Buckinghamshire Healthcare NHS Trust
Antimicrobial Susceptibility Review
January 2021-December 2021

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Objectives

1. To review patterns of antibiotic susceptibility of clinically significant isolates from blood cultures analysed at Buckinghamshire Healthcare NHS Trust (BHT).
2. To review patterns of antibiotic susceptibility of *Haemophilus influenzae* and *Streptococcus pneumoniae* isolated from sputum cultures
3. To review susceptibility patterns of organisms isolated from urine cultures sent from General practice and within secondary care
4. Compare results of this data with previous annual reviews (dated back to 2014) as well as available National data from ESPAUR 2020-2021 and 2021-2022 (English Surveillance Programme for Antimicrobial Utilisation and Resistance). The Reports are available at:
   2021:
   https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1069632/espaur-report-2020-to-2021-16-Nov-FINAL-v2.pdf
   2022:
   https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1118310/ESPAUR-report-2021-to-2022.pdf

Methods:

Data range: samples with isolates between January 1st 2021-December 31st 2021 were identified and analysed.

- Most isolates were identified using MALD-TOF.
- Sensitivity testing was done manually using the antibiotic disc diffusion method and confirmed using the BD Phoenix ™ automated AST system.
- Sensitivity breakpoints were obtained from EUCAST database. Significant organisms were pulled from the dataset and analysed.

Blood cultures:

- All positive blood cultures were retrieved from WinPath using a data retrieval tool.
- A second run was conducted to identify the Gram-Negative pathogens with Extended Spectrum Beta-Lactamase, Amp C beta lactamase and Carbapenem resistance.
- Likely contaminants such as coagulase-negative staphylococci, *Micrococcus* sp. and oral streptococci were not analysed.

Sputum cultures:

- Only sputum cultures with a growth of *Streptococcus pneumoniae* or *Haemophilus influenzae* were analysed from the data set.

Urine cultures:

- All positive urine cultures both from primary and secondary care were acquired from WinPath.
- Cultures with mixed flora and *Candida* sp were excluded.
- Community (including outpatient, GP and community Hospitals or Rehabilitation centres) and Hospitals (inpatient or acute assessment) samples were identified using the location code.
- The isolates have been analysed separately.

Colour-coding:

For ease of reading all susceptibility results are presented as below:

90-100% of isolates susceptible (green)
75-89% of isolates susceptible (orange)
50-74% of isolates susceptible (pale pink)
<50% of isolates susceptible (red)

Antibiotics have been colour-coded according to their England AWaRe classification:
Access antibiotics are in green.
Watch antibiotics are in orange.
Reserve antibiotics are in red.

Results:

Blood Culture

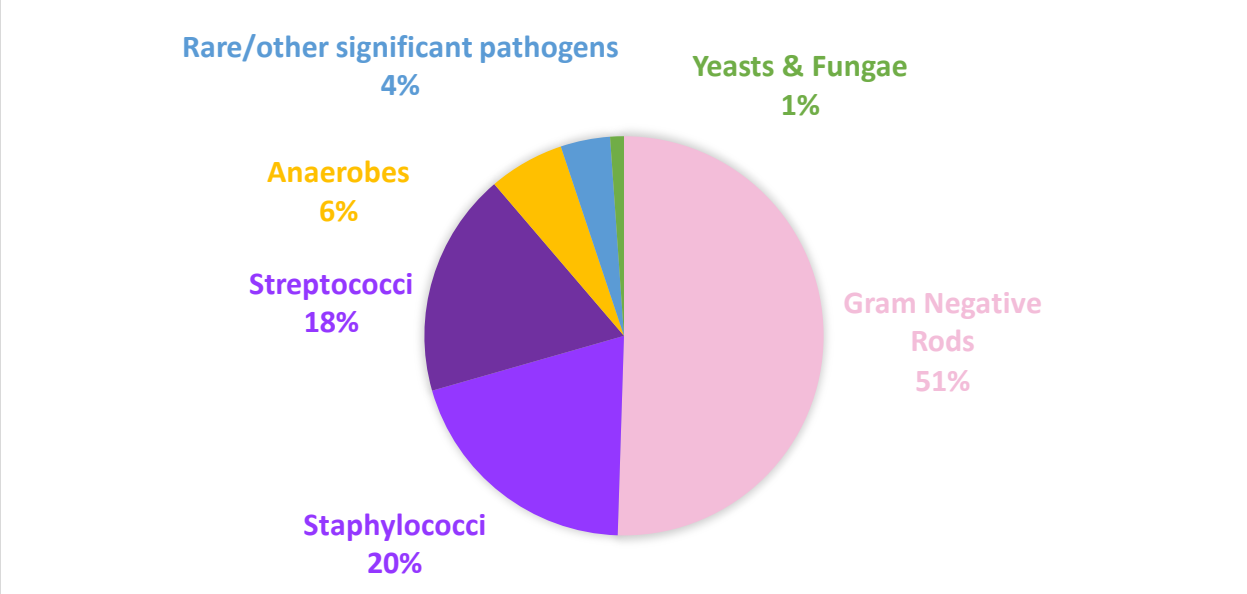
There were 1,477 blood culture positive results with 1,698 isolates. There were 915 significant isolates (53.9%) with 783 cultures containing suspected contaminant organisms, such as coagulase negative staphylococci, micrococcus and (46.1%). **Table 1** compares the average blood cultures isolates over the past 7 years. In 2021 there was an average of 4.0 positive blood cultures per day, 2.5 containing significant isolates. Due to polymicrobial blood culture results, some of these significant cultures may have also included contaminant organisms. On average 2.1 cultures flagged positive containing an insignificant (contaminant) organism; however only 1.5 cultures a day were classified as non-significant (i.e., only containing contaminant organisms).

Pie Chart 1 shows the breakdown of the significant cultures by their gram stain reading. The majority of flagged cultures were Gram Negative Rods, with E. coli the most frequently cultured organisms (27.8%), see **Table 8.**

Table 1 *Comparison of daily average blood culture isolates across years.*

	2015	2016	2017	2018	2019	2020	2021
Average BC /day	3.2	3.9	4	4.6	4.3	4.3	**4.0**
Significant	1.7	2.4	2.2	2.4	2.6	2.4	**2.5**
Non-significant	1.5	1.5	1.8	2.2	1.7	1.9	**1.5**

Pie Chart 2 *Breakdown of positive significant Blood Cultures in 2021.*



Gram Positive Blood Cultures

Table 2 shows the breakdown of the significant gram-positive isolates. The number of *Staphylococcus aureus* and remained relatively stable on last year's data; however, there were 11 MRSA isolates (6.1% of Staph aureus strains see **Pie Chart 2**) which is considerably higher than the 1.1% of 2020 data. However the 11 isolates were only from 6 patients, with one patient making up 4 isolates and another 3 of the isolates. ESPAUR 2022 data showed a stable number of MRSA bacteraemia isolates across England, and that there is an association with income inequality.

