Summary Report on Antimicrobial Resistance in Public Hospitals Report 2018

Infection Control Branch
Centre for Health Protection
Department of Health

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Executive summary

1. The emergence of antimicrobial resistance (AMR) makes regular treatments of infections less effective and more expensive. It is affecting many parts of the world, including both developing and developed countries.

2. The Government of the Hong Kong Special Administrative Region recognised the threat of AMR and issued the Hong Kong Strategy and Action Plan on Antimicrobial Resistance (2017-2022) after considering the views of various experts and stakeholders from relevant fields. One of the recommended actions is to strengthen AMR surveillance in healthcare settings in alignment with international standards, i.e. the Global Antimicrobial Resistance Surveillance System (GLASS) from the World Health Organization (WHO).

3. Hospital Authority (HA) is the Government-funded body to manage all the public hospitals and a number of general and specialist out-patient clinics in Hong Kong. It has an advanced information system capturing the clinical and laboratory data of its patients.

4. With the help and support of the Information Technology and Health Informatics Division of HA, laboratory data with antimicrobial susceptibility test results of isolated pathogens and demographic data from patients with blood culture specimens were extracted and provided to the Department of Health (DH) for analysis.

5. This report summarises the findings of the surveillance exercise using existing blood culture data from year 2012 to 2018.

Overview of results

6. During the surveillance period, total number of patients with blood culture specimen collected was on the rise from 123,000 in year 2012 to 159,000 in year 2018. Over half of those specimens were collected among patients aged 65 or above.

7. The annual blood culture positive rate during the surveillance period ranged from 10.1% to 11.1%. Patients aged 65 or above had the highest positive rate for blood culture specimen of community-onset (CO), hospital-onset (HO) and undifferentiated location of onset (UO).

8. Distribution of patients with these organisms isolated from blood culture specimen remained similar. In year 2018, the three commonest WHO GLASS priority organisms were *Escherichia coli* (CO: 46.4%; HO: 24.8%), *Klebsiella pneumoniae* (CO: 11.6%; HO: 10.3%) and *Staphylococcus aureus* (CO: 8.4%; HO: 17.9%).

9. Generally speaking, among blood culture specimens collected in public hospitals, the non-susceptibility percentages on majority of different antimicrobials for the six WHO GLASS priority organisms remained stable or with slight decreasing trends during the surveillance period. However, increasing trends of non-susceptibility percentage was also observed among several pathogen-antimicrobial combinations that may warrant further monitoring.

10. Below are some of the highlights of non-susceptibility findings for the six WHO GLASS priority organisms. All trends on non-susceptibility percentage mentioned here imply the presence of statistical significance, and are referring to the period of year 2012-2018 unless otherwise specified.

11. ***Escherichia coli*** (*E. coli*): In general, non-susceptibility percentages on different antimicrobials were lower among *E. coli* isolates of community-onset than those of hospital-onset. Decreasing trends with statistical significance were observed for amoxicillin/clavulanate[1,2], piperacillin/tazobactam[3,4], gentamicin[5,6] and amikacin[7,8] among the isolates of both community- and hospital-onset, and cefuroxime[9], cefotaxime[10], ceftazidime[11] and levofloxacin[12] among isolates of hospital-onset. Non-susceptibility percentage for cefepime[13,14] showed an increasing trend with statistical significance for isolates of community-onset, but such trend was not observed for isolates of hospital-onset. When adopting year 2016 data as the baseline, a decreasing trend with statistical significance was observed for piperacillin/tazobactam for isolates of both community- and hospital-onset, while trends on non-susceptibility percentage of antimicrobials above-mentioned remained stable.

[1] Non-susceptibility percentage (NS%) of amoxicillin/clavulanate for *E. coli* of community-onset ranged from the lowest 25.4% in year 2018 to the highest 32.5% in year 2013.

[2] NS% of amoxicillin/clavulanate for *E. coli* of hospital-onset ranged from the lowest 38.3% in year 2017 to the highest 47.1% in year 2013.

[3] NS% of piperacillin/tazobactam for *E. coli* of community-onset ranged from the lowest 3.7% in year 2018 to the highest 7.2% in year 2016.

[4] NS% of piperacillin/tazobactam for *E. coli* of hospital-onset ranged from the lowest 9.0% in year 2018 to the highest 15.1% in year 2012.

[5] NS% of gentamicin for *E. coli* of community-onset ranged from the lowest 28.2% in year 2018 to the highest 31.2% in year 2012.

[6] NS% of gentamicin for *E. coli* of hospital-onset ranged from the lowest 32.7% in year 2018 to the highest 39.5% in year 2012.

[7] NS% of amikacin for *E. coli* of community-onset ranged from the lowest 0.4% in year 2018 to the highest 1.4% in year 2013.

[8] NS% of amikacin for *E. coli* of hospital-onset ranged from the lowest 1.3% in year 2017 to the highest 3.1% in year 2012.

[9] NS% of cefuroxime for *E. coli* of hospital-onset ranged from the lowest 38.4% in year 2017 to the highest 48.6% in year 2012.

[10] NS% of cefotaxime for *E. coli* of hospital-onset ranged from the lowest 35.6% in year 2017 to the highest 44.4% in year 2012.

[11] NS% of ceftazidime for *E. coli* of hospital-onset ranged from the lowest 18.3% in year 2018 to the highest 27.2% in year 2012.

[12] NS% of levofloxacin for *E. coli* of hospital-onset ranged from the lowest 39.5% in year 2017 to the highest 49.7% in year 2013.

[13] NS% of cefepime for *E. coli* of community-onset ranged from the lowest 12.5% in year 2013 to the highest 24.0% in year 2015.

[14] Readers should take note of a new (revised) cefepime interpretive criterion for *E. coli* was released by Clinical Laboratory Standards Institute (CLSI) in year 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility percentage.

12. ***Klebsiella pneumoniae*** (*K. pneumoniae*): Non-susceptibility percentages on different antimicrobials were generally lower among *K. pneumoniae* isolates of community-onset than those of hospital-onset. Increasing trends with statistical significance were observed for ciprofloxacin[15] and levofloxacin[16] for isolates of hospital-onset, and cefepime[17,18,19] for isolates of both community- and hospital-onset. When adopting year 2016 data as the baseline, trends on non-susceptibility percentage of antimicrobial above-mentioned remained stable. For carbapenems, the non-susceptibility percentages showed a significant increase from less than one percent in year 2017 to more than three percent in year 2018 for both imipenem[20] and meropenem[21] for isolates from hospital-onset specimens.

13. ***Staphylococcus aureus*** (*S. aureus*): Non-susceptibility percentage on oxacillin was higher among *S. aureus* isolates of hospital-onset than those of community-onset. Trend on non-susceptibility for oxacillin remained stable during the period of year 2012-2018 and 2016-2018. None of the tested isolates were non-susceptible towards vancomycin.

14. ***Salmonella*** **species**[22] (*Salmonella* spp.): Non-susceptibility percentage for ampicillin[23], ciprofloxacin[24,25] and levofloxacin[26,27] showed increasing trends with statistical significance from year 2012 to 2018. These trends were not observed when year 2016 data was adopted as the baseline.

[15] NS% of ciprofloxacin for *K. pneumoniae* of hospital-onset ranged from the lowest 18.4% in year 2012 to the highest 46.7% in year 2018.
[16] NS% of levofloxacin for *K. pneumoniae* of hospital-onset ranged from the lowest 12.8% in year 2012 to the highest 22.8% in year 2017.
[17] NS% of cefepime for *K. pneumoniae* of community-onset ranged from the lowest 4.8% in year 2012 to the highest 8.4% in year 2016.
[18] NS% of cefepime for *K. pneumoniae* of hospital-onset ranged from the lowest 9.3% in year 2013 to the highest 22.2% in year 2017.
[19] Readers should take note of a new (revised) cefepime interpretive criterion for *K. pneumoniae* was released by CLSI in year 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility percentage.
[20] NS% of imipenem for *K. pneumoniae* of hospital-onset ranged from 0.5% in year 2017 to 3.2% in year 2018.
[21] NS% of meropenem for *K. pneumoniae* of hospital-onset ranged from 0.4% in year 2017 to 3.9% in year 2018.
[22] *Salmonella* species and *Streptococcus pneumoniae* are pathogens primarily causing community-acquired infections. They are rare to cause hospital-associated infections. Hence, information on location of onset was not considered when analysing and interpreting non-susceptibility results of these two organisms. For administrative convenience, these NS results were interpreted as isolates of undifferentiated location of onset.
[23] NS% of ampicillin for *Salmonella* spp. ranged from the lowest 35.0% in year 2012 to the highest 62.4% in year 2016.
[24] NS% of ciprofloxacin for *Salmonella* spp. ranged from the lowest 51.9% in year 2012 to the highest 76.4% in year 2017.
[25] Readers should take note of a new ciprofloxacin interpretive criterion for *Salmonella* spp. was released in year 2012, and modified recommendations to use the separate interpretive criteria were released by CLSI in year 2013, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility percentage.
[26] NS% of levofloxacin for *Salmonella* spp. ranged from the lowest 0% in year 2013 to the highest 86.4% in year 2017.
[27] Readers should take note of a new levofloxacin interpretive criterion for *Salmonella* spp. was released by CLSI in year 2013, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility percentage.

15. ***Acinetobacter* species** (*Acinetobacter* spp.): Non-susceptibility percentages on different antimicrobials were generally lower among *Acinetobacter* spp. isolates of community-onset than those of hospital-onset from year 2012 to 2018. Decreasing trends with statistical significance were observed for minocycline[28], gentamicin[29] and amikacin[30] for isolates of hospital-onset. When adopting year 2016 data as the baseline, trends on non-susceptibility percentage of antimicrobial above-mentioned remained stable for isolates of both community- and hospital-onset.

16. ***Streptococcus pneumoniae***[31] (*S. pneumoniae*): Non-susceptibility percentages for co-trimoxazole[32] showed an increasing trend with statistical significance from year 2012 to 2018. The trend was not observed when year 2016 data was adopted as the baseline.

Discussion and conclusion

17. Among blood culture specimens collected from year 2012 to 2018, non-susceptibility percentages on majority of different antimicrobials for the six WHO GLASS priority organisms remained stable or with a slight decreasing trend during the surveillance period.

18. However, increasing trends were observed among several pathogen-antimicrobial combinations. In particular, trends of non-susceptibility percentages for carbapenems among *Klebsiella pneumoniae* warrant further monitoring.

19. Surveillance of AMR contributes to the understanding of AMR situation and for monitoring the effectiveness of measures implemented. This surveillance exercise helps to contribute to the understanding of the AMR situation in Hong Kong.

20. AMR remains a serious threat in the world and Hong Kong is of no exception. Concerted efforts of different parties, including the prudent antimicrobial use and comprehensive infection prevention and control strategies, are the key measures to combat AMR.

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[28] NS% of minocycline for *Acinetobacter* spp. of hospital-onset ranged from the lowest 18.9% in year 2018 to the highest 75.0% in year 2012.

[29] NS% of gentamicin for *Acinetobacter* spp. of hospital-onset ranged from the lowest 26.2% in year 2017 to the highest 50.3% in year 2013.

[30] NS% of amikacin for *Acinetobacter* spp. of hospital-onset ranged from the lowest 20.8% in year 2017 to the highest 40.7% in year 2013.

[31] *Salmonella* species and *Streptococcus pneumoniae* are pathogens primarily causing community-acquired infections. They are rare to cause hospital-associated infections. Hence, information on location of onset was not considered when analysing and interpreting non-susceptibility results of these two organisms. For administrative convenience, these NS results were interpreted as isolates of undifferentiated location of onset.

[32] NS% of co-trimoxazole for *S. pneumoniae* ranged from the lowest 47.0% in year 2013 to the highest 70.0% in year 2017.

1 Introduction

1. The emergence of antimicrobial resistance (AMR) makes the regular treatments of infections become less effective and more expensive. It is affecting many parts of the world, including both developing and developed countries.

2. The Government of the Hong Kong Special Administrative Region recognised the threat of AMR and issued the Hong Kong Strategy and Action Plan on Antimicrobial Resistance (2017-2022) after considering the views of various experts and stakeholders from relevant fields[1]. One of the recommended actions is to strengthen AMR surveillance in healthcare settings in alignment with international standards, i.e. the Global Antimicrobial Resistance Surveillance System (GLASS) from the World Health Organization (WHO).

3. Hospital Authority (HA) is the Government-funded body to manage all the public hospitals and a number of general and specialist out-patient clinics in Hong Kong. It has an advanced information system capturing the clinical and laboratory data of its patients.

4. With the help and support of the Information Technology and Health Informatics Division (IT&HI) of HA, laboratory data with antimicrobial susceptibility test (AST) results of isolated pathogens and demographic data from patients with blood culture specimen collected were extracted and provided to the Department of Health (DH) for analysis with the aim to contribute to the understanding of AMR situation in Hong Kong. The first Summary Report on Antimicrobial Resistance Surveillance in Public Hospitals (2012 - 2017) taking reference to the Global Antimicrobial Resistance Surveillance System (GLASS) from the World Health Organization (WHO) was published in October 2019 at the website of the Centre of Health Protection (CHP) of DH[2].

5. To continue with this surveillance activity, DH analysed the data for year 2018 provided by HA and prepared this report. The year 2018 results are put together with the results of the previous report for easy reference, and compared with the results of year 2016 which was chosen as the baseline by the Government.

2 Definitions

6. The following definitions are used throughout the surveillance report:

2.1 Blood culture specimen result

- **Positive blood culture specimen**: Blood culture specimen with any micro-organism isolated
- **Negative blood culture specimen**: Blood culture specimen with no micro-organism isolated

2.2 Location of onset

7. Based on the WHO GLASS Manual for Early Implementation[3] with local adaptation, specimens and isolates cultured from the respective specimens were categorised according to the following operational definition:

- **Community-onset (CO) specimen/isolate**:
  - Difference between specimen reference datetime[33] and linked admission datetime is less than or equal to 48 hours; OR
  - Patient episode number[34] does not start with "HN"
- **Hospital-onset (HO) specimen/isolate**:
  - Difference between specimen reference datetime[33] and linked admission datetime is more than 48 hours; AND
  - Patient episode number[35] starts with "HN"

[33] The reference datetime is used to determine the display sequence of culture test report in IT systems of HA. The reference datetime is assigned according to the following rule: 1) Specimen collection datetime; 2) Specimen arrival datetime if 1) is not available; 3) Laboratory request registration datetime if 2) is not available.[4]

[34] Episode number is a unique reference number assigned by each hospital to an episode of care.[5] For an episode of care of inpatient nature, "HN" is assigned as the prefix of the episode number. For an episode of non-inpatient nature, other prefix is assigned as appropriate.

[35] Episode number is a unique reference number assigned by each hospital to an episode of care.[5] For an episode of care of inpatient nature, "HN" is assigned as the prefix of the episode number. For an episode of non-inpatient nature, other prefix is assigned as appropriate.

8. For *Salmonella* species and *Streptococcus pneumoniae* isolates, regardless of specimen being defined as **CO** or **HO**, the isolates were all defined as **undifferentiated location of onset (UO)** during the analysis and interpretation of AST results of these two organisms.[36]

2.3 Antimicrobial susceptibility test (AST) result

9. Definition of AST result is as below:

- **Susceptible (S)**: Isolates that were tested and interpreted as "Susceptible" to a given antimicrobial[37] in accordance with the clinical breakpoint criteria used by the local laboratory.
- **Intermediate (I)**: Isolates that were tested and interpreted as "Intermediate" to a given antimicrobial[37] in accordance with the clinical breakpoint criteria used by the local laboratory.
- **Resistant (R)**: Isolates that were tested and interpreted as "Resistant" to a given antimicrobial[37] in accordance with the clinical breakpoint criteria used by the local laboratory.

10. An isolate was defined as **non-susceptible (NS)** to a given antimicrobial when it was tested and interpreted as **intermediate (I)** or **resistant (R)** based on the above definition.

[36] *Salmonella* species and *Streptococcus pneumoniae* are pathogens primarily causing community-acquired infections. They are rare to cause hospital-associated infections. Hence, information on location of onset was not considered when analysing and interpreting non-susceptibility (NS) results of these two organisms. For administrative convenience, these NS results were interpreted as **UO** isolates.

[37] For *Streptococcus pneumoniae*, the interpretations for penicillin, cefotaxime and ceftriaxone were based on clinical breakpoint criteria for non-meningitis.

2.3.1 Change in interpretive criteria for AST results

11. Readers should take note of the changes listed in Table 1 regarding the interpretive criteria of antimicrobials release by the Clinical Laboratory Standards Institute (CLSI) when interpreting AST results. These changes may be one of the contributing factors leading to the observed trend of respective non-susceptibility percentage.

Table 1: Changes in interpretive criteria for AST results

Antimicrobial	Modification Details
Escherichia coli	
Cefepime	A new (revised) interpretive criterion was released in year 2014.
Ertapenem	A new (revised) interpretive criterion was released in year 2012.
Klebsiella pneumoniae	
Cefepime	A new (revised) interpretive criterion was released in year 2014.
Ertapenem	A new (revised) interpretive criterion was released in year 2012.
***Salmonella* spp.**	
Ciprofloxacin	A new interpretive criterion was released in year 2012, and modified recommendations to use the separate interpretive criteria were released in year 2013.
Levofloxacin	A new interpretive criterion was released in year 2013.
***Acinetobacter* spp.**	
Meropenem	A new (revised) interpretive criterion was released in year 2014.
Imipenem	A new (revised) interpretive criterion was released in year 2014.

2.4 Inclusion of isolates for analysis

12. Non-duplicated isolate of WHO GLASS priority organisms from each patient were included based on the WHO GLASS Manual for Early Implementation[3] with local adaptation[38].

[38] For local adaptation, multiple/duplicate positive cultures within a two-week period from the same patient was regarded as a single episode.

2.5 Other definitions

- **Patient with positive blood culture specimen**: Patient having at least one positive blood culture specimen reported during a single surveillance period (i.e. one calendar year)
- **Positive percentage/rate**

$$\text{(Patient with positive blood culture specimen)} \div \text{(Total number of patients with blood culture specimen collected)} \times 100\%$$

- **NS percentage/rate**

$$\text{(Number of patients with particular organism isolated and tested I/R to a specific antimicrobial)} \div \text{(Total number of patients with particular organism isolated and tested S/I/R to a specific antimicrobial)} \times 100\%$$

2.6 Terminology

13. For simplicity, names of antimicrobial listed in the second column of Table 2 are used.

Table 2: Interchangeable names of antimicrobial

Name	Alternative Name
Amoxicillin and beta-lactamase inhibitor	Amoxicillin/clavulanate
Ampicillin and beta-lactamase inhibitor	Ampicillin/sulbactam
Cefoperazone and beta-lactamase inhibitor	Cefoperazone/sulbactam
Piperacillin and beta-lactamase inhibitor	Piperacillin/tazobactam
Sulfamethoxazole and trimethoprim	Co-trimoxazole

3 Data sources and methodology

3.1 Surveillance period

14. The surveillance period for this report covered the period 1 January 2012 through 31 December 2018 of the reference date[39] of specimen collected.

3.2 Data sources

15. Annual retrospective datasets were prepared and provided by IT&HI of HA:

- AST result data of organisms from positive blood culture specimen
- Demographic data, including age at specimen collection and sex, of patients with blood culture specimen collected

3.3 Inclusion and exclusion criteria

3.3.1 Culture test result

16. Only blood culture specimens were included for analysis.[40,41]

3.3.2 AST result

17. Isolated micro-organisms that did not belong to any of the following, as selected by WHO GLASS, were defined as "Others" and excluded from AST result analysis:

- *Escherichia coli* (*E. coli*)
- *Klebsiella pneumoniae* (*K. pneumoniae*)
- *Acinetobacter* species (*Acinetobacter* spp.)
- *Staphylococcus aureus* (*S. aureus*)
- *Salmonella* species (*Salmonella* spp.)
- *Streptococcus pneumoniae* (*S. pneumoniae*)

[39] The reference datetime is used to determine the display sequence of culture test report in IT systems of HA. The reference datetime is assigned according to the following rule: 1) Specimen collection datetime; 2) Specimen arrival datetime if 1) is not available; 3) Laboratory request registration datetime if 2) is not available.[4]

[40] Culture result from blood specimens were included from analysis if: i) Specimen name was either "Blood" or "Blood, culture"; and ii) "Culture, Blood" test was performed for the specimen.

[41] Specimens were excluded from analysis if: i) Specimen name was neither "Blood" nor "Blood, culture"; or ii) "Culture, Blood" test was not performed for the specimen; or iii) Blood culture specimen with negative result from the same patient having positive blood culture specimen within the same calendar year.

18. AST results other than Susceptible (S)/Intermediate (I)/Resistant (R) were excluded.

19. As recommended by WHO GLASS, AST results of an antimicrobial derived from less than 10 isolates per year were excluded from analysis.[6]

3.4 Statistical analysis

20. For identification of temporal trends on changes in percentage of patients with positive culture specimen and non-susceptibility percentage, Cochran-Armitage trend test[42], a statistical test applied by the European Antimicrobial Resistance Surveillance Network for reporting AMR surveillance data[7], was used. P-value smaller than 0.05 was considered to be statistically significant. Confidence intervals (CI) for non-susceptibility percentages were calculated using the Wilson method.

21. For comparison on NS percentage between two years, Chi-squared test or Fisher's exact test, whether appropriate, was performed. Difference in NS percentage with p-value smaller than 0.05 was considered to be statistically significant.

22. In this report, only trends on changes in non-susceptibility with **statistical significance** are discussed.

3.5 Rounding

23. Whenever appropriate, figures on number of patients/cultures/isolates were rounded to the nearest hundred or thousand, percentages were rounded to one or two decimal places, and p-values were rounded to three decimal places.

[42] Bonferroni corrections were applied to adjust for multiple comparison testing.

4 Results

4.1 Patient characteristics

24. Figure 1 and Table 3 summarise number of patients with blood culture specimen collected, stratified by age group and surveillance year.

25. During the surveillance period, total number of patients with blood culture specimen collected was on the rise from 123,000 in year 2012 to 159,000 in year 2018. Over half of those specimens were collected among patients aged 65 or above.

Figure 1: Number of patients with blood culture specimen collected, stratified by age group and surveillance year

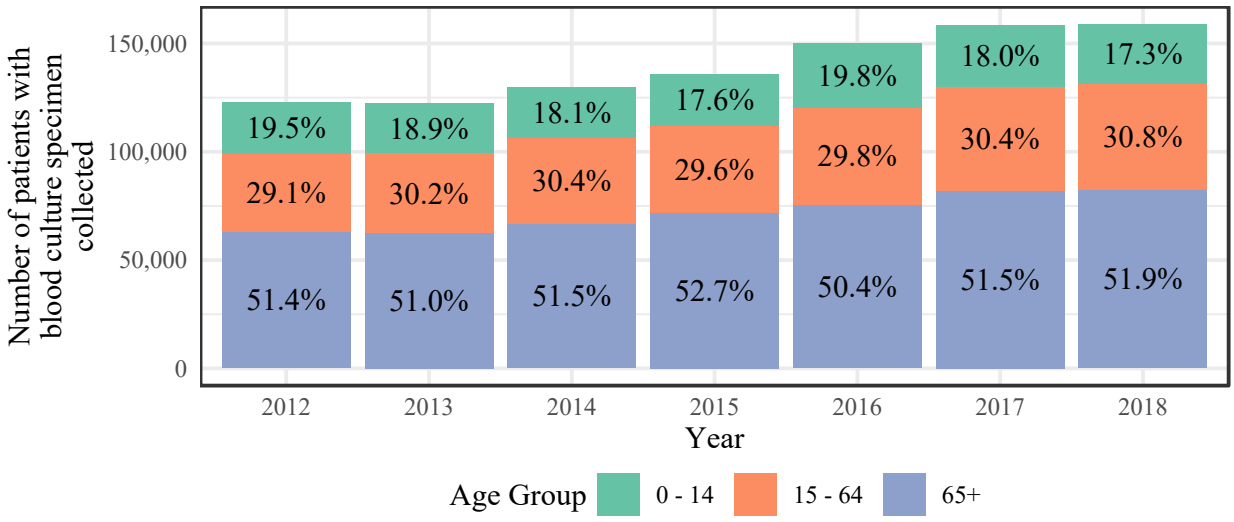


Table 3: Number of patients with blood culture specimen collected, stratified by age group and surveillance year

	Age 0 - 14		Age 15 - 64		Age 65+		Total	
Year	Patient count*	%†	Patient count*	%†	Patient count*	%†	Patient count*	%
2012	24,000	19.5%	36,000	29.1%	63,000	51.4%	123,000	100%
2013	23,000	18.9%	37,000	30.2%	62,000	51.0%	122,000	100%
2014	23,000	18.1%	39,000	30.4%	67,000	51.5%	130,000	100%
2015	24,000	17.6%	40,000	29.6%	72,000	52.7%	136,000	100%
2016	30,000	19.8%	45,000	29.8%	76,000	50.4%	150,000	100%
2017	29,000	18.0%	48,000	30.4%	82,000	51.5%	159,000	100%
2018	27,000	17.3%	49,000	30.8%	83,000	51.9%	159,000	100%

* Rounded to the nearest thousand

† Rounded to one decimal place

26. Table 4 summarises the number of patients with positive blood culture specimen and respective positive rate.

27. The annual blood culture positive rates during the surveillance period ranged from 10.1% to 11.1%. In year 2018, a total of 16,000 (10.3%) patients had positive blood culture specimen out of 159,000 tested patients.[43]

28. Stratified by location of onset and age group, patients aged 65 or above had the highest positive rate for blood culture specimen of all three types of location of onset. (Table 6)

Table 4: Number and percentage of patients with positive blood culture specimen

	Year					
2012	2013	2014	2015	2016	2017	2018
Number of patients with blood culture specimen collected*						
123,000	122,000	130,000	136,000	150,000	159,000	159,000
Number of patients with positive blood culture*						
13,000	13,000	14,000	15,000	15,000	16,000	16,000
Positive blood culture percentage†						
10.8%	10.8%	10.9%	11.1%	10.3%	10.1%	10.3%

* Rounded to the nearest thousand

† Rounded to one decimal place

[43] Patients with positive blood culture specimen refer to those with at least single positive blood culture within each surveillance period. Details on definitions can be referred to Section 2.

