Antimicrobial Resistance Surveillance from sentinel public hospitals, South Africa, 2013

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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 systems (LIS), either DISALAB or TrakCare [2].

Bloodstream infections for one year period (January – December 2013) 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 the two different LIS, each with its own coding system of organisms and antibiotics as well as a lack of standardized data capturing across NHLS laboratories, extensive cleaning and recoding of data was necessary. Data cleaning involved creating unique patient identifiers, de-duplication and 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

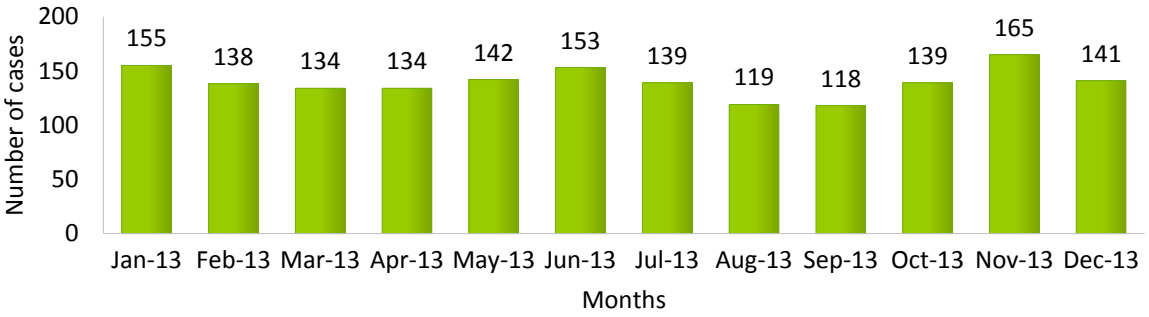
Table 2. Antimicrobial susceptibility testing methods

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). Distribution of susceptibility by hospital was presented in Tables 3-10, total number of isolates ≤ 30 would mislead susceptibility ratio and wasn't demonstrated.



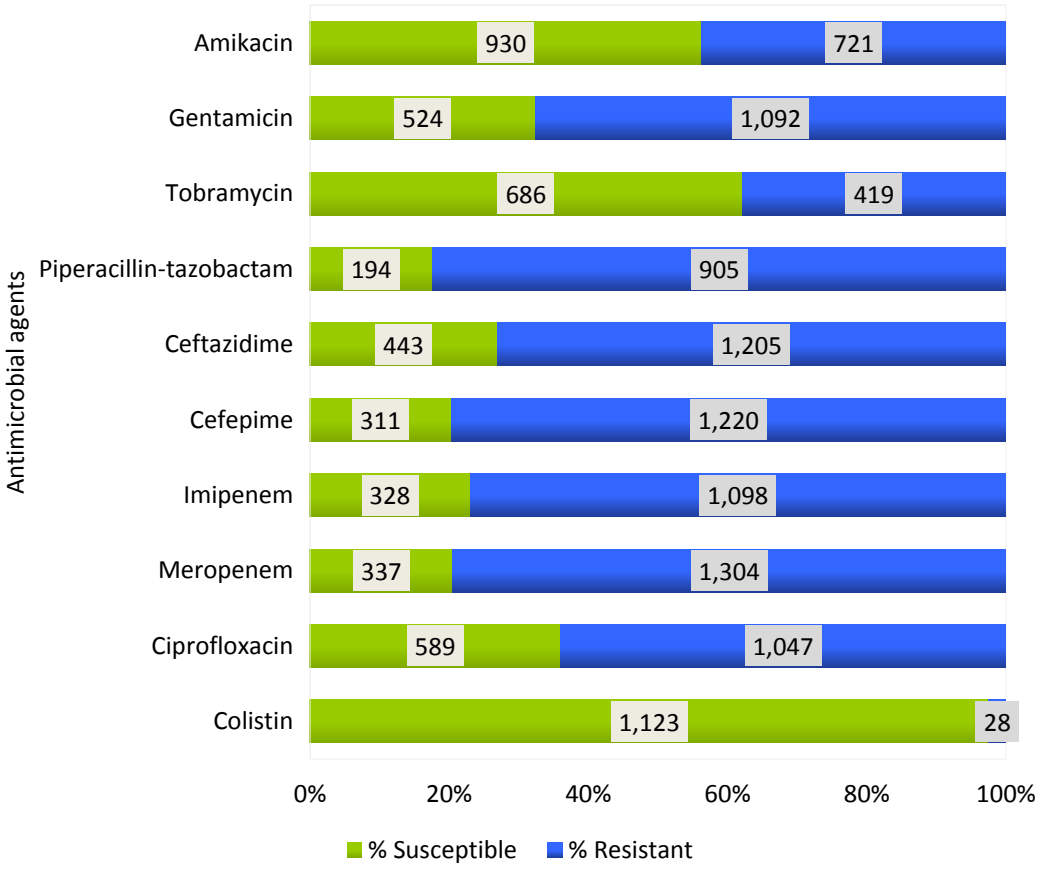


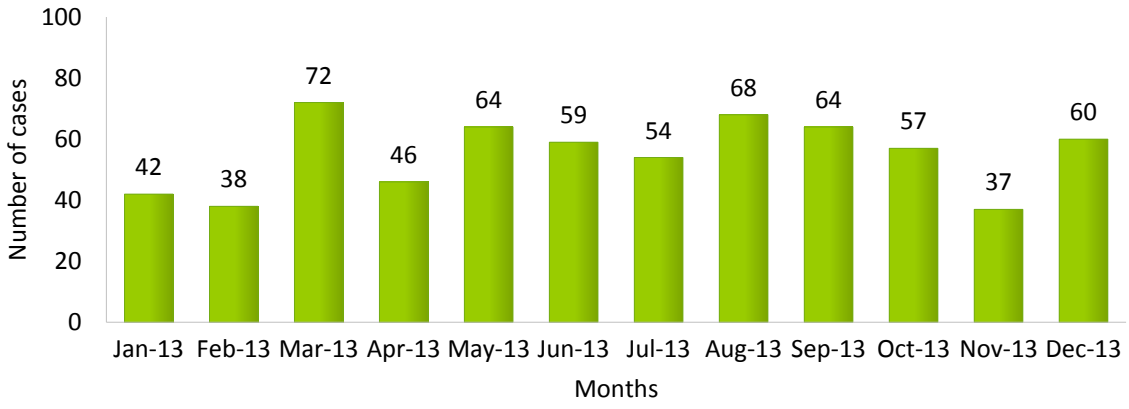
Figure 1: Number of isolates per month and susceptibility profile of *Acinetobacter baumannii* complex from blood culture at public-sector sentinel sites, 2013, Total number = 1677

