</b>	<b>83.7</b>	<b>69.1</b>	<b>61</b>	<b>86.4</b>	<b>69.2</b>	<b>89.4</b>	<b>81.4</b>	<b>93.2</b>	<b>76.8</b>	<b>58.1</b>
Imipenem	376	224	78	124	186	173	142	83	67	66	52	47	41	59	53	
	<b>97.9</b>	<b>99.1</b>	<b>100.0</b>	<b>98.4</b>	<b>100.0</b>	<b>100.0</b>	<b>98.6</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
Meropenem	371	223	78	123	185	172	143	82	67	67	52	47	42	59	58	40
	<b>97.6</b>	<b>99.1</b>	<b>100.0</b>	<b>98.4</b>	<b>100.0</b>	<b>100.0</b>	<b>98.6</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
Piperacillin/tazobactam	369	220	79	124	187	173	141	82	68	67	52	-	43	59	58	45
	<b>87.0</b>	<b>86.4</b>	<b>77.2</b>	<b>62.9</b>	<b>93.0</b>	<b>90.8</b>	<b>85.1</b>	<b>82.9</b>	<b>88.2</b>	<b>76.1</b>	<b>78.8</b>	<b>-</b>	<b>81.4</b>	<b>94.9</b>	<b>94.8</b>	<b>95.6</b>

Data were omitted for those sentinel hospitals that tested less than 30 ESKAPE pathogens for a particular antimicrobial agent

## Non-fermentative Gram-negative bacteria

Of the 2318 non-fermentative Gram-negative bacteria, 71% (1637/2318) were identified as *Acinetobacter baumannii* and 29% (681/2318) were identified as *Pseudomonas aeruginosa*. Both pathogens were reported from all 16 sentinel hospitals in South Africa. Approximately 32% (738/2318) of both pathogens were reported from Chris Hani Baragwanath Hospital (Figure 3).

Of the panel of antimicrobial agents that were tested, more than 80% of *Acinetobacter baumannii* isolates were non-susceptible to imipenem and meropenem, while 72% (1140/1583) and 60% (791/1320) were non-susceptible to gentamicin and amikacin (Table 6). In comparison to 2015, isolates non-susceptible to gentamicin and amikacin increased but, susceptibility to carbapenems and tigecycline remained constant (Figure 4). High proportion of *Acinetobacter baumannii* isolates reported from Chris Hani Baragwanath Hospital, Charlotte Maxeke Johannesburg Academic Hospital, Dr George Mukhari Hospital, Helen Joseph Hospital, Inkosi Albert Luthuli Central Hospital, King Edward VIII Hospital, Steve Biko Academic Hospital and Universitas Hospital showed reduced susceptibility to carbapenems (Table 7).

Approximately 80% and 75% of *Pseudomonas aeruginosa* isolates were susceptible to cephalosporins and carbapenems (Table 6). Antimicrobial susceptibility to imipenem ( $p=0.21$ ), cefepime ( $p=0.57$ ) and piperacillin/tazobactam ( $p=0.39$ ) increased in *Pseudomonas aeruginosa*, however this was not statistically significant over the two-year period (Figure 4). Almost 50% of *Pseudomonas aeruginosa* isolates reported from Tygerberg Hospital showed reduced susceptibility to carbapenems (Table 8).