Table 5: Number and percentage of patients with positive blood culture specimen, stratified by location of onset

	Year						
	2012	2013	2014	2015	2016	2017	2018
Undifferentiated location of onset							
Number of patients with blood culture specimen collected[*]	123,000	122,000	130,000	136,000	150,000	159,000	159,000
Number of patients with positive blood culture[*]	13,000	13,000	14,000	15,000	15,000	16,000	16,000
Positive blood culture percentage[†]	10.8%	10.8%	10.9%	11.1%	10.3%	10.1%	10.3%
Community-onset							
Number of patients with blood culture specimen collected[*]	104,000	103,000	109,000	115,000	127,000	135,000	134,000
Number of patients with positive blood culture[*]	10,000	10,000	11,000	11,000	12,000	12,000	12,000
Positive blood culture percentage[†]	9.4%	9.5%	9.7%	9.8%	9.2%	8.9%	9.2%
Hospital-onset							
Number of patients with blood culture specimen collected[*]	37,000	38,000	41,000	42,000	46,000	49,000	51,000
Number of patients with positive blood culture[*]	4,000	4,000	4,000	4,000	4,000	5,000	5,000
Positive blood culture percentage[†]	11.1%	10.3%	10.2%	10.4%	9.5%	9.5%	9.2%

[*] Rounded to the nearest thousand

[†] Rounded to one decimal place

Note:

Since a single patient may have both positive community- and hospital-onset blood specimen collected for culture during each surveillance period, total number of patients with positive community-onset blood culture specimen and those with positive hospital-onset blood culture specimen may not tally with patients having positive blood culture specimen of undifferentiated location of onset.

Table 6: Number and percentage of patients with blood culture specimen collected, stratified by age group and location of onset

Age Group		Year						
		2012	2013	2014	2015	2016	2017	2018
Undifferentiated location of onset								
0 - 14	Number of patients with blood culture specimen collected*	24,000	23,000	23,000	24,000	30,000	29,000	27,000
	Number of patients with positive blood culture*	1,000	§	1,000	1,000	1,000	§	§
	Positive blood culture percentage†	2.5%	2.1%	2.4%	2.2%	1.8%	1.7%	1.6%
15 - 64	Number of patients with blood culture specimen collected*	36,000	37,000	39,000	40,000	45,000	48,000	49,000
	Number of patients with positive blood culture*	4,000	4,000	4,000	4,000	4,000	4,000	4,000
	Positive blood culture percentage†	10.6%	10.0%	9.7%	10.3%	9.6%	8.7%	8.8%
65+	Number of patients with blood culture specimen collected*	63,000	62,000	67,000	72,000	76,000	82,000	83,000
	Number of patients with positive blood culture*	9,000	9,000	10,000	10,000	11,000	11,000	12,000
	Positive blood culture percentage†	14.1%	14.5%	14.7%	14.5%	14.1%	13.8%	14.1%
Total	Number of patients with blood culture specimen collected*	123,000	122,000	130,000	136,000	150,000	159,000	159,000
	Number of patients with positive blood culture*	13,000	13,000	14,000	15,000	15,000	16,000	16,000
	Positive blood culture percentage†	10.8%	10.8%	10.9%	11.1%	10.3%	10.1%	10.3%

Table 6: Number and percentage of patients with blood culture specimen collected, stratified by age group and location of onset *(continued)*

Age Group		Year						
		2012	2013	2014	2015	2016	2017	2018
Community-onset								
0 - 14	Number of patients with blood culture specimen collected*	23,000	22,000	22,000	23,000	28,000	27,000	26,000
	Number of patients with positive blood culture*	§	§	§	§	§	§	§
	Positive blood culture percentage†	1.4%	1.3%	1.5%	1.3%	1.1%	1.0%	0.9%
15 - 64	Number of patients with blood culture specimen collected*	30,000	30,000	33,000	33,000	37,000	41,000	41,000
	Number of patients with positive blood culture*	3,000	3,000	3,000	3,000	3,000	3,000	3,000
	Positive blood culture percentage†	9.0%	8.6%	8.2%	8.8%	8.2%	7.4%	7.5%
65+	Number of patients with blood culture specimen collected*	52,000	51,000	54,000	58,000	62,000	67,000	67,000
	Number of patients with positive blood culture*	7,000	7,000	8,000	8,000	8,000	9,000	9,000
	Positive blood culture percentage†	13.1%	13.6%	13.9%	13.7%	13.5%	13.0%	13.5%
Total	Number of patients with blood culture specimen collected*	104,000	103,000	109,000	115,000	127,000	135,000	134,000
	Number of patients with positive blood culture*	10,000	10,000	11,000	11,000	12,000	12,000	12,000
	Positive blood culture percentage†	9.4%	9.5%	9.7%	9.8%	9.2%	8.9%	9.2%

Table 6: Number and percentage of patients with blood culture specimen collected, stratified by age group and location of onset *(continued)*

Age Group		Year						
		2012	2013	2014	2015	2016	2017	2018
Hospital-onset								
0 - 14	Number of patients with blood culture specimen collected*	3,000	3,000	3,000	3,000	3,000	3,000	3,000
	Number of patients with positive blood culture*	§	§	§	§	§	§	§
	Positive blood culture percentage†	10.3%	8.3%	8.5%	9.4%	6.7%	7.1%	6.8%
15 - 64	Number of patients with blood culture specimen collected*	12,000	12,000	13,000	13,000	14,000	15,000	15,000
	Number of patients with positive blood culture*	1,000	1,000	1,000	1,000	1,000	1,000	1,000
	Positive blood culture percentage†	11.3%	10.2%	10.4%	10.6%	9.8%	9.2%	9.2%
65+	Number of patients with blood culture specimen collected*	22,000	23,000	25,000	27,000	29,000	31,000	32,000
	Number of patients with positive blood culture*	2,000	2,000	3,000	3,000	3,000	3,000	3,000
	Positive blood culture percentage†	11.0%	10.6%	10.4%	10.4%	9.7%	9.9%	9.4%
Total	Number of patients with blood culture specimen collected*	37,000	38,000	41,000	42,000	46,000	49,000	51,000
	Number of patients with positive blood culture*	4,000	4,000	4,000	4,000	4,000	5,000	5,000
	Positive blood culture percentage†	11.1%	10.3%	10.2%	10.4%	9.5%	9.5%	9.2%

* Rounded to the nearest thousand

† Rounded to one decimal place

§ Less than 500 patients

4.2 Distribution of patients with WHO GLASS priority organism isolated from positive blood culture specimen

29. Table 7 presents the number of patients with WHO GLASS priority organism isolated, among those with positive blood culture specimen, stratified by location of onset. A graphical presentation is at Figure 2.

30. During the surveillance period, distribution of patients with these organisms isolated from blood culture specimen remained similar. In year 2018, the three commonest WHO GLASS priority organisms were *Escherichia coli* (CO: 46.4%; HO: 24.8%), *Klebsiella pneumoniae* (CO: 11.6%; HO: 10.3%) and *Staphylococcus aureus* (CO: 8.4%; HO: 17.9%). (Table 7)

Figure 2: Distribution of patients with WHO GLASS priority organism isolated from positive blood culture specimen, stratified by location of onset

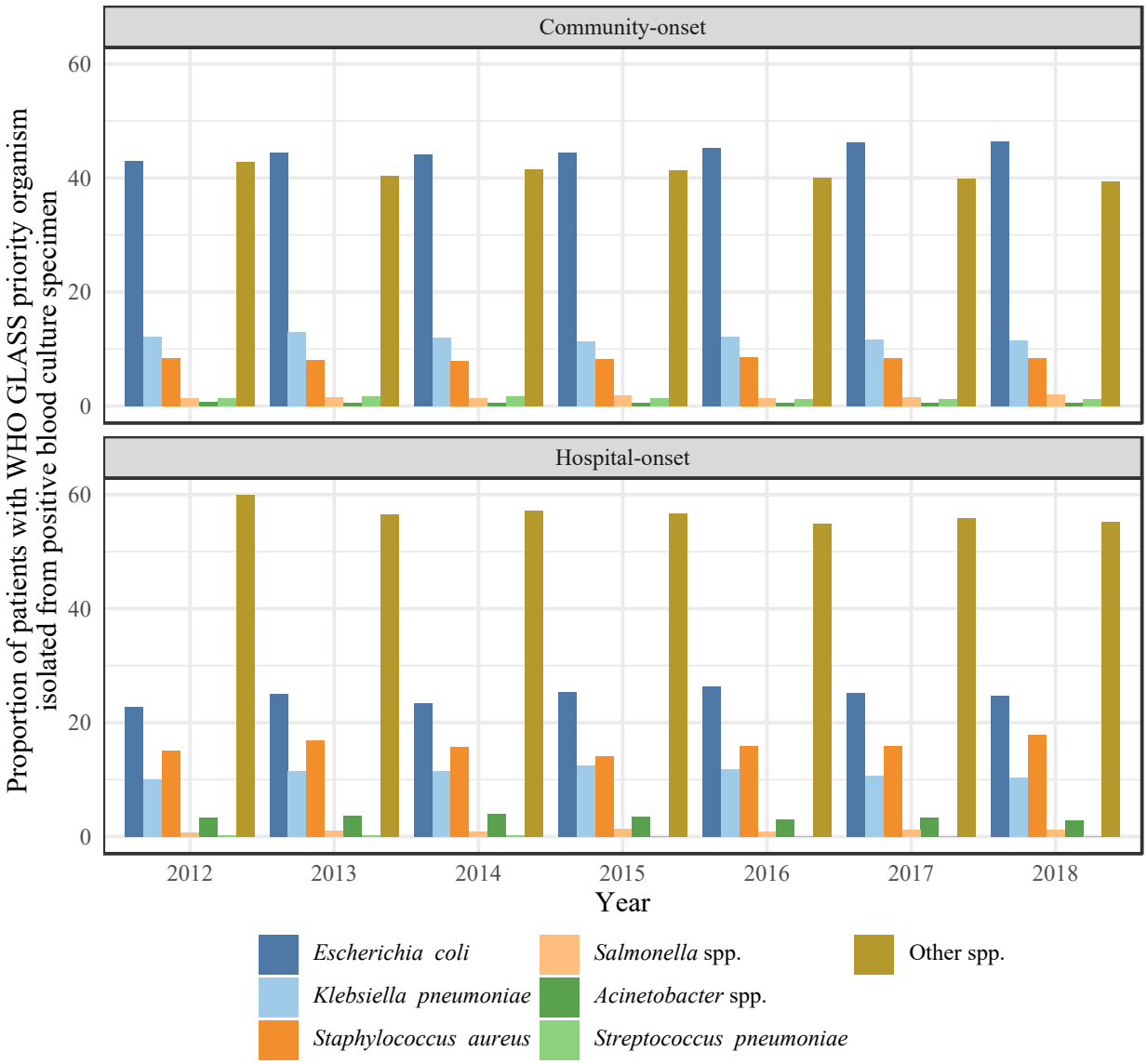


Table 7: Number of patients with WHO GLASS priority organism isolated from positive blood culture specimen, stratified by location of onset

		Year						
		2012	2013	2014	2015	2016	2017	2018
Community-onset								
E. coli	Number of patients with organism isolated*	4,200	4,400	4,700	5,000	5,300	5,600	5,700
	Percentage of patients with organism isolated†	42.9%	44.5%	44.2%	44.4%	45.2%	46.2%	46.4%
K. pneumoniae	Number of patients with organism isolated*	1,200	1,300	1,300	1,300	1,400	1,400	1,400
	Percentage of patients with organism isolated†	12.1%	13.0%	12.0%	11.4%	12.2%	11.6%	11.6%
S. aureus	Number of patients with organism isolated*	800	800	800	900	1,000	1,000	1,000
	Percentage of patients with organism isolated†	8.4%	8.1%	7.9%	8.2%	8.6%	8.3%	8.4%
Salmonella spp.	Number of patients with organism isolated*	100	100	100	200	200	200	300
	Percentage of patients with organism isolated†	1.3%	1.5%	1.4%	1.9%	1.5%	1.5%	2.0%
Acinetobacter spp.	Number of patients with organism isolated*	100	100	100	100	100	100	100
	Percentage of patients with organism isolated†	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%
S. pneumoniae	Number of patients with organism isolated*	100	200	200	200	100	200	100
	Percentage of patients with organism isolated†	1.3%	1.7%	1.7%	1.3%	1.3%	1.3%	1.2%
Other spp.	Number of patients with organism isolated*	4,200	4,000	4,400	4,700	4,700	4,800	4,900
	Percentage of patients with organism isolated†	42.9%	40.4%	41.5%	41.4%	40.1%	39.8%	39.4%

Table 7: Number of patients with WHO GLASS priority organism isolated from positive blood culture specimen, stratified by location of onset *(continued)*

		Year						
		2012	2013	2014	2015	2016	2017	2018
Hospital-onset								
E. coli	Number of patients with organism isolated*	900	1,000	1,000	1,100	1,200	1,200	1,200
	Percentage of patients with organism isolated†	22.8%	25.0%	23.4%	25.4%	26.4%	25.2%	24.8%
K. pneumoniae	Number of patients with organism isolated*	400	400	500	600	500	500	500
	Percentage of patients with organism isolated†	10.0%	11.4%	11.6%	12.5%	11.8%	10.7%	10.3%
S. aureus	Number of patients with organism isolated*	600	700	700	600	700	700	800
	Percentage of patients with organism isolated†	15.1%	16.8%	15.7%	14.1%	15.9%	15.9%	17.9%
Salmonella spp.	Number of patients with organism isolated*	§	§	§	100	§	100	100
	Percentage of patients with organism isolated†	0.8%	1.0%	0.9%	1.5%	0.9%	1.2%	1.2%
Acinetobacter spp.	Number of patients with organism isolated*	100	100	200	200	100	200	100
	Percentage of patients with organism isolated†	3.4%	3.7%	4.0%	3.5%	3.0%	3.3%	2.9%
S. pneumoniae	Number of patients with organism isolated*	§	§	§	§	§	§	§
	Percentage of patients with organism isolated†	0.2%	0.3%	0.2%	0.1%	0.09%	0.2%	0.04%
Other spp.	Number of patients with organism isolated*	2,400	2,200	2,400	2,500	2,400	2,600	2,600
	Percentage of patients with organism isolated†	59.9%	56.5%	57.1%	56.7%	55.0%	56.0%	55.3%

* Rounded to the nearest hundred

† Rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%

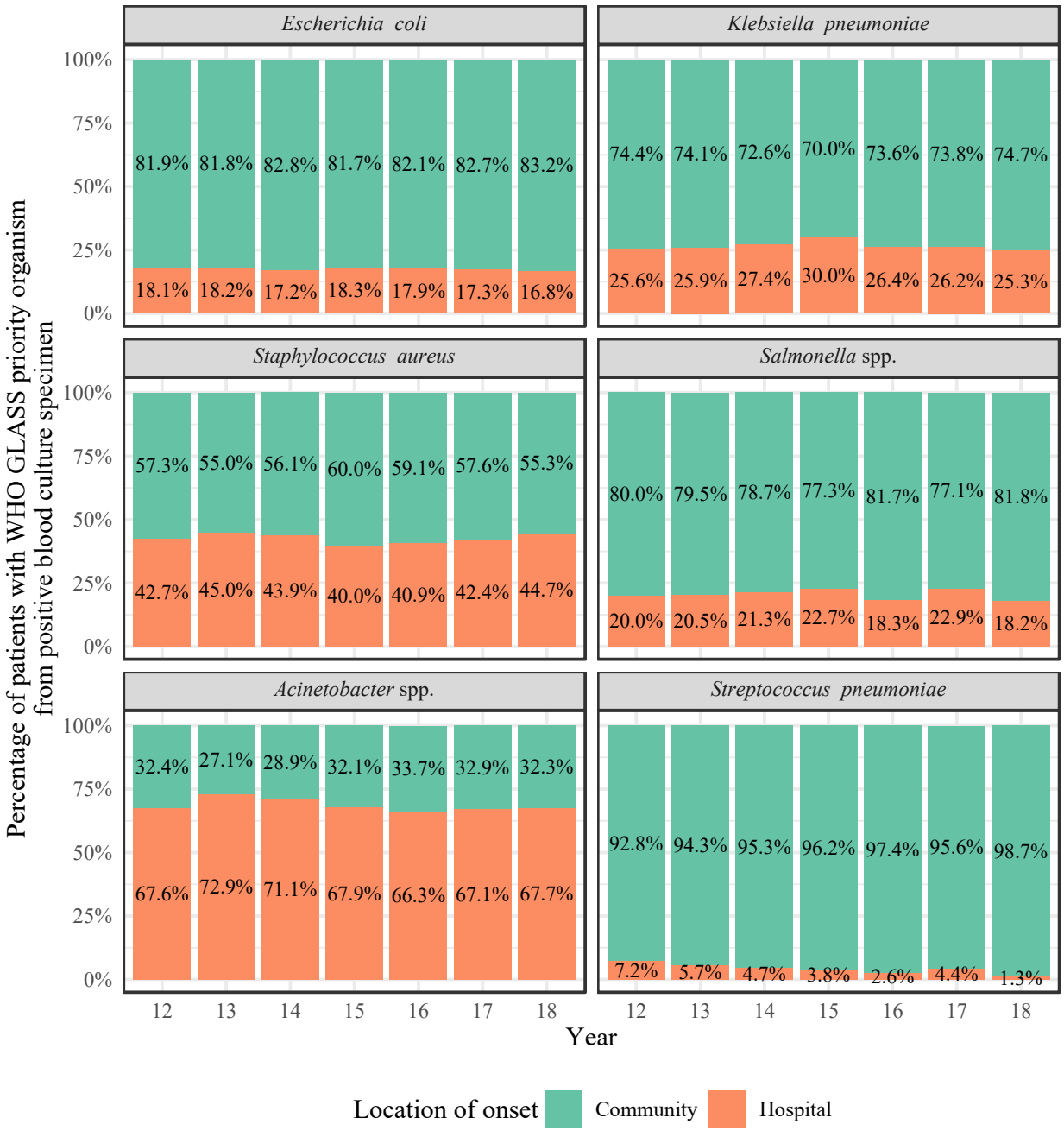
§ Less than 50 patients

Note:

Since single patient may have multiple organisms isolated from single blood culture specimen during each surveillance period, total number of patients with any WHO GLASS priority organism isolated may differ from total number of patients with positive blood culture specimen.

31. Figure 3 presents the distribution of patients with WHO GLASS priority organism isolated from positive blood culture specimen of community- and hospital-onset respectively. During the surveillance period, *Streptococcus pneumoniae*, *Escherichia coli*, *Salmonella* species and *Klebsiella pneumoniae* were predominantly of community-onset. While *Acinetobacter* species were predominantly of hospital-onset.

Figure 3: Distribution of patients with WHO GLASS priority organism isolated from positive blood culture specimen, stratified by location of onset



4.3 Non-susceptibility pattern and trend on WHO GLASS priority organisms

4.3.1 *Escherichia coli*

Health effects and common treatment options of *Escherichia coli* and *Klebsiella pneumoniae* infection

Escherichia coli and *Klebsiella pneumoniae* are gut flora and are common pathogens causing various infections at different body sites such as urinary tract infections, intra-abdominal infections or bacteraemia. They can cause both community and nosocomial infections.

Beta-lactam/beta-lactamase inhibitor, such as amoxicillin/clavulanate and second generation cephalosporins, such as cefuroxime, are two commonly used first line antimicrobials to treat infections caused by *E. coli* and *K. pneumoniae*.

Other broad spectrum beta-lactam/beta-lactamase inhibitor such as piperacillin/tazobactam, and third generation cephalosporins are agents used for serious infections. Carbapenems are a group of antimicrobials usually reserved for severe infections caused by resistant bacteria (such as extended spectrum beta-lactamases (ESBL) producing strains).

32. Among the six WHO GLASS priority organisms, *Escherichia coli* was the commonest WHO GLASS priority organism isolated from community- and hospital-onset blood culture specimen respectively from year 2012 to 2018. (Figure 2) Among all patients with positive blood culture specimen in year 2018, *E. coli* contributed to 46.4% and 24.8% of all WHO GLASS priority organisms isolated from patients with suspected infection of community- and hospital-onset respectively. (Table 7)

33. Overview on number of patients with *E. coli* isolated from blood culture specimen, stratified by location of onset, and the respective percentage of patients with *E. coli* from positive blood culture specimen being non-susceptible towards different antimicrobials are shown in Figure 4.

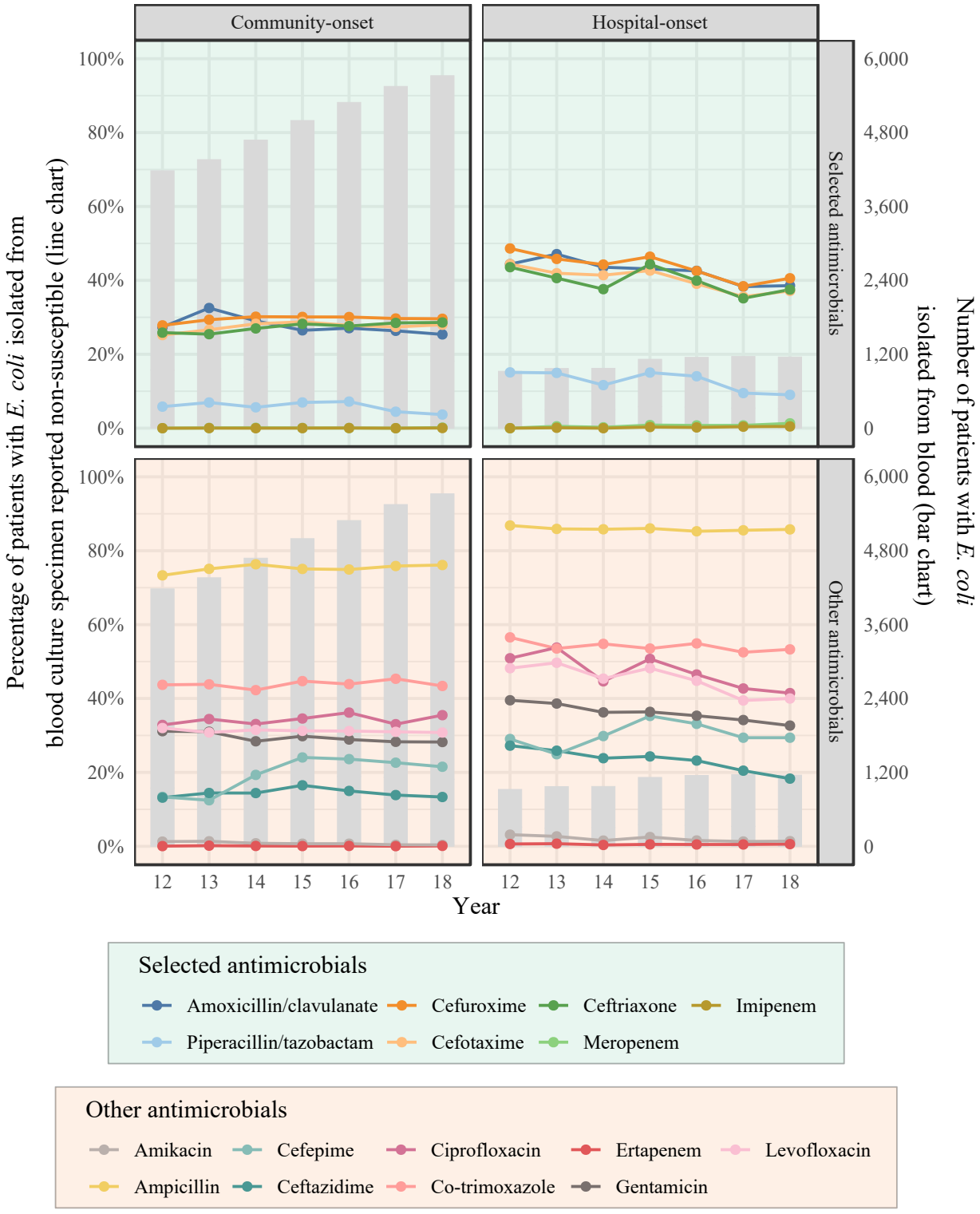
34. Number of patients with *E. coli* isolated from blood culture specimen of community-onset increased from 4,200 in year 2012 to 5,700 in year 2018. Number of patients also increased for *E. coli* isolated from blood culture specimen of hospital-onset, from 900 in year 2012 to 1,200 in year 2018.[44,45]

35. In general, non-susceptibility percentages were lower among *E. coli* isolates of community-onset than those of hospital-onset.

[44] Details on number of patients with WHO GLASS priority organism isolated from positive blood culture specimen can be referred to Section 4.2.

[45] Readers should take note of the total number of patients with blood culture specimen of community- and hospital-onset collected also increased during the surveillance period.

Figure 4: Overview on percentage of patients with *Escherichia coli* isolated from blood culture specimen, reported non-susceptible to different antimicrobials, stratified by location of onset



4.3.1.1 Non-susceptibility percentage in year 2017 and 2018

36. Table 8 summarises percentages of patients with *E. coli* isolated from blood culture specimens and being tested non-susceptible to selected antimicrobials in year 2017 and 2018.

37. Non-susceptibility percentages[46] of amoxicillin/clavulanate for *E. coli* isolated from community-onset (from 26.4% in year 2017 to 25.4% in year 2018) and hospital-onset (from 38.3% in year 2017 to 38.6% in year 2018) specimen remained comparable[47] for year 2017 and 2018. For cefuroxime, non-susceptibility percentage also remained comparable[47] for isolates from community- (from 29.7% in year 2017 to 29.6% in year 2018) and hospital-onset specimen (from 38.4% in year 2017 to 40.6% in year 2018) during the same period.

38. Non-susceptibility percentage of piperacillin/tazobactam for *E. coli* isolated from community-onset specimen has shown a significant decrease from 4.5% in year 2017 to 3.7% in year 2018, while non-susceptibility percentage for those isolated from hospital-onset specimen remained similar[47,48].