Table 3. Antimicrobial susceptibility of *Acinetobacter baumannii* by the hospital, 2013

Number of Total Cases / Susceptibility Ratio	Charlotte Maxeke hospital	Chris Hani Baragwanath hospital	Dr George Mukhari hospital	Grey's hospital	Groote Schuur hospital	Helen Joseph hospital	Inkosi Albert Luthuli central hospital	King Edward viii hospital	Nelson Mandela academic hosp	Rk Khan hospital	Steve Biko academic hospital	Tygerberg hospital
Amikacin	169	347	57	73	188	66	131	103	82	51	217	142
	31%	49%	23%	59%	48%	68%	69%	62%	46%	57%	95%	49%
Gentamicin	158	335	50	73	187	70	126	105	82	52	214	144
	46%	33%	12%	23%	52%	20%	40%	30%	10%	19%	21%	39%
Tobramycin	170	344	55	50	188	69			81			142
	64%	53%	15%	70%	77%	68%			56%			81%
Piperacillin-tazobactam	93	338		55		60	133	94	79	49		137
	16%	16%		11%		10%	18%	15%	29%	16%		20%
Ceftazidime	169	354	53	74	182	70	132	107	81	52	206	145
	57%	41%	26%	11%	20%	29%	15%	14%	14%	15%	8%	32%
Cefepime	166	348	59	76	188	68	118		82	52	209	143
	16%	29%	17%	21%	24%	13%	22%		12%	19%	11%	19%
Imipenem	95	358		74	186	62	113		85	52	210	144
	16%	20%		23%	26%	13%	27%		62%	19%	14%	22%
Meropenem	167	352	57	76	180	69	135	103	80	49	206	146
	14%	15%	16%	22%	27%	14%	29%	22%	51%	20%	13%	21%
Ciprofloxacin	166	348	53	74	187	70	136	97	80	57	203	145
	61%	39%	26%	20%	46%	21%	24%	26%	29%	21%	48%	19%
Colistin	103	101		74	184	56	124	99		46	217	103
	99%	100%		95%	96%	96%	94%	99%		98%	100%	100%

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 imipenem, cefepime and ceftazidime 77%, 80%, 73%, respectively; whereas it was 64% to ciprofloxacin and 44% to amikacin. Colistin resistance was 2.4%.



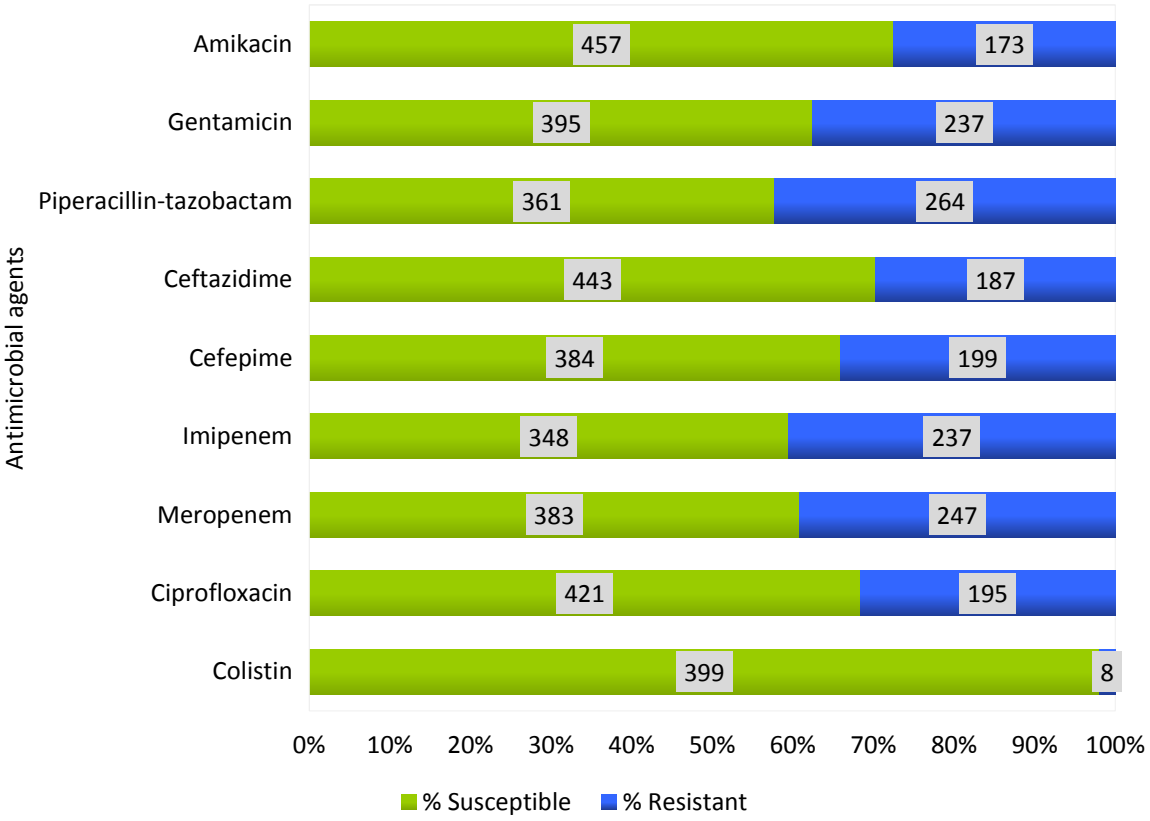


Figure 2: Number of isolates per month and susceptibility profile of *Pseudomonas aeruginosa* from blood culture at public-sector sentinel sites, 2013, Total number = 661

Table 4. Antimicrobial susceptibility of *Pseudomonas aeruginosa* by the hospital, 2013

Number of Total Cases / Susceptibility Ratio	Charlotte Maxeke hospital	Chris Hani Baragwanath hospital	Dr George Mukhari hospital	Groote Schuur hospital	Inkosi Albert Luthuli central hospital	academic hospital	Tygerberg hospital
Amikacin	87	153	31	73	66	103	37
	63%	70%	87%	79%	71%	64%	78%
Gentamicin	84	155	32	74	67	101	39
	68%	56%	81%	69%	51%	66%	46%
Piperacillin-tazobactam	82	163		73	64	103	32
	84%	58%		18%	58%	52%	69%
Ceftazidime	87	159		75	61	103	38
	62%	72%		72%	44%	74%	84%
Cefepime	87	156		73	43	101	39
	66%	60%		67%	56%	71%	74%
Imipenem	89	149		75	45	101	38
	60%	60%		55%	42%	50%	76%
Meropenem	87	158		73	62	103	37
	56%	47%		59%	55%	61%	76%
Ciprofloxacin	88	147	31	74	67	95	37
	63%	68%	90%	59%	67%	69%	68%
Colistin	81			73	48	101	
	98%			100%	100%	99%	

Pseudomonas aeruginosa isolates were found to be moderately resistant to antimicrobial agents compared to *A. baumannii*. Resistance to ceftazidime and ciprofloxacin was 30% and 32%, respectively. A higher resistance was found to piperacillin-tazobactam (42%) and imipenem (40%). Colistin resistance was the lowest at 2%.