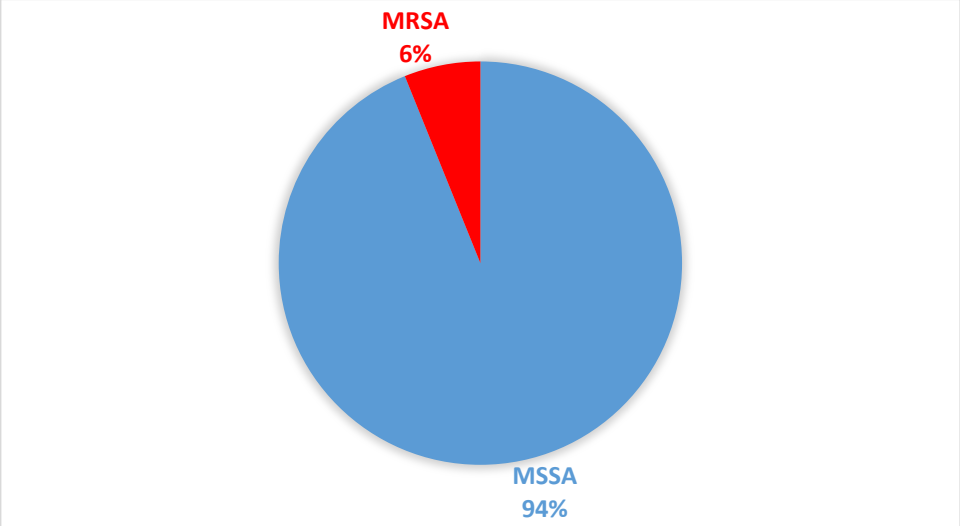
Pie Chart 3 shows the breakdown of Gram-positive Cocci in chains, even accounting for the 3 duplicated organism, Enterococci sp. make up half of these significant isolates. The number of Enterococcus isolates has decreased, although there has been a slight increase in the number of Vancomycin-resistant isolates, up by 4 isolates from 7 in 2020 and 2019.

Table 2 *Breakdown of Gram-Positive isolates Jan-Dec 2021*

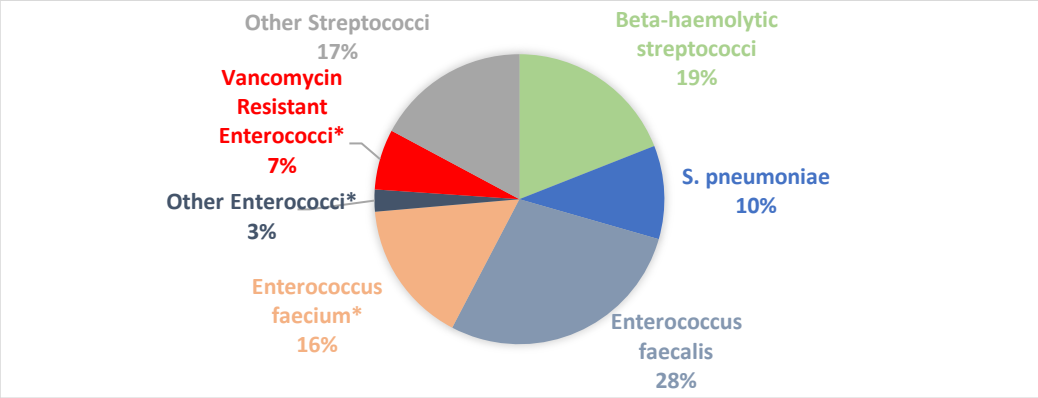
	Organism	Isolates (n)	Percentage of significant isolates (%)
Staphylococci	*S. aureus*	169	18.5
	MRSA	11	1.2
Streptococci	*Beta-haemolytic streptococci* (Group A, Group B, Group C/G)	31	3.4
	S. pneumoniae	17	1.9
	Enterococcus faecalis	46	5.0
	*Enterococcus faecium**	26	2.8
	*Other Enterococci**	4	
	Vancomycin Resistant Enterococci*	11	1.2
	Other Streptococci	28	3.5

**numbers contain duplicates (n=3), these resistant organisms have been counted twice*

Pie Chart 2 *Breakdown of the Staphylococcus aureus isolates from blood cultures in 2021.*



Pie Chart 3 *Breakdown of the Gram-positive Cocci in chains isolated from blood cultures in 2021.*



**numbers contain duplicates (n=3), these resistant organisms have been counted twice*

Staphylococcus aureus (S. aureus) isolates

Table 3 shows the susceptibility patterns for the S. aureus isolates over the past 7 years. Firstly, it is worth noting that not all 170 isolates in 2021 reported susceptibilities. As patients with an MSSA or MRSA bacteraemia often have daily blood cultures until clearance, susceptibilities from the same patient are often not repeated.

Generally, the results are similar to 2020 data, however the reduced susceptibility to Clindamycin and Erythromycin suggests an increase in resistance in S. aureus. For 2021 data the 'Susceptible Increased Exposure', reported in the lab as 'Intermediate', has been reported. This shows where the MIC is greater than the Susceptible breakpoint but below the breakpoint for resistant. Most isolates are therefore susceptible to Ciprofloxacin, but would require a high dose (e.g. 750mg PO BD).

Table 3: *Susceptibility profiles of Staphylococcus aureus in blood cultures from 2015- 2021*

	Percentage of isolates susceptible (%)								
	2021 n=170**			2020 n=175	2019 n=135	2018 n=140	2017 n=156	2016 n=164	2015 n=79
	I*	S*	**I + S**	S	S	S	S	S	S
Ciprofloxacin	82	11	**93**	99	93	92	88	90	86
Clindamycin	1	76	**77**	89	73	86	90	85	80
Gentamicin	0	97	**97**	95	95	98	99	98	96
Erythromycin	0	74	**74**	89	70	83	87	82	72
Flucloxacillin	0	93	**93**	98	96	94	92	93	95
Fusidic Acid	0	92	**92**	92	83	89	94	83	90
Penicillin	0	18	**18**	22	26	22	21	25	16
Rifampicin	0	100	**100**	96	100	98	100	100	99
Tetracycline	0	91	**91**	92	98	98	97	98	95
Trimethoprim	0	94	**94**	97	96	97	92	90	94
Vancomycin	0	100	**100**	100	100	100	100	99	100
Teicoplanin	0	100	**100**	100					
Linezolid	0	100	**100**	100	100	100	100	100	100

