

Summary Report on Antimicrobial Resistance in Public Hospitals

Blood Culture for Year 2012 - 2017

Infection Control Branch
Centre for Health Protection
Department of Health

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Contents

Executive Summary	i
1 Introduction	1
2 Data Sources and Methodology	3
2.1 Data sources	3
2.2 Culture test result	3
2.3 Micro-organisms isolated from positive culture	3
2.4 Antimicrobial susceptibility result	4
2.5 Determination on location of onset	4
2.6 Deduplication	5
2.7 Statistical analysis	5
2.8 Antimicrobial names	5
3 Results	7
3.1 Patient characteristics	7
3.2 Distribution of patients with priority pathogens isolated from blood culture	13
3.3 Resistant pattern on selected antimicrobial among WHO priority pathogens	17
3.3.1 <i>Escherichia coli</i>	17
3.3.2 <i>Klebsiella pneumoniae</i>	21
3.3.3 <i>Staphylococcus aureus</i>	25
3.3.4 <i>Salmonella</i> species	27
3.3.5 <i>Acinetobacter</i> species	30
3.3.6 <i>Streptococcus pneumoniae</i>	32
4 Discussion	34
4.1 Data interpretation and limitations	34
5 Conclusion and Way forward	35
6 Annex	36
6.1 Non-susceptibility percentage of WHO GLASS priority pathogens towards selected antimicrobials	36

6.1.1	<i>Escherichia coli</i>	36
6.1.2	<i>Klebsiella pneumoniae</i>	43
6.1.3	<i>Staphylococcus aureus</i>	49
6.1.4	<i>Salmonella</i> species	51
6.1.5	<i>Acinetobacter</i> species	56
6.1.6	<i>Streptococcus pneumoniae</i>	62
	References	66
	List of Abbreviations	67
	Index	68

List of Tables

1	Interchangeable names of antimicrobial	6
2	Demographic information of patients with blood culture specimen collected . . .	8
3	Number of patients with blood culture specimen collected and percentage with positive blood culture	10
4	Summary table on patients with blood culture specimen collected, stratified by age group	11
5	Annual percentage of patients with positive blood culture and 95% confidence interval stratified by age group	12
6	Distribution of WHO GLASS priority pathogens isolated among patients with positive blood culture	14
7	Distribution of priority pathogens isolated from blood, stratified by location of onset	16
8	Non-susceptibility of <i>Escherichia coli</i> on antimicrobials showing trend with statistical significance	19
9	Non-susceptibility of <i>Klebsiella pneumoniae</i> on antimicrobials showing trend with statistical significance	23
10	Non-susceptibility of <i>Staphylococcus aureus</i> for selected antimicrobials with statistical significance	26
11	Non-susceptibility of <i>Salmonella</i> species on antimicrobials showing trend with statistical significance	28
12	Non-susceptibility of <i>Acinetobacter</i> species on antimicrobials showing trend with statistical significance	31
13	Non-susceptibility of <i>Streptococcus pneumoniae</i> on antimicrobials showing trend with statistical significance	33
14	Non-susceptibility percentage of <i>Escherichia coli</i> for WHO GLASS selected antimicrobials	36
15	Non-susceptibility percentage of <i>Klebsiella pneumoniae</i> for WHO GLASS selected antimicrobials	43
16	Non-susceptibility percentage of <i>Staphylococcus aureus</i> for WHO GLASS selected antimicrobials	49
17	Non-susceptibility percentage of <i>Salmonella</i> species for WHO GLASS selected antimicrobials	51

18	Non-susceptibility percentage of <i>Acinetobacter</i> species for WHO GLASS selected antimicrobials	56
19	Non-susceptibility percentage of <i>Streptococcus pneumoniae</i> for WHO GLASS selected antimicrobials	62

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Executive Summary

1. The emergence of antimicrobial resistance (AMR) makes regular treatments of infections less effective and more costly. 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 (IT&HI) of HA, laboratory data with antibiotic 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 exploration.
5. This draft report summarises the findings of the exploration exercise using existing blood culture data from Year 2012 to 2017.

Overview of results

6. Generally speaking, among blood culture specimens collected in public hospitals, the percentage of non-susceptibility on majority of selected antimicrobials for the six WHO GLASS priority organisms remains stable or with slight decreasing trend during the study period. However, increasing trend were also observed among several drug-bug combinations that may warrant further investigations.
7. Below are some of the highlights of the non-susceptibility results for the six priority organisms. All trends on non-susceptibility percentage mentioned here imply presence of statistical significance.

8. For *Escherichia coli*, isolates of community-onset show lower non-susceptibility percentage than those of hospital-onset. No statistically significant changes on non-susceptibility was observed for many commonly used antibiotics treating *Escherichia coli* infections, with decreasing trend observed towards amoxicillin/clavulanate, gentamicin and amikacin among community-onset isolates, and amoxicillin/clavulanate, cefuroxime, cefotaxime and levofloxacin among hospital-onset isolates. Increasing trend of non-susceptibility towards cefepime¹ (range: 12.46% - 24.05%) among community-onset isolates warranted further monitoring and deliberation for using the drug as empirical therapy for treating severe *Escherichia coli* infection. Non-susceptibility to carbapenems² remained low, with no statistical significance on trends observed.

9. For *Klebsiella pneumoniae*, isolates of community-onset show lower percentage of non-susceptibility to antimicrobials than those of hospital-onset. No statistically significant trend on percentage of non-susceptibility of commonly used beta-lactam/beta-lactamase inhibitor combinations, including amoxicillin/clavulanate and piperacillin/tazobactam, as well as major parenteral second- and third-generation cephalosporins, among isolates of both community-onset and hospital-onset was observed, except for an increasing trend of cefotaxime non-susceptibility among isolates of hospital-onset (range: 25.00% - 35.37%). Non-susceptibility towards carbapenems remained low during the period. Increasing trend of non-susceptibility towards cefepime³ among isolates of community-onset (range: 4.76% - 8.40%) and hospital-onset (range: 9.25% - 22.15%), and that of levofloxacin among hospital-onset isolates (range: 12.76% - 22.80%) warranted further monitoring.

10. For *Staphylococcus aureus*, isolates of community have lower non-susceptibility percentage towards oxacillin than those of hospital-onset. No statistically significant trend on non-susceptibility percentage for oxacillin was observed during the period for both isolates of hospital-onset (range: 53.11% - 59.97%) and community-onset (range: 35.65% - 40.26%). Non-susceptibility to vancomycin remained at zero during the study period.

¹Readers should take note that a new (revised) cefepime interpretive criteria for Enterobacteriaceae was released by the Clinical & Laboratory Standards Institute (CLSI) in 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

²In this report, carbapenems refer to meropenem and imipenem/cilastatin

³Readers should take note that a new (revised) cefepime interpretive criteria for Enterobacteriaceae was released by CLSI in 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

11. For *Salmonella* species, an increasing trend of non-susceptibility of fluoroquinolones and ampicillin was observed. In year 2017, 59.40% and 76.39% of the isolates showed non-susceptibility to ampicillin and ciprofloxacin⁴ respectively. Trend on non-susceptibility percentage of third-generation cephalosporins did not show statistical significance, with non-susceptibility percentage being 5.18% for ceftriaxone in 2017. Non-susceptibility towards carbapenems remained at zero during the period.

12. For isolates of *Acinetobacter* species, community-onset isolates showed a lower non-susceptibility percentage than those of hospital-onset. Except a decreasing trend of non-susceptibility percentage of gentamicin and minocycline among hospital-onset isolates being identified, no change with statistical significance was observed among major groups of antimicrobials, including beta-lactam, cephalosporins, carbapenems⁵, fluoroquinolones and aminoglycosides.

13. For *Streptococcus pneumoniae*, trend on non-susceptibility percentage of penicillin (range: 0.66% - 1.96%), cefotaxime (range: 0.89% - 7.63%) and ceftriaxone (range: 1.16% - 7.23%) did not show statistical significance⁶, Non-susceptibility percentage of erythromycin remained high. An increasing trend of non-susceptibility percentage towards sulfamethoxazole/trimethoprim (range: 46.98% - 70.00%) was observed during the period.

Discussion and Way Forward

14. Among blood culture specimens collected in public hospitals in Year 2012 to 2017, the percentage of non-susceptibility on majority of selected antimicrobials for the six WHO GLASS priority organisms remains stable or with slight decreasing trend during the study period.

15. Yet, increased trends were observed among several drug-bug combinations that may warrant further monitoring and investigations.

⁴Readers should take note that a new ciprofloxacin interpretive criteria for *Salmonella* species was released in 2012 and modified recommendations to use separate ciprofloxacin interpretive criteria for *Salmonella* species was released in 2013 by CLSI respectively, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

⁵Readers should take note that a new (revised) imipenem and meropenem interpretive criteria was released by CLSI in 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

⁶The interpretations for penicillin, cefotaxime and ceftriaxone are based on clinical breakpoint criteria for non-meningitis.

16. Antimicrobial resistance 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.

17. Surveillance of AMR contributes to the understanding of AMR situation and for monitoring the effectiveness of measures implemented.

18. This exercise helps to contribute to the understanding of the AMR situation in Hong Kong.

19. Department of Health will work closely with Hospital Authority to develop a sustainable long-term AMR surveillance system based on the data from HA.

1 Introduction

1. The emergence of antimicrobial resistance (AMR) makes the regular treatments of infections become less effective and more costly. 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 antibiotic susceptibility test results of isolated pathogens and demographic data from patients with blood culture specimen collected from Year 2012 to 2017 were extracted and provided to the Department of Health (DH) for exploration with the aim to contribute to the understanding of AMR situation in Hong Kong.
5. This report summarises the results of this exploration exercise.

Details on WHO GLASS (Surveillance on blood culture specimen)[2]

GLASS combines patient, laboratory and epidemiological data to enhance understanding on the extent and impact of AMR

Different priority specimens, pathogens, and pathogen-antibacterial combinations had been identified

For blood culture specimen, GLASS gathers data on AMR in six priority bacteria identified:

- *Escherichia coli*
- *Klebsiella pneumoniae*
- *Acinetobacter* species
- *Staphylococcus aureus*
- *Salmonella* species
- *Streptococcus pneumoniae*

Specimens are defined as hospital-onset/ community-onset based on the following definition:

- Specimen defined as hospital-onset:
 1. patient admitted to a health care facility for >2 calendar days, or
 2. patient admitted to a health care facility for <2 calendar days but transferred from another health care facility where admitted for ≥ 2 calendar days
- Specimen defined as community-onset:
 1. patient being cared for at an outpatient clinic when the specimen was taken, or
 2. patient hospitalised for ≤ 2 calendar days when the specimen was taken

2 Data Sources and Methodology

2.1 Data sources

6. The following datasets were prepared and provided by IT&HI of HA:
- Data on antibiotic susceptibility of pathogens isolated from blood culture
 - Demographic data, including age of specimen collection and sex, from patients with blood culture specimen collected

2.2 Culture test result

7. blood culture specimens⁷ collected from year 2012 to 2017 with any micro-organism cultured are defined as positive specimen.
8. blood culture specimens⁸ collected from year 2012 to 2017 with no micro-organism cultured are defined as negative specimen.

2.3 Micro-organisms isolated from positive culture

9. Isolated micro-organisms not belonging to any one of the following are defined as “Others” and will be considered as one single type of micro-organism.
- *Escherichia coli*
 - *Klebsiella pneumoniae*
 - *Acinetobacter* species
 - *Staphylococcus aureus*
 - *Salmonella* species
 - *Streptococcus pneumoniae*

⁷blood culture specimen is defined as the following list of specimen documented in information systems of HA that performed the “Culture, Blood” test: i) Blood; ii) Blood, culture. Specimens either: i) not being one of the two specimen types listed; or ii) being one of the two specimen types listed but not performing the “Culture, Blood” test, are not included.

⁸ditto.

2.4 Antimicrobial susceptibility result

10. Antimicrobial susceptibility test returning results other than the following will be excluded

- **Susceptible (S):** isolates that were tested and interpreted as “susceptible” to a given antimicrobial 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 in accordance with the clinical breakpoint criteria used by the local laboratory.
- **Resistance (R):** isolates that were tested and interpreted as “resistant” to a given antimicrobial in accordance with the clinical breakpoint criteria used by the local laboratory.

11. An isolate is defined as non-susceptible to a given antimicrobial when it is tested and interpreted as “intermediate” (I) or “resistant” (R) based on the above definition. For *Streptococcus pneumoniae*, the interpretations for penicillin, cefotaxime and ceftriaxone are based on clinical breakpoint criteria for non-meningitis.

2.5 Determination on location of onset

12. Based on the GLASS Manual for Early Implementation prepared by WHO with local adaptation, specimens are categorised as community-onset or hospital-onset according to the following operational definition[2]:

- Specimen defined as hospital-onset:
 - Difference between specimen reference date and linked admission date is more than 48 hours; AND
 - Patient case number starts with “HN” (i.e. Hospital Number)
- Specimen defined as community-onset:
 - Specimens not fulfilling either one of the above criteria

2.6 Deduplication

13. Based on WHO GLASS Manual for Early Implementation, duplicate findings for the same patient should be excluded, which only one result should be reported for each patient per surveyed specimen type and surveyed pathogen[2].
14. Data received from IT&HI of HA is de-duplicated according to the principle stated in WHO GLASS manual[2], with local modification adopted⁹.
15. *Salmonella* species and *Streptococcus pneumoniae* are pathogens primarily causing community-acquired infections. They are rare to cause hospital-associated infections. Information on location of onset is not considered when analysing and interpreting non-susceptibility results of these two pathogens. These results will be interpreted as isolates of onset of unknown location.
16. Non-susceptibility results of an antimicrobial derived from less than 10 isolates per year are excluded from analysis.

2.7 Statistical analysis

17. For identification of temporal trends on changes in non-susceptibility percentage, Cochran-Armitage trend test, which is a statistical test applied by the European Antimicrobial Resistance Surveillance Network for reporting AMR surveillance data[3], was used. P-value smaller than 0.05 is considered to be statistically significant.

2.8 Antimicrobial names

For simplicity, names of antimicrobial listed in Table 1 are used interchangeably.

⁹Based on "HA Protocol for MRSA Surveillance Program", duplicate positive cultures within a two-week period from the same patient should be regarded as a single episode

Table 1: Interchangeable names of antimicrobial

Name	Alternative Name
Amoxicillin and beta-lactamase inhibitor	Amoxicillin/clavulanate
Ampicillin and beta-lactamase inhibitor	Ampicillin/sulbactam
Imipenem and Cilastatin	Imipenem/cilastatin
Piperacillin and beta-lactamase inhibitor	Piperacillin/tazobactam
Sulfamethoxazole and trimethoprim	Sulfamethoxazole/trimethoprim

3 Results

3.1 Patient characteristics

18. Table 2 summarises number of patients with blood culture specimen collected for blood culture, stratified by age group and sex.

