Antimicrobial Resistance Surveillance from sentinel public hospitals, South Africa, 2012

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Introduction

Antimicrobial resistance (AMR) is a key public health concern that threatens effective treatment of antimicrobial infections, both locally and globally. Surveillance is conducted to determine the extent and pattern of resistance amongst the most important disease causing pathogens in humans [1].

Objectives

1. To determine the number of cases reported from selected hospitals by month for the following organisms isolated from blood cultures: *Acinetobacter baumannii* complex, *Enterobacter cloacae* complex, *Escherichia coli, Enterococcus faecalis, Enterococcus faecium, Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Staphylococcus aureus.*
2. To describe the antimicrobial susceptibility to the most important agents by individual pathogen and by hospital

Methods

The data for this report were sourced from the National Health Laboratory Service (NHLS) Corporate Data Warehouse (CDW). This is a national repository for all public health hospitals in South Africa which contains archived data from two laboratory information system (LIS), either DISALAB or TrakCare [2].

Bloodstream infections for one year period (January – December 2012) were extracted for the following pathogens:
Acinetobacter baumannii complex, *Enterobacter cloacae* complex, *Escherichia coli, Enterococcus faecalis, Enterococcus faecium, Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Staphylococcus aureus.* Routine data were collected from sentinel sites (mostly academic sites) (Table 1).

Antimicrobial susceptibility testing reporting was based on CLSI guidelines (3). Table 2 describes the different laboratory methods used at laboratories based at the sentinel sites.

Due to two different LIS each with its own coding system of organisms and antibiotics as well as a lack of standardization across NHLS laboratories on how data was captured, extensive cleaning and recoding of data was necessary. Cleaning of the data involved creating unique patient identifiers, which enabled de-duplication and the generation of patient-level data. Data may be incomplete due to missing cases not captured on the LIS or non-standardized coding of pathogens and antibiotics.

Table 1. Hospital characteristics involved in the surveillance

Hospital Site	Province	Academic Hospital	No of beds
Charlotte Maxeke Johannesburg Academic Hospital (CMJAH)	Gauteng	Yes	1088
Chris Hani Baragwanath Hospital (CHBH)	Gauteng	Yes	3200
Dr George Mukhari Hospital (DGMH)	Gauteng	Yes	1200
Grey's Hospital (GH)	KwaZulu-Natal	Yes	530
Groote Schuur Hospital (GSH)	Western Cape	Yes	893
Helen Joseph Hospital (HJH)	Gauteng	Yes	700
Inkosi Albert Luthuli Central Hospital (IALCH)	KwaZulu-Natal	Yes	846
King Edward VIII Hospital (KEH)	KwaZulu-Natal	Yes	922
Mahatma Gandhi Hospital (MGH)*	KwaZulu-Natal	No	350
Nelson Mandela Academic Hospital/Mthatha Tertiary (NMAH)	Eastern Cape	Yes	520
RK Khan Hospital (RKKH)*	KwaZulu-Natal	No	543
Steve Biko Academic Hospital (SBAH)	Gauteng	Yes	832
Tygerberg Hospital (TH)	Western Cape	Yes	1310

- * Non academic sites

Table 2. Antimicrobial susceptibility testing methods

NHLS Laboratories at Public Hospitals	MicroScan	Vitek 2	Disk diffusion method
Charlotte Maxeke Johannesburg Academic Hospital	√		√
Chris Hani Baragwanath Hospital	√		√
Dr George Mukhari Hospital	√		
Grey's Hospital/Northdale laboratory		√	
Groote Schuur Hospital		√	
Helen Joseph Hospital	√		
Inkosi Albert Luthuli Central Hospital		√	
King Edward VIII Hospital		√	
Mahatma Gandhi Hospital		√	
Nelson Mandela Academic Hospital/Mthata tertiary			√

RK Khan Hospital		√	
Steve Biko Academic Hospital		√	
Tygerberg Hospital		√	

Results

Reports on antimicrobial susceptibility testing are shown for: *Acinetobacter baumannii* complex (Figure 1), *Pseudomonas aeruginosa* (Figure 2), *Enterobacter cloacae* complex (Figure 3), *Escherichia coli (*Figure 4*), Klebsiella pneumoniae* (Figure 5), *Staphylococcus aureus* (Figure 6), *Enterococcus faecalis* (Figure 7), *Enterococcus faecium* (Figure 8). For each organism, total number of cases, susceptibility to selected antimicrobial agents with number and ratios, and percentages of antimicrobial susceptibility per site was analyzed (Figures 1-8).