***I** = Susceptible Increased Exposure S= Susceptible* *** only 136 isolates had antibiotic susceptibilities reported*

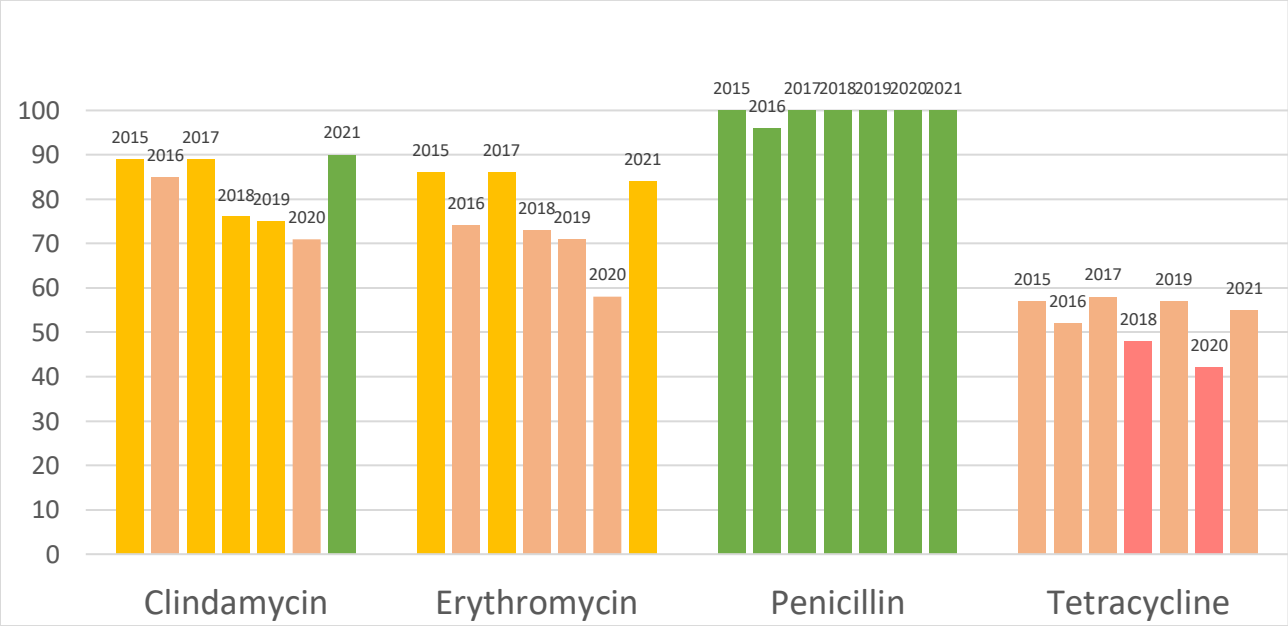
Beta-haemolytic *Streptococci* isolates

Table 4: *Susceptibility profiles of beta haemolytic Streptococci in blood cultures from 2015- 2021*

	Percentage of isolates susceptible (%)								
	2021 n=31			2020 n=34	2019 n=63	2018 n=66	2017 n=57	2016 n=46	2015 n=35
	I	S	I + S	S	S	S	S	S	S
Clindamycin	3	87	**90**	71	75	76	89	85	89
Erythromycin	0	84	**84**	58	71	73	86	74	86
Penicillin	0	10	**100**	100	100	100	100	96	100
Tetracycline	0	55	**55**	42	57	48	58	52	57

Table 4 shows the susceptibility patterns for beta haemolytic streptococci (Lancefield groups A, B, C and G). The isolates remain universally sensitive to penicillin, this data has also been shown in **Bar Chart 1**. Data from this year suggests increased susceptibility to macrolides compared to the previous years. The Group A (*Streptococcus pyogenes*) were universally sensitive to all four antibiotics, whilst the Group B (*Streptococcus agalactiae*) made up all the resistant isolates to Erythromycin and the majority were resistant to Tetracycline (80%, n=10).

Bar Chart 1: *Susceptibilities of beta haemolytic Streptococci in blood cultures from 2015- 2021(%)*



Streptococcus pneumoniae isolates

Table 5: *Susceptibility profiles of* Streptococcus pneumoniae *in blood cultures from 2015- 2021*

	Percentage of isolates susceptible (%)								
	2021 n=17			2020 n=21	2019 n=25	2018 n=30	2017 n=60	2016 n=42	2015 n=30
	I	S	I + S	S	S	S	S	S	S
Clindamycin	0	88	**88**	100	92	86	95	95	90
Erythromycin	0	87	**87**	100	92	87	93	93	87
Penicillin (Amoxicillin)	19	81	**100**	100	92	97	95	98	97
Tetracycline	0	80	**80**	81	92	90	98	88	100

Table 5 shows the susceptibility patterns for *Streptococcus pneumoniae* isolates. They remain universally sensitive to penicillin. Note there has been a drop in susceptibility to Clindamycin and Erythromycin; however the sample size is very small. Two isolates were resistant to Clindamycin and Erythromycin, the percentages varying because one isolate in the sample did not have a sensitivity reported for Erythromycin.

Enterococci isolates

The susceptibility of Enterococci isolates is shown in **Tables 6 and 7.** There were no isolates with 'Susceptible Increased Exposure' designation, all isolates were reported as either Susceptible or Resistant.

The number of Enterococci isolates from blood cultures remains stable from 2020 data, with slightly lower frequencies reported from 2021 data; however, there was a small increase in the number of Vancomycin-Resistant isolates. Trimethoprim resistance to all enterococci isolates remains high, with the percentages of susceptible isolates falling for both enterococcus faecalis and enterococcus faecium species. However interestingly amongst the Vancomycin-Resistant isolates, Trimethoprim susceptibility was higher than previous years.

There were 11 Vancomycin-resistant isolates, many of them did not give a speciation (from the given dataset), there were two Enterococus faecium and one Enterococcus gallinarum isolates which were Vancomycin-resistant; these have been included in both their individual tables and the Vancomycin-Resistant Enterococci (VRE) table. The Enterococcus gallinarum was Vancomycin-Resistant but susceptible to Teicoplanin, shown by the 9% susceptibility in the VRE table.

Table 6: *Susceptibility profiles of Enterococcus faecalis in blood cultures from 2015- 2021*

	Percentage of Enterococcus faecalis isolates susceptible (%)							Percentage of Enterococcus faecium isolates susceptible (%)						
	2021 n=46	**2020 n=51**	**2019 n=29**	**2018 n=35**	**2017 n=34**	**2016 n=34**	**2015 n=23**	**2021 n=46**	**2020 n=51**	**2019 n=47**	**2018 n=19**	**2017 n=33**	**2016 n=19**	**2015 n=26**
	S	S	S	S	S	S	S	**S**	S	S	S	S	S	S
Amoxicillin	**100**	100	100	100	100	100	100	**9**	0	0	0	0	0	8
Linezolid	**100**	100	100	100	100	100	100	**100**	100	100	100	100	100	100
Trimethoprim	**30**	45	54	52	94	79	52	**21**	35	16	26	39	45	85
Vancomycin	**100**	100	100	100	100	100	100	**91**	86	96	89	64	100	69
Teicoplanin	**100**	100	100	100	100	100	100	**91**	96	96	89	64	100	69

Table 7: *Susceptibility profiles of other Enterococci and Vancomycin Resistant Enterococci in blood cultures from 2015- 2021*

	Percentage of other Enterococci isolates susceptible (%)				Percentage of Vancomycin Resistant isolates susceptible (%)			
	2021 n=5	**2020 n=4**	**2019 n=0**	**2018 n=3**	**2021 n=11**	**2020 n=7**	**2019 n=7**	**2018 n=5**
	S	S	S	S	**S**	S	S	S
Amoxicillin	**100**	75		66	**9**	0	0	0
Linezolid	**100**	100		100	**100**	100	100	100
Trimethoprim	**50**	50		66	**70**	29	40	0
Vancomycin	**75**	50		100	**0**	0	0	0
Teicoplanin	**100**	100		100	**9**	0	0	0

Gram Negative Blood Cultures

The total number of gram-negative rod isolates was 474 (as shown in **Table 8**), a slight increase on 436 of 2020 data: however similar to the average of the past 4 years. E. coli remains the most frequent gram-negative rod isolated in blood cultures making up 54% of the isolates (see **Pie Chart 3**) with Klebsiella the second most frequent (19%). ESPAUR 2022 data showed that E. coli made up 22% of monocrobial isolates, second to coagulase negative staphylococci (CoNS 31%).

