Thailand's One Health Report

on Antimicrobial Consumption and Antimicrobial Resistance

in 2019

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International Health Policy Program, Ministry of Public Health, Thailand

Address:
Ministry of Public Health,
Tiwanon Rd. Nonthaburi 11000, Thailand
Phone: +66 (0) 2590-2366-7
Fax: +66 (0) 2590-2385

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Correspondence:
Any correspondence relating to this report should be sent by e-mail to:
hpsr_amr@ihpp.thaigov.net

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Foreword

On behalf of the National Steering Committee on Antimicrobial Resistance, we welcome the publication of Thailand's One Health Report on Antimicrobial Consumption and Antimicrobial Resistance 2019.

In 2016, Thailand's first National Strategic Plan on Antimicrobial Resistance 2017-2021 (NSP-AMR) was endorsed by the Cabinet. In response to the strategic goals of NSP-AMR, the One Health Report on Antimicrobial Consumption and Antimicrobial Resistance has been produced to monitor antimicrobial consumption and antimicrobial resistance in humans and animals, and knowledge and public awareness on antimicrobial resistance since 2017.

Regarding the strategic goals, by 2021, we need to reduce morbidity attributable to antimicrobial resistance by 50%; reduce antimicrobial consumption by 20% in the human sector and 30% in the animal sector; and increase the proportion of the populations level of knowledge and awareness of antimicrobial resistance by 20%.

This year, the report provides data in 2019, and compares it with 2017 baseline data for the monitoring of NSP-AMR (2017-2021) strategic goals. The overall consumption of human antimicrobials was 83.0 Defined Daily Doses/1000 inhabitants/day (+20.9% from 2017) and the overall consumption of veterinary antimicrobials was 336.3 mg/$PCU_{Thailand}$ (-49.0% from 2017). The level of knowledge on AMR and antibiotic use was 24.3% (+0.6% in 2017).

We thank the members of the Health Policy and Systems Research on Antimicrobial Resistance (HPSR-AMR) Network, led by the International Health Policy Program, Ministry of Public Health, Thailand for their contribution to the development of this report. This report was produced through a collaborative process involving professionals working in the human and animal health sectors in Thailand.

We fully believe that cross-sectoral collaboration based on the One Health approach can effectively address antimicrobial resistance.

Dr. Paisarn Dunkum
Secretary-General
Food and Drug Administration
Ministry of Public Health

Dr. Supakit Sirilak
Director-General
Department of Medical Sciences
Ministry of Public Health

Dr. Opart Karnkawinpong
Director-General
Department of Disease Control
Ministry of Public Health

Dr. Sorravis Thaneto
Director-General
Department of Livestock Development
Ministry of Agriculture and Cooperatives

Mr. Mesak Pakdeekong
Director-General
Department of Fisheries
Ministry of Agriculture and Cooperatives

Mr. Athapol Charoenchasa
Director-General
Pollution Control Department
Ministry of Natural Resources and Environment
On behalf of the National Steering Committee on Antimicrobial Resistance

Contributor

Editor-in-Chief: Viroj Tangcharoensathien

Editorial team: Angkana Lekagul
Supapat Kirivan
Wanwisa Kaewkhankhaeng
Saowapa Khotchalai

	Data sources	Authors	Expert reviewers
SECTION A ANTIMICROBIAL CONSUMPTION			
A1. Antimicrobial Consumption in Humans	Food and Drug Administration, Ministry of Public Health	- Supapat Kirivan - Charunee Krisanaphan - Kritsada Limpananont - Chutamas Luangaroonchai - Pongsathid Virungrojint	- Khunjira Udomaksorn - Inthira Kanchanaphibool
A2. Antimicrobial Consumption in Food-Producing Animals			- Nackanun Chitaroon - Natthasit Tansakul
A3. Antimicrobial Consumption in Food-Producing Animals (Medicated Feed through Feed Mills)	Department of Livestock Development, Ministry of Agriculture and Cooperatives	- Supapat Kirivan - Julaporn Srinha - Somsajee Sivilaikul - Suchana Sukklad - Passawee Pakpong	- Boonyita Rujtikumporn - Nattasit Tansakul
SECTION B ANTIMICROBIAL RESISTANCE			
B1. Antimicrobial Resistance in Humans	• National Antimicrobial Resistance Surveillance Center Thailand (NARST), National Institute of Health, Department of Medical Sciences, Ministry of Public Health • Department of Disease Control, Ministry of Public Health	- Sang Usayaporn - Ratchanu Charoenpak - Abhisit Prawang - Noppavan Janejai - Wantana Paveenkittiporn - Aekkawat Unahalekhaka - Pimrata Leethongdee	- Kumthorn Malathum - Chanwit Tribuddharat - Angkana Lekagul
B2. Morbidity of AMR in patients with Hospital-Associated Infections	Bamrasnaradura Infectious Disease Institute, Department of Disease Control, Ministry of Public Health	- Anond Kulthanmanusorn - Wanwisa Kaewkhankhaeng - Weerawat Manosuthi - Visal Moolasart - Varaporn Thienthong	- Lantharita Charoenpong - Suvaporn Anugulruengkitt
B3. Antimicrobial resistance in Food-Producing Animals	Department of Livestock Development, Ministry of Agriculture and Cooperatives	- Julaporn Srinha - Thammarat Sujit - Supaporn Wongsrichai - Suchana Sukklad - Thanawan Na Thalang - Sunicha Chanvatik	- Sanpech Angkititrakul - Saharuetai Jeamsripong
SECTION C KNOWLEDGE AND AWARENESS ON ANTIBIOTIC USE AND AMR			
C. Knowledge and Awareness on Antibiotic Use and AMR	National Statistic Office, Ministry of Digital Economy and Society	- Sunicha Chanvatik - Hathairat Kosiyaporn - Apichart Thunyahan	- Wirun Limsawat - Angkana Lekagul

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ABBREVIATIONS AND ACRONYMS

AMC	Antimicrobial consumption
AMR	Antimicrobial resistance
API	Active pharmaceutical ingredient
AST	Antimicrobial Susceptibility Testing
ATC	Anatomical Therapeutic Chemical
ATCvet	Anatomical Therapeutic Chemical classification system for veterinary medicinal products
AWaRe	Access, Watch, Reserve classification of antibiotics
Aw	Average weight at the time of treatment
BLI	Beta-lactamase inhibitor
CAUTI	Catheter-associated urinary tract infection
CIA	Critically important antimicrobial
CLABSI	Central line-associated bloodstream infection
CLSI	Clinical and Laboratory Standards Institute
CRPA	Carbapenem-resistant *Pseudomonas aeruginosa*
CRE	Carbapenem-resistant *Enterococci*
DDD	Defined Daily Dose
DID	Defined Daily Doses/1000 inhabitants/day
DLD	Department of Livestock Development, Ministry of Agriculture and Cooperatives
DOF	Department of Fisheries, Ministry of Agriculture and Cooperatives
EFSA	European Food Safety Authority
ESAC-Net	European Surveillance of Antimicrobial Consumption Network
ESVAC	European Surveillance of Veterinary Antimicrobial Consumption
EUCAST	European Committee on Antimicrobial Susceptibility Testing
FAO	Food and Agriculture Organization of the United Nations
FDA	Thai Food and Drug Administration, Ministry of Public Health
HPSR-AMR	Health Policy and Systems Research on Antimicrobial Resistance
HAI	Hospital-Associated Infections
I	Intermediate
ICN	Infection control nurse
ICWN	Infection control ward nurse
ISO	International Organization for Standardization
IHPP	International Health Policy Program
MIC	Minimal Inhibitory Concentration
MOPH	Ministry of Public Health
MRCNS	Methicillin-resistant coagulase-negative *Staphylococcus*
MRSA	methicillin-resistant *Staphylococcus aureus*
NARST	National Surveillance System for Antimicrobial Resistance
NSP-AMR	National Strategic Plan on Antimicrobial Resistance
NIAH	National Institute of Animal Health
OIE	World Organisation for Animal Health
PCU	Population Correction Unit
PLO	Provincial Livestock Offices
R	Resistant
S	Susceptible
SAC	Surveillance of Antimicrobial Consumption
SD	Standard deviation
SDD	Susceptible-dose dependent
SSI	Surgical site infection
VAP	Ventilator-associated pneumonia
VRE	Vancomycin-resistant Enterococcus
WHO	World Health Organization

GLOSSARY

Antimicrobial consumption (AMC)

Antimicrobial consumption is the quantity of consumption of antimicrobial drugs, which is measured at the national level as the quantity of its production plus imports minus the quantity of its exports. AMC is expressed as the number of Defined Daily Doses (DDDs) per 1,000 inhabitants per day for human antimicrobials, and mi lligram per Population Correction Unit, modified by Thailand (mg/$PCU_{Thailand}$) for food-producing animals.

Antimicrobial resistance (AMR)

Antimicrobial resistance is the ability of microbes (e.g. bacteria, viruses and fungi) to grow or survive even after exposure to antimicrobial agents at concentrations that are normally sufficient to inhibit or kill that particular strain of microbe. In this report, AMR predominantly means AMR in bacteria.

Antituberculous drug

Antituberculous drugs in Thailand Surveillance of antimicrobial consumption (Thailand SAC) are drugs used solely for treatment of tuberculosis; however, this may or may not include certain groups of drugs such as macrolides, fluoroquinolones and ansamycins due to their other indications for non-mycobacterial infections.

Antimicrobial agent

Antimicrobial agents are substances with antimicrobial properties or the ability to inhibit growth or metabolic processes in microbes (e.g. bacteria, viruses and fungi). They are obtained from living organisms or through synthesis. In this report, antimicrobial agents predominantly refer to antibacterial agents; except for the human antimicrobial consumption chapters in which antimicrobial agents cover antimicrobials of all origins, antivirals, antifungals, antimycotics, antituberculous drugs, and antimalarials.

Antibiotics

Antibiotics are antimicrobial medicines with bactericidal properties, (including those with the ability to stop bacterial growth), obtained from living organisms or through synthesis. Examples include penicillin, amoxicillin, tetracycline, norfloxacin and azithromycin. The terms microbicide (microbe killer), antibacterial medicines and antibiotics are used interchangeably.

Bacteria

Bacteria are one of the major groups of microorganisms or microbes, some of which can infect and cause diseases in humans and animals. A range of descriptive terms are used. Bacteria cultivated in a laboratory are referred to as isolates, capable of causing disease are referred to as pathogens (pathogens that are transmissible between animals and humans are zoonotic), and those that are normally resident on or in humans or animals without causing disease are referred to as commensals or colonizers.

Critically Important Antimicrobials

In this report, the Critically Important Antimicrobials (CIA) refers to the lists of CIA for human medicine defined by the World Health Organization (1). It ranks medically important antimicrobials for risk management of antimicrobial resistance due to non-human use. It was developed for cautious use in mitigating the human health risks associated with antimicrobial use (AMU) in both humans and food-producing animals.

Intermediate

A category which includes isolates with antimicrobial agent MICs that approach usually attainable blood and tissue levels and for which response rates may be lower than those for susceptible isolates, leading to less success rates of treatment (1).

Non-susceptible

A category used for isolates for which only a susceptible breakpoint is designated because of the absence or rare occurrence of resistant strains. This includes isolates for which the antimicrobial agent minimum inhibitory concentrations (MICs) are above a susceptible breakpoint or their zone diameters fall below the value indicated for the susceptible.

One Health

A concept promoting a 'whole of society' approach to attain optimal health for people and animals, and a healthy environment.

Resistant

A category that implies that isolates are not inhibited by the usually achievable concentrations of the antimicrobial agent with normal dosage regimen and/or demonstrate MICs/zone diameters that fall in the range where specific microbial resistance mechanisms (e.g., β-lactamases) are likely to do and that clinical efficacy against the isolate has not been shown reliably in treatment studies (1).

Surveillance

Surveillance means a continuing process of collecting, collating and analysing data and communicating information to all relevant actors. It involves the generation and timely provision of information that can inform appropriate decision-making and action.

Susceptible

A category which implies that isolates are inhibited by the usually achievable concentrations of antimicrobial agent when the recommended dosage (dosage regimen) is used for achieving therapeutic effects at the site of infection (2).

Susceptible-dose dependent (SDD)

A category defined by a breakpoint that implies the susceptibility of an isolate is dependent on the dosing regimen that is used in the patient. In order to achieve levels that are likely to be clinically effective against isolates for which the susceptibility testing results are in the SDD category, it is necessary to use a dosing regimen (i.e., higher doses, more frequent doses, or both) that results in higher drug exposure than the dose that was used to establish the susceptible breakpoint.

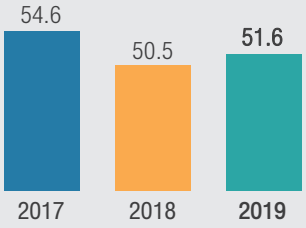
HIGHLIGHTS

HIGHLIGHTS

Data on monitoring and evaluation of the Goals of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021

Target by 2021	Indicator	Data		
		2017	2018	2019
20% reduction in antimicrobial consumption in humans	Antimicrobial consumption in humans (Defined Daily Doses/1,000 inhabitants/day, DID)[1]	54.6	50.5 (↓7.5%)	51.6 (↓5.6%)
30% reduction in antimicrobial consumption in animals	Antimicrobial consumption in food-producing animals ($mg/PCU_{Thailand}$)[1]	658.7	522.0 (↓20.8%)	336.3 (↓49.0%)
20% increase of public knowledge on AMR and awareness of appropriate use of antimicrobials	Public knowledge on AMR (percent)[2]	23.7	-	24.3 (↑0.6 percentage point)

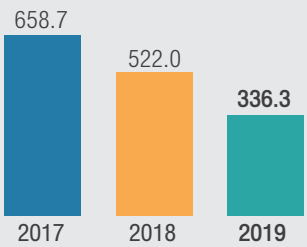
Antimicrobial consumption in humans (DID)



↓ 7.5%
2018 compared with 2017

↓ 5.6%
2019 compared with 2017

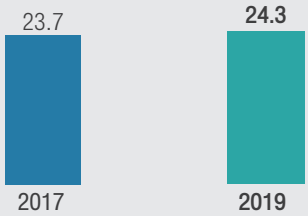
Antimicrobial consumption in animals ($mg/PCU_{Thailand}$)



↓ 20.8%
2018 compared with 2017

↓ 49.0%
2019 compared with 2017

Public knowledge on AMR and awareness of appropriate use of antimicrobials (%)

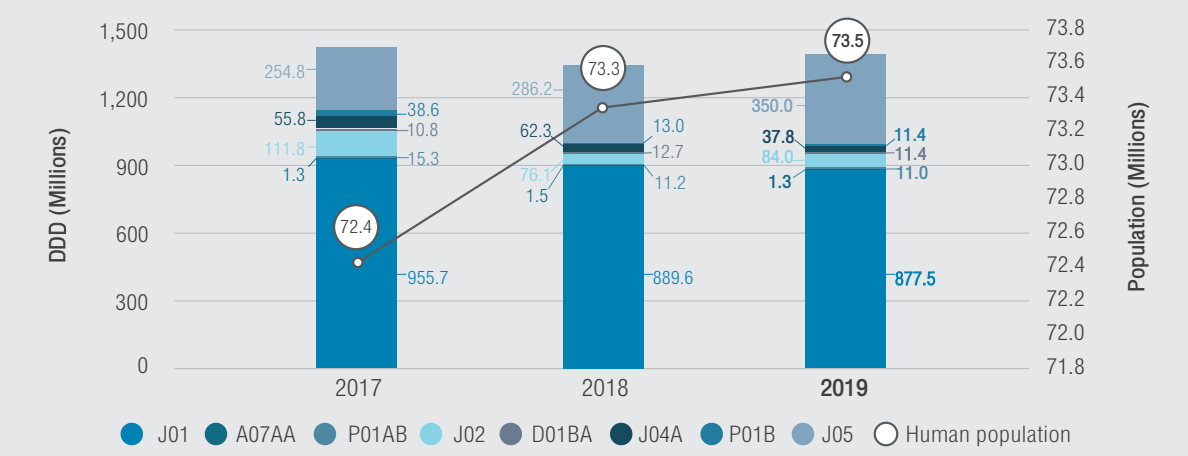


↑ 0.6 percentage point
2019 compared with 2017

[1] Data source: Thailand Surveillance of Antimicrobial Consumption
[2] Data source: Health and Welfare Survey: antibiotic use, knowledge of antibiotics and awareness of AMR in 2017 and 2019

I. Antimicrobial Consumption in Humans[3]

Human antimicrobial consumption (Defined Daily Doses, DDDs) and population in Thailand (including migrants) (Millions)

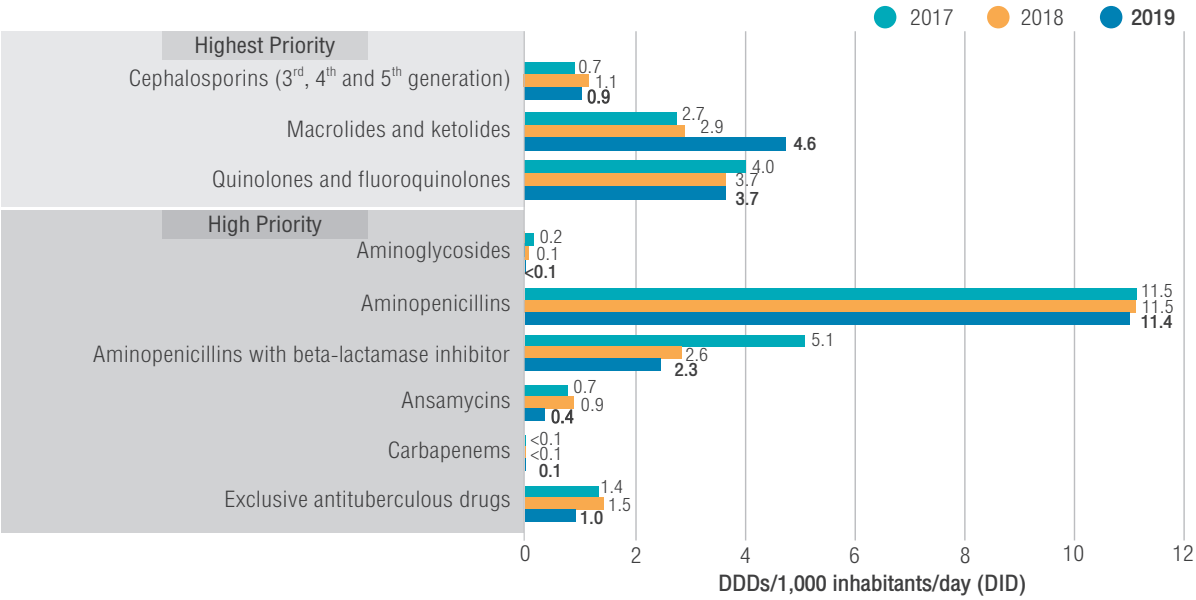


J01, antibacterials for systemic use; A07AA, antibiotics for alimentary tract; P01AB, nitroimidazole derivatives; J02, antimycotics for systemic use; D01BA, antifungals for systemic use; J04A, drugs for treatment of tuberculosis; P01B, antimalarials; J05, antivirals for systemic use

Top 10 antimicrobials consumption in human in 2017, 2018 and 2019 (DDDs/1,000 inhabitants/day, DID)

Rank	Antimicrobial agent	DDDs/1,000 inhabitants/day (DID)		
		2019	2018	2017
1	Amoxicillin	9.2	9.3	10.1
2	Azithromycin	2.8	0.6	0.5
3	Emtricitabine, tenofovir disoproxil and efavirenz	2.5	1.8	1.3
4	Ketoconazole	2.4	2.1	3.7
5	Tetracycline	2.3	3.7	3.4
6	Amoxicillin with beta-lactamase inhibitor	2.3	2.6	5.1
7	Ampicillin	2.2	2.2	1.4
8	Doxycycline	2.0	2.2	2.4
9	Lamivudine	1.8	2.5	2.6
10	Tenofovir disoproxil	1.6	0.2	0.1

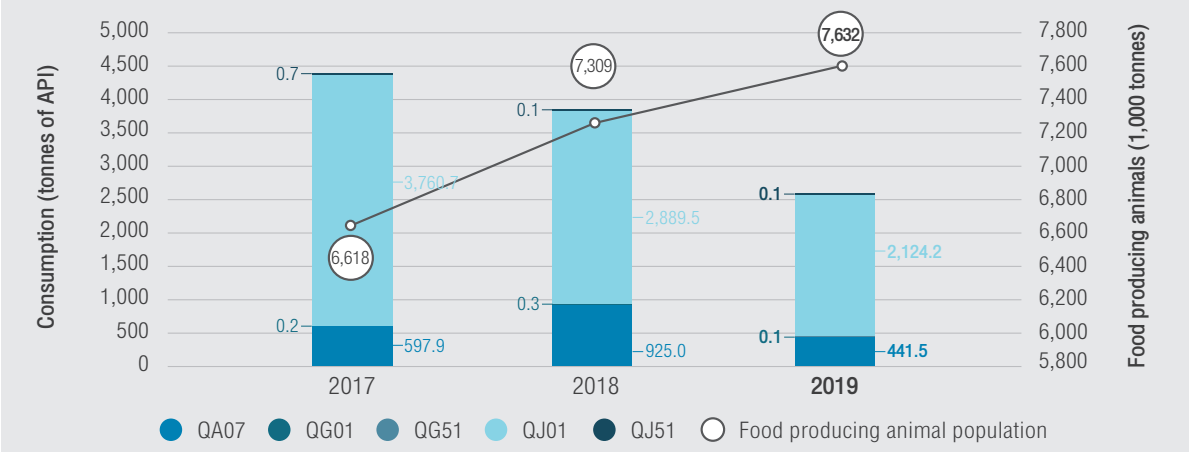
Human Antimicrobial Consumption Classified by WHO Critically Important Antimicrobials[4]



[3] Data source: Thailand Surveillance of Antimicrobial Consumption, Food and Drug Administration
[4] Source: WHO lists of Critically Important Antimicrobials for Human Medicine 6th edition

II. Antimicrobial Consumption in Food-Producing Animals[5]

Antimicrobial consumption in food-producing animals (tonnes of active pharmaceutical ingredient, API) and food-producing animal population (1,000 tonnes of $PCU_{Thailand}$)

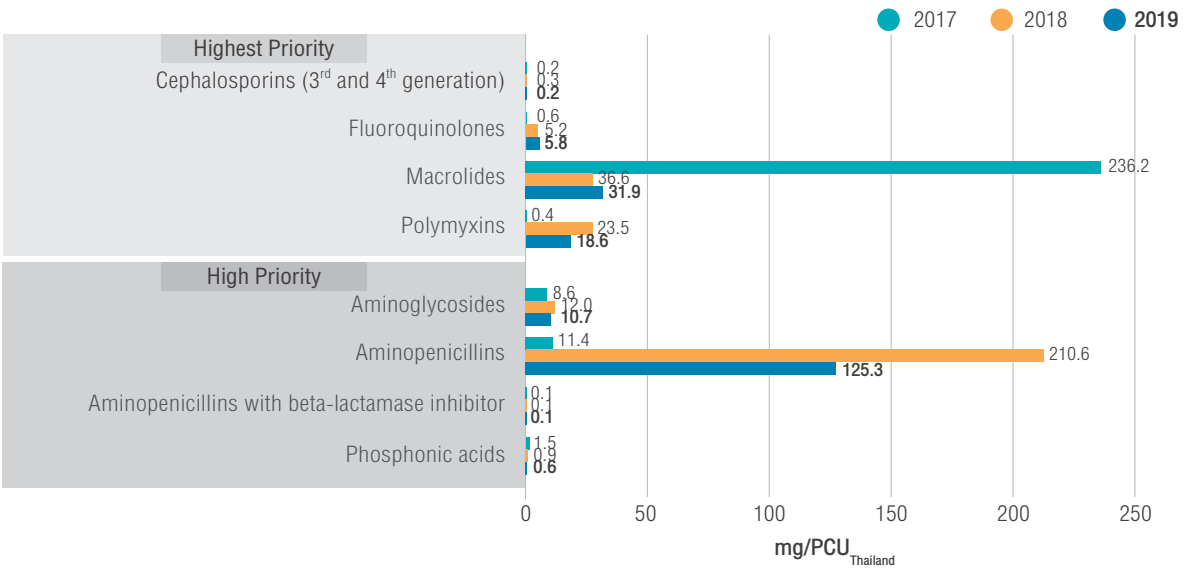


QA07, antimicrobial agents for intestinal use; QG01, Gynecological antiinfectives and antiseptics; QG51, antiinfectives and antiseptics for intrauterine use; QJ01, antimicrobial agents for systemic use; QJ51, antimicrobial agents for intramammary use
Note: The <0.1 tonnes of API not labeled (QG51).