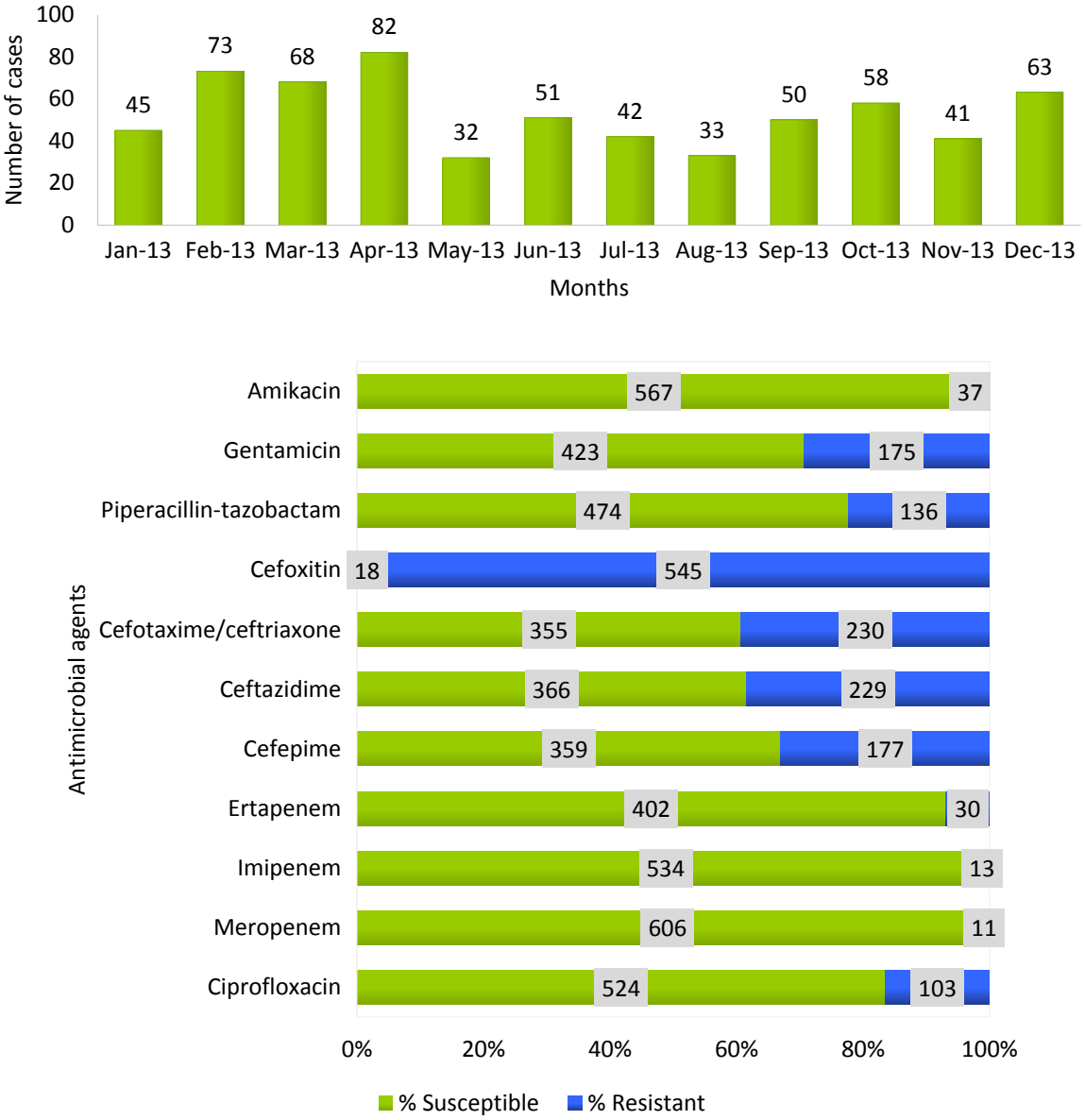
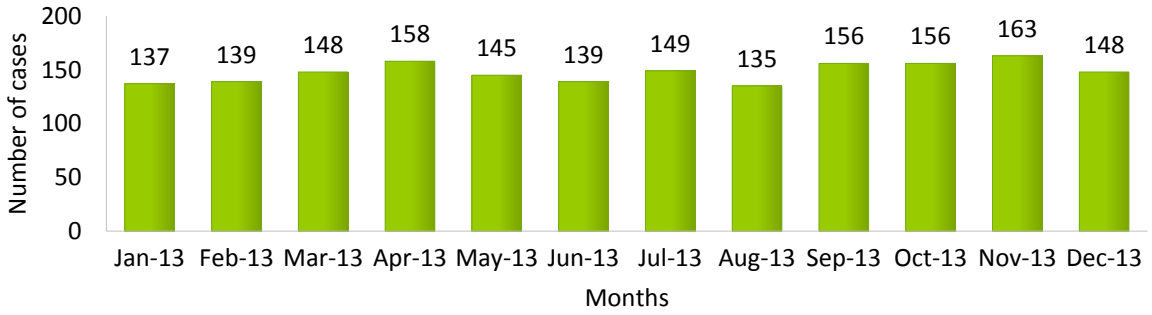


Figure 3. Number of isolates per month and susceptibility profile of *Enterobacter cloacae* complex from blood culture at public-sector sentinel sites, 2013, total number = 638

Table 5. Antimicrobial susceptibility of *Enterobacter cloacae* complex by the hospital, 2013