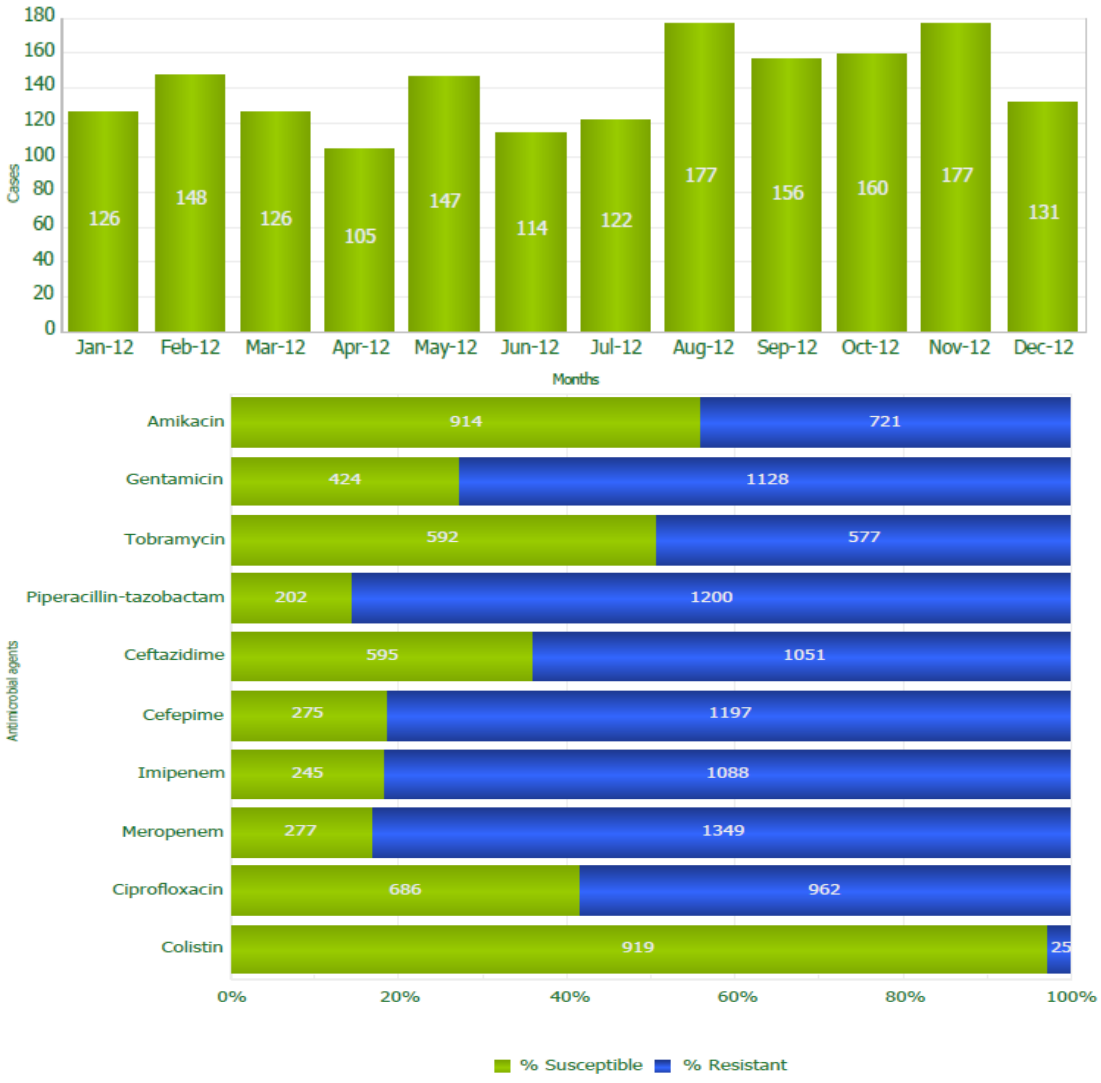


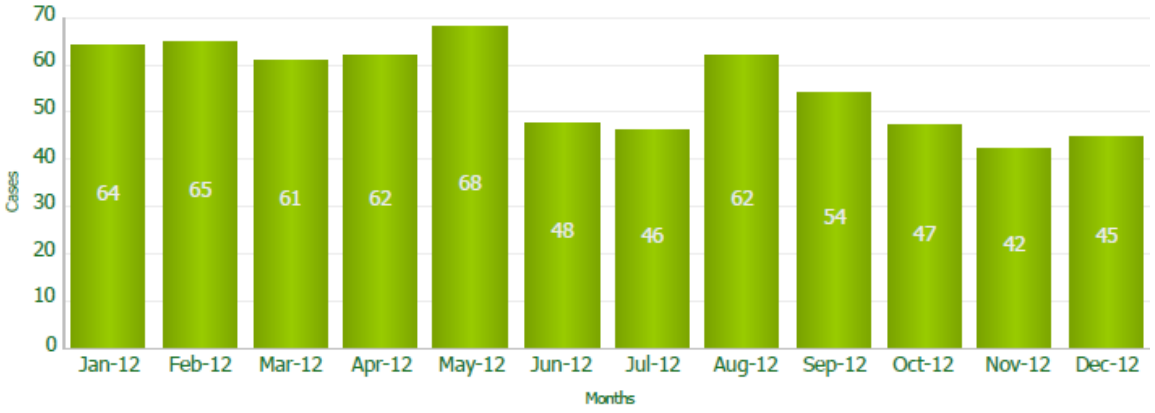
Figure 1: Number of isolates and susceptibility profile of *Acinetobacter baumannii* complex from blood culture at public-sector sentinel sites, 2012, Total number = 1689

Table 3. Antimicrobial susceptibility of *Acinetobacter baumannii* at the hospital level

Number of Total Cases / Susceptibility Ratio	Charlotte maxeke hospital	Chris hani baragwanath hosp	Dr george mukhari hospital	Grey's hospital	Groote schuur hospital	Helen joseph hospital	Inkosi albert luthuli central hospital	King edward viii hospital	Mahatma gandhi hospital	Nelson mandela academic hosp	Steve biko academic hospital	Tygerberg hospital
Amikacin	191	497	52	57	155	34	140	104	40	52	143	142
	31%	52%	13%	44%	47%	35%	78%	81%	95%	35%	80%	68%
Gentamicin	171	435	48	60	158	34	138	101	41	51	143	142
	37%	23%	8%	37%	42%	32%	30%	35%	15%	6%	16%	30%
Tobramycin	184	495	50	56	156	34				51		141
	58%	40%	24%	61%	66%	44%				31%		76%
Piperacillin-tazobactam	66	501		61	135	33	137	108	41	48	113	125
	12%	10%		13%	13%	9%	32%	23%	12%	27%	8%	11%
Ceftazidime	197	496	52	59	158	34	137	108	41	51	142	142
	50%	57%	60%	17%	18%	18%	20%	23%	12%	16%	8%	38%
Cefepime	194	497	50	59	159	34	83		39	51	142	140
	9%	30%	12%	14%	15%	9%	24%		8%	14%	10%	12%
Imipenem	78	498		57	159	33	84		39	54	145	142
	22%	16%		14%	13%	12%	29%		10%	81%	10%	15%
Meropenem	191	499	49	59	155	34	142	101	41	52	140	141
	9%	13%	8%	14%	14%	9%	33%	34%	15%	56%	11%	16%
Ciprofloxacin	192	500	54	57	158	33	135	109	41	52	146	142
	52%	51%	61%	12%	47%	24%	42%	33%	24%	33%	34%	20%
Colistin	86	92		59	157	32	117	86	38		141	108
	99%	100%		100%	99%	97%	88%	100%	97%		99%	96%

A. baumannii is resistant to a majority of antimicrobial agents, due to its ability to contain various mechanisms of resistance such as loss of outer membrane porins and permeability, efflux system, Amp C beta-lactamases and others.

Resistance was high to carbapenems, cefepime and ceftazidime, whereas it was lower to ciprofloxacin (58%) and amikacin (44%). Colistin resistance was only 3%.