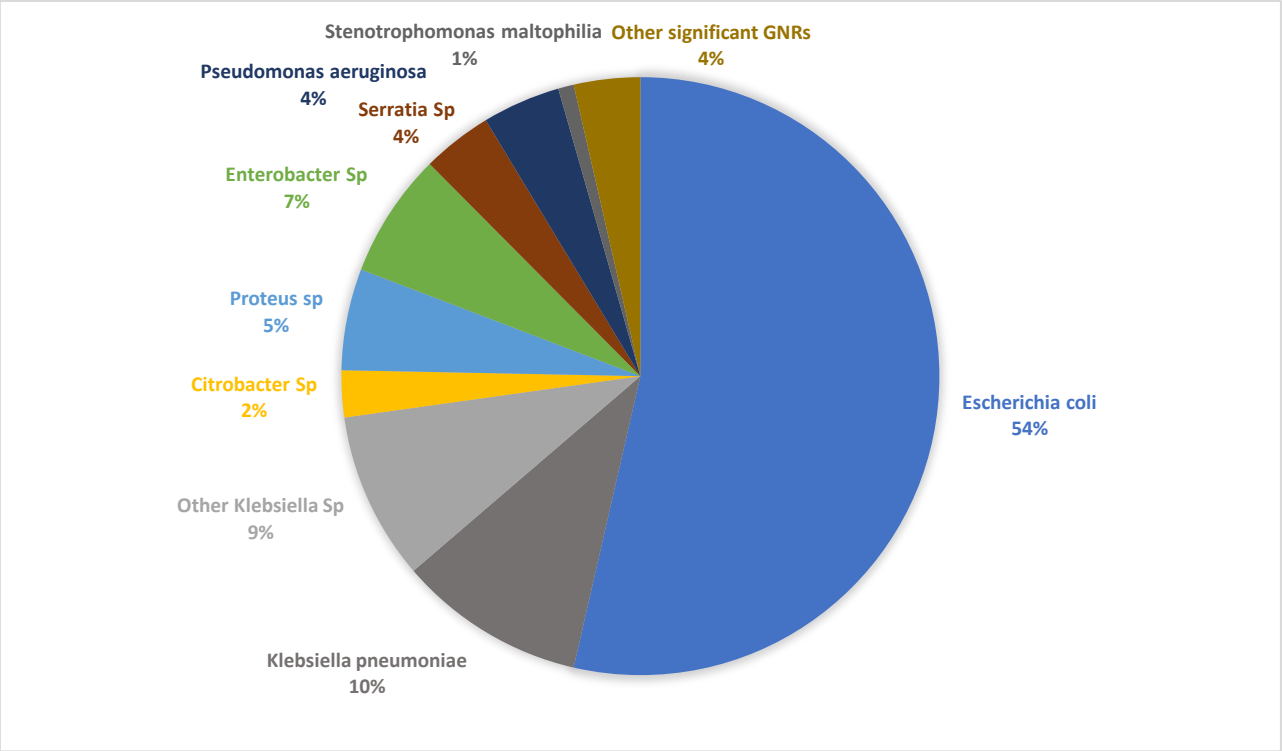
There were 32 isolates which demonstrated enzyme resistance (see **Pie Chart 4**), one E. coli showed both Extended-Spectrum Beta-Lactam (ESBL)-producing and Amp C-producing enzymes. E. coli and Enterobacter species make up 66% of the isolates expressing resistance genes, with 31% of all the Enterobacter pathogens isolated demonstrating resistant enzyme activity.

Table 8 *Breakdown of Gram-Negative and Anaerobic isolates January-December 2021*

	Organism	Isolates (n)	Percentage of significant isolates (%)
Gram Negative Rods	*Escherichia coli*	254	27.8
	Klebsiella pneumoniae	48	5.2
	Other Klebsiella Sp	43	4.7
	Citrobacter Sp	12	1.3
	Proteus sp	26	2.8
	Enterobacter Sp	32	3.5
	Serratia Sp	18	2
	Pseudomonas aeruginosa	20	2.2
	Stenotrophomonas maltophilia	4	0.4
	Other significant GNRs	17	1.9
Assorted	*Anaerobes*	41	4.5
	Yeasts & Fungae	10	1.1
	Rare/other significant pathogens	50	5.5
Resistant Enzymes	*ESBL-producing**	8	0.9
	*Amp C-producing**	23	2.5
	*Carbapenem-resistant**	2	0.2

**these organisms have been also counted in their speciation group (n=32)*

Pie Chart 3 *Breakdown of the Gram-Negative Rods isolated from blood cultures in 2021.*



Pie Chart 4 *Isolates expressing resistance enzymes from blood cultures in 2021 (n=32).*