Number of Total Cases / Susceptibility Ratio	Charlotte Maxeke hospital	Chris Hani Baragwanath hospital	Grey's hospital	Groote Schuur hospital	Inkosi Albert Luthuli central hospital	Nelson Mandela academic hosp	Steve Biko academic hospital	Tygerberg hospital
Amikacin	66	113	32	71	40		137	42
	98%	95%	88%	92%	93%		94%	98%
Gentamicin	67	109	35	70	39		134	41
	78%	71%	69%	81%	33%		82%	68%
Piperacillin-tazobactam	67	109	32	68	43		133	39
	82%	89%	69%	84%	74%		73%	77%
Cefoxitin	68	108	34	68	34	31	134	
	10%	2%	0%	0%	6%	19%	0%	
Cefotaxime/ceftriaxone	67	108		72	37		131	41
	49%	60%		78%	68%		72%	71%
Ceftazidime	66	107	34	70	40		142	41
	55%	61%	62%	77%	58%		68%	68%
Cefepime	65	106	32	68			138	41
	58%	69%	63%	81%			76%	68%
Ertapenem	67	106	34	72				42
	93%	96%	94%	96%				90%
Imipenem	67	106		68			148	41
	99%	100%		97%			95%	98%
Meropenem	67	115	32	67	48		134	40
	100%	100%	100%	100%	100%		96%	98%
Ciprofloxacin	66	99	33	70	55		153	41
	76%	90%	91%	90%	76%		92%	83%

The high level of presumptive (no molecular confirmation) resistance of *Enterobacter cloacae* complex to ertapenem (7%) is a major concern. Resistance to cefepime (33%) indicates possession of de-repressed mutants resistant to all cephalosporins.



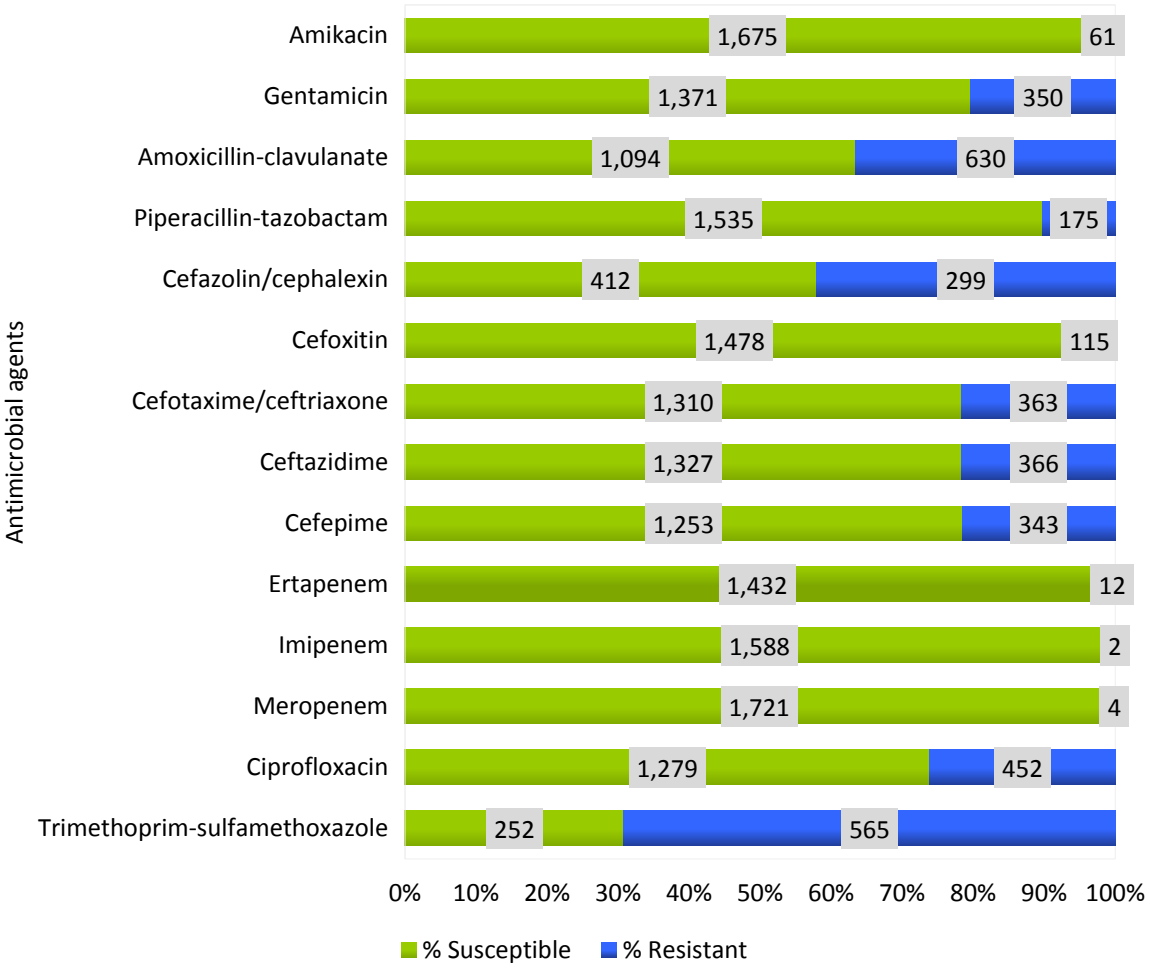


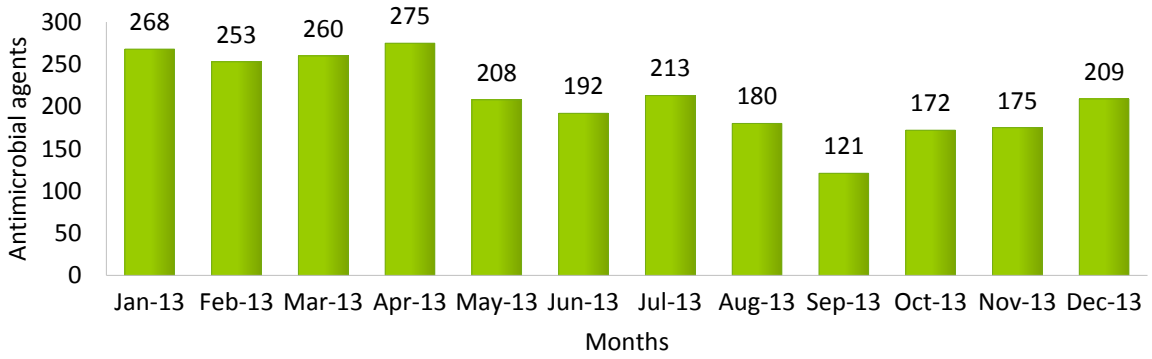
Figure 4. Number of isolates per month and susceptibility profile of *Escherichia coli* from blood culture at public-sector sentinel sites, 2013, Total number = 1773

Table 6. Antimicrobial susceptibility of *Escherichia coli* by the hospital, 2013