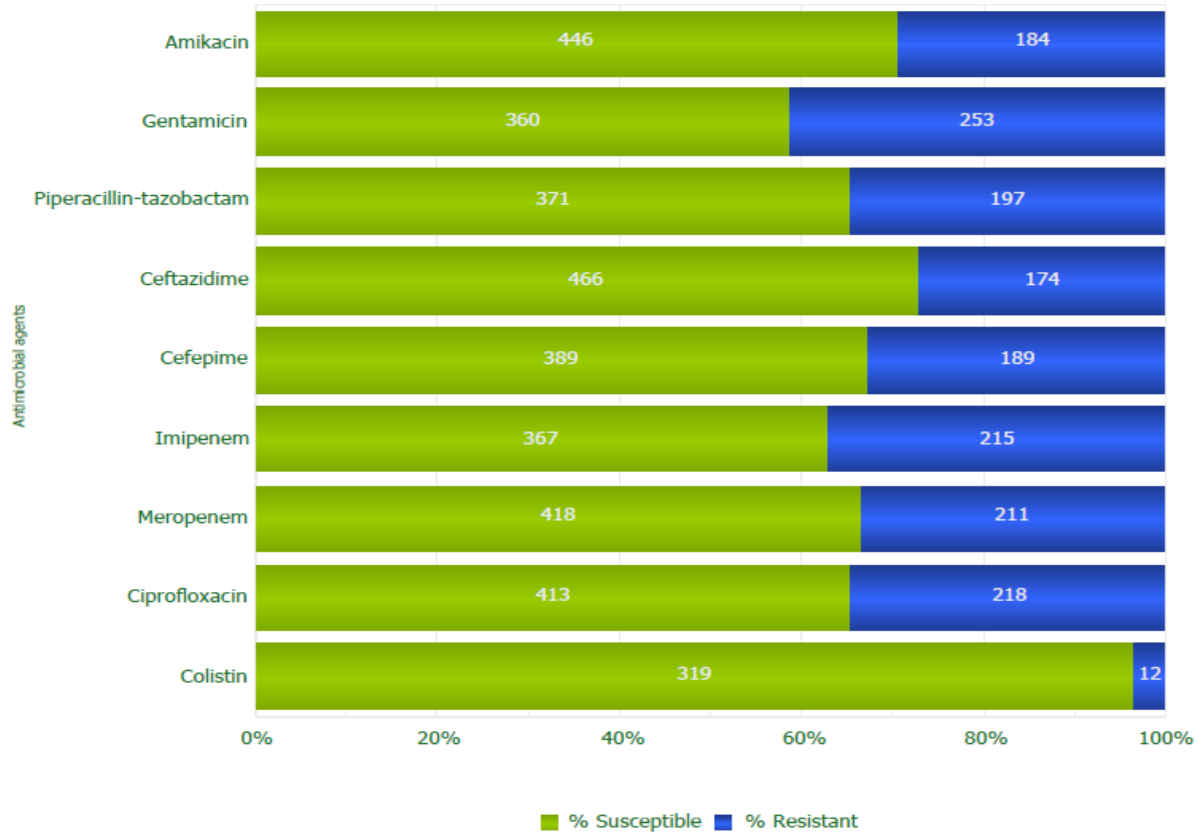


Figure 2: Number of isolates and susceptibility profile of *Pseudomonas aeruginosa* from blood culture at public-sector sentinel sites, 2012, Total number = 664

Table 4. Antimicrobial susceptibility of *Pseudomonas aeruginosa* at the hospital level

Number of Total Cases / Susceptibility Ratio	Charlotte maxeke hospital	Chris hani baragwanath hosp	Groote schuur hospital	Inkosi albert luthuli central hospital	Steve biko academic hospital	Tygerberg hospital
Amikacin	101 73%	167 62%	50 54%	44 61%	103 67%	62 95%
Gentamicin	97 63%	155 53%	50 54%	44 32%	103 61%	62 55%
Piperacillin-tazobactam	98 77%	163 61%		45 62%	105 54%	54 65%
Ceftazidime	103 78%	168 67%	50 70%	48 56%	105 73%	62 79%
Cefepime	105 79%	166 61%	49 61%		103 71%	62 61%
Imipenem	109 73%	166 60%	49 53%		104 43%	62 76%
Meropenem	104 73%	164 57%	49 65%	45 60%	105 56%	62 71%
Ciprofloxacin	98 79%	164 61%	50 50%	48 52%	104 61%	62 56%
Colistin	78 99%		48 94%		104 95%	

Pseudomonas aeruginosa isolates were founded to be moderately resistant to antimicrobial agents compared to *A. baumannii*. Resistance to ceftazidime was 27%, higher to piperacillin-tazobactam 35% and imipenem 37%, colistin resistance was 4%.