19. It was observed blood culture specimen was more commonly collected among patients aged below one, and 65 or above.

20. Table 3 summarises number of patients with blood culture specimen collected for blood culture, number of these patients having positive culture result, and percentage of patients with blood culture specimen collected that yielded positive culture result.

21. Number of patients with blood culture specimen collected increase from 123,026 in year 2012 to 158,749 in year 2017. Percentage of patient with positive blood culture ranged from 10.08% to 11.10% from year 2012 to 2017.

Table 2: Demographic information of patients with blood culture specimen collected

Age group	Year 2012		Year 2013		Year 2014		Year 2015		Year 2016		Year 2017	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
0	5,585 (9.40%)	7,165 (11.27%)	5,180 (8.68%)	6,499 (10.38%)	5,433 (8.67%)	6,852 (10.21%)	5,634 (8.52%)	7,194 (10.31%)	6,381 (8.71%)	7,628 (9.94%)	5,950 (7.70%)	7,353 (9.02%)
1-4	3,310 (5.57%)	3,900 (6.13%)	3,340 (5.59%)	4,015 (6.41%)	3,210 (5.12%)	3,957 (5.89%)	3,344 (5.05%)	3,953 (5.66%)	4,491 (6.13%)	5,395 (7.03%)	4,384 (5.68%)	5,350 (6.56%)
5-14	1,896 (3.19%)	2,136 (3.36%)	1,950 (3.27%)	2,088 (3.33%)	1,824 (2.91%)	2,161 (3.22%)	1,736 (2.62%)	2,100 (3.01%)	2,681 (3.66%)	3,087 (4.02%)	2,607 (3.38%)	2,953 (3.62%)
15-24	1,849 (3.11%)	1,336 (2.10%)	1,842 (3.09%)	1,453 (2.32%)	1,832 (2.92%)	1,485 (2.21%)	1,877 (2.84%)	1,391 (1.99%)	2,152 (2.94%)	1,615 (2.11%)	2,201 (2.85%)	1,734 (2.13%)
25-34	3,521 (5.93%)	1,644 (2.58%)	3,549 (5.94%)	1,768 (2.82%)	3,822 (6.10%)	1,822 (2.71%)	3,929 (5.94%)	1,818 (2.60%)	4,521 (6.17%)	2,136 (2.78%)	4,779 (6.19%)	2,273 (2.79%)
35-44	3,177 (5.35%)	2,360 (3.71%)	3,309 (5.54%)	2,427 (3.88%)	3,599 (5.75%)	2,701 (4.02%)	3,753 (5.67%)	2,667 (3.82%)	4,190 (5.72%)	2,818 (3.67%)	4,638 (6.00%)	3,145 (3.86%)
45-54	4,213 (7.09%)	4,670 (7.34%)	4,240 (7.10%)	4,591 (7.33%)	4,451 (7.11%)	4,852 (7.23%)	4,661 (7.05%)	4,748 (6.80%)	4,980 (6.80%)	5,149 (6.71%)	5,440 (7.04%)	5,513 (6.76%)
55-64	5,294 (8.91%)	7,788 (12.24%)	5,661 (9.48%)	8,071 (12.89%)	6,020 (9.61%)	8,906 (13.27%)	6,330 (9.57%)	9,133 (13.08%)	7,065 (9.64%)	10,085 (13.15%)	7,805 (10.10%)	10,804 (13.25%)




Table 2: Demographic information of patients with blood culture specimen collected (*continued*)

Age group	Year 2012		Year 2013		Year 2014		Year 2015		Year 2016		Year 2017	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
65-74	5,476 (9.22%)	9,470 (14.89%)	5,540 (9.28%)	9,322 (14.89%)	5,885 (9.40%)	9,961 (14.84%)	6,461 (9.77%)	10,812 (15.49%)	7,269 (9.92%)	11,838 (15.43%)	8,282 (10.72%)	13,310 (16.33%)
75-84	12,204 (20.54%)	15,124 (23.78%)	11,945 (20.01%)	14,319 (22.87%)	12,366 (19.74%)	15,303 (22.80%)	12,681 (19.17%)	15,864 (22.73%)	12,695 (17.33%)	16,024 (20.89%)	13,085 (16.94%)	16,877 (20.71%)
≥85	12,899 (21.71%)	8,009 (12.59%)	13,143 (22.02%)	8,067 (12.88%)	14,194 (22.66%)	9,126 (13.60%)	15,750 (23.81%)	10,126 (14.51%)	16,842 (22.99%)	10,941 (14.26%)	18,068 (23.39%)	12,198 (14.97%)
Total	59,424 (100.00%)	63,602 (100.00%)	59,699 (100.00%)	62,620 (100.00%)	62,636 (100.00%)	67,126 (100.00%)	66,156 (100.00%)	69,806 (100.00%)	73,267 (100.00%)	76,716 (100.00%)	77,239 (100.00%)	81,510 (100.00%)

Note:

- ¹ Percentage is calculated as the number of patient of a particular age group and sex divided by total number of patient with blood culture specimen collected that year, it is rounded to two decimal places.
- ² Since the same patient may have blood culture specimens collected across two age group (i.e. specimens 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 patient with blood culture specimen taken.

Table 3: Number of patients with blood culture specimen collected and percentage with positive blood culture

	2012	2013	2014	2015	2016	2017	
Patient with positive blood culture (A)	13,311	13,186	14,191	15,097	15,495	16,002	
Patient with blood culture specimen collected (B)	123,026	122,319	129,762	135,962	149,983	158,749	
Percentage of patient with positive blood culture ($A \div B \times 100\%$)*	10.82%	10.78%	10.94%	11.10%	10.33%	10.08%	

* Rounded to two decimal places

Note:

- ¹ Line chart(s) and bar chart(s) in the table aim at presenting the general shape of variation, charts are not on the same scale, they are not meant for inter-chart comparison.
- ² Since the same patient may have blood culture specimens collected across two age group (i.e. specimens collected before and after birthday), for simplicity, only the first positive specimen from each patient is included when counting for number of patient with positive blood culture, and only the first specimen for each patient, regardless of culture result, is included when counting for number of patient with blood culture specimen taken.

22. Table 4 presents number of patients with blood culture specimen collected, positive blood culture results, and percentage of patients with positive blood culture results, stratified by age group.

23. Table 5 presents percentage of patient with positive blood culture results, and respective 95% confidence interval calculated using the Wilson method[4].

24. It was observed that stratified by age group, positive blood culture specimens were more commonly collected among patients aged 65 or above (range: 13.82% - 14.66%) when compared with other age group (age 0-14: 1.65% - 2.53%; age 15-64: 8.73% - 10.61%).

Table 4: Summary table on patients with blood culture specimen collected, stratified by age group

Description	2012	2013	2014	2015	2016	2017	
0-14 (children)							
Number of patient with positive blood culture (A)	606	488	557	536	533	473	
Number of patient with blood culture specimen taken (B)	23,992	23,072	23,437	23,961	29,663	28,597	
Percentage of patient with positive blood culture (A÷B×100%)*	2.53%	2.12%	2.38%	2.24%	1.80%	1.65%	
15-64 (adults)							
Number of patient with positive blood culture (A)	3,805	3,675	3,839	4,143	4,272	4,218	
Number of patient with blood culture specimen taken (B)	35,852	36,911	39,490	40,307	44,711	48,332	
Percentage of patient with positive blood culture (A÷B×100%)*	10.61%	9.96%	9.72%	10.28%	9.55%	8.73%	
≥65 (elders)							
Number of patient with positive blood culture (A)	8,900	9,023	9,795	10,418	10,690	11,311	
Number of patient with blood culture specimen taken (B)	63,182	62,336	66,835	71,694	75,609	81,820	
Percentage of patient with positive blood culture (A÷B×100%)*	14.09%	14.47%	14.66%	14.53%	14.14%	13.82%	
Total							
Number of patient with positive blood culture (A)	13,311	13,186	14,191	15,097	15,495	16,002	
Number of patient with blood culture specimen taken (B)	123,026	122,319	129,762	135,962	149,983	158,749	
Percentage of patient with positive blood culture (A÷B×100%)*	10.82%	10.78%	10.94%	11.10%	10.33%	10.08%	

* Rounded to two decimal places

Note:

- Line chart(s) and bar chart(s) in the table aim at presenting the general shape of variation, charts are not on the same scale, they are not meant for inter-chart comparison.
- Since the same patient may have blood culture specimens collected across two age group (i.e. specimens collected before and after birthday), for simplicity, only the first positive specimen from each patient is included when counting for number of patient with positive blood culture, and only the first specimen for each patient, regardless of culture result, is included when counting for number of patient with blood culture specimen taken.

Table 5: Annual percentage of patients with positive blood culture and 95% confidence interval stratified by age group

Year	0-14 (children)	15-64 (adults)	≥65 (elders)	Total
2012	2.53% (2.33% - 2.73%)	10.61% (10.30% - 10.94%)	14.09% (13.82% - 14.36%)	10.82% (10.65% - 10.99%)
2013	2.12% (1.94% - 2.31%)	9.96% (9.66% - 10.27%)	14.47% (14.20% - 14.75%)	10.78% (10.61% - 10.96%)
2014	2.38% (2.19% - 2.58%)	9.72% (9.43% - 10.02%)	14.66% (14.39% - 14.93%)	10.94% (10.77% - 11.11%)
2015	2.24% (2.06% - 2.43%)	10.28% (9.99% - 10.58%)	14.53% (14.28% - 14.79%)	11.10% (10.94% - 11.27%)
2016	1.80% (1.65% - 1.95%)	9.55% (9.29% - 9.83%)	14.14% (13.89% - 14.39%)	10.33% (10.18% - 10.49%)
2017	1.65% (1.51% - 1.81%)	8.73% (8.48% - 8.98%)	13.82% (13.59% - 14.06%)	10.08% (9.93% - 10.23%)

Note:

- ¹ Proportion confidence intervals are calculated using the Wilson method
- ² Since the same patient may have blood culture specimens collected across two age group (i.e. specimens collected before and after birthday), for simplicity, only the first positive specimen from each patient is included when counting for number of patient with positive blood culture, and only the first specimen for each patient, regardless of culture result, is included when counting for number of patient with blood culture specimen taken.

3.2 Distribution of patients with priority pathogens isolated from blood culture

25. Table 6 presents the distribution of patients with WHO GLASS priority pathogen isolated from blood culture specimen. Distribution of the six WHO GLASS priority pathogens were similar over the years. In year 2017, 41.21% of patients with positive blood culture had *Escherichia coli* isolated, followed by *Klebsiella pneumoniae* (11.65%) and *Staphylococcus aureus* (10.62%).

Table 6: Distribution of WHO GLASS priority pathogens isolated among patients with positive blood culture

Description	2012	2013	2014	2015	2016	2017	
<i>Escherichia coli</i>							
Number of patient with the pathogen isolated from blood (A)	5,023	5,232	5,547	6,006	6,334	6,594	
Number of patient with positive blood culture (B)	13,311	13,186	14,191	15,097	15,495	16,002	
Percentage of patient with positive blood culture (A÷B×100%)*	37.74%	39.68%	39.09%	39.78%	40.88%	41.21%	
<i>Klebsiella pneumoniae</i>							
Number of patient with the pathogen isolated from blood (A)	1,559	1,684	1,715	1,795	1,908	1,865	
Number of patient with positive blood culture (B)	13,311	13,186	14,191	15,097	15,495	16,002	
Percentage of patient with positive blood culture (A÷B×100%)*	11.71%	12.77%	12.09%	11.89%	12.31%	11.65%	
<i>Staphylococcus aureus</i>							
Number of patient with the pathogen isolated from blood (A)	1,401	1,422	1,446	1,517	1,658	1,699	
Number of patient with positive blood culture (B)	13,311	13,186	14,191	15,097	15,495	16,002	
Percentage of patient with positive blood culture (A÷B×100%)*	10.53%	10.78%	10.19%	10.05%	10.70%	10.62%	
<i>Salmonella species</i>							
Number of patient with the pathogen isolated from blood (A)	157	183	176	273	206	235	
Number of patient with positive blood culture (B)	13,311	13,186	14,191	15,097	15,495	16,002	
Percentage of patient with positive blood culture (A÷B×100%)*	1.18%	1.39%	1.24%	1.81%	1.33%	1.47%	

Table 6: Distribution of WHO GLASS priority pathogens isolated among patients with positive blood culture (*continued*)

Description	2012	2013	2014	2015	2016	2017	
<i>Acinetobacter</i> species							
Number of patient with the pathogen isolated from blood (A)	203	197	230	224	199	228	
Number of patient with positive blood culture (B)	13,311	13,186	14,191	15,097	15,495	16,002	
Percentage of patient with positive blood culture (A÷B×100%)*	1.53%	1.49%	1.62%	1.48%	1.28%	1.42%	
<i>Streptococcus pneumoniae</i>							
Number of patient with the pathogen isolated from blood (A)	139	174	190	156	153	157	
Number of patient with positive blood culture (B)	13,311	13,186	14,191	15,097	15,495	16,002	
Percentage of patient with positive blood culture (A÷B×100%)*	1.04%	1.32%	1.34%	1.03%	0.99%	0.98%	

* Rounded to two decimal places

Note:

¹ Line chart(s) and bar chart(s) in the table aim at presenting the general shape of variation, they are not meant for inter-chart comparison.

26. Table 7 presents the distribution of WHO GLASS priority pathogen isolated from blood, stratified by location of onset. Distribution of location of onset among the six priority pathogens over the years were stable. In year 2017, *Streptococcus pneumoniae* (95.57%), *Escherichia coli* (82.66%), *Salmonella* species (77.12%) and *Klebsiella pneumoniae* (73.77%) were predominantly of community-onset. While *Acinetobacter* species (67.11%) were predominantly of hospital-onset.