Number of Total Cases / Susceptibility Ratio	Charlotte Maxeke hospital	Chris Hani Baragwanath hospital	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	229	375	72	95	212	84	112	48	69	74	72	155	139
	97%	98%	94%	94%	93%	100%	98%	96%	97%	99%	93%	93%	99%
Gentamicin	228	379	76	93	212	78	93	43	70	76	83	153	137
	79%	74%	78%	81%	88%	82%	65%	77%	80%	71%	81%	86%	91%
Amoxicillin-clavulanate	227	376	72	95	215	77	101	45	69	75	84	151	137
	67%	52%	63%	63%	71%	60%	53%	64%	70%	44%	83%	70%	77%
Piperacillin-tazobactam	228	375	80	93	202	80	108	46	68	74	72	146	138
	94%	91%	85%	81%	89%	88%	90%	93%	97%	97%	94%	75%	95%
Cefazolin/cephalexin	225	375	78			31							
	57%	60%	59%			32%							
Cefoxitin	225	379	76	95	210	75	94	48	67	76	67	158	
	95%	92%	93%	94%	90%	97%	87%	88%	96%	97%	94%	95%	
Cefotaxime/ceftriaxone	227	363	70	93	211	75	95	43	70	76	68	142	140

	78%	73%	83%	77%	82%	76%	76%	81%	80%	58%	85%	82%	91%
Ceftazidime	227	374	74	97	208	80	90	46	69	70	68	150	140
	78%	72%	81%	78%	81%	79%	73%	83%	80%	61%	85%	83%	91%
Cefepime	228	374	75	95	213	83	65		36	74	64	149	140
	79%	74%	79%	78%	83%	81%	74%		72%	62%	84%	79%	91%
Ertapenem	224	374	74	97	209	80	62		34	72	63		136
	100%	98%	97%	100%	100%	99%	100%		100%	99%	100%		100%
Imipenem	227	375	76	97	210	80	64		36	68	69	149	137
	100%	100%	97%	100%	100%	100%	100%		100%	100%	100%	100%	100%
Meropenem	226	378	78	95	212	77	108	42	72	73	68	157	139
	100%	100%	100%	100%	100%	99%	100%	100%	97%	100%	100%	100%	100%
Ciprofloxacin	225	377	72	92	211	76	113	50	66	75	80	154	140
	73%	71%	76%	66%	74%	70%	62%	76%	76%	80%	76%	81%	85%
Trimethoprim-sulfamethoxazole	220	179			198					74			140
	33%	20%			40%					19%			36%

It is evident that resistance to antimicrobials was high in *E. coli.* Resistance to amoxicillin-clavulanate was 36%, to 1st generation cephalosporins 42% and 22% to 3rd generation which indicates presence of extended spectrum beta-lactamases. Ciprofloxacin resistance (26%) is concerning.



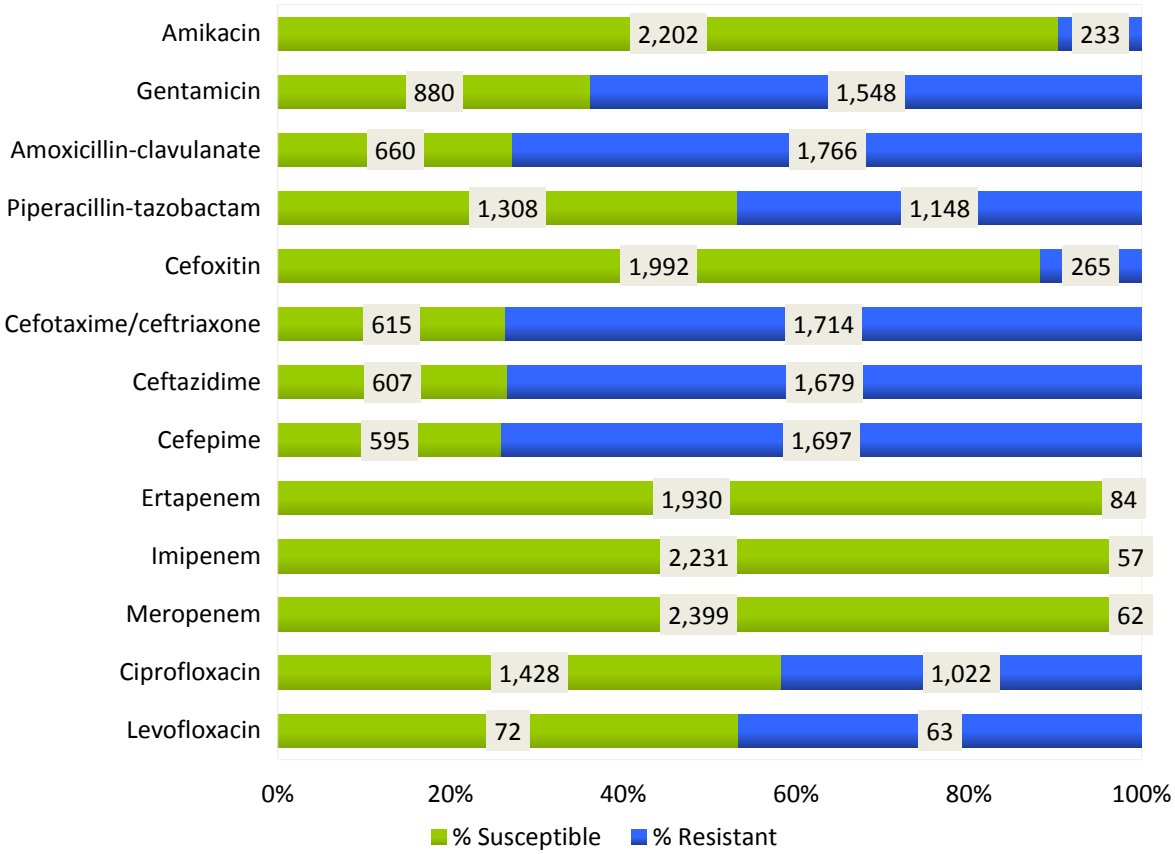


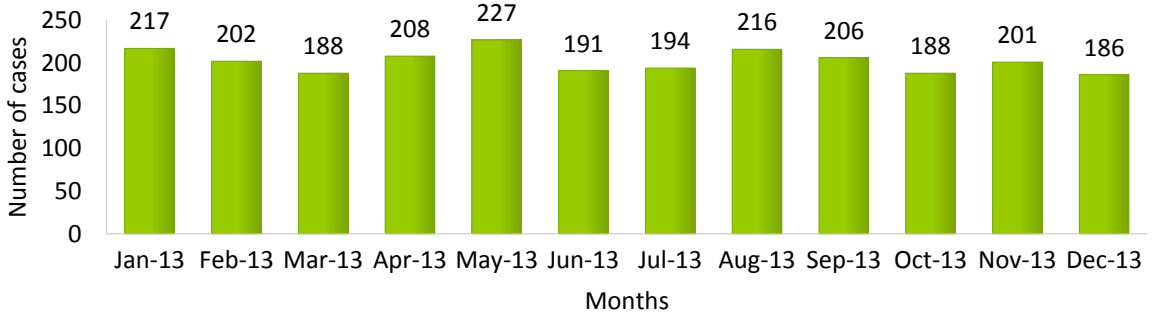
Figure 5. Number of isolates per month and susceptibility profile of *Klebsiella pneumoniae* from blood culture at public-sector sentinel sites, 2013, Total number = 2526