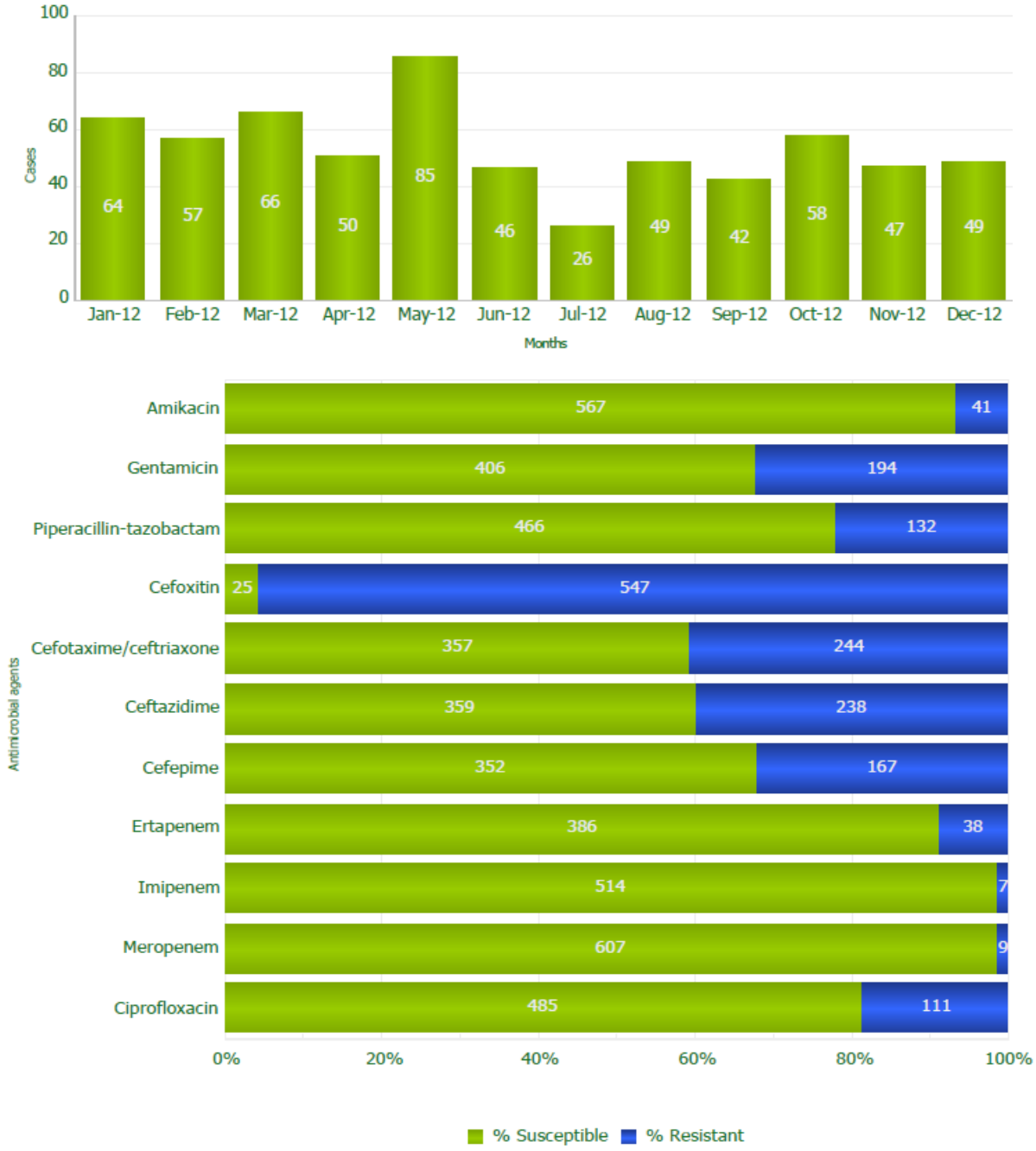


Figure 3. Number of isolates and susceptibility profile of *Enterobacter cloacae* complex from blood culture at public-sector sentinel sites, 2012, total number = 639

Table 5. Antimicrobial susceptibility of *Enterobacter cloacae* complex at the hospital level

Number of Total Cases / Susceptibility Ratio	Charlotte maxeke hospital	Chris hani baragwanath hosp	Dr george mukhari hospital	Grey's hospital	Groote schuur hospital	Inkosi albert luthuli central hospital	Steve biko academic hospital
Amikacin	66	141	37	38	38	58	107
	94%	94%	92%	95%	92%	91%	93%
Gentamicin	64	144	35	36	39	61	105
	78%	63%	71%	89%	72%	46%	85%
Piperacillin-tazobactam	65	146	34	38	38	62	104
	86%	77%	85%	95%	76%	82%	69%
Cefoxitin	65	145	35	37	39	57	103
	8%	7%	0%	0%	0%	7%	0%
Cefotaxime/ceftriaxone	65	144	38	37	39	59	104
	71%	52%	53%	84%	67%	56%	68%
Ceftazidime	65	144	35	37	39	58	104
	68%	51%	66%	89%	67%	55%	67%
Cefepime	65	144	37	37	38		105
	68%	63%	65%	92%	74%		77%
Ertapenem	65	143	38	37	38		
	91%	88%	87%	100%	100%		
Imipenem	65	146	37	38	37		104
	98%	97%	100%	100%	100%		100%
Meropenem	65	143	37	37	38	70	105
	100%	97%	100%	100%	100%	97%	100%
Ciprofloxacin	63	144	36	35	37	66	104
	79%	81%	78%	97%	95%	82%	81%

The high resistance of *Enterobacter cloacae* complex to ertapenem (9%) is a major concern. Resistance to carbapenems and cefepime (32%) indicates possession of de-repressed mutants resistant to all cephalosporins.

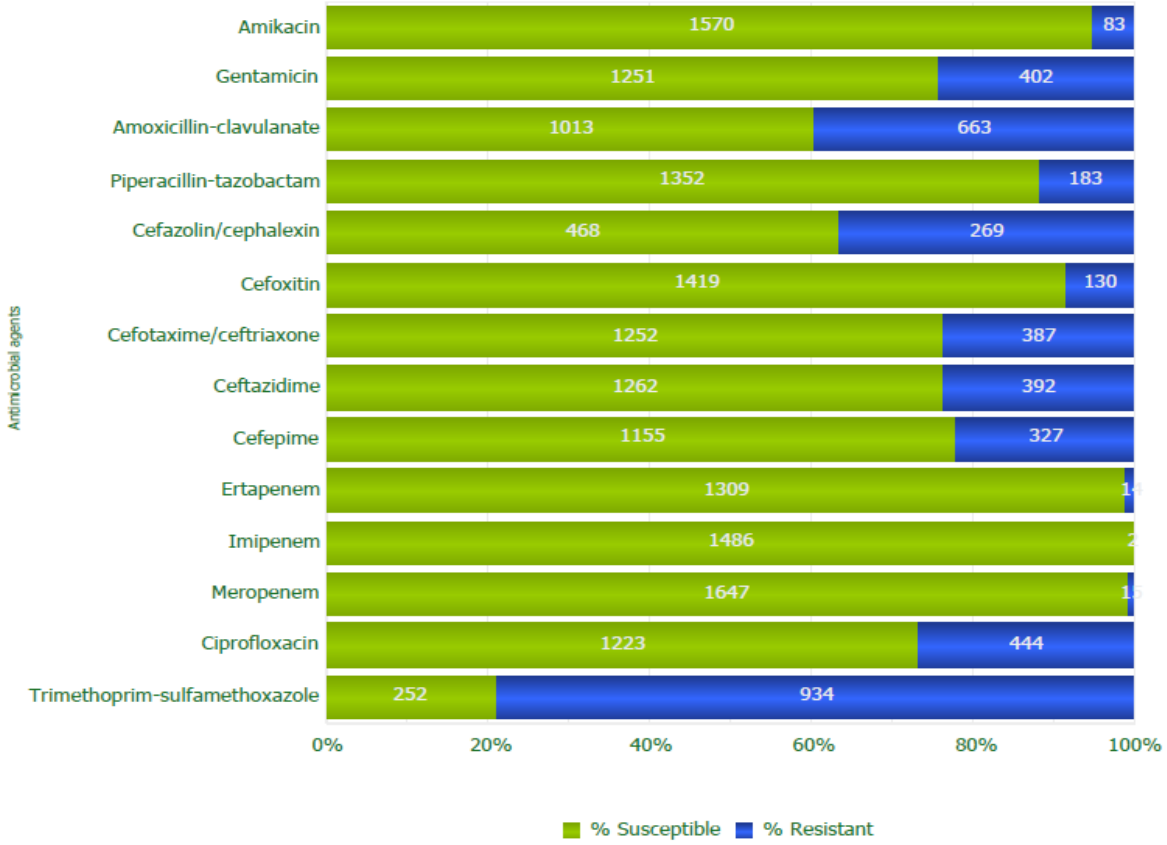


Figure 4. Number of isolates and susceptibility profile of *Escherichia coli* from blood culture at public-sector sentinel sites, 2012, Total number = 1727