Table 7: Distribution of priority pathogens isolated from blood, stratified by location of onset

Location of Onset	2012	2013	2014	2015	2016	2017
<i>Escherichia coli</i>						
Community	4,180 (81.90%)	4,361 (81.80%)	4,679 (82.80%)	4,996 (81.70%)	5,290 (82.14%)	5,550 (82.66%)
Hospital	924 (18.10%)	970 (18.20%)	972 (17.20%)	1,119 (18.30%)	1,150 (17.86%)	1,164 (17.34%)
<i>Klebsiella pneumoniae</i>						
Community	1,178 (74.42%)	1,270 (74.14%)	1,270 (72.57%)	1,281 (69.96%)	1,431 (73.57%)	1,398 (73.77%)
Hospital	405 (25.58%)	443 (25.86%)	480 (27.43%)	550 (30.04%)	514 (26.43%)	497 (26.23%)
<i>Staphylococcus aureus</i>						
Community	819 (57.27%)	797 (55.00%)	832 (56.14%)	928 (59.99%)	1,001 (59.09%)	1,000 (57.60%)
Hospital	611 (42.73%)	652 (45.00%)	650 (43.86%)	619 (40.01%)	693 (40.91%)	736 (42.40%)
<i>Salmonella</i> species						
Community	128 (80.00%)	147 (79.46%)	144 (78.69%)	218 (77.30%)	170 (81.73%)	182 (77.12%)
Hospital	32 (20.00%)	38 (20.54%)	39 (21.31%)	64 (22.70%)	38 (18.27%)	54 (22.88%)
<i>Acinetobacter</i> species						
Community	66 (32.35%)	54 (27.14%)	67 (28.88%)	72 (32.14%)	67 (33.67%)	75 (32.89%)
Hospital	138 (67.65%)	145 (72.86%)	165 (71.12%)	152 (67.86%)	132 (66.33%)	153 (67.11%)
<i>Streptococcus pneumoniae</i>						
Community	129 (92.81%)	164 (94.25%)	182 (95.29%)	150 (96.15%)	149 (97.39%)	151 (95.57%)
Hospital	10 (7.19%)	10 (5.75%)	9 (4.71%)	6 (3.85%)	4 (2.61%)	7 (4.43%)

Note:

¹ Percentage calculated is the proportion between isolates of community-onset and hospital-onset per organism per year

² Percentage is rounded to two decimal places

3.3 Resistant pattern on selected antimicrobial among WHO priority pathogens

All trends mentioned in this section imply presence of statistical significance, readers may refer to respective tables for details.

3.3.1 *Escherichia coli*

27. Table 8 presents the percentage of patient having isolates of *Escherichia coli* showing trend with statistical significance on non-susceptibility towards selected antimicrobials, stratified by location of onset. Please refer to Table 14 in annex for further details.

28. In general, non-susceptibility percentage was lower among *Escherichia coli* isolate of community-onset than those of hospital-onset.

29. Among most beta-lactam antimicrobials, trend observed on non-susceptibility percentage for *Escherichia coli* isolates of **community-onset did not reach statistical significance** during the period except amoxicillin/clavulanate¹⁰ and cefepime¹¹. For isolates of **hospital-onset**, a **decreasing** trend was observed for non-susceptibility percentage of amoxicillin/clavulanate, cefuroxime, and cefotaxime.

30. Non-susceptibility percentage for amoxicillin/clavulanate ranged from 26.35% to 32.52% and 38.32% to 47.11% for isolates of community-onset and hospital-onset respectively. Decreasing trend was observed also for both isolates of community-onset and hospital-onset.

31. For non-susceptibility to cefuroxime, decreasing trend was observed for isolates of hospital-onset with percentage ranged from 38.41% to 48.64%, while no trend with statistical significance was observed for those of community-onset, with range of percentage being 27.82% and 30.17%.

32. Non-susceptibility percentage of cefotaxime for isolates of community-onset ranged from 25.20% to 28.78% and no trend with statistical significance was observed. Isolates of hospital-onset showed a decreasing trend with range of percentage being 35.59% and 44.41%.

¹⁰Refer to Table 1 for interchangeable names of antimicrobial

¹¹Readers should take note that a new (revised) cefepime interpretive criteria for Enterobacteriaceae was released by CLSI in 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

33. For ceftriaxone, no trend with statistical significance was observed for isolates of community-onset (range: 25.44% - 28.49%) and hospital-onset (range: 35.15% - 44.37%).

34. For non-susceptibility to ceftazidime for isolates of both community-onset and hospital-onset, no trend with statistical significance was observed. Non-susceptibility percentage ranged from 13.17% to 16.51% and from 20.47% to 27.24% for isolates of community-onset and hospital-onset respectively.

35. In contrast, no trend with statistical significance was observed on non-susceptibility percentage of cefepime¹² for isolates of community-onset, with percentage ranged from 12.46% to 24.05%. No trend with statistical significance was observed for isolates of hospital-onset, with percentage range being 24.92% and 35.28%.

36. Trend for non-susceptibility percentage of piperacillin/tazobactam¹³ did not show statistical significance over the years for both isolates of hospital-onset and community-onset. Non-susceptibility percentage ranged from 4.46% to 7.20% and from 9.50% to 15.10% for isolates of community-onset and hospital-onset respectively.

37. Non-susceptibility percentage of meropenem and imipenem/cilastatin¹⁴ remained low during the period. No trend with statistical significance was observed for meropenem among isolates of community-onset (range: <0.005% - 0.10%) and hospital-onset (range: <0.005% - 0.84%). No trend with statistical significance was observed also for imipenem/cilastatin among isolates of community-onset (range: <0.005% - 0.04%) and hospital-onset (range: <0.005% - 0.41%).

38. For non-beta-lactam antimicrobials, decreasing trend was observed in isolates of community-onset for amikacin (range: 0.42% - 1.35%) and gentamicin (range: 28.28% - 31.16%). Decreasing trend was observed in hospital-onset isolate for levofloxacin (range: 39.47% - 49.67%).

¹²Readers should take note that a new (revised) cefepime interpretive criteria for Enterobacteriaceae was released by CLSI in 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.



¹³Refer to Table 1 for interchangeable names of antimicrobial

¹⁴Refer to Table 1 for interchangeable names of antimicrobial

Table 8: Non-susceptibility of *Escherichia coli* on antimicrobials showing trend with statistical significance

Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b	
Amoxicillin and Beta-Lactamase Inhibitor								
Community	27.34% (26.01-28.72%) (1,143/ 4,180)	32.52% (31.15-33.93%) (1,417/ 4,357)	29.04% (27.75-30.35%) (1,358/ 4,677)	26.48% (25.28-27.72%) (1,323/ 4,996)	27.07% (25.89-28.28%) (1,431/ 5,287)	26.35% (25.21-27.53%) (1,461/ 5,544)	<0.005	
Hospital	44.41% (41.23-47.63%) (409/ 921)	47.11% (43.98-50.26%) (456/ 968)	43.56% (40.48-46.70%) (423/ 971)	43.10% (40.22-46.02%) (481/ 1,116)	42.58% (39.75-45.47%) (488/ 1,146)	38.32% (35.56-41.16%) (443/ 1,156)	0.021	
Cefuroxime								
Hospital	48.64% (45.43-51.87%) (448/ 921)	45.81% (42.69-48.96%) (443/ 967)	44.28% (41.19-47.42%) (430/ 971)	46.42% (43.51-49.35%) (518/ 1,116)	42.53% (39.70-45.42%) (487/ 1,145)	38.41% (35.65-41.25%) (444/ 1,156)	<0.005	
Cefotaxime								
Hospital	44.41% (40.59-48.30%) (282/ 635)	41.94% (38.29-45.67%) (286/ 682)	41.41% (37.91-44.99%) (306/ 739)	42.65% (39.47-45.90%) (386/ 905)	39.08% (36.03-42.21%) (372/ 952)	35.59% (32.60-38.69%) (337/ 947)	0.016	
Cefepime[†]								
Community	13.38% (12.16-14.69%) (374/ 2,796)	12.46% (11.33-13.68%) (379/ 3,042)	19.33% (18.02-20.70%) (648/ 3,353)	24.05% (22.74-25.40%) (957/ 3,980)	23.59% (22.43-24.80%) (1,162/ 4,925)	22.63% (21.52-23.79%) (1,183/ 5,227)	<0.005	
Gentamicin								
Community	31.16% (29.77-32.58%) (1,302/ 4,179)	31.01% (29.65-32.40%) (1,351/ 4,357)	28.42% (27.15-29.73%) (1,329/ 4,676)	29.80% (28.55-31.09%) (1,489/ 4,996)	28.90% (27.69-30.14%) (1,528/ 5,287)	28.28% (27.11-29.48%) (1,568/ 5,544)	0.031	

Table 8: Non-susceptibility of *Escherichia coli* on antimicrobials showing trend with statistical significance (*continued*)

Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b	
Amikacin								
Community	1.27% (0.97-1.65%) (53/ 4,180)	1.35% (1.05-1.74%) (59/ 4,357)	0.81% (0.59-1.11%) (38/ 4,676)	0.70% (0.50-0.97%) (35/ 4,989)	0.70% (0.51-0.96%) (37/ 5,285)	0.42% (0.28-0.62%) (23/ 5,539)	<0.005	
Levofloxacin								
Hospital	48.20% (44.88-51.54%) (415/ 861)	49.67% (46.46-52.90%) (458/ 922)	45.38% (42.24-48.55%) (432/ 952)	48.21% (45.26-51.18%) (526/ 1,091)	44.80% (41.91-47.73%) (500/ 1,116)	39.47% (36.66-42.35%) (446/ 1,130)	<0.005	

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists
Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital-onset and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

[†] New (revised) cefepime interpretive criteria for Enterobacteriaceae was released by CLSI in 2014.

3.3.2 *Klebsiella pneumoniae*

39. Table 9 presents the percentage of patient having isolates of *Klebsiella pneumoniae* showing trend with statistical significance on non-susceptibility towards selected antimicrobials, stratified by location of onset. Please refer to Table 15 in annex for further details.

40. In general, results from the exercise suggested isolates of *Klebsiella pneumoniae* of community-onset having lower non-susceptibility percentage than those of hospital-onset.

41. For non-susceptibility towards beta-lactam antimicrobials of **community-onset** isolates, no trend with statistical significance was observed among the two commonly used antibiotics amoxicillin/clavulanate (range: 13.42% - 15.09%) and cefuroxime (range: 14.33% - 16.08%).

42. Non-susceptibility percentage of cefotaxime was higher for hospital-onset isolates (range: 25.00% - 35.37%) than those of community-onset isolates (range: 11.10% - 13.16%). No trend with statistical significance was observed for isolates of community-onset, while increasing trend was observed for those of hospital-onset.

43. For ceftazidime, non-susceptibility percentage ranges from 7.32% to 8.48% and from 17.75% to 25.44% for isolates of community-onset and hospital-onset respectively. No trend with statistical significance was observed for both types of isolates.

44. Similar finding was observed for ceftriaxone, no trend with statistical significance was observed for both isolates of hospital-onset (range: 20.54% - 26.12%) and community-onset (range: 8.56% - 11.68%).

45. For cefepime¹⁵, a fourth-generation cephalosporin, no trend with statistical significance was observed for both isolates of community-onset (range: 4.76% - 8.40%) and hospital-onset (range: 9.25% - 22.15%).

46. For piperacillin/tazobactam¹⁶, no trend with statistical significance was observed for isolates of community-onset (range: 4.57% - 5.81%) and hospital-onset (range: 13.79% - 21.49%).

¹⁵Readers should take note that a new (revised) cefepime interpretive criteria for Enterobacteriaceae was released by CLSI in 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

¹⁶Refer to Table 1 for interchangeable names of antimicrobial

47. Non-susceptibility of carbapenems¹⁷ was observed to remain low during the period. For meropenem, no trend with statistical significance was observed for isolates of hospital-onset (range: 0.42% - 2.53%) and community-onset (range: <0.005% - 0.43%). For imipenem/cilastatin¹⁸, no trend with statistical significance was observed for isolates of community-onset (range: <0.005% - 0.28%) and hospital-onset (range: 0.48% - 1.34%).

48. For non-beta-lactam antimicrobials, increasing trend were observed for levofloxacin (range: 12.76% - 22.80%) and ciprofloxacin (range: 18.42% - 42.67%) non-susceptibility among hospital-onset isolates.

¹⁷In this report, carbapenems refer to meropenem and imipenem/cilastatin.

¹⁸Refer to Table 1 for interchangeable names of antimicrobial

Table 9: Non-susceptibility of *Klebsiella pneumoniae* on antimicrobials showing trend with statistical significance





Location of Onset (Total headcount) ^a	2012 (1,559)	2013 (1,684)	2014 (1,715)	2015 (1,795)	2016 (1,908)	2017 (1,865)	P-value ^b	
Cefotaxime								
Hospital	25.97% (21.00-31.64%) (67/ 258)	25.00% (20.38-30.27%) (73/ 292)	26.14% (21.82-30.97%) (92/ 352)	27.01% (23.00-31.44%) (114/ 422)	35.37% (30.80-40.22%) (139/ 393)	32.64% (28.16-37.47%) (126/ 386)	0.047	
Cefepime*								
Community	4.76% (3.50-6.44%) (39/ 820)	4.92% (3.69-6.54%) (44/ 894)	5.01% (3.76-6.63%) (45/ 899)	7.20% (5.78-8.93%) (75/ 1,042)	8.40% (7.02-10.01%) (112/ 1,334)	7.35% (6.06-8.88%) (97/ 1,320)	<0.005	
Hospital	11.95% (8.50-16.55%) (30/ 251)	9.25% (6.39-13.21%) (26/ 281)	16.13% (12.45-20.63%) (50/ 310)	19.52% (16.02-23.58%) (82/ 420)	20.33% (16.98-24.15%) (98/ 482)	22.15% (18.61-26.14%) (103/ 465)	<0.005	
Ciprofloxacin								
Hospital	18.42% (12.38-26.52%) (21/ 114)	22.02% (15.27-30.68%) (24/ 109)	27.45% (19.73-36.81%) (28/ 102)	39.05% (30.26-48.61%) (41/ 105)	42.67% (32.10-53.95%) (32/ 75)	38.78% (26.43-52.75%) (19/ 49)	<0.005	

Table 9: Non-susceptibility of *Klebsiella pneumoniae* on antimicrobials showing trend with statistical significance (continued)

Location of Onset (Total headcount) ^a	2012 (1,559)	2013 (1,684)	2014 (1,715)	2015 (1,795)	2016 (1,908)	2017 (1,865)	P-value ^b
Levofloxacin							
Hospital	12.76% (9.79-16.47%) (49/ 384)	17.39% (14.04-21.34%) (72/ 414)	14.56% (11.67-18.02%) (69/ 474)	18.28% (15.24-21.78%) (98/ 536)	19.52% (16.29-23.22%) (98/ 502)	22.80% (19.27-26.77%) (109/ 478)	<0.005

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists
Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital-onset and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

* New (revised) cefepime interpretive criteria for Enterobacteriaceae was released by CLSI in 2014.

3.3.3 *Staphylococcus aureus*

49. No trend with statistical significance was observed for percentage on non-susceptibility towards selected antimicrobial during the period. Please refer to Table 16 in annex for details.

50. Results from the exercise suggested isolates of *Staphylococcus aureus* of community-onset having lower non-susceptibility percentage towards oxacillin than those of hospital-onset.

51. Trends on non-susceptibility percentage for oxacillin did not show statistical significance during the period for both isolates of hospital-onset (range: 53.11% - 59.97%) and community-onset (range: 35.65% - 40.26%).

52. Percentage on non-susceptibility to vancomycin remained at zero for isolates of both hospital-onset and community-onset from year 2012 to 2017 for *Staphylococcus aureus*.