Table 7. Antimicrobial susceptibility of *Klebsiella pneumoniae* by the hospital, 2013

Number of Total Cases / Susceptibility Ratio	Charlotte Maxeke hospital	Chris Hani Baragwanath hospital	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	283	554	260	118	202	51	173	99	41	93	60	296	205
	95%	88%	97%	93%	85%	98%	86%	85%	90%	91%	85%	86%	97%
Gentamicin	280	549	261	118	202	50	159	97	45	94	64	300	209
	42%	27%	26%	38%	33%	52%	41%	36%	33%	20%	45%	49%	47%
Amoxicillin-clavulanate	282	552	259	116	202	52	164	93	43	97	63	297	206
	36%	15%	19%	30%	40%	35%	32%	33%	37%	8%	41%	34%	28%
Piperacillin-tazobactam	281	559	262	119	204	51	184	94	42	95	64	298	203
	79%	43%	38%	57%	61%	51%	60%	51%	45%	79%	47%	35%	70%
Cefoxitin	282	545	262	116	203	51	153	92	48	96	57	300	52
	93%	88%	89%	92%	94%	88%	69%	79%	88%	95%	86%	89%	96%
Cefotaxime/ceftriaxone	279	555	149	122	202	54	159	92	44	97	62	307	207
	32%	18%	26%	20%	32%	28%	28%	22%	34%	10%	39%	37%	28%
Ceftazidime	280	549	144	114	193	49	156	91	43	100	58	304	205
	33%	17%	29%	18%	33%	35%	27%	22%	35%	13%	36%	36%	28%
Cefepime	284	566	263	118	204	53	111		32	95	55	306	205
	33%	18%	16%	21%	34%	30%	33%		34%	13%	36%	35%	28%

Ertapenem	283	557	253	113	204	52	114		37	91	56		207
	98%	91%	98%	100%	97%	94%	99%		100%	95%	98%		100%
Imipenem	282	565	253	117	204	56	114		32	96	58	300	207
	99%	94%	97%	100%	97%	98%	99%		100%	100%	97%	100%	100%
Meropenem	283	547	255	115	205	51	192	98	44	96	62	306	207
	99%	93%	98%	100%	97%	98%	99%	98%	100%	99%	100%	99%	100%
Ciprofloxacin	281	538	268	120	203	55	188	96	46	93	61	296	205
	58%	66%	44%	58%	65%	38%	57%	45%	48%	71%	70%	56%	60%
Levofloxacin			129										
			52%										

K. pneumoniae was resistant to multiple antimicrobials: 73% were ESBLs; 42% was resistant to ciprofloxacin and 9.6% 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.



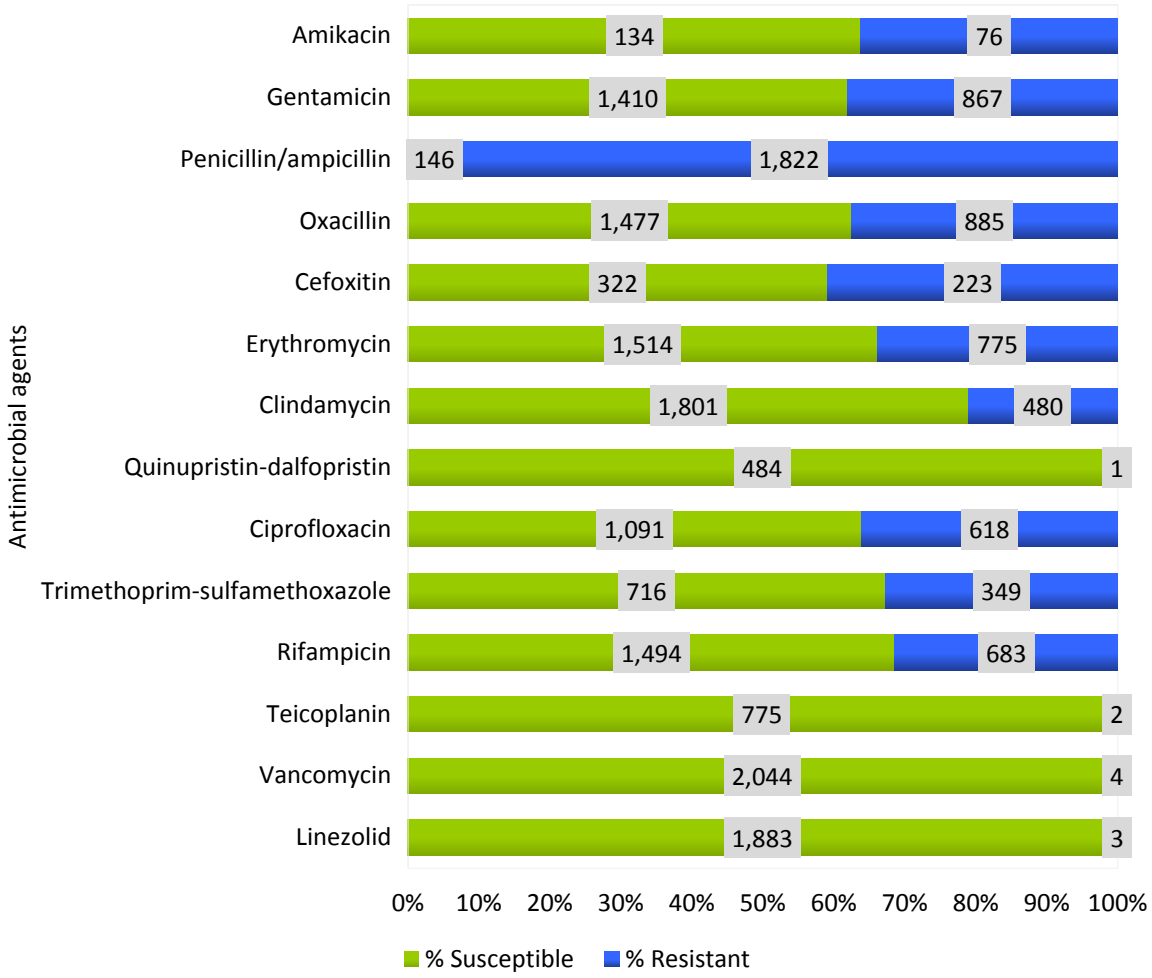


Figure 6. Number of isolates per month and susceptibility profile of *Staphylococcus aureus* from blood culture at public-sector sentinel sites, 2013, Total number = 2424