Table 6. Antimicrobial susceptibility of *Escherichia coli* at the hospital level

Number of Total Cases / Susceptibility Ratio	Charlotte maxeke hospital	Chris hani baragwanath hosp	Dr george mukhari hospital	Grey's hospital	Groote schuur hospital	Helen joseph hospital	Inkosi albert luthuli central hospital	King edward viii hospital	Mahatma gandhi hospital	Nelson mandela academic hosp	Rk khan hospital	Steve biko academic hospital	Tygerberg hospital
Amikacin	202	467	55	89	126	91	95	53	91	71	55	142	116
	98%	99%	100%	93%	88%	100%	93%	85%	92%	99%	87%	88%	97%
Gentamicin	195	470	51	91	125	94	92	58	90	68	63	138	118
	77%	72%	86%	73%	79%	73%	58%	71%	70%	72%	79%	88%	92%
Amoxicillin-clavulanate	202	472	55	91	126	93	103	53	94	71	57	142	117
	63%	55%	69%	56%	67%	60%	40%	51%	72%	51%	70%	72%	70%
Piperacillin-tazobactam	204	471	54	84		92	93	55	90	70	53	142	114
	91%	90%	89%	94%		79%	88%	87%	88%	94%	87%	76%	91%
Cefazolin/cephalexin	202	466	52										
	65%	63%	71%										
Cefoxitin	203	466	55	89	121	92	96	56	88	72	52	143	
	94%	92%	100%	87%	92%	92%	89%	84%	97%	89%	87%	94%	
Cefotaxime/ceftriaxone	201	465	53	88	127	93	89	56	78	70	58	143	118
	84%	71%	85%	67%	80%	80%	70%	63%	77%	63%	81%	87%	85%
Ceftazidime	203	474	50	85	127	93	96	52	91	71	52	143	117
	83%	71%	82%	65%	81%	84%	70%	62%	78%	63%	77%	87%	85%
Cefepime	201	469	55	92	124	93			44	74	45	141	117
	84%	72%	82%	67%	80%	86%			70%	70%	78%	87%	85%
Ertapenem	204	458	52	89	126	93			47	69	44		113
	100%	97%	98%	100%	100%	100%			100%	99%	100%		100%
Imipenem	205	467	53	91	126	95			47	69	51	142	117
	100%	100%	98%	100%	100%	100%			100%	100%	100%	100%	100%
Meropenem	203	465	58	87	125	94	102	56	93	72	46	143	118
	100%	100%	98%	100%	100%	100%	99%	100%	89%	99%	100%	100%	100%
Ciprofloxacin	200	467	53	88	128	92	99	51	91	73	64	143	118
	75%	69%	79%	65%	76%	83%	65%	59%	73%	85%	80%	74%	86%
Trimethoprim-sulfamethoxazole	190	466			120	91				72		113	118
	19%	15%			36%	20%				19%		30%	28%

It is evident that resistance to antimicrobials was high in *E. coli*. Resistance to amoxicillin-clavulanate was 39%, to 1st generation cephalosporins 36% and 24% to 3rd generation which indicates presence of extended spectrum beta-lactamases. Ciprofloxacin resistance (27%) is concerning.

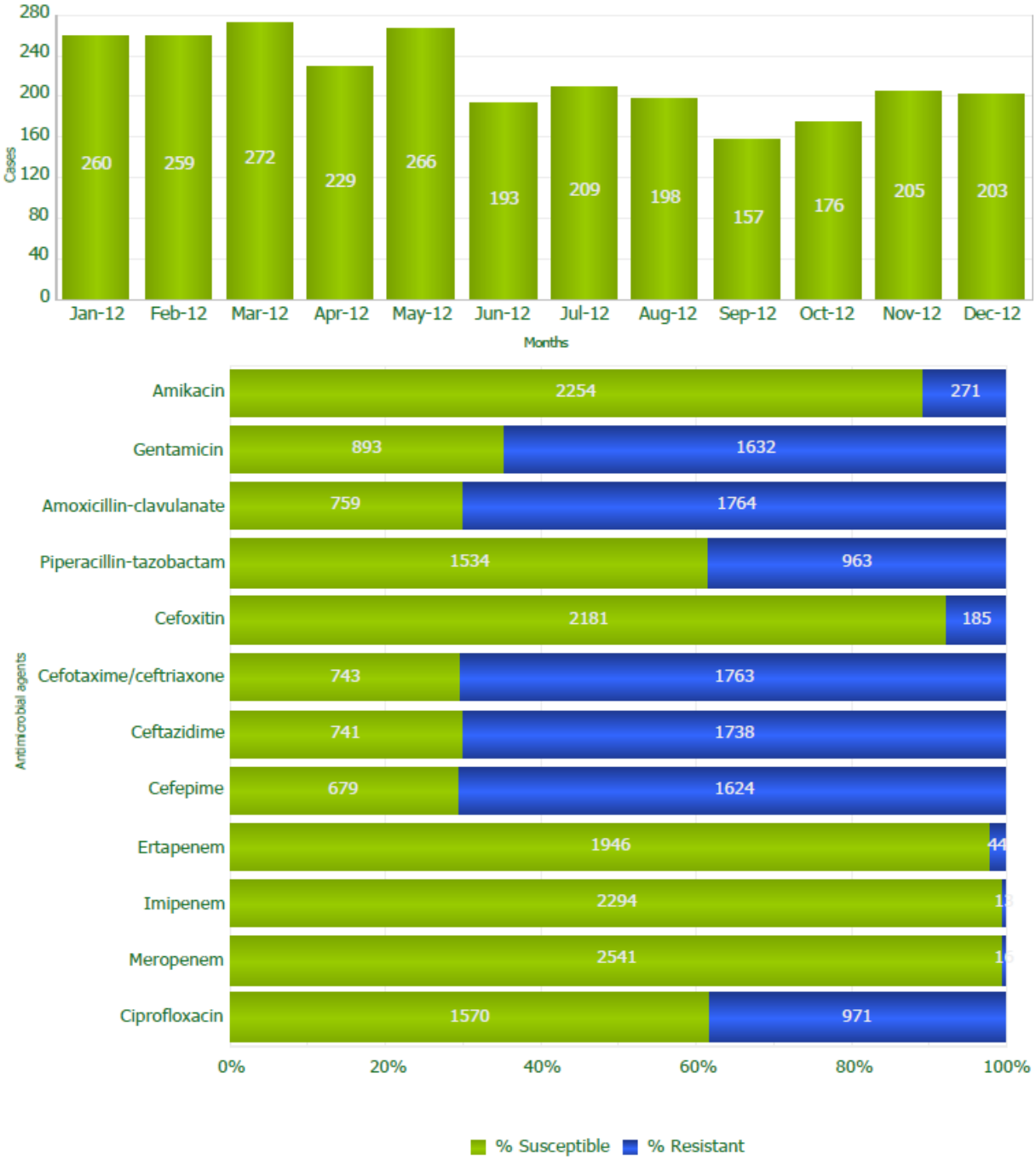


Figure 5. Number of isolates and susceptibility profile of *Klebsiella pneumoniae* from blood culture at public-sector sentinel sites, 2012, Total number = 2627