Top 10 antimicrobials for food-producing animals in 2019 and their consumption in 2017 and 2018 ($mg/PCU_{Thailand}$)

Rank	Antimicrobial agent	$mg/PCU_{Thailand}$		
		2019	2018	2017
1	Amoxicillin	125.1	210.4	11.4
2	Chlortetracycline	44.8	42.8	52.9
3	Tiamulin	36.2	60.2	7.7
4	Colistin	18.6	23.5	0.4
5	Bacitracin	18.4	14.6	10.5
6	Tilmicosin	16.3	16.7	8.9
7	Halquinol	14.8	80.5	73.3
8	Doxycycline	13.0	14.6	19.1
9	Tylosin	8.8	14.3	223.7
10	Neomycin	6.0	7.8	5.9

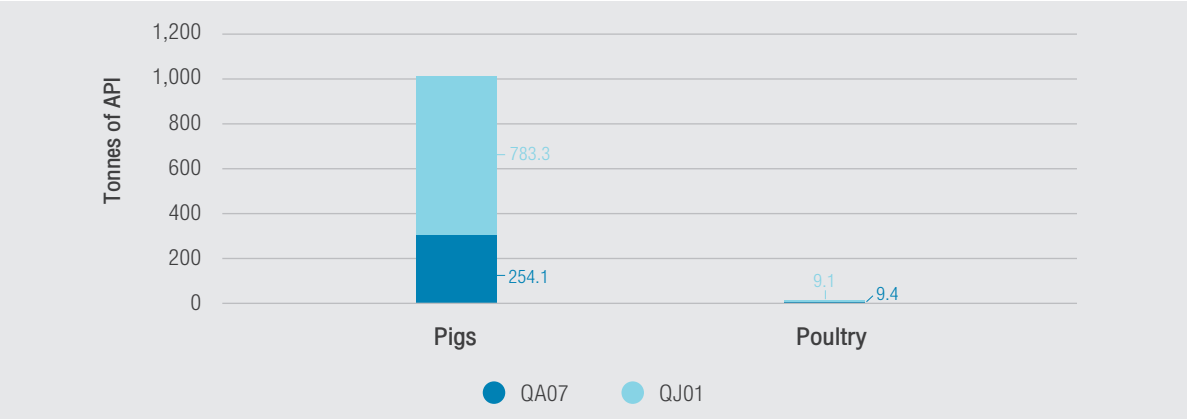
Antimicrobial consumption in food-producing animals classified by WHO Critically Important Antimicrobials ($mg/PCU_{Thailand}$)



[5] Data source: Thailand Surveillance of Antimicrobial Consumption, Food and Drug Administration and Department of Livestock Development

III. Antibacterial Consumption in Food-Producing Animals through Medicated Feed Produced by Feed mills[6]

Antibacterial consumption in medicated feed by species of food-producing animals in 2019 (tonnes of active pharmaceutical ingredient, API)

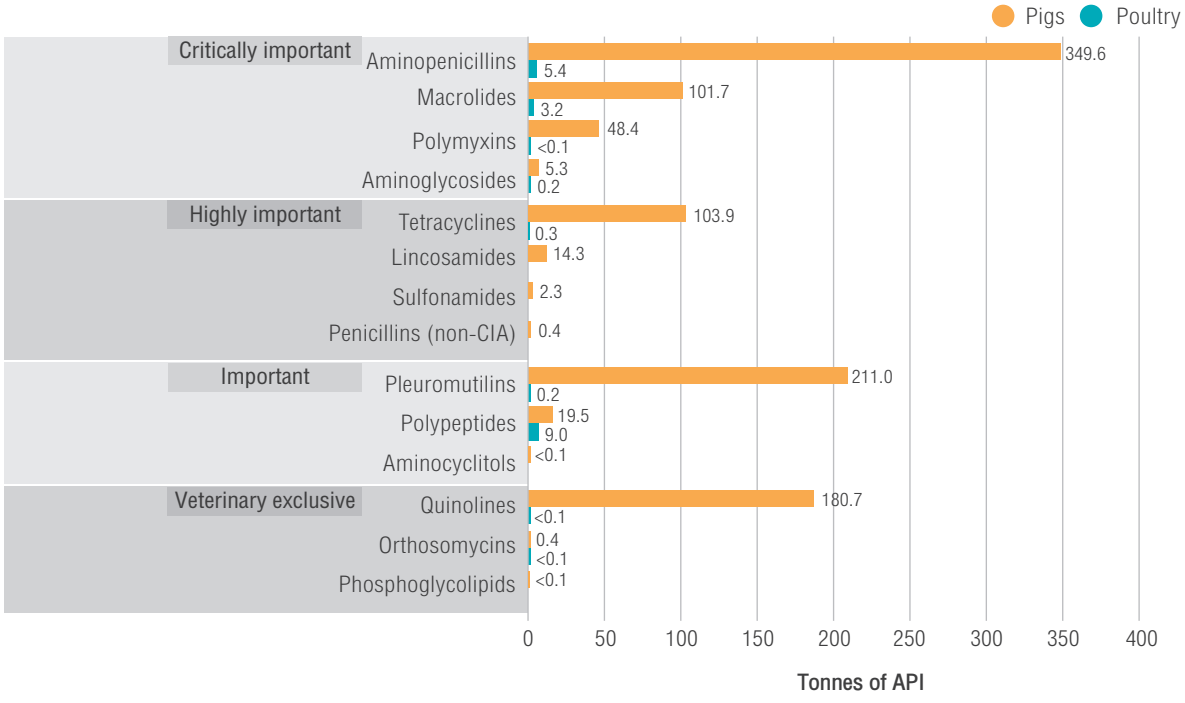


QA07, antimicrobial agents for intestinal use; QJ01, antimicrobial agents for systemic use

Top 10 antibacterials used in medicated feed for pigs and poultry in 2019 (tonnes of API)

Rank	Pigs		Poultry	
	Antibacterial	Tonnes	Antibacterial	Tonnes
1	Amoxicillin	349.6	Bacitracin	9.0
2	Tiamulin	211.0	Amoxicillin	5.4
3	Halquinol	180.7	Tylosin	2.9
4	Chlortetracycline	87.9	Tylvalosin	0.3
5	Tilmicosin	54.8	Tiamulin	0.2
6	Colistin	48.4	Chlortetracycline	0.2
7	Tylosin	32.7	Neomycin	0.2
8	Bacitracin	19.5	Doxycycline	0.1
9	Lincomycin	14.3	Halquinol	<0.1
10	Doxycycline	12.9	Avilamycin	<0.1

Antibacterial consumption in medicated feed for pigs and poultry by WHO Critically Important Antimicrobials and chemical class in 2019 (tonnes of API)

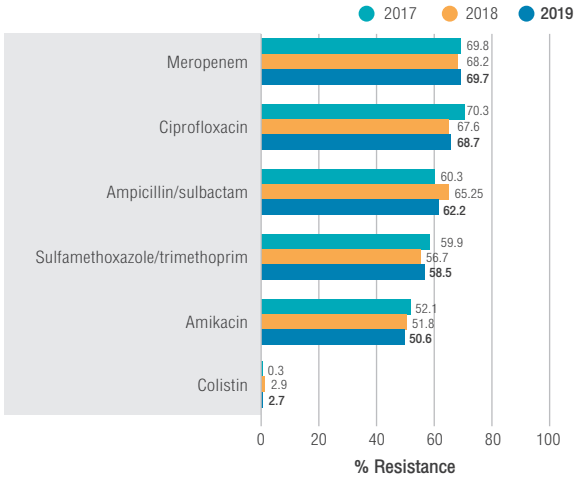


[6] Data source: Thailand Surveillance of Antimicrobial Consumption, Department of Livestock Development, Ministry of Agriculture and Cooperatives

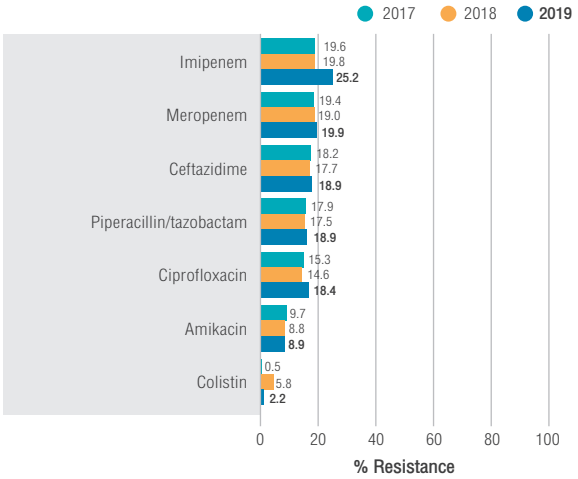
IV. Antimicrobial Resistance in Humans[7]

Gram-negative bacteria

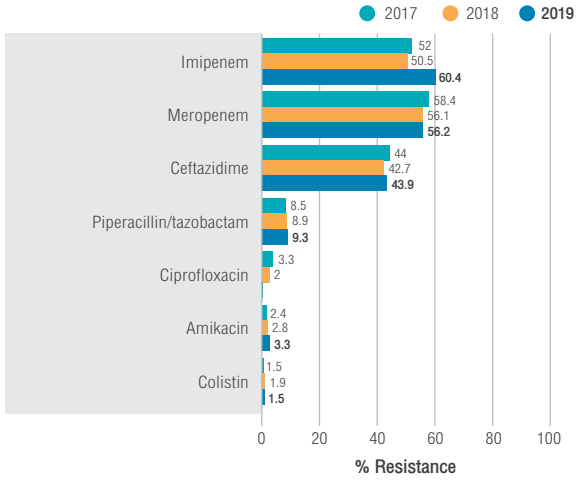
Percentage of antimicrobial resistance of *Acinetobacter calcoaceticus-baumannii* complex (2017-2019)



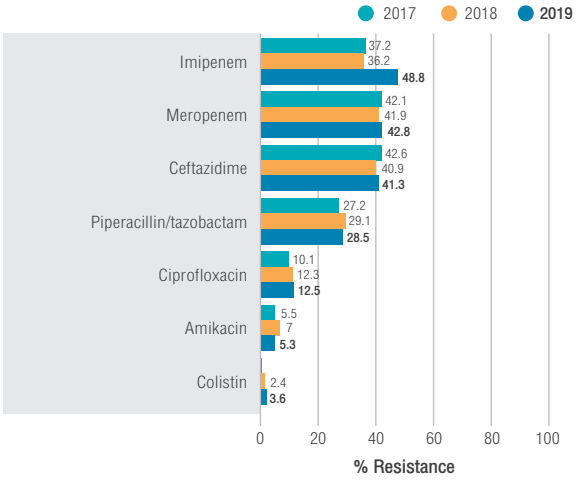
Percentage of antimicrobial resistance of *Pseudomonas aeruginosa* (2017-2019)



Percentage of antimicrobial resistance of *Escherichia coli* (2017-2019)

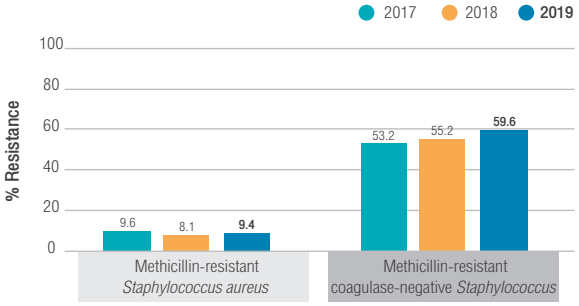


Percentage of antimicrobial resistance of *Klebsiella pneumoniae* (2017-2019)

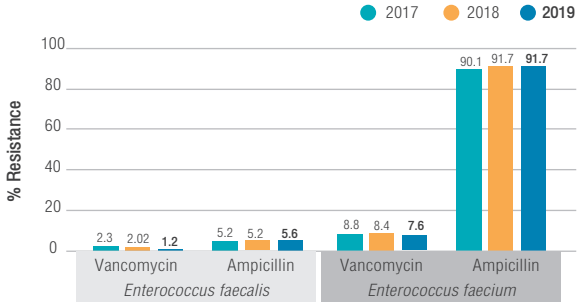


Gram-positive bacteria

Percentage of antimicrobial resistance of *Staphylococcus aureus* (2017-2019)



Percentage of antimicrobial resistance of *Enterococcus faecalis* and *Enterococcus faecium* (2017-2019)



[7] Data source: National Antimicrobial Resistance Surveillance Center Thailand (NARST), National Institute of Health, Department of Medical Sciences, and Department of Disease Control, Ministry of Public Health

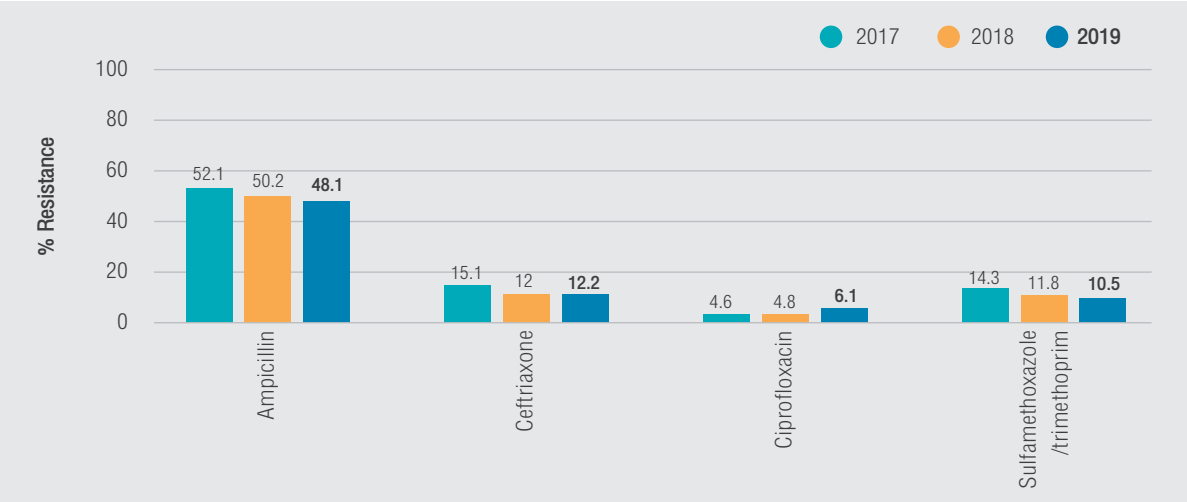
Percentage of antimicrobial resistance of *Streptococcus pneumoniae* (2017-2019)

Drug	% resistant (number isolates)			E-test, (number isolates)					
				Meningitis			Non-meningitis		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
Penicillin*	65.8 (371)	63.4 (366)	64.3 (1,276)	50.0 (2)	57.1 (7)	88.9 (9)	10.0 (369)	5.6 (359)	7.2 (1,267)
Cefotaxime*	-	-	-	0.0 (11)	0.0 (3)	-	0.0 (144)	1.0 (209)	6.9 (663)
Levofloxacin	0.9 (1,437)	1.0 (1,750)	1.2 (2,383)	-	-	-	-	-	-

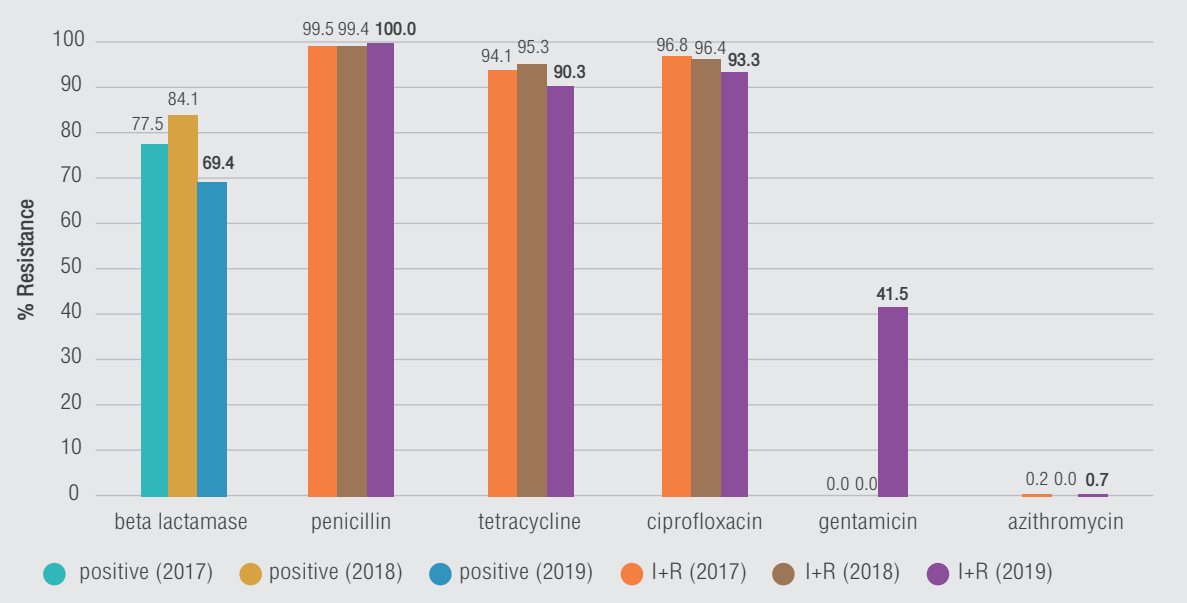
*Interpretation by minimum inhibitory concentration test

Other antimicrobial resistant bacteria

Percentage of antimicrobial resistance of Non-typhoidal *Salmonella* spp. (2017-2019)



Percentage of antimicrobial resistance of *Neisseria gonorrhoeae* (2017-2019)



Note: None of the isolates in 2017-2019 were resistant to cefixime, ceftriazone, spectinomycin.