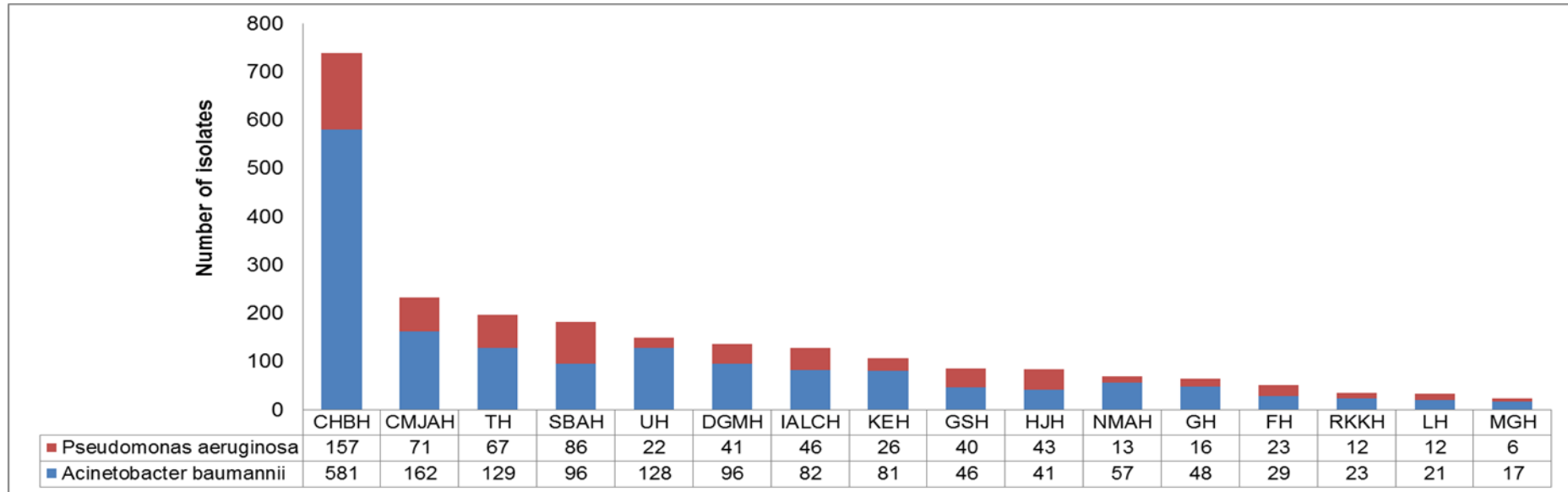


Figure 3 Number of non-fermenters: *Acinetobacter baumannii* (n=1637) and *Pseudomonas aeruginosa* (n=681) reported from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

Table 6 Antimicrobial susceptibility patterns of non-fermenters isolated from blood cultures reported from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

Antimicrobial agent	<i>Acinetobacter baumannii</i>				<i>Pseudomonas aeruginosa</i>			
	Non-susceptible		Susceptible		Non-susceptible		Susceptible	
	n	%	n	%	n	%	n	%
Amikacin	791	59.9	529	40.1	-	-	-	-
Gentamicin	1140	72.0	443	28.0	-	-	-	-
Imipenem	1294	81.0	304	19.0	172	26.1	488	73.9
Meropenem	1290	81.3	296	18.7	164	24.8	498	75.2
Minocycline	21	87.5	3	12.5	-	-	-	-
Tigecycline	53	7.5	652	92.5	-	-	-	-
Cefepime	-	-	-	-	139	21.75	500	78.2
Ceftazidime	-	-	-	-	134	20.12	532	79.9
Piperacillin/tazobactam	-	-	-	-	151	23.45	493	76.6