Table 8. Antimicrobial susceptibility of *Staphylococcus aureus* by the hospital, 2013

Number of Total Cases / Susceptibility Ratio	Charlotte Maxeke hospital	Chris Hani Baragwanath hospital	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		207											
		64%											
Gentamicin	232	472	99	164	245	77	144	89	67	101	74	233	280
	56%	52%	33%	68%	69%	64%	39%	65%	81%	70%	78%	74%	73%
Penicillin/ampicillin	222	474	65	162	240	77	144	91	69	101	85	229	
	12%	5%	8%	1%	6%	10%	7%	10%	10%	0%	8%	15%	
Oxacillin	211	452	97	163	249	77	242	96	70	94	96	233	282
	62%	54%	41%	66%	66%	75%	45%	67%	79%	80%	73%	77%	64%
Cefoxitin	212	208						67		49			
	59%	53%						60%		82%			
Erythromycin	232	475	95	161	249	79	141	89	67	101	85	233	282
	56%	58%	48%	86%	71%	59%	60%	63%	79%	72%	86%	76%	66%
Clindamycin	231	475	97	162	248	76	141	87	67	101	85	229	282
	83%	95%	47%	86%	74%	79%	70%	75%	81%	74%	88%	77%	67%

Quinupristin-dalfopristin	232	210	37										
	100%	100%	100%										
Ciprofloxacin	230	461	91	159	53	78	132	45	69	43	72	204	72
	62%	58%	51%	72%	68%	69%	38%	58%	90%	79%	78%	81%	53%
Trimethoprim-sulfamethoxazole	224	209			248					101			282
	56%	51%			71%					75%			82%
Rifampicin	233	463	94	163	246	79	140		68	100	76	234	281
	85%	88%	95%	0%	78%	75%	0%		0%	80%	0%	91%	90%
Teicoplanin			37	160	43		139		68		75	234	
			97%	99%	100%		100%		100%		100%	100%	
Vancomycin	78	476	98	163	240	64	172	90	69		86	231	281
	99%	100%	100%	99%	100%	100%	100%	100%	100%		99%	100%	100%
Linezolid	233	481	91	159	246	78	138		67		72	234	86
	100%	100%	99%	100%	100%	100%	100%		100%		100%	100%	100%

Four *Staphylococcus aureus* isolates were reported to be vancomycin resistant; however this was not confirmed and should be taken with reserve. Resistance to methicillin/oxacillin and all other beta-lactams was 37%. Cefoxitin resistance was higher at 41% which indicates MRSA. Resistance to erythromycin and clindamycin was 34% and 21% respectively.

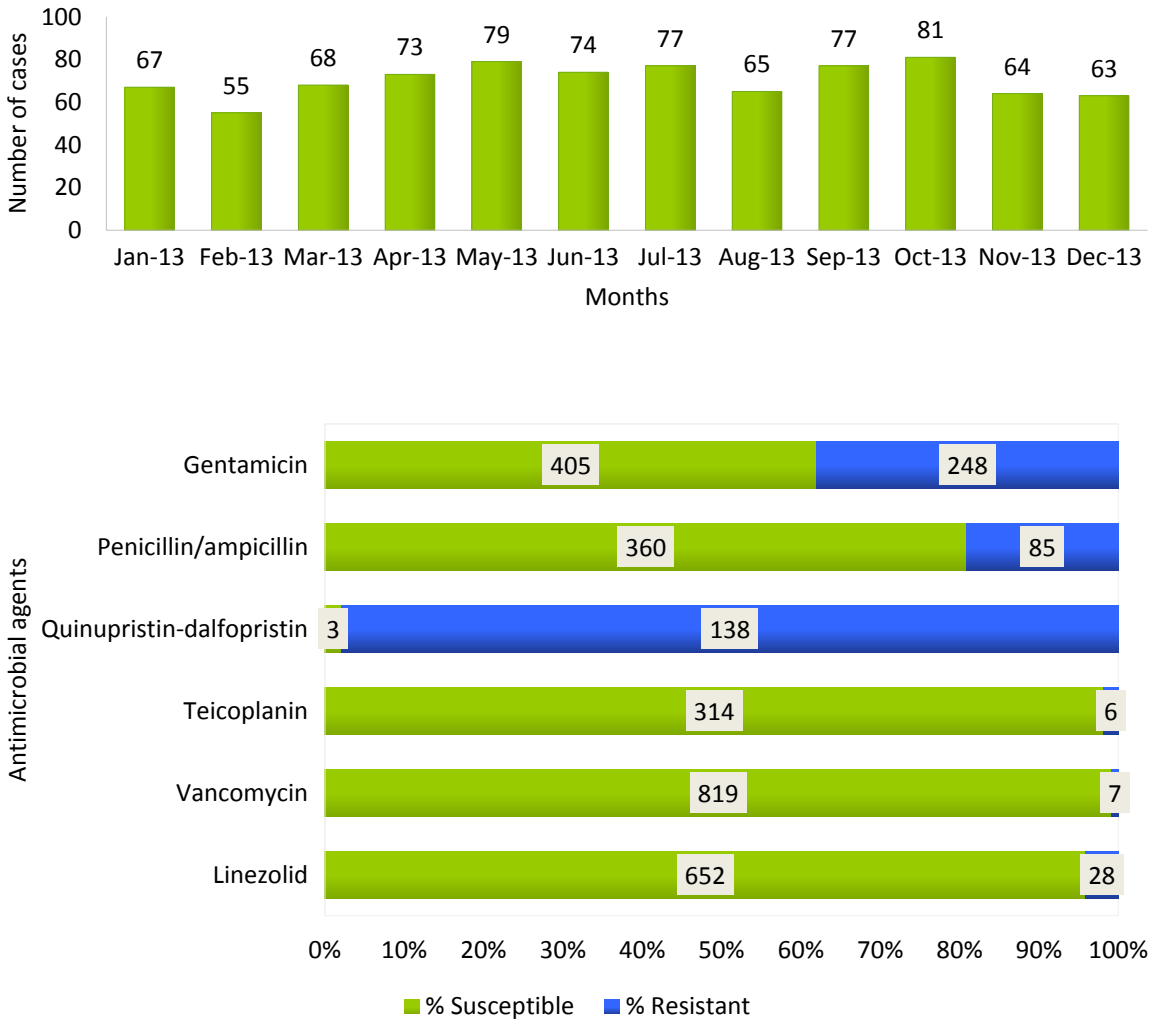


Figure 7. Number of isolates per month and susceptibility profile of *Enterococcus faecalis* from blood culture at public-sector sentinel sites, 2013, Total number = 843