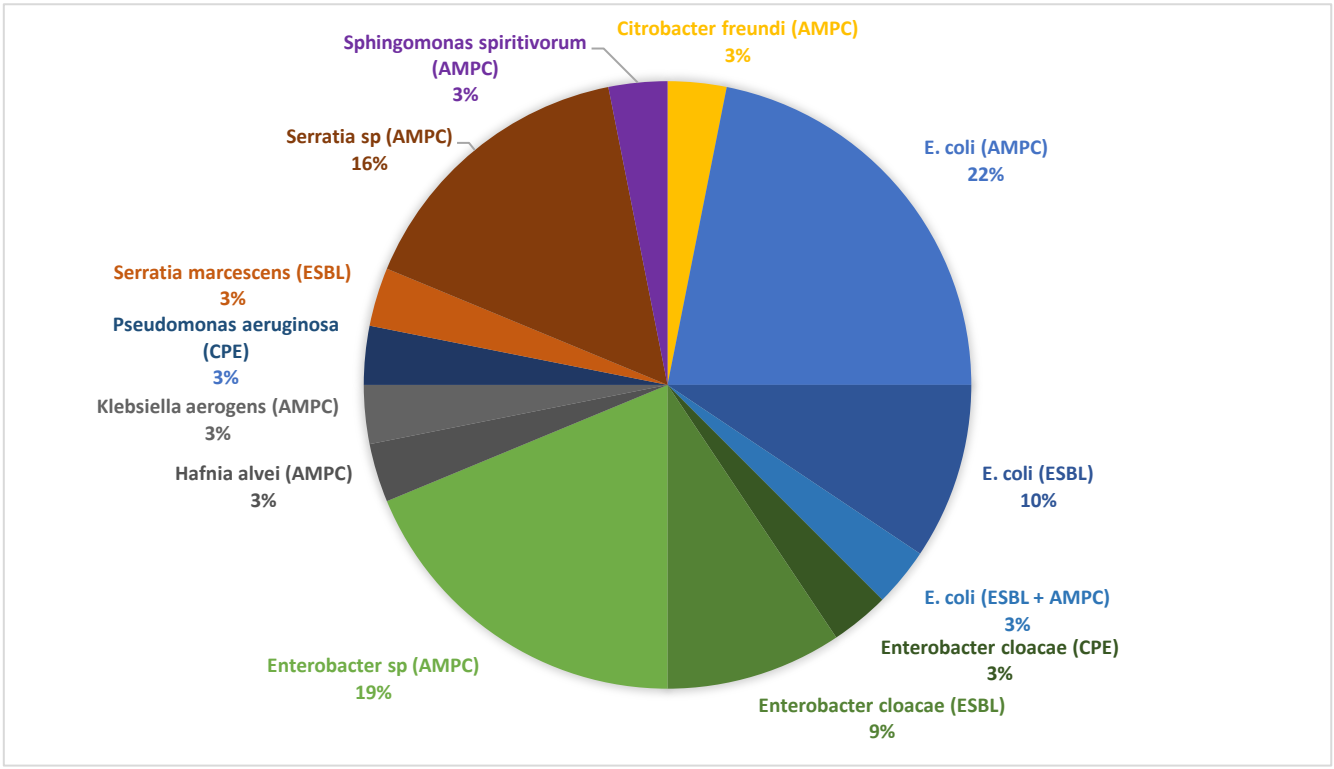
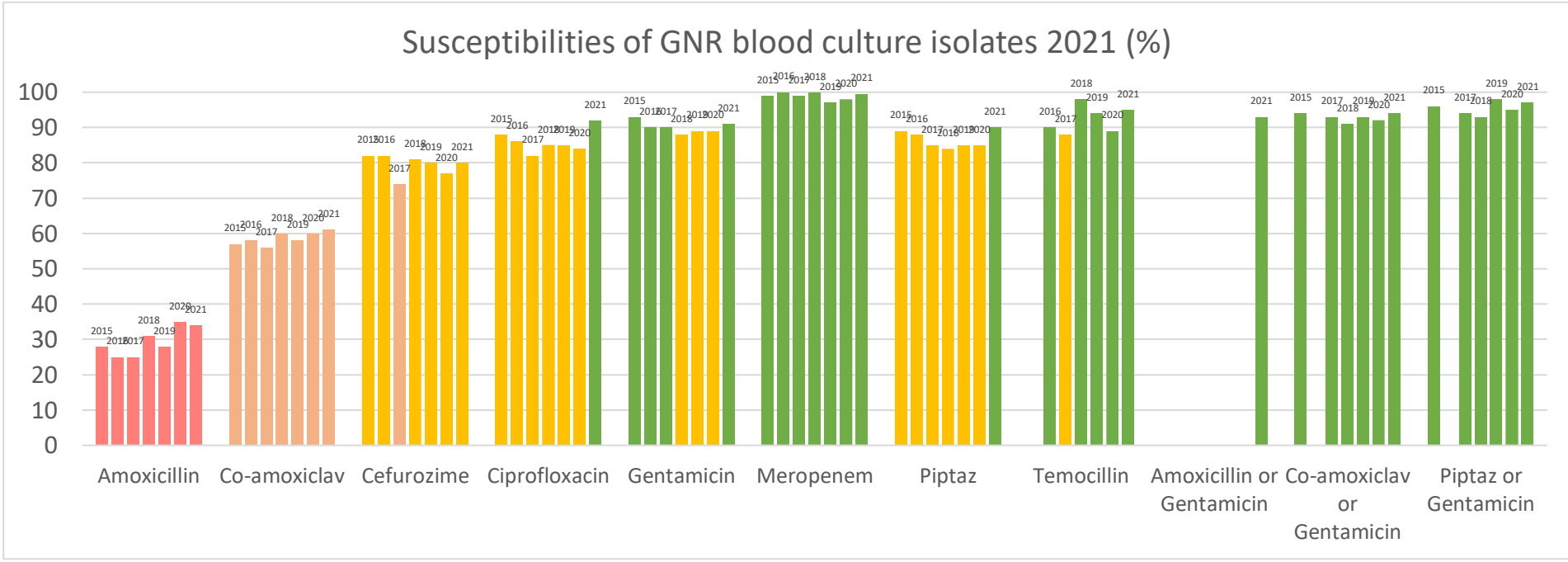


Table 9 *Susceptibility profiles of the Gram-Negative isolates in blood cultures from 2015-2021.*

	Percentage of isolates susceptible (%)								
	2021 n=474			2020 n=436	2019 n=534	2018 n=482	2017 n=550	2016 n=452	2015 n=374
	I	S	I + S	S	S	S	S	S	S
Amoxicillin	0	34	**34**	35	28	31	25	25	28
Co-amoxiclav	0	61	**61**	60	58	60	56	58	57
Cefuroxime	50	30	**80**	77	80	81	74	82	82
Ciprofloxacin	8	84	**92**	84	85	85	82	86	88
Gentamicin	0	91	**91**	89	89	88	90	90	93
Meropenem	0.2	99.3	**99.5**	98	97	99.8	99	100	99
Piperacillin-Tazobactam	6	84	**90**	85	85	84	85	88	89
Temocillin	50	44	**95**	89	94	98	88	90	
Amoxicillin or Gentamicin	1	92	**93**						
Co-amoxiclav or Gentamicin	0	94	**94**	92	93	91	93		94
Pip-Taz or Gentamicin	0.5	96	**97**	95	98	93	94		96

Table 9 shows the susceptibility profiles of all isolates, this data is also shown in **Bar Chart 2** (p12) Note that the isolates included are those organisms where the susceptibilities are reported, this number is less than 474, and varies from antibiotic. Amoxicillin resistance remains high, with over 65% of all isolates reporting resistance to Amoxicillin; however, Gentamicin susceptibility is high (91%), therefore 93% of all isolates are sensitive to either Amoxicillin or Gentamicin. In fact there is only marginal improvement with Co-amoxiclav or Gentamicin susceptibility (94%). This means the addition of empiric Gentamicin to either Amoxicillin or Co-amoxiclav should provide good cover in GNR Bloodstream Infections (BSI). There has been an increase in the susceptibility to both Ciprofloxacin and Piperacillin-tazobactam. Gentamicin and Piperacillin-tazobactam, used first line in neutropaenic sepsis at Stoke Mandeville Hospital, should have effectively treated 97% of all the GNR BSIs identified in 2021.

Bar Chart 2 *Susceptibility profiles of the Gram-Negative isolates in blood cultures from 2015-2021 (%)*



E Coli isolates

Table 10 shows the susceptibilities for E. coli. Around half of the E. coli grown in blood cultures are resistant to Amoxicillin, this is an improvement on previous years. 61% of isolates are susceptible to Co-amoxiclav, according to the latest ESPAUR data (**Table 11)** 43.7% of E. coli were resistant to Co-amoxiclav so our data reflects national data. National data suggests that E. coli Piperacillin-tazobactam resistance is around 10%, our results suggest a resistance rate of 11%, like last year slightly higher than national data, possibly reflecting local use. National resistance to Ciprofloxacin is 17.2%, local resistance is similar estimated at 17%. Reassuringly, as it is such a common cause of BSI, all of the E. coli bloodstream isolates in 2021 were susceptible to Meropenem.