**Abbreviations:** number of isolates (n), percentage (%), not reported (-)

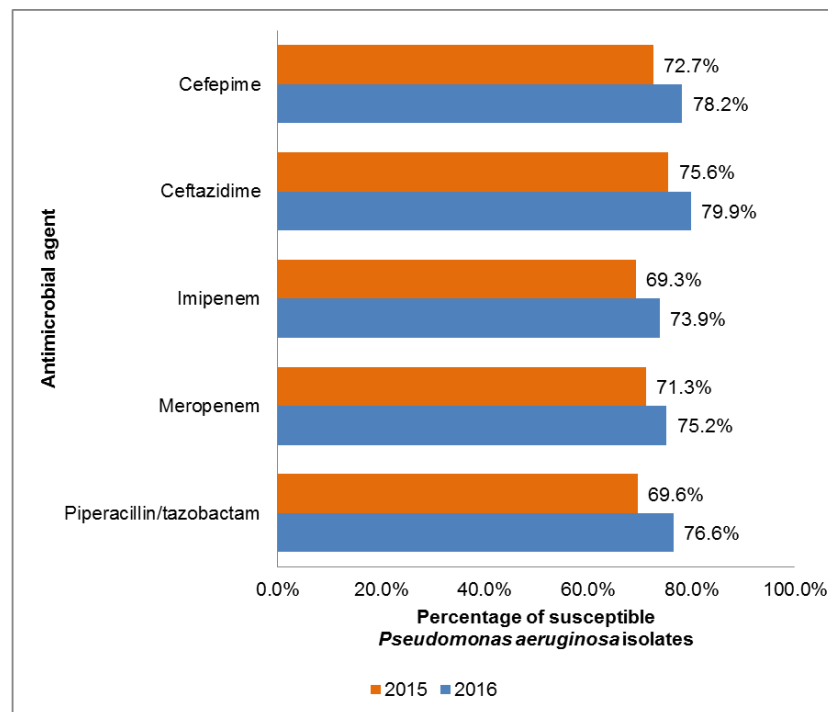
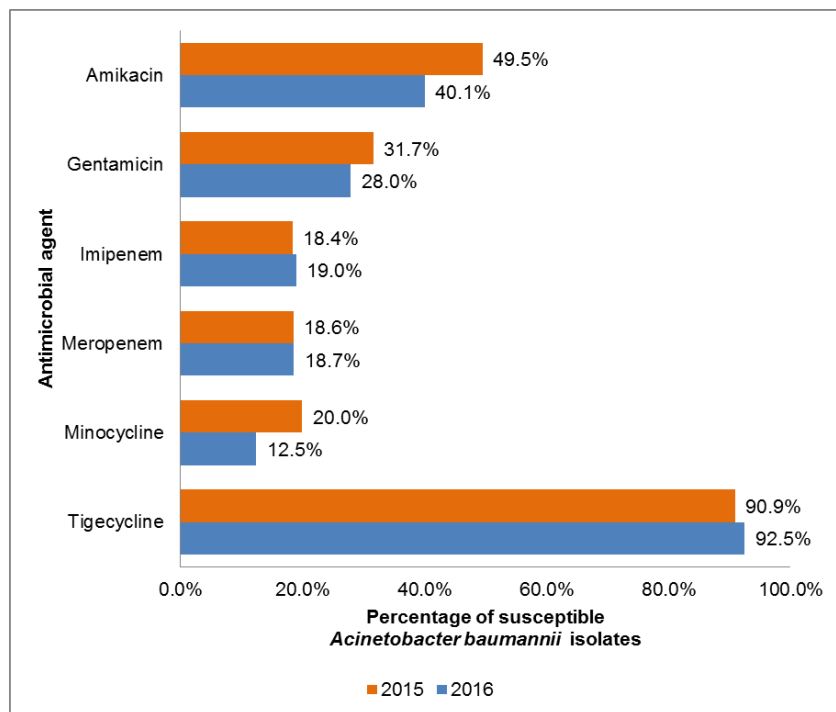


Figure 4 Percentage of susceptible *Acinetobacter baumannii* and *Pseudomonas aeruginosa* isolates, 2015 to 2016.

Table 7 Number and percentage of susceptible *Acinetobacter baumannii* isolates per antimicrobial agent from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

	CHBH	CMJAH	DGMH	SBAH	GSH	TH	HJH	KEH	IALCH	UH	GH	FH	NMAH	LH	RKKH	MGH
	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
<b>Antimicrobial agent</b>	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Amikacin	561	110	91	-	44	119	36	47	68	120	43	-	-	-	-	-
	<b>32.6</b>	<b>43.6</b>	<b>34.1</b>	-	<b>70.5</b>	<b>41.2</b>	<b>41.7</b>	<b>70.2</b>	<b>72.1</b>	<b>20.8</b>	<b>39.5</b>	-	-	-	-	-
Gentamicin	557	155	96	96	44	125	40	77	75	125	48	-	56	-	-	-
	<b>16.5</b>	<b>35.5</b>	<b>21.9</b>	<b>21.9</b>	<b>75.0</b>	<b>44.8</b>	<b>37.5</b>	<b>41.6</b>	<b>42.7</b>	<b>10.4</b>	<b>43.8</b>	-	<b>23.2</b>	-	-	-
Imipenem	567	157	94	96	46	125	40	77	78	125	48	-	56	-	-	-
	<b>6.7</b>	<b>12.1</b>	<b>24.5</b>	<b>17.7</b>	<b>58.7</b>	<b>26.4</b>	<b>12.5</b>	<b>33.8</b>	<b>33.3</b>	<b>9.6</b>	<b>20.8</b>	-	<b>46.4</b>	-	-	-
Meropenem	558	157	94	96	43	126	38	77	78	126	47	-	57	-	-	-
	<b>6.1</b>	<b>12.1</b>	<b>25.5</b>	<b>17.7</b>	<b>58.1</b>	<b>25.4</b>	<b>15.8</b>	<b>32.5</b>	<b>33.3</b>	<b>9.5</b>	<b>21.3</b>	-	<b>47.4</b>	-	-	-
Tigecycline	-	136	86	95	44	-	-	76	75	-	47	-	54	-	-	-
	-	<b>94.9</b>	<b>95.3</b>	<b>100.0</b>	<b>95.5</b>	-	-	<b>93.4</b>	<b>84.0</b>	-	<b>87.2</b>	-	<b>96.3</b>	-	-	-