V. Antimicrobial Resistance in Patients with Hospital-Associated Infections[8]

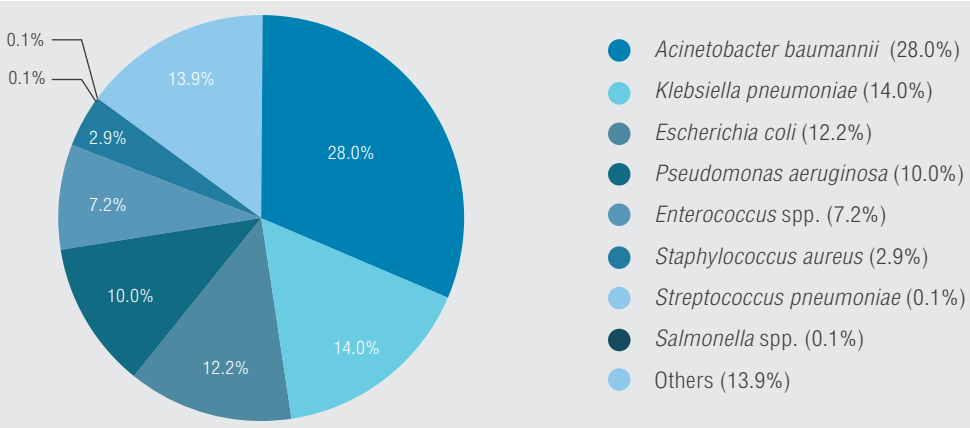
Hospital-associated infections (HAI)

Incidence rate (per 1,000 patient-days) and incidence proportion (%) of HAI by type of hospital

Hospital type	2019						2018	
	HAI events	HAI patient	Patient-days	Discharged patient	Weighted HAI incidence rate	Weighted HAI incidence proportion (%)	Weighted HAI incidence rate	Weighted HAI incidence proportion (%)
Regional hospital	7,841	6,234	3,318,945	627,416	2.4	1.0	3.4	1.2
General hospital	2,945	2,508	2,305,557	592,309	1.3	0.4	1.2	0.4
Community hospital	113	100	285,008	90,048	0.4	0.1	1.0	0.3
Other MOPH hospital	145	105	45,325	8,388	3.2	1.3	2.9	1.0
Other public hospital	897	729	232,348	31,664	3.9	2.3	3.3	1.7
Private hospital	46	44	101,873	44,655	0.5	0.1	0.7	0.2
Total	**11,987**	**9,720**	**6,289,056**	**1,394,480**	**1.5**	**0.5**	**2.5**	**0.8**

Note: Incidence proportion = (HAI patient/discharged patient)*100

Causative organisms of HAI events by targeted



Antimicrobial resistance in HAI patients

Incidence rate (per 1,000 patient-days) and incidence proportion (%) of AMR by types of hospital

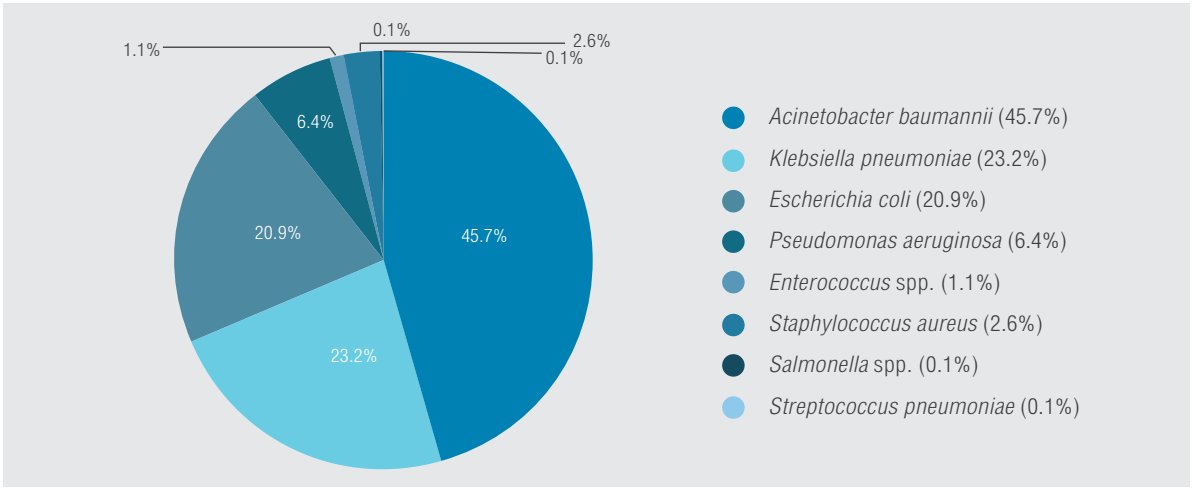
Hospital type	2019						2018	
	AMR events	AMR patient	Patient-days	Discharged patient	Weighted AMR incidence rate	Weighted AMR incidence proportion (%)	Weighted AMR incidence rate	Weighted AMR incidence proportion (%)
Regional hospital	3,629	2,910	3,318,945	627,416	1.1	0.5	1.8	0.7
General hospital	1,252	1,035	2,305,557	592,309	0.5	0.2	0.9	0.3
Community hospital	26	23	285,008	90,048	0.1	0.0	0.6	0.2
Other MOPH hospital	70	42	45,325	8,388	1.5	0.5	1.7	0.7
Other public hospital	365	291	232,348	31,664	1.6	0.9	1.4	0.8
Private hospital	1	1	101,873	44,655	<0.1*	<0.1**	0.5	0.1
Total	**5,343**	**4,302**	**6,289,056**	**1,394,480**	**0.6**	**0.2**	**1.4**	**0.5**

*0.01, **0.002

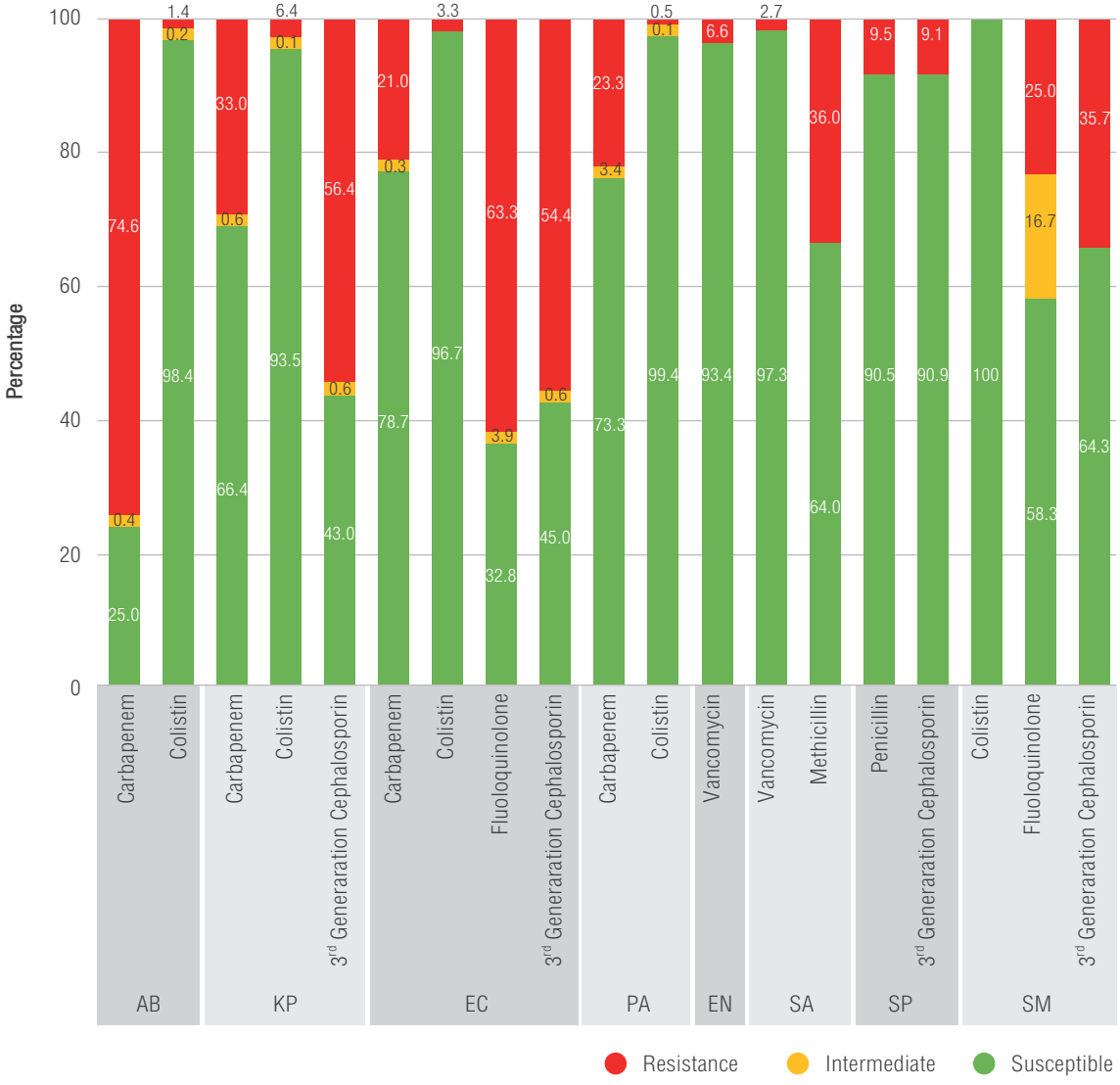
Note: Incidence proportion = (AMR patient/discharged patient)*100

[8] Data source: Surveillance of Hospital-associated Infection, Bamrasnaradura Infectious Disease Institute, Ministry of Public Health

Percentage of AMR events in HAI patients by targeted pathogen



Percentage of antimicrobial resistance in targeted pathogens in HAI patients



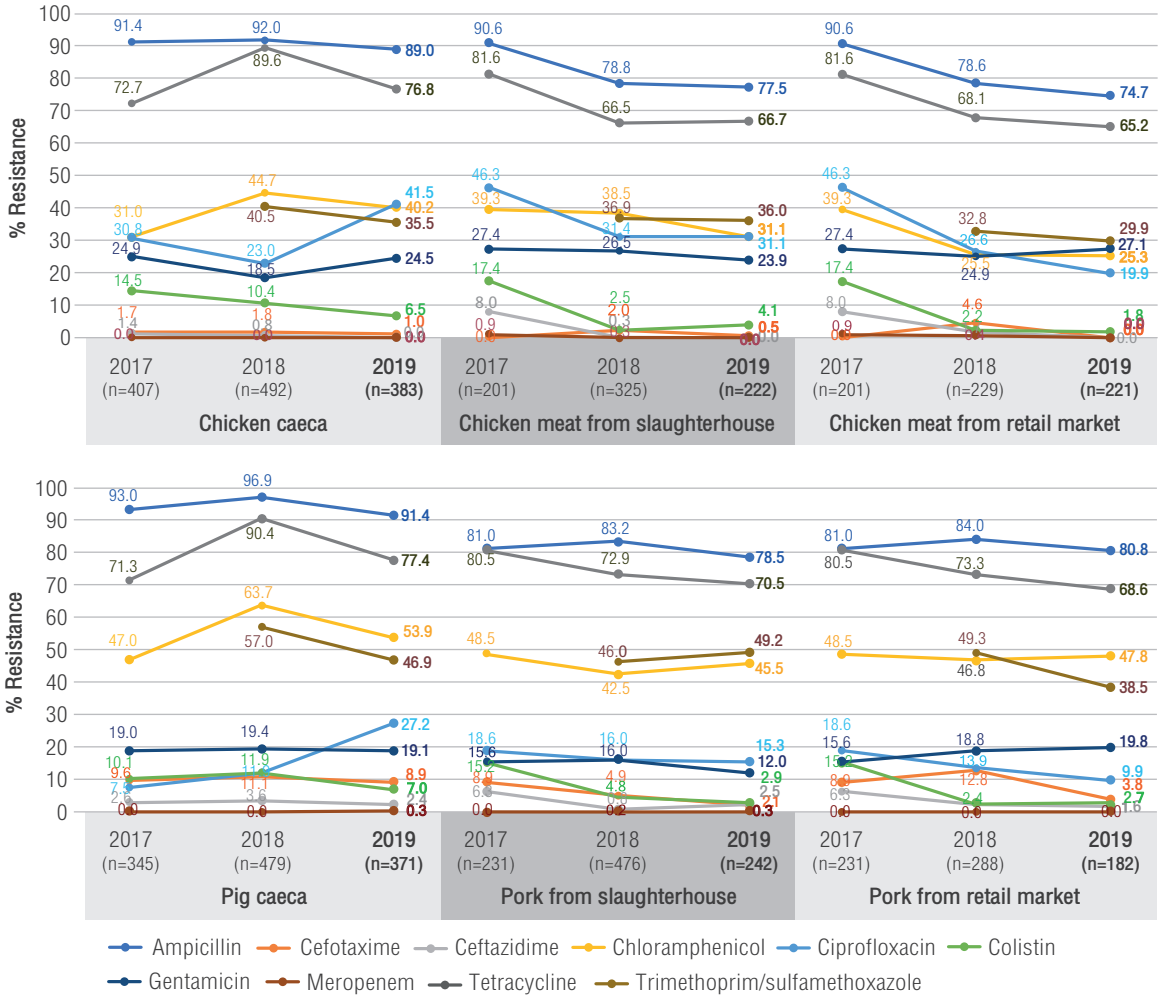
AB: *A. baumannii,* KP: *K. pneumoniae,* EC: *E. coli,* PA: *P. aeruginosa,* EN: *Enterococcus* spp., SA: *S. aureus,* SP: *S. pneumoniae,* SM: *Salmonella* spp.

Note: Count only first isolate pathogen

VI. Antimicrobial Resistance in Food-Producing Animals[9]

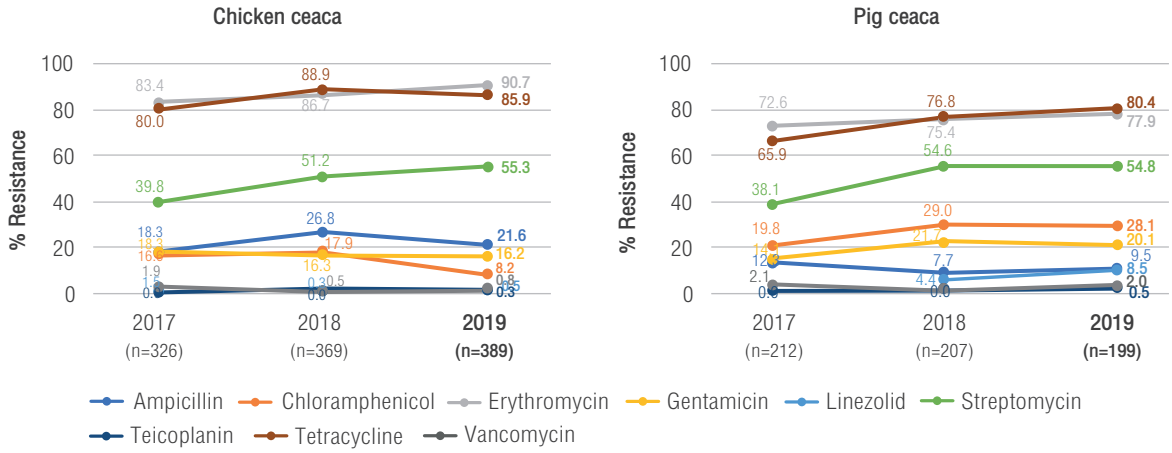
Escherichia coli

Percentage of antimicrobial resistance of *Escherichia coli* (2017-2019)



Enterococcus faecium and *Enterococcus faecalis*

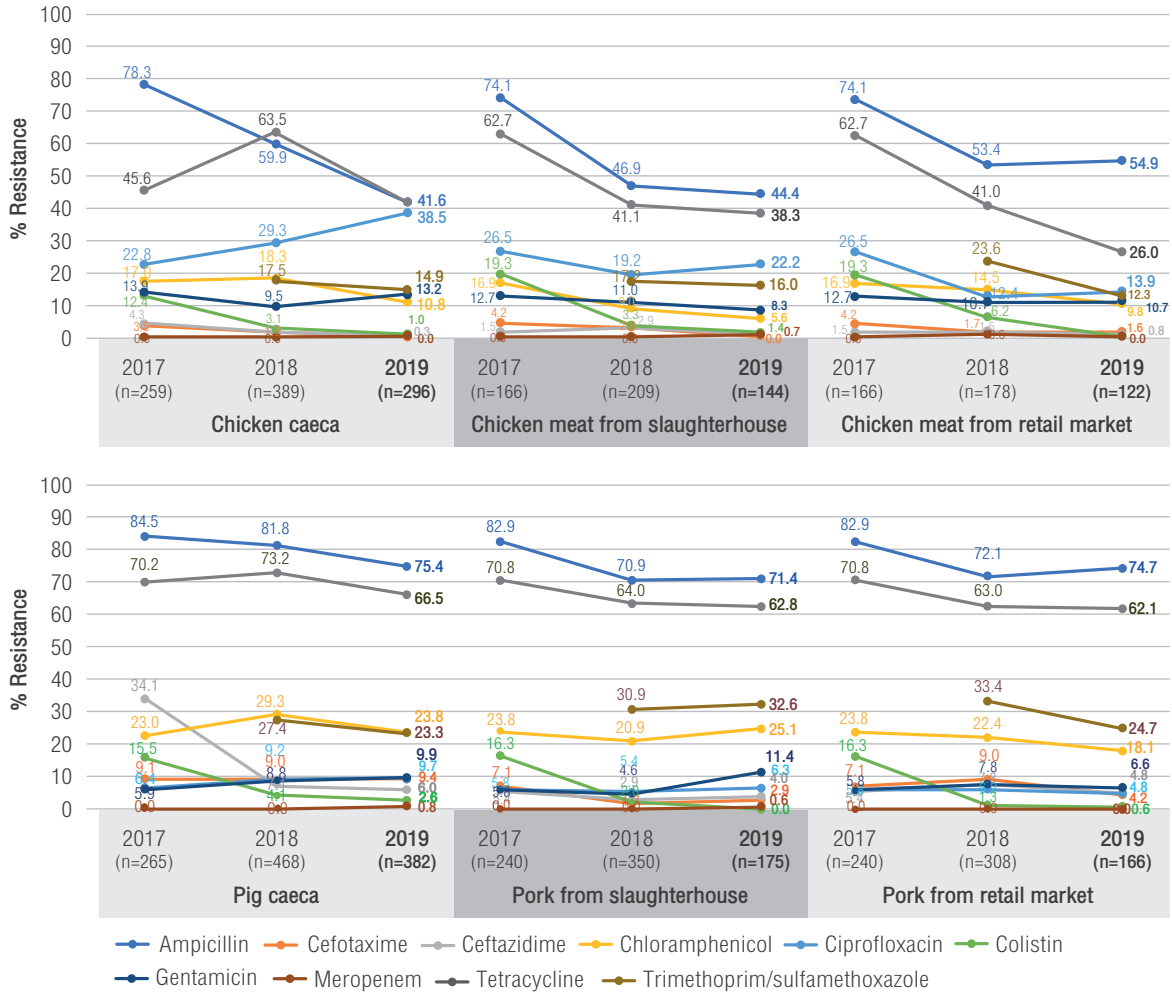
Percentage of antimicrobial resistance of *Enterococcus faecium* and *E. faecalis* (2017-2019)



[9] Data source: Thailand Surveillance of Antimicrobial Resistance, Department of Livestock Development, Ministry of Agriculture and Cooperatives

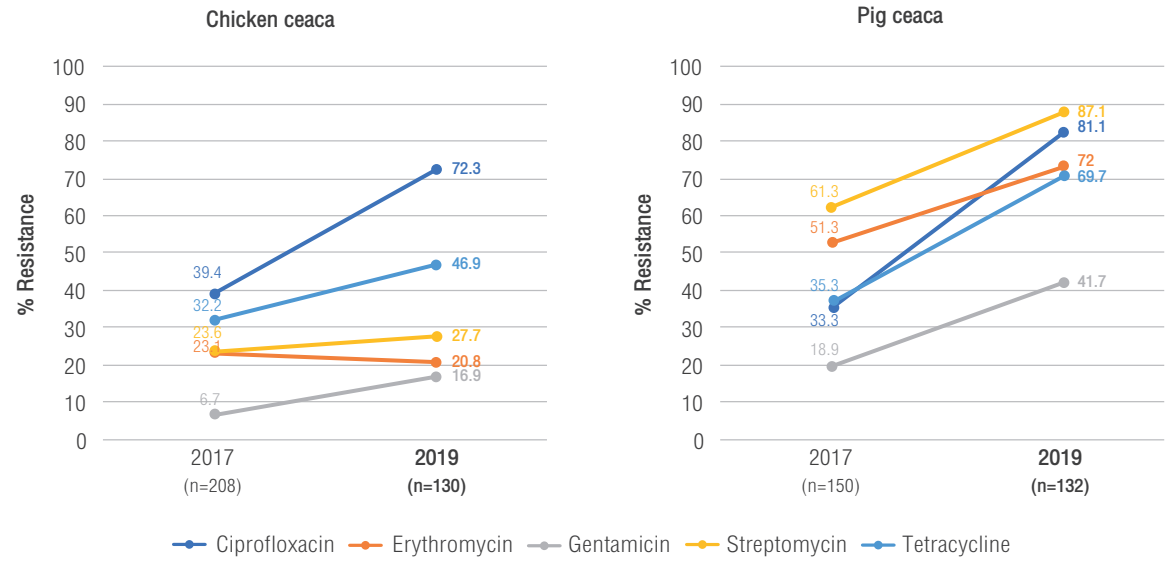
Salmonella spp.

Percentage of antimicrobial resistance of *Salmonella* spp. (2017-2019)



Campylobacter coli and *Campylobacter jejuni*

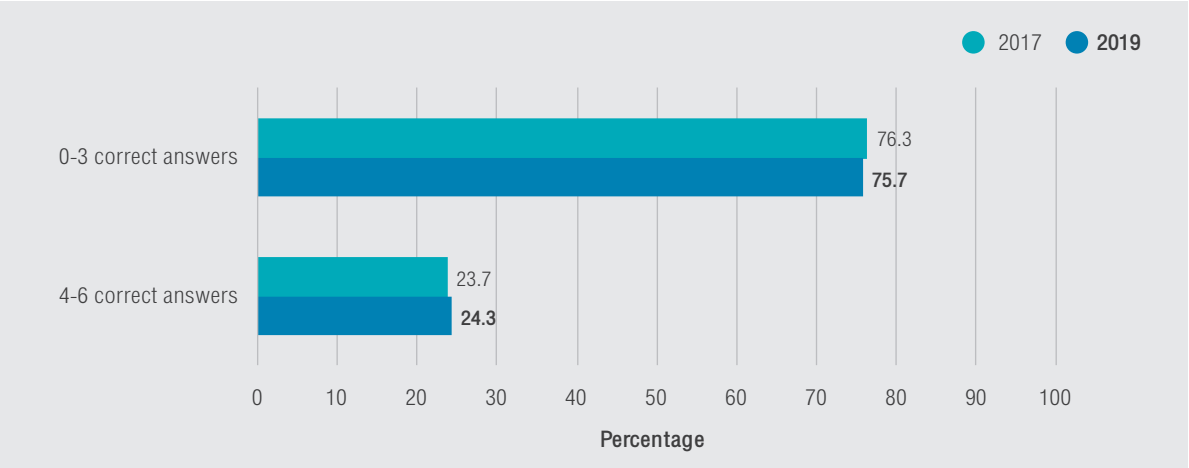
Percentage of antimicrobial resistance of *Campylobacter coli* and *C. jejuni* (2017-2019)



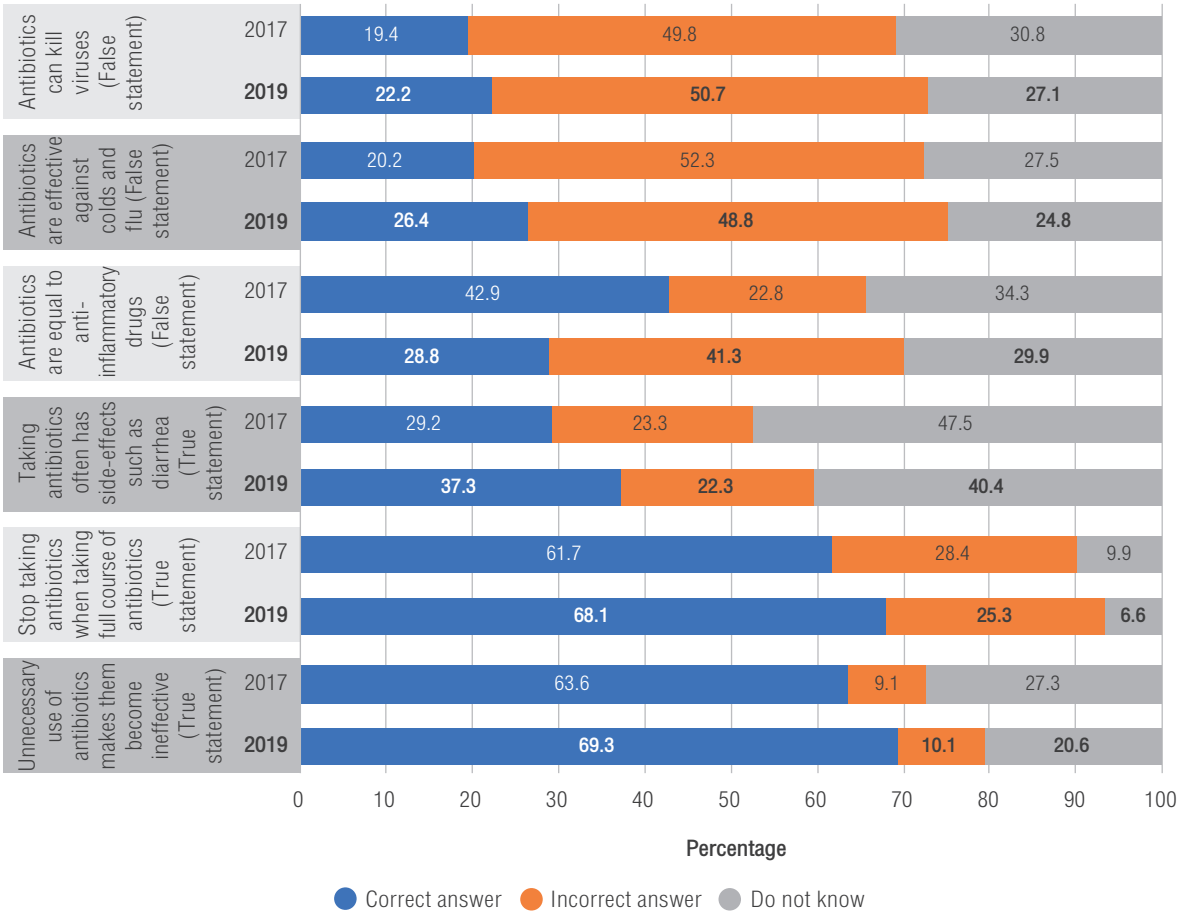
VII. Knowledge and Awareness on Antibiotic Use and AMR[10]