Table 10: *Susceptibility profiles of E. coli in blood cultures from 2015-2021.*

	Percentage of isolates susceptible (%)								
	2021 n=254			**2020 n=262**	**2019 n=311**	**2018 n=288**	**2017 n=336**	**2016 n=312**	**2015 n=23**
	I	S	**I + S**	S	S	S	S	S	S
Amoxicillin	0	49	**49**	47	37	36	31	31	35
Co-amoxiclav	0	61	**61**	58	55	54	62	59	60
Cefuroxime	59	28	**87**	84	77	81	83	89	86
Ciprofloxacin	3	80	**83**	82	82	79	77	83	87
Gentamicin	0.4	91.5	**92**	89	86	84	90	87	92
Meropenem	0	100	**100**	100	99	100	100	100	100
Piperacillin-Tazobactam	1	88	**89**	87	81	79	83	90	88
Temocillin	53	40	**93**	93	92	98	98	98	
Amoxicillin or Gentamicin	0.4	91.5	**92**						
Co-amoxiclav or Gentamicin	0	92	**92**	89	90	87	93		94
Pip-Taz or Gentamicin			**96**	94	97	91	94	95	97

Table 11: *Trends in resistance in key drug/bug combinations in bacteraemia, 2015 to 2020, England. From ESPAUR Report 2020-2021.*

Bacteria	Antibiotics	% Resistant 2016	% Resistant 2020	P value	Trend
Escherichia coli	ciprofloxacin	18.2	18.4	0.566	
	third-generation cephalosporins	11.9	14.0	<0.001	
	gentamicin	9.8	10.4	0.022	
	carbapenems	0.1	0.2	<0.001	
	co-amoxiclav	40.0	43.7	<0.001	
	piperacillin/tazobactam	9.2	9.3	0.874	
Klebsiella pneumoniae	ciprofloxacin	9.9	14.2	<0.001	
	third-generation cephalosporins	11.1	15.2	<0.001	
	gentamicin	8.3	8.4	0.825	
	carbapenems	0.5	0.8	0.077	
	co-amoxiclav	26.1	30.5	<0.001	
	piperacillin/tazobactam	13.6	16.4	<0.001	
Klebsiella oxytoca	ciprofloxacin	2.0	1.9	0.956	
	third-generation cephalosporins	5.9	6.2	0.727	
	gentamicin	1.4	1.2	0.655	
	carbapenems	0.4	0.1	0.223	
	piperacillin/tazobactam	11.8	9.0	0.013	
Pseudomonas spp.	ceftazidime	6.4	6.8	0.530	
	carbapenems	7.9	7.6	0.614	
Acinetobacter spp.	colistin	1.7	12.2	0.294	
Streptococcus pneumoniae	penicillin	1.7	2.4	0.065	
	erythromycin	6.0	6.8	0.305	
Enterococcus spp.	glycopeptides	15.1	15.0	0.878	

Other Enterobacteriaceae isolates

The susceptibilities of other Enterobacteriaceae including Klebsiella, Citrobacter, Proteus, Enterobacter and Serratia species have been shown **Tables 12** and **13**. With the exception of the Proteus isolates, all are very resistant to Amoxicillin. Local Klebsiella pneumoniae resistance patterns can be compared to ESPAR 2021 national data in **Table 11.** Although small numbers, local Co-amoxiclav resistance is estimated at 21%, which is lower than 30.5% reported in the National data. Local Piperacillin-tazobactam resistance is 14%, nationally it has been reported at 16.4% in 2021, and increased to 18.3% in 2022.

Of the Citrobacter species isolates, the majority were Citrobacter koseri, with only one isolate identified as Citrobacter freundii, this may explain the high beta-lactam susceptibility (91% susceptible to Co-amoxiclav and 100% susceptible to Piperacillin-tazobactam); given that Citrobacter freundii is a identified as a moderate to high risk of producing clinically significant AmpC enzyme.

25 out of the 26 isolates were Proteus mirabilis. ESPAUR data has shown that the Gentamicin resistance in Proteus mirabilis is increasing (7.5% in 2019, to 11.9% in 2021), although this report cannot show a local trend, resistance in 2021 was 40%. This is very high and should be noted. However reassuringly 96% of isolates were susceptible to either Co-amoxiclav or Gentamicin.

Table 12: Susceptibility profiles Klebsiella and Citrobacter blood culture isolates 2020-2021.

	Percentage of isolates susceptible (%)								
	Klebsiella pneumoniae n=48			Other Klebsiella species n=43			Citrobacter species n=12		
	I	S	I + S	I	S	I+S	I	S	I+S
Amoxicillin	0	2	**2**	0	3	**3**	0	0	**0**
Co-amoxiclav	0	79	**79**	0	80	**80**	0	91	**91**
Cefuroxime	53	30	**84**	33	50	**83**	18	64	**82**
Ciprofloxacin	7	81	**88**	0	97	**97**	0	100	**100**
Gentamicin	0	93	**93**	0	100	**100**	0	100	**100**
Meropenem	0	100	**100**	0	100	**100**	0	100	**100**
Piperacillin-Tazobactam	0	86	**86**	0	93	**93**	0	100	**100**
Temocillin	43	57	**100**	50	50	**100**	33	67	**100**
Amoxicillin or Gentamicin	0	93	**93**	0	100	**100**	0	100	**100**
Co-amoxiclav or Gentamicin	0	95	**95**	0	100	**100**	0	100	**100**
Pip-Taz or Gentamicin	0	95	**95**	0	100	**100**	0	100	**100**

Table 13: *Susceptibility profiles of Proteus, Enterobacter and Serratia blood culture isolates in 2020-2021.*

	Percentage of isolates susceptible (%)								
	Proteus Species n=26			Enterobacter Species n=32			Serratia Species n=18		
	I	S	I + S	I	S	I + S	I	S	I + S
Amoxicillin	**0**	60	**60**	0	0	**0**	0	0	**0**
Co-amoxiclav	**0**	80	**80**	0	0	**0**	0	0	**0**
Cefuroxime	63	39	**92**	5	14	**19**	0	0	**0**
Ciprofloxacin	0	92	**92**	9	83	**91**	0	100	**100**
Gentamicin	4	56	**60**	0	91	**91**	0	100	**100**
Meropenem	0	100	**100**	0	96	**96**	8	92	**100**
Piperacillin-Tazobactam	0	100	**100**	0	83	**83**	0	100	**100**
Temocillin	43	57	**100**	50	44	**94**	25	50	**75**
Amoxicillin or Gentamicin	4	84	**88**	0	91	**91**	0	100	**100**
Co-amoxiclav or Gentamicin	0	96	**96**	0	91	**91**	0	100	**100**
Pip-Taz or Gentamicin	0	100	**100**	0	91	**91**	0	100	**100**

Pseudomonas aeruginosa isolates

The susceptibility profiles for Pseudomonas aeruginosa isolates are shown in **Table 14.** The susceptibilities have improved on previous years, although note the relatively small numbers of isolates. There was one isolate which was sensitive to gentamicin but resistant to all other isolates reported, and one isolate which was Gentamicin only resistant. In line with EUCAST updates, the majority of isolates have been reported as I for Ciprofloxacin, Piperacillin-tazobactam and Ceftazidime. ESPAUR data reported that nationally 6.8% P. aeruginosa isolates were resistant to Ceftazidime in 2020 (see **Table 11**), and a declining trend in Ciprofloxacin resistance (from 8.2% in 2017 to 6.9% in 2021).