Data were omitted for those sentinel hospitals that tested less than 30 ESKAPE pathogens for a particular antimicrobial agent



Table 8 Number and percentage of susceptible *Pseudomonas aeruginosa* isolates per antimicrobial agent from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

	CHBH	CMJAH	DGMH	SBAH	GSH	TH	HJH	KEH	IALCH	UH	GH	FH	NMAH	LH	RKKH	MGH
	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Antimicrobial agent	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Cefepime	154	69	39	88	38	65	42	-	34	-	-	-	-	-	-	-
	<b>87.0</b>	<b>73.9</b>	<b>87.2</b>	<b>76.1</b>	<b>78.9</b>	<b>63.1</b>	<b>95.2</b>	-	<b>58.8</b>	-	-	-	-	-	-	-
Ceftazidime	153	69.0	40.0	88	37	65	43	-	44	-	-	-	-	-	-	-
	<b>86.3</b>	<b>75.4</b>	<b>92.5</b>	<b>76.1</b>	<b>81.1</b>	<b>66.2</b>	<b>93.0</b>	-	<b>72.7</b>	-	-	-	-	-	-	-
Imipenem	153	70	38	88	39	64	42	-	45	-	-	-	-	-	-	-
	<b>70.6</b>	<b>72.9</b>	<b>92.1</b>	<b>65.9</b>	<b>74.4</b>	<b>48.4</b>	<b>88.1</b>	-	<b>77.8</b>	-	-	-	-	-	-	-
Meropenem	152	70	38	88	38.0	65	41	-	45	-	-	-	-	-	-	-
	<b>70.4</b>	<b>74.3</b>	<b>89.5</b>	<b>67.0</b>	<b>76.3</b>	<b>52.3</b>	<b>92.7</b>	-	<b>77.8</b>	-	-	-	-	-	-	-
Piperacillin/tazobactam	154	67	40	84	38	62	42	-	45	-	-	-	-	-	-	-
	<b>79.2</b>	<b>71.6</b>	<b>87.5</b>	<b>76.2</b>	<b>76.3</b>	<b>79.0</b>	<b>85.7</b>	-	<b>71.1</b>	-	-	-	-	-	-	-

Data were omitted for those sentinel hospitals that tested less than 30 ESKAPE pathogens for a particular antimicrobial agent

## Gram-positive bacteria

Of the 3369 Gram-positive bacteria, 20% (785/3369) were identified as *Enterococcus faecalis*, 21% (846/3369) were identified as *Enterococcus faecium* and 59% (2338/3369) were identified as *Staphylococcus aureus*. All three pathogens were reported from all 16 sentinel hospitals in South Africa. Approximately 29% (968/3369) of all three pathogens were reported from Chris Hani Baragwanath Hospital (Figure 5).

Of the panel of antimicrobial agents that were tested, more than 90% of *Enterococcus faecalis* and *Enterococcus faecium* isolates were shown to be susceptible to oxazolidinones and glycopeptides (Table 9). In comparison to 2015, AST patterns for the particular antimicrobial agents remained similar in both *Enterococcus faecalis* and *Enterococcus faecium* isolates over the two-year period (Figure 6). There were no unusual AST patterns reported for *Enterococcus faecalis* isolates (Table 10). Approximately 48% of *Enterococcus faecium* isolates from Universitas Hospital were shown to be non-susceptible to vancomycin, however this finding should be interpreted with caution as AST testing for these non-susceptible isolates may not have been confirmed using a supplementary method (Table 11).