Table 7. Antimicrobial susceptibility of *Klebsiella pneumoniae* at the hospital level

Number of Total Cases / Susceptibility Ratio	Charlotte maxeke hospital	Chris hani baragwanath hosp	Dr george mukhari hospital	Grey's hospital	Groote schuur hospital	Helen joseph hospital	Inkosi albert luthuli central hospital	King edward viii hospital	Mahatma gandhi hospital	Nelson mandela academic hosp	Rk khan hospital	Steve biko academic hospital	Tygerberg hospital
Amikacin	340	639	138	155	150	62	217	78	33	146	51	334	182
	94%	94%	100%	81%	83%	98%	83%	86%	73%	90%	86%	80%	92%
Gentamicin	341	635	135	154	151	59	202	79	33	152	58	343	183
	30%	27%	29%	38%	46%	37%	24%	51%	39%	25%	47%	53%	46%
Amoxicillin-clavulanate	345	632	140	154	151	60	203	76	31	157	53	338	183
	35%	18%	23%	42%	56%	28%	27%	42%	39%	11%	49%	37%	33%
Piperacillin-tazobactam	343	630	145	153	111	61	225	75	34	151	49	339	181
	74%	50%	83%	78%	79%	34%	69%	65%	65%	80%	51%	37%	65%
Cefoxitin	343	637	137	156	147	61	209	76	35	154	47	340	
	95%	94%	90%	92%	97%	85%	80%	88%	97%	90%	91%	95%	
Cefotaxime/ceftriaxone	336	636	130	157	148	60	211	72	32	154	51	336	183
	27%	21%	28%	37%	41%	35%	28%	31%	34%	16%	41%	40%	37%
Ceftazidime	334	628	124	156	148	60	204	75	33	149	43	341	184
	27%	21%	30%	37%	41%	35%	28%	32%	33%	16%	44%	40%	38%
Cefepime	342	636	142	154	151	60	71			148	45	343	183
	26%	21%	27%	37%	42%	37%	21%			16%	38%	40%	37%
Ertapenem	343	624	141	155	150	61	77			155	46		182
	99%	98%	99%	99%	99%	93%	97%			94%	100%		99%
Imipenem	341	634	143	154	151	59	74			150	50	341	183
	99%	100%	97%	100%	99%	100%	97%			100%	100%	100%	100%
Meropenem	338	638	142	157	150	60	235	80	31	147	55	342	182
	99%	100%	99%	100%	99%	97%	100%	100%	97%	97%	100%	100%	99%
Ciprofloxacin	343	632	141	151	148	61	225	76	33	152	56	340	183
	58%	61%	74%	70%	59%	44%	52%	58%	64%	71%	79%	63%	60%

K. pneumoniae was resistant to multiple antimicrobials: 70% were ESBLs; 38% was resistant to ciprofloxacin and 11% to amikacin. Ertapenem resistance was 2%; although resistance to other carbapenemases was very low, the rapid emergence of strains with carbapenemases production threaten the last line of therapeutic option. Thus continuous monitoring of resistance trends need to be implemented.

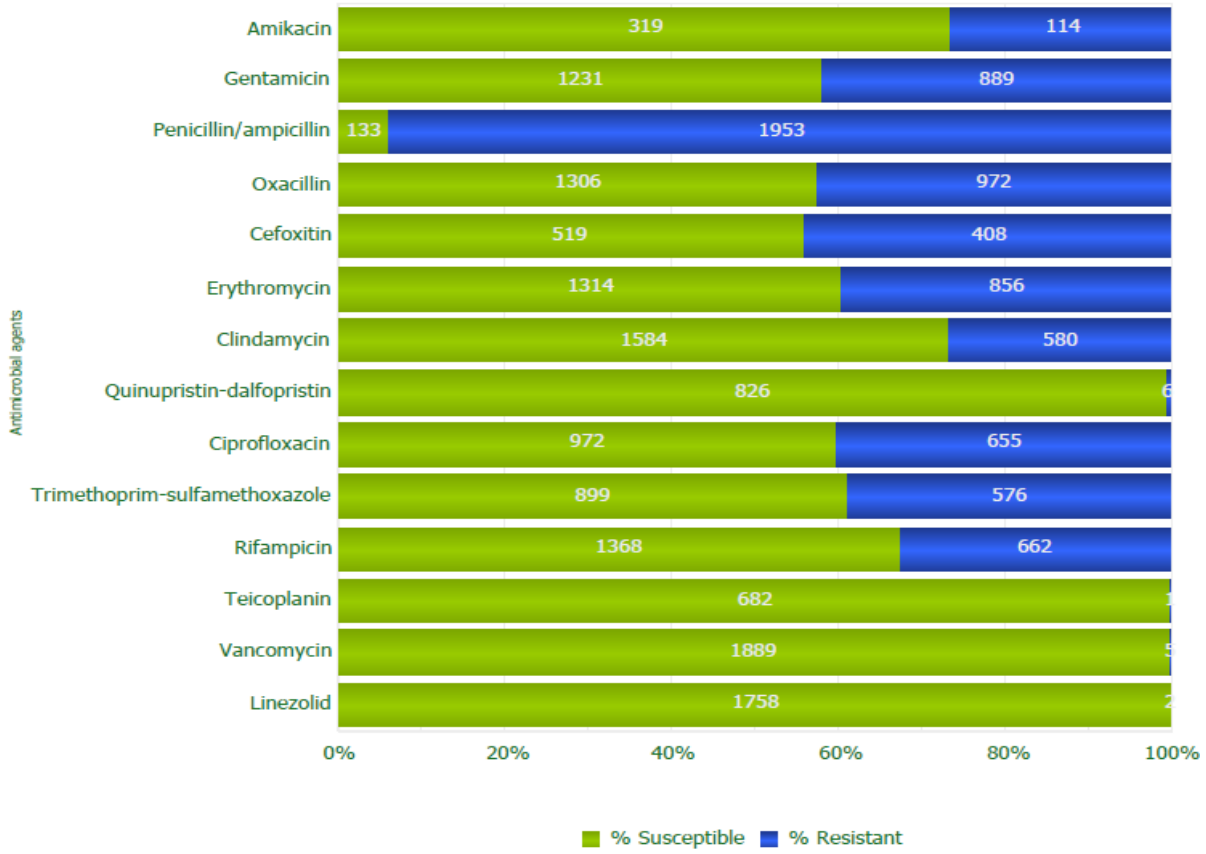


Figure 6. Number of isolates and susceptibility profile of *Staphylococcus aureus* from blood culture at public-sector sentinel sites, 2012, Total number = 2369