Table 10: Non-susceptibility of *Staphylococcus aureus* for selected antimicrobials with statistical significance

Location of Onset (Total headcount) ^a	2012 (1,401)	2013 (1,422)	2014 (1,446)	2015 (1,517)	2016 (1,658)	2017 (1,699)	P-value ^b	
Oxacillin								
Community	35.65% (32.45-38.99%) (292/ 819)	39.20% (35.86-42.63%) (312/ 796)	38.58% (35.33-41.93%) (321/ 832)	39.12% (36.03-42.29%) (363/ 928)	40.26% (37.26-43.33%) (403/ 1,001)	37.90% (34.94-40.95%) (379/ 1,000)	1.000	
Hospital	53.11% (49.15-57.04%) (324/ 610)	56.00% (52.16-59.77%) (364/ 650)	56.19% (52.34-59.97%) (363/ 646)	54.05% (50.10-57.94%) (334/ 618)	59.97% (56.28-63.56%) (415/ 692)	54.22% (50.61-57.80%) (398/ 734)	1.000	
Vancomycin								
Community	<0.005% (<0.005-0.47%) (0/ 813)	<0.005% (<0.005-0.48%) (0/ 790)	<0.005% (<0.005-0.46%) (0/ 824)	<0.005% (<0.005-0.41%) (0/ 926)	<0.005% (<0.005-0.38%) (0/ 997)	<0.005% (<0.005-0.39%) (0/ 981)	-	
Hospital	<0.005% (<0.005-0.63%) (0/ 610)	<0.005% (<0.005-0.59%) (0/ 646)	<0.005% (<0.005-0.59%) (0/ 644)	<0.005% (<0.005-0.62%) (0/ 618)	<0.005% (<0.005-0.55%) (0/ 691)	<0.005% (<0.005-0.53%) (0/ 726)	-	

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital-onset and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

3.3.4 *Salmonella* species

53. Table 11 presents the percentage of patient having isolates of *Salmonella* species showing non-susceptibility towards selected antimicrobials. Please refer to Table 17 in annex for further details.

54. For results observed from isolates of *Salmonella* species of this section, information on location of onset was not considered.

55. Increasing trend was observed for non-susceptibility percentage of ampicillin from year 2012 to 2017, with percentage ranged from 35.03% to 62.44%.

56. For cephalosporin antimicrobials, no trend with statistical significance was observed for non-susceptibility percentage of ceftriaxone, with non-susceptibility percentage ranged from <0.005% to 8.51%. Similar pattern was also observed for cefotaxime, with percentage ranged from 2.33% to 8.62%, and no trend with statistical significance was observed.

57. Non-susceptibility percentage for carbapenems¹⁹ **remained at zero** during the period. For quinolone antimicrobials, **sharp increasing** trends of non-susceptibility to ciprofloxacin²⁰ and levofloxacin²¹ were observed. Percentage of non-susceptibility towards ciprofloxacin ranged from 51.88% to 76.39%, and that of levofloxacin ranged from <0.005% to 86.36%. It is worth noting that smaller number of isolates were tested for levofloxacin susceptibility than those tested for ciprofloxacin.

¹⁹In this report, carbapenems refer to meropenem and imipenem/cilastatin.

²⁰Readers should take note that a new ciprofloxacin interpretive criteria for *Salmonella* species was released in 2012 and modified recommendations to use separate ciprofloxacin interpretive criteria for *Salmonella* species was released in 2013 by CLSI respectively, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

²¹Readers should take note that a new levofloxacin interpretive criteria for *Salmonella* species was released by CLSI in 2013, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

Table 11: Non-susceptibility of *Salmonella* species on antimicrobials showing trend with statistical significance







Location of Onset (Total headcount) ^a	2012 (157)	2013 (183)	2014 (176)	2015 (273)	2016 (206)	2017 (235)	P-value ^b	
Ampicillin								
Community	32.03% (24.57-40.54%) (41/ 128)	34.01% (26.85-41.99%) (50/ 147)	47.92% (39.92-56.02%) (69/ 144)	50.23% (43.63-56.82%) (109/ 217)	61.54% (54.02-68.54%) (104/ 169)	51.65% (44.43-58.80%) (94/ 182)	<0.005	
Hospital	43.75% (28.17-60.67%) (14/ 32)	55.26% (39.71-69.85%) (21/ 38)	61.54% (45.90-75.11%) (24/ 39)	65.62% (53.40-76.08%) (42/ 64)	65.79% (49.89-78.79%) (25/ 38)	84.91% (72.95-92.15%) (45/ 53)	<0.005	
Undifferentiated	35.03% (28.01-42.77%) (55/ 157)	37.70% (31.00-44.91%) (69/ 183)	50.00% (42.69-57.31%) (88/ 176)	53.68% (47.74-59.51%) (146/ 272)	62.44% (55.64-68.78%) (128/ 205)	59.40% (53.01-65.49%) (139/ 234)	<0.005	
Ciprofloxacin^{‡§}								
Community	53.27% (43.87-62.45%) (57/ 107)	65.25% (57.08-72.61%) (92/ 141)	62.24% (54.07-69.77%) (89/ 143)	70.51% (64.13-76.18%) (153/ 217)	75.74% (68.75-81.58%) (128/ 169)	73.48% (66.61-79.38%) (133/ 181)	<0.005	
Hospital	44.83% (28.41-62.45%) (13/ 29)	72.97% (57.02-84.60%) (27/ 37)	74.36% (58.92-85.43%) (29/ 39)	81.25% (70.03-88.94%) (52/ 64)	76.32% (60.79-87.01%) (29/ 38)	84.91% (72.95-92.15%) (45/ 53)	0.014	
Undifferentiated	51.88% (43.46-60.20%) (69/ 133)	66.48% (59.22-73.03%) (117/ 176)	64.77% (57.47-71.45%) (114/ 176)	72.43% (66.83-77.40%) (197/ 272)	76.10% (69.81-81.42%) (156/ 205)	76.39% (70.54-81.39%) (178/ 233)	<0.005	

Table 11: Non-susceptibility of *Salmonella* species on antimicrobials showing trend with statistical significance (*continued*)

Location of Onset (Total headcount) ^a	2012 (157)	2013 (183)	2014 (176)	2015 (273)	2016 (206)	2017 (235)	P-value ^b
Levofloxacin[¶]							
Community	2.22% (0.11-11.57%) (1/ 45)	<0.005% (<0.005-14.87%) (0/ 22)	<0.005% (<0.005-12.87%) (0/ 26)	4.65% (1.28-15.46%) (2/ 43)	36.36% (19.73-57.05%) (8/ 22)	94.12% (73.02-99.70%) (16/ 17)	<0.005
Undifferentiated	2.04% (0.10-10.69%) (1/ 49)	<0.005% (<0.005-11.03%) (0/ 31)	3.12% (0.16-15.74%) (1/ 32)	3.85% (1.06-12.98%) (2/ 52)	37.04% (21.53-55.77%) (10/ 27)	86.36% (66.67-95.25%) (19/ 22)	<0.005

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital-onset and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

[‡] New ciprofloxacin interpretive criteria for *Salmonella* species was released by CLSI in 2012.

[§] Modified recommendations to use separate ciprofloxacin interpretive criteria for *Salmonella* species was released by CLSI in 2013.

[¶] New levofloxacin interpretive criteria for *Salmonella* species was released by CLSI in 2013.

3.3.5 *Acinetobacter* species

58. Table 12 presents the percentage of patient having isolates of *Acinetobacter* species showing trend with statistical significance on non-susceptibility towards selected antimicrobials. Please refer to Table 18 in annex for further details.

59. In general, results from the exercise suggested isolates of *Acinetobacter* species of community-onset having lower non-susceptibility percentage than those of hospital-onset.

60. For beta-lactam antimicrobials, *Acinetobacter* species isolates of community-onset returned a lower percentage of non-susceptibility to ampicillin/sulbactam²² (Community: 17.74% - 25.93% vs Hospital: 43.07% - 57.93%), piperacillin/tazobactam²³ (Community: 22.64% - 31.25% vs Hospital: 55.91% - 66.20%), ceftazidime (Community: 10.77% - 22.95% vs Hospital: 34.69% - 50.00%), meropenem²⁴ (Community: 27.78% - 47.83% vs Hospital: 59.04% - 72.73%), and imipenem/cilastatin^{25 26} (Community: 21.28% - 33.33% vs Hospital: 46.46% - 63.24%), than those of hospital-onset.

61. No trend with statistical significance was observed among non-susceptibility percentage towards beta-lactam antimicrobials for both types of isolates.

62. For non-beta-lactam antimicrobials, non-susceptibility percentage to gentamicin (range: 26.17% - 50.34%) and minocycline (range: 28.89% - 75.00%) for isolates of hospital-onset showed a decreasing trend with statistical significance.

²²Refer to Table 1 for interchangeable names of antimicrobial

²³Refer to Table 1 for interchangeable names of antimicrobial

²⁴Readers should take note that a new (revised) imipenem and meropenem interpretive criteria was released by CLSI in 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

²⁵Refer to Table 1 for interchangeable names of antimicrobial

²⁶Readers should take note that a new (revised) imipenem and meropenem interpretive criteria was released by CLSI in 2014, which may be one of the contributing factors leading to the observed trend of respective non-susceptibility.

Table 12: Non-susceptibility of *Acinetobacter* species on antimicrobials showing trend with statistical significance

Location of Onset (Total headcount) ^a	2012 (203)	2013 (197)	2014 (230)	2015 (224)	2016 (199)	2017 (228)	P-value ^b	
Minocycline								
Hospital	75.00% (46.77-91.11%) (9/ 12)	72.22% (49.13-87.50%) (13/ 18)	57.58% (40.81-72.76%) (19/ 33)	60.00% (40.74-76.60%) (15/ 25)	32.56% (20.49-47.48%) (14/ 43)	28.89% (17.73-43.37%) (13/ 45)	<0.005	
Gentamicin								
Hospital	39.42% (31.63-47.78%) (54/ 137)	50.34% (42.30-58.37%) (73/ 145)	45.45% (38.05-53.07%) (75/ 165)	42.11% (34.55-50.05%) (64/ 152)	27.91% (20.89-36.20%) (36/ 129)	26.17% (19.78-33.77%) (39/ 149)	<0.005	

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital-onset and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation



⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

3.3.6 *Streptococcus pneumoniae*

63. For results observed from isolates of *Streptococcus pneumoniae* of this section, information on location of onset was not considered.
64. For beta-lactam antimicrobials, no trend with statistical significance were observed among penicillin (range: 0.66% - 1.96%), cefotaxime (range: 0.89% - 7.63%), and ceftriaxone (range: 1.16% - 7.23%).
65. For non-beta-lactam antimicrobials, non-susceptibility to levofloxacin remained low (range: <0.005% - 1.34%), and no trend with statistical significance was observed.
66. Besides, non-susceptibility percentage was observed to be high for erythromycin (range: 69.53% - 80.56%) and sulfamethoxazole/trimethoprim²⁷ (range: 46.98% - 70.00%). No trend with statistical significance was observed for erythromycin, while increasing trend was observed for sulfamethoxazole/trimethoprim.

²⁷Refer to Table 1 for interchangeable names of antimicrobial

Table 13: Non-susceptibility of *Streptococcus pneumoniae* on antimicrobials showing trend with statistical significance

Location of Onset (Total headcount) ^a	2012 (139)	2013 (174)	2014 (190)	2015 (156)	2016 (153)	2017 (157)	P-value ^b	
Sulfamethoxazole and Trimethoprim								
Community	48.54% (39.12-58.07%) (50/ 103)	46.43% (38.37-54.67%) (65/ 140)	60.59% (53.09-67.62%) (103/ 170)	61.03% (52.64-68.82%) (83/ 136)	56.82% (48.29-64.96%) (75/ 132)	70.16% (61.60-77.51%) (87/ 124)	<0.005	
Undifferentiated	48.65% (39.55-57.84%) (54/ 111)	46.98% (39.14-54.97%) (70/ 149)	60.67% (53.35-67.55%) (108/ 178)	62.14% (53.89-69.75%) (87/ 140)	57.04% (48.61-65.08%) (77/ 135)	70.00% (61.64-77.21%) (91/ 130)	<0.005	

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital-onset and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

⁷ The interpretations for penicillin, cefotaxime and ceftriaxone are based on clinical breakpoint criteria for non-meningitis

4 Discussion

4.1 Data interpretation and limitations

67. Results presented in this report are based on antimicrobial non-susceptible results of isolates cultured from blood culture specimens. Clinical significance on detecting the WHO GLASS priority organisms in blood culture is indisputable. The restriction of using blood culture specimens while discarding specimens from other anatomical sites can prevent inconsistencies arose from different sampling frames or heterogeneous healthcare utilization that may lead to confounding. Yet, results based on blood culture isolates may not be representative to the same bacterial species isolated from other anatomical sites.

68. Readers are reminded to take the following limitations into consideration when interpreting findings of this report.

69. This exercise adopted specimen classification definition from WHO GLASS surveillance manual, which a two-day cut-off after patient being admitted to a healthcare facility was applied to define specimen as hospital-onset/ community-onset[2]. The first proposal of this classification to define healthcare-associated infection were made in 2002 by Siegman-Igra et al. and Friedman et al.[5, 6] 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) hospitalization in the last year; or iii) previous antibiotic treatment[7]. The method adopted from WHO GLASS on categorizing specimens as hospital-onset/ community-onset is based on the operational definition and does not take into account of other clinical information. Readers should not take these findings at face value, as additional clinical information is needed to ascertain origin of infections.

70. Besides, for the same bacterial species identified in blood, panels of antibiotic susceptibility test applied by different laboratories may vary based on local clinical guideline and clinical context of individual patient. Representative on non-susceptibility result of particular pathogen-antimicrobial combination may bias toward particular laboratories performing a major proportion of that particular antibiotic susceptibility test.

71. In addition, antibiotic susceptibility test results provided by HA for analysis were in form of three possible value: Susceptible, Intermediate and Resistance. Prior quantitative results generated by the different tests^{28,29} were interpreted by local laboratories before determination of Susceptible, Intermediate and Resistance. These results were not collected in this exercise. Readers should also note that clinical breakpoints³⁰ may change over time and may be revised.

72. Furthermore, case identification of patients with bloodstream infections is related to the diagnostic practices and the frequency and timing with which blood cultures are taken, which cannot be addressed in this report.

5 Conclusion and Way forward

73. Antimicrobial resistance remains a serious threat in the world and Hong Kong is of no exception. Bloodstream infections is associated with significant morbidity and mortality, prompt treatment with effective antimicrobial agents is especially important and is one of the single most effective interventions to reduce the risk of fatal outcome.

74. Concerted efforts of different parties, including the prudent antimicrobial use and comprehensive infection prevention and control strategies, are the key measures to combat AMR.

75. Surveillance of AMR is an important area to contribute to the understanding of AMR situation and for monitoring the effectiveness of measures implemented.

76. Based on the experience gained by the exploration project, the Department of Health will work closely with Hospital Authority to work towards the development of a sustainable long-term AMR surveillance system based on the data from HA.

²⁸E.g. disk diffusion zone diameters, minimum inhibitory concentration

²⁹Minimum inhibitory concentration is the lower concentration of an antibiotic required to inhibit the growth of an organism[8].