Approximately 69% of *Staphylococcus aureus* isolates were susceptible to cloxacillin (Table 9). In comparison to 2015, susceptibility to cloxacillin ( $p=0.23$ ) increased from 65% to 69%, however this was not statistically significant (Figure 6). In addition, 50% of *Staphylococcus aureus* isolates reported from Chris Hani Baragwanath Hospital were shown to be non-susceptible to cloxacillin (Table 12).

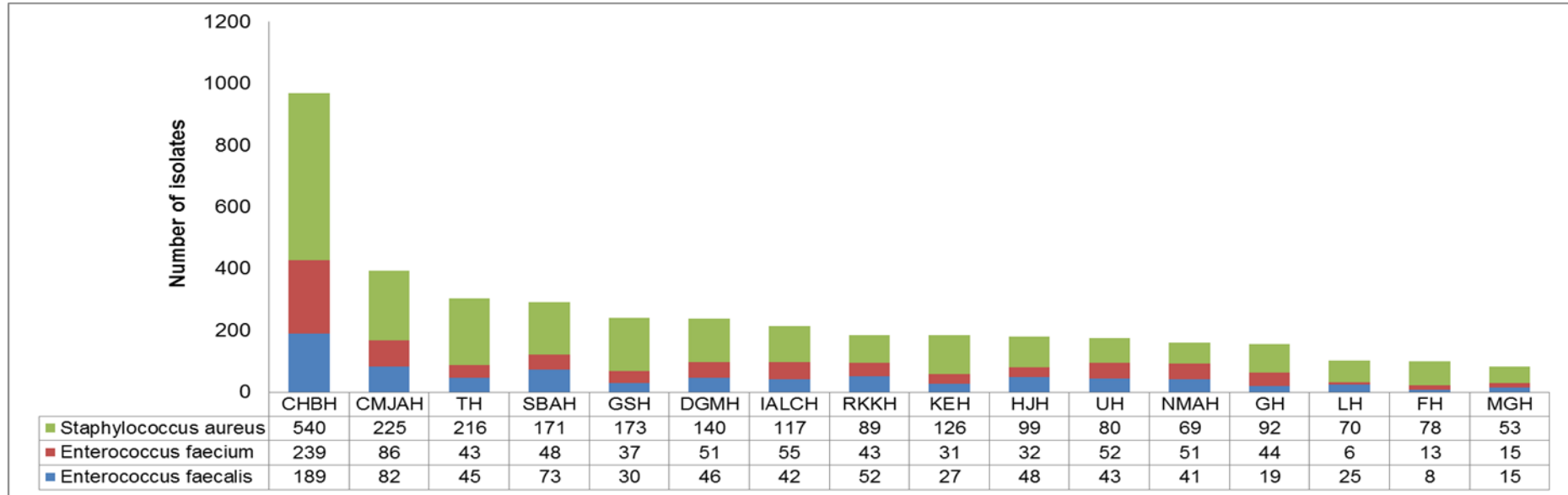


Figure 5 Number of Gram-positive bacteria: *Enterococcus faecalis* (n=785), *Enterococcus faecium* (n=846) and *Staphylococcus aureus* (n=2338) reported from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

Table 9 Antimicrobial susceptibility patterns of Gram-positive bacteria isolated from blood cultures reported from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

Antimicrobial agent	<i>Enterococcus faecalis</i>				<i>Enterococcus faecium</i>				<i>Staphylococcus aureus</i>			
	Non-susceptible		Susceptible		Non-susceptible		Susceptible		Non-susceptible		Susceptible	
	n	%	n	%	n	%	n	%	n	%	n	%
Linezolid	3	0.4	687	99.6	5	0.7	734	99.3	-	-	-	-
Penicillin/ampicillin	33	9.7	306	90.3	383	97.5	10	2.5	-	-	-	-
Teicoplanin	5	1.2	409	98.8	12	2.7	426	97.3	-	-	-	-
Vancomycin	8	1.0	759	99.0	45	5.4	796	94.6	-	-	-	-
Cloxacillin	-	-	-	-	-	-	-	-	709	30.8	1590	69.2