Table 14: *Susceptibility profile of Pseudomonas aeruginosa blood culture isolates in 2020-2021.*

	Percentage of isolates susceptible (%)								
	2021 n=20			2020 n=35	2019 n=42	2018 n=29	2017 n=38	2016 n=24	2015 n=35
	I	S	I + S	S	S	S	S	S	S
Ciprofloxacin	85	10	95	91	90	96	95	92	97
Gentamicin	0	95	95	97	90	100	100	96	100
Meropenem	0	95	95	88	76	96	89	96	97
Piperacillin-tazobactam	95	0	95	91	85	96	97	91	97
Ceftazidime	85.7	9.5	95						
Co-amoxiclav or Gentamicin	0	95	95	97	90	100	100		100
Pip-Taz or Gentamicin	5	95	100	97	98	100	100		100

Anaerobic isolates

Anaerobic isolates were made up of a mixture of Actinomyctes sp., Prevotella sp., Bacteroides sp, Clostridium sp., Fusobacterium sp. and unnamed anaerobes, with MALDI-TOF identification often providing speciation. The number of anaerobic isolates has remained steady. Metronidazole susceptibility is reported at 81% for 2021, which is an improvement on 2020 data, but still down compared with historical data. Susceptibility to Meropenem remains unchanged, however there has been a drop in the Co-amoxiclav susceptibility this year.

Table 15: *Susceptibility profile of Anaerobic blood culture isolates in 2015-2021.*

	Percentage of isolates susceptible (%)								
	2021 40			**2020 n=47**	**2019 n=21**	**2018 n=27**	**2017 n=20**	**2016 n=24**	**2015 n=29**
	I	S	**I + S**	S	S	S	S	S	S
Clindamycin	0	86	**86**	77	84	76	70	63	67
Co-amoxiclav	0	92	**92**	97	100	95	100	92	95
Meropenem	0	97	**97**	94	100	95	100	92	96
Metronidazole	0	81	**81**	72	95	91	100	96	96
Penicillin	5	45	50	50	52	38	35	25	28

Sputum

There were 1,570 positive sputum cultures in 2021. However, of these only 146 were *Haemophilus influenzae* or *Streptococcus pneumoniae*. Overall, the number of isolates continues to fall. The susceptibility for *S. pneumoniae* (shown in **Table 16)** is similar to last year, although there has been a drop in the susceptibility to Tetracyclines. Reassuringly 100% of the isolates were amoxicillin and ceftriaxone sensitive. Conversely 100% of the *H. influenzae* isolates were susceptible to Tetracycline. The susceptibilities are shown in **Table 17**, the pattern remains stable, with slight improvement in susceptibility from 2020, although note there are fewer isolates.

Streptococcus pneumoniae (S. pneumoniae) isolates

Table 16: *Susceptibility profile of Streptococcus pneumoniae sputum isolates in 2016-2021.*

	Percentage of isolates susceptible (%)							
	2021 n=39			**2020 n=40**	**2019 n=76**	**2018 n=52**	**2017 n=66**	**2016 n=44**
	I	S	**I + S**	S	S	S	S	S
Amoxicillin	3	97	**100**	94	95	94		90
Clarithromycin	0	73	**73**	72	80	78		82
Erythromycin	0	73	**73**	72	79	85	89	70
Penicillin	8	92	**100**	90	95	94	91	80
Tetracycline	0	72	**72**	85	87	88	95	73
Ceftriaxone	3	97	**100**	97	95	95		

Haemophilus influenzae (H. influenzae) isolates

Table 17: *Susceptibility profile of Streptococcus pneumoniae sputum isolates in 2016-2021.*

	Percentage of isolates susceptible (%)							
	2021 n=107			**2020 n=162**	**2019 n=323**	**2018 n=272**	**2017 n=306**	**2016 n=196**
	I	S	**I + S**	S	S	S	S	S
Amoxicillin	54	4	**58**	56	66	60	61	70
Co-amoxiclav	69	0	**69**	64	79	81	87	86
Clarithromycin	59	5	**64**	56	3	9	17	21
Moxifloxacin	0	95	**95**	97	99	99	98	98
Tetracycline	1	99	**100**	98	98	98	98	98

Urine

There were 16,853 urine samples included in the original data sweep. Of these 2,849 were from Inpatient settings (including wards, theatres, acute assessment areas and A&E), 356 samples were excluded as they were candida or mixed faecal flora, leaving 2493 isolates analysed as Hospital samples. The majority (13,524) of samples came from the community (including GP surgery, Sexual health centres, outpatient departments, Prisons, Community Hospital and rehabilitation settings), 316 urines were excluded from analysis as they were candida or mixed faecal flora, leaving 13,208 isolates analysed as Community samples. There were a further 480 samples that were excluded as they were 'unknown'.

Tables 18 and **19** show the breakdown of urine isolates in the Hospital (inpatient) and Community (outpatient) samples respectively. Numbers can be compared to the previous 5 years. Notably there are fewer isolates from Hospital patients than Community patients, however data may be subject to auditor interpretation of the codes used by the laboratory as it was a manual process to filter the samples as Hospital or Community. In general, the percentages are fairly stable, note that proteus has been included separately as it is not a coliform, but is a significant isolate.

Table 18: *Breakdown of urine culture isolates received from Hospitalised patients*

Organism type	2014/15		2016/17		2018		2019		2020		2021	
	n	%	n	%	n	%	n	%	n	%	n	%
E. coli	2506	54	3634	65	2139	54	1732	52	1752	47	1204	48
Other coliforms	728	15	406	7	788	20	666	20	656	18	356	14
Pseudomonas aeruginosa	259	6	343	5	206	5	188	6	242	6	194	8
Enterococcus species	720	16	787	12	545	14	358	11	484	13	299	12
Staphylococcus species	194	4	233	4	123	3	131	4	164	4	99	4
Proteus species											168	7
Other	228	5	432	7	141	4	248	7	436	12	173	7
Total	4635		5835		3942		3309		3734		**2493**	

Table 19*: Breakdown of urine culture isolates received from Community patients*

Organism type	2014/15		2016/17		2018		2019		2020		2021	
	n	%	n	%	n	%	n	%	n	%	n	%
E. coli	11360	69	15219	76	9617	68	9714	66	6857	63	7868	60
Other coliforms	1928	12	1010	5	1846	13	2219	15	1778	16	1524	11
Pseudomonas aeruginosa	342	2	408	2	254	2	288	2	303	3	415	3
Enterococcus species	1990	12	2126	11	1723	12	1535	10	1115	10	1517	12
Staphylococcus species	384	2	419	2	230	2	295	2	296	3	460	3
Proteus species											650	5
Other	542	3	391	2	568	4	779	5	548	5	774	6
Total	16546		19573		14238		14821		10,897		**13,208**	