39. No significant changes were observed for non-susceptibility percentage of cefotaxime for *E. coli* isolated from community-onset (from 27.4% in year 2017 to 28.0% in year 2018) and hospital-onset (from 35.6% in year 2017 to 37.2% in year 2018), similar findings were also observed for ceftriaxone.[49,50]

[46] Non-susceptibility percentage in this report is defined as the ratio of: i) number of patients with particular organism from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Details on definition of AST result can be referred to Section 3.3.2.

[47] Chi-squared test or Fisher's exact test, whether appropriate, was performed, details on statistical method can be referred to Section 3.4.

[48] NS% of piperacillin/tazobactam for *E. coli* of hospital-onset ranged from 9.5% in year 2017 to 9.0% in year 2018.

[49] NS% of ceftriaxone for *E. coli* of community-onset ranged from 28.5% in year 2017 to 28.6% in year 2018.

[50] NS% of ceftriaxone for *E. coli* of hospital-onset ranged from 35.2% in year 2017 to 37.5% in year 2018.

Table 8: Percentage of patients with *Escherichia coli* isolated from blood culture specimen reported non-susceptible to selected antimicrobials in year 2017 and 2018

	Community-onset			Hospital-onset		
	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial	2017	2018	(17 vs 18)	2017	2018	(17 vs 18)
Amoxicillin/clavulanate	26.4%	25.4%	0.247	38.3%	38.6%	0.934
Cefuroxime	29.7%	29.6%	0.948	38.4%	40.6%	0.307
Piperacillin/tazobactam	4.5%	3.7%	**0.047**	9.5%	9.0%	0.759
Cefotaxime	27.4%	28.0%	0.532	35.6%	37.2%	0.503
Ceftriaxone	28.5%	28.6%	0.941	35.2%	37.5%	0.433
Imipenem	0%	0.05%	0.228	0.4%	0.5%	1.000
Meropenem	0%	0.2%	0.069	0.8%	1.3%	0.412

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Escherichia coli* from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-values were calculated using Chi-squared test or Fisher's exact test, whether appropriate. Figures were rounded to three decimal places, cells with p-value <0.05 are highlighted.

4.3.1.2 Overall trend of non-susceptibility percentage

40. Table 9 summarises trends on non-susceptibility percentage of different antimicrobials among *E. coli* isolates of community- and hospital-onset during the surveillance period.[51]

41. Only trends on changes in non-susceptibility percentage with statistical significance (i.e. p-value less than 0.05) are discussed in this report. Details on statistical method can be referred to Section 3.4.

Community-onset isolates

42. From year 2012 to 2018, non-susceptibility percentage for cefepime showed an increasing trend[52,53,54] with statistical significance, while the percentage for amoxicillin/clavulanate[55], piperacillin/tazobactam[56], gentamicin[57] and amikacin[58] showed decreasing trends with statistical significance during the same period of time.

43. By adopting surveillance data in year 2016 as the baseline, only non-susceptibility percentage for piperacillin/tazobactam showed a decreasing trend[59] with statistical significance, while percentages for other different antimicrobials above-mentioned remained stable.

[51] Details on trend of non-susceptibility percentage from year 2012 to 2018 can be referred to Table 24 in Appendix.
[52] NS% of cefepime for *E. coli* of community-onset ranged from the lowest 12.5% in year 2013 to the highest 24.0% in year 2015.
[53] A new (revised) interpretive criterion of cefepime for *Escherichia coli* was released for in year 2014. Details on changes in interpretive criteria for AST results can be referred to Section 2.3.1.
[54] Readers should interpret this finding with caution, as cefepime AST was performed for less than 70% of all *E. coli* isolates (community-onset) from year 2012 to 2013. Refer to Table 24 in Appendix for details.
[55] NS% of amoxicillin/clavulanate for *E. coli* of community-onset ranged from the lowest 25.4% in year 2018 to the highest 32.5% in year 2013.
[56] NS% of piperacillin/tazobactam for *E. coli* of community-onset ranged from the lowest 3.7% in year 2018 to the highest 7.2% in year 2016.
[57] NS% of gentamicin for *E. coli* of community-onset ranged from the lowest 28.2% in year 2018 to the highest 31.2% in year 2012.
[58] NS% of amikacin for *E. coli* of community-onset ranged from the lowest 0.4% in year 2018 to the highest 1.4% in year 2013.
[59] NS% of piperacillin/tazobactam for *E. coli* of community-onset ranged from the lowest 3.7% in year 2018 to the highest 7.2% in year 2016.

Hospital-onset isolates

44. From year 2012 to 2018, non-susceptibility trends decreased with statistical significance for the same list of drugs as mentioned for community-onset isolates (i.e. amoxicillin/clavulanate[60], piperacillin/tazobactam[61], gentamicin[62] and amikacin[63]). Furthermore, the trend also decreased for cefuroxime[64], cefotaxime[65,66], ceftazidime[67,68] and levofloxacin[69] with statistical significance.

45. By adopting surveillance data in year 2016 as the baseline, only non-susceptibility percentage for piperacillin/tazobactam showed a decreasing trend[70] with statistical significance, while percentages for other different antimicrobials above-mentioned remained stable.

[60] NS% of amoxicillin/clavulanate for *E. coli* of hospital-onset ranged from the lowest 38.3% in year 2017 to the highest 47.1% in year 2013.
[61] NS% of piperacillin/tazobactam for *E. coli* of hospital-onset ranged from the lowest 9.0% in year 2018 to the highest 15.1% in year 2012.
[62] NS% of gentamicin for *E. coli* of hospital-onset ranged from the lowest 32.7% in year 2018 to the highest 39.5% in year 2012.
[63] NS% of amikacin for *E. coli* of hospital-onset ranged from the lowest 1.3% in year 2017 to the highest 3.1% in year 2012.
[64] NS% of cefuroxime for *E. coli* of hospital-onset ranged from the lowest 38.4% in year 2017 to the highest 48.6% in year 2012.
[65] NS% of cefotaxime for *E. coli* of hospital-onset ranged from the lowest 35.6% in year 2017 to the highest 44.4% in year 2012.
[66] Readers should interpret this finding with caution, as cefotaxime AST was performed for less than 70% of all *E. coli* isolates (hospital-onset) in year 2012. Refer to Table 24 in Appendix for details.
[67] NS% of ceftazidime for *E. coli* of hospital-onset ranged from the lowest 18.3% in year 2018 to the highest 27.2% in year 2012.
[68] Readers should interpret this finding with caution, as ceftazidime AST was performed for less than 70% of all *E. coli* isolates (hospital-onset) from year 2017 to 2018. Refer to Table 24 in Appendix for details.
[69] NS% of levofloxacin for *E. coli* of hospital-onset ranged from the lowest 39.5% in year 2017 to the highest 49.7% in year 2013.
[70] NS% of piperacillin/tazobactam for *E. coli* of hospital-onset ranged from the lowest 9.0% in year 2018 to the highest 14.1% in year 2016.

Table 9: Time trends and significance levels for patients with *Escherichia coli* isolated from blood culture specimen reported non-susceptible to different antimicrobials in year 2012-2018 and 2016-2018

		Community-onset						Hospital-onset					
		% Non-susceptible*		p-value†	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial group	Antimicrobial	2012	2018	12 - 18	2016	2018	16 - 18	2012	2018	12 - 18	2016	2018	16 - 18
Penicillins with extended spectrum	Ampicillin	73.3%	76.1%	↗ p = 1.000	74.9%	76.1%	⟶ p = 1.000	86.8%	85.8%	⟶ p = 1.000	85.3%	85.8%	⟶ p = 1.000
Combinations of penicillins, incl. beta-lactamase inhibitors	Amoxicillin/clavulanate	27.3%	25.4%	↘ **p <0.005**	27.1%	25.4%	↘ p = 1.000	44.4%	38.6%	↘ **p <0.005**	42.6%	38.6%	↘ p = 1.000
	Piperacillin/tazobactam	5.8%	3.7%	↘ **p <0.005**	7.2%	3.7%	↘ **p <0.005**	15.1%	9.0%	↘ **p <0.005**	14.1%	9.0%	↘ **p = 0.008**
Second-generation cephalosporins	Cefuroxime	27.8%	29.6%	⟶ p = 1.000	30.1%	29.6%	⟶ p = 1.000	48.6%	40.6%	↘ **p <0.005**	42.5%	40.6%	⟶ p = 1.000
Third-generation cephalosporins	Cefotaxime	25.2%	28.0%	↗ p = 1.000	27.8%	28.0%	⟶ p = 1.000	44.4%	37.2%	↘ **p <0.005**	39.1%	37.2%	⟶ p = 1.000
	Ceftazidime	13.2%	13.3%	⟶ p = 1.000	15.0%	13.3%	↘ p = 1.000	27.2%	18.3%	↘ **p <0.005**	23.2%	18.3%	↘ p = 0.661
	Ceftriaxone	25.9%	28.6%	↗ p = 0.095	27.6%	28.6%	⟶ p = 1.000	43.6%	37.5%	↘ p = 0.906	39.9%	37.5%	⟶ p = 1.000
Fourth-generation cephalosporins	Cefepime§	13.4%	21.5%	↗ **p <0.005**	23.6%	21.5%	↘ p = 0.542	29.0%	29.4%	⟶ p = 1.000	33.1%	29.4%	↘ p = 1.000
Carbapenems	Meropenem	0%	0.16%	⟶ p = 1.000	0.04%	0.16%	↗ p = 1.000	0%	1.3%	↗ p = 0.546	0.74%	1.3%	⟶ p = 1.000
	Ertapenem¶	0.05%	0.12%	⟶ p = 1.000	0.10%	0.12%	⟶ p = 1.000	0.63%	0.59%	⟶ p = 1.000	0.49%	0.59%	⟶ p = 1.000
	Imipenem	0%	0.05%	⟶ p = 1.000	0.04%	0.05%	⟶ p = 1.000	0%	0.48%	↗ p = 0.496	0.21%	0.48%	⟶ p = 1.000
Combinations of sulfonamides and trimethoprim, incl. derivatives	Co-trimoxazole	43.7%	43.4%	⟶ p = 1.000	43.9%	43.4%	⟶ p = 1.000	56.5%	53.3%	⟶ p = 1.000	54.9%	53.3%	⟶ p = 1.000
Other aminoglycosides	Gentamicin	31.2%	28.2%	↘ **p <0.005**	28.9%	28.2%	⟶ p = 1.000	39.5%	32.7%	↘ **p = 0.006**	35.3%	32.7%	⟶ p = 1.000
	Amikacin	1.3%	0.38%	↘ **p <0.005**	0.70%	0.38%	↘ p = 0.910	3.1%	1.4%	↘ **p = 0.025**	1.6%	1.4%	⟶ p = 1.000
Fluoroquinolones	Ciprofloxacin	32.8%	35.5%	⟶ p = 1.000	36.2%	35.5%	⟶ p = 1.000	50.9%	41.5%	↘ p = 0.327	46.5%	41.5%	⟶ p = 1.000
	Levofloxacin	32.0%	30.8%	⟶ p = 1.000	31.2%	30.8%	⟶ p = 1.000	48.2%	40.0%	↘ **p <0.005**	44.8%	40.0%	↘ p = 0.976

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Escherichia coli* from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-value reports the statistical significance of trend observed during the captioned time period, it was calculated using Cochran-Armitage test with Bonferroni correction. Figures were rounded to three decimal places.

§ A new (revised) interpretive criterion of cefepime for *Escherichia coli* was released for in year 2014.

¶ A new (revised) interpretive criterion of ertapenem for *Escherichia coli* was released in year 2012.

Legend:

↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed

Highlighted cells: Observation with statistical significance (p-value <0.05)

4.3.2 *Klebsiella pneumoniae*

> Health effects and treatment options of *Klebsiella pneumoniae* infection can be referred to Section 4.3.1.

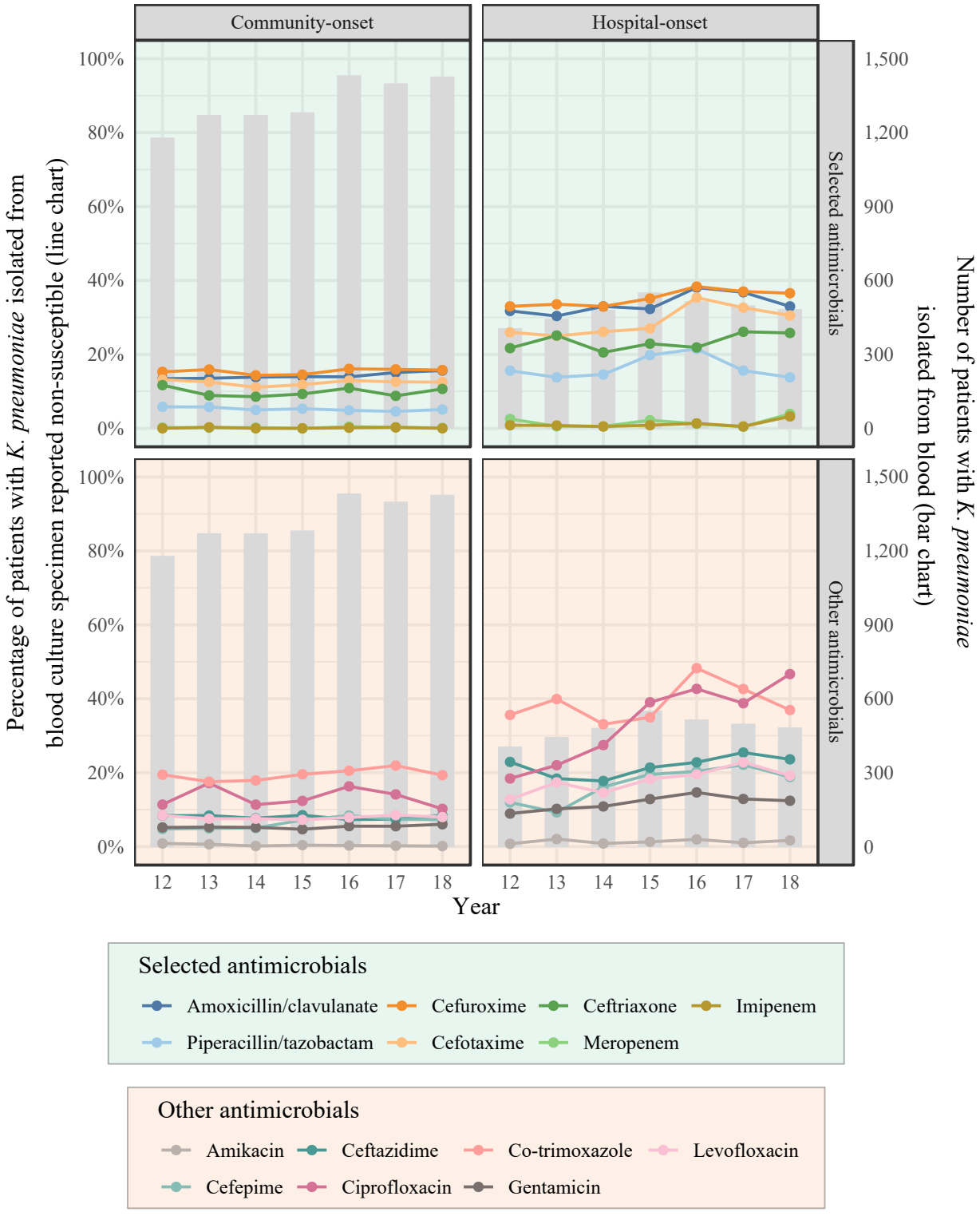
46. *Klebsiella pneumoniae* was the second commonest WHO GLASS priority organism isolated from community-onset blood culture specimen, and the third commonest organism for blood culture specimen of hospital-onset from year 2012 to 2018. (Figure 2) Among all patients with positive blood culture specimen in 2018, *K. pneumoniae* contributed to 11.6% and 10.3% of all WHO GLASS priority organisms isolated from specimen showing infection of community-onset and hospital-onset respectively. (Table 7)

47. Overview on number of patients with *K. pneumoniae* isolated from blood culture specimen, stratified by location of onset, and the respective percentage of patients with *K. pneumoniae* from positive blood culture specimen being non-susceptible towards different antimicrobials are shown in Figure 5.

48. Number of patients with *K. pneumoniae* isolated from blood culture specimen of community-onset increased from 1,200 in year 2012 to 1,400 in year 2018. Number of patients for *K. pneumoniae* of hospital-onset increased from 400 in year 2012 to 600 in year 2015, and then decreased to 500 in year 2018.

49. Similar to the findings from *E. coli* isolates, it is noted that non-susceptibility percentages were generally lower among *K. pneumoniae* isolates of community-onset than those of hospital-onset.

Figure 5: Overview on percentage of patients with *Klebsiella pneumoniae* isolated from blood culture specimen, reported non-susceptible to different antimicrobials, stratified by location of onset



4.3.2.1 Non-susceptibility percentage in year 2017 and 2018

50. Table 10 summarises percentage of patients with *K. pneumoniae* isolated from blood culture specimen and being tested non-susceptible to selected antimicrobials in year 2017 and 2018.

51. Non-susceptibility percentage of amoxicillin/clavulanate for *K. pneumoniae* isolated from community-onset (from 15.1% in year 2017 to 15.6% in year 2018) and hospital-onset (from 36.8% in year 2017 to 33.0% in year 2018) specimen remained comparable[71] for year 2017 and 2018. Similar observation was also seen for cefuroxime among the isolates of community- (from 16.0% in year 2017 to 15.8% in year 2018) and hospital-onset (from 37.0% in year 2017 to 36.6% in year 2018).

52. For piperacillin/tazobactam, no significant change[71] in non-susceptibility percentage was observed for *K. pneumoniae* isolated from community- and hospital-onset specimen.[72,73]

53. For third-generation cephalosporins, no significant change[71] in non-susceptibility percentage for cefotaxime[74,75] and ceftriaxone[76,77] were observed in year 2017 and 2018 for *K. pneumoniae* isolated from hospital-onset and community-onset blood culture specimen.

54. For carbapenems, non-susceptibility percentages of imipenem[78] and meropenem[79] remained stable[71] for *K. pneumoniae* isolated from community-onset specimen. For isolates from hospital-onset specimen, the non-susceptibility percentages showed significant increases[71] from less than one percent to more than three percent for both imipenem[80] and meropenem[81].

[71] Chi-squared test or Fisher's exact test, whether appropriate, was performed, details on statistical method can be referred to Section 3.4.
[72] NS% of piperacillin/tazobactam for *K. pneumoniae* of community-onset ranged from 4.6% in year 2017 to 5.1% in year 2018.
[73] NS% of piperacillin/tazobactam for *K. pneumoniae* of hospital-onset ranged from 15.6% in year 2017 to 13.8% in year 2018.
[74] NS% of cefotaxime for *K. pneumoniae* of community-onset ranged from 12.6% in year 2017 to 12.5% in year 2018.
[75] NS% of cefotaxime for *K. pneumoniae* of hospital-onset ranged from 32.6% in year 2017 to 30.5% in year 2018.
[76] NS% of ceftriaxone for *K. pneumoniae* of community-onset ranged from 8.8% in year 2017 to 10.7% in year 2018.
[77] NS% of ceftriaxone for *K. pneumoniae* of hospital-onset ranged from 26.1% in year 2017 to 25.8% in year 2018.
[78] NS% of imipenem for *K. pneumoniae* of community-onset ranged from 0.3% in year 2017 to 0% in year 2018.
[79] NS% of meropenem for *K. pneumoniae* of community-onset ranged from 0.3% in year 2017 to 0.1% in year 2018.
[80] NS% of imipenem for *K. pneumoniae* of hospital-onset ranged from 0.5% in year 2017 to 3.2% in year 2018.
[81] NS% of meropenem for *K. pneumoniae* of hospital-onset ranged from 0.4% in year 2017 to 3.9% in year 2018.

Table 10: Percentage of patients with *Klebsiella pneumoniae* isolated from blood culture specimen reported non-susceptible to selected antimicrobials in year 2017 and 2018

	Community-onset			Hospital-onset		
	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial	2017	2018	(17 vs 18)	2017	2018	(17 vs 18)
Amoxicillin/clavulanate	15.1%	15.6%	0.727	36.8%	33.0%	0.238
Cefuroxime	16.0%	15.8%	0.941	37.0%	36.6%	0.935
Piperacillin/tazobactam	4.6%	5.1%	0.596	15.6%	13.8%	0.490
Cefotaxime	12.6%	12.5%	1.000	32.6%	30.5%	0.590
Ceftriaxone	8.8%	10.7%	0.218	26.1%	25.8%	1.000
Imipenem	0.3%	0%	0.253	0.5%	3.2%	**0.007**
Meropenem	0.3%	0.1%	0.587	0.4%	3.9%	**0.007**

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Klebsiella pneumoniae* from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-values were calculated using Chi-squared test or Fisher's exact test, whether appropriate. Figures were rounded to three decimal places, cells with p-value <0.05 are highlighted.

4.3.2.2 Overall trend of non-susceptibility percentage

55. Table 11 summarises trends on non-susceptibility percentage of different antimicrobials among *K. pneumoniae* isolates of community- and hospital-onset during the surveillance period.[82]

Community-onset isolates

56. From year 2012 to 2018, similar to *Escherichia coli*, non-susceptibility percentage for cefepime showed an increasing trend[83,84,85] with statistical significance. By adopting surveillance data in year 2016 as the baseline, trend on the percentages for all tested antimicrobials, including cefepime, remained stable.

Hospital-onset isolates

57. From year 2012 to 2018, non-susceptibility percentage increased with statistical significance for cefepime[84,86,87], ciprofloxacin[88,89] and levofloxacin[90].

[82] Details on trend of non-susceptibility percentage from year 2012 to 2018 can be referred to Table 25 in Appendix.
[83] NS% of cefepime for *K. pneumoniae* of community-onset ranged from the lowest 4.8% in year 2012 to the highest 8.4% in year 2016.
[84] A new (revised) interpretive criterion of cefepime for *Klebsiella pneumoniae* was released in year 2014. Details on changes in interpretive criteria for AST results can be referred to Section 2.3.1.
[85] Readers should interpret this finding with caution, as cefepime AST was performed for less than 70% of all *K. pneumoniae* isolates (community-onset) in year 2012. Refer to Table 25 in Appendix for details.
[86] NS% of cefepime for *K. pneumoniae* of hospital-onset ranged from the lowest 9.3% in year 2013 to the highest 22.2% in year 2017.
[87] Readers should interpret this finding with caution, as cefepime AST was performed for less than 70% of all *K. pneumoniae* isolates (hospital-onset) from year 2012 to 2014. Refer to Table 25 in Appendix for details.
[88] NS% of ciprofloxacin for *K. pneumoniae* of hospital-onset ranged from the lowest 18.4% in year 2012 to the highest 46.7% in year 2018.
[89] Readers should interpret this finding with caution, as ciprofloxacin AST was performed for less than 70% of all *K. pneumoniae* isolates (hospital-onset) from year 2012 to 2018. Refer to Table 25 in Appendix for details.
[90] NS% of levofloxacin for *K. pneumoniae* of hospital-onset ranged from the lowest 12.8% in year 2012 to the highest 22.8% in year 2017.

Table 11: Time trends and significance levels for patients with *Klebsiella pneumoniae* isolated from blood culture specimen reported non-susceptible to different antimicrobials in year 2012-2018 and 2016-2018

		Community-onset						Hospital-onset					
		% Non-susceptible*		p-value†	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial group	Antimicrobial	2012	2018	12 - 18	2016	2018	16 - 18	2012	2018	12 - 18	2016	2018	16 - 18
Combinations of penicillins, incl. beta-lactamase inhibitors	Amoxicillin/clavulanate	13.4%	15.6%	↗ p = 1.000	13.9%	15.6%	⟶ p = 1.000	31.8%	33.0%	↗ p = 1.000	38.1%	33.0%	↘ p = 1.000
	Piperacillin/tazobactam	5.8%	5.1%	⟶ p = 1.000	4.9%	5.1%	⟶ p = 1.000	15.6%	13.8%	⟶ p = 1.000	21.5%	13.8%	↘ p = 0.066
Second-generation cephalosporins	Cefuroxime	15.3%	15.8%	⟶ p = 1.000	16.1%	15.8%	⟶ p = 1.000	33.0%	36.6%	↗ p = 1.000	38.4%	36.6%	⟶ p = 1.000
Third-generation cephalosporins	Cefotaxime	13.2%	12.5%	⟶ p = 1.000	12.9%	12.5%	⟶ p = 1.000	26.0%	30.5%	↗ p = 0.170	35.4%	30.5%	⟶ p = 1.000
	Ceftazidime	8.4%	8.4%	⟶ p = 1.000	7.3%	8.4%	⟶ p = 1.000	22.9%	23.6%	↗ p = 1.000	22.8%	23.6%	⟶ p = 1.000
	Ceftriaxone	11.7%	10.7%	⟶ p = 1.000	10.9%	10.7%	⟶ p = 1.000	21.7%	25.8%	⟶ p = 1.000	21.9%	25.8%	⟶ p = 1.000
Fourth-generation cephalosporins	Cefepime§	4.8%	7.3%	↗ **p = 0.009**	8.4%	7.3%	⟶ p = 1.000	12.0%	18.8%	↗ **p <0.005**	20.3%	18.8%	⟶ p = 1.000
Carbapenems	Meropenem	0.20%	0.11%	⟶ p = 1.000	0.43%	0.11%	⟶ p = 1.000	2.5%	3.9%	↗ p = 1.000	1.2%	3.9%	↗ p = 0.624
	Imipenem	0%	0%	⟶ p = 1.000	0.16%	0%	⟶ p = 1.000	0.83%	3.2%	↗ p = 0.951	1.3%	3.2%	↗ p = 1.000
Combinations of sulfonamides and trimethoprim, incl. derivatives	Co-trimoxazole	19.5%	19.3%	⟶ p = 1.000	20.5%	19.3%	⟶ p = 1.000	35.6%	36.9%	⟶ p = 1.000	48.3%	36.9%	↘ p = 0.143
Other aminoglycosides	Gentamicin	5.2%	6.0%	⟶ p = 1.000	5.5%	6.0%	⟶ p = 1.000	8.9%	12.4%	↗ p = 0.847	14.6%	12.4%	⟶ p = 1.000
	Amikacin	0.85%	0.14%	↘ p = 0.084	0.28%	0.14%	⟶ p = 1.000	0.74%	1.7%	⟶ p = 1.000	2.0%	1.7%	⟶ p = 1.000
Fluoroquinolones	Ciprofloxacin	11.4%	10.2%	⟶ p = 1.000	16.3%	10.2%	⟶ p = 1.000	18.4%	46.7%	↗ **p <0.005**	42.7%	46.7%	⟶ p = 1.000
	Levofloxacin	8.4%	8.0%	⟶ p = 1.000	7.9%	8.0%	⟶ p = 1.000	12.8%	19.2%	↗ **p = 0.016**	19.5%	19.2%	⟶ p = 1.000

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Klebsiella pneumoniae* from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-value reports the statistical significance of trend observed during the captioned time period, it was calculated using Cochran-Armitage test with Bonferroni correction. Figures were rounded to three decimal places.