**Abbreviations:** number of isolates (n), percentage (%), not reported (-)

Vancomycin was not reported for *Staphylococcus aureus* as non-susceptibility is rare

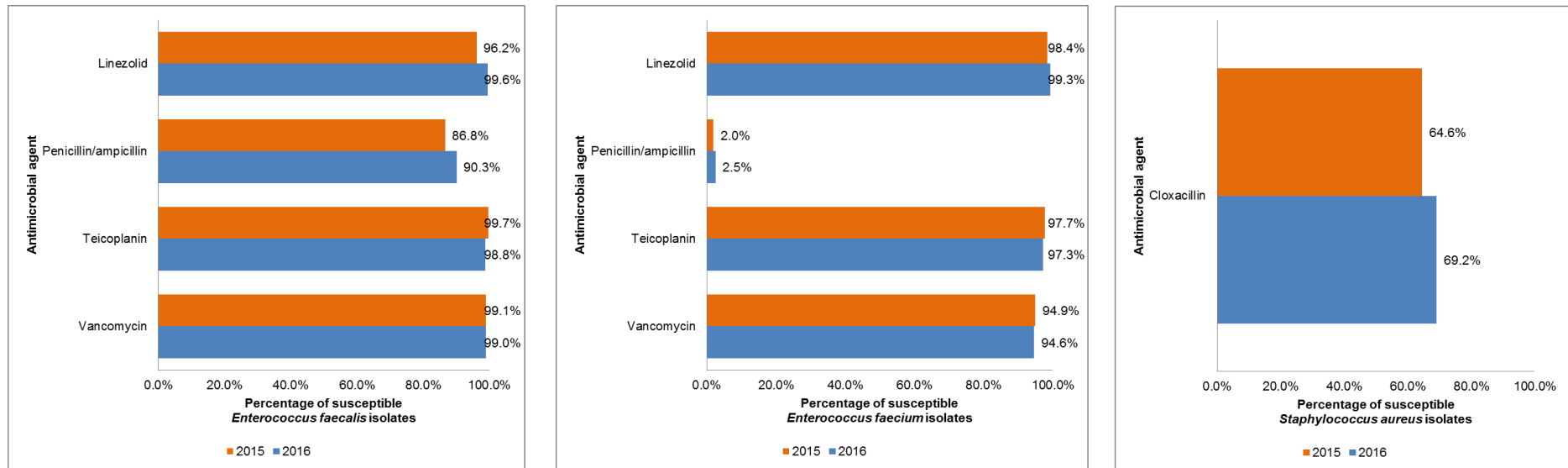


Figure 6 Percentage of susceptible *Enterococcus faecalis*, *Enterococcus faecium* and *Staphylococcus aureus* isolates, 2015 to 2016.

Table 10 Number and percentage of susceptible *Enterococcus faecalis* isolates per antimicrobial agent from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

	CHBH	CMJAH	DGMH	SBAH	GSH	TH	HJH	KEH	IALCH	UH	GH	FH	NMAH	LH	RKKH	MGH
Antimicrobial agent	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Linezolid	188	79	43	73	-	40	45	-	40	43	-	-	-	-	36	-
	<b>100.0</b>	<b>100.0</b>	<b>97.7</b>	<b>100.0</b>	-	<b>100.0</b>	<b>97.8</b>	-	<b>100.0</b>	<b>100.0</b>	-	-	-	-	<b>100.0</b>	-
Penicillin/ampicillin	-	62	-	69	-	-	-	-	39	-	-	-	-	-	46	-
	-	<b>91.9</b>	-	<b>98.6</b>	-	-	-	-	<b>100.0</b>	-	-	-	-	-	<b>91.3</b>	-
Teicoplanin	-	64	41	72	-	42	-	-	40	-	-	-	-	-	38	-
	-	<b>100.0</b>	<b>97.6</b>	<b>100.0</b>	-	<b>100.0</b>	-	-	<b>100.0</b>	-	-	-	-	-	<b>97.4</b>	-
Vancomycin	189	79	43	72	-	45	43	-	42	43	-	-	39	-	53	-
	<b>99.5</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	-	<b>100.0</b>	<b>100.0</b>	-	<b>100.0</b>	<b>95.3</b>	-	-	<b>94.9</b>	-	<b>96.2</b>	-