³⁰A breakpoint is a chosen concentration of an antibiotic which defines whether a species of bacteria is susceptible or resistant to the antibiotic.

6 Annex

6.1 Non-susceptibility percentage of WHO GLASS priority pathogens towards selected antimicrobials

6.1.1 *Escherichia coli*

Table 14: Non-susceptibility percentage of *Escherichia coli* for WHO GLASS selected antimicrobials





Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b	
Ampicillin								
Community	73.33% (71.87-74.74%) (2,686/ 3,663)	75.09% (73.69-76.43%) (2,857/ 3,805)	76.33% (75.00-77.61%) (3,118/ 4,085)	75.07% (73.77-76.32%) (3,306/ 4,404)	74.91% (73.58-76.20%) (3,159/ 4,217)	75.85% (74.52-77.14%) (3,129/ 4,125)	1.000	
Hospital	86.83% (84.30-89.00%) (692/ 797)	85.90% (83.39-88.09%) (725/ 844)	85.80% (83.27-88.00%) (719/ 838)	86.04% (83.72-88.07%) (838/ 974)	85.26% (82.75-87.45%) (746/ 875)	85.52% (82.97-87.76%) (709/ 829)	1.000	
Amoxicillin and Beta-Lactamase Inhibitor								
Community	27.34% (26.01-28.72%) (1,143/ 4,180)	32.52% (31.15-33.93%) (1,417/ 4,357)	29.04% (27.75-30.35%) (1,358/ 4,677)	26.48% (25.28-27.72%) (1,323/ 4,996)	27.07% (25.89-28.28%) (1,431/ 5,287)	26.35% (25.21-27.53%) (1,461/ 5,544)	<0.005	
Hospital	44.41% (41.23-47.63%) (409/ 921)	47.11% (43.98-50.26%) (456/ 968)	43.56% (40.48-46.70%) (423/ 971)	43.10% (40.22-46.02%) (481/ 1,116)	42.58% (39.75-45.47%) (488/ 1,146)	38.32% (35.56-41.16%) (443/ 1,156)	0.021	

Table 14: Non-susceptibility percentage of *Escherichia coli* for WHO GLASS selected antimicrobials (continued)

Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b	
Piperacillin and Beta-Lactamase Inhibitor								
Community	5.83% (5.14-6.61%) (227/ 3,893)	6.95% (6.21-7.78%) (281/ 4,042)	5.65% (5.00-6.37%) (247/ 4,373)	6.97% (6.27-7.74%) (321/ 4,608)	7.20% (6.51-7.96%) (354/ 4,917)	4.46% (3.94-5.05%) (234/ 5,245)	1.000	
Hospital	15.10% (12.86-17.64%) (130/ 861)	14.96% (12.79-17.43%) (136/ 909)	11.66% (9.74-13.89%) (107/ 918)	15.05% (13.01-17.35%) (157/ 1,043)	14.06% (12.09-16.28%) (149/ 1,060)	9.50% (7.91-11.37%) (105/ 1,105)	0.104	
Cefuroxime								
Community	27.82% (26.49-29.20%) (1,163/ 4,180)	29.36% (28.02-30.72%) (1,279/ 4,357)	30.17% (28.87-31.50%) (1,411/ 4,677)	30.11% (28.85-31.40%) (1,504/ 4,995)	30.09% (28.86-31.34%) (1,590/ 5,285)	29.68% (28.50-30.90%) (1,646/ 5,545)	1.000	
Hospital	48.64% (45.43-51.87%) (448/ 921)	45.81% (42.69-48.96%) (443/ 967)	44.28% (41.19-47.42%) (430/ 971)	46.42% (43.51-49.35%) (518/ 1,116)	42.53% (39.70-45.42%) (487/ 1,145)	38.41% (35.65-41.25%) (444/ 1,156)	<0.005	
Cefotaxime								
Community	25.20% (23.69-26.77%) (770/ 3,056)	26.62% (25.12-28.17%) (858/ 3,223)	28.25% (26.86-29.69%) (1,094/ 3,872)	28.78% (27.45-30.14%) (1,253/ 4,354)	27.82% (26.54-29.14%) (1,275/ 4,583)	27.41% (26.17-28.68%) (1,327/ 4,842)	1.000	
Hospital	44.41% (40.59-48.30%) (282/ 635)	41.94% (38.29-45.67%) (286/ 682)	41.41% (37.91-44.99%) (306/ 739)	42.65% (39.47-45.90%) (386/ 905)	39.08% (36.03-42.21%) (372/ 952)	35.59% (32.60-38.69%) (337/ 947)	0.016	

Table 14: Non-susceptibility percentage of *Escherichia coli* for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b	
Ceftazidime								
Community	13.17% (12.07-14.35%) (447/ 3,394)	14.43% (13.30-15.64%) (500/ 3,464)	14.41% (13.31-15.58%) (528/ 3,664)	16.51% (15.37-17.71%) (638/ 3,865)	14.99% (13.88-16.17%) (560/ 3,736)	13.87% (12.78-15.03%) (500/ 3,606)	1.000	
Hospital	27.24% (24.28-30.42%) (219/ 804)	25.88% (23.01-28.97%) (214/ 827)	23.84% (21.06-26.87%) (196/ 822)	24.32% (21.66-27.20%) (224/ 921)	23.21% (20.47-26.19%) (194/ 836)	20.47% (17.76-23.48%) (156/ 762)	0.067	
Ceftriaxone								
Community	25.86% (23.98-27.84%) (510/ 1,972)	25.44% (23.67-27.30%) (562/ 2,209)	26.99% (25.27-28.79%) (657/ 2,434)	28.23% (26.55-29.99%) (742/ 2,628)	27.64% (26.02-29.32%) (778/ 2,815)	28.49% (26.90-30.14%) (851/ 2,987)	0.319	
Hospital	43.58% (38.78-48.49%) (173/ 397)	40.62% (36.18-45.23%) (182/ 448)	37.63% (33.45-42.00%) (184/ 489)	44.37% (40.33-48.48%) (252/ 568)	39.93% (35.98-44.02%) (226/ 566)	35.15% (31.50-38.98%) (219/ 623)	1.000	
Cefepime[†]								
Community	13.38% (12.16-14.69%) (374/ 2,796)	12.46% (11.33-13.68%) (379/ 3,042)	19.33% (18.02-20.70%) (648/ 3,353)	24.05% (22.74-25.40%) (957/ 3,980)	23.59% (22.43-24.80%) (1,162/ 4,925)	22.63% (21.52-23.79%) (1,183/ 5,227)	<0.005	
Hospital	29.04% (25.58-32.75%) (178/ 613)	24.92% (21.77-28.37%) (164/ 658)	29.83% (26.46-33.44%) (196/ 657)	35.28% (32.18-38.51%) (308/ 873)	33.15% (30.39-36.02%) (355/ 1,071)	29.39% (26.75-32.17%) (318/ 1,082)	1.000	

Table 14: Non-susceptibility percentage of *Escherichia coli* for WHO GLASS selected antimicrobials (continued)

Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b	
Meropenem								
Community	<0.005% (<0.005-0.23%) (0/ 1,652)	0.06% (<0.005-0.32%) (1/ 1,748)	0.10% (0.03-0.37%) (2/ 1,986)	0.05% (<0.005-0.27%) (1/ 2,119)	0.04% (<0.005-0.23%) (1/ 2,428)	<0.005% (<0.005-0.15%) (0/ 2,598)	1.000	
Hospital	<0.005% (<0.005-0.98%) (0/ 388)	0.51% (0.14-1.83%) (2/ 394)	0.24% (0.01-1.34%) (1/ 419)	0.84% (0.33-2.14%) (4/ 477)	0.74% (0.29-1.90%) (4/ 537)	0.76% (0.29-1.93%) (4/ 528)	1.000	
Ertapenem*								
Community	0.05% (0.01-0.19%) (2/ 3,783)	0.18% (0.09-0.36%) (7/ 3,971)	0.09% (0.04-0.24%) (4/ 4,269)	0.07% (0.02-0.19%) (3/ 4,577)	0.10% (0.04-0.24%) (5/ 4,817)	0.04% (0.01-0.14%) (2/ 5,076)	1.000	
Hospital	0.63% (0.27-1.47%) (5/ 792)	0.71% (0.33-1.54%) (6/ 843)	0.36% (0.12-1.06%) (3/ 825)	0.52% (0.22-1.22%) (5/ 958)	0.49% (0.21-1.15%) (5/ 1,015)	0.50% (0.21-1.16%) (5/ 1,006)	1.000	
Doripenem								
Community	<0.005% (<0.005-19.36%) (0/ 16)	<0.005% (<0.005-21.53%) (0/ 14)	No record	No record	No record	No record	-	
Hospital	No record	No record	No record	No record	No record	No record	-	

Table 14: Non-susceptibility percentage of *Escherichia coli* for WHO GLASS selected antimicrobials (*continued*)







Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b	
Imipenem and Cilastatin								
Community	<0.005% (<0.005-0.11%) (0/ 3,591)	0.03% (<0.005-0.15%) (1/ 3,746)	<0.005% (<0.005-0.10%) (0/ 4,039)	0.02% (<0.005-0.13%) (1/ 4,326)	0.04% (0.01-0.16%) (2/ 4,566)	<0.005% (<0.005-0.08%) (0/ 4,748)	1.000	
Hospital	<0.005% (<0.005-0.47%) (0/ 810)	0.12% (0.01-0.67%) (1/ 843)	<0.005% (<0.005-0.46%) (0/ 840)	0.31% (0.11-0.92%) (3/ 956)	0.21% (0.06-0.75%) (2/ 965)	0.41% (0.16-1.04%) (4/ 983)	1.000	
Sulfamethoxazole and Trimethoprim								
Community	43.70% (41.76-45.66%) (1,089/ 2,492)	43.84% (41.93-45.77%) (1,124/ 2,564)	42.27% (40.45-44.11%) (1,178/ 2,787)	44.71% (42.88-46.55%) (1,259/ 2,816)	43.89% (42.18-45.62%) (1,398/ 3,185)	45.34% (43.64-47.05%) (1,489/ 3,284)	1.000	
Hospital	56.55% (52.28-60.72%) (298/ 527)	53.53% (49.36-57.64%) (296/ 553)	54.78% (50.70-58.81%) (315/ 575)	53.53% (49.60-57.41%) (334/ 624)	54.91% (51.13-58.63%) (369/ 672)	52.51% (48.74-56.24%) (356/ 678)	1.000	
Gentamicin								
Community	31.16% (29.77-32.58%) (1,302/ 4,179)	31.01% (29.65-32.40%) (1,351/ 4,357)	28.42% (27.15-29.73%) (1,329/ 4,676)	29.80% (28.55-31.09%) (1,489/ 4,996)	28.90% (27.69-30.14%) (1,528/ 5,287)	28.28% (27.11-29.48%) (1,568/ 5,544)	0.031	
Hospital	39.52% (36.41-42.72%) (364/ 921)	38.64% (35.62-41.74%) (374/ 968)	36.25% (33.29-39.32%) (352/ 971)	36.38% (33.61-39.24%) (406/ 1,116)	35.34% (32.63-38.15%) (405/ 1,146)	34.17% (31.49-36.95%) (395/ 1,156)	0.202	

Table 14: Non-susceptibility percentage of *Escherichia coli* for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b	
Amikacin								
Community	1.27% (0.97-1.65%) (53/ 4,180)	1.35% (1.05-1.74%) (59/ 4,357)	0.81% (0.59-1.11%) (38/ 4,676)	0.70% (0.50-0.97%) (35/ 4,989)	0.70% (0.51-0.96%) (37/ 5,285)	0.42% (0.28-0.62%) (23/ 5,539)	<0.005	
Hospital	3.15% (2.20-4.49%) (29/ 921)	2.69% (1.84-3.91%) (26/ 968)	1.54% (0.94-2.53%) (15/ 971)	2.51% (1.74-3.60%) (28/ 1,116)	1.57% (1.00-2.47%) (18/ 1,146)	1.30% (0.79-2.13%) (15/ 1,155)	0.102	
Ciprofloxacin								
Community	32.84% (29.81-36.02%) (288/ 877)	34.44% (31.36-37.66%) (300/ 871)	33.09% (29.65-36.72%) (224/ 677)	34.58% (31.37-37.94%) (277/ 801)	36.19% (32.96-39.54%) (296/ 818)	33.05% (29.91-36.34%) (271/ 820)	1.000	
Hospital	50.89% (44.39-57.37%) (114/ 224)	53.78% (47.25-60.17%) (121/ 225)	44.64% (37.33-52.20%) (75/ 168)	50.72% (43.99-57.42%) (106/ 209)	46.49% (40.13-52.97%) (106/ 228)	42.71% (36.04-49.66%) (85/ 199)	1.000	
Levofloxacin								
Community	32.01% (30.56-33.49%) (1,247/ 3,896)	30.81% (29.42-32.24%) (1,267/ 4,112)	31.51% (30.18-32.87%) (1,434/ 4,551)	31.24% (29.95-32.56%) (1,514/ 4,846)	31.19% (29.94-32.46%) (1,612/ 5,169)	30.98% (29.76-32.22%) (1,679/ 5,420)	1.000	
Hospital	48.20% (44.88-51.54%) (415/ 861)	49.67% (46.46-52.90%) (458/ 922)	45.38% (42.24-48.55%) (432/ 952)	48.21% (45.26-51.18%) (526/ 1,091)	44.80% (41.91-47.73%) (500/ 1,116)	39.47% (36.66-42.35%) (446/ 1,130)	<0.005	

Table 14: Non-susceptibility percentage of *Escherichia coli* for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (5,023)	2013 (5,232)	2014 (5,547)	2015 (6,006)	2016 (6,334)	2017 (6,594)	P-value ^b
Colistin							
Community	No record	No record	No record	No record	No record	No record	-
Hospital	No record	No record	No record	No record	No record	No record	-

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital- and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

* New (revised) ertapenem interpretive criteria was released by CLSI in 2012.

† New (revised) cefepime interpretive criteria for Enterobacteriaceae was released by CLSI in 2014.