§ A new (revised) interpretive criterion of cefepime for *Klebsiella pneumoniae* was released in year 2014.

Legend:

↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed

Highlighted cells: Observation with statistical significance (p-value <0.05)

4.3.3 *Staphylococcus aureus*

Health effects and common treatment options of *Staphylococcus aureus* infection

Staphylococcus aureus is a bacterium that can be found in the nasal cavity and on the skin of some healthy people without signs or symptoms of infection. Yet, the bacteria may cause diseases such as infection of skin, wound, urinary tract, lung, bloodstream and food poisoning. It can cause both community and nosocomial infections.

Most *S. aureus* infections can be treated by antibiotics effectively such as oxacillin. However, methicillin-resistant *S. aureus* (MRSA) is a strain of *S. aureus* that is resistant to commonly used beta-lactam antibiotics including methicillin, oxacillin, carbapenems and most cephalosporins. Alternative agents, such as vancomycin, is required to treat MRSA infections.

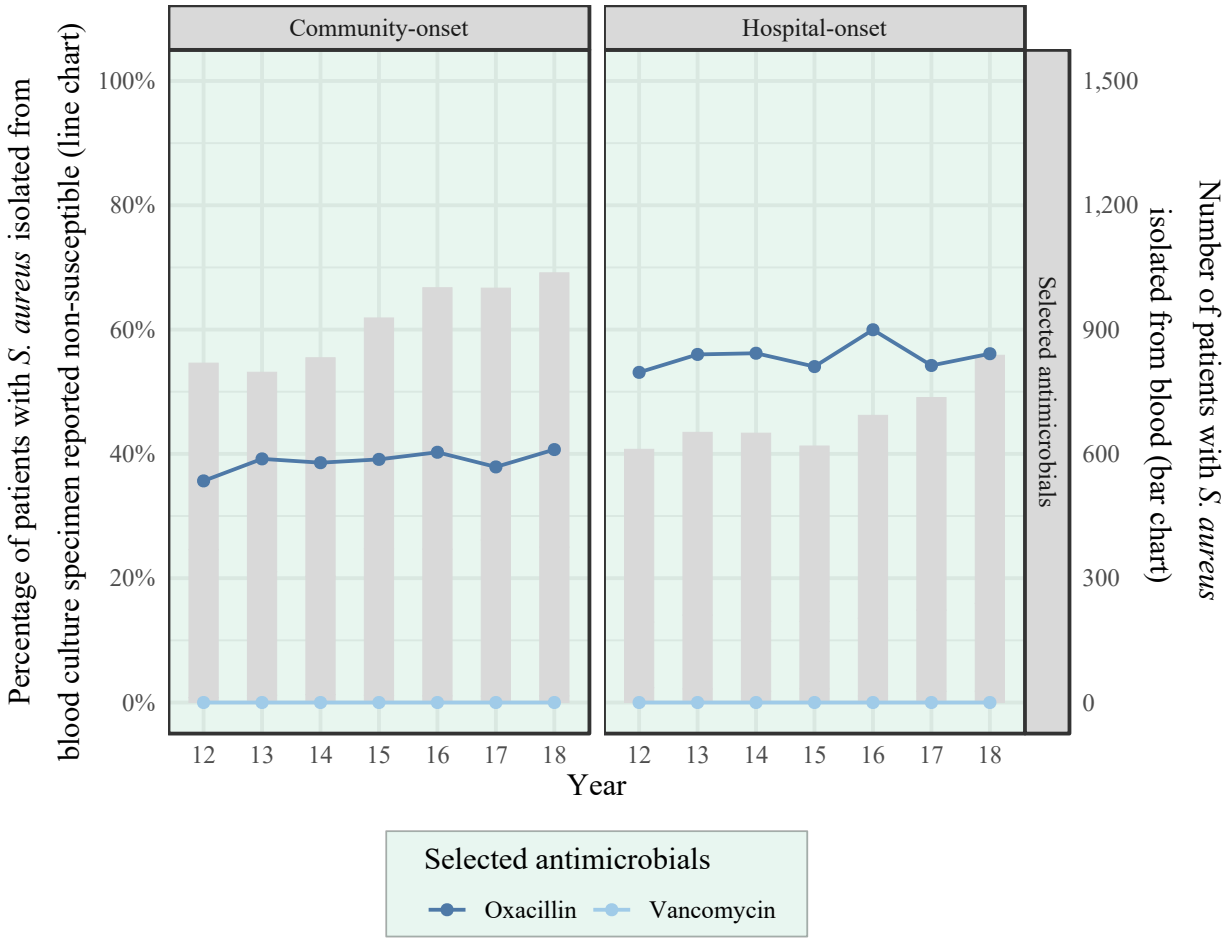
58. *Staphylococcus aureus* was the third commonest WHO GLASS priority organism isolated from community-onset blood culture specimen, and the second commonest organism for hospital-onset specimen from year 2012 to 2018. (Figure 2) Among all patients with positive blood culture specimen in year 2018, *S. aureus* contributed to 8.4% and 17.9% of all WHO GLASS priority organisms isolated from specimen collected for infection of community-onset and hospital-onset respectively. (Table 7)

59. Overview on number of patients with *S. aureus* isolated, stratified by location of onset, and the respective percentage of patients with *S. aureus* from positive blood culture specimen being non-susceptible towards oxacillin and vancomycin are shown in Figure 6.

60. Number of patients with *S. aureus* from positive blood culture specimen of community-onset increases from 800 in year 2012 to 1,000 in year 2018. Number of patients for *S. aureus* of hospital-onset plateaued from 600 in year 2012 to 600 in year 2015, and then increased to 800 in year 2018.

61. It is noted that non-susceptibility percentage of oxacillin for *S. aureus* isolates of hospital-onset is higher than those of community-onset.

Figure 6: Overview on percentage of patients with *Staphylococcus aureus* from positive blood culture specimen, reported non-susceptible to oxacillin and vancomycin, stratified by location of onset



4.3.3.1 Non-susceptibility percentage in year 2017 and 2018

62. Table 12 summarises percentage of patients with *S. aureus* isolated from blood culture specimen and being tested non-susceptible to oxacillin and vancomycin in year 2017 and 2018.

63. Non-susceptibility percentages of oxacillin for *S. aureus* isolated from community-onset (from 37.9% in year 2017 to 40.7% in year 2018) and hospital-onset (from 54.2% in year 2017 to 56.1% in year 2018) specimen remained stable[91] in year 2017 and 2018. For vancomycin, none of the tested *S. aureus* isolates were non-susceptible towards this antimicrobial.

[91] Chi-squared test or Fisher's exact test, whether appropriate, was performed, details on statistical method can be referred to Section 3.4.

Table 12: Percentage of patients with *Staphylococcus aureus* isolated from positive blood culture specimen reported non-susceptible to oxacillin and vancomycin in year 2017 and 2018

	Community-onset			Hospital-onset		
	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial	2017	2018	(17 vs 18)	2017	2018	(17 vs 18)
Oxacillin	37.9%	40.7%	0.213	54.2%	56.1%	0.483
Vancomycin	0%	0%	-	0%	0%	-

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Staphylococcus aureus* from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-values were calculated using Chi-squared test or Fisher's exact test, whether appropriate. Figures were rounded to three decimal places, cells with p-value <0.05 are highlighted.

4.3.3.2 Overall trend of non-susceptibility percentage

64. Table 13 summarises trends on non-susceptibility percentage of oxacillin and vancomycin among *S. aureus* isolates of community- and hospital-onset during the surveillance period.[92].

Community-onset isolates

65. From year 2012 to 2018, trend of non-susceptibility percentage for oxacillin remained stable.[93] The trend remained stable when year 2016 surveillance data was adopted as the baseline.[94] None of the tested *S. aureus* isolates were non-susceptible towards vancomycin.

Hospital-onset isolates

66. Similar trend on non-susceptibility percentage for oxacillin was also observed that the trend was stable from year 2012 to 2018[95] and from year 2016 to 2018[96]. None of the tested *S. aureus* isolates were non-susceptible towards vancomycin.

[92] Details on trend of non-susceptibility percentage from year 2012 to 2018 can be referred to Table 26 in Appendix.
[93] NS% of oxacillin for *S. aureus* of community-onset ranged from the lowest 35.7% in year 2012 to the highest 40.7% in year 2018.
[94] NS% of oxacillin for *S. aureus* of community-onset ranged from the lowest 37.9% in year 2017 to the highest 40.7% in year 2018.
[95] NS% of oxacillin for *S. aureus* of hospital-onset ranged from the lowest 53.1% in year 2012 to the highest 60.0% in year 2016.
[96] NS% of oxacillin for *S. aureus* of hospital-onset ranged from the lowest 54.2% in year 2017 to the highest 60.0% in year 2016.

Table 13: Time trends and significance levels for patients with *Staphylococcus aureus* isolated from blood culture specimen reported non-susceptible to oxacillin and vancomycin in year 2012-2018 and 2016-2018

		Community-onset						Hospital-onset					
		% Non-susceptible*		p-value†	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial group	Antimicrobial	2012	2018	12 - 18	2016	2018	16 - 18	2012	2018	12 - 18	2016	2018	16 - 18
Beta-lactamase resistant penicillins	Oxacillin	35.7%	40.7%	⟶ p = 1.000	40.3%	40.7%	⟶ p = 1.000	53.1%	56.1%	⟶ p = 1.000	60.0%	56.1%	⟶ p = 1.000
Glycopeptide antibacterials	Vancomycin	0%	0%	-	0%	0%	-	0%	0%	-	0%	0%	-

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Staphylococcus aureus* from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-value reports the statistical significance of trend observed during the captioned time period, it was calculated using Cochran-Armitage test with Bonferroni correction. Figures were rounded to three decimal places.

Legend:

↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed

Highlighted cells: Observation with statistical significance (p-value <0.05)

4.3.4 *Salmonella* species

Health effects and common treatment options of *Salmonella* infection

Salmonella can cause a number of clinical infections, ranging from gastroenteritis, enteric fever, bacteraemia with endovascular infection, focal infections such as osteomyelitis.

Enteric fever (a collective term commonly refers to both typhoid and paratyphoid fever) is caused by *Salmonella typhi* and *Salmonella paratyphi*, which can affect many organs and is usually characterised by severe systemic illness with fever and abdominal pain. Non-typhoidal salmonellosis is a collective term for infections caused by *Salmonella* of other serotypes. *Salmonella* is a pathogen primarily causing community-acquired infections and is rare to cause hospital-associated infections.

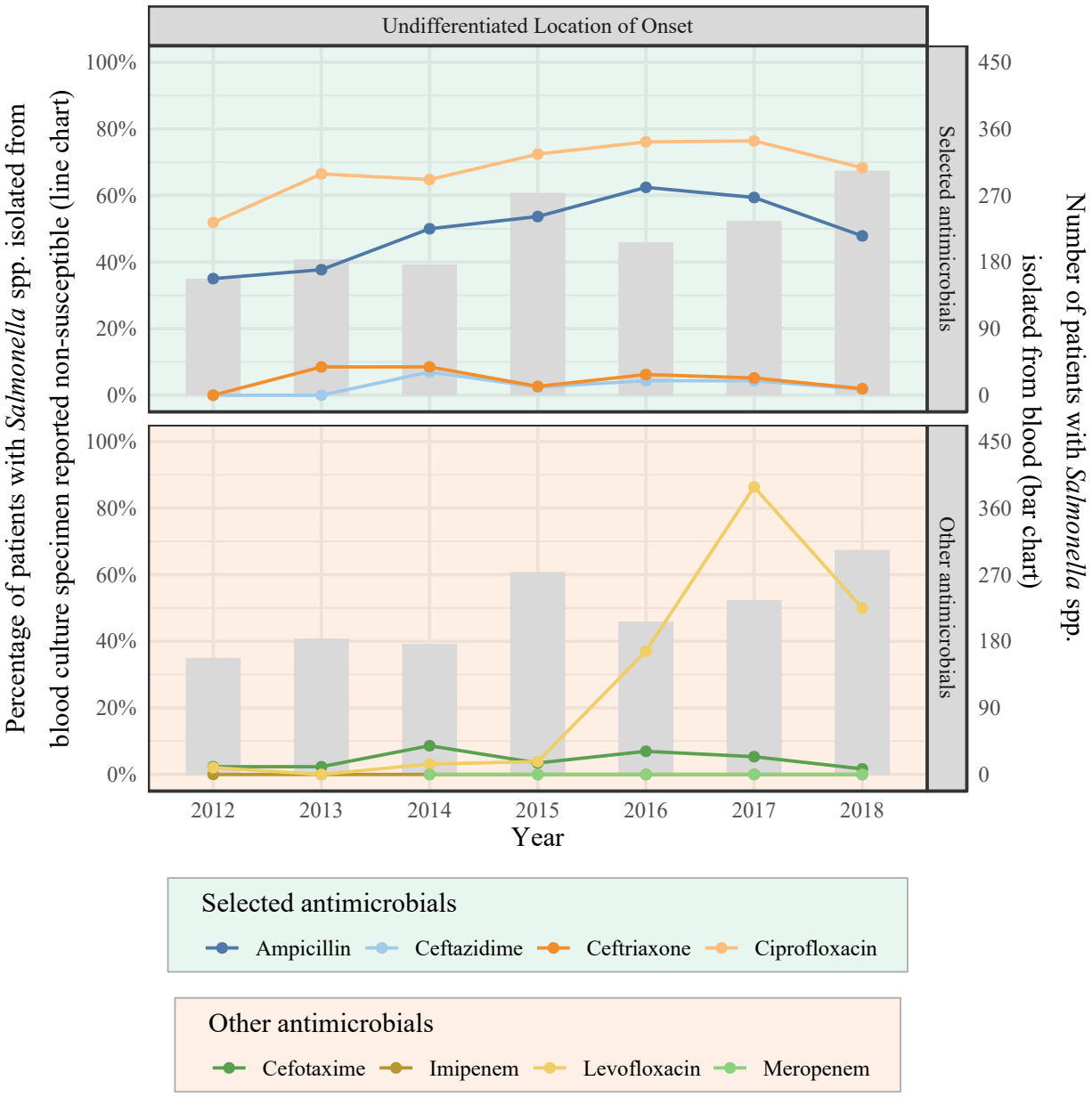
Salmonella gastroenteritis is usually self-limiting and antimicrobial therapy is generally not required except for patients with severe illness or at higher risk of invasive diseases (e.g. patients who are immunocompromised or have prosthetic vascular grafts). For enteric fever and extraintestinal non-typhoidal Salmonellosis, the main antibiotic treatment options are third-generation cephalosporins, such as ceftriaxone, and fluoroquinolones. Carbapenems are reserved for infection caused by drug-resistant strains.

67. *Salmonella* species was a less common WHO GLASS priority organism isolated from blood culture specimen among the six WHO GLASS priority organisms during the surveillance period (Figure 2), consistently contributing to less than two percent of all WHO GLASS priority organism isolated from specimen showing infection of community-onset and hospital-onset from year 2012 to 2018. *Salmonella* is a pathogen primarily causing community-acquired infections and it is rare to cause hospital-associated infections. In this regard, information on location of onset was not considered when analysing and interpreting non-susceptibility results, and non-susceptibility results were interpreted as isolates of undifferentiated location of onset.

68. Overview on number of patients with *Salmonella* spp. isolated and the respective percentage of patients with *Salmonella* specimen from positive blood culture specimen being non-susceptible towards different antimicrobials are shown in Figure 7.

69. Number of patients with *Salmonella* spp. isolated from blood culture specimen increased from 200 in year 2012 to 300 in year 2018.

Figure 7: Overview on percentage of patients with *Salmonella* species isolated from blood, reported non-susceptible to different antimicrobials, stratified by location of onset



4.3.4.1 Non-susceptibility percentage in year 2017 and 2018

70. Table 14 summarises percentage of patients with *Salmonella* spp. isolated from blood and being tested non-susceptible to different antimicrobials in year 2017 and 2018.

71. The main antimicrobial treatment options of *Salmonella* infections, if indicated, are usually third-generation cephalosporins, such as ceftriaxone and cefotaxime, and fluoroquinolones such as ciprofloxacin. Non-susceptibility percentages of ceftriaxone (from 5.2% in year 2017 to 2.0% in year 2018), cefotaxime (from 5.3% in year 2017 to 1.7% in year 2018) and ciprofloxacin (from 76.4% in year 2017 to 68.3% in year 2018) remained stable[97] in year 2017 and 2018. Besides, a significant decrease in non-susceptibility percentage for ampicillin (from 59.4% in year 2017 to 47.9% in year 2018) was observed during the same period.

72. It is noted that a significant decrease in non-susceptibility percentage for levofloxacin[98] in year 2017 and 2018 (from 86.4% in year 2017 to 50.0% in year 2018). This finding should be interpreted with caution as less than 70% of *Salmonella* spp. isolates were tested for levofloxacin in year 2017 and 2018.[99]

[97] Chi-squared test or Fisher's exact test, whether appropriate, was performed, details on statistical method can be referred to Section 3.4.

[98] A new interpretive criterion of levofloxacin for *Salmonella* spp. was released in year 2013. Details on changes in interpretive criteria for AST results can be referred to Section 2.3.1.

[99] Refer to Table 27 in Appendix for details.

Table 14: Percentage of patients with *Salmonella* species isolated from blood culture specimen reported non-susceptible to different antimicrobials in year 2017 and 2018

	Undifferentiated Location of Onset		
	% Non-susceptible*		p-value†
Antimicrobial	2017	2018	(17 vs 18)
Ampicillin	59.4%	47.9%	**0.010**
Ceftazidime	4.3%	1.8%	0.505
Ceftriaxone	5.2%	2.0%	0.069
Ciprofloxacin	76.4%	68.3%	0.050
Cefotaxime	5.3%	1.7%	0.207
Meropenem	0%	0%	-
Imipenem	0%	0%	-
Levofloxacin	86.4%	50.0%	**0.019**

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Salmonella* spp. from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-values were calculated using Chi-squared test or Fisher's exact test, whether appropriate. Figures were rounded to three decimal places, cells with p-value <0.05 are highlighted.

4.3.4.2 Overall trend of non-susceptibility percentage

73. Table 15 summarises trends on non-susceptibility percentage of different antimicrobials among *Salmonella* spp. isolates with undifferentiated location of onset during the surveillance period.[100]

[100] Details on trend of non-susceptibility percentage from year 2012 to 2018 can be referred to Table 27 in Appendix.

Isolates of undifferentiated location of onset

74. From year 2012 to 2018, non-susceptibility percentage for ampicillin[101], ciprofloxacin[102,103] and levofloxacin[104,105,106] showed increasing trends with statistical significance. These trends were not observed when year 2016 data was adopted as the baseline.

Table 15: Time trends and significance levels for patients with *Salmonella* species isolated from blood culture specimen reported non-susceptible to different antimicrobials in year 2012-2018 and 2016-2018

		Undifferentiated Location of Onset					
		% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial group	Antimicrobial	2012	2018	12 - 18	2016	2018	16 - 18
Penicillins with extended spectrum	Ampicillin	35.0%	47.9%	↗ **p <0.005**	62.4%	47.9%	↘ p = 0.051
Third-generation cephalosporins	Cefotaxime	2.3%	1.7%	⟶ p = 1.000	6.9%	1.7%	↘ p = 1.000
	Ceftazidime	0%	1.8%	⟶ p = 1.000	4.3%	1.8%	⟶ p = 1.000
	Ceftriaxone	0%	2.0%	⟶ p = 1.000	6.2%	2.0%	↘ p = 1.000
Carbapenems	Meropenem	‡	0%	-	0%	0%	-
	Imipenem	0%	0%	-	0%	0%	-
Fluoroquinolones	Ciprofloxacin§	51.9%	68.3%	↗ **p = 0.021**	76.1%	68.3%	↘ p = 1.000
	Levofloxacin¶	2.0%	50.0%	↗ **p <0.005**	37.0%	50.0%	⟶ p = 1.000

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Salmonella* spp. from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-value reports the statistical significance of trend observed during the captioned time period, it was calculated using Cochran-Armitage test with Bonferroni correction. Figures were rounded to three decimal places.

‡ No isolates had been tested on the susceptibility of the antimicrobial.

§ For interpretive criterion of ciprofloxacin for *Salmonella* spp., a new interpretive criterion was released in year 2012, and modified recommendations to use the separate interpretive criteria were released in year 2013.

¶ A new interpretive criterion of levofloxacin for *Salmonella* spp. was released in year 2013.

Legend:

↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed

Highlighted cells: Observation with statistical significance (p-value <0.05)

[101] NS% of ampicillin for *Salmonella* spp. ranged from the lowest 35.0% in year 2012 to the highest 62.4% in year 2016.

[102] NS% of ciprofloxacin for *Salmonella* spp. ranged from the lowest 51.9% in year 2012 to the highest 76.4% in year 2017.

[103] For interpretive criterion of ciprofloxacin for *Salmonella* spp., a new interpretive criterion was released in year 2012, and modified recommendations to use the separate interpretive criteria were released in year 2013. Details on changes in interpretive criteria for AST results can be referred to Section 2.3.1.

[104] NS% of levofloxacin for *Salmonella* spp. ranged from the lowest 0% in year 2013 to the highest 86.4% in year 2017.

[105] A new interpretive criterion of levofloxacin for *Salmonella* spp. was released in year 2013. Details on changes in interpretive criteria for AST results can be referred to Section 2.3.1.

[106] Readers should interpret this finding with caution, as levofloxacin AST was performed for less than 70% of all *Salmonella* spp. isolates from year 2012 to 2018. Refer to Table 27 in Appendix for details.

4.3.5 *Acinetobacter* species

Health effects and common treatment options of *Acinetobacter* infection

Acinetobacter species is a heterogeneous group of environmental organisms that is ubiquitous in fresh water and soil. It has emerged as a significant nosocomial pathogen and can cause different infections, such as ventilator associated pneumonia, skin and soft tissue infections, urinary tract infections and bacteraemia, in patients with compromised physical barriers and immunity.

Acinetobacter spp. can cause nosocomial outbreaks in different clinical settings, such as intensive care and burn units.

It has the propensity to acquire resistance, resulting in emergence of Multi-drug Resistant *Acinetobacter* that are resistant to major classes of available antibiotics, including fluoroquinolones, aminoglycosides, cephalosporins, beta-lactam/beta-lactamase inhibitor combinations and carbapenems.

Sulbactam is active against many *Acinetobacter* isolates. To treat *Acinetobacter* infections, beta-lactam/beta-lactamase inhibitor combination (i.e., ampicillin/sulbactam or cefoperazone/sulbactam) that includes sulbactam; broad-spectrum cephalosporins, such as ceftazidime; or a carbapenem may be used. Fluoroquinolones and aminoglycosides are other alternatives.

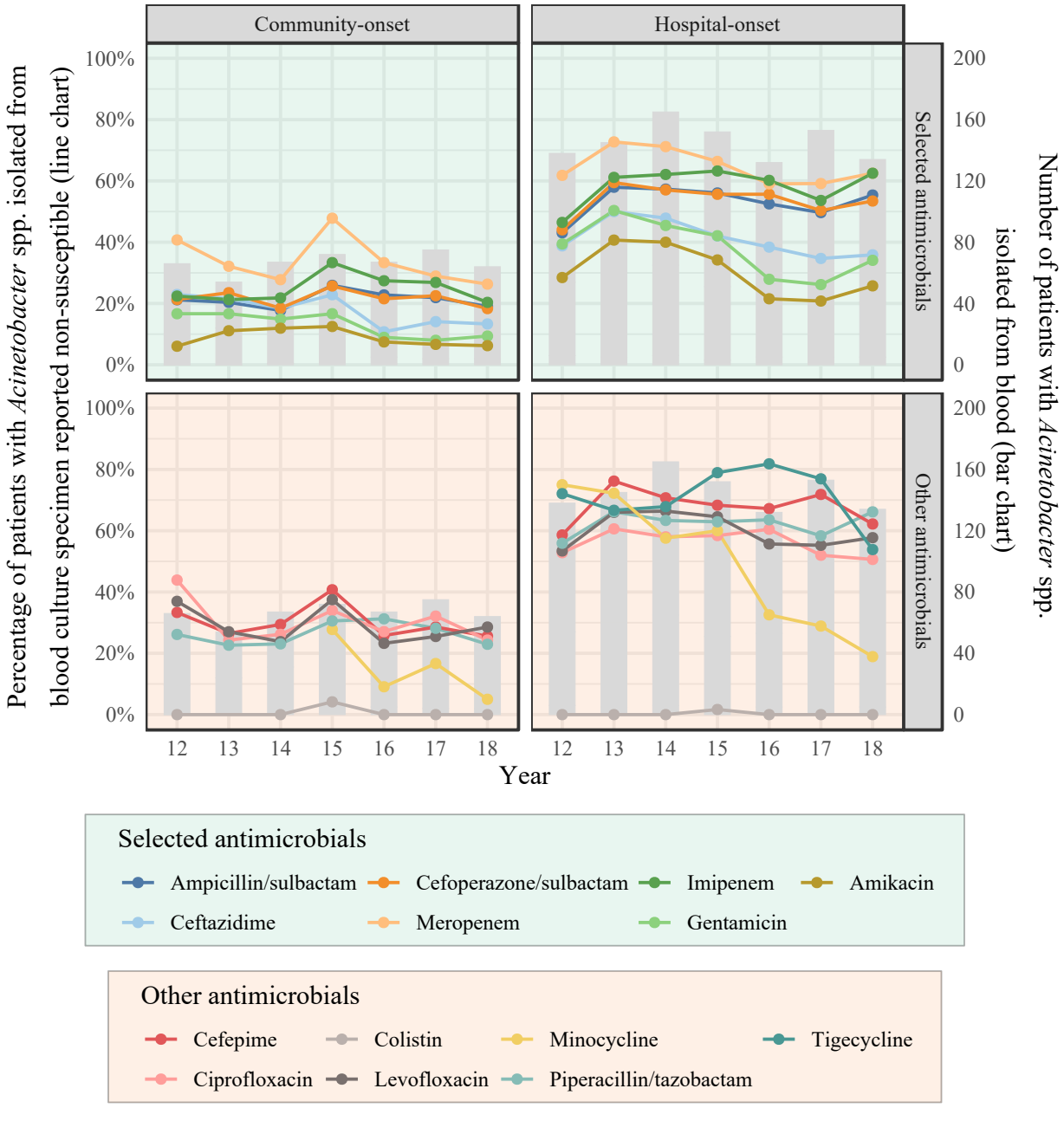
75. Similar to *Salmonella* spp., *Acinetobacter* spp. was a less common WHO GLASS priority organism isolated from blood culture specimen among the six WHO GLASS priority organisms during the surveillance period. (Figure 2) Being a significant nosocomial pathogen, more than 65% of *Acinetobacter* spp. isolates were categorised as infection of hospital-onset based on surveillance definition. (Figure 3) It contributed for about three percent of patients with WHO GLASS priority organisms isolated from hospital-onset specimen, and less than one percent of those with the organisms isolated from community-onset specimen from year 2012 to 2018. (Table 7)

76. Overview on number of patients with *Acinetobacter* spp. isolated and the respective percentage of patients *Acinetobacter* spp. from positive blood culture specimen being non-susceptible towards different antimicrobials are shown in Figure 8.