Table 9. Antimicrobial susceptibility of *Enterococcus faecalis* by the hospital, 2013

Number of Total Cases / Susceptibility Ratio	Charlotte Maxeke hospital	Chris Hani Baragwanath hospital	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
Gentamicin		146		42	45	45	46		39		45	138	59
		71%		57%	53%	33%	54%		64%		80%	65%	73%
Penicillin/ampicillin	46	51		39			41			33	53	107	
	96%	100%		69%			71%			91%	75%	79%	
Quinupristin-dalfopristin	69	59											
	4%	0%											
Teicoplanin				39	46		43				44	110	
				90%	100%		100%				100%	100%	
Vancomycin	70	149	33	38	50	53	57	36	42	33	54	139	72
	100%	100%	100%	89%	100%	100%	98%	100%	95%	100%	100%	100%	100%
Linezolid	71	141	36	44	46	55	40				44	124	55
	100%	99%	97%	98%	87%	100%	95%				95%	96%	93%

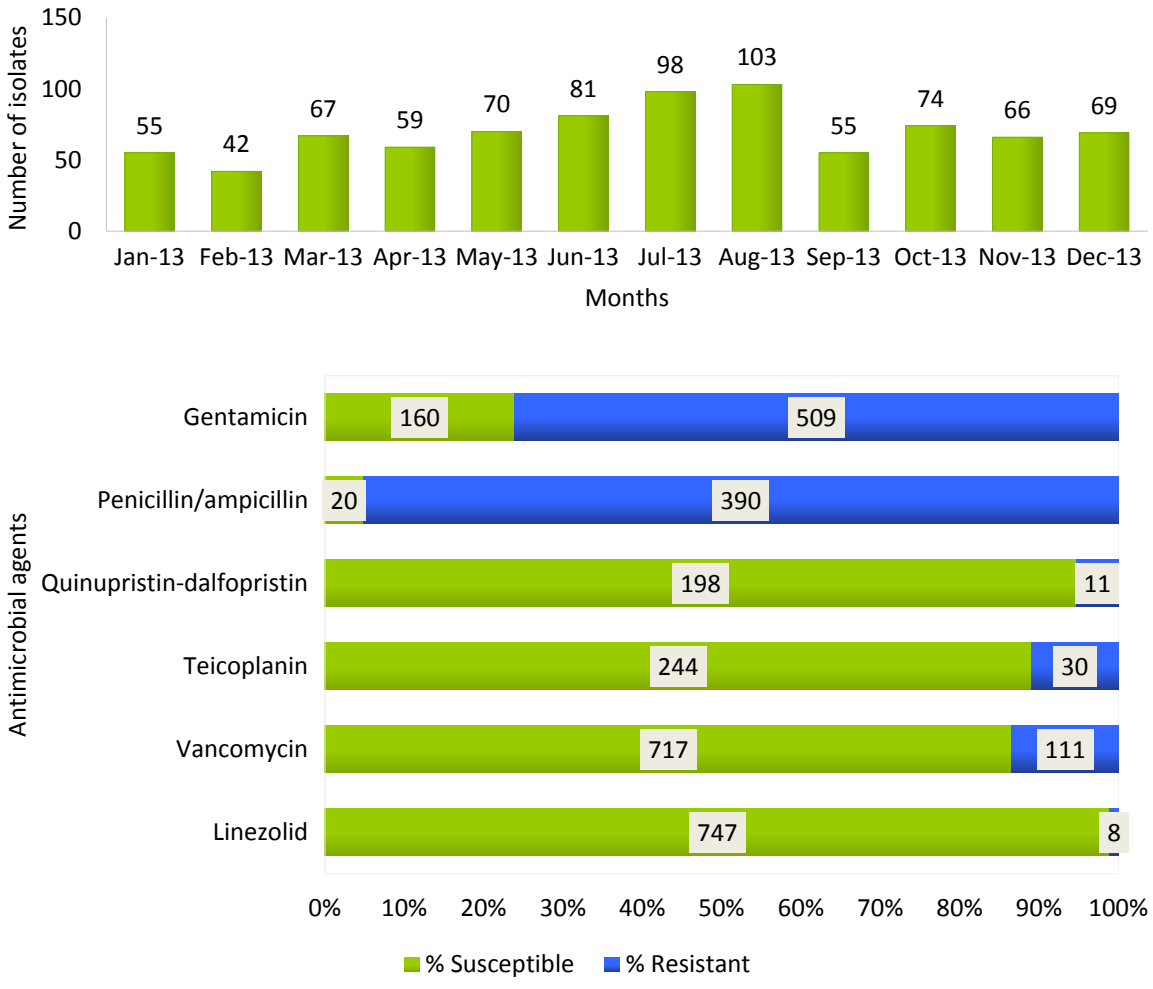


Figure 8. Number of isolates per month and susceptibility profile of *Enterococcus faecium* from blood culture at public-sector sentinel sites, 2013, Total number = 839

Table 10. Antimicrobial susceptibility of *Enterococcus faecium* by the hospital, 2013

Number of Total Cases / Susceptibility Ratio	Charlotte Maxeke hospital	Chris Hani Baragwanath hospital	Grey's hospital	Groote Schuur hospital	Helen Joseph hospital	Inkosi Albert Luthuli central hospital	RK Khan hospital	Steve Biko academic hospital
Gentamicin		295	44	59	38	43	31	80
		22%	23%	47%	37%	9%	6%	24%
Penicillin/ampicillin	62	104	43			39	33	59
	3%	5%	5%			0%	0%	5%
Quinupristin-dalfopristin	78	114						
	95%	96%						
Teicoplanin			44	58		40		60
			91%	91%		90%		75%
Vancomycin	78	302	51	59	50	55	35	80
	86%	82%	92%	93%	88%	95%	100%	71%
Linezolid	77	306	44	58	52	44		72
	97%	100%	98%	97%	98%	100%		100%

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 average of 13% of isolates from number of sentinel sites which may indicate persistence of the strains or an outbreak situation.

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.

Acknowledgements

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