6.1.2 *Klebsiella pneumoniae*Table 15: Non-susceptibility percentage of *Klebsiella pneumoniae* for WHO GLASS selected antimicrobials

Location of Onset (Total headcount) ^a	2012 (1,559)	2013 (1,684)	2014 (1,715)	2015 (1,795)	2016 (1,908)	2017 (1,865)	P-value ^b	
Amoxicillin and Beta-Lactamase Inhibitor								
	13.42%	13.54%	13.86%	13.98%	13.93%	15.09%		
Community	(11.59-15.49%) (158/ 1,177)	(11.77-15.54%) (172/ 1,270)	(12.07-15.87%) (176/ 1,270)	(12.19-15.99%) (179/ 1,280)	(12.23-15.82%) (199/ 1,429)	(13.31-17.07%) (211/ 1,398)	1.000	
Hospital	(27.41-36.46%) (128/ 403)	(26.28-34.83%) (134/ 441)	(28.92-37.32%) (158/ 479)	(28.50-36.33%) (176/ 545)	(33.98-42.37%) (195/ 512)	(32.65-41.17%) (180/ 489)	0.340	
Piperacillin and Beta-Lactamase Inhibitor								
	5.81%	5.77%	4.96%	5.30%	4.87%	4.57%		
Community	(4.57-7.37%) (63/ 1,084)	(4.57-7.25%) (68/ 1,179)	(3.87-6.35%) (59/ 1,189)	(4.17-6.71%) (64/ 1,207)	(3.84-6.16%) (65/ 1,335)	(3.58-5.83%) (61/ 1,334)	1.000	
Hospital	(12.30-19.55%) (60/ 385)	(10.78-17.49%) (56/ 406)	(11.64-18.08%) (67/ 460)	(16.59-23.47%) (102/ 515)	(18.06-25.36%) (104/ 484)	(12.59-19.21%) (72/ 461)	1.000	
Cefuroxime								
	15.28%	15.91%	14.33%	14.53%	16.08%	15.95%		
Community	(13.34-17.45%) (180/ 1,178)	(14.00-18.02%) (202/ 1,270)	(12.51-16.37%) (182/ 1,270)	(12.71-16.57%) (186/ 1,280)	(14.27-18.08%) (230/ 1,430)	(14.13-17.96%) (223/ 1,398)	1.000	
Hospital	(28.59-37.73%) (133/ 403)	(29.31-38.09%) (148/ 441)	(28.92-37.32%) (158/ 479)	(31.22-39.21%) (191/ 544)	(34.24-42.64%) (196/ 511)	(32.85-41.38%) (181/ 489)	1.000	

Table 15: Non-susceptibility percentage of *Klebsiella pneumoniae* for WHO GLASS selected antimicrobials (continued)

Location of Onset (Total headcount) ^a	2012 (1,559)	2013 (1,684)	2014 (1,715)	2015 (1,795)	2016 (1,908)	2017 (1,865)	P-value ^b	
Cefotaxime								
Community	13.16% (11.07-15.58%) (114/ 866)	12.54% (10.57-14.82%) (117/ 933)	11.10% (9.31-13.19%) (112/ 1,009)	11.83% (10.05-13.87%) (130/ 1,099)	12.93% (11.17-14.92%) (159/ 1,230)	12.57% (10.81-14.58%) (150/ 1,193)	1.000	
Hospital	25.97% (21.00-31.64%) (67/ 258)	25.00% (20.38-30.27%) (73/ 292)	26.14% (21.82-30.97%) (92/ 352)	27.01% (23.00-31.44%) (114/ 422)	35.37% (30.80-40.22%) (139/ 393)	32.64% (28.16-37.47%) (126/ 386)	0.047	
Ceftazidime								
Community	8.37% (6.78-10.29%) (80/ 956)	8.40% (6.84-10.28%) (84/ 1,000)	7.68% (6.17-9.52%) (75/ 977)	8.48% (6.91-10.39%) (84/ 990)	7.32% (5.88-9.08%) (75/ 1,025)	7.42% (5.94-9.23%) (73/ 984)	1.000	
Hospital	22.91% (18.85-27.53%) (82/ 358)	18.39% (14.85-22.56%) (71/ 386)	17.75% (14.38-21.70%) (74/ 417)	21.38% (17.84-25.41%) (96/ 449)	22.79% (18.99-27.11%) (93/ 408)	25.44% (21.09-30.35%) (86/ 338)	1.000	
Ceftriaxone								
Community	11.68% (9.32-14.55%) (68/ 582)	8.90% (6.94-11.33%) (58/ 652)	8.56% (6.70-10.89%) (59/ 689)	9.29% (7.38-11.63%) (67/ 721)	10.89% (8.96-13.17%) (92/ 845)	8.79% (7.08-10.86%) (76/ 865)	1.000	
Hospital	21.69% (16.41-28.10%) (41/ 189)	25.11% (19.91-31.13%) (57/ 227)	20.54% (15.76-26.30%) (46/ 224)	22.90% (18.48-28.00%) (68/ 297)	21.89% (17.56-26.93%) (65/ 297)	26.12% (21.40-31.45%) (76/ 291)	1.000	

Table 15: Non-susceptibility percentage of *Klebsiella pneumoniae* for WHO GLASS selected antimicrobials (continued)

Location of Onset (Total headcount) ^a	2012 (1,559)	2013 (1,684)	2014 (1,715)	2015 (1,795)	2016 (1,908)	2017 (1,865)	P-value ^b	
Cefepime*								
Community	4.76% (3.50-6.44%) (39/ 820)	4.92% (3.69-6.54%) (44/ 894)	5.01% (3.76-6.63%) (45/ 899)	7.20% (5.78-8.93%) (75/ 1,042)	8.40% (7.02-10.01%) (112/ 1,334)	7.35% (6.06-8.88%) (97/ 1,320)	<0.005	
Hospital	11.95% (8.50-16.55%) (30/ 251)	9.25% (6.39-13.21%) (26/ 281)	16.13% (12.45-20.63%) (50/ 310)	19.52% (16.02-23.58%) (82/ 420)	20.33% (16.98-24.15%) (98/ 482)	22.15% (18.61-26.14%) (103/ 465)	<0.005	
Meropenem								
Community	0.20% (0.01-1.12%) (1/ 500)	0.20% (0.01-1.12%) (1/ 500)	0.19% (0.01-1.08%) (1/ 523)	<0.005% (<0.005-0.65%) (0/ 583)	0.43% (0.15-1.26%) (3/ 693)	0.28% (0.08-1.03%) (2/ 706)	1.000	
Hospital	2.53% (0.99-6.33%) (4/ 158)	0.56% (0.03-3.08%) (1/ 180)	0.53% (0.03-2.95%) (1/ 188)	2.18% (0.94-5.01%) (5/ 229)	1.23% (0.42-3.55%) (3/ 244)	0.42% (0.02-2.36%) (1/ 236)	1.000	
Imipenem and Cilastatin								
Community	<0.005% (<0.005-0.38%) (0/ 1,003)	0.28% (0.10-0.83%) (3/ 1,061)	<0.005% (<0.005-0.35%) (0/ 1,100)	<0.005% (<0.005-0.34%) (0/ 1,112)	0.16% (0.04-0.58%) (2/ 1,255)	0.25% (0.09-0.74%) (3/ 1,183)	1.000	
Hospital	0.83% (0.28-2.41%) (3/ 362)	0.77% (0.26-2.25%) (3/ 388)	0.48% (0.13-1.75%) (2/ 413)	0.84% (0.33-2.14%) (4/ 476)	1.34% (0.62-2.89%) (6/ 448)	0.50% (0.14-1.82%) (2/ 397)	1.000	

Table 15: Non-susceptibility percentage of *Klebsiella pneumoniae* for WHO GLASS selected antimicrobials (continued)

Location of Onset (Total headcount) ^a	2012 (1,559)	2013 (1,684)	2014 (1,715)	2015 (1,795)	2016 (1,908)	2017 (1,865)	P-value ^b	
Sulfamethoxazole and Trimethoprim								
Community	19.45% (16.68-22.56%) (135/ 694)	17.55% (14.97-20.47%) (129/ 735)	17.89% (15.33-20.78%) (136/ 760)	19.55% (16.80-22.63%) (139/ 711)	20.51% (17.95-23.33%) (177/ 863)	21.92% (19.36-24.71%) (201/ 917)	1.000	
Hospital	35.62% (29.75-41.96%) (83/ 233)	39.92% (34.14-46.00%) (103/ 258)	33.11% (27.97-38.68%) (97/ 293)	34.95% (29.85-40.42%) (108/ 309)	48.28% (42.85-53.75%) (154/ 319)	42.63% (37.33-48.12%) (136/ 319)	0.295	
Gentamicin								
Community	5.18% (4.05-6.60%) (61/ 1,178)	5.28% (4.18-6.65%) (67/ 1,270)	5.20% (4.11-6.56%) (66/ 1,270)	4.69% (3.66-5.99%) (60/ 1,280)	5.52% (4.46-6.83%) (79/ 1,430)	5.51% (4.43-6.83%) (77/ 1,398)	1.000	
Hospital	8.93% (6.52-12.12%) (36/ 403)	10.20% (7.71-13.38%) (45/ 441)	10.86% (8.38-13.96%) (52/ 479)	12.84% (10.29-15.92%) (70/ 545)	14.65% (11.85-17.97%) (75/ 512)	12.88% (10.20-16.14%) (63/ 489)	0.230	
Amikacin								
Community	0.85% (0.46-1.56%) (10/ 1,178)	0.63% (0.32-1.24%) (8/ 1,269)	0.16% (0.04-0.57%) (2/ 1,270)	0.39% (0.17-0.91%) (5/ 1,280)	0.28% (0.11-0.72%) (4/ 1,430)	0.21% (0.07-0.63%) (3/ 1,397)	0.339	
Hospital	0.74% (0.25-2.17%) (3/ 403)	2.04% (1.08-3.83%) (9/ 441)	0.84% (0.33-2.13%) (4/ 479)	1.28% (0.62-2.63%) (7/ 545)	1.95% (1.06-3.56%) (10/ 512)	1.02% (0.44-2.37%) (5/ 489)	1.000	

Table 15: Non-susceptibility percentage of *Klebsiella pneumoniae* for WHO GLASS selected antimicrobials (continued)





Location of Onset (Total headcount) ^a	2012 (1,559)	2013 (1,684)	2014 (1,715)	2015 (1,795)	2016 (1,908)	2017 (1,865)	P-value ^b	
Ciprofloxacin								
Community	11.36% (8.08-15.76%) (30/ 264)	17.19% (13.06-22.29%) (44/ 256)	11.35% (7.55-16.73%) (21/ 185)	12.36% (8.31-18.00%) (22/ 178)	16.29% (11.59-22.42%) (29/ 178)	14.12% (8.26-23.07%) (12/ 85)	1.000	
Hospital	18.42% (12.38-26.52%) (21/ 114)	22.02% (15.27-30.68%) (24/ 109)	27.45% (19.73-36.81%) (28/ 102)	39.05% (30.26-48.61%) (41/ 105)	42.67% (32.10-53.95%) (32/ 75)	38.78% (26.43-52.75%) (19/ 49)	<0.005	
Levofloxacin								
Community	8.40% (6.89-10.21%) (91/ 1,083)	7.54% (6.18-9.18%) (90/ 1,193)	7.54% (6.20-9.14%) (94/ 1,246)	7.24% (5.93-8.81%) (91/ 1,257)	7.87% (6.57-9.40%) (110/ 1,397)	8.52% (7.15-10.12%) (116/ 1,362)	1.000	
Hospital	12.76% (9.79-16.47%) (49/ 384)	17.39% (14.04-21.34%) (72/ 414)	14.56% (11.67-18.02%) (69/ 474)	18.28% (15.24-21.78%) (98/ 536)	19.52% (16.29-23.22%) (98/ 502)	22.80% (19.27-26.77%) (109/ 478)	<0.005	

Table 15: Non-susceptibility percentage of *Klebsiella pneumoniae* for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (1,559)	2013 (1,684)	2014 (1,715)	2015 (1,795)	2016 (1,908)	2017 (1,865)	P-value ^b
Colistin							
Community	No record	No record	No record	No record	No record	No record	-
Hospital	No record	No record	No record	No record	No record	No record	-

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital- and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

* New (revised) cefepime interpretive criteria for Enterobacteriaceae was released by CLSI in 2014.

6.1.3 *Staphylococcus aureus*

Table 16: Non-susceptibility percentage of *Staphylococcus aureus* for WHO GLASS selected antimicrobials



Location of Onset (Total headcount) ^a	2012 (1,401)	2013 (1,422)	2014 (1,446)	2015 (1,517)	2016 (1,658)	2017 (1,699)	P-value ^b	
Oxacillin								
Community	35.65% (32.45-38.99%) (292/ 819)	39.20% (35.86-42.63%) (312/ 796)	38.58% (35.33-41.93%) (321/ 832)	39.12% (36.03-42.29%) (363/ 928)	40.26% (37.26-43.33%) (403/ 1,001)	37.90% (34.94-40.95%) (379/ 1,000)	1.000	
Hospital	53.11% (49.15-57.04%) (324/ 610)	56.00% (52.16-59.77%) (364/ 650)	56.19% (52.34-59.97%) (363/ 646)	54.05% (50.10-57.94%) (334/ 618)	59.97% (56.28-63.56%) (415/ 692)	54.22% (50.61-57.80%) (398/ 734)	1.000	

Table 16: Non-susceptibility percentage of *Staphylococcus aureus* for WHO GLASS selected antimicrobials (continued)

Location of Onset (Total headcount) ^a	2012 (1,401)	2013 (1,422)	2014 (1,446)	2015 (1,517)	2016 (1,658)	2017 (1,699)	P-value ^b
Vancomycin							
Community	<0.005% (<0.005-0.47%) (0/ 813)	<0.005% (<0.005-0.48%) (0/ 790)	<0.005% (<0.005-0.46%) (0/ 824)	<0.005% (<0.005-0.41%) (0/ 926)	<0.005% (<0.005-0.38%) (0/ 997)	<0.005% (<0.005-0.39%) (0/ 981)	-
Hospital	<0.005% (<0.005-0.63%) (0/ 610)	<0.005% (<0.005-0.59%) (0/ 646)	<0.005% (<0.005-0.59%) (0/ 644)	<0.005% (<0.005-0.62%) (0/ 618)	<0.005% (<0.005-0.55%) (0/ 691)	<0.005% (<0.005-0.53%) (0/ 726)	-

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists
Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital- and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

6.1.4 *Salmonella* speciesTable 17: Non-susceptibility percentage of *Salmonella* species for WHO GLASS selected antimicrobials

Location of Onset (Total headcount) ^a	2012 (157)	2013 (183)	2014 (176)	2015 (273)	2016 (206)	2017 (235)	P-value ^b	
Ampicillin								
Community	32.03% (24.57-40.54%) (41/ 128)	34.01% (26.85-41.99%) (50/ 147)	47.92% (39.92-56.02%) (69/ 144)	50.23% (43.63-56.82%) (109/ 217)	61.54% (54.02-68.54%) (104/ 169)	51.65% (44.43-58.80%) (94/ 182)	<0.005	
Hospital	43.75% (28.17-60.67%) (14/ 32)	55.26% (39.71-69.85%) (21/ 38)	61.54% (45.90-75.11%) (24/ 39)	65.62% (53.40-76.08%) (42/ 64)	65.79% (49.89-78.79%) (25/ 38)	84.91% (72.95-92.15%) (45/ 53)	<0.005	
Undifferentiated	35.03% (28.01-42.77%) (55/ 157)	37.70% (31.00-44.91%) (69/ 183)	50.00% (42.69-57.31%) (88/ 176)	53.68% (47.74-59.51%) (146/ 272)	62.44% (55.64-68.78%) (128/ 205)	59.40% (53.01-65.49%) (139/ 234)	<0.005	
Cefotaxime								
Community	<0.005% (<0.005-9.89%) (0/ 35)	<0.005% (<0.005-11.03%) (0/ 31)	10.64% (4.63-22.59%) (5/ 47)	1.16% (0.06-6.30%) (1/ 86)	5.26% (1.81-14.37%) (3/ 57)	<0.005% (<0.005-6.76%) (0/ 53)	1.000	
Hospital	No record	8.33% (0.43-35.39%) (1/ 12)	<0.005% (<0.005-22.81%) (0/ 13)	8.82% (3.05-22.96%) (3/ 34)	12.50% (3.50-36.02%) (2/ 16)	18.18% (7.31-38.52%) (4/ 22)	1.000	
Undifferentiated	2.33% (0.12-12.06%) (1/ 43)	2.33% (0.12-12.06%) (1/ 43)	8.62% (3.74-18.64%) (5/ 58)	3.45% (1.35-8.53%) (4/ 116)	6.94% (3.00-15.25%) (5/ 72)	5.33% (2.09-12.93%) (4/ 75)	1.000	