77. Number of patients with *Acinetobacter* spp. of community-onset isolated from blood culture specimen shows little variation with less than 100 patients from year 2012 to 2018. Variation of similar magnitude was also observed on number of patients with the organism of hospital-onset isolated from blood.

78. In general, non-susceptibility percentages were lower among *Acinetobacter* spp. isolates of community-onset than those of hospital-onset.

Figure 8: Overview on percentage of patients with *Acinetobacter* species isolated from blood, reported non-susceptible to different antimicrobials, stratified by location of onset



4.3.5.1 Non-susceptibility percentage in year 2017 and 2018

79. Table 16 summarises percentage of patients with *Acinetobacter* spp. isolated from blood and being tested non-susceptible to selected antimicrobials in year 2017 and 2018.

80. Among the selected antimicrobials of commonly used for treating infections caused by *Acinetobacter* spp., non-susceptible percentage for these antimicrobials remained stable.[107]

Table 16: Percentage of patients with *Acinetobacter* species isolated from blood culture specimen reported non-susceptible to selected antimicrobials in year 2017 and 2018

	Community-onset			Hospital-onset		
	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial	2017	2018	(17 vs 18)	2017	2018	(17 vs 18)
Ampicillin/sulbactam	21.9%	19.0%	0.841	49.7%	55.4%	0.406
Cefoperazone/sulbactam	22.5%	18.3%	0.707	50.3%	53.4%	0.693
Ceftazidime	14.1%	13.3%	1.000	34.7%	35.9%	0.936
Meropenem	28.9%	26.3%	1.000	59.1%	62.5%	0.756
Imipenem	26.9%	20.4%	0.537	53.6%	62.5%	0.189
Gentamicin	8.0%	9.4%	1.000	26.2%	34.1%	0.188
Amikacin	6.7%	6.3%	1.000	20.8%	25.8%	0.400

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Acinetobacter* spp. from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value $\geq$0.1% and two decimal places for value <0.1%.

† P-values were calculated using Chi-squared test or Fisher's exact test, whether appropriate. Figures were rounded to three decimal places, cells with p-value <0.05 are highlighted.

[107] Chi-squared test or Fisher's exact test, whether appropriate, was performed, details on statistical method can be referred to Section 3.4.

4.3.5.2 Overall trend of non-susceptibility percentage

81. Table 17 summarises trends on non-susceptibility percentage of different antimicrobials among *Acinetobacter* spp. isolates of community- and hospital-onset during the surveillance period.[108]

Community-onset isolates

82. From year 2012 to 2018, non-susceptibility percentage for different antimicrobials remained stable. The trends for the antimicrobials above-mentioned also remained stable when year 2016 surveillance data was adopted as the baseline.

Hospital-onset isolates

83. Non-susceptibility percentage for minocycline[109,110], gentamicin[111] and amikacin[112] showed decreasing trends with statistical significance. By adopting year 2016 surveillance data as the baseline, non-susceptibility percentage for these antimicrobials remained stable.

[108] Details on trend of non-susceptibility percentage from year 2012 to 2018 can be referred to Table 28 in Appendix.
[109] NS% of minocycline for *Acinetobacter* spp. of hospital-onset ranged from the lowest 18.9% in year 2018 to the highest 75.0% in year 2012.
[110] Readers should interpret this finding with caution, as minocycline AST was performed for less than 70% of all *Acinetobacter* spp. isolates (hospital-onset) from year 2012 to 2018. Refer to Table 28 in Appendix for details.
[111] NS% of gentamicin for *Acinetobacter* spp. of hospital-onset ranged from the lowest 26.2% in year 2017 to the highest 50.3% in year 2013.
[112] NS% of amikacin for *Acinetobacter* spp. of hospital-onset ranged from the lowest 20.8% in year 2017 to the highest 40.7% in year 2013.

Table 17: Time trends and significance levels for patients with *Acinetobacter* species isolated from blood culture specimen reported non-susceptible to different antimicrobials in year 2012-2018 and 2016-2018

		Community-onset						Hospital-onset					
		% Non-susceptible*		p-value†	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial group	Antimicrobial	2012	2018	12 - 18	2016	2018	16 - 18	2012	2018	12 - 18	2016	2018	16 - 18
Tetracyclines	Minocycline	‡	5.0%	⟶ p = 1.000	9.1%	5.0%	⟶ p = 1.000	75.0%	18.9%	↘ **p <0.005**	32.6%	18.9%	⟶ p = 1.000
	Tigecycline	‡	‡	-	‡	‡	-	72.1%	53.8%	⟶ p = 1.000	81.8%	53.8%	⟶ p = 1.000
Combinations of penicillins, incl. beta-lactamase inhibitors	Ampicillin/sulbactam	21.2%	19.0%	⟶ p = 1.000	22.8%	19.0%	⟶ p = 1.000	43.1%	55.4%	⟶ p = 1.000	52.5%	55.4%	⟶ p = 1.000
	Piperacillin/tazobactam	26.2%	23.0%	⟶ p = 1.000	31.3%	23.0%	⟶ p = 1.000	55.9%	66.2%	⟶ p = 1.000	63.6%	66.2%	⟶ p = 1.000
Third-generation cephalosporins	Ceftazidime	23.0%	13.3%	↘ p = 1.000	10.8%	13.3%	⟶ p = 1.000	38.8%	35.9%	↘ p = 1.000	38.4%	35.9%	⟶ p = 1.000
	Cefoperazone/sulbactam	21.3%	18.3%	⟶ p = 1.000	21.5%	18.3%	⟶ p = 1.000	44.0%	53.4%	⟶ p = 1.000	55.6%	53.4%	⟶ p = 1.000
Fourth-generation cephalosporins	Cefepime	33.3%	25.6%	⟶ p = 1.000	25.8%	25.6%	⟶ p = 1.000	58.6%	62.2%	⟶ p = 1.000	67.2%	62.2%	⟶ p = 1.000
Carbapenems	Meropenem§	40.7%	26.3%	⟶ p = 1.000	33.3%	26.3%	⟶ p = 1.000	61.8%	62.5%	⟶ p = 1.000	59.0%	62.5%	⟶ p = 1.000
	Imipenem¶	22.4%	20.4%	⟶ p = 1.000	27.4%	20.4%	⟶ p = 1.000	46.5%	62.5%	⟶ p = 1.000	60.2%	62.5%	⟶ p = 1.000
Other aminoglycosides	Gentamicin	16.7%	9.4%	↘ p = 1.000	9.0%	9.4%	⟶ p = 1.000	39.4%	34.1%	↘ **p = 0.005**	27.9%	34.1%	⟶ p = 1.000
	Amikacin	6.1%	6.3%	⟶ p = 1.000	7.5%	6.3%	⟶ p = 1.000	28.5%	25.8%	↘ **p = 0.039**	21.5%	25.8%	⟶ p = 1.000
Fluoroquinolones	Ciprofloxacin	43.9%	24.3%	⟶ p = 1.000	27.1%	24.3%	⟶ p = 1.000	52.8%	50.6%	⟶ p = 1.000	60.5%	50.6%	⟶ p = 1.000
	Levofloxacin	37.0%	28.6%	⟶ p = 1.000	23.3%	28.6%	⟶ p = 1.000	53.4%	57.7%	⟶ p = 1.000	55.7%	57.7%	⟶ p = 1.000
Polymyxins	Colistin	0%	0%	⟶ p = 1.000	0%	0%	-	0%	0%	⟶ p = 1.000	0%	0%	-

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Acinetobacter* spp. from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-value reports the statistical significance of trend observed during the captioned time period, it was calculated using Cochran-Armitage test with Bonferroni correction. Figures were rounded to three decimal places.

‡ No isolates had been tested on the susceptibility of the antimicrobial.

§ A new (revised) interpretive criterion of meropenem for *Acinetobacter* spp. was released in year 2014.

¶ A new (revised) interpretive criterion of imipenem for *Acinetobacter* spp. was released in year 2014.

Legend:

↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed

Highlighted cells: Observation with statistical significance (p-value <0.05)

4.3.6 *Streptococcus pneumoniae*

Health effects and common treatment options of *Streptococcus pneumoniae* infection

Streptococcus pneumoniae is a pathogen that can cause acute otitis media, acute sinusitis, acute exacerbation of chronic obstructive pulmonary disease and pneumonia. It can also cause septicaemia and bacterial meningitis. *S. pneumoniae* is a pathogen primarily causing community-acquired infections and is rare to cause hospital-associated infections.

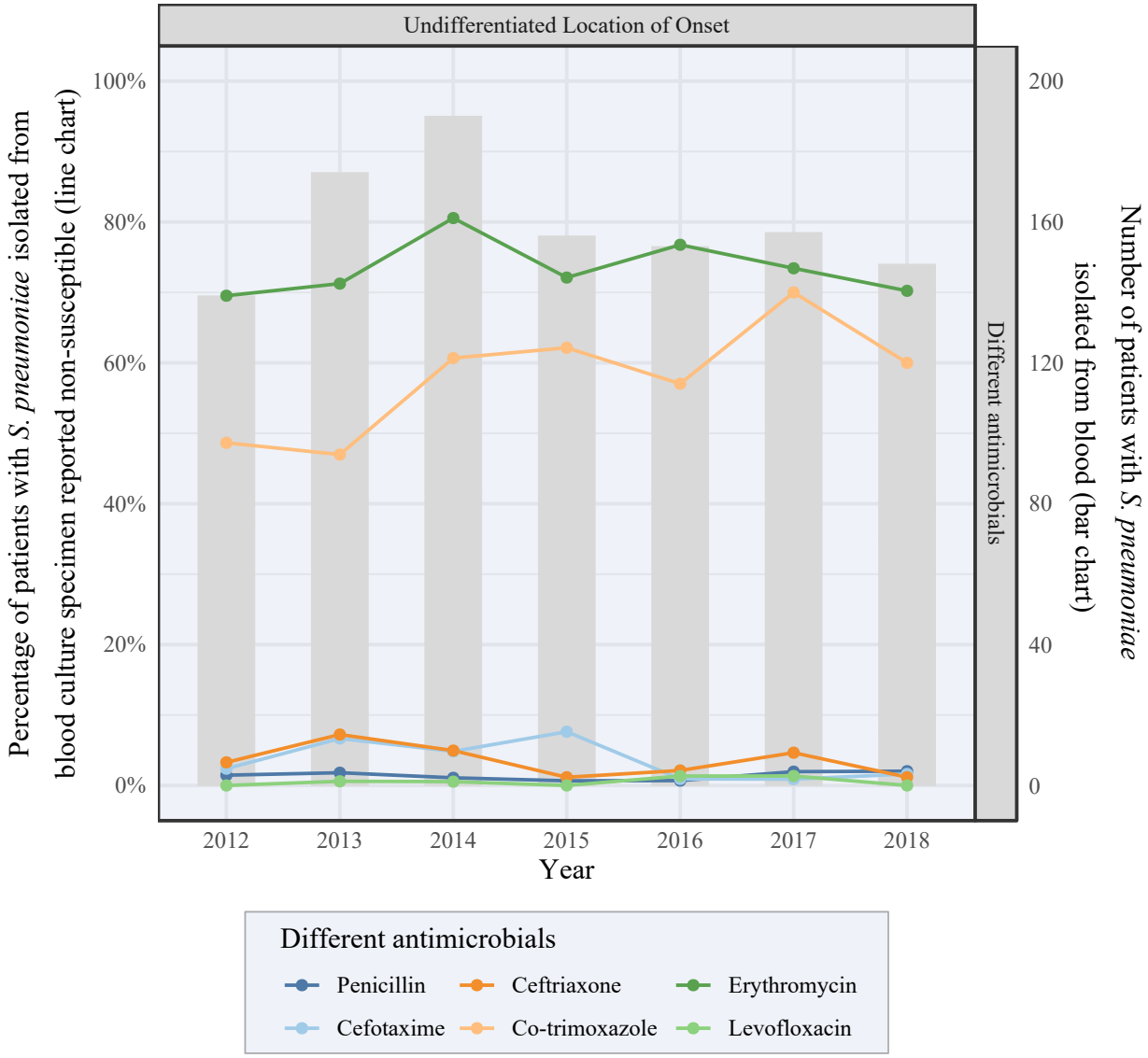
For infections outside central nervous system, most can be treated with intravenous penicillin if the strain is susceptible, or third generation cephalosporins such as ceftriaxone or cefotaxime for penicillin-nonsusceptible strains. Strains causing meningitis that are non-susceptible to penicillin and ceftriaxone/cefotaxime require the use of alternative antimicrobials such as vancomycin.

84. *Streptococcus pneumoniae* was the least common isolates among the six WHO GLASS priority organisms isolated from blood culture specimen. (Figure 2) Being a pathogen primarily causing community-acquired infections and rare to cause hospital-associated infections. Information on location of onset was not considered when analysing and interpreting non-susceptibility results, and non-susceptibility results were interpreted as isolates of undifferentiated location of onset.

85. Overview on number of patients with *S. pneumoniae* isolated and the respective percentage of patients with *S. pneumoniae* from positive blood culture specimen being non-susceptible towards different antimicrobials are shown in Figure 9.

86. Number of patients with *S. pneumoniae* isolated from blood culture specimen remained stable with less than 200 patients annually from year 2012 to 2018.

Figure 9: Overview on percentage of patients with *Streptococcus pneumoniae* isolated from blood, reported non-susceptible to different antimicrobials, stratified by location of onset



4.3.6.1 Non-susceptibility percentage in year 2017 and 2018

87. Table 18 summarises percentage of patients with *S. pneumoniae* isolated from blood and being tested non-susceptible to different antimicrobials in year 2017 and 2018.

88. Penicillins and third-generation cephalosporins are commonly used for the treatment of invasive pneumococcal infections. Non-susceptibility percentages of penicillin (from 2.0% in year 2017 to 2.0% in year 2018), cefotaxime (from 0.9% in year 2017 to 1.6% in year 2018), ceftriaxone (from 4.7% in year 2017 to 1.2% in year 2018) remained comparable[113] for year 2017 and 2018.

Table 18: Percentage of patients with *Streptococcus pneumoniae* isolated from blood culture specimen reported non-susceptible to different antimicrobials in year 2017 and 2018

	Undifferentiated Location of Onset		
	% Non-susceptible*		p-value†
Antimicrobial	2017	2018	(17 vs 18)
Penicillin‡	2.0%	2.0%	1.000
Erythromycin	73.4%	70.2%	0.650
Cefotaxime‡	0.9%	1.6%	1.000
Ceftriaxone‡	4.7%	1.2%	0.368
Co-trimoxazole	70.0%	60.0%	0.132
Levofloxacin	1.3%	0%	0.498

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Streptococcus pneumoniae* from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-values were calculated using Chi-squared test or Fisher's exact test, whether appropriate. Figures were rounded to three decimal places, cells with p-value <0.05 are highlighted.

‡ The interpretation was based on clinical breakpoint criterion for non-meningitis.

[113] Chi-squared test or Fisher's exact test, whether appropriate, was performed, details on statistical method can be referred to Section 3.4.

4.3.6.2 Overall trend of non-susceptibility percentage

89. Table 19 summarises trends on non-susceptibility percentage of different antimicrobials of *S. pneumoniae* isolates with undifferentiated location of onset during the surveillance period.[114]

Isolates of undifferentiated location of onset

90. From year 2012 to 2018, non-susceptibility percentage for co-trimoxazole[115] showed an increasing trend with statistical significance. The trend was not observed when year 2016 data was adopted as the baseline.

Table 19: Time trends and significance levels for patients with *Streptococcus pneumoniae* isolated from blood culture specimen reported non-susceptible to different antimicrobials in year 2012-2018 and 2016-2018

		Undifferentiated Location of Onset					
		% Non-susceptible*		p-value†	% Non-susceptible*		p-value†
Antimicrobial group	Antimicrobial	2012	2018	12 - 18	2016	2018	16 - 18
	Penicillin§	1.5%	2.0%	⟶ p = 1.000	0.69%	2.0%	⟶ p = 1.000
Third-generation cephalosporins	Cefotaxime§	2.4%	1.6%	↘ p = 1.000	0.93%	1.6%	⟶ p = 1.000
	Ceftriaxone§	3.3%	1.2%	⟶ p = 1.000	2.1%	1.2%	⟶ p = 1.000
Combinations of sulfonamides and trimethoprim, incl. derivatives	Co-trimoxazole	48.6%	60.0%	↗ **p = 0.039**	57.0%	60.0%	⟶ p = 1.000
Macrolides	Erythromycin	69.5%	70.2%	⟶ p = 1.000	76.8%	70.2%	⟶ p = 1.000
Fluoroquinolones	Levofloxacin	0%	0%	⟶ p = 1.000	1.3%	0%	⟶ p = 1.000

* Non-susceptible percentage is defined as the ratio of: i) number of patients with *Streptococcus pneumoniae* from positive blood culture specimen(s), while the isolate reported "Intermediate" or "Resistant" to a specific antimicrobial; and ii) number of patients with the same organism from positive blood culture specimen(s), multiplied by 100. Figures were rounded to one decimal place for value ≥0.1% and two decimal places for value <0.1%.

† P-value reports the statistical significance of trend observed during the captioned time period, it was calculated using Cochran-Armitage test with Bonferroni correction. Figures were rounded to three decimal places.

§ The interpretation was based on clinical breakpoint criterion for non-meningitis.

Legend:

↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed

Highlighted cells: Observation with statistical significance (p-value <0.05)

[114] Details on trend of non-susceptibility percentage from year 2012 to 2018 can be referred to Table 29 in Appendix.

[115] NS% of co-trimoxazole for *S. pneumoniae* ranged from the lowest 47.0% in year 2013 to the highest 70.0% in year 2017.

5 Discussion

91. Blood stream infections are usually serious infections and most patients will require hospital care. With around 90% of secondary healthcare services[116] being provided by HA[117][8], findings from this surveillance exercise have covered a majority of patients with bloodstream infection in Hong Kong.

92. During the surveillance period, an increase in number of patients with blood culture specimen(s) collected[118], and number of patients with positive blood culture specimen[119] were observed, which may signify an increasing number of bloodstream infections in Hong Kong.

93. Non-susceptibility percentage on a majority of different antimicrobials for the six WHO GLASS priority organisms remained stable or with a slight decreasing trend during the surveillance period. However, increasing trend of non-susceptibility percentage was also observed among several pathogen-antimicrobial combinations. In particular, the trend of non-susceptibility percentage for carbapenems among *K. pneumoniae* warrants further monitoring.

5.1 Limitations

94. When interpreting the surveillance findings, readers should take note of the number of limitations for this surveillance exercise identified as below:

95. **Limitation to extrapolate findings to organisms isolated from other anatomical sites:** Results presented in this report are based on AST results of non-duplicate isolates from positive blood culture specimen. Limiting AST result of isolates cultured from positive blood culture specimen while excluding specimens collected from other anatomical sites[120] can prevent findings on antimicrobial non-susceptibility to be distorted by isolates cultured from other specimens. In this regard, results from this surveillance exercise are only applicable to WHO GLASS priority organisms isolates from blood culture specimen, which the appropriateness of extrapolating findings for these organisms from blood culture specimen to organisms isolated from other anatomical sites has not been assessed.

[116] Secondary healthcare services refer to hospital or inpatient service, in terms of number of hospital beds.
[117] In terms of number of hospital beds
[118] This figure may suggest an increasing number of patients suspected to have bloodstream infection.
[119] This figure reflects an increasing number of patients with genuine bloodstream infection.
[120] As discussed in 3.3.1, only isolates from positive blood culture specimen were included for analysis on antimicrobial non-susceptibility. Isolates cultured from other specimens, such as blood clot, cord blood and bone marrow, were excluded from analysis.

96. **Limitation in ascertaining origin of infections**: This surveillance exercise adopted specimen classification definition from WHO GLASS Manual for Early Implementation[3], which a 48-hour cut-off after patient being admitted to a healthcare facility was adopted to determine whether the specimen is of hospital-onset or community-onset. The first proposal of this classification to define healthcare-associated infection was made in year 2002 by Siegman-Igra et al. and Friedman et al.[9],[10] Although being widely accepted, a systematic review conducted by Cardoso et al. reviewing definition of healthcare-associated infections used in clinical studies commented that future review of the definition should include: i) recent invasive procedures; ii) hospitalisation in the last year; or iii) previous antibiotic treatment[11]. The method adopted from WHO GLASS on categorising specimen as hospital-onset/community-onset is based on the operational definition[121] and does not take into account of other clinical information. As additional clinical information is needed to ascertain origin of infections, readers are reminded not to take these findings at face value.

97. **Surveillance result may be over-represented towards particular laboratories performed a majority volume of AST for particular pathogen**: For the same bacterial species identified in blood, application of AST panel may vary among laboratories based on the clinical context of individual patient and Standard Operating Procedure of individual laboratories. Given the adoption of deduplication methodology from WHO GLASS in this surveillance exercise has already prevented the surveillance result from over-estimating non-susceptibility percentage caused by AST results being skewed towards same patient with duplicate isolates[12], readers should note of the possibility that findings on antimicrobial non-susceptibility of a particular pathogen-antimicrobial combination in this report may still be over-represented by data contributed by particular laboratories which performed a majority volume of that particular AST.

[121] For local adaptation of WHO GLASS methodology, multiple/duplicate positive cultures within a two-week period from the same patient was regarded as a single episode. Details on definitions can be referred to Section 2.

98. **Guideline change, and variation in practice in adopting new guideline by different laboratories**: AST results from different testing methods[122] were interpreted as one of the following three values: Susceptible, Intermediate and Resistant, based on prevailing guidelines on clinical breakpoints[123] adopted by each laboratory, before being aggregated for further analysis. With the understanding that clinical breakpoints may change over time, readers are reminded to take this factor into consideration when interpreting the surveillance results. Besides, readers should note of the fact that the exact timing of individual laboratories adopting an updated guideline on clinical breakpoints might vary and the schedule of individual laboratories in adopting the updated guidelines were not captured in this report.

[122] For example, Kirby-Bauer Disk Diffusion Susceptibility Test, and Minimum Inhibitory Concentration Assays
[123] Breakpoint is a chosen concentration of an antimicrobial which defines whether a species of bacteria is susceptible or resistant to the antimicrobial.

6 Conclusion

99. Ongoing surveillance is an important area in monitoring the trend and the effectiveness of measures implemented in AMR control. Together with surveillance data from other sources, this surveillance exercise contributes to the understanding of AMR situation in Hong Kong. While non-susceptibility percentage on a majority of different antimicrobials for the six WHO GLASS priority organisms remained stable or with a slight decreasing trend during the surveillance period, increasing trend observed among several pathogen-antimicrobial combinations warrants the need for ongoing surveillance.

100. AMR remains a serious threat in the world and Hong Kong is of no exception. Concerted efforts of different parties, including the prudent antimicrobial use and comprehensive infection prevention and control strategies, are the key measures to combat AMR.