Knowledge of appropriate antibiotic use and AMR

Percentages of respondents who gave correct answer to six true and false statement related to antibiotics: comparative findings for 2017 and 2019



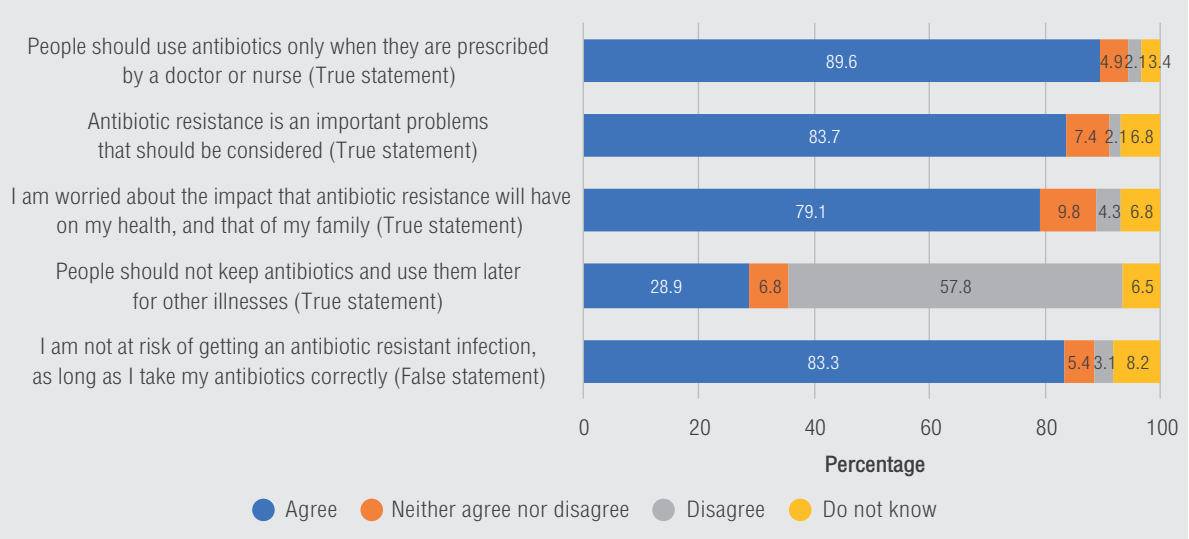
Percentage of respondents who gave correct answer in each statement of knowledge on antibiotic use: comparative findings between 2017 and 2019 (%)



[10] Data source: National Statistical Office, Ministry of Digital Economy and Society, Thailand

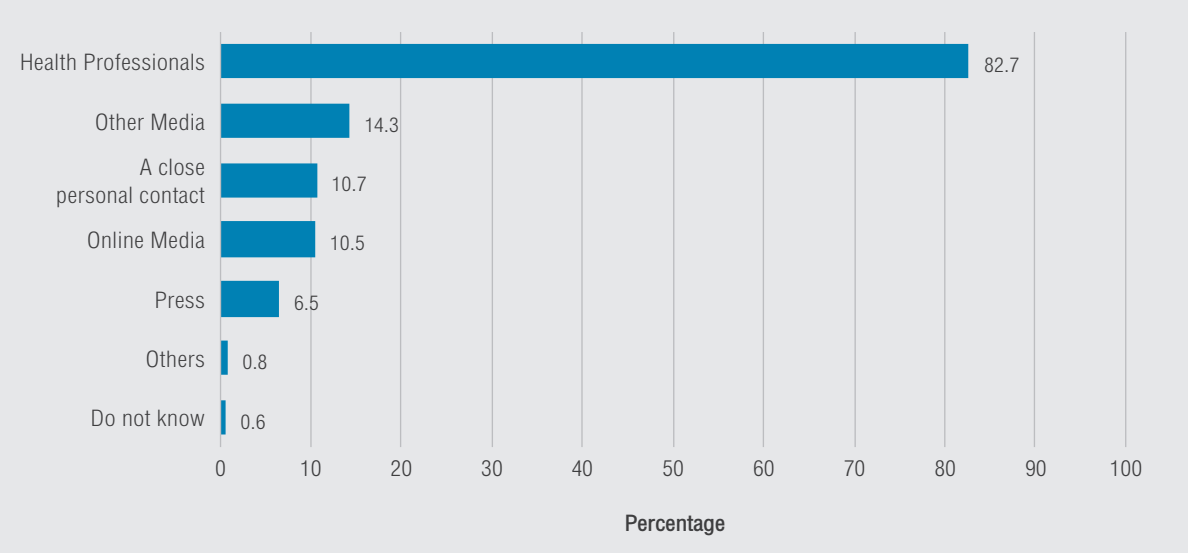
Awareness of the importance of appropriate antibiotic use and AMR

Level of agreement by respondents on five statements on awareness of appropriate antibiotic use and AMR in 2019



Public information about appropriate antibiotic use and AMR

Source of information on appropriate use of antibiotics and AMR in the last year (2019)



Note: Total percentages were more than 100% due to multiple answers.

SECTION A

ANTIMICROBIAL CONSUMPTION

SECTION A:
ANTIMICROBIAL CONSUMPTION

A1: Antimicrobial Consumption in Humans

A1.1 Overall consumption

- The overall consumption of human antimicrobials in Defined Daily Doses (DDDs) within the scope of the study has decreased to 1,384,361,726.7 DDDs (-4.1% from 2017-19) (Figure A1.1). Similarly, the population in Thailand has increased to 73,538,840 (+1.5% from 2017-19). As a result, the national indicator for human antimicrobial consumption has decreased to 51.6 Defined Daily Doses/1000 inhabitants/day (DID) (-5.6% from 2017-19).
- Overall, from 2017 to 2019, the majority of decreases in consumption came from antibacterials for systemic use (J01) (-3.5 DID,-9.6% from 2017-19). J01 consumtion in 2019 accounted for 63.4% of the decrease was antimycotics for systemic use (J02) (-1.1 DID, -26.0% from 2017-2019), which accounted for 6.1% of overall consumption in 2019 consumption (6.1%).
- On the contrary, the group with highest increasing rate was antivirals for systemic use (J05) (+3.4 DID, +35.3%, from 2017-19).

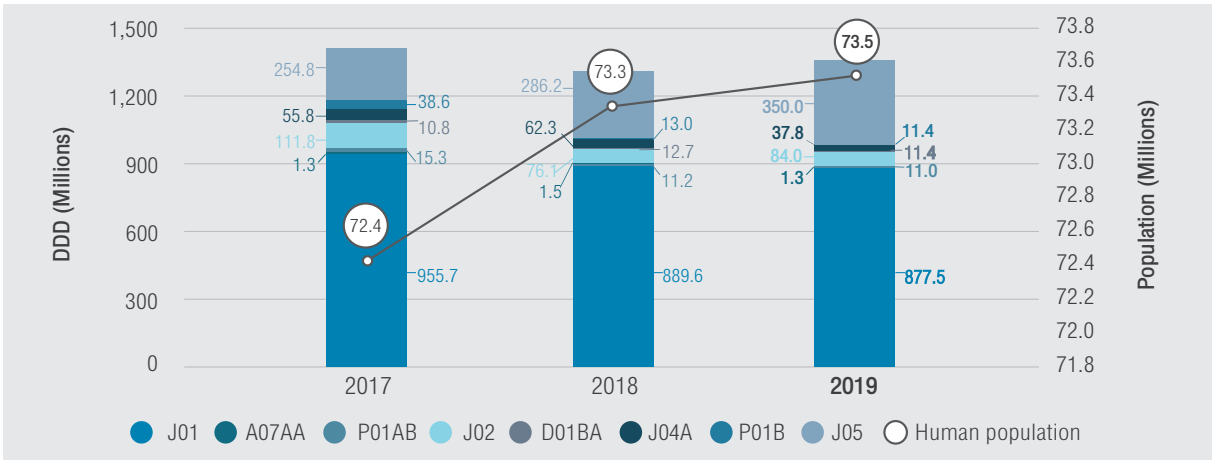


Figure A1.1 Consumption of target human antimicrobials classified by WHO Anatomical Therapeutic Chemical Classification (ATC) code, 2019 compared with 2017 and 2018

A1.2 Core and optional class breakdowns

Consumption of core class with highest proportion overall

- As the major contributor to total human antimicrobial consumption (63.4% in 2019), the profile of antibacterials for systemic use (J01) still has penicillins (J01C) as the main group (16.3 DID, 49.9% of J01 in 2019) (Figure A1.2).
- The decrease of J01 from 2017-19 mainly came from decreases in penicillins (J01C) (-2.5 DID from 2017-19) and in tetracyclines (J01A) (-1.5 DID from 2017-19). In contrast to the decreased counterpart, some antimicrobial groups in J01 increased, including macrolides, lincosamides and streptogramins (J01F) (+1.9 DID from 2017-19) and other antibacterials (J01X) (+0.047 DID from 2017-19)
- The most consumed antibacterial for systemic use in 2019 by ATC level 5 was amoxicillin (J01CA04) (9.2 DID, 28.3% of J01) (Figure A1.3).

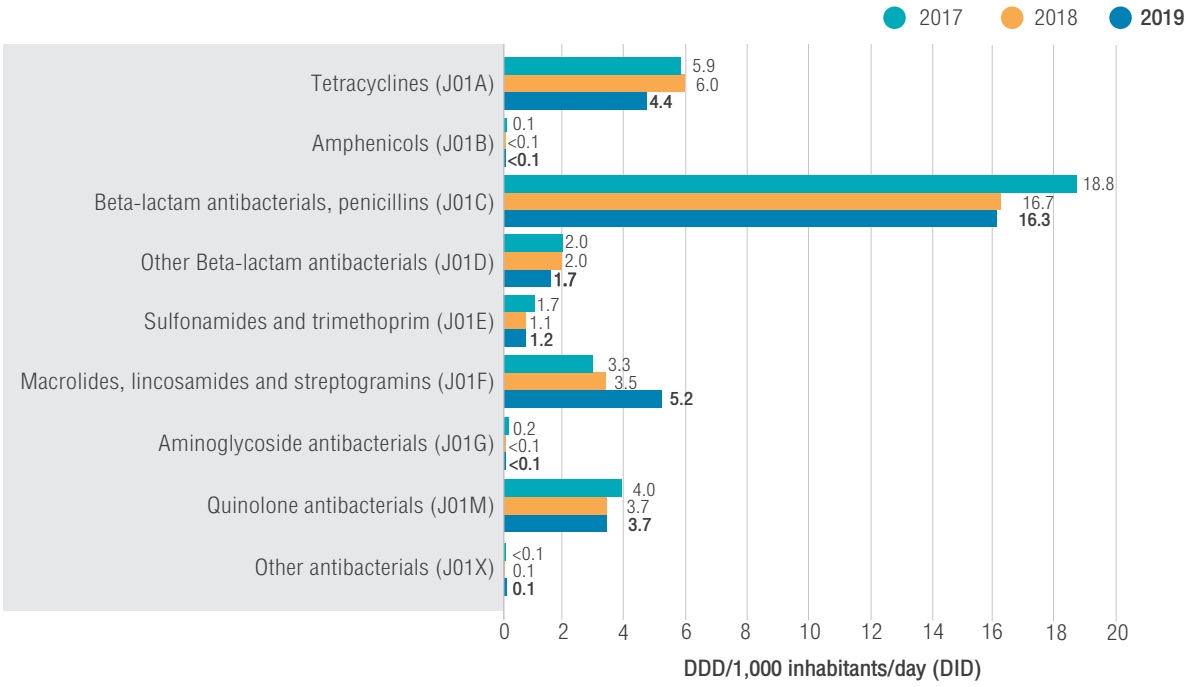


Figure A1.2 Consumption of human antimicrobials indicated for systemic use (J01) classified by ATC level 3, (DDD/1,000 inhabitants/day, DID), 2019 compared with 2017 and 2018

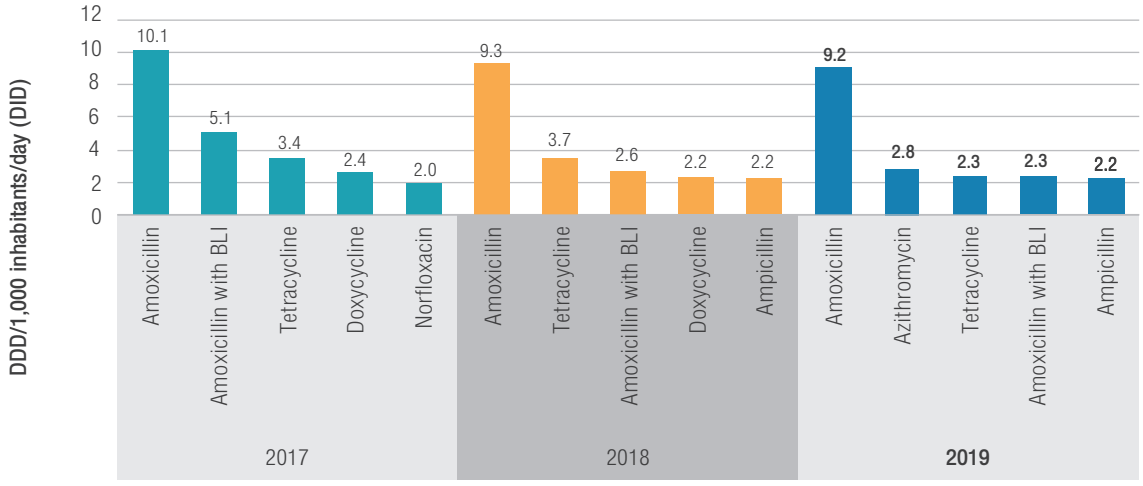


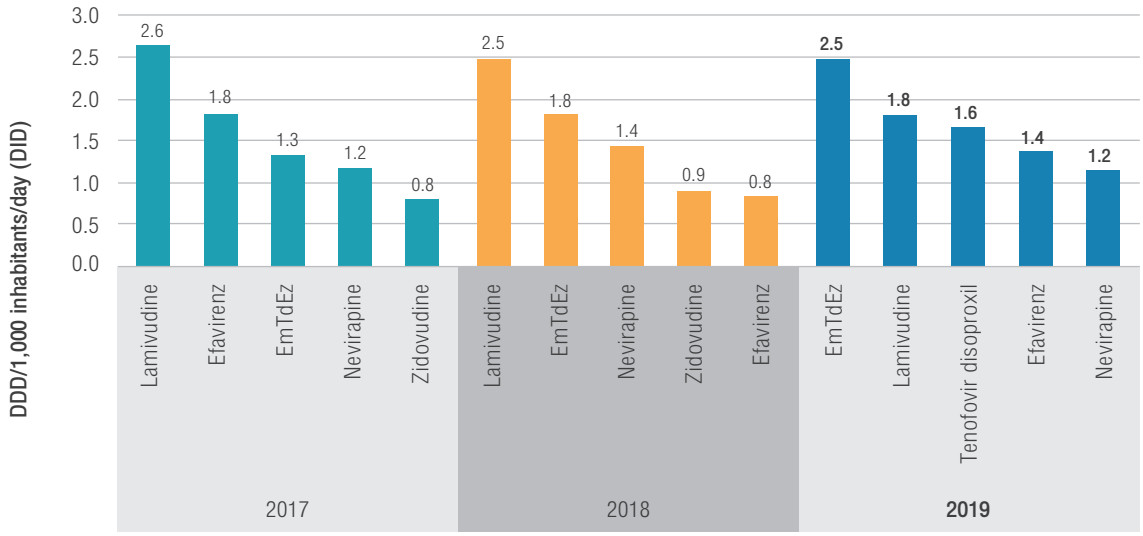
Figure A1.3 Consumption of the top-five antibacterials indicated for systemic use (J01) classified by ATC level 5 (DDD/1,000 inhabitants/day, DID), 2019 compared with 2017 and 2018

Consumption of the other core classes overall

- As the second rank in core class, nitroimidazole derivatives (P01AB) were decreased to 0.4 DID (-0.2 DID from 2017-19) (Figure A1.1). The most consumed nitroimidazole in 2019 by ATC level 5 was metronidazole (P01AB01) (0.4 DID, 95.0% of P01AB consumption. The intestinal anti-infectives (A07AA) were consumed with annual fluctuations. The intestinal anti-infective most consumed in 2019 by ATC level 5 was nystatin (A07AA02) (<0.1 DID, 78.8 % of A07AA consumption).
- Antivirals for systemic use (J05) (ranked second in overall consumption and first in the optional class) have been increasingly consumed to 13.0 DID (+3.4 DID from 2017-19). Overall, the major increase came from antivirals for treatment of HIV infections, combinations (J05AR) (+2.0 DID from 2017-19), which contributed to >20% of J05 consumption for the three years. This increase was also reinforced by nucleoside and nucleotide reverse transcriptase inhibitors (J05AR) (+1.4 DID from 2017-19).

Consumption of the top-five antimicrobials in the optional classes classified by ATC level 5

- For antivirals for systemic use (J05), the most consumed antiviral in 2019 was the combination of emtricitabine, tenofovir disoproxil and efavirenz (J05AR06) (2.5 DID, 18.9% of J05 consumption) (Figure A1.4). Lamivudine ranked second in 2019 (1.8 DID, 13.9% of J05 consumption), and remained in the top-three antivirals consumed from 2017 to 2019, despite decreases in consumption over the years.



EmTdEz = Emtricitabine, tenofovir disproxia and efavirenz

Figure A1.4 Consumption of the top-five antivirals indicated for systemic use (J05) classified by ATC level 5 (DDD/1,000 inhabitants/day, DID), 2019 compared with 2017 and 2018

- For antimycotics (J02) and antifungals for systemic use (D01BA), ketoconazole (J02AB02), an antimycotic for systemic infections, ranked first from 2017 to 2019 with annual fluctuations (Figure A1.5). Second rank for the three years, griseofulvin (D01BA01), an antifungal for systemic use, was consumed 0.4 DID in 2019 with fluctuations. The other two antimycotics, which remained top-five from 2017 to 2019 were fluconazole and itraconazole.

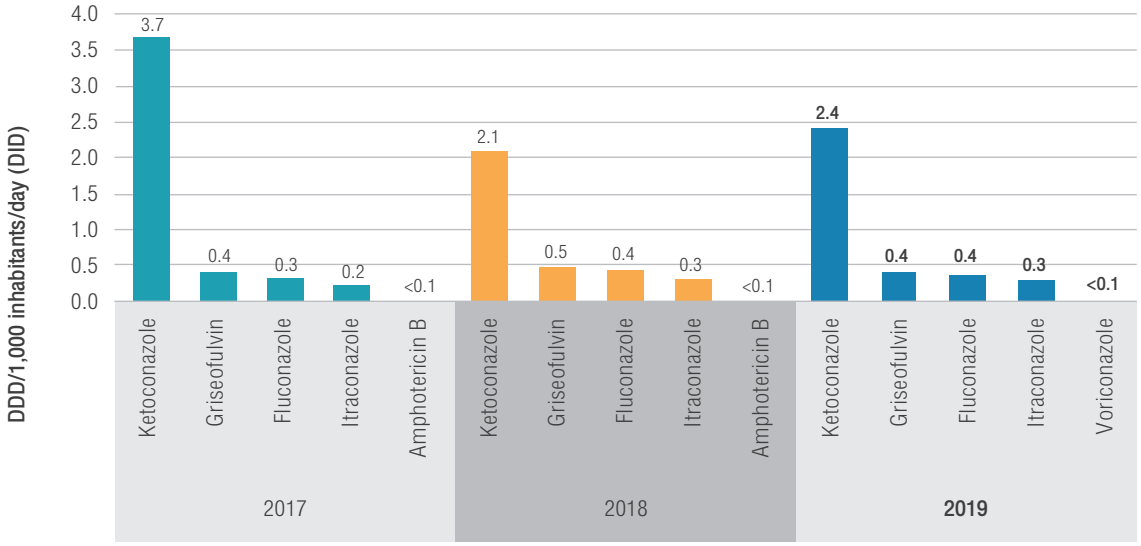


Figure A1.5 Consumption of the top-five antimycotics (J02) and antifungals for systemic use (D01BA) classified by ATC level 5 (DDD/1,000 inhabitants/day, DID), 2019 compared with 2017 and 2018

- From 2017 to 2019, the top-two antituberculous drugs remained isoniazid (INH) (>30% of J04A consumption) and rifampicin (RIF)(>25% of J04A consumption)(Figure A1.6). Isoniazid was consumed 0.8 DID constantly from 2017 to 2019, but with adecrease in 2019. Rifampicin was consumed 0.4 DID in 2019 with fluctuations from 2017-19. Pyrazinamide (PZA) and ethambutol (EMB) also remained among the top five antituberculous drugs from 2017 and 2019.