Table 17: Non-susceptibility percentage of *Salmonella* species for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (157)	2013 (183)	2014 (176)	2015 (273)	2016 (206)	2017 (235)	P-value ^b	
Ceftazidime								
Community	<0.005% (<0.005-24.25%) (0/ 12)	<0.005% (<0.005-19.36%) (0/ 16)	8.82% (3.05-22.96%) (3/ 34)	<0.005% (<0.005-6.21%) (0/ 58)	5.00% (1.38-16.50%) (2/ 40)	<0.005% (<0.005-18.43%) (0/ 17)	1.000	
Hospital	No record	No record	<0.005% (<0.005-25.88%) (0/ 11)	8.00% (2.22-24.97%) (2/ 25)	No record	No record	1.000	
Undifferentiated	<0.005% (<0.005-22.81%) (0/ 13)	<0.005% (<0.005-14.31%) (0/ 23)	6.98% (2.40-18.61%) (3/ 43)	2.47% (0.68-8.56%) (2/ 81)	4.35% (1.20-14.53%) (2/ 46)	4.35% (0.22-20.99%) (1/ 23)	1.000	
Ceftriaxone								
Community	<0.005% (<0.005-3.50%) (0/ 106)	8.80% (4.98-15.07%) (11/ 125)	7.89% (4.21-14.33%) (9/ 114)	1.67% (0.57-4.78%) (3/ 180)	6.08% (3.23-11.15%) (9/ 148)	4.64% (2.26-9.26%) (7/ 151)	1.000	
Hospital	<0.005% (<0.005-13.32%) (0/ 25)	6.67% (1.85-21.32%) (2/ 30)	15.62% (6.86-31.75%) (5/ 32)	5.66% (1.94-15.37%) (3/ 53)	6.67% (1.85-21.32%) (2/ 30)	6.98% (2.40-18.61%) (3/ 43)	1.000	
Undifferentiated	<0.005% (<0.005-2.89%) (0/ 129)	8.50% (5.03-13.99%) (13/ 153)	8.51% (4.94-14.29%) (12/ 141)	2.65% (1.22-5.67%) (6/ 226)	6.21% (3.51-10.78%) (11/ 177)	5.18% (2.84-9.27%) (10/ 193)	1.000	

Table 17: Non-susceptibility percentage of *Salmonella* species for WHO GLASS selected antimicrobials (*continued*)







Location of Onset (Total headcount) ^a	2012 (157)	2013 (183)	2014 (176)	2015 (273)	2016 (206)	2017 (235)	P-value ^b	
Meropenem								
Community	No record	No record	<0.005% (<0.005-15.46%) (0/ 21)	<0.005% (<0.005-8.97%) (0/ 39)	<0.005% (<0.005-7.56%) (0/ 47)	<0.005% (<0.005-8.57%) (0/ 41)	-	
Hospital	No record	No record	No record	<0.005% (<0.005-14.87%) (0/ 22)	<0.005% (<0.005-20.39%) (0/ 15)	<0.005% (<0.005-21.53%) (0/ 14)	-	
Undifferentiated	No record	No record	<0.005% (<0.005-12.87%) (0/ 26)	<0.005% (<0.005-6.02%) (0/ 60)	<0.005% (<0.005-5.83%) (0/ 62)	<0.005% (<0.005-6.53%) (0/ 55)	-	
Imipenem and Cilastatin								
Community	<0.005% (<0.005-16.82%) (0/ 19)	<0.005% (<0.005-13.80%) (0/ 24)	<0.005% (<0.005-8.97%) (0/ 39)	<0.005% (<0.005-6.02%) (0/ 60)	<0.005% (<0.005-7.56%) (0/ 47)	<0.005% (<0.005-16.82%) (0/ 19)	-	
Hospital	No record	No record	<0.005% (<0.005-24.25%) (0/ 12)	<0.005% (<0.005-13.32%) (0/ 25)	No record	No record	-	
Undifferentiated	<0.005% (<0.005-16.11%) (0/ 20)	<0.005% (<0.005-10.43%) (0/ 33)	<0.005% (<0.005-7.27%) (0/ 49)	<0.005% (<0.005-4.42%) (0/ 83)	<0.005% (<0.005-6.42%) (0/ 56)	<0.005% (<0.005-12.06%) (0/ 28)	-	

Table 17: Non-susceptibility percentage of *Salmonella* species for WHO GLASS selected antimicrobials (*continued*)




Location of Onset (Total headcount) ^a	2012 (157)	2013 (183)	2014 (176)	2015 (273)	2016 (206)	2017 (235)	P-value ^b	
Ciprofloxacin^{‡§}								
Community	53.27% (43.87-62.45%) (57/ 107)	65.25% (57.08-72.61%) (92/ 141)	62.24% (54.07-69.77%) (89/ 143)	70.51% (64.13-76.18%) (153/ 217)	75.74% (68.75-81.58%) (128/ 169)	73.48% (66.61-79.38%) (133/ 181)	<0.005	
Hospital	44.83% (28.41-62.45%) (13/ 29)	72.97% (57.02-84.60%) (27/ 37)	74.36% (58.92-85.43%) (29/ 39)	81.25% (70.03-88.94%) (52/ 64)	76.32% (60.79-87.01%) (29/ 38)	84.91% (72.95-92.15%) (45/ 53)	0.014	
Undifferentiated	51.88% (43.46-60.20%) (69/ 133)	66.48% (59.22-73.03%) (117/ 176)	64.77% (57.47-71.45%) (114/ 176)	72.43% (66.83-77.40%) (197/ 272)	76.10% (69.81-81.42%) (156/ 205)	76.39% (70.54-81.39%) (178/ 233)	<0.005	

Table 17: Non-susceptibility percentage of *Salmonella* species for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (157)	2013 (183)	2014 (176)	2015 (273)	2016 (206)	2017 (235)	P-value ^b
Levofloxacin[¶]							
Community	2.22% (0.11-11.57%) (1/ 45)	<0.005% (<0.005-14.87%) (0/ 22)	<0.005% (<0.005-12.87%) (0/ 26)	4.65% (1.28-15.46%) (2/ 43)	36.36% (19.73-57.05%) (8/ 22)	94.12% (73.02-99.70%) (16/ 17)	<0.005
Hospital	No record	No record	No record	<0.005% (<0.005-27.75%) (0/ 10)	No record	No record	-
Undifferentiated	2.04% (0.10-10.69%) (1/ 49)	<0.005% (<0.005-11.03%) (0/ 31)	3.12% (0.16-15.74%) (1/ 32)	3.85% (1.06-12.98%) (2/ 52)	37.04% (21.53-55.77%) (10/ 27)	86.36% (66.67-95.25%) (19/ 22)	<0.005

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital- and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

[‡] New ciprofloxacin interpretive criteria for *Salmonella* species was released by CLSI in 2012.

[§] Modified recommendations to use separate ciprofloxacin interpretive criteria for *Salmonella* species was released by CLSI in 2013.

[¶] New levofloxacin interpretive criteria for *Salmonella* species was released by CLSI in 2013.

6.1.5 *Acinetobacter* species

Table 18: Non-susceptibility percentage of *Acinetobacter* species for WHO GLASS selected antimicrobials

Location of Onset (Total headcount) ^a	2012 (203)	2013 (197)	2014 (230)	2015 (224)	2016 (199)	2017 (228)	P-value ^b	
Minocycline								
Community	No record	No record	No record	27.78% (12.50-50.87%) (5/ 18)	9.09% (2.53-27.81%) (2/ 22)	16.67% (6.68-35.85%) (4/ 24)	1.000	
Hospital	75.00% (46.77-91.11%) (9/ 12)	72.22% (49.13-87.50%) (13/ 18)	57.58% (40.81-72.76%) (19/ 33)	60.00% (40.74-76.60%) (15/ 25)	32.56% (20.49-47.48%) (14/ 43)	28.89% (17.73-43.37%) (13/ 45)	<0.005	
Tigecycline								
Community	No record	No record	No record	No record	No record	No record	-	
Hospital	72.09% (57.31-83.25%) (31/ 43)	66.67% (51.55-78.99%) (28/ 42)	67.86% (49.34-82.07%) (19/ 28)	78.95% (56.67-91.49%) (15/ 19)	81.82% (52.30-94.86%) (9/ 11)	76.92% (49.74-91.82%) (10/ 13)	1.000	
Ampicillin and Beta-Lactamase Inhibitor								
Community	21.21% (13.08-32.51%) (14/ 66)	20.37% (11.77-32.90%) (11/ 54)	17.74% (10.21-29.04%) (11/ 62)	25.93% (16.12-38.93%) (14/ 54)	22.81% (13.84-35.21%) (13/ 57)	21.92% (13.97-32.68%) (16/ 73)	1.000	
Hospital	43.07% (35.07-51.43%) (59/ 137)	57.93% (49.79-65.66%) (84/ 145)	57.32% (49.50-64.80%) (90/ 157)	56.06% (47.54-64.24%) (74/ 132)	52.50% (43.63-61.22%) (63/ 120)	49.66% (41.69-57.65%) (73/ 147)	1.000	

Table 18: Non-susceptibility percentage of *Acinetobacter* species for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (203)	2013 (197)	2014 (230)	2015 (224)	2016 (199)	2017 (228)	P-value ^b	
Piperacillin and Beta-Lactamase Inhibitor								
Community	26.15% (17.02-37.95%) (17/ 65)	22.64% (13.45-35.53%) (12/ 53)	23.08% (14.51-34.64%) (15/ 65)	30.56% (21.13-41.95%) (22/ 72)	31.25% (21.23-43.39%) (20/ 64)	28.17% (19.04-39.54%) (20/ 71)	1.000	
Hospital	55.91% (47.22-64.24%) (71/ 127)	66.20% (58.08-73.46%) (94/ 142)	63.35% (55.68-70.40%) (102/ 161)	62.91% (54.98-70.21%) (95/ 151)	63.57% (54.98-71.37%) (82/ 129)	58.33% (50.17-66.07%) (84/ 144)	1.000	
Ceftazidime								
Community	22.95% (14.19-34.91%) (14/ 61)	21.57% (12.49-34.63%) (11/ 51)	18.46% (10.89-29.55%) (12/ 65)	22.86% (14.59-33.95%) (16/ 70)	10.77% (5.32-20.60%) (7/ 65)	14.08% (7.83-24.02%) (10/ 71)	1.000	
Hospital	38.81% (30.98-47.26%) (52/ 134)	50.00% (41.94-58.06%) (72/ 144)	47.85% (40.32-55.48%) (78/ 163)	42.00% (34.40-50.00%) (63/ 150)	38.40% (30.34-47.15%) (48/ 125)	34.69% (27.48-42.69%) (51/ 147)	1.000	
Cefoperazone and Beta-Lactamase Inhibitor								
Community	21.31% (12.90-33.12%) (13/ 61)	23.53% (14.00-36.76%) (12/ 51)	18.46% (10.89-29.55%) (12/ 65)	25.71% (16.93-37.03%) (18/ 70)	21.54% (13.29-32.97%) (14/ 65)	22.54% (14.37-33.52%) (16/ 71)	1.000	
Hospital	44.03% (35.91-52.49%) (59/ 134)	59.44% (51.25-67.14%) (85/ 143)	57.06% (49.38-64.41%) (93/ 163)	55.63% (47.66-63.32%) (84/ 151)	55.65% (46.86-64.09%) (69/ 124)	50.34% (42.35-58.31%) (74/ 147)	1.000	

Table 18: Non-susceptibility percentage of *Acinetobacter* species for WHO GLASS selected antimicrobials (*continued*)







Location of Onset (Total headcount) ^a	2012 (203)	2013 (197)	2014 (230)	2015 (224)	2016 (199)	2017 (228)	P-value ^b	
Cefepime								
Community	33.33% (19.75-50.39%) (11/ 33)	26.47% (14.60-43.12%) (9/ 34)	29.41% (16.83-46.17%) (10/ 34)	40.74% (28.68-54.03%) (22/ 54)	25.81% (13.70-43.25%) (8/ 31)	28.57% (16.33-45.05%) (10/ 35)	1.000	
Hospital	58.62% (48.12-68.39%) (51/ 87)	76.19% (66.06-84.03%) (64/ 84)	70.73% (62.16-78.05%) (87/ 123)	68.32% (58.71-76.58%) (69/ 101)	67.21% (54.72-77.66%) (41/ 61)	71.83% (60.46-80.96%) (51/ 71)	1.000	
Meropenem*								
Community	40.74% (24.51-59.27%) (11/ 27)	32.14% (17.93-50.66%) (9/ 28)	27.78% (15.85-43.99%) (10/ 36)	47.83% (34.12-61.86%) (22/ 46)	33.33% (19.23-51.22%) (10/ 30)	28.95% (17.00-44.76%) (11/ 38)	1.000	
Hospital	61.80% (51.41-71.21%) (55/ 89)	72.73% (62.62-80.93%) (64/ 88)	71.19% (62.45-78.59%) (84/ 118)	66.36% (56.97-74.60%) (71/ 107)	59.04% (48.29-68.99%) (49/ 83)	59.14% (48.98-68.57%) (55/ 93)	1.000	
Imipenem and Cilastatin*								
Community	22.41% (13.59-34.66%) (13/ 58)	21.28% (11.99-34.90%) (10/ 47)	21.82% (12.95-34.37%) (12/ 55)	33.33% (23.35-45.07%) (23/ 69)	27.42% (17.88-39.59%) (17/ 62)	26.87% (17.72-38.52%) (18/ 67)	1.000	
Hospital	46.46% (38.01-55.11%) (59/ 127)	61.15% (52.85-68.85%) (85/ 139)	62.09% (54.20-69.39%) (95/ 153)	63.24% (54.87-70.87%) (86/ 136)	60.18% (50.96-68.72%) (68/ 113)	53.62% (45.32-61.73%) (74/ 138)	1.000	