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8 Appendix

8.1 Supplementary information on number of patients with positive blood culture specimen

Table 20: Age and sex distribution of patients with blood culture specimen collected

	Patient count* and percentage†													
	Year 2012		Year 2013		Year 2014		Year 2015		Year 2016		Year 2017		Year 2018	
Age gp	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
0	6,000 (9.4%)	7,000 (11.3%)	5,000 (8.7%)	6,000 (10.4%)	5,000 (8.7%)	7,000 (10.2%)	6,000 (8.5%)	7,000 (10.3%)	6,000 (8.7%)	8,000 (9.9%)	6,000 (7.7%)	7,000 (9.0%)	6,000 (7.2%)	7,000 (8.4%)
1 - 4	3,000 (5.6%)	4,000 (6.1%)	3,000 (5.6%)	4,000 (6.4%)	3,000 (5.1%)	4,000 (5.9%)	3,000 (5.1%)	4,000 (5.7%)	4,000 (6.1%)	5,000 (7.0%)	4,000 (5.7%)	5,000 (6.6%)	4,000 (5.7%)	5,000 (6.4%)
5 - 14	2,000 (3.2%)	2,000 (3.4%)	2,000 (3.3%)	2,000 (3.3%)	2,000 (2.9%)	2,000 (3.2%)	2,000 (2.6%)	2,000 (3.0%)	3,000 (3.7%)	3,000 (4.0%)	3,000 (3.4%)	3,000 (3.6%)	2,000 (3.2%)	3,000 (3.6%)
15 - 24	2,000 (3.1%)	1,000 (2.1%)	2,000 (3.1%)	1,000 (2.3%)	2,000 (2.9%)	1,000 (2.2%)	2,000 (2.8%)	1,000 (2.0%)	2,000 (2.9%)	2,000 (2.1%)	2,000 (2.8%)	2,000 (2.1%)	2,000 (2.7%)	2,000 (2.0%)
25 - 34	4,000 (5.9%)	2,000 (2.6%)	4,000 (5.9%)	2,000 (2.8%)	4,000 (6.1%)	2,000 (2.7%)	4,000 (5.9%)	2,000 (2.6%)	5,000 (6.2%)	2,000 (2.8%)	5,000 (6.2%)	2,000 (2.8%)	5,000 (6.2%)	2,000 (2.8%)
35 - 44	3,000 (5.3%)	2,000 (3.7%)	3,000 (5.5%)	2,000 (3.9%)	4,000 (5.7%)	3,000 (4.0%)	4,000 (5.7%)	3,000 (3.8%)	4,000 (5.7%)	3,000 (3.7%)	5,000 (6.0%)	3,000 (3.9%)	5,000 (6.0%)	3,000 (3.8%)
45 - 54	4,000 (7.1%)	5,000 (7.3%)	4,000 (7.1%)	5,000 (7.3%)	4,000 (7.1%)	5,000 (7.2%)	5,000 (7.0%)	5,000 (6.8%)	5,000 (6.8%)	5,000 (6.7%)	5,000 (7.0%)	6,000 (6.8%)	6,000 (7.2%)	5,000 (6.5%)
55 - 64	5,000 (8.9%)	8,000 (12.2%)	6,000 (9.5%)	8,000 (12.9%)	6,000 (9.6%)	9,000 (13.3%)	6,000 (9.6%)	9,000 (13.1%)	7,000 (9.6%)	10,000 (13.1%)	8,000 (10.1%)	11,000 (13.3%)	8,000 (10.5%)	11,000 (13.8%)

Table 20: Age and sex distribution of patients with blood culture specimen collected *(continued)*

	Patient count* and percentage†													
	Year 2012		Year 2013		Year 2014		Year 2015		Year 2016		Year 2017		Year 2018	
Age gp	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
65 - 74	5,000 (9.2%)	9,000 (14.9%)	6,000 (9.3%)	9,000 (14.9%)	6,000 (9.4%)	10,000 (14.8%)	6,000 (9.8%)	11,000 (15.5%)	7,000 (9.9%)	12,000 (15.4%)	8,000 (10.7%)	13,000 (16.3%)	9,000 (11.4%)	14,000 (17.0%)
75 - 84	12,000 (20.5%)	15,000 (23.8%)	12,000 (20.0%)	14,000 (22.9%)	12,000 (19.7%)	15,000 (22.8%)	13,000 (19.2%)	16,000 (22.7%)	13,000 (17.3%)	16,000 (20.9%)	13,000 (16.9%)	17,000 (20.7%)	13,000 (16.1%)	16,000 (20.0%)
85+	13,000 (21.7%)	8,000 (12.6%)	13,000 (22.0%)	8,000 (12.9%)	14,000 (22.7%)	9,000 (13.6%)	16,000 (23.8%)	10,000 (14.5%)	17,000 (23.0%)	11,000 (14.3%)	18,000 (23.4%)	12,000 (15.0%)	19,000 (23.7%)	13,000 (15.6%)
Total	59,000 (100.0%)	64,000 (100.0%)	60,000 (100.0%)	63,000 (100.0%)	63,000 (100.0%)	67,000 (100.0%)	66,000 (100.0%)	70,000 (100.0%)	73,000 (100.0%)	77,000 (100.0%)	77,000 (100.0%)	82,000 (100.0%)	78,000 (100.0%)	81,000 (100.0%)

* Rounded to the nearest thousand

† Rounded to one decimal place

Note:

Since the same patient may have blood culture specimens collected across two age groups (i.e. specimen collected before and after birthday), for simplicity, only the first specimen for each patient, regardless of culture result, is included when counting for number of patients with blood culture specimen collected.

Minor adjustment on headcount is made when compared with last report, in order to more accurately reflect the deduplication requirement of WHO GLASS.

Table 21: Number of patients with blood culture specimen collected and percentage of patients with positive blood culture specimen

	Prevalence of positive blood culture (%) (95% CI)			
Year	Age 0 - 14	Age 15 - 64	Age 65+	Total
2012	600/ 24,000 (2.5%) (2.3% - 2.7%)	3,800/ 35,800 (10.6%) (10.3% - 10.9%)	8,900/ 63,200 (14.1%) (13.8% - 14.4%)	13,300/ 123,000 (10.8%) (10.6% - 11.0%)
2013	500/ 23,100 (2.1%) (1.9% - 2.3%)	3,700/ 36,900 (10.0%) (9.7% - 10.3%)	9,000/ 62,300 (14.5%) (14.2% - 14.8%)	13,200/ 122,300 (10.8%) (10.6% - 11.0%)
2014	600/ 23,400 (2.4%) (2.2% - 2.6%)	3,800/ 39,500 (9.7%) (9.4% - 10.0%)	9,800/ 66,800 (14.7%) (14.4% - 14.9%)	14,200/ 129,800 (10.9%) (10.8% - 11.1%)
2015	500/ 24,000 (2.2%) (2.1% - 2.4%)	4,100/ 40,300 (10.3%) (10.0% - 10.6%)	10,400/ 71,700 (14.5%) (14.3% - 14.8%)	15,100/ 136,000 (11.1%) (10.9% - 11.3%)
2016	500/ 29,700 (1.8%) (1.7% - 2.0%)	4,300/ 44,700 (9.6%) (9.3% - 9.8%)	10,700/ 75,600 (14.1%) (13.9% - 14.4%)	15,500/ 150,000 (10.3%) (10.2% - 10.5%)
2017	500/ 28,600 (1.7%) (1.5% - 1.8%)	4,200/ 48,300 (8.7%) (8.5% - 9.0%)	11,300/ 81,800 (13.8%) (13.6% - 14.1%)	16,000/ 158,700 (10.1%) (9.9% - 10.2%)
2018	400/ 27,400 (1.6%) (1.4% - 1.7%)	4,300/ 49,000 (8.8%) (8.6% - 9.1%)	11,700/ 82,600 (14.1%) (13.9% - 14.4%)	16,400/ 159,000 (10.3%) (10.2% - 10.5%)

Note:

Patient count was rounded to the nearest hundred.

Prevalence and CI were rounded to one decimal place.

Since the same patient may have blood culture specimens collected across two age groups (i.e. specimen collected before and after birthday), for simplicity, only the first positive specimen from each patient is included when counting for number of patients with positive blood culture specimen, and only the first specimen for each patient, regardless of culture result, is included when counting for number of patients with blood culture specimen collected.

8.2 Supplementary information on number of patients with WHO GLASS priority organism isolated from positive blood culture specimen

Table 22: Distribution of WHO GLASS priority organism isolated from positive blood culture specimen

Year	Number of patients with WHO GLASS priority organism isolated from positive blood culture specimen (%) (95% CI)						
	Escherichia coli	*Klebsiella pneumoniae*	*Staphylococcus aureus*	*Salmonella* spp.	*Acinetobacter* spp.	*Streptococcus pneumoniae*	Other spp.
2012	5,000/ 13,300 (37.7%) (36.9% - 38.6%)	1,600/ 13,300 (11.7%) (11.2% - 12.3%)	1,400/ 13,300 (10.5%) (10.0% - 11.1%)	200/ 13,300 (1.2%) (1.0% - 1.4%)	200/ 13,300 (1.5%) (1.3% - 1.7%)	100/ 13,300 (1.0%) (0.9% - 1.2%)	6,500/ 13,300 (48.8%) (47.9% - 49.6%)
2013	5,200/ 13,200 (39.7%) (38.8% - 40.5%)	1,700/ 13,200 (12.8%) (12.2% - 13.4%)	1,400/ 13,200 (10.8%) (10.3% - 11.3%)	200/ 13,200 (1.4%) (1.2% - 1.6%)	200/ 13,200 (1.5%) (1.3% - 1.7%)	200/ 13,200 (1.3%) (1.1% - 1.5%)	6,000/ 13,200 (45.7%) (44.9% - 46.6%)
2014	5,500/ 14,200 (39.1%) (38.3% - 39.9%)	1,700/ 14,200 (12.1%) (11.6% - 12.6%)	1,400/ 14,200 (10.2%) (9.7% - 10.7%)	200/ 14,200 (1.2%) (1.1% - 1.4%)	200/ 14,200 (1.6%) (1.4% - 1.8%)	200/ 14,200 (1.3%) (1.2% - 1.5%)	6,600/ 14,200 (46.7%) (45.8% - 47.5%)
2015	6,000/ 15,100 (39.8%) (39.0% - 40.6%)	1,800/ 15,100 (11.9%) (11.4% - 12.4%)	1,500/ 15,100 (10.0%) (9.6% - 10.5%)	300/ 15,100 (1.8%) (1.6% - 2.0%)	200/ 15,100 (1.5%) (1.3% - 1.7%)	200/ 15,100 (1.0%) (0.9% - 1.2%)	7,000/ 15,100 (46.4%) (45.6% - 47.2%)
2016	6,300/ 15,500 (40.9%) (40.1% - 41.7%)	1,900/ 15,500 (12.3%) (11.8% - 12.8%)	1,700/ 15,500 (10.7%) (10.2% - 11.2%)	200/ 15,500 (1.3%) (1.2% - 1.5%)	200/ 15,500 (1.3%) (1.1% - 1.5%)	200/ 15,500 (1.0%) (0.8% - 1.2%)	7,000/ 15,500 (45.0%) (44.2% - 45.7%)
2017	6,600/ 16,000 (41.2%) (40.4% - 42.0%)	1,900/ 16,000 (11.7%) (11.2% - 12.2%)	1,700/ 16,000 (10.6%) (10.1% - 11.1%)	200/ 16,000 (1.5%) (1.3% - 1.7%)	200/ 16,000 (1.4%) (1.3% - 1.6%)	200/ 16,000 (1.0%) (0.8% - 1.1%)	7,200/ 16,000 (45.0%) (44.2% - 45.8%)
2018	6,800/ 16,400 (41.2%) (40.4% - 41.9%)	1,900/ 16,400 (11.4%) (11.0% - 11.9%)	1,800/ 16,400 (11.2%) (10.7% - 11.7%)	300/ 16,400 (1.8%) (1.7% - 2.1%)	200/ 16,400 (1.2%) (1.1% - 1.4%)	100/ 16,400 (0.9%) (0.8% - 1.1%)	7,300/ 16,400 (44.5%) (43.7% - 45.2%)

Note:
Patient count was rounded to the nearest hundred.
Percentage and CI were rounded to one decimal place.

Table 23: Distribution of WHO GLASS priority organism isolated from positive blood culture specimen, stratified by location of onset

	Patient count* and percentage†‡						
Location of Onset	2012	2013	2014	2015	2016	2017	2018
Escherichia coli							
Community¶	4,200 (81.9%)	4,400 (81.8%)	4,700 (82.8%)	5,000 (81.7%)	5,300 (82.1%)	5,600 (82.7%)	5,700 (83.2%)
Hospital**	900 (18.1%)	1,000 (18.2%)	1,000 (17.2%)	1,100 (18.3%)	1,200 (17.9%)	1,200 (17.3%)	1,200 (16.8%)
Klebsiella pneumoniae							
Community¶	1,200 (74.4%)	1,300 (74.1%)	1,300 (72.6%)	1,300 (70.0%)	1,400 (73.6%)	1,400 (73.8%)	1,400 (74.7%)
Hospital**	400 (25.6%)	400 (25.9%)	500 (27.4%)	600 (30.0%)	500 (26.4%)	500 (26.2%)	500 (25.3%)
Staphylococcus aureus							
Community¶	800 (57.3%)	800 (55.0%)	800 (56.1%)	900 (60.0%)	1,000 (59.1%)	1,000 (57.6%)	1,000 (55.3%)
Hospital**	600 (42.7%)	700 (45.0%)	700 (43.9%)	600 (40.0%)	700 (40.9%)	700 (42.4%)	800 (44.7%)
***Salmonella* spp.**							
Community¶	100 (80.0%)	100 (79.5%)	100 (78.7%)	200 (77.3%)	200 (81.7%)	200 (77.1%)	300 (81.8%)
Hospital**	§ (20.0%)	§ (20.5%)	§ (21.3%)	100 (22.7%)	§ (18.3%)	100 (22.9%)	100 (18.2%)
***Acinetobacter* spp.**							
Community¶	100 (32.4%)	100 (27.1%)	100 (28.9%)	100 (32.1%)	100 (33.7%)	100 (32.9%)	100 (32.3%)
Hospital**	100 (67.6%)	100 (72.9%)	200 (71.1%)	200 (67.9%)	100 (66.3%)	200 (67.1%)	100 (67.7%)
Streptococcus pneumoniae							
Community¶	100 (92.8%)	200 (94.3%)	200 (95.3%)	200 (96.2%)	100 (97.4%)	200 (95.6%)	100 (98.7%)
Hospital**	§ (7.2%)	§ (5.7%)	§ (4.7%)	§ (3.8%)	§ (2.6%)	§ (4.4%)	§ (1.3%)
Other spp.							
Community¶	4,200 (63.3%)	4,000 (64.4%)	4,400 (64.9%)	4,700 (65.1%)	4,700 (66.2%)	4,800 (64.9%)	4,900 (65.3%)
Hospital**	2,400 (36.7%)	2,200 (35.6%)	2,400 (35.1%)	2,500 (34.9%)	2,400 (33.8%)	2,600 (35.1%)	2,600 (34.7%)

* Rounded to the nearest hundred
† Rounded to one decimal place
§ Less than 50 patients
¶ Percentage: Community-onset patient count÷Hospital- and Community-onset patient count
** Percentage: Hospital-onset patient count ÷ Hospital- and Community-onset patient count

8.3 Supplementary information on non-susceptibility pattern and trend of WHO GLASS priority organisms

8.3.1 *Escherichia coli*

Table 24: Non-susceptibility percentage of *Escherichia coli* for different antimicrobials

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(5,000)*	2013 *(5,200)*	2014 *(5,500)*	2015 *(6,000)*	2016 *(6,300)*	2017 *(6,600)*	2018 *(6,800)*	p-value[**]
Ampicillin								
Community	73.3% (71.9-74.7%) (2,700/3,700)	75.1% (73.7-76.4%) (2,900/3,800)	76.3% (75.0-77.6%) (3,100/4,100)	75.1% (73.8-76.3%) (3,300/4,400)	74.9% (73.6-76.2%) (3,200/4,200)	75.9% (74.5-77.1%) (3,100/4,100)	76.1% (74.8-77.4%) (3,200/4,200)	↗ 1.000
Hospital	86.8% (84.3-89.0%) (700/800)	85.9% (83.4-88.1%) (700/800)	85.8% (83.3-88.0%) (700/800)	86.0% (83.7-88.1%) (800/1,000)	85.3% (82.8-87.5%) (700/900)	85.5% (83.0-87.8%) (700/800)	85.8%[††] (83.2-88.0%) (700/800)	⟶ 1.000
Amoxicillin/clavulanate								
Community	27.3% (26.0-28.7%) (1,100/4,200)	32.5% (31.1-33.9%) (1,400/4,400)	29.0% (27.8-30.4%) (1,400/4,700)	26.5% (25.3-27.7%) (1,300/5,000)	27.1% (25.9-28.3%) (1,400/5,300)	26.4% (25.2-27.5%) (1,500/5,500)	25.4% (24.3-26.5%) (1,500/5,700)	↘ **<0.005**
Hospital	44.4% (41.2-47.6%) (400/900)	47.1% (44.0-50.3%) (500/1,000)	43.6% (40.5-46.7%) (400/1,000)	43.1% (40.2-46.0%) (500/1,100)	42.6% (39.7-45.5%) (500/1,100)	38.3% (35.6-41.2%) (400/1,200)	38.6% (35.8-41.4%) (400/1,200)	↘ **<0.005**

Table 24: Non-susceptibility percentage of *Escherichia coli* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(5,000)*	2013 *(5,200)*	2014 *(5,500)*	2015 *(6,000)*	2016 *(6,300)*	2017 *(6,600)*	2018 *(6,800)*	p-value[**]
Piperacillin/tazobactam								
Community	5.8% (5.1-6.6%) (200/3,900)	7.0% (6.2-7.8%) (300/4,000)	5.6% (5.0-6.4%) (200/4,400)	7.0% (6.3-7.7%) (300/4,600)	7.2% (6.5-8.0%) (400/4,900)	4.5% (3.9-5.1%) (200/5,200)	3.7% (3.2-4.2%) (200/5,500)	↘ **<0.005**
Hospital	15.1% (12.9-17.6%) (100/900)	15.0% (12.8-17.4%) (100/900)	11.7% (9.7-13.9%) (100/900)	15.1% (13.0-17.4%) (200/1,000)	14.1% (12.1-16.3%) (100/1,100)	9.5% (7.9-11.4%) (100/1,100)	9.0% (7.5-10.9%) (100/1,100)	↘ **<0.005**
Cefuroxime								
Community	27.8% (26.5-29.2%) (1,200/4,200)	29.4% (28.0-30.7%) (1,300/4,400)	30.2% (28.9-31.5%) (1,400/4,700)	30.1% (28.9-31.4%) (1,500/5,000)	30.1% (28.9-31.3%) (1,600/5,300)	29.7% (28.5-30.9%) (1,600/5,500)	29.6% (28.4-30.8%) (1,700/5,700)	⟶ 1.000
Hospital	48.6% (45.4-51.9%) (400/900)	45.8% (42.7-49.0%) (400/1,000)	44.3% (41.2-47.4%) (400/1,000)	46.4% (43.5-49.3%) (500/1,100)	42.5% (39.7-45.4%) (500/1,100)	38.4% (35.6-41.2%) (400/1,200)	40.6% (37.8-43.4%) (500/1,200)	↘ **<0.005**
Cefotaxime								
Community	25.2% (23.7-26.8%) (800/3,100)	26.6% (25.1-28.2%) (900/3,200)	28.3% (26.9-29.7%) (1,100/3,900)	28.8% (27.5-30.1%) (1,300/4,400)	27.8% (26.5-29.1%) (1,300/4,600)	27.4% (26.2-28.7%) (1,300/4,800)	28.0% (26.8-29.3%) (1,400/4,900)	↗ 1.000
Hospital	44.4%[††] (40.6-48.3%) (300/600)	41.9% (38.3-45.7%) (300/700)	41.4% (37.9-45.0%) (300/700)	42.7% (39.5-45.9%) (400/900)	39.1% (36.0-42.2%) (400/1,000)	35.6% (32.6-38.7%) (300/900)	37.2% (34.2-40.3%) (400/1,000)	↘ **<0.005**

Table 24: Non-susceptibility percentage of *Escherichia coli* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(5,000)*	2013 *(5,200)*	2014 *(5,500)*	2015 *(6,000)*	2016 *(6,300)*	2017 *(6,600)*	2018 *(6,800)*	p-value[**]
Ceftazidime								
Community	13.2% (12.1-14.3%) (400/3,400)	14.4% (13.3-15.6%) (500/3,500)	14.4% (13.3-15.6%) (500/3,700)	16.5% (15.4-17.7%) (600/3,900)	15.0% (13.9-16.2%) (600/3,700)	13.9%[††] (12.8-15.0%) (500/3,600)	13.3% (12.3-14.4%) (500/4,000)	→ 1.000
Hospital	27.2% (24.3-30.4%) (200/800)	25.9% (23.0-29.0%) (200/800)	23.8% (21.1-26.9%) (200/800)	24.3% (21.7-27.2%) (200/900)	23.2% (20.5-26.2%) (200/800)	20.5%[††] (17.8-23.5%) (200/800)	18.3%[††] (15.8-21.1%) (100/800)	↘ **<0.005**
Ceftriaxone								
Community	25.9%[††] (24.0-27.8%) (500/2,000)	25.4%[††] (23.7-27.3%) (600/2,200)	27.0%[††] (25.3-28.8%) (700/2,400)	28.2%[††] (26.5-30.0%) (700/2,600)	27.6%[††] (26.0-29.3%) (800/2,800)	28.5%[††] (26.9-30.1%) (900/3,000)	28.6%[††] (27.0-30.2%) (900/3,100)	↗ 0.095
Hospital	43.6%[††] (38.8-48.5%) (200/400)	40.6%[††] (36.2-45.2%) (200/400)	37.6%[††] (33.4-42.0%) (200/500)	44.4%[††] (40.3-48.5%) (300/600)	39.9%[††] (36.0-44.0%) (200/600)	35.2%[††] (31.5-39.0%) (200/600)	37.5%[††] (33.6-41.6%) (200/600)	↘ 0.906
Cefepime[‡‡]								
Community	13.4%[††] (12.2-14.7%) (400/2,800)	12.5%[††] (11.3-13.7%) (400/3,000)	19.3% (18.0-20.7%) (600/3,400)	24.0% (22.7-25.4%) (1,000/4,000)	23.6% (22.4-24.8%) (1,200/4,900)	22.6% (21.5-23.8%) (1,200/5,200)	21.5% (20.5-22.6%) (1,200/5,400)	↗ **<0.005**
Hospital	29.0%[††] (25.6-32.8%) (200/600)	24.9%[††] (21.8-28.4%) (200/700)	29.8%[††] (26.5-33.4%) (200/700)	35.3% (32.2-38.5%) (300/900)	33.1% (30.4-36.0%) (400/1,100)	29.4% (26.8-32.2%) (300/1,100)	29.4% (26.8-32.2%) (300/1,100)	→ 1.000

Table 24: Non-susceptibility percentage of *Escherichia coli* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(5,000)*	2013 *(5,200)*	2014 *(5,500)*	2015 *(6,000)*	2016 *(6,300)*	2017 *(6,600)*	2018 *(6,800)*	p-value[**]
Meropenem								
Community	0%[††] (0-0.2%) (0/1,700)	0.1%[††] (<0.05-0.3%) (§/1,700)	0.1%[††] (<0.05-0.4%) (§/2,000)	<0.05%[††] (<0.05-0.3%) (§/2,100)	<0.05%[††] (<0.05-0.2%) (§/2,400)	0%[††] (0-0.1%) (0/2,600)	0.2%[††] (0.1-0.4%) (§/3,200)	⟶ 1.000
Hospital	0%[††] (<0.05-1.0%) (0/400)	0.5%[††] (0.1-1.8%) (§/400)	0.2%[††] (<0.05-1.3%) (§/400)	0.8%[††] (0.3-2.1%) (§/500)	0.7%[††] (0.3-1.9%) (§/500)	0.8%[††] (0.3-1.9%) (§/500)	1.3%[††] (0.7-2.5%) (§/700)	↗ 0.546
Ertapenem[§§]								
Community	0.1% (<0.05-0.2%) (§/3,800)	0.2% (0.1-0.4%) (§/4,000)	0.1% (<0.05-0.2%) (§/4,300)	0.1% (<0.05-0.2%) (§/4,600)	0.1% (<0.05-0.2%) (§/4,800)	<0.05% (<0.05-0.1%) (§/5,100)	0.1% (0.1-0.3%) (§/5,200)	⟶ 1.000
Hospital	0.6% (0.3-1.5%) (§/800)	0.7% (0.3-1.5%) (§/800)	0.4% (0.1-1.1%) (§/800)	0.5% (0.2-1.2%) (§/1,000)	0.5% (0.2-1.1%) (§/1,000)	0.5% (0.2-1.2%) (§/1,000)	0.6% (0.3-1.3%) (§/1,000)	⟶ 1.000
Doripenem								
Community	0%[††] (0-19.4%) (0/§)	0%[††] (0-21.5%) (0/§)	No record	No record	No record	No record	No record	-
Hospital	No record	No record	No record	No record	No record	No record	No record	-

Table 24: Non-susceptibility percentage of *Escherichia coli* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(5,000)*	2013 *(5,200)*	2014 *(5,500)*	2015 *(6,000)*	2016 *(6,300)*	2017 *(6,600)*	2018 *(6,800)*	p-value[**]
Imipenem								
Community	0% (<0.05-0.1%) (0/3,600)	<0.05% (<0.05-0.2%) (§/3,700)	0% (0-0.1%) (0/4,000)	<0.05% (<0.05-0.1%) (§/4,300)	<0.05% (<0.05-0.2%) (§/4,600)	0% (0-0.1%) (0/4,700)	<0.05% (<0.05-0.2%) (§/4,300)	⟶ 1.000
Hospital	0% (<0.05-0.5%) (0/800)	0.1% (<0.05-0.7%) (§/800)	0% (0-0.5%) (0/800)	0.3% (0.1-0.9%) (§/1,000)	0.2% (0.1-0.8%) (§/1,000)	0.4% (0.2-1.0%) (§/1,000)	0.5% (0.2-1.2%) (§/800)	↗ 0.496
Co-trimoxazole								
Community	43.7%[††] (41.8-45.7%) (1,100/2,500)	43.8%[††] (41.9-45.8%) (1,100/2,600)	42.3%[††] (40.4-44.1%) (1,200/2,800)	44.7%[††] (42.9-46.6%) (1,300/2,800)	43.9%[††] (42.2-45.6%) (1,400/3,200)	45.3%[††] (43.6-47.0%) (1,500/3,300)	43.4%[††] (41.7-45.1%) (1,500/3,400)	⟶ 1.000
Hospital	56.5%[††] (52.3-60.7%) (300/500)	53.5%[††] (49.4-57.6%) (300/600)	54.8%[††] (50.7-58.8%) (300/600)	53.5%[††] (49.6-57.4%) (300/600)	54.9%[††] (51.1-58.6%) (400/700)	52.5%[††] (48.7-56.2%) (400/700)	53.3%[††] (49.5-57.0%) (400/700)	⟶ 1.000
Gentamicin								
Community	31.2% (29.8-32.6%) (1,300/4,200)	31.0% (29.7-32.4%) (1,400/4,400)	28.4% (27.1-29.7%) (1,300/4,700)	29.8% (28.6-31.1%) (1,500/5,000)	28.9% (27.7-30.1%) (1,500/5,300)	28.3% (27.1-29.5%) (1,600/5,500)	28.2% (27.1-29.4%) (1,600/5,700)	↘ **<0.005**
Hospital	39.5% (36.4-42.7%) (400/900)	38.6% (35.6-41.7%) (400/1,000)	36.3% (33.3-39.3%) (400/1,000)	36.4% (33.6-39.2%) (400/1,100)	35.3% (32.6-38.2%) (400/1,100)	34.2% (31.5-37.0%) (400/1,200)	32.7% (30.0-35.4%) (400/1,200)	↘ **0.006**