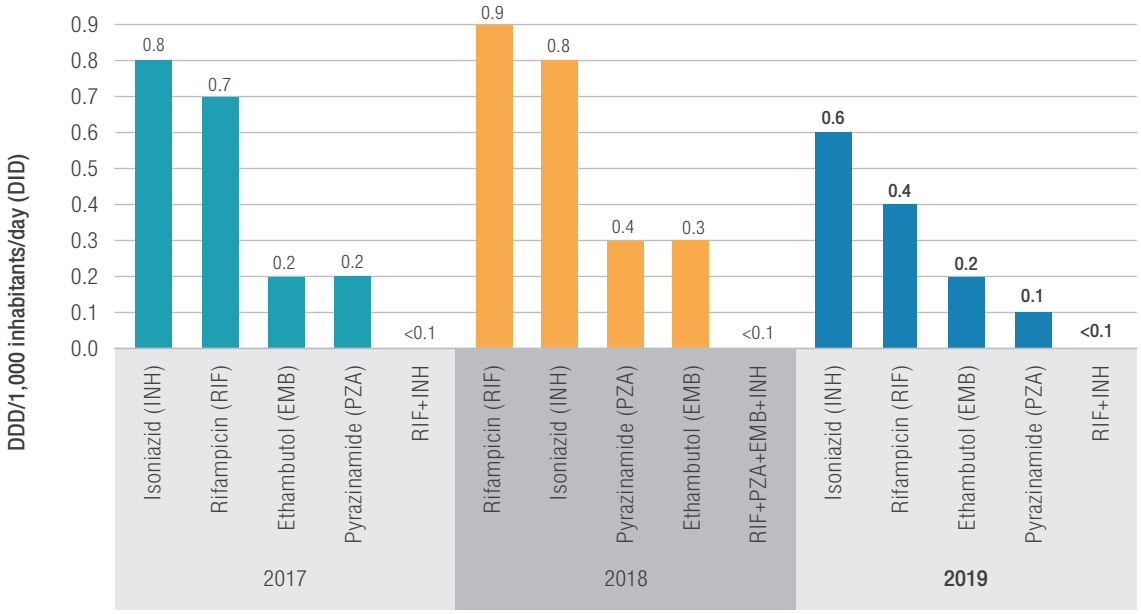


Figure A1.6 Consumption of the top-five antituberculous drugs for systemic use (J04A) classified by ATC level 5 (DDD/1,000 inhabitants/day, DID), 2019 compared with 2017 and 2018

A1.3 Consumption of Critically Important Antimicrobials (CIA)

- Non-CIA was the majority of human antimicrobials consumption from 2017 to 2019. Regarding the proportion of CIA consumption, the highest priority CIA tended to increase over time from 7.4 DID (13.5%) in 2017 to 9.1 (17.7%) of total in 2019 (Figure A1.7).

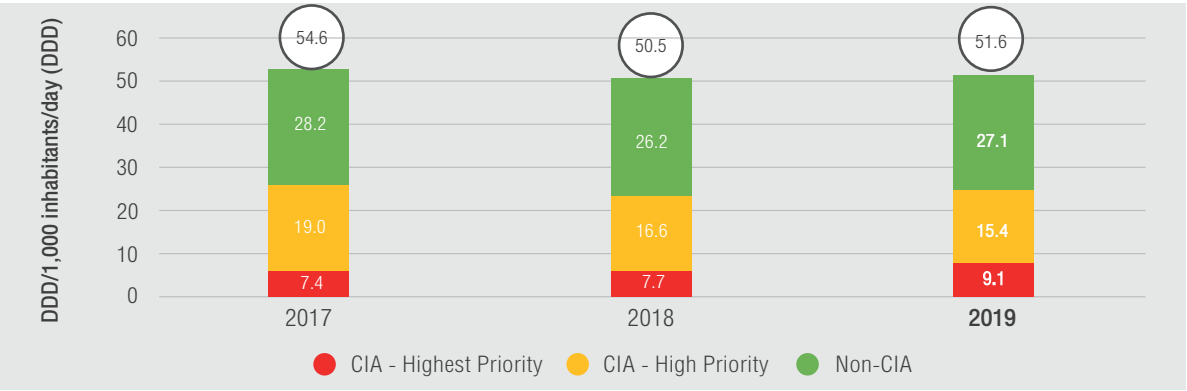
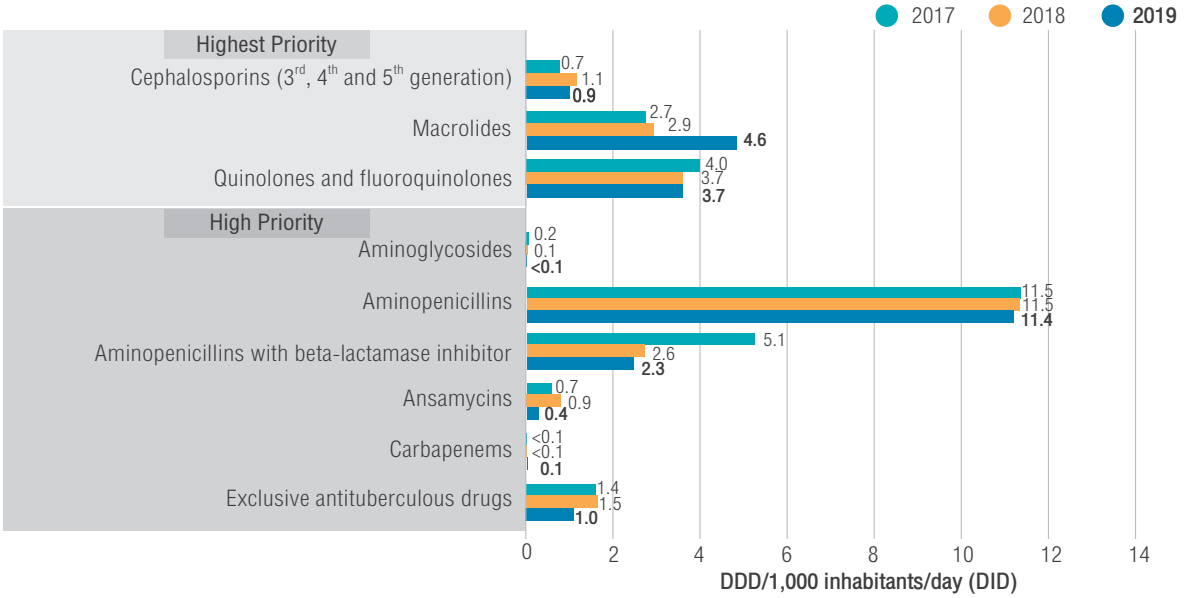


Figure A1.7 Comparative proportional consumption profile of Critically Important Antimicrobials (CIA) in humans from 2017 to 2019 (Non-CIA includes other antimicrobials in the scope of study, which are not categorized as CIA)

- In the highest priority CIA, the major contributor to the increase was macrolides and ketolides (+1.9 DID from 2017-19), and high-generation cephalosporins (3rd, 4th and 5th generation) (+ 0.2 DID from 2017-19) (Figure A1.8) The two main macrolides and ketolides consumed were azithromycin and roxithromycin. For high-generation cephalosporins, the two main antimicrobials were ceftriaxone and cefixime.
- In contrast to highest priority CIA, the consumption of the high priority CIA has decreased from 19.0 DID in 2017 to 15.4 DID in 2019 (Figure A1.7). The major contributors for this decrease were aminopenicillins with beta-lactamase inhibitor (BLI), ansamycins, and exclusive antituberculous drugs. Amoxicillin with BLI was the CIA in this priority with highest decrease. The major contributor to the decrease in high-priority CIA was amoxicillin with BLI (Figure A1.8).



Antimicrobial classes with <0.1 DID from 2017 to 2019 were not shown (polymyxins, glycopeptides and lipoglycopeptides for highest priority, antipseudomonal penicillins, phosphonic acid derivatives, glycylcyclines, and oxazolidinones for high priority).

Figure A1.8 Consumption of Critically Important Antimicrobials classified by class of antimicrobials, 2019 compared with 2017 and 2018

A1.4 Consumption of Antimicrobials on AWaRe List

- Classified by WHO Access, Watch, Reserve classification of antibiotics (AWaRe), the access group (A) is still the main group of antibacterials consummed, followed by the watch group (Wa) (Figure A1.9). The consumption of antimicrobials on the access list has decreased from 26.4 to 20.4 DID (-22.6% from 2017-19). On the other hand, the consumption on the watch has increased from 8.8 to 10.1 DID (+14.9% from 2017 to 2019) as well as on the reserved list (Re) (+63.0% from 2017-19), even if the latter was consumed less than 0.1 DID from 2017 to 2019.

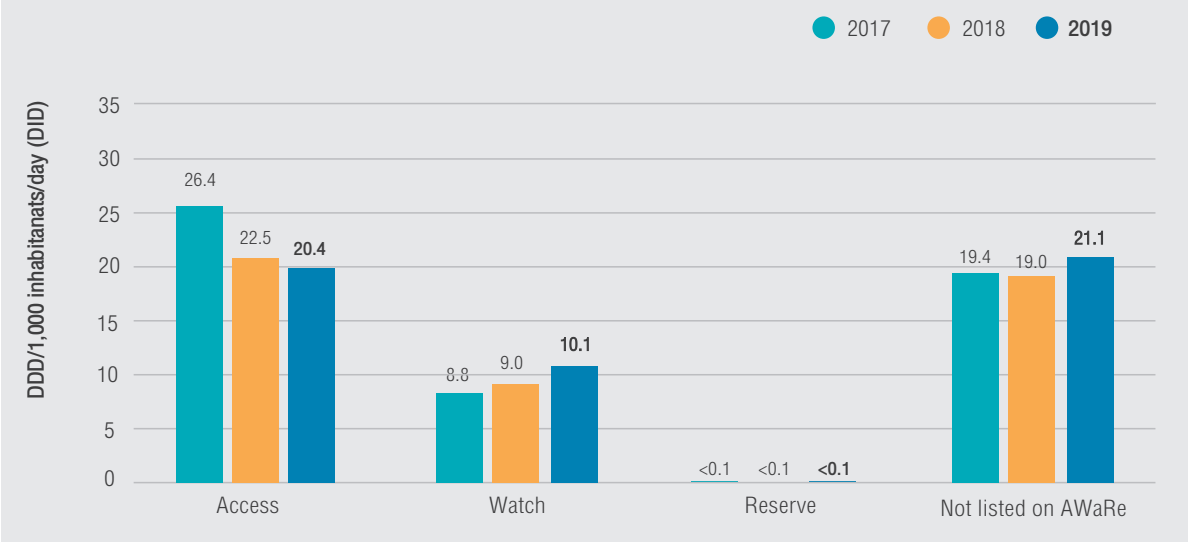


Figure A1.9 Consumption of antimicrobials by AWaRe classification from 2017 to 2019 (excluding antimicrobials by ATC level 5 not listed or recommended by AWaRe classification)

- On the watch list, the most concerning antimicrobial was azithromycin, which has been increasingly consumed from 0.5 DID in 2017 to 2.8 DID in 2019 (Figure A1.10). The other three antimicrobials remaining in the top five from 2017-19 were criprofloxacin, norfloxacin and roxithromycin.

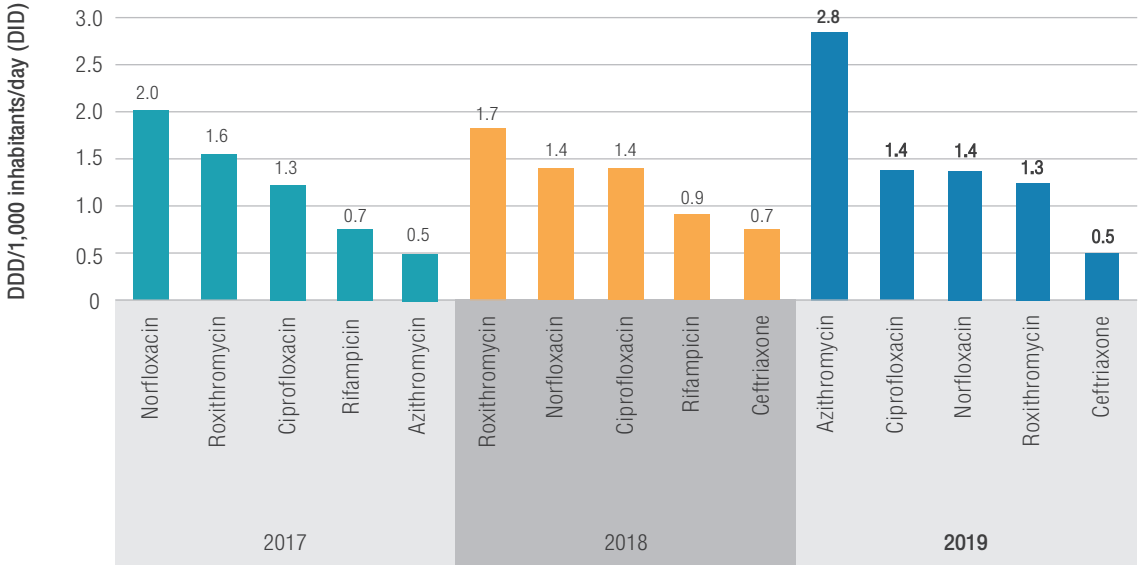
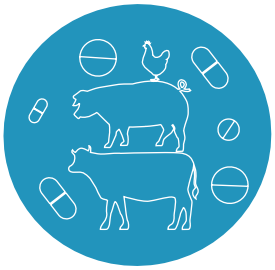


Figure A1.10 Consumption of top five antimicrobials on the Watch list by AWaRe classification from 2017 to 2019

A2: Antimicrobial Consumption in Food-producing Animals



A2.1 Overall consumption

- Overall, the numerator (tonnes of active pharmaceutical ingredient (API)) tended to decrease while the denominator (estimated food-producing animal population) was likely to increase (Figure A2.1). From 2017 to 2019, the amount of API consumed in food-producing animals decreased by 41.1% while the Population Correction Unit modified by Thailand's methodology ($PCU_{Thailand}$) in 2019 increased by 15.3%, from estimated terrestrial food-producing animals (14.9% increase) and projected aquatic animals (18.6% increase). As a result, the national consumption indicator in 2019 was 336.3 mg/$PCU_{Thailand}$, which decreased by 35.6% from 2018, and by 49.0% from 2017.
- The majority of consumption in 2019 still belonged to antibacterials for systemic use (QJ01; 82.8%), followed by intestinal anti-infectives (QA07; 17.2%). Hence, the 49.0% decrease in the national indicator was derived from decreases in QA07 by 36.0% and QJ01 by 51.0% from 2017 to 2019. For the minority group of consumption (QG01, QG51, and QJ51; <0.1% each), the same decreasing pattern was also found.

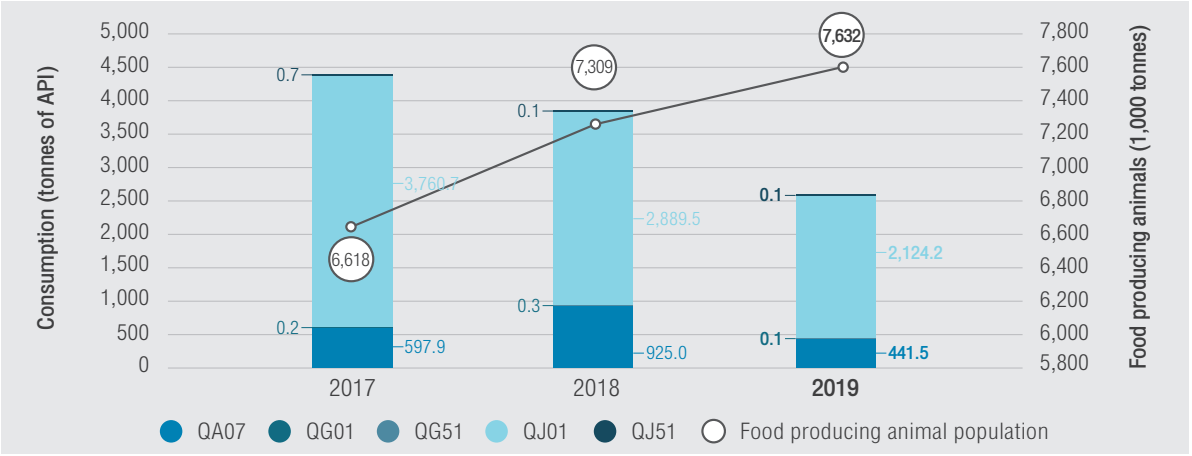


Figure A2.1 Consumption of veterinary antimicrobials classified by Anatomical Therapeutic Chemical classification system for veterinary medicinal products (ATCvet) code, 2019 compared with 2017 and 2018

A2.2 Consumption breakdown by chemical class of antimicrobials and dosage form

Consumption by ATC vet code

- When comparing antibacterials for systemic use (QJ01) from 2017 to 2019, the most consumed QJ01 profile had shifted from dominance of macrolides (QJ01F) and sulfonamides (QJ01E) in 2017 to penicillins (QJ01C) and tetracyclines (QJ01A) in 2018 and 2019 (Figure A2.2).
- The majority of QJ01 consumption came from QJ01C (45.8%), followed by QJ01A (22.4% and other antibacterials (QJ01X) (13.4%). However, the decrease in QJ01 came from decreases in QJ01E and QJ01F.
- The most consumed of antibacterials in QJ01C was amoxicillin (QJ01CA04) (125.1 mg/$PCU_{Thailand}$, 98.2% of QJ01C consumption). The second rank was procaine benzylpenicillin (QJ01CE09) (1.2 mg/$PCU_{Thailand}$, 1.0% QJ01C consumption).

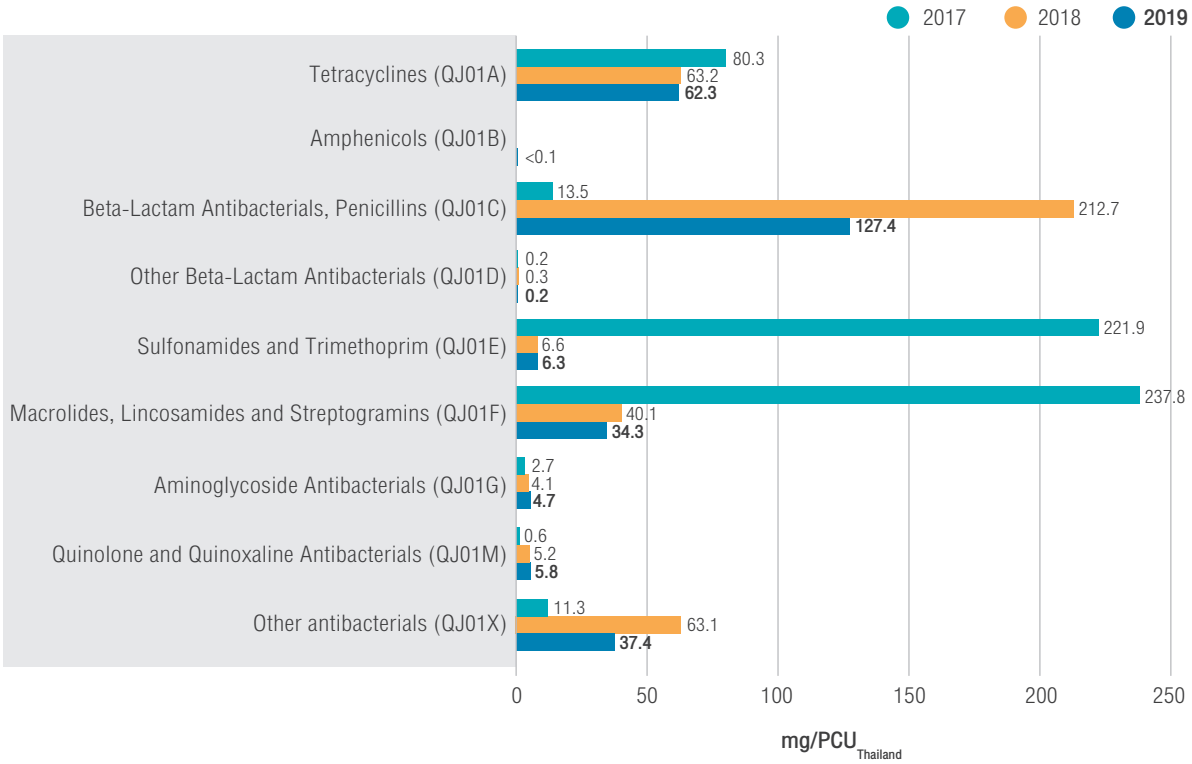
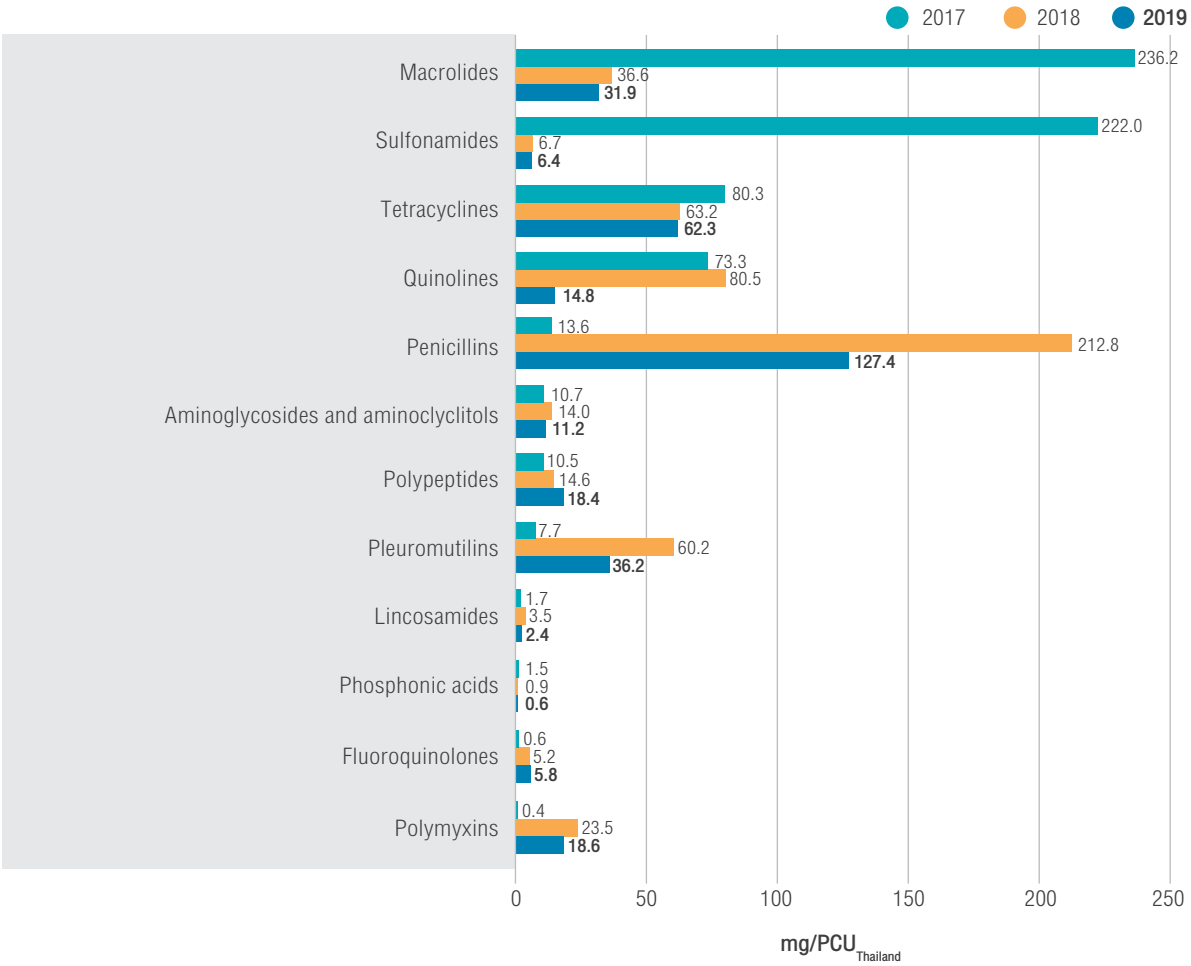


Figure A2.2 Consumption of veterinary antimicrobials indicated for systemic use classified by ATC level 3, 2019 compared with 2017 and 2018

Consumption by chemical class

- Comparing consumption profiles by chemical class from 2017 to 2019, the profile was shifted from macrolides-in 2017 to penicillins-dominant consumption in 2018-19 (Figure A2.3). The most proportional differences from 2017 to 2019 were found in polymyxins (+18.1 mg/$PCU_{Thailand}$) and fluoroquinolones (+5.2 mg/$PCU_{Thailand}$) and penicillins (+113.8 mg/$PCU_{Thailand}$).
- However, when compared with 2017, the two antimicrobial classes with most decrease in proportional consumption in 2019 were sulfonamides (-215.6 mg/PCUThailand) and macrolides (-204.3 mg/$PCU_{Thailand}$). Both of these antimicrobial classes were the top two classes with highest consumption in 2017.
- The most fluctuation in veterinary antimicrobial consumption was polymyxins, solely from colistin due to an increase in 2018 (+23.0 mg/$PCU_{Thailand}$) and a decrease in 2019 (-4.9 mg/$PCU_{Thailand}$).