Table 18: Non-susceptibility percentage of *Acinetobacter* species for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (203)	2013 (197)	2014 (230)	2015 (224)	2016 (199)	2017 (228)	P-value ^b	
Gentamicin								
Community	16.67% (9.57-27.43%) (11/ 66)	16.67% (9.02-28.74%) (9/ 54)	14.93% (8.31-25.34%) (10/ 67)	16.67% (9.80-26.91%) (12/ 72)	8.96% (4.17-18.19%) (6/ 67)	8.00% (3.72-16.37%) (6/ 75)	1.000	
Hospital	39.42% (31.63-47.78%) (54/ 137)	50.34% (42.30-58.37%) (73/ 145)	45.45% (38.05-53.07%) (75/ 165)	42.11% (34.55-50.05%) (64/ 152)	27.91% (20.89-36.20%) (36/ 129)	26.17% (19.78-33.77%) (39/ 149)	<0.005	
Amikacin								
Community	6.06% (2.38-14.57%) (4/ 66)	11.11% (5.19-22.19%) (6/ 54)	11.94% (6.18-21.83%) (8/ 67)	12.50% (6.72-22.08%) (9/ 72)	7.46% (3.23-16.31%) (5/ 67)	6.67% (2.88-14.68%) (5/ 75)	1.000	
Hospital	28.47% (21.58-36.53%) (39/ 137)	40.69% (33.03-48.83%) (59/ 145)	40.00% (32.83-47.62%) (66/ 165)	34.21% (27.14-42.06%) (52/ 152)	21.54% (15.34-29.37%) (28/ 130)	20.81% (15.06-28.02%) (31/ 149)	0.059	

Table 18: Non-susceptibility percentage of *Acinetobacter* species for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (203)	2013 (197)	2014 (230)	2015 (224)	2016 (199)	2017 (228)	P-value ^b	
Ciprofloxacin								
Community	43.90% (29.89-58.96%) (18/ 41)	24.32% (13.36-40.12%) (9/ 37)	26.19% (15.30-41.07%) (11/ 42)	33.96% (22.69-47.41%) (18/ 53)	27.08% (16.57-41.00%) (13/ 48)	32.14% (21.40-45.18%) (18/ 56)	1.000	
Hospital	52.83% (43.40-62.07%) (56/ 106)	60.61% (50.76-69.66%) (60/ 99)	58.00% (48.21-67.20%) (58/ 100)	58.42% (48.67-67.55%) (59/ 101)	60.47% (49.90-70.14%) (52/ 86)	52.00% (42.32-61.54%) (52/ 100)	1.000	
Levofloxacin								
Community	36.96% (24.52-51.40%) (17/ 46)	27.03% (15.40-42.98%) (10/ 37)	23.81% (13.48-38.53%) (10/ 42)	37.50% (26.01-50.59%) (21/ 56)	23.26% (13.15-37.74%) (10/ 43)	25.49% (15.55-38.87%) (13/ 51)	1.000	
Hospital	53.40% (43.82-62.74%) (55/ 103)	66.00% (56.28-74.54%) (66/ 100)	66.41% (57.96-73.93%) (87/ 131)	64.55% (55.25-72.86%) (71/ 110)	55.68% (45.28-65.61%) (49/ 88)	55.24% (45.71-64.40%) (58/ 105)	1.000	
Colistin								
Community	<0.005% (<0.005-27.75%) (0/ 10)	No record	<0.005% (<0.005-25.88%) (0/ 11)	4.17% (0.21-20.24%) (1/ 24)	<0.005% (<0.005-16.82%) (0/ 19)	<0.005% (<0.005-19.36%) (0/ 16)	1.000	
Hospital	<0.005% (<0.005-9.18%) (0/ 38)	<0.005% (<0.005-6.88%) (0/ 52)	<0.005% (<0.005-4.93%) (0/ 74)	1.67% (0.09-8.86%) (1/ 60)	<0.005% (<0.005-6.11%) (0/ 59)	<0.005% (<0.005-6.76%) (0/ 53)	1.000	

Table 18: Non-susceptibility percentage of *Acinetobacter* species for WHO GLASS selected antimicrobials (*continued*)

Location of Onset (Total headcount) ^a	2012 (203)	2013 (197)	2014 (230)	2015 (224)	2016 (199)	2017 (228)	P-value ^b
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^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital- and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

* New (revised) imipenem and meropenem interpretive criteria was released by CLSI in 2014.

6.1.6 *Streptococcus pneumoniae*

Table 19: Non-susceptibility percentage of *Streptococcus pneumoniae* for WHO GLASS selected antimicrobials

Location of Onset (Total headcount) ^a	2012 (139)	2013 (174)	2014 (190)	2015 (156)	2016 (153)	2017 (157)	P-value ^b	
Penicillin								
Community	0.79% (0.04-4.33%) (1/ 127)	1.28% (0.35-4.55%) (2/ 156)	1.14% (0.31-4.05%) (2/ 176)	0.69% (0.04-3.80%) (1/ 145)	0.71% (0.04-3.91%) (1/ 141)	2.04% (0.70-5.83%) (3/ 147)	1.000	
Hospital	10.00% (0.51-40.42%) (1/ 10)	10.00% (0.51-40.42%) (1/ 10)	No record	No record	No record	No record	1.000	
Undifferentiated	1.46% (0.40-5.17%) (2/ 137)	1.81% (0.62-5.18%) (3/ 166)	1.09% (0.30-3.88%) (2/ 184)	0.66% (0.03-3.66%) (1/ 151)	0.69% (0.04-3.80%) (1/ 145)	1.96% (0.67-5.61%) (3/ 153)	1.000	
Cefotaxime								
Community	1.28% (0.07-6.91%) (1/ 78)	6.00% (2.78-12.48%) (6/ 100)	5.08% (2.35-10.65%) (6/ 118)	6.96% (3.57-13.13%) (8/ 115)	0.94% (0.05-5.15%) (1/ 106)	0.93% (0.05-5.10%) (1/ 107)	1.000	
Hospital	No record	No record	No record	No record	No record	No record	-	
Undifferentiated	2.38% (0.66-8.27%) (2/ 84)	6.67% (3.27-13.13%) (7/ 105)	4.84% (2.24-10.16%) (6/ 124)	7.63% (4.06-13.86%) (9/ 118)	0.93% (0.05-5.06%) (1/ 108)	0.89% (0.05-4.88%) (1/ 112)	1.000	

Table 19: Non-susceptibility percentage of *Streptococcus pneumoniae* for WHO GLASS selected antimicrobials (continued)

Location of Onset (Total headcount) ^a	2012 (139)	2013 (174)	2014 (190)	2015 (156)	2016 (153)	2017 (157)	P-value ^b	
Ceftriaxone								
Community	1.72% (0.09-9.14%) (1/ 58)	6.58% (2.84-14.49%) (5/ 76)	5.10% (2.20-11.39%) (5/ 98)	1.20% (0.06-6.51%) (1/ 83)	2.20% (0.60-7.66%) (2/ 91)	4.82% (1.89-11.75%) (4/ 83)	1.000	
Hospital	No record	No record	No record	No record	No record	No record	-	
Undifferentiated	3.28% (0.90-11.19%) (2/ 61)	7.23% (3.36-14.89%) (6/ 83)	4.95% (2.13-11.07%) (5/ 101)	1.16% (0.06-6.30%) (1/ 86)	2.13% (0.59-7.43%) (2/ 94)	4.65% (1.82-11.36%) (4/ 86)	1.000	
Sulfamethoxazole and Trimethoprim								
Community	48.54% (39.12-58.07%) (50/ 103)	46.43% (38.37-54.67%) (65/ 140)	60.59% (53.09-67.62%) (103/ 170)	61.03% (52.64-68.82%) (83/ 136)	56.82% (48.29-64.96%) (75/ 132)	70.16% (61.60-77.51%) (87/ 124)	<0.005	
Hospital	No record	No record	No record	No record	No record	No record	-	
Undifferentiated	48.65% (39.55-57.84%) (54/ 111)	46.98% (39.14-54.97%) (70/ 149)	60.67% (53.35-67.55%) (108/ 178)	62.14% (53.89-69.75%) (87/ 140)	57.04% (48.61-65.08%) (77/ 135)	70.00% (61.64-77.21%) (91/ 130)	<0.005	

Table 19: Non-susceptibility percentage of *Streptococcus pneumoniae* for WHO GLASS selected antimicrobials (continued)



Location of Onset (Total headcount) ^a	2012 (139)	2013 (174)	2014 (190)	2015 (156)	2016 (153)	2017 (157)	P-value ^b	
Erythromycin								
Community	68.07% (59.24-75.77%) (81/ 119)	69.54% (61.79-76.32%) (105/ 151)	80.81% (74.28-86.00%) (139/ 172)	71.13% (63.19-77.95%) (101/ 142)	76.09% (68.33-82.44%) (105/ 138)	72.99% (65.01-79.73%) (100/ 137)	1.000	
Hospital	No record	No record	No record	No record	No record	No record	-	
Undifferentiated	69.53% (61.08-76.84%) (89/ 128)	71.25% (63.80-77.70%) (114/ 160)	80.56% (74.16-85.67%) (145/ 180)	72.11% (64.37-78.72%) (106/ 147)	76.76% (69.16-82.95%) (109/ 142)	73.43% (65.64-79.98%) (105/ 143)	1.000	

Table 19: Non-susceptibility percentage of *Streptococcus pneumoniae* for WHO GLASS selected antimicrobials (continued)

Location of Onset (Total headcount) ^a	2012 (139)	2013 (174)	2014 (190)	2015 (156)	2016 (153)	2017 (157)	P-value ^b	
Levofloxacin								
Community	<0.005% (<0.005-3.03%) (0/ 123)	0.63% (0.03-3.48%) (1/ 159)	0.57% (0.03-3.15%) (1/ 176)	<0.005% (<0.005-2.51%) (0/ 149)	1.38% (0.38-4.89%) (2/ 145)	0.70% (0.04-3.85%) (1/ 143)	1.000	
Hospital	<0.005% (<0.005-27.75%) (0/ 10)	<0.005% (<0.005-27.75%) (0/ 10)	No record	No record	No record	No record	-	
Undifferentiated	<0.005% (<0.005-2.81%) (0/ 133)	0.59% (0.03-3.28%) (1/ 169)	0.54% (0.03-3.01%) (1/ 184)	<0.005% (<0.005-2.43%) (0/ 154)	1.34% (0.37-4.76%) (2/ 149)	1.34% (0.37-4.76%) (2/ 149)	1.000	

^a Total headcount refers to annual number of patients with particular bacteria isolated from blood

^b P-value was calculated using Cochran-Armitage Test with Bonferroni correction to examine whether a trend with statistical significance exists

Note:

¹ Information presented in each cell is described as below. Row 1: percentage of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial; Row 2: 95% confidence interval; Row 3: number of patient with targeted bacteria identified in blood culture, reporting non-susceptibility towards particular antimicrobial, and total number of patient with targeted bacteria identified in blood culture and tested for non-susceptibility towards particular antimicrobial

² Dataset is deduplicated with consideration on location of onset

³ Proportion confidence intervals are calculated using the Wilson method

⁴ Compare with deduplication without consideration on location of onset, number of isolates selected for analysis will be increased because isolates from both hospital- and community-onset will be selected for each patient, if available

⁵ Non-susceptibility percentages calculated from less than 10 isolates (after deduplication) are excluded from presentation

⁶ Results of susceptibility testing performed for less than 70% of isolates are shown in cells with grey border

⁷ The interpretations for penicillin, cefotaxime and ceftriaxone is based on clinical breakpoint criteria for non-meningitis

References

- [1] The Government of the Hong Kong Special Administrative Region. Hong Kong Strategy and Action Plan on Antimicrobial Resistance 2017-2022. The Government of the Hong Kong Special Administrative Region; 2017.
- [2] World Health Organization. Global Antimicrobial Resistance Surveillance System: Manual for Early Implementation. World Health Organization; 2015.
- [3] European Centre for Disease Prevention and Control. Surveillance of antimicrobial resistance in Europe – Annual report of the European Antimicrobial Resistance Surveillance Network (EARS-Net) 2017. Stockholm: ECDC; 2018.
- [4] World Health Organization. Global Antimicrobial Resistance Surveillance System (GLASS) Report: Early Implementation 2016-2017. World Health Organization; 2017.
- [5] Siegman-Igra Y, Fourer B, Orni-Wasserlauf R, Golan Y, Noy A, Schwartz D, et al. Reappraisal of community-acquired bacteremia: a proposal of a new classification for the spectrum of acquisition of bacteremia. *Clin Infect Dis*. 2002 Jun;34(11):1431–1439.
- [6] Friedman ND, Kaye KS, Stout JE, McGarry SA, Trivette SL, Briggs JP, et al. Health care–associated bloodstream infections in adults: a reason to change the accepted definition of community-acquired infections. *Ann Intern Med*. 2002 Nov;137(10):791–797.
- [7] Cardoso T, Almeida M, Friedman ND, Aragão I, Costa-Pereira A, Sarmiento AE, et al. Classification of healthcare-associated infection: a systematic review 10 years after the first proposal. *BMC Med*. 2014 Mar;12:40.
- [8] The British Society for Antimicrobial Chemotherapy. The British Society for Antimicrobial Chemotherapy - Definitions;. Accessed: 2 April 2019. <http://www.bsacsurv.org/science/mics/>.

List of Abbreviations

AMR Antimicrobial Resistance

DH Department of Health

GLASS Global Antimicrobial Resistance Surveillance System

HA Hospital Authority

I Intermediate

IT&HI Information Technology and Health Informatics Division

MRSA Methicillin-resistant *Staphylococcus aureus*

R Resistance

S Susceptible

WHO World Health Organization

Index

Antimicrobial

Amikacin, 18
Amoxicillin/clavulanate, 17, 21
Ampicillin/sulbactam, 30
Ampicillin, 27
Cefepime, 17, 18, 21
Cefotaxime, 4, 17, 21, 27, 32
Ceftazidime, 18, 21, 30
Ceftriaxone, 4, 18, 21, 27, 32
Cefuroxime, 17, 21
Ciprofloxacin, 22, 27
Erythromycin, 32
Gentamicin, 18, 30
Imipenem/cilastatin, 18, 22, 27, 30
Levofloxacin, 18, 22, 27, 32
Meropenem, 18, 22, 27, 30
Minocycline, 30
Oxacillin, 25
Penicillin, 4, 32
Piperacillin/tazobactam, 18, 21, 30
Sulfamethoxazole/trimethoprim, 32
Vancomycin, 25

Bacteria

Acinetobacter species, 2, 3, 16, 30
Escherichia coli, 2, 3, 13, 16, 17
Klebsiella pneumoniae, 2, 3, 13, 16, 21
Salmonella species, 2, 3, 5, 16, 27
Staphylococcus aureus, 2, 3, 13, 25
Streptococcus pneumoniae, 2–5, 16, 32