Table 24: Non-susceptibility percentage of *Escherichia coli* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)**‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(5,000)*	2013 *(5,200)*	2014 *(5,500)*	2015 *(6,000)*	2016 *(6,300)*	2017 *(6,600)*	2018 *(6,800)*	p-value**
Amikacin								
Community	1.3% (1.0-1.7%) (100/4,200)	1.4% (1.1-1.7%) (100/4,400)	0.8% (0.6-1.1%) (§/4,700)	0.7% (0.5-1.0%) (§/5,000)	0.7% (0.5-1.0%) (§/5,300)	0.4% (0.3-0.6%) (§/5,500)	0.4% (0.3-0.6%) (§/5,700)	↘ **<0.005**
Hospital	3.1% (2.2-4.5%) (§/900)	2.7% (1.8-3.9%) (§/1,000)	1.5% (0.9-2.5%) (§/1,000)	2.5% (1.7-3.6%) (§/1,100)	1.6% (1.0-2.5%) (§/1,100)	1.3% (0.8-2.1%) (§/1,200)	1.4% (0.9-2.2%) (§/1,200)	↘ **0.025**
Ciprofloxacin								
Community	32.8%†† (29.8-36.0%) (300/900)	34.4%†† (31.4-37.7%) (300/900)	33.1%†† (29.6-36.7%) (200/700)	34.6%†† (31.4-37.9%) (300/800)	36.2%†† (33.0-39.5%) (300/800)	33.0%†† (29.9-36.3%) (300/800)	35.5%†† (32.4-38.7%) (300/900)	⟶ 1.000
Hospital	50.9%†† (44.4-57.4%) (100/200)	53.8%†† (47.3-60.2%) (100/200)	44.6%†† (37.3-52.2%) (100/200)	50.7%†† (44.0-57.4%) (100/200)	46.5%†† (40.1-53.0%) (100/200)	42.7%†† (36.0-49.7%) (100/200)	41.5%†† (34.9-48.3%) (100/200)	↘ 0.327

Table 24: Non-susceptibility percentage of *Escherichia coli* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*‡¶	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(5,000)*	2013 *(5,200)*	2014 *(5,500)*	2015 *(6,000)*	2016 *(6,300)*	2017 *(6,600)*	2018 *(6,800)*	p-value**
Levofloxacin								
Community	32.0% (30.6-33.5%) (1,200/3,900)	30.8% (29.4-32.2%) (1,300/4,100)	31.5% (30.2-32.9%) (1,400/4,600)	31.2% (30.0-32.6%) (1,500/4,800)	31.2% (29.9-32.5%) (1,600/5,200)	31.0% (29.8-32.2%) (1,700/5,400)	30.8% (29.6-32.0%) (1,700/5,600)	⟶ 1.000
Hospital	48.2% (44.9-51.5%) (400/900)	49.7% (46.5-52.9%) (500/900)	45.4% (42.2-48.6%) (400/1,000)	48.2% (45.3-51.2%) (500/1,100)	44.8% (41.9-47.7%) (500/1,100)	39.5% (36.7-42.3%) (400/1,100)	40.0% (37.2-42.9%) (500/1,100)	↘ **<0.005**

* Rounded to the nearest hundred
† Rounded to one decimal place
‡ Total headcount refers to annual number of patients with particular organism isolated from blood.
§ Less than 50 patients
¶ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis increases because isolates from both hospital-onset and community-onset was selected for each patient, if available.
** P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend is observed with statistical significance, cells with p-value <0.05 are highlighted.
†† Since the antimicrobial susceptibility test was performed for less than 70% of the isolates of particular location of onset, readers should interpret the findings with caution.
‡‡ A new (revised) interpretive criterion of cefepime for *Escherichia coli* was released for in year 2014.
§§ A new (revised) interpretive criterion of ertapenem for *Escherichia coli* was released in year 2012.
Note:
1 Information presented in each cell is described as below. Row 1: Non-susceptibility percentage (NS%); Row 2: 95% confidence interval of NS%; Row 3: Number of patients with particular isolated and tested I/R to a specific antimicrobial, and total number of patients with particular organism isolated and the specific antimicrobial tested
2 ↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed
3 Dataset was deduplicated with consideration on location of onset.
4 Proportion confidence intervals were calculated using the Wilson method.
5 Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) were excluded from presentation.

8.3.2 *Klebsiella pneumoniae*

Table 25: Non-susceptibility percentage of *Klebsiella pneumoniae* for different antimicrobials

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(1,600)*	2013 *(1,700)*	2014 *(1,700)*	2015 *(1,800)*	2016 *(1,900)*	2017 *(1,900)*	2018 *(1,900)*	p-value[**]
Amoxicillin/clavulanate								
Community	13.4% (11.6-15.5%) (200/1,200)	13.5% (11.8-15.5%) (200/1,300)	13.9% (12.1-15.9%) (200/1,300)	14.0% (12.2-16.0%) (200/1,300)	13.9% (12.2-15.8%) (200/1,400)	15.1% (13.3-17.1%) (200/1,400)	15.6% (13.8-17.6%) (200/1,400)	↗ 1.000
Hospital	31.8% (27.4-36.5%) (100/400)	30.4% (26.3-34.8%) (100/400)	33.0% (28.9-37.3%) (200/500)	32.3% (28.5-36.3%) (200/500)	38.1% (34.0-42.4%) (200/500)	36.8% (32.7-41.2%) (200/500)	33.0% (28.9-37.3%) (200/500)	↗ 1.000
Piperacillin/tazobactam								
Community	5.8% (4.6-7.4%) (100/1,100)	5.8% (4.6-7.2%) (100/1,200)	5.0% (3.9-6.3%) (100/1,200)	5.3% (4.2-6.7%) (100/1,200)	4.9% (3.8-6.2%) (100/1,300)	4.6% (3.6-5.8%) (100/1,300)	5.1% (4.0-6.4%) (100/1,400)	⟶ 1.000
Hospital	15.6% (12.3-19.5%) (100/400)	13.8% (10.8-17.5%) (100/400)	14.6% (11.6-18.1%) (100/500)	19.8% (16.6-23.5%) (100/500)	21.5% (18.1-25.4%) (100/500)	15.6% (12.6-19.2%) (100/500)	13.8% (11.0-17.2%) (100/500)	⟶ 1.000

Table 25: Non-susceptibility percentage of *Klebsiella pneumoniae* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)**‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(1,600)*	2013 *(1,700)*	2014 *(1,700)*	2015 *(1,800)*	2016 *(1,900)*	2017 *(1,900)*	2018 *(1,900)*	p-value**
Cefuroxime								
Community	15.3% (13.3-17.4%) (200/1,200)	15.9% (14.0-18.0%) (200/1,300)	14.3% (12.5-16.4%) (200/1,300)	14.5% (12.7-16.6%) (200/1,300)	16.1% (14.3-18.1%) (200/1,400)	16.0% (14.1-18.0%) (200/1,400)	15.8% (14.0-17.8%) (200/1,400)	→ 1.000
Hospital	33.0% (28.6-37.7%) (100/400)	33.6% (29.3-38.1%) (100/400)	33.0% (28.9-37.3%) (200/500)	35.1% (31.2-39.2%) (200/500)	38.4% (34.2-42.6%) (200/500)	37.0% (32.9-41.4%) (200/500)	36.6% (32.4-41.0%) (200/500)	↗ 1.000
Cefotaxime								
Community	13.2% (11.1-15.6%) (100/900)	12.5% (10.6-14.8%) (100/900)	11.1% (9.3-13.2%) (100/1,000)	11.8% (10.1-13.9%) (100/1,100)	12.9% (11.2-14.9%) (200/1,200)	12.6% (10.8-14.6%) (200/1,200)	12.5% (10.7-14.5%) (100/1,200)	→ 1.000
Hospital	26.0%†† (21.0-31.6%) (100/300)	25.0%†† (20.4-30.3%) (100/300)	26.1% (21.8-31.0%) (100/400)	27.0% (23.0-31.4%) (100/400)	35.4% (30.8-40.2%) (100/400)	32.6% (28.2-37.5%) (100/400)	30.5% (26.0-35.5%) (100/400)	↗ 0.170
Ceftazidime								
Community	8.4% (6.8-10.3%) (100/1,000)	8.4% (6.8-10.3%) (100/1,000)	7.7% (6.2-9.5%) (100/1,000)	8.5% (6.9-10.4%) (100/1,000)	7.3% (5.9-9.1%) (100/1,000)	7.4% (5.9-9.2%) (100/1,000)	8.4% (6.9-10.2%) (100/1,100)	→ 1.000
Hospital	22.9% (18.9-27.5%) (100/400)	18.4% (14.8-22.6%) (100/400)	17.7% (14.4-21.7%) (100/400)	21.4% (17.8-25.4%) (100/400)	22.8% (19.0-27.1%) (100/400)	25.4%†† (21.1-30.3%) (100/300)	23.6% (19.7-28.0%) (100/400)	↗ 1.000

Table 25: Non-susceptibility percentage of *Klebsiella pneumoniae* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)**‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(1,600)*	2013 *(1,700)*	2014 *(1,700)*	2015 *(1,800)*	2016 *(1,900)*	2017 *(1,900)*	2018 *(1,900)*	p-value**
Ceftriaxone								
Community	11.7%†† (9.3-14.5%) (100/600)	8.9%†† (6.9-11.3%) (100/700)	8.6%†† (6.7-10.9%) (100/700)	9.3%†† (7.4-11.6%) (100/700)	10.9%†† (9.0-13.2%) (100/800)	8.8%†† (7.1-10.9%) (100/900)	10.7%†† (8.8-12.9%) (100/900)	⟶ 1.000
Hospital	21.7%†† (16.4-28.1%) (§/200)	25.1%†† (19.9-31.1%) (100/200)	20.5%†† (15.8-26.3%) (§/200)	22.9%†† (18.5-28.0%) (100/300)	21.9%†† (17.6-26.9%) (100/300)	26.1%†† (21.4-31.5%) (100/300)	25.8%†† (21.0-31.2%) (100/300)	⟶ 1.000
Cefepime‡‡								
Community	4.8%†† (3.5-6.4%) (§/800)	4.9% (3.7-6.5%) (§/900)	5.0% (3.8-6.6%) (§/900)	7.2% (5.8-8.9%) (100/1,000)	8.4% (7.0-10.0%) (100/1,300)	7.3% (6.1-8.9%) (100/1,300)	7.3% (6.0-8.8%) (100/1,300)	↗ **0.009**
Hospital	12.0%†† (8.5-16.5%) (§/300)	9.3%†† (6.4-13.2%) (§/300)	16.1%†† (12.5-20.6%) (100/300)	19.5% (16.0-23.6%) (100/400)	20.3% (17.0-24.2%) (100/500)	22.2% (18.6-26.1%) (100/500)	18.8% (15.4-22.7%) (100/400)	↗ **<0.005**
Meropenem								
Community	0.2%†† (<0.05-1.1%) (§/500)	0.2%†† (<0.05-1.1%) (§/500)	0.2%†† (<0.05-1.1%) (§/500)	0%†† (0-0.7%) (0/600)	0.4%†† (0.1-1.3%) (§/700)	0.3%†† (0.1-1.0%) (§/700)	0.1%†† (<0.05-0.6%) (§/900)	⟶ 1.000
Hospital	2.5%†† (1.0-6.3%) (§/200)	0.6%†† (<0.05-3.1%) (§/200)	0.5%†† (<0.05-3.0%) (§/200)	2.2%†† (0.9-5.0%) (§/200)	1.2%†† (0.4-3.6%) (§/200)	0.4%†† (<0.05-2.4%) (§/200)	3.9% (2.3-6.5%) (§/400)	↗ 1.000

Table 25: Non-susceptibility percentage of *Klebsiella pneumoniae* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)**‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(1,600)*	2013 *(1,700)*	2014 *(1,700)*	2015 *(1,800)*	2016 *(1,900)*	2017 *(1,900)*	2018 *(1,900)*	p-value**
Imipenem								
Community	0% (<0.05-0.4%) (0/1,000)	0.3% (0.1-0.8%) (§/1,100)	0% (0-0.3%) (0/1,100)	0% (0-0.3%) (0/1,100)	0.2% (<0.05-0.6%) (§/1,300)	0.3% (0.1-0.7%) (§/1,200)	0% (0-0.4%) (0/1,000)	⟶ 1.000
Hospital	0.8% (0.3-2.4%) (§/400)	0.8% (0.3-2.2%) (§/400)	0.5% (0.1-1.7%) (§/400)	0.8% (0.3-2.1%) (§/500)	1.3% (0.6-2.9%) (§/400)	0.5% (0.1-1.8%) (§/400)	3.2%†† (1.8-5.8%) (§/300)	↗ 0.951
Co-trimoxazole								
Community	19.5%†† (16.7-22.6%) (100/700)	17.6%†† (15.0-20.5%) (100/700)	17.9%†† (15.3-20.8%) (100/800)	19.5%†† (16.8-22.6%) (100/700)	20.5%†† (17.9-23.3%) (200/900)	21.9%†† (19.4-24.7%) (200/900)	19.3%†† (16.9-22.0%) (200/1,000)	⟶ 1.000
Hospital	35.6%†† (29.8-42.0%) (100/200)	39.9%†† (34.1-46.0%) (100/300)	33.1%†† (28.0-38.7%) (100/300)	35.0%†† (29.8-40.4%) (100/300)	48.3%†† (42.8-53.7%) (200/300)	42.6%†† (37.3-48.1%) (100/300)	36.9%†† (31.9-42.2%) (100/300)	⟶ 1.000
Gentamicin								
Community	5.2% (4.1-6.6%) (100/1,200)	5.3% (4.2-6.6%) (100/1,300)	5.2% (4.1-6.6%) (100/1,300)	4.7% (3.7-6.0%) (100/1,300)	5.5% (4.5-6.8%) (100/1,400)	5.5% (4.4-6.8%) (100/1,400)	6.0% (4.9-7.4%) (100/1,400)	⟶ 1.000
Hospital	8.9% (6.5-12.1%) (§/400)	10.2% (7.7-13.4%) (§/400)	10.9% (8.4-14.0%) (100/500)	12.8% (10.3-15.9%) (100/500)	14.6% (11.8-18.0%) (100/500)	12.9% (10.2-16.1%) (100/500)	12.4% (9.7-15.7%) (100/500)	↗ 0.847

Table 25: Non-susceptibility percentage of *Klebsiella pneumoniae* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)**‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(1,600)*	2013 *(1,700)*	2014 *(1,700)*	2015 *(1,800)*	2016 *(1,900)*	2017 *(1,900)*	2018 *(1,900)*	p-value**
Amikacin								
Community	0.8% (0.5-1.6%) (§/1,200)	0.6% (0.3-1.2%) (§/1,300)	0.2% (<0.05-0.6%) (§/1,300)	0.4% (0.2-0.9%) (§/1,300)	0.3% (0.1-0.7%) (§/1,400)	0.2% (0.1-0.6%) (§/1,400)	0.1% (<0.05-0.5%) (§/1,400)	↘ 0.084
Hospital	0.7% (0.3-2.2%) (§/400)	2.0% (1.1-3.8%) (§/400)	0.8% (0.3-2.1%) (§/500)	1.3% (0.6-2.6%) (§/500)	2.0% (1.1-3.6%) (§/500)	1.0% (0.4-2.4%) (§/500)	1.7% (0.9-3.3%) (§/500)	⟶ 1.000
Ciprofloxacin								
Community	11.4%†† (8.1-15.8%) (§/300)	17.2%†† (13.1-22.3%) (§/300)	11.4%†† (7.5-16.7%) (§/200)	12.4%†† (8.3-18.0%) (§/200)	16.3%†† (11.6-22.4%) (§/200)	14.1%†† (8.3-23.1%) (§/100)	10.2%†† (5.6-17.8%) (§/100)	⟶ 1.000
Hospital	18.4%†† (12.4-26.5%) (§/100)	22.0%†† (15.3-30.7%) (§/100)	27.5%†† (19.7-36.8%) (§/100)	39.0%†† (30.3-48.6%) (§/100)	42.7%†† (32.1-53.9%) (§/100)	38.8%†† (26.4-52.8%) (§/§)	46.7%†† (30.2-63.9%) (§/§)	↗ **<0.005**

Table 25: Non-susceptibility percentage of *Klebsiella pneumoniae* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(1,600)*	2013 *(1,700)*	2014 *(1,700)*	2015 *(1,800)*	2016 *(1,900)*	2017 *(1,900)*	2018 *(1,900)*	p-value[**]
Levofloxacin								
Community	8.4% (6.9-10.2%) (100/1,100)	7.5% (6.2-9.2%) (100/1,200)	7.5% (6.2-9.1%) (100/1,200)	7.2% (5.9-8.8%) (100/1,300)	7.9% (6.6-9.4%) (100/1,400)	8.5% (7.1-10.1%) (100/1,400)	8.0% (6.7-9.5%) (100/1,400)	⟶ 1.000
Hospital	12.8% (9.8-16.5%) (§/400)	17.4% (14.0-21.3%) (100/400)	14.6% (11.7-18.0%) (100/500)	18.3% (15.2-21.8%) (100/500)	19.5% (16.3-23.2%) (100/500)	22.8% (19.3-26.8%) (100/500)	19.2% (15.9-23.0%) (100/500)	↗ **0.016**

[*] Rounded to the nearest hundred
[†] Rounded to one decimal place
[‡] Total headcount refers to annual number of patients with particular organism isolated from blood.
[§] Less than 50 patients
[¶] Compare with deduplication without consideration on location of onset, number of isolates selected for analysis increases because isolates from both hospital-onset and community-onset was selected for each patient, if available.
[**] P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend is observed with statistical significance, cells with p-value <0.05 are highlighted.
[††] Since the antimicrobial susceptibility test was performed for less than 70% of the isolates of particular location of onset, readers should interpret the findings with caution.
[‡‡] A new (revised) interpretive criterion of cefepime for *Klebsiella pneumoniae* was released in year 2014.
Note:
[1] Information presented in each cell is described as below. Row 1: Non-susceptibility percentage (NS%); Row 2: 95% confidence interval of NS%; Row 3: Number of patients with particular isolated and tested I/R to a specific antimicrobial, and total number of patients with particular organism isolated and the specific antimicrobial tested
[2] ↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed
[3] Dataset was deduplicated with consideration on location of onset.
[4] Proportion confidence intervals were calculated using the Wilson method.
[5] Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) were excluded from presentation.

8.3.3 *Staphylococcus aureus*

Table 26: Non-susceptibility percentage of *Staphylococcus aureus* for different antimicrobials

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(1,400)*	2013 *(1,400)*	2014 *(1,400)*	2015 *(1,500)*	2016 *(1,700)*	2017 *(1,700)*	2018 *(1,800)*	p-value[**]
Oxacillin								
Community	35.7% (32.4-39.0%) (300/800)	39.2% (35.9-42.6%) (300/800)	38.6% (35.3-41.9%) (300/800)	39.1% (36.0-42.3%) (400/900)	40.3% (37.3-43.3%) (400/1,000)	37.9% (34.9-40.9%) (400/1,000)	40.7% (37.7-43.7%) (400/1,000)	⟶ 1.000
Hospital	53.1% (49.1-57.0%) (300/600)	56.0% (52.2-59.8%) (400/700)	56.2% (52.3-60.0%) (400/600)	54.0% (50.1-57.9%) (300/600)	60.0% (56.3-63.6%) (400/700)	54.2% (50.6-57.8%) (400/700)	56.1% (52.7-59.4%) (500/800)	⟶ 1.000

Table 26: Non-susceptibility percentage of *Staphylococcus aureus* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*‡¶	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(1,400)*	2013 *(1,400)*	2014 *(1,400)*	2015 *(1,500)*	2016 *(1,700)*	2017 *(1,700)*	2018 *(1,800)*	p-value**
Vancomycin								
Community	0% (0-0.5%) (0/800)	0% (0-0.5%) (0/800)	0% (0-0.5%) (0/800)	0% (0-0.4%) (0/900)	0% (<0.05-0.4%) (0/1,000)	0% (<0.05-0.4%) (0/1,000)	0% (0-0.4%) (0/1,000)	-
Hospital	0% (<0.05-0.6%) (0/600)	0% (<0.05-0.6%) (0/600)	0% (<0.05-0.6%) (0/600)	0% (<0.05-0.6%) (0/600)	0% (0-0.6%) (0/700)	0% (0-0.5%) (0/700)	0% (<0.05-0.5%) (0/800)	-

* Rounded to the nearest hundred
† Rounded to one decimal place
‡ Total headcount refers to annual number of patients with particular organism isolated from blood.
§ Less than 50 patients
¶ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis increases because isolates from both hospital-onset and community-onset was selected for each patient, if available.
** P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend is observed with statistical significance, cells with p-value <0.05 are highlighted.
Note:
1 Information presented in each cell is described as below. Row 1: Non-susceptibility percentage (NS%); Row 2: 95% confidence interval of NS%; Row 3: Number of patients with particular isolated and tested I/R to a specific antimicrobial, and total number of patients with particular organism isolated and the specific antimicrobial tested
2 ↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed
3 Dataset was deduplicated with consideration on location of onset.
4 Proportion confidence intervals were calculated using the Wilson method.
5 Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) were excluded from presentation.

8.3.4 *Salmonella* species

Table 27: Non-susceptibility percentage of *Salmonella* spp. for different antimicrobials

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(300)*	2016 *(200)*	2017 *(200)*	2018 *(300)*	p-value[**]
Ampicillin								
Community	32.0% (24.6-40.5%) (§/100)	34.0% (26.8-42.0%) (100/100)	47.9% (39.9-56.0%) (100/100)	50.2% (43.6-56.8%) (100/200)	61.5% (54.0-68.5%) (100/200)	51.6% (44.4-58.8%) (100/200)	46.8% (40.8-53.0%) (100/300)	↗ **0.010**
Hospital	43.8% (28.2-60.7%) (§/§)	55.3% (39.7-69.9%) (§/§)	61.5% (45.9-75.1%) (§/§)	65.6% (53.4-76.1%) (§/100)	65.8% (49.9-78.8%) (§/§)	84.9% (72.9-92.1%) (§/100)	53.6% (40.7-66.0%) (§/100)	↗ 1.000
Undifferentiated	35.0% (28.0-42.8%) (100/200)	37.7% (31.0-44.9%) (100/200)	50.0% (42.7-57.3%) (100/200)	53.7% (47.7-59.5%) (100/300)	62.4% (55.6-68.8%) (100/200)	59.4% (53.0-65.5%) (100/200)	47.9% (42.3-53.5%) (100/300)	↗ **<0.005**
Cefotaxime								
Community	0%[††] (0-9.9%) (0/§)	0%[††] (<0.05-11.0%) (0/§)	10.6%[††] (4.6-22.6%) (§/§)	1.2%[††] (0.1-6.3%) (§/100)	5.3%[††] (1.8-14.4%) (§/100)	0%[††] (0-6.8%) (0/100)	2.1%[††] (0.6-7.2%) (§/100)	⟶ 1.000
Hospital	No record	8.3%[††] (0.4-35.4%) (§/§)	0%[††] (0-22.8%) (0/§)	8.8%[††] (3.0-23.0%) (§/§)	12.5%[††] (3.5-36.0%) (§/§)	18.2%[††] (7.3-38.5%) (§/§)	0%[††] (0-12.9%) (0/§)	⟶ 1.000
Undifferentiated	2.3%[††] (0.1-12.1%) (§/§)	2.3%[††] (0.1-12.1%) (§/§)	8.6%[††] (3.7-18.6%) (§/100)	3.4%[††] (1.3-8.5%) (§/100)	6.9%[††] (3.0-15.2%) (§/100)	5.3%[††] (2.1-12.9%) (§/100)	1.7%[††] (0.5-5.9%) (§/100)	⟶ 1.000

Table 27: Non-susceptibility percentage of *Salmonella* spp. for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(300)*	2016 *(200)*	2017 *(200)*	2018 *(300)*	p-value[**]
Ceftazidime								
Community	0%[††] (0-24.2%) (0/§)	0%[††] (0-19.4%) (0/§)	8.8%[††] (3.0-23.0%) (§/§)	0%[††] (0-6.2%) (0/100)	5.0%[††] (1.4-16.5%) (§/§)	0%[††] (<0.05-18.4%) (0/§)	2.2%[††] (0.1-11.6%) (§/§)	⟶ 1.000
Hospital	No record	No record	0%[††] (0-25.9%) (0/§)	8.0%[††] (2.2-25.0%) (§/§)	No record	No record	0%[††] (0-24.2%) (0/§)	⟶ 1.000
Undifferentiated	0%[††] (0-22.8%) (0/§)	0%[††] (0-14.3%) (0/§)	7.0%[††] (2.4-18.6%) (§/§)	2.5%[††] (0.7-8.6%) (§/100)	4.3%[††] (1.2-14.5%) (§/§)	4.3%[††] (0.2-21.0%) (§/§)	1.8%[††] (0.1-9.6%) (§/100)	⟶ 1.000
Ceftriaxone								
Community	0% (0-3.5%) (0/100)	8.8% (5.0-15.1%) (§/100)	7.9% (4.2-14.3%) (§/100)	1.7% (0.6-4.8%) (§/200)	6.1% (3.2-11.2%) (§/100)	4.6% (2.3-9.3%) (§/200)	1.4% (0.5-4.1%) (§/200)	⟶ 1.000
Hospital	0% (0-13.3%) (0/§)	6.7% (1.8-21.3%) (§/§)	15.6% (6.9-31.8%) (§/§)	5.7% (1.9-15.4%) (§/100)	6.7% (1.8-21.3%) (§/§)	7.0% (2.4-18.6%) (§/§)	4.3% (1.2-14.2%) (§/§)	⟶ 1.000
Undifferentiated	0% (0-2.9%) (0/100)	8.5% (5.0-14.0%) (§/200)	8.5% (4.9-14.3%) (§/100)	2.7% (1.2-5.7%) (§/200)	6.2% (3.5-10.8%) (§/200)	5.2% (2.8-9.3%) (§/200)	2.0% (0.8-4.5%) (§/300)	⟶ 1.000