*Antimicrobial classes with less than 0.5 mg/PCUThailand (amphenicols, cephalosporins, orthosomycins and phosphoglycolipids) were not shown.

Figure A2.3 Consumption of veterinary antimicrobials by class of antimicrobials, from 2017 to 2019*

Consumption by route of administration and pharmaceutical dosage form

- Classified by route of administration and dosage form, the profiles of 2017-19 were similar in that premix was the main dosage form (94.5%, 59.1%, and 61.9%, respectively) (Figure A2.4). The top five antimicrobials used as premix for medicated feeding stuff were changed in rank over time, but the list of top ten antimicrobials almost remained the same, except for the second rank in 2017, sulfadimidine (Figure A.2.5).
- As the second route and dosage form with increasing trend in proportion, oral powder was consumed more than 80% in the form of powder for use in drinking water, mainly from amoxicillin for the three consecutive years. One type of oral powder with anincrease in proportion was powder for use in drinking water/milk, mainly from amoxicillin (>95% from 2017-19).
- Injection dosage form was consistently ranked third in proportion from 2017 to 2019 (1.6%, 2.9%, and 4.3% of total, respectively). From 2017 to 2019, the main pharmaceutical dosage forms in this group were suspension (>50.0%) and solution (>20.0%). The top-three mainan timicrobials in injectable suspension from 2017 to 2019 remained amoxicillin, dihydrostreptomycin, and procaine benzylpenicillin, respectively. For injectable solution, oxytetracycline and enrofloxacin remained among the top five from 2017 to 2019.

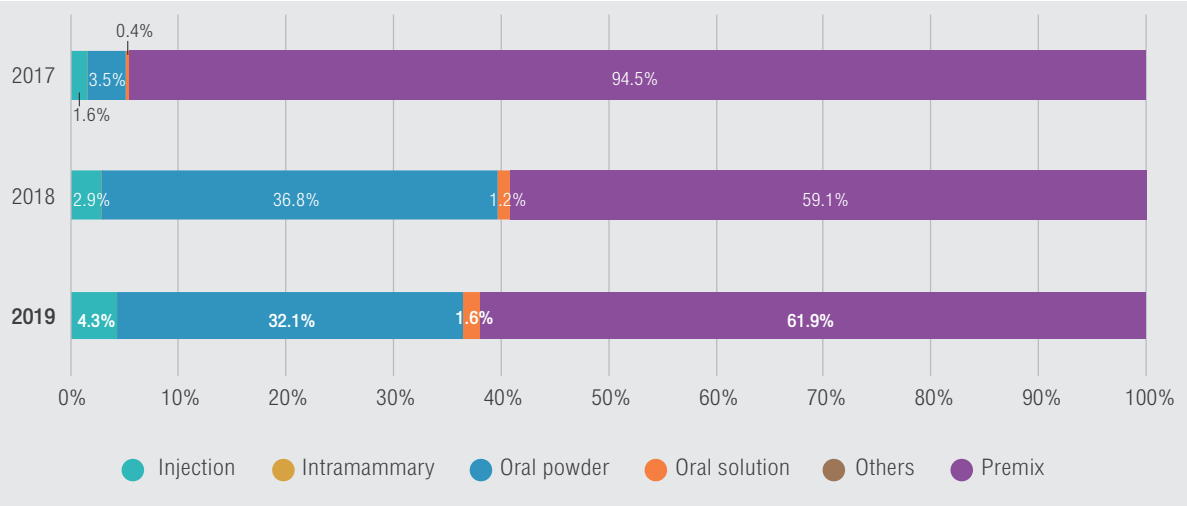


Figure A2.4 Proportional consumption of veterinary antimicrobials by route of administration and pharmaceutical dosage form: 2019 compared with 2017 and 2018 (intramammary and others accounted for <0.1% each from 2017 to 2019)

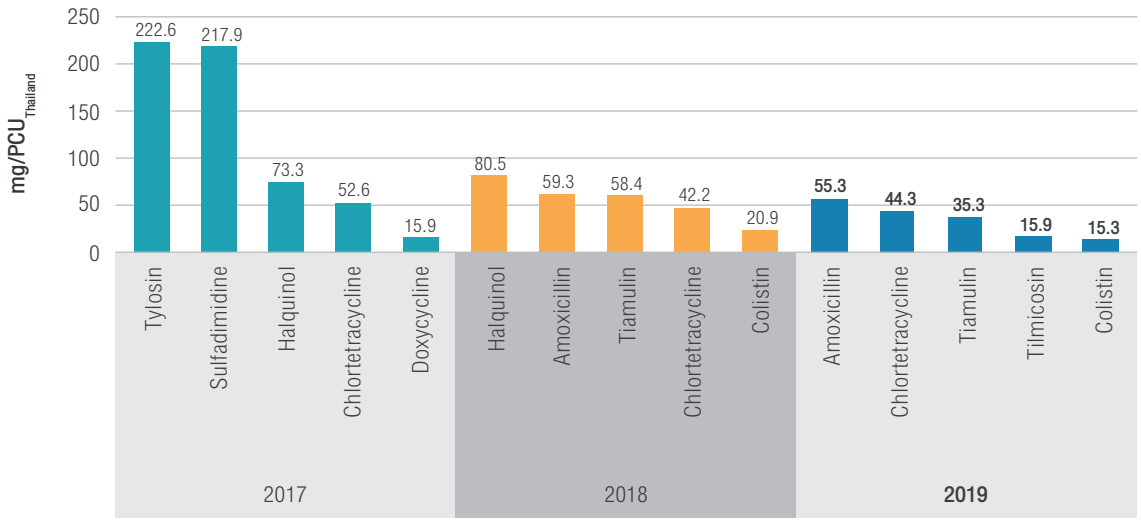


Figure A2.5 Consumption of top five veterinary antimicrobials used as medicated premix, 2019 compared with 2017 and 2018

A2.3 Consumption of Critically Important Antimicrobials (CIA)

- Overall, the consumption profile was shifted to more proportion of CIA in 2018 and 2019 (Figure A2.6). It was due to the fact that the consumption of CIA increased by 11.6% (from 2017-18) and decreased by 33.2% (from 2018-19), but highly important antimicrobials decreased by 76.1% (from 2017-19). Moreover, the proportion of CIA consumption was changed from highest to high priority.
- For highest priority CIA, the consumption had decreased over the three years (Figure A2.6). The decreasing trend was derived from constant drops in macrolide consumption, mainly from tylosin (Figure A2.7). Ranked second in proportion of highest priority CIA, polymyxins had a fluctuation, solely from colistin.
- For high priority CIA, the consumption had increased overall (Figure A2.6). The main contributing class to this increase was aminopenicillins, mainly from amoxicillin (Figure A2.7). The second rank in this priority with similar trend was aminoglycosides, mainly from neomycin and kanamycin.

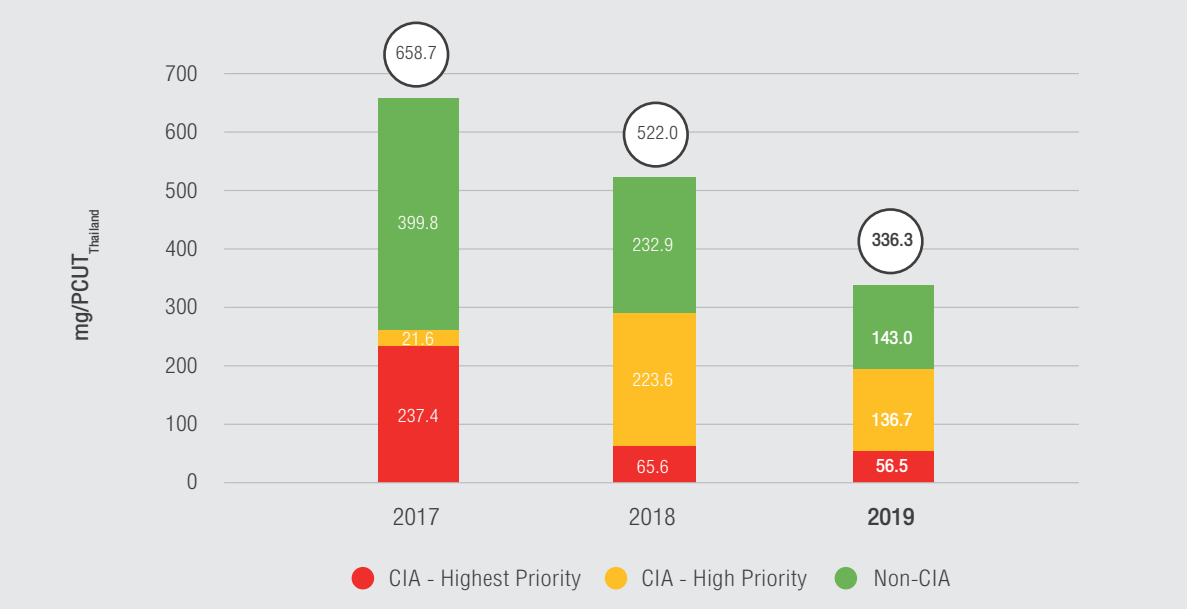


Figure A2.6 Comparative proportional consumption profile of critically important antimicrobials in food-producing animals from 2017 to 2019

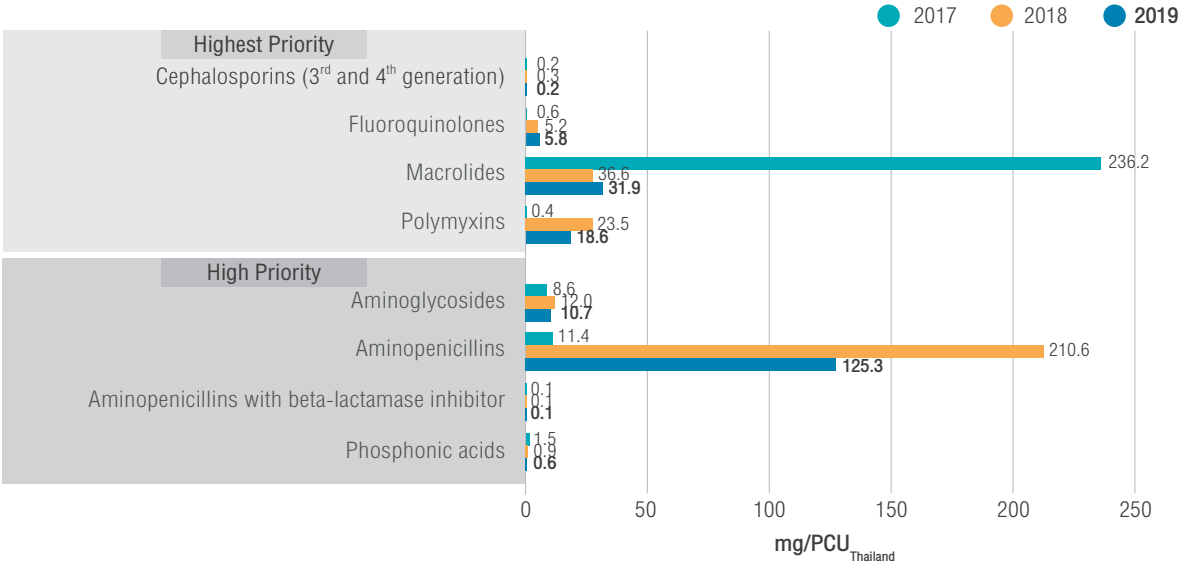


Figure A2.7 Consumption profile of CIA in food-producing animals from 2017 to 2019

- Comparing consumption profiles of CIA between humans and food-producing animals in 2019, food-producing animals consumed CIA overall more than humans by 45.7% (1,474.6 vs 800.8 tonnes), mainly as high priority CIA (more than humans by 38.9%, or 1,043.6 vs 637.8 tonnes) (Figure A2.8). For highest priority CIA, humans mainly consumed fluoroquinolones (78.4 tonnes) and cephalosporins (3rd, 4th and 5th generation) (42.4 tonnes) while food-producing animals consumed polymyxins (141.8 tonnes of API) and macrolides (243.3 tonnes).
- Regarding high priority CIA, humans consumed aminopenicillins with BLI (92.3 tonnes) more than food-producing animals (1.1 tonnes), and some other human-exclusive antimicrobials (oxazolidinones, ansamycins, antipseudomonal penicillins, carbapenems, exclusive antituberculous drugs, and glycylcyclines). Food-producing animals consumed aminopenicillins and aminoglycosides more than humans. The antimicrobial class with least difference was phosphonic acid derivatives, solely from fosfomycin in both humans and food-producing animals.

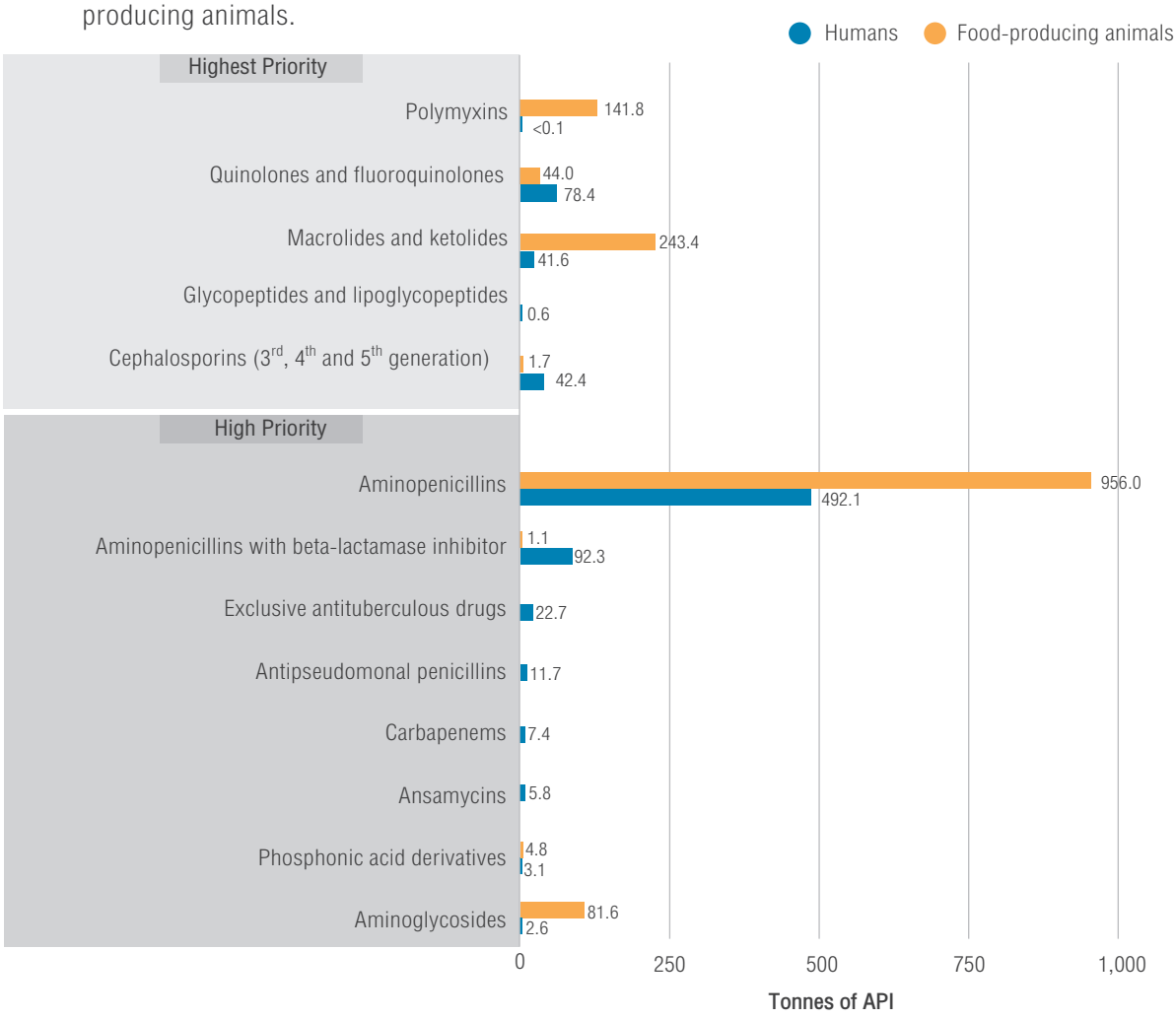


Figure A2.8 Comparative profile of CIA consumption between humans and food-producing animals in 2019

*Glycylcyclines and oxazolidinones were not shown due to their consumption less than 0.1 tonnes of API and only consumption in humans; 5th generation cephalosporins, glycopeptides and lipoglycopeptides, ansamycins, antipseudomonal penicillins, carbapenems, and exclusive antituberculous drugs were not registered for animals in Thailand.

A3: Antimicrobial Consumption in Food-producing Animals through Medicated Feed Produced by Feed mills

A3.1 Overall consumption

- Total annual feed produced in 2019 was 880,938.9 tonnes, of which 31.1% was medicated feed.
- Classified by ATC vet code level 2 and animal species, pigs mostly consumed antibacterials for systematic (QJ01) (792.4 tonnes, 75.0%) and for intestinal infections (QA07) (263.5 tonnes, 25.0%). Poultry, on the other hand, equally consumed QJ01 (9.1 tonnes, 49.3%) and QA07 (9.4 tonnes, 50.7%) (Figure A3.1).

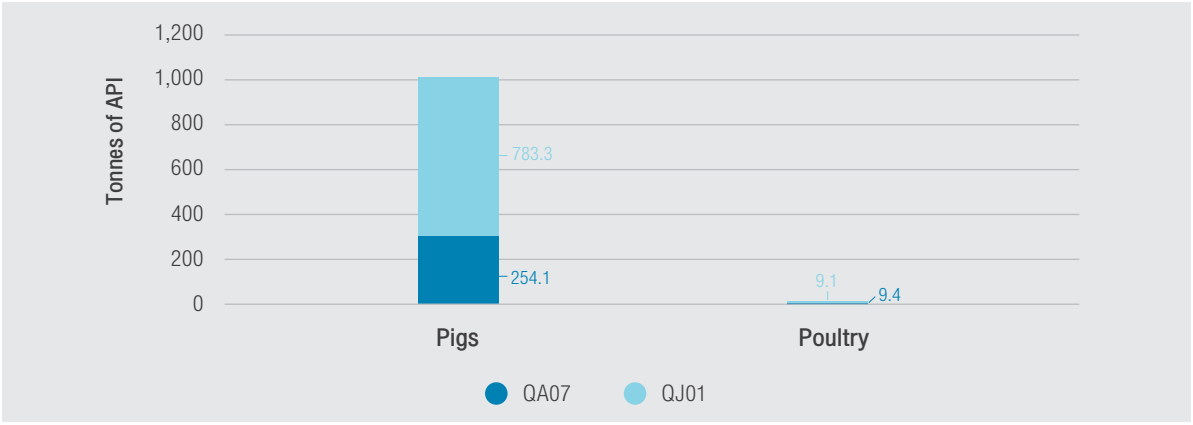


Figure A3.1 Antibacterial consumption through medicated feed by ATC vet code level 2 and animal species

A3.2 Consumption by chemical class of antibacterials and animal species

- Consumption profiles in medicated feed of pigs and poultry were different in the profile of chemical class (Figure A3.2).
- Of pigs' antibacterial consumption in medicated feed, the top-three antibacterial classes were penicillins (350.0 tonnes, 33.7%), pleuromutilins (211.0 tonnes, 20.3%), and quinolines (180.7 tonnes, 17.4%). Piglets weighing less than 25 kg consumed the majority of the top three antimicrobials in pigs (180.0 tonnes of penicillins or 51.4%, 117.4 tonnes of pleuromutilins or 55.6%, and 150.8 tonnes of quinolines or 83.5%). Amoxicillin was the most common penicillin consumed by piglets (179.6 tonnes, 51.4%), pig breeders (96.9 tonnes, 27.7%) and fattening pigs (73.1 tonnes, 20.9%).
- For poultry antibacterial consumption in medicated feed, the top three antibacterials were polypeptides (9.0 tonnes, 49%), penicillins (5.4 tonnes, 29.1%), and macrolides (3.2 tonnes, 17.3%). Comparing consumption in poultry, broiler breeders consumed antibacterials the most (10.0 tonnes, 54% of poultry consumption), and mainly consumed penicillins (4.6 tonnes, 86.2% of penicillin consumption in poultry), macrolides (2.9 tonnes, 90.2% of macrolide consumption in poultry). However, bacitracin, as the sole polypeptides, was consumed most by broilers (5.1 tonnes, 56.6%), followed by broiler breeders (2.3 tonnes, 24.9%).