Tables 20 shows the susceptibility profiles of all Hospitalised patients over the past 6 years. In general, the resistance pattern is fairly stable, with a little over half the isolates being resistant to Amoxicillin, and a quarter resistant to Co-amoxiclav. If we compare this to the **Table 21**, the susceptibility improves in the community: Amoxicillin susceptibility 55% in Community vs 47% in Hospitalised patients and Co-amoxiclav 84% vs 76. This may reflect more frequent exposure to antibiotics in inpatients, and/or nosocomial resistant infection. There has been an increase in Nitrofurantoin and Trimethoprim resistance in both Hospitalised and Community samples, with susceptibility to Nitrofurantoin dropping to 88% in Community samples. Notably Fosfomycin susceptibility is high (above 90%) in all samples, however not all isolates report susceptibility so the numbers are based on a smaller sample set.

***Table 20**: Breakdown of the urine culture susceptibilities of all Hospitalised (in)patients from 2016-2021.*

	Percentage of isolates susceptible (%)							
	2021 n=2493			2020 n=3729	2019 n=3309	2018 n=3942	2017 n=6459	2016 n=4635
	I	S	I + S	S	S	S	S	S
Amoxicillin	0	47	47	49	60	51	49	48
Co-amoxiclav	0	76	76	78	91	78	88	84
Cefalexin/Cephradine	0	65	65	65	81	98	67	64
Ciprofloxacin	9.7	63.7	73	73	71	70	72	72
Gentamicin	0	75	75	71	85	72	74	74
Nitrofurantoin	0	83	83	86	89	87	86	87
Trimethoprim	0.1	71.9	72	75	75	70	69	65
Mecillinam	0	69	69	58	78	71	71	
Fosofomycin	0	93	93	88	92	89		

***Table 21**: Breakdown of the urine culture susceptibilities of all Community (out)patients from 2016-2021.*

	Percentage of isolates susceptible (%)							
	2021 n=13151			2020 n=10,897	2019 n=14,821	2018 n=14,238	2017 n=19,982	2016 n=16,546
	I	S	I + S	S	S	S	S	S
Amoxicillin	0	55	55	48	61	55	52	51
Co-amoxiclav	0	84	84	84	93	85	93	90
Cefalexin/Cephradine	0	71	71	74	90	99	75	73
Ciprofloxacin	5.6	72.4	78	79	77	79	80	78
Gentamicin	0	80	80	81	95	80	82	81
Nitrofurantoin	0	88	88	90	91	91	91	92
Trimethoprim	0	77	77	82	74	74	70	66
Mecillinam	0	75	75	70	78	79	80	
Fosofomycin	0	94	94	89	85	90		

Tables 22 shows the susceptibility of E. coli isolates from Hospitalised patients over the past 6 years. In general, the resistance pattern is fairly stable, although resistance to Co-amoxiclav has increased. **Table** 23 shows that Community Co-amoxiclav susceptibility is stable, however. Reassuringly 97% of all E. coli isolates are susceptible to Nitrofurantoin. Trimethoprim resistance has not changed, with over a quarter of all E. coli urine isolates being reported as resistant. Samples from the Community demonstrate less resistance to antimicrobials than samples from Hospitalised patients.

***Table 22**: Breakdown of the susceptibilities of the E. coli urine culture isolates from Hospitalised (in)patients from 2016-2021.*

	Percentage of isolates susceptible (%)							
	2021 n=1204			**2020 n=1752**	**2019 n=1731**	**2018 n=2139**	**2017 n=3634**	**2016 n=2506**
	I	S	**I + S**	S	S	S	S	S
Amoxicillin	0	45	45	41	48	42	36	42
Co-amoxiclav	0	73	**73**	78	82	75	91	90
Cefalexin/Cephradine	0	77	**77**	80	68		82	88
Ciprofloxacin	0	87	87	88	89	86	72	80
Gentamicin	0	90	**90**	91	89	90	93	91
Nitrofurantoin	0	97	**97**	98	97	97	96	97
Trimethoprim	0	73	73	72	63	68	70	62
Mecillinam	0	85	85	79	91	88	89	
Fosofomycin	0	99	99	99	100	96		

***Table 23**: Breakdown of the susceptibilities of the E. coli urine culture isolates from the Community (out)patients from 2016-2021.*

	Percentage of isolates susceptible (%)							
	2021 n=7823			**2020 n=6857**	**2019 n=9714**	**2018 n=9617**	**2017 n=15219**	**2016 n=11360**
	I	S	**I + S**	S	S	S	S	S
Amoxicillin	0	52	**52**	44	53	51	44	46
Co-amoxiclav	0	82	**82**	83	83	83	93	93
Cefalexin/Cephradine	0	81	**81**	85	88		88	91
Ciprofloxacin	0	92	**92**	91	92	92	92	84
Gentamicin	0	95	**95**	95	95	94	95	94
Nitrofurantoin	0	97	**97**	98	99	98	97	98
Trimethoprim	0	75	**75**	72	72	71	69	63
Mecillinam	0	89	**89**	83	89	92	91	
Fosofomycin	0	97	**99**	99	97	97		

Summary Points

Blood cultures

- There has been an increase in the number of VRE isolates reported in 2021, compared to 2020. However numbers remain small.
- There is increased resistance to Clindamycin and Erythromycin in Staphylococcus aureus isolates and Streptococcus pneumoniae. Beta haemolytic streptococci such as Group B and C/G demonstrate high resistance to tetracyclines.
- All Group A streptococci isolates were fully susceptible.
- Susceptibility to Gram-Negative Rods remains stable, with 93% of all Gram-Negative organisms with susceptibilities reported, being reported as susceptible to either Amoxicillin or Gentamicin. This high number is a reflection of high susceptibility to Gentamicin.
- Proteus species demonstrated a 40% resistance to Gentamicin, however susceptibility to Amoxicillin was 60%, so overall 88% were reported as susceptible to either Amoxicillin or Gentamicin.
- Pseudomonas susceptibilities are high (all >90%), and largely unchanged from previous years.
- Similarly anaerobic susceptibility pattern is static.

Sputums

- The number of Streptococcus pneumoniae and Haemophilus influenzae isolates continues to fall, however susceptibility remains broadly stable. There is an increase in resistance to Tetracyclines, however note this has not been observed in the blood culture isolates.

Urines

- The majority of urine samples come from community settings rather than from hospitalised patients.
- Isolates from hospitalised patients show increased resistance to all antibiotics compared with isolates from patients in the community, for example 55% of isolates from the community are susceptible to Amoxicillin, compared with 47% of isolates from hospitalised patients.
- Generally, susceptibility patterns are stable. There has been a small increase in the overall resistance to Trimethoprim and Nitrofurantoin (all pathogens), though E. coli remains universally sensitive to Nitrofurantoin; susceptibilities of 97% reported from both Hospital and Community samples.