Table 27: Non-susceptibility percentage of *Salmonella* spp. for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(300)*	2016 *(200)*	2017 *(200)*	2018 *(300)*	p-value**
Meropenem								
Community	No record	No record	0%†† (0-15.5%) (0/§)	0%†† (0-9.0%) (0/§)	0%†† (0-7.6%) (0/§)	0%†† (0-8.6%) (0/§)	0%†† (<0.05-5.1%) (0/100)	-
Hospital	No record	No record	No record	0%†† (0-14.9%) (0/§)	0%†† (<0.05-20.4%) (0/§)	0%†† (0-21.5%) (0/§)	0%†† (0-15.5%) (0/§)	-
Undifferentiated	No record	No record	0%†† (0-12.9%) (0/§)	0%†† (<0.05-6.0%) (0/100)	0%†† (<0.05-5.8%) (0/100)	0%†† (0-6.5%) (0/100)	0%†† (0-4.1%) (0/100)	-
Imipenem								
Community	0%†† (<0.05-16.8%) (0/§)	0%†† (0-13.8%) (0/§)	0%†† (0-9.0%) (0/§)	0%†† (<0.05-6.0%) (0/100)	0%†† (0-7.6%) (0/§)	0%†† (<0.05-16.8%) (0/§)	0%†† (0-7.3%) (0/§)	-
Hospital	No record	No record	0%†† (0-24.2%) (0/§)	0%†† (0-13.3%) (0/§)	No record	No record	0%†† (0-22.8%) (0/§)	-
Undifferentiated	0%†† (0-16.1%) (0/§)	0%†† (<0.05-10.4%) (0/§)	0%†† (0-7.3%) (0/§)	0%†† (0-4.4%) (0/100)	0%†† (0-6.4%) (0/100)	0%†† (0-12.1%) (0/§)	0%†† (<0.05-6.0%) (0/100)	-

Table 27: Non-susceptibility percentage of *Salmonella* spp. for different antimicrobials *(continued)*

Location of Onset *(Total headcount)**‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(300)*	2016 *(200)*	2017 *(200)*	2018 *(300)*	p-value**
Ciprofloxacin‡‡								
Community	53.3% (43.9-62.4%) (100/100)	65.2% (57.1-72.6%) (100/100)	62.2% (54.1-69.8%) (100/100)	70.5% (64.1-76.2%) (200/200)	75.7% (68.8-81.6%) (100/200)	73.5% (66.6-79.4%) (100/200)	66.4% (60.3-72.0%) (200/300)	↗ 0.504
Hospital	44.8% (28.4-62.5%) (§/§)	73.0% (57.0-84.6%) (§/§)	74.4% (58.9-85.4%) (§/§)	81.3% (70.0-88.9%) (100/100)	76.3% (60.8-87.0%) (§/§)	84.9% (72.9-92.1%) (§/100)	76.4% (63.7-85.6%) (§/100)	↗ 0.390
Undifferentiated	51.9% (43.5-60.2%) (100/100)	66.5% (59.2-73.0%) (100/200)	64.8% (57.5-71.4%) (100/200)	72.4% (66.8-77.4%) (200/300)	76.1% (69.8-81.4%) (200/200)	76.4% (70.5-81.4%) (200/200)	68.3% (62.9-73.3%) (200/300)	↗ **0.021**

Table 27: Non-susceptibility percentage of *Salmonella* spp. for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(300)*	2016 *(200)*	2017 *(200)*	2018 *(300)*	p-value[**]
Levofloxacin[§§]								
Community	2.2%[††] (0.1-11.6%) (§/§)	0%[††] (0-14.9%) (0/§)	0%[††] (0-12.9%) (0/§)	4.7%[††] (1.3-15.5%) (§/§)	36.4%[††] (19.7-57.0%) (§/§)	94.1%[††] (73.0-99.7%) (§/§)	47.1%[††] (26.2-69.0%) (§/§)	↗ **<0.005**
Hospital	No record	No record	No record	0%[††] (0-27.8%) (0/§)	No record	No record	No record	-
Undifferentiated	2.0%[††] (0.1-10.7%) (§/§)	0%[††] (<0.05-11.0%) (0/§)	3.1%[††] (0.2-15.7%) (§/§)	3.8%[††] (1.1-13.0%) (§/100)	37.0%[††] (21.5-55.8%) (§/§)	86.4%[††] (66.7-95.3%) (§/§)	50.0%[††] (29.9-70.1%) (§/§)	↗ **<0.005**

[*] Rounded to the nearest hundred
[†] Rounded to one decimal place
[‡] Total headcount refers to annual number of patients with particular organism isolated from blood.
[§] Less than 50 patients
[¶] Compare with deduplication without consideration on location of onset, number of isolates selected for analysis increases because isolates from both hospital-onset and community-onset was selected for each patient, if available.
[**] P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend is observed with statistical significance, cells with p-value <0.05 are highlighted.
[††] Since the antimicrobial susceptibility test was performed for less than 70% of the isolates of particular location of onset, readers should interpret the findings with caution.
[‡‡] For interpretive criterion of ciprofloxacin for *Salmonella* spp., a new interpretive criterion was released in year 2012, and modified recommendations to use the separate interpretive criteria were released in year 2013.
[§§] A new interpretive criterion of levofloxacin for *Salmonella* spp. was released in year 2013.

Note:

[1] Information presented in each cell is described as below. Row 1: Non-susceptibility percentage (NS%); Row 2: 95% confidence interval of NS%; Row 3: Number of patients with particular isolated and tested I/R to a specific antimicrobial, and total number of patients with particular organism isolated and the specific antimicrobial tested
[2] ↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed
[3] Dataset was deduplicated with consideration on location of onset.
[4] Proportion confidence intervals were calculated using the Wilson method.
[5] Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) were excluded from presentation.

8.3.5 *Acinetobacter* species

Table 28: Non-susceptibility percentage of *Acinetobacter* spp. for different antimicrobials

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(200)*	p-value[**]
Minocycline								
Community	No record	No record	No record	27.8%[††] (12.5-50.9%) (§/§)	9.1%[††] (2.5-27.8%) (§/§)	16.7%[††] (6.7-35.9%) (§/§)	5.0%[††] (0.3-23.6%) (§/§)	⟶ 1.000
Hospital	75.0%[††] (46.8-91.1%) (§/§)	72.2%[††] (49.1-87.5%) (§/§)	57.6%[††] (40.8-72.8%) (§/§)	60.0%[††] (40.7-76.6%) (§/§)	32.6%[††] (20.5-47.5%) (§/§)	28.9%[††] (17.7-43.4%) (§/§)	18.9%[††] (9.5-34.2%) (§/§)	↘ **<0.005**
Tigecycline								
Community	No record	No record	No record	No record	No record	No record	No record	-
Hospital	72.1%[††] (57.3-83.3%) (§/§)	66.7%[††] (51.6-79.0%) (§/§)	67.9%[††] (49.3-82.1%) (§/§)	78.9%[††] (56.7-91.5%) (§/§)	81.8%[††] (52.3-94.9%) (§/§)	76.9%[††] (49.7-91.8%) (§/§)	53.8%[††] (29.1-76.8%) (§/§)	⟶ 1.000
Ampicillin/sulbactam								
Community	21.2% (13.1-32.5%) (§/100)	20.4% (11.8-32.9%) (§/100)	17.7% (10.2-29.0%) (§/100)	25.9% (16.1-38.9%) (§/100)	22.8% (13.8-35.2%) (§/100)	21.9% (14.0-32.7%) (§/100)	19.0% (11.2-30.4%) (§/100)	⟶ 1.000
Hospital	43.1% (35.1-51.4%) (100/100)	57.9% (49.8-65.7%) (100/100)	57.3% (49.5-64.8%) (100/200)	56.1% (47.5-64.2%) (100/100)	52.5% (43.6-61.2%) (100/100)	49.7% (41.7-57.6%) (100/100)	55.4% (46.8-63.7%) (100/100)	⟶ 1.000

Table 28: Non-susceptibility percentage of *Acinetobacter* spp. for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(200)*	p-value[**]
Piperacillin/tazobactam								
Community	26.2% (17.0-38.0%) (§/100)	22.6% (13.5-35.5%) (§/100)	23.1% (14.5-34.6%) (§/100)	30.6% (21.1-42.0%) (§/100)	31.3% (21.2-43.4%) (§/100)	28.2% (19.0-39.5%) (§/100)	23.0% (14.2-34.9%) (§/100)	⟶ 1.000
Hospital	55.9% (47.2-64.2%) (100/100)	66.2% (58.1-73.5%) (100/100)	63.4% (55.7-70.4%) (100/200)	62.9% (55.0-70.2%) (100/200)	63.6% (55.0-71.4%) (100/100)	58.3% (50.2-66.1%) (100/100)	66.2% (57.7-73.7%) (100/100)	⟶ 1.000
Ceftazidime								
Community	23.0% (14.2-34.9%) (§/100)	21.6% (12.5-34.6%) (§/100)	18.5% (10.9-29.6%) (§/100)	22.9% (14.6-34.0%) (§/100)	10.8% (5.3-20.6%) (§/100)	14.1% (7.8-24.0%) (§/100)	13.3% (6.9-24.2%) (§/100)	↘ 1.000
Hospital	38.8% (31.0-47.3%) (100/100)	50.0% (41.9-58.1%) (100/100)	47.9% (40.3-55.5%) (100/200)	42.0% (34.4-50.0%) (100/200)	38.4% (30.3-47.2%) (§/100)	34.7% (27.5-42.7%) (100/100)	35.9% (28.2-44.4%) (§/100)	↘ 1.000
Cefoperazone/sulbactam								
Community	21.3% (12.9-33.1%) (§/100)	23.5% (14.0-36.8%) (§/100)	18.5% (10.9-29.6%) (§/100)	25.7% (16.9-37.0%) (§/100)	21.5% (13.3-33.0%) (§/100)	22.5% (14.4-33.5%) (§/100)	18.3% (10.6-29.9%) (§/100)	⟶ 1.000
Hospital	44.0% (35.9-52.5%) (100/100)	59.4% (51.2-67.1%) (100/100)	57.1% (49.4-64.4%) (100/200)	55.6% (47.7-63.3%) (100/200)	55.6% (46.9-64.1%) (100/100)	50.3% (42.4-58.3%) (100/100)	53.4% (44.9-61.8%) (100/100)	⟶ 1.000

Table 28: Non-susceptibility percentage of *Acinetobacter* spp. for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(200)*	p-value[**]
Cefepime								
Community	33.3%[††] (19.8-50.4%) (§/§)	26.5%[††] (14.6-43.1%) (§/§)	29.4%[††] (16.8-46.2%) (§/§)	40.7% (28.7-54.0%) (§/100)	25.8%[††] (13.7-43.2%) (§/§)	28.6%[††] (16.3-45.1%) (§/§)	25.6%[††] (14.9-40.2%) (§/§)	⟶ 1.000
Hospital	58.6%[††] (48.1-68.4%) (100/100)	76.2%[††] (66.1-84.0%) (100/100)	70.7% (62.2-78.0%) (100/100)	68.3%[††] (58.7-76.6%) (100/100)	67.2%[††] (54.7-77.7%) (§/100)	71.8%[††] (60.5-81.0%) (100/100)	62.2%[††] (51.4-71.9%) (100/100)	⟶ 1.000
Meropenem[‡‡]								
Community	40.7%[††] (24.5-59.3%) (§/§)	32.1%[††] (17.9-50.7%) (§/§)	27.8%[††] (15.8-44.0%) (§/§)	47.8%[††] (34.1-61.9%) (§/§)	33.3%[††] (19.2-51.2%) (§/§)	28.9%[††] (17.0-44.8%) (§/§)	26.3%[††] (15.0-42.0%) (§/§)	⟶ 1.000
Hospital	61.8%[††] (51.4-71.2%) (100/100)	72.7%[††] (62.6-80.9%) (100/100)	71.2% (62.4-78.6%) (100/100)	66.4% (57.0-74.6%) (100/100)	59.0%[††] (48.3-69.0%) (§/100)	59.1%[††] (49.0-68.6%) (100/100)	62.5%[††] (52.1-71.9%) (100/100)	⟶ 1.000
Imipenem[§§]								
Community	22.4% (13.6-34.7%) (§/100)	21.3% (12.0-34.9%) (§/§)	21.8% (12.9-34.4%) (§/100)	33.3% (23.4-45.1%) (§/100)	27.4% (17.9-39.6%) (§/100)	26.9% (17.7-38.5%) (§/100)	20.4% (11.8-32.9%) (§/100)	⟶ 1.000
Hospital	46.5% (38.0-55.1%) (100/100)	61.2% (52.9-68.8%) (100/100)	62.1% (54.2-69.4%) (100/200)	63.2% (54.9-70.9%) (100/100)	60.2% (51.0-68.7%) (100/100)	53.6% (45.3-61.7%) (100/100)	62.5% (53.6-70.6%) (100/100)	⟶ 1.000

Table 28: Non-susceptibility percentage of *Acinetobacter* spp. for different antimicrobials *(continued)*

Location of Onset *(Total headcount)**‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(200)*	p-value**
Gentamicin								
Community	16.7% (9.6-27.4%) (§/100)	16.7% (9.0-28.7%) (§/100)	14.9% (8.3-25.3%) (§/100)	16.7% (9.8-26.9%) (§/100)	9.0% (4.2-18.2%) (§/100)	8.0% (3.7-16.4%) (§/100)	9.4% (4.4-19.0%) (§/100)	↘ 1.000
Hospital	39.4% (31.6-47.8%) (100/100)	50.3% (42.3-58.4%) (100/100)	45.5% (38.0-53.1%) (100/200)	42.1% (34.5-50.1%) (100/200)	27.9% (20.9-36.2%) (§/100)	26.2% (19.8-33.8%) (§/100)	34.1% (26.6-42.5%) (§/100)	↘ **0.005**
Amikacin								
Community	6.1% (2.4-14.6%) (§/100)	11.1% (5.2-22.2%) (§/100)	11.9% (6.2-21.8%) (§/100)	12.5% (6.7-22.1%) (§/100)	7.5% (3.2-16.3%) (§/100)	6.7% (2.9-14.7%) (§/100)	6.3% (2.5-15.0%) (§/100)	⟶ 1.000
Hospital	28.5% (21.6-36.5%) (§/100)	40.7% (33.0-48.8%) (100/100)	40.0% (32.8-47.6%) (100/200)	34.2% (27.1-42.1%) (100/200)	21.5% (15.3-29.4%) (§/100)	20.8% (15.1-28.0%) (§/100)	25.8% (19.1-33.8%) (§/100)	↘ **0.039**
Ciprofloxacin								
Community	43.9%†† (29.9-59.0%) (§/§)	24.3%†† (13.4-40.1%) (§/§)	26.2%†† (15.3-41.1%) (§/§)	34.0% (22.7-47.4%) (§/100)	27.1% (16.6-41.0%) (§/§)	32.1% (21.4-45.2%) (§/100)	24.3%†† (13.4-40.1%) (§/§)	⟶ 1.000
Hospital	52.8% (43.4-62.1%) (100/100)	60.6%†† (50.8-69.7%) (100/100)	58.0%†† (48.2-67.2%) (100/100)	58.4%†† (48.7-67.5%) (100/100)	60.5%†† (49.9-70.1%) (100/100)	52.0%†† (42.3-61.5%) (100/100)	50.6%†† (39.8-61.4%) (§/100)	⟶ 1.000

Table 28: Non-susceptibility percentage of *Acinetobacter* spp. for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(200)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(200)*	p-value**
Levofloxacin								
Community	37.0%†† (24.5-51.4%) (§/§)	27.0%†† (15.4-43.0%) (§/§)	23.8%†† (13.5-38.5%) (§/§)	37.5% (26.0-50.6%) (§/100)	23.3%†† (13.2-37.7%) (§/§)	25.5%†† (15.5-38.9%) (§/100)	28.6% (17.8-42.4%) (§/§)	⟶ 1.000
Hospital	53.4% (43.8-62.7%) (100/100)	66.0%†† (56.3-74.5%) (100/100)	66.4% (58.0-73.9%) (100/100)	64.5% (55.3-72.9%) (100/100)	55.7%†† (45.3-65.6%) (§/100)	55.2%†† (45.7-64.4%) (100/100)	57.7% (47.8-67.1%) (100/100)	⟶ 1.000
Colistin								
Community	0%†† (0-27.8%) (0/§)	No record	0%†† (0-25.9%) (0/§)	4.2%†† (0.2-20.2%) (§/§)	0%†† (<0.05-16.8%) (0/§)	0%†† (0-19.4%) (0/§)	0%†† (0-21.5%) (0/§)	⟶ 1.000
Hospital	0%†† (<0.05-9.2%) (0/§)	0%†† (0-6.9%) (0/100)	0%†† (0-4.9%) (0/100)	1.7%†† (0.1-8.9%) (§/100)	0%†† (0-6.1%) (0/100)	0%†† (0-6.8%) (0/100)	0%†† (0-7.7%) (0/§)	⟶ 1.000

* Rounded to the nearest hundred
† Rounded to one decimal place
‡ Total headcount refers to annual number of patients with particular organism isolated from blood.
§ Less than 50 patients
¶ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis increases because isolates from both hospital-onset and community-onset was selected for each patient, if available.
** P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend is observed with statistical significance, cells with p-value <0.05 are highlighted.
†† Since the antimicrobial susceptibility test was performed for less than 70% of the isolates of particular location of onset, readers should interpret the findings with caution.
‡‡ A new (revised) interpretive criterion of meropenem for *Acinetobacter* spp. was released in year 2014.
§§ A new (revised) interpretive criterion of imipenem for *Acinetobacter* spp. was released in year 2014.
Note:
1 Information presented in each cell is described as below. Row 1: Non-susceptibility percentage (NS%); Row 2: 95% confidence interval of NS%; Row 3: Number of patients with particular isolated and tested I/R to a specific antimicrobial, and total number of patients with particular organism isolated and the specific antimicrobial tested
2 ↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed
3 Dataset was deduplicated with consideration on location of onset.
4 Proportion confidence intervals were calculated using the Wilson method.
5 Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) were excluded from presentation.

8.3.6 *Streptococcus pneumoniae*

Table 29: Non-susceptibility percentage of *Streptococcus pneumoniae* for different antimicrobials

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(100)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(100)*	p-value[**]
Penicillin[‡‡]								
Community	0.8% (<0.05-4.3%) (§/100)	1.3% (0.4-4.6%) (§/200)	1.1% (0.3-4.0%) (§/200)	0.7% (<0.05-3.8%) (§/100)	0.7% (<0.05-3.9%) (§/100)	2.0% (0.7-5.8%) (§/100)	2.7% (1.1-6.8%) (§/100)	⟶ 1.000
Hospital	10.0% (0.5-40.4%) (§/§)	10.0% (0.5-40.4%) (§/§)	No record	No record	No record	No record	No record	⟶ 1.000
Undifferentiated	1.5% (0.4-5.2%) (§/100)	1.8% (0.6-5.2%) (§/200)	1.1% (0.3-3.9%) (§/200)	0.7% (<0.05-3.7%) (§/200)	0.7% (<0.05-3.8%) (§/100)	2.0% (0.7-5.6%) (§/200)	2.0% (0.7-5.8%) (§/100)	⟶ 1.000
Cefotaxime[‡‡]								
Community	1.3%[††] (0.1-6.9%) (§/100)	6.0%[††] (2.8-12.5%) (§/100)	5.1%[††] (2.4-10.7%) (§/100)	7.0% (3.6-13.1%) (§/100)	0.9% (<0.05-5.2%) (§/100)	0.9% (<0.05-5.1%) (§/100)	1.6% (0.5-5.8%) (§/100)	↘ 1.000
Hospital	No record	No record	No record	No record	No record	No record	No record	-
Undifferentiated	2.4%[††] (0.7-8.3%) (§/100)	6.7%[††] (3.3-13.1%) (§/100)	4.8%[††] (2.2-10.2%) (§/100)	7.6% (4.1-13.9%) (§/100)	0.9% (<0.05-5.1%) (§/100)	0.9% (<0.05-4.9%) (§/100)	1.6% (0.4-5.7%) (§/100)	↘ 1.000

Table 29: Non-susceptibility percentage of *Streptococcus pneumoniae* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)**‡¶*	Non-susceptibility %† (95% CI†) (Numerator*/Denominator*) 2012 *(100)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(100)*	p-value**
Ceftriaxone‡‡								
Community	1.7%†† (0.1-9.1%) (§/100)	6.6%†† (2.8-14.5%) (§/100)	5.1%†† (2.2-11.4%) (§/100)	1.2%†† (0.1-6.5%) (§/100)	2.2%†† (0.6-7.7%) (§/100)	4.8%†† (1.9-11.7%) (§/100)	2.4%†† (0.7-8.3%) (§/100)	⟶ 1.000
Hospital	No record	No record	No record	No record	No record	No record	No record	-
Undifferentiated	3.3%†† (0.9-11.2%) (§/100)	7.2%†† (3.4-14.9%) (§/100)	5.0%†† (2.1-11.1%) (§/100)	1.2%†† (0.1-6.3%) (§/100)	2.1%†† (0.6-7.4%) (§/100)	4.7%†† (1.8-11.4%) (§/100)	1.2%†† (0.1-6.4%) (§/100)	⟶ 1.000
Co-trimoxazole								
Community	48.5% (39.1-58.1%) (100/100)	46.4% (38.4-54.7%) (100/100)	60.6% (53.1-67.6%) (100/200)	61.0% (52.6-68.8%) (100/100)	56.8% (48.3-65.0%) (100/100)	70.2% (61.6-77.5%) (100/100)	59.6% (50.5-68.2%) (100/100)	↗ 0.055
Hospital	No record	No record	No record	No record	No record	No record	No record	-
Undifferentiated	48.6% (39.6-57.8%) (100/100)	47.0% (39.1-55.0%) (100/100)	60.7% (53.3-67.6%) (100/200)	62.1% (53.9-69.8%) (100/100)	57.0% (48.6-65.1%) (100/100)	70.0% (61.6-77.2%) (100/100)	60.0% (50.9-68.5%) (100/100)	↗ **0.039**

Table 29: Non-susceptibility percentage of *Streptococcus pneumoniae* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(100)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(100)*	p-value[**]
Erythromycin								
Community	68.1% (59.2-75.8%) (100/100)	69.5% (61.8-76.3%) (100/200)	80.8% (74.3-86.0%) (100/200)	71.1% (63.2-77.9%) (100/100)	76.1% (68.3-82.4%) (100/100)	73.0% (65.0-79.7%) (100/100)	70.0% (61.6-77.2%) (100/100)	⟶ 1.000
Hospital	No record	No record	No record	No record	No record	No record	No record	-
Undifferentiated	69.5% (61.1-76.8%) (100/100)	71.3% (63.8-77.7%) (100/200)	80.6% (74.2-85.7%) (100/200)	72.1% (64.4-78.7%) (100/100)	76.8% (69.2-82.9%) (100/100)	73.4% (65.6-80.0%) (100/100)	70.2% (61.9-77.4%) (100/100)	⟶ 1.000

Table 29: Non-susceptibility percentage of *Streptococcus pneumoniae* for different antimicrobials *(continued)*

Location of Onset *(Total headcount)*[*‡¶]	Non-susceptibility %[†] (95% CI[†]) (Numerator[*]/Denominator[*]) 2012 *(100)*	2013 *(200)*	2014 *(200)*	2015 *(200)*	2016 *(200)*	2017 *(200)*	2018 *(100)*	p-value[**]
Levofloxacin								
Community	0% (<0.05-3.0%) (0/100)	0.6% (<0.05-3.5%) (§/200)	0.6% (<0.05-3.1%) (§/200)	0% (0-2.5%) (0/100)	1.4% (0.4-4.9%) (§/100)	0.7% (<0.05-3.9%) (§/100)	0% (0-2.6%) (0/100)	⟶ 1.000
Hospital	0% (0-27.8%) (0/§)	0% (0-27.8%) (0/§)	No record	No record	No record	No record	No record	-
Undifferentiated	0% (0-2.8%) (0/100)	0.6% (<0.05-3.3%) (§/200)	0.5% (<0.05-3.0%) (§/200)	0% (0-2.4%) (0/200)	1.3% (0.4-4.8%) (§/100)	1.3% (0.4-4.8%) (§/100)	0% (<0.05-2.6%) (0/100)	⟶ 1.000

[*] Rounded to the nearest hundred
[†] Rounded to one decimal place
[‡] Total headcount refers to annual number of patients with particular organism isolated from blood.
[§] Less than 50 patients
[¶] Compare with deduplication without consideration on location of onset, number of isolates selected for analysis increases because isolates from both hospital-onset and community-onset was selected for each patient, if available.
[**] P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend is observed with statistical significance, cells with p-value <0.05 are highlighted.
[††] Since the antimicrobial susceptibility test was performed for less than 70% of the isolates of particular location of onset, readers should interpret the findings with caution.
[‡‡] The interpretation was based on clinical breakpoint criterion for non-meningitis.
Note:
[1] Information presented in each cell is described as below. Row 1: Non-susceptibility percentage (NS%); Row 2: 95% confidence interval of NS%; Row 3: Number of patients with particular isolated and tested I/R to a specific antimicrobial, and total number of patients with particular organism isolated and the specific antimicrobial tested
[2] ↗ Increasing trend; ↘ Decreasing trend; ⟶ Increasing/decreasing trend not observed
[3] Dataset was deduplicated with consideration on location of onset.
[4] Proportion confidence intervals were calculated using the Wilson method.
[5] Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) were excluded from presentation.