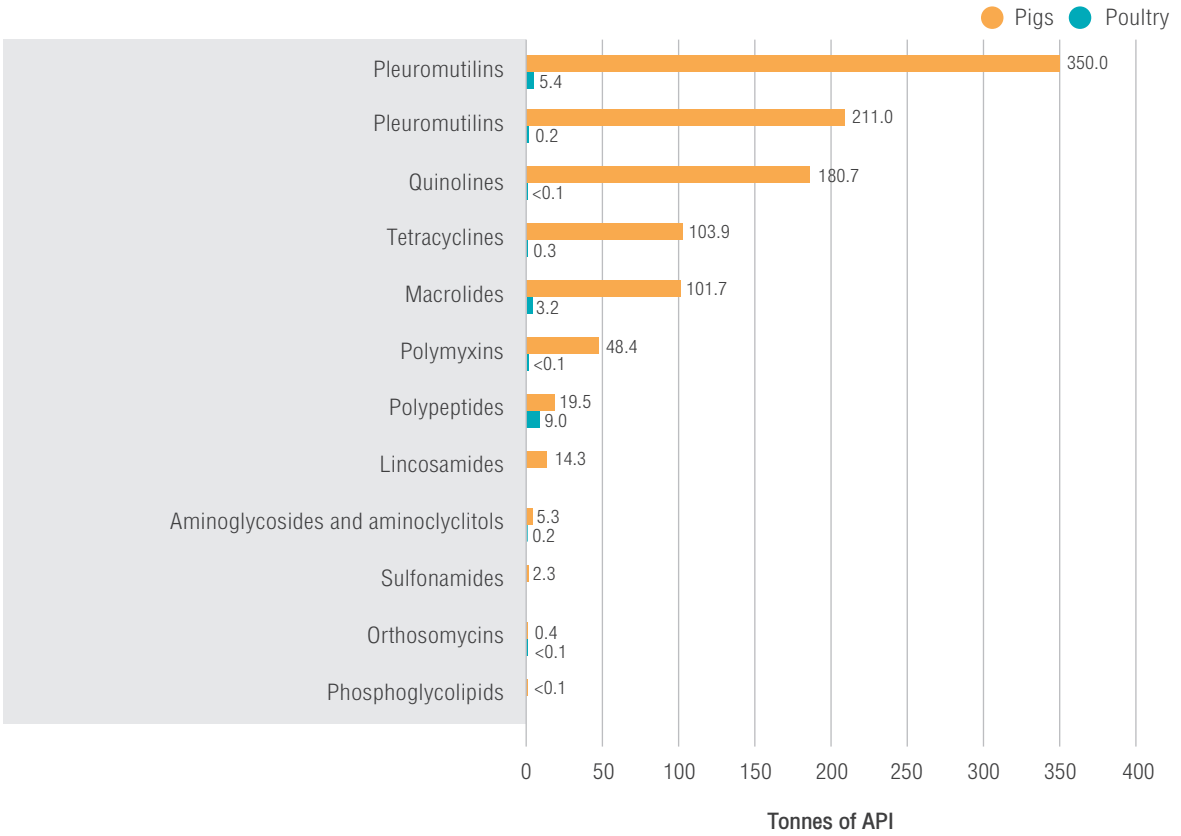


Figure A3.2 Antibacterial consumption through medicated feed in feed mills by chemical class and animal species

A3.3 Consumption of Critically Important Antimicrobials by animal species

- Classified by human CIA, the consumption profiles through medicated feed in feed mills between pigs and poultry were similar. Pigs mainly consumed CIAs at 505.0 tonnes (48.7%) and important antimicrobials at 230.5 tonnes (22.2%) while poultry principally consumed important antimicrobials at 9.3 tonnes (50.2%), and CIAs at 8.8 tonnes (47.5%) (Figure A3.3).
- Regarding CIAs consumed in medicated feed, pigs consumed high priority (354.9 tonnes, 70.3%) more than highest priority CIA (150.1 tonnes, 29.7%). More than half of the highest priority CIA consumed in pigs were tilmicosin (54.8 tonnes), colistin (48.4 tonnes), and tylosin (32.7 tonnes). Piglets consumed the three antimicrobials most (42.3% of tilmicosin, 70% of colistin, and 78.9% of tylosin in pigs). As for high priority CIA, amoxicillin was the antimicrobial most consumed (349.6 tonnes, 98.5% of high priority CIA), mainly by piglets (179.6 tonnes, 51.4%) and pig breeders (96.9 tonnes, 27.7%)
- Poultry consumed CIA high priority (5.6 tonnes, 63.5%) more than highest priority CIA (3.2 tonnes, 36.5%). The most consumed antimicrobials in the highest priority CIA were tylosin (2.9 tonnes) and tylvalosin (0.3 tonnes). Broiler breeders consumed most of the two antimicrobials (93.8% of tylosin and 55.5% of tylvalosin in poultry). For high priority CIA, amoxicillin was consumed most (5.4 tonnes, 96.4%) and most of it was consumed by broiler breeders (4.6 tonnes, 86.2%) and layers (0.7 tonnes, 13.8%).

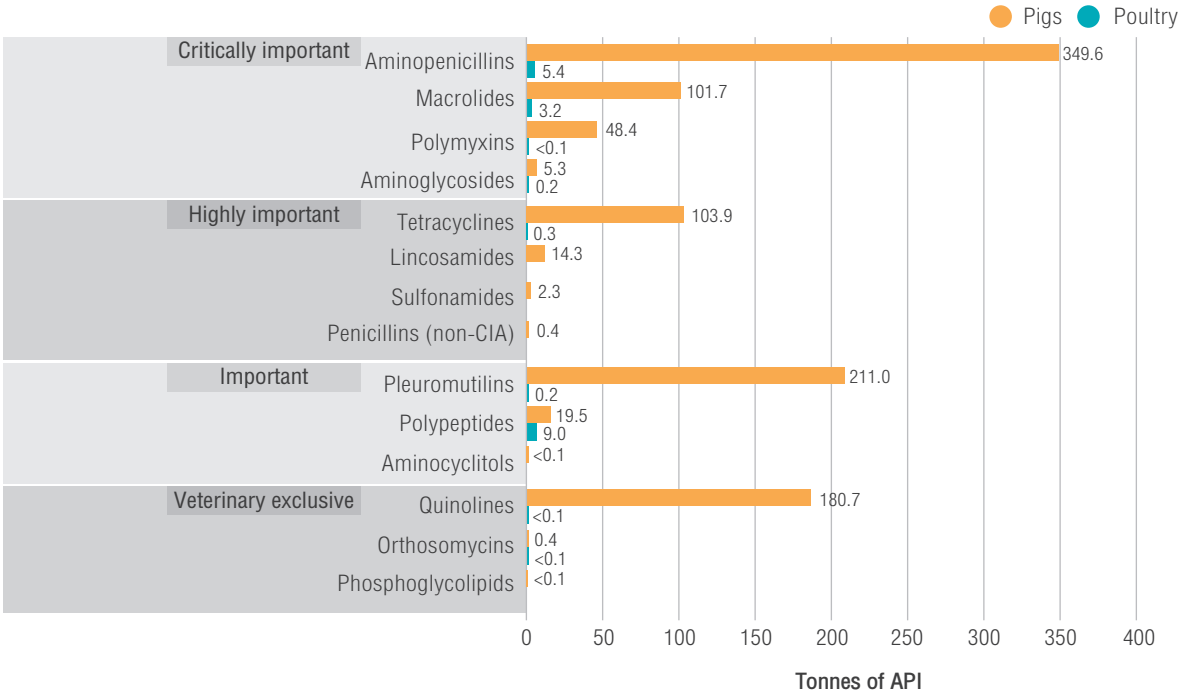


Figure A3.3 Consumption of CIAs through medicated feed in feed mills by chemical class and animal species

SECTION B

ANTIMICROBIAL RESISTANCE

SECTION B:
ANTIMICROBIAL RESISTANCE

B1. Antimicrobial Resistance in Humans

B1.1 Gram-negative bacteria

***Acinetobacter calcoaceticus-baumannii* complex**[11]

- The proportion of carbapenem-resistant *A. calcoaceticus-baumannii* complex from 2017 to 2019 was steady at around 70.0%. Meanwhile, a decreasing trend in resistance was observed for ampicillin/sulbactam from 69.3% in 2018 to 67.0% in 2019 (-2.3%).
- The proportion of colistin resistant *A. calcoaceticus-baumannii* complex was 2.7% in 2019, increased from 2.4% in 2017 (+0.3%). In 2019, the minimum inhibitory concentration 90 (MIC90) of colistin was 2 mg/L as same as to MIC90 in 2018.

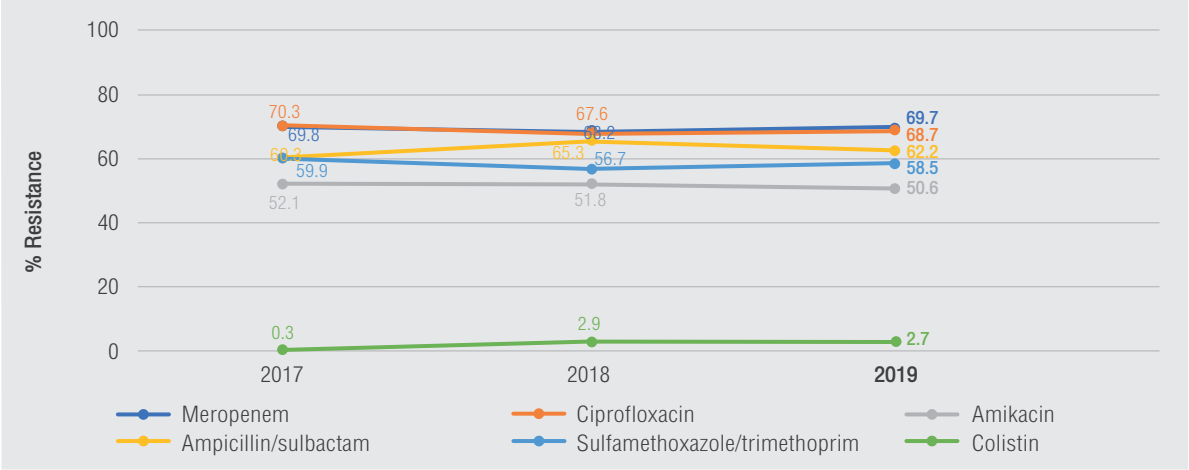
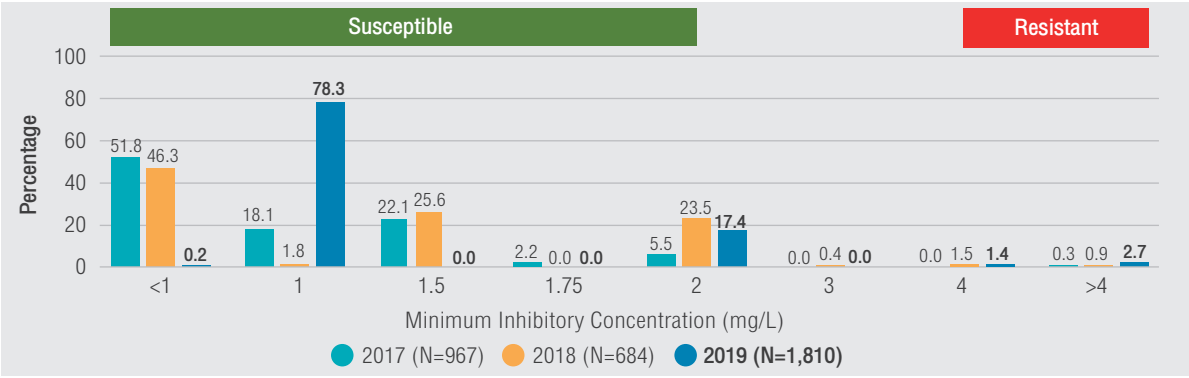


Figure B1.1 Resistance (%) among *Acinetobacter calcoaceticus-baumannii* complex (2017-2019)



Colistin MIC by Sensititre® (number of hospitals)	2017 (7)	2018 (6)	2019 (5)
MIC_{50} (mg/L)	<1.0	1.5	1.0
MIC_{90} (mg/L)	1.5	2.0	2.0

Figure B1.2 MIC distribution of colistin for *Acinetobacter calcoaceticus-baumannii* complex (2017-2019)

[11] *A. calcoaceticus-baumannii* complex is gram-negative, non-glucose fermenter bacteria that usually associated with hospital acquired infection especially in immunocompromised and critically ill patients. Multidrug-resistant *A. calcoaceticus-baumannii* complex has been in creasing and several studies have reported high morbidity and mortality ratesassociated with this organism. Given its higher prevalence in clinical specimenstested in laboratories where accurate species can be performed the majority of *A. Calcoaceticus-baumannii* complex is considered as *A. baumannii* in this report.

***Pseudomonas aeruginosa*[12]**

- Between 2017-2019, the proportion of carbapenem-resistant *P. aeruginosa* (CRPA) was approximately 19-19.9%, in which the proportion of imipenem-resistant *P. aeruginosa* increased from 19.8 % in 2018 to 25.2% in 2019 (+5.4%).
- CRPA isolates in 2019 were susceptible to ceftazidime, cefepime and piperacillin/tazobactam around 36.9%, 8.9%, and 36.8%, respectively.
- A considerably decreasing trend in colistin resistance was observed among isolates of *P. aeruginosa* from 5.8% in 2018 to 2.2% in 2019 (-3.6%). The colistin MIC90 value over the two-year period was steady at 2 mg/L in 2018 and 2019.

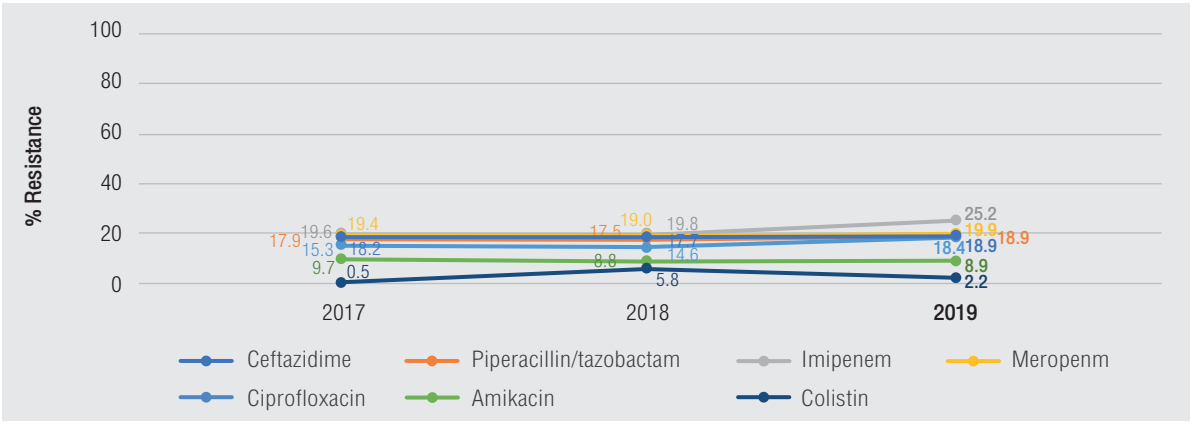


Figure B1.3 Resistance (%) among *Pseudomonas aeruginosa* (2017-2019)

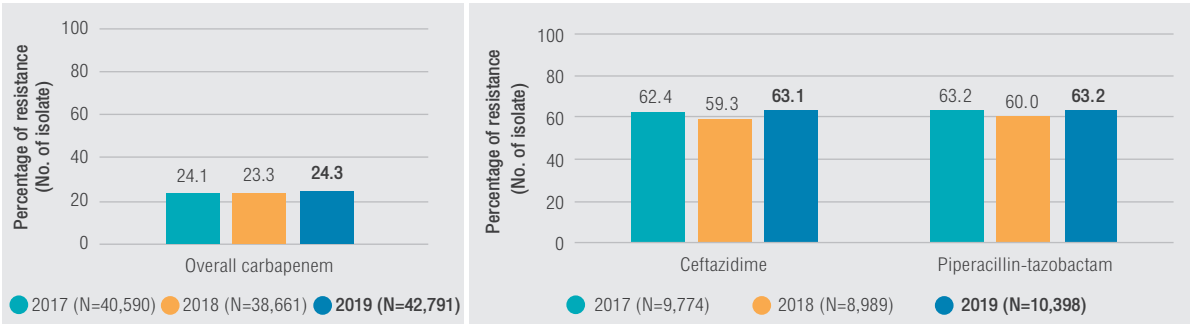
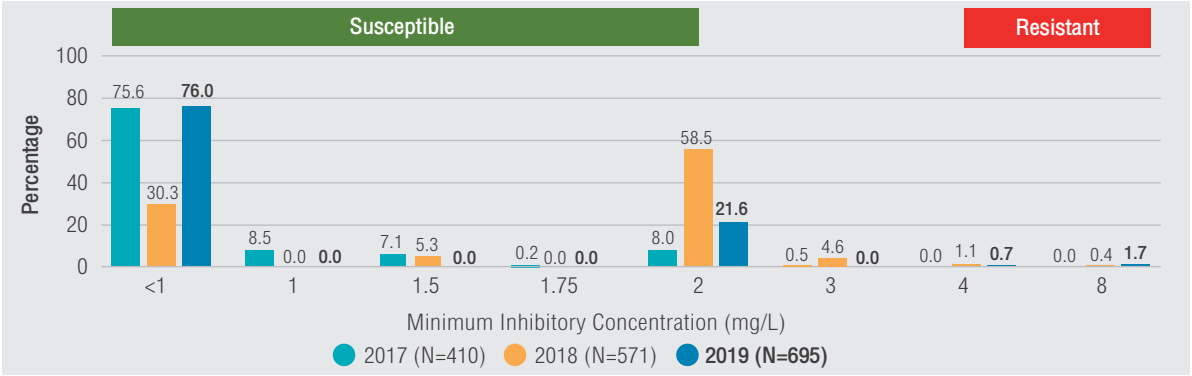


Figure B1.4 Resistance (%) among carbapenem-resistant *Pseudomonas aeruginosa* (2017-2019)



Colistin MIC by Sensititre® (number of hospitals)	2017 (7)	2018 (6)	2019 (5)
MIC_{50} (mg/L)	≤1.0	2.0	<1.0
MIC_{90} (mg/L)	1.5	2.0	2.0

Figure B1.5 MIC distribution of colistin for *Pseudomonas aeruginosa* (2017-2019)

[12] *P. aeruginosa* is gram-negative bacteria that has propensity to possess several mechanisms of drug resistance. In recent years, *P. aeruginosa* was identified as major pathogen causing nosocomial in fection. We should recognise the threat by this species in clinical and public health.

Escherichia coli[13]

- Between 2017 and 2019, the proportion of third-generation cephalosporin resistant *E. coli* slightly changed and accounted for 44% in 2017 and 43.5% in 2019. The percentage of ceftazidime resistance was between 34.3% and 36.0%.
- The proportion of fluoroquinolone-resistant *E. coli* in 2019 increased from 50.5% in 2018 to 60.4% in 2019 (+9.9%).
- Regarding carbapenem-resistant *Enterobacteriaceae* (CRE), *E. coli* resistance rate against carbapenems was low (<3.5%) in 2019 but it slightly increased over the three-year period.
- Of the total 1,600 *E. coli* isolates tested for colistin MIC, the majority of *E. coli* were still susceptible to colistin, having MIC90 of lower than ≤ 1 mg/L. However, the proportion of *E. coli* isolates with higher colistin MIC (non-wild type, ≥4 mg/L) was 2% in 2019.
- In 2019, more than half (54.3%) of urinary *E. coli* isolates were susceptible to cefazolin. In the era of antimicrobial resistance, transition to oral therapy is an opportunity for improvement in therapy. For *E. coli* isolated from urine, cefazolin was used as a surrogate for oral antimicrobial agent susceptibilities; e.g., cefaclor, cefdinir, cefpodoxime, cefuroxime, cephalexin, etc.

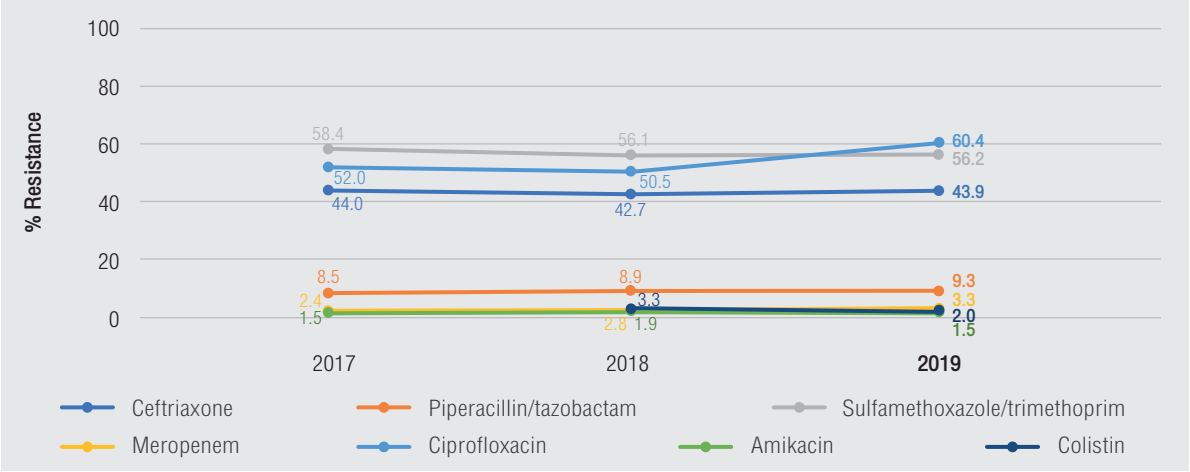
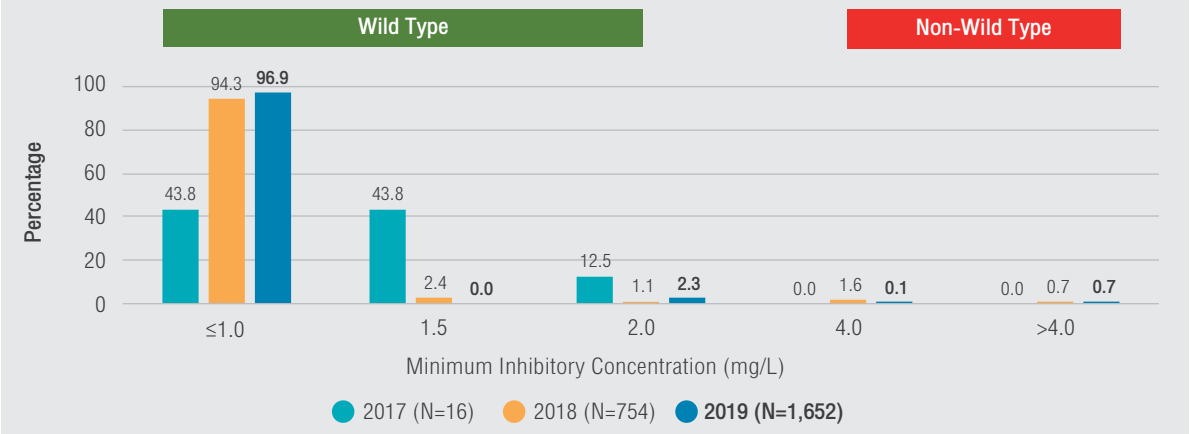


Figure B1.6 Resistance (%) among *Escherichia coli* (2017-2019)



Colistin MIC by Sensititre® (number of hospitals)	2017 (4)	2018 (4)	2019 (4)
MIC_{50} (mg/L)	1.5	≤1.0	≤1.0
MIC_{90} (mg/L)	2.0	≤1.0	≤1.0

Figure B1.7 MIC distribution of colistin for *Escherichia coli* (2017-2019)

[13] *E. coli* is Gram-negative bacteria that categorized as member of *Enterobacteriaceae* family. *E. coli* is a common pathogen that cause community and hospital-acquired infection such as bloodstream infection (BSI), pneumonia, urinary tract infection (UTI), etc.