Table 7. Antimicrobial susceptibility of *Staphylococcus aureus* at the hospital level

Number of Total Cases / Susceptibility Ratio	Charlotte maxeke hospital	Chris hani baragwanath hosp	Dr george mukhari hospital	Grey's hospital	Groote schuur hospital	Helen joseph hospital	Inkosi albert luthuli central hospital	King edward viii hospital	Mahatma gandhi hospital	Nelson mandela academic hosp	Rk khan hospital	Steve biko academic hospital	Tygerberg hospital
Amikacin		430											
		74%											
Gentamicin	296	432	81	206	179	85	106	88	51	113	69	223	191
	43%	54%	41%	49%	79%	75%	42%	56%	61%	63%	71%	74%	63%
Penicillin/ampicillin	304	432	83	209	175	86	116	89	52	114	71	228	127
	6%	7%	8%	9%	7%	14%	2%	6%	0%	3%	6%	6%	6%
Oxacillin	288	404	87	213	179	80	275	100	52	106	80	221	193
	43%	55%	47%	47%	68%	85%	55%	58%	58%	63%	74%	69%	57%
Cefoxitin	273	432				86		41		60			
	44%	57%				84%		49%		68%			
Erythromycin	313	432	87	210	179	86	112	90	51	114	73	230	193
	44%	57%	47%	64%	69%	78%	56%	62%	67%	60%	78%	71%	63%
Clindamycin	312	432	86	216	179	86	108	90	50	114	71	227	193
	68%	94%	49%	66%	70%	91%	60%	69%	66%	57%	79%	76%	63%
Quinupristin-dalfopristin	314	432				86							
	100%	99%				98%							
Ciprofloxacin	311	432	78	202	107	86	77		51		71	193	
	45%	60%	55%	59%	77%	78%	42%		61%		76%	69%	
Trimethoprim-sulfamethoxazole	294	432			179	86				114		155	193
	44%	55%			80%	72%				64%		59%	75%
Rifampicin	313	426	85	212	178	86	74		52	113	68	230	193
	84%	85%	91%	0%	88%	81%	0%		0%	68%	0%	86%	85%
Teicoplanin				209	42		73		50		68	227	
				100%	100%		100%		100%		100%	100%	
Vancomycin	116	432	80	208	165		145	91	51	98	71	231	193
	100%	99%	100%	100%	100%		99%	100%	100%	100%	100%	100%	100%
Linezolid	316	432	79	208	179	85	73		51		68	229	40
	100%	100%	100%	100%	100%	100%	100%		100%		100%	100%	100%

Six *Staphylococcus aureus* isolates were reported to be vancomycin resistant; however this was not confirmed and should be taken with reserve. Resistance to methicillin and all other beta-lactams was 43% (oxacillin). Resistance to erythromycin and clindamycin was 40% and 27% respectively.

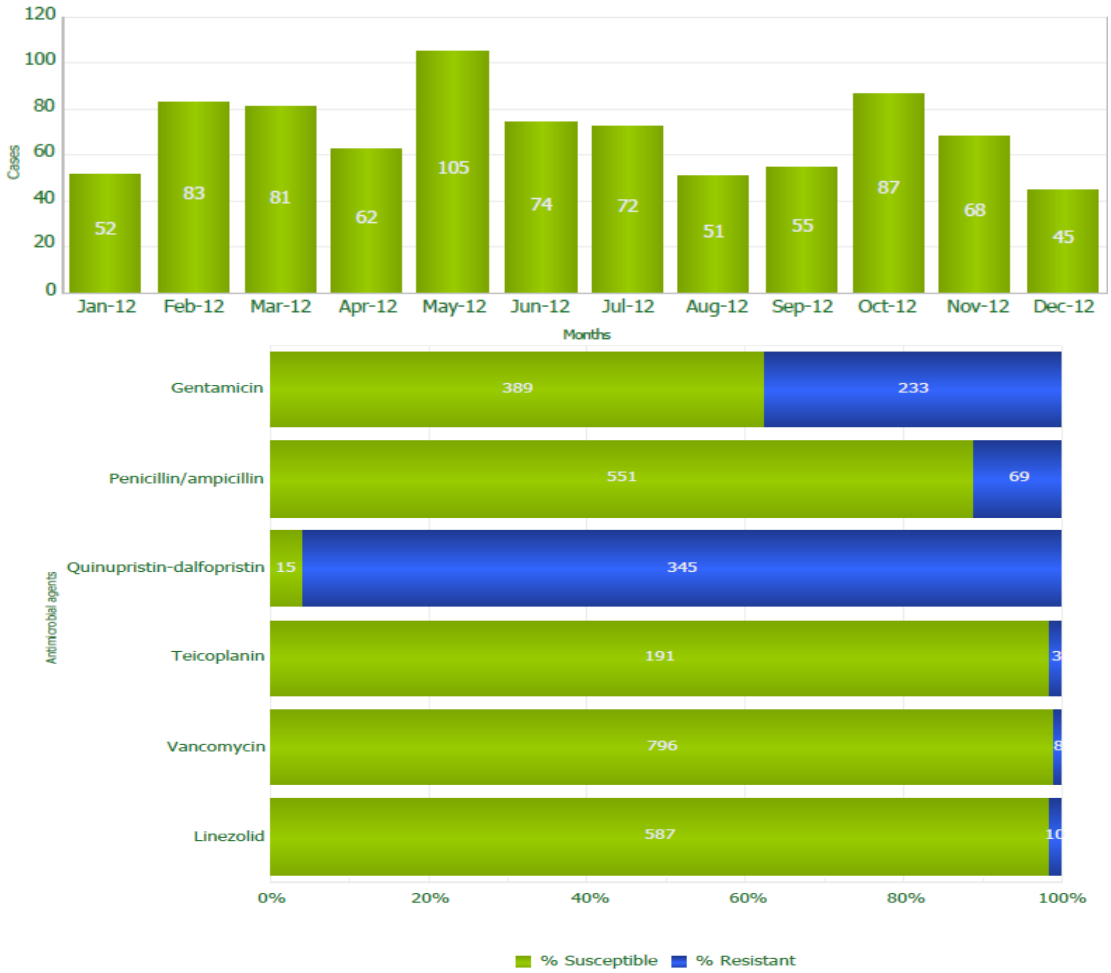


Figure 7. Number of isolates and susceptibility profile of *Enterococcus faecalis* from blood culture at public-sector sentinel sites, 2012, Total number = 835