Data were omitted for those sentinel hospitals that tested less than 30 ESKAPE pathogens for a particular antimicrobial agent

Table 11 Number and percentage of susceptible *Enterococcus faecium* isolates per antimicrobial agent from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

	CHBH	CMJAH	DGMH	SBAH	GSH	TH	HJH	KEH	IALCH	UH	GH	FH	NMAH	LH	RKKH	MGH
Antimicrobial agent	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Linezolid	232	84	51	43	37	39	32	-	49	52	39	-	-	-	-	-
	<b>100.0</b>	<b>98.8</b>	<b>94.1</b>	<b>100.0</b>	<b>100</b>	<b>97.4</b>	<b>100.0</b>	-	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	-	-	-	-	-
Penicillin/ampicillin	-	79	-	43	37	-	-	-	53	-	41	-	-	-	38	-
	-	<b>2.5</b>	-	<b>2.3</b>	<b>0.0</b>	-	-	-	<b>1.9</b>	-	<b>7.3</b>	-	-	-	<b>2.6</b>	-
Teicoplanin	-	81	47	45	37	40	-	30	52	-	39	-	-	-	-	-
	-	<b>96.3</b>	<b>93.6</b>	<b>97.8</b>	<b>100.0</b>	<b>100.0</b>	-	<b>100.0</b>	<b>98.1</b>	-	<b>100.0</b>	-	-	-	-	-
Vancomycin	236	87	51	46	37	44	30	31	55	52	44	-	51	-	43	-
	<b>96.2</b>	<b>95.4</b>	<b>96.1</b>	<b>97.8</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>98.2</b>	<b>51.9</b>	<b>100.0</b>	-	<b>96.1</b>	-	<b>97.7</b>	-

Data were omitted for those sentinel hospitals that tested less than 30 ESKAPE pathogens for a particular antimicrobial agent

Table 12 Number and percentage of susceptible *Staphylococcus aureus* isolates per antimicrobial agent from 16 sentinel hospitals across South Africa, 1 January 2016 to 31 December 2016.

	CHBH	CMJAH	DGMH	SBAH	GSH	TH	HJH	KEH	IALCH	UH	GH	FH	NMAH	LH	RKKH	MGH
Antimicrobial agent	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Cloxacillin	535	214	137	172	172	213	97	122	113	80	90	77	65	71	88	53
	<b>50.1</b>	<b>72.9</b>	<b>71.5</b>	<b>84.9</b>	<b>82.0</b>	<b>70.4</b>	<b>89.7</b>	<b>66.4</b>	<b>76.1</b>	<b>71.3</b>	<b>66.7</b>	<b>63.6</b>	<b>58.5</b>	<b>81.7</b>	<b>85.2</b>	<b>75.5</b>

## Carbapenemase-producing Enterobacteriaceae

In 2016, AMRL/CHARM identified 1182 CPE isolates. Approximately 72% (846/1182) of CPE isolates were identified as *Klebsiella pneumoniae*. Approximately 34% (400/1182) and 63% (741/1182) of CPE isolates were shown to be positive for *bla*<sub>NDM-1</sub> and *bla*<sub>OXA-48</sub>-like encoding genes (Table 13). In 2016, CPE isolates encoding for *bla*<sub>OXA-48</sub>-like genes were shown to be most prevalent compared to 2015.<sup>6</sup>

Table 13 Total number of confirmed Carbapenemase-producing Enterobacteriaceae, 1 January 2016 to 31 December 2016