Table 8. Antimicrobial susceptibility of *Enterococcus faecalis* at the hospital level

Number of Total Cases / Susceptibility Ratio	Charlotte maxeke hospital	Chris hani baragwanath hosp	Grey's hospital	Groote schuur hospital	Inkosi albert luthuli central hospital	King edward viii hospital	Rk khan hospital	Steve biko academic hospital	Tygerberg hospital
Gentamicin		238	66	52				112	38
		73%	67%	48%				54%	68%
Penicillin/ampicillin	69	232	66				33	110	44
	99%	98%	67%				88%	87%	95%
Quinupristin-dalfopristin	89	243							
	6%	3%							
Teicoplanin			66	51					
			95%	100%					
Vancomycin	89	235	68	51	53	32	42	120	47
	100%	100%	97%	100%	100%	97%	100%	100%	98%
Linezolid	92	239	68	51				35	
	100%	100%	99%	96%				97%	

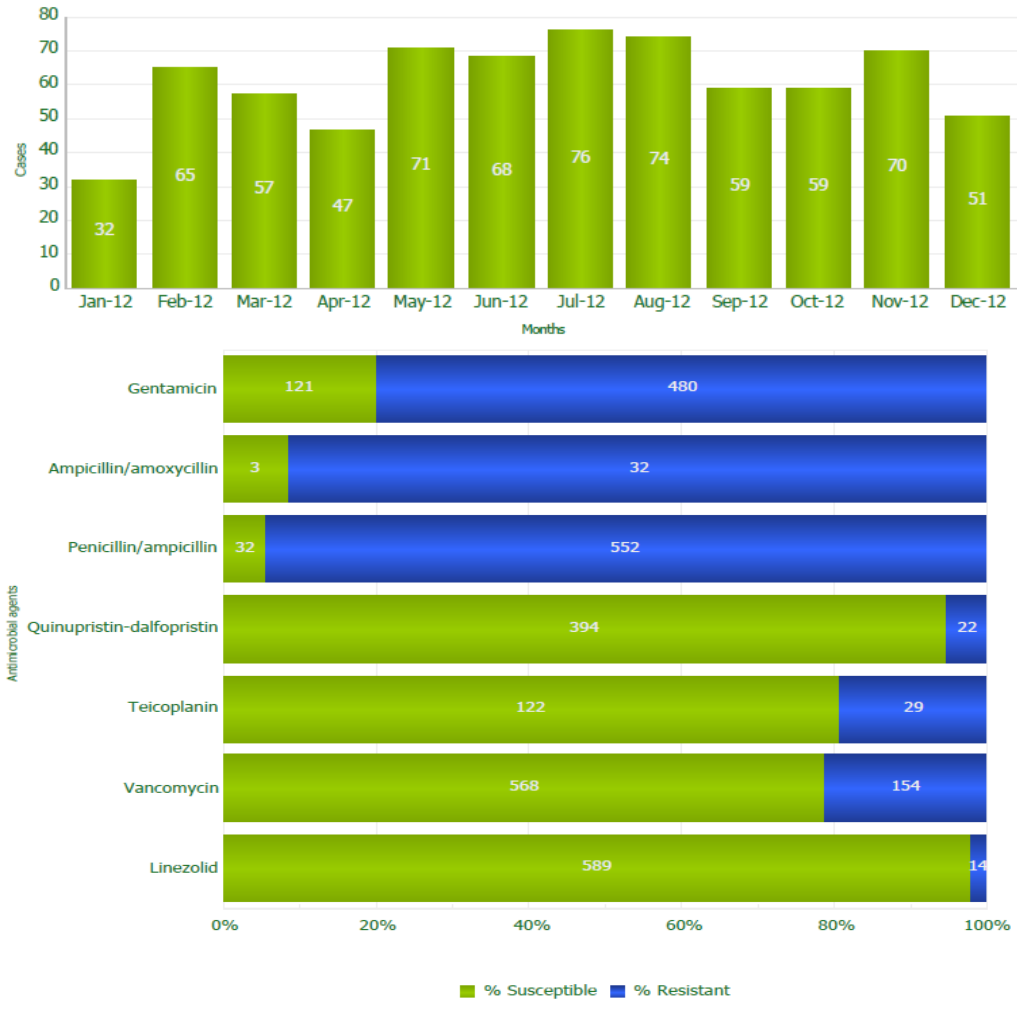


Figure 8. Number of isolates and susceptibility profile of *Enterococcus faecium* from blood culture at public-sector sentinel sites, 2012, Total number = 729

Table 8. Antimicrobial susceptibility of *Enterococcus faecium* at the hospital level

Number of Total Cases / Susceptibility Ratio	Charlotte maxeke hospital	Chris hani baragwanath hosp	Grey's hospital	Groote schuur hospital	Helen joseph hospital	Steve biko academic hospital
Gentamicin		283	34	35	33	107
		26%	15%	23%	30%	11%
Penicillin/ampicillin	83	277	33		35	79
	4%	6%	6%		3%	5%
Quinupristin-dalfopristin	95	282			38	
	93%	96%			95%	
Teicoplanin			31	36		32
			97%	100%		56%
Vancomycin	95	289	35	38	38	106
	72%	79%	97%	100%	63%	64%
Linezolid	95	286	35	36	38	34
	99%	99%	94%	94%	95%	94%

Enterococci are intrinsically resistant to a broad range of antibiotics including cephalosporins, penicillins (*E. faecium*), sulfonamides, and low concentration of aminoglycosides. Vancomycin resistant *E. faecium* was recorded in 21% of isolates which may indicate an outbreak situation in the hospital setting.

Conclusion and final remarks

The data presented in this report highlighted the importance of surveillance for antimicrobial resistance patterns. Surveillance needs to be ongoing in order to identify trends as well as possible outbreaks.

Disclaimer

Data are reported as received through the CDW. No clinical data or molecular data are available to distinguish between hospital-associated and community acquired infection.

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