CPE	Carbapenemase class						Total
	GES	IMP	KPC	OXA-48 and variants	NDM	VIM	
<i>Citrobacter amalonaticus</i>	-	-	-	2	-	-	2
<i>Citrobacter braakii</i>	-	-	-	1	1	-	2
<i>Citrobacter freundii</i>	-	-	1	8	9	-	18
<i>Citrobacter koseri</i>	-	-	-	1	-	-	1
<i>Citrobacter sedlakii</i>	-	-	-	-	1	-	1
<i>Enterobacter aerogenes</i>	-	-	-	8	1	-	9
<i>Enterobacter cloacae</i>	1	-	2	57	32	2	94
<i>Enterobacter gergoviae</i>	-	-	-	1	-	-	1
<i>Enterobacter kobei</i>	-	-	-	1	2	-	3
<i>Escherichia coli</i>	-	-	-	90	11	-	101
<i>Klebsiella oxytoca</i>	1	-	-	6	2	-	9
<i>Klebsiella pneumoniae</i>	11	-	3	531	287	14	846
<i>Klebsiella species</i>	-	-	-	6	-	2	8
<i>Morganella morganii</i>	-	-	-	2	6	-	8
<i>Proteus mirabilis</i>	-	-	-	2	-	-	2
<i>Proteus vulgaris</i>	-	-	-	-	1	-	1
<i>Providencia rettgeri</i>	-	-	-	1	17	-	18
<i>Salmonella species</i>	-	-	-	-	1	-	1
<i>Serratia marcescens</i>	3	-	-	24	29	1	57
<b>Total</b>	<b>16</b>	<b>0</b>	<b>6</b>	<b>741</b>	<b>400</b>	<b>19</b>	<b>1182</b>

**Abbreviations:** imipenemase (IMP), Guiana extended-spectrum carbapenemase (GES) *Klebsiella pneumoniae* carbapenemase (KPC), oxacillinase (OXA), New Delhi metallo-beta-lactamase (NDM) and veronica integron metallo-beta-lactamases types (VIM)



## **LIMITATIONS**

### **Interpretation of results**

The results of this report should be interpreted with caution. A number of factors might have introduced bias, resulting in either an overestimation or underestimation of AST reporting.

1. Data may have been incomplete due to missing cases not captured on the LIS or non-standardised coding of ESKAPE pathogens and antimicrobial agents at diagnostic laboratories. Testing methods and microbiological practice may have varied between sentinel hospitals and this could account for variations in the results presented in this report.
2. Confirmatory AST methods may not have been performed or recorded for any of these ESKAPE pathogens as the results presented here were reported as captured on the LIS by diagnostic laboratories. We haven't been able to report on colistin AST as new methods have been recommended by CLSI and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines, which have not yet been implemented by diagnostic laboratories.
3. For some sentinel hospitals, not all ESKAPE pathogens may have been represented. This may be due to ESKAPE pathogens not being isolated at a particular sentinel hospital in 2016.
4. Data were omitted for those sentinel hospitals that tested less than 30 ESKAPE pathogens for a particular antimicrobial agent.
5. Vancomycin resistance for *Staphylococcus aureus* requires confirmatory testing, which may not have been available at routine laboratory level. All *Staphylococcus aureus* isolates that are non-susceptible to vancomycin should be referred to AMRL/CHARM at the NICD.
6. Results for CPE may not be representative as not all CRE isolates are referred to CHARM for CPE confirmatory testing.

## **CONCLUSION**

In this report, data showed that antimicrobial susceptibility patterns for *Klebsiella pneumoniae* remained the same over the two-year period. Antimicrobial resistance to third and fourth generation cephalosporins increased for *Escherichia coli*. Carbapenem resistance in *Acinetobacter baumannii* is of concern as there are limited antimicrobial options available for treatment of significant infections. Although, a large proportion of vancomycin-resistant *Enterococcus faecium* was reported from Universitas Hospital, these isolates need laboratory confirmation as this may have been an unidentified outbreak. In most pathogens, the AST patterns remained unchanged. There has been a large increase in the number of CPEs identified across South Africa over the two-year period. Enhanced surveillance together with effective antimicrobial stewardship programmes and strict infection control practices are needed to combat AMR in both ESKAPE pathogens and CPEs. The limitations highlighted in this report emphasise the need for continuous improvement in quality of data obtained by electronic surveillance.

## **DISCLAIMER**

Data are reported as received through the CDW. No demographic, epidemiological, clinical or molecular data were available to distinguish between hospital-associated and community-associated infections.

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[http://www.fidssa.co.za/Content/images/2015\\_SASCM\\_Public\\_Sector\\_Report\\_FINAL.pdf](http://www.fidssa.co.za/Content/images/2015_SASCM_Public_Sector_Report_FINAL.pdf)