Klebsiella pneumoniae[14]

- The proportion of third-generation cephalosporin resistant *K. pneumoniae* slightly changed between 2017 and 2019 (41.9-42.8%).
- Between 2017 and 2019, the overall trend in carbapenem-resistant *K. pneumoniae* gradually increased from 10.1% in 2017 to 12.5% in 2019.
- The percentage of colistin-resistant *K. pneumoniae* (non-wild type *K. pneumoniae*) slightly increased from 2.4% in 2018 to 3.6% in 2019, while MIC90 was ≤ 1.0 mg/L in 2019.

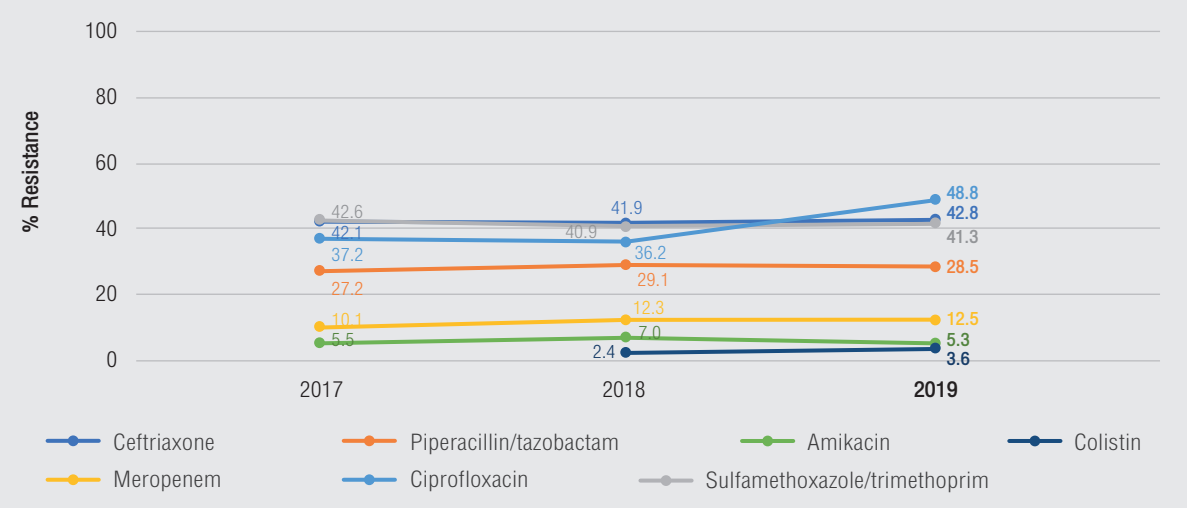
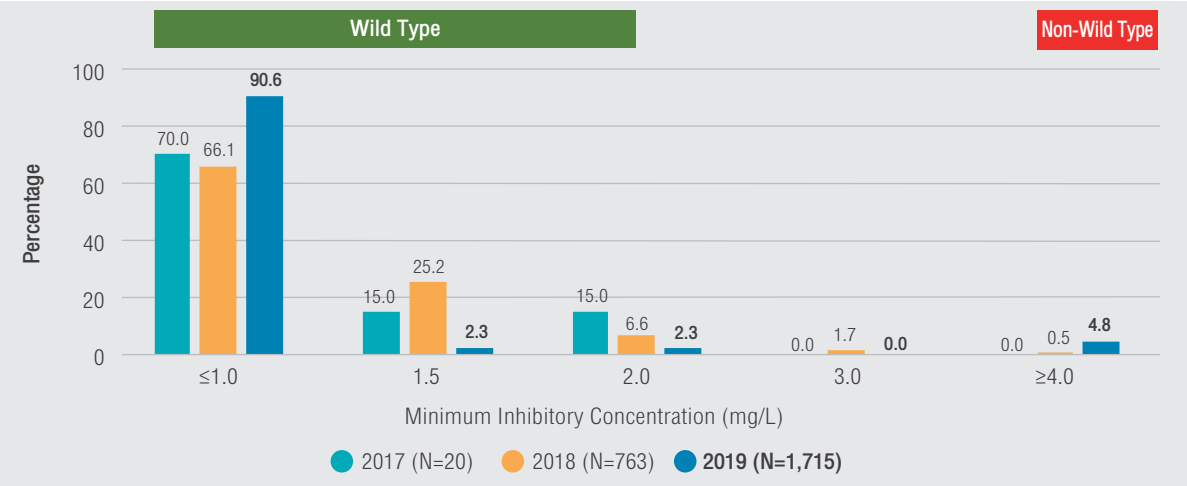


Figure B1.8 Resistance (%) among *Klebsiella pneumoniae* (2017-2019)



Colistin MIC by Sensititre® (number of hospitals)	2017 (4)	2018 (6)	2019 (5)
MIC_{50} (mg/L)	≤1.0	≤1.0	≤1.0
MIC_{90} (mg/L)	2.0	1.5	≤1.0

Figure B1.9 MIC distribution of colistin for *Klebsiella pneumoniae* (2017-2019)

[14] *K. pneumoniae* also has been categorized in *Enterobacteriaceae* family. This pathogen is a common cause of various infectious diseases with which we should be concerned, rather than *E. coli* because the rate of carbapenem-resistant has increased dramatically among *K. pneumoniae* in Thailand in the last eight years.

B1.2 Gram-positive bacteria

Staphylococcus aureus[15]

- Between 2017 and 2019, the proportion of methicillin-resistant *Staphylococcus aureus* (MRSA) was less than 10.0%, and slightly increased from 8.1% in 2018 to 9.4% in 2019
- The proportion of methicillin resistance coagulase-negative *Staphylococcus* (MRCNS) increased from 55.2% in 2018 to 59.6% in 2019.
- None of the isolates in 2019 were resistant to vancomycin.

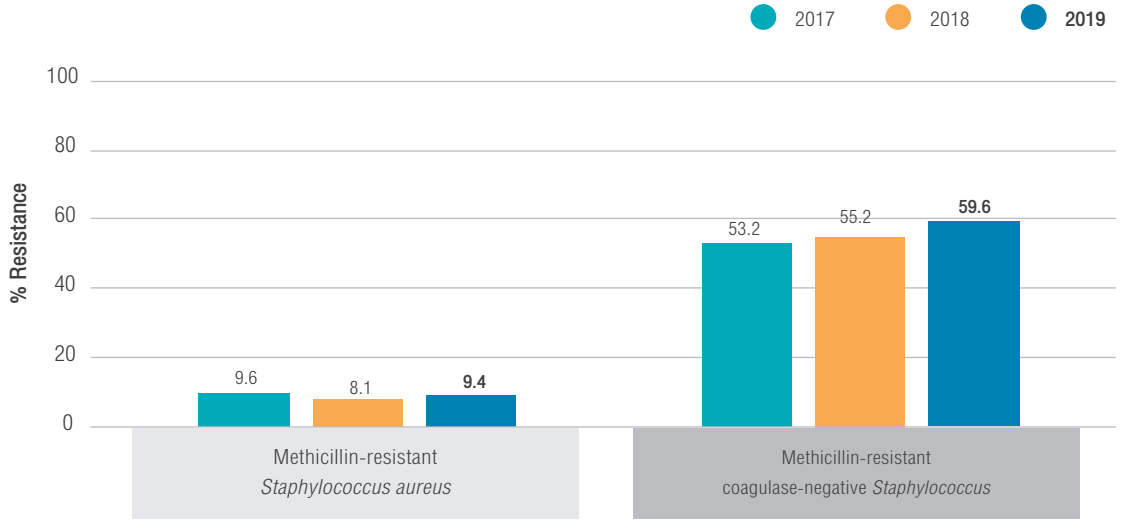


Figure B1.10 Percentage of methicillin resistance among *Staphylococcus aureus* (MRSA) and coagulase-negative *Staphylococcus* (MRCNS) (2017-2019)

Streptococcus pneumoniae[16]

- The proportion of penicillin non-susceptible *S. pneumoniae* (PNSP) including *S. pneumoniae* with intermediate-level of resistance to penicillin was at 7.2% for non-cerebrospinal fluid (CSF) samples.
- Despite a very low number of CSF isolates, almost 90.0% in 2019 were resistant to penicillin. This implies that penicillin should not be used for empirical treatment of acute bacterial meningitis in Thailand.

Table B1.1 The proportion (%) of antimicrobial resistance in *Streptococcus pneumoniae*

Drug	% resistant (number isolates)			E-test, (number isolates)					
				Meningitis			Non-meningitis		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
Penicillin*	65.8 (371)	63.4 (366)	64.3 (1,276)	50.0 (2)	57.1 (7)	88.9 (9)	10.0 (369)	5.62 (359)	7.2 (1,267)
Cefotaxime*	-	-	-	0.0 (11)	0.0 (3)	-	0.0 (144)	0.98 (209)	6.9 (663)
Levofloxacin	0.9 (1,437)	1.0 (1,750)	1.2 (2,383)	-	-	-	-	-	-

*Interpretation by minimum inhibitory concentration test

[15] *S. aureus* typically colonizes the skin and nose, but in some situations, it becomes a pathogen which causes nosocomial infection such as BSI, infective endocarditis, pneumonia.

[16] *S. pneumoniae* is Gram-positive bacteria and the most common cause of the community-acquired pneumonia, sinusitis, meningitis, BSI, etc.

***Enterococcus* spp.**[17]

- Ampicillin-resistant *Enterococcus faecalis* was found in around 5.6% of all isolates tested. The percentage of vancomycin-resistant *Enterococcus* (VRE) isolates was approximately 1.2% of *E. faecalis* and 7.6% of *E. faecium*.
- Among 2,142 isolates of *E. faecalis* and 1,249 isolates of *E. faecium*, 0.1% and 14.8% were VRE, respectively.
- Of the 3,580 of *Enterococcus* spp. isolates (not identified at species levels), 5.9% of them were resistant to vancomycin.

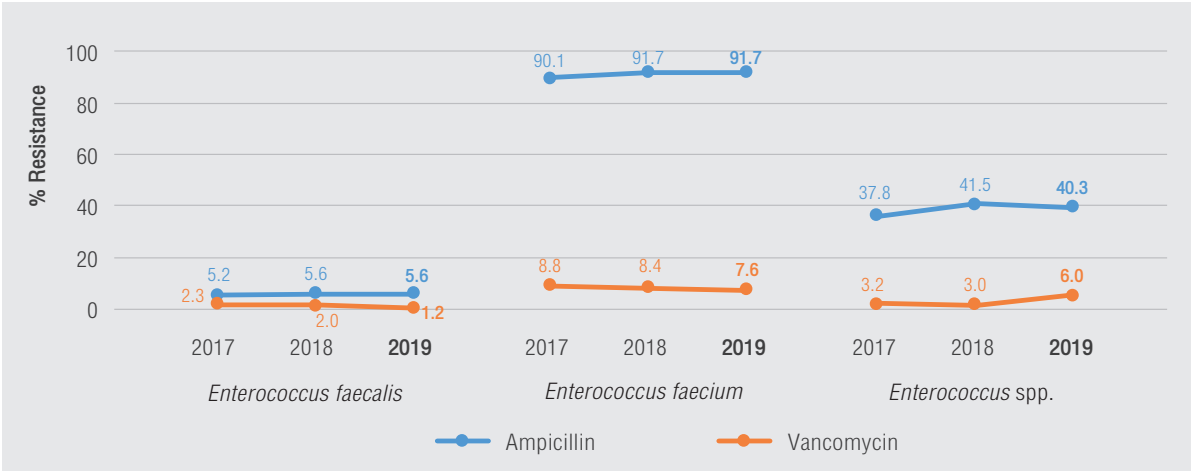


Figure B1.11 Resistance (%) among *Enterococcus faecalis, Enterococcus faecium, Enterococcus* spp. (2017-2019)

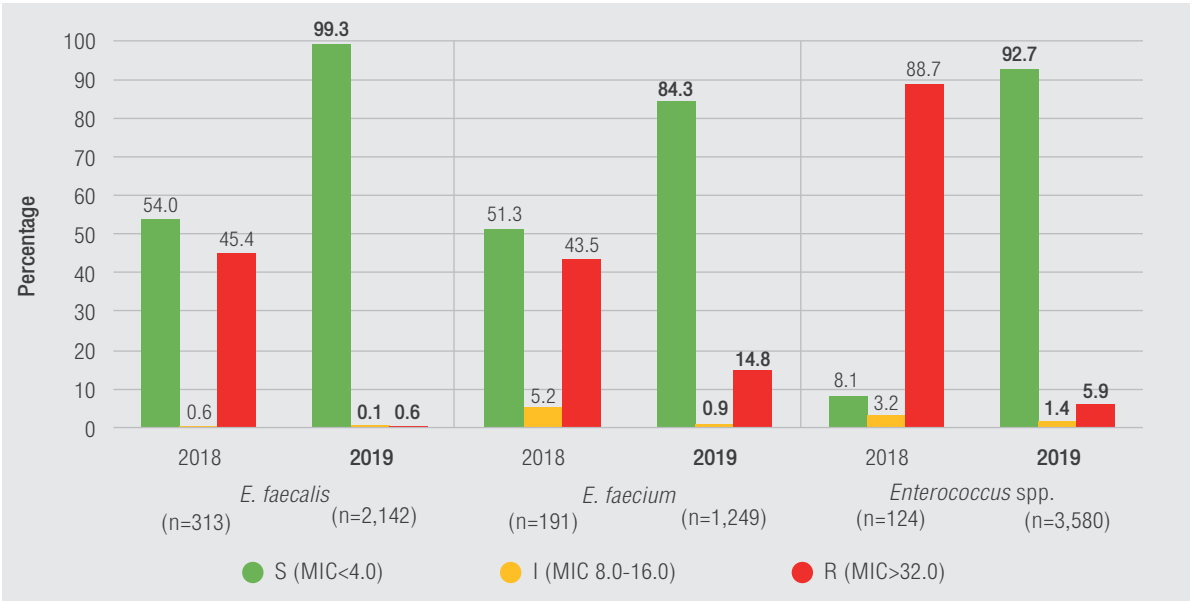


Figure B1.12 Percentage of susceptible, intermediate and resistance to vancomycin among *Enterococcus faecalis, Enterococcus faecium, Enterococcus* spp., 2018-2019

[17] Enterococci are Gram-positive bacteria found in the gastrointestinal (GI) tract and live as normal flora harmlessly. In some situations, this could develop to become pathogens and cause infection in the human body such as BSI, UTI, skin and soft tissue infection, and GI tract infection.

B1.3 Other antimicrobial-resistant bacteria

Non-typhoidal *Salmonella* spp.[18]

- The proportion of ciprofloxacin resistance in non-typhoidal *Salmonella* was 6.1% in 2019, increased from 4.6% in 2017.
- The overall proportion of resistance to third-generation cephalosporin in non-typhoidal *Salmonella* spp. slightly decreased from 15.1% in 2017 to 12.2% in 2019.

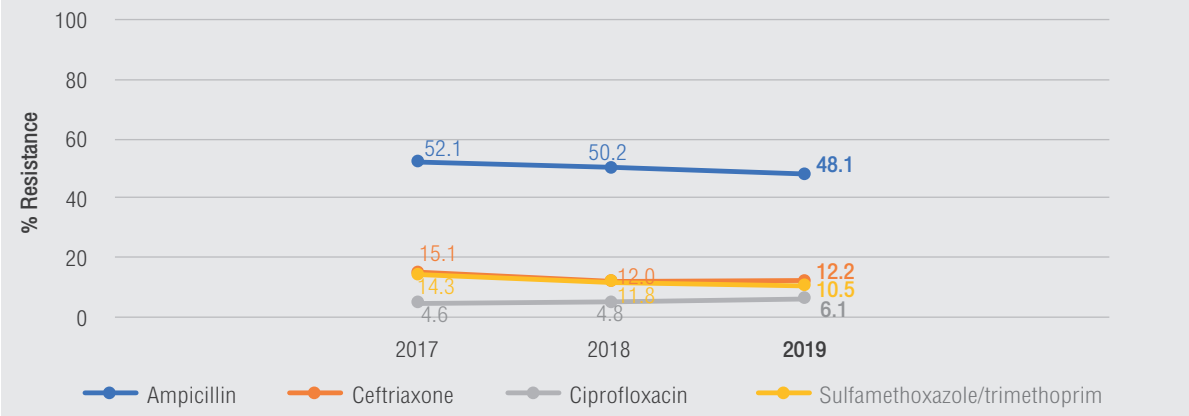


Figure B1.13 Resistance (%) among Non-typhoidal *Salmonella* spp. (2017-2019)

Neisseria gonorrhoeae[19]

- All *N. gonorrhoeae* isolates were resistant to penicillin. In addition, about 93.3% and 90.3% of *N. gonorrhoeae* isolates were non-susceptible to ciprofloxacin and tetracycline in 2019.
- However, no resistance to cefixime or ceftriaxone was reported. Most isolates were susceptible to azithromycin, except only 0.7% of total isolates were resistant.

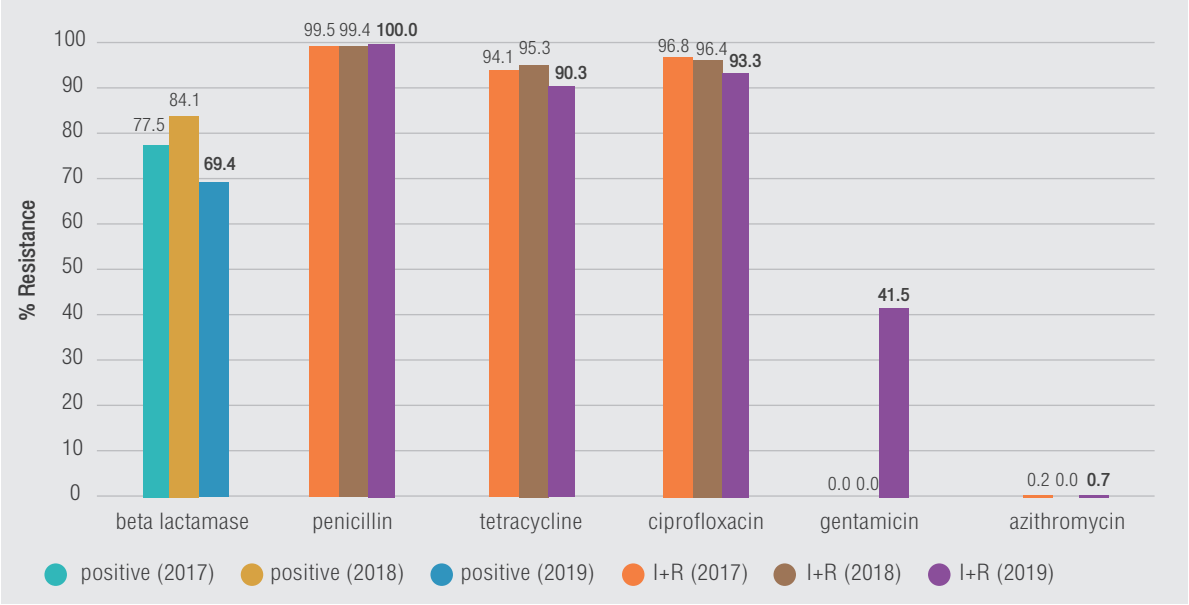


Figure B1.14 Resistance (%) among *Neisseria gonorrhoeae* (2017-2019)
Note: None of the isolates in 2017-2019 were resistant to cefixime, ceftriazone, spectinomycin.

[18] Non-typhoidal *Salmonella* spp. is Gram-negative, non-lactose fermenting bacteria. Its original nomenclature is *Salmonella enterica,* of which 99 % of subsp. I enterica can cause infection in both human and animals. In humans, it can be the cause of gastroenteritis, BSI and focal infection.
[19] *N. gonorrhoeae* is Gram-negative cocci bacteria and usually has been reported as common cause of sexually transmitted infection.

B2. Antimicrobial Resistance in Patients with Hospital-Associated Infections

B2.1 Hospital-associated infection

Incidence of Hospital-Associated Infections (HAI)

- Overall, in 2019, there were total 11,987 HAI events reported in 9,720 patients with HAI in 50 hospitals. The incidence rate (per 1,000 patient-days) and incidence proportion (%) of HAI by year and type of hospital are shown in Table B2.1.
- The incidence rate and incidence proportion of HAI decreased from 2.5 per 1,000 patient-days and 0.8% of total inpatients in 2018 to 1.5 per 1,000 patient-days and 0.5% of total inpatients in 2019.
- In 2019, other public hospitals had the highest HAI incidence rate (3.9 per 1,000 patient-days) but in 2018, regional hospitals had the highest HAI incidence rate (3.4 per 1,000 patient-days). In 2018 and 2019, other public hospitals had the highest HAI incidence proportion as 1.7% and 2.3% of total in patients, respectively.
- The lowest HAI incidence rate and incidence proportion were found in community hospitals at 0.4 per 1,000 patient-days and 0.1% of total inpatients, respectively. However, in 2018, private hospitals had the lowest incidence (0.7 per 1,000 patient-days and 0.2% of total inpatients).

Table B2.1 Incidence rate (per 1,000 patient-days) and incidence proportion (%) of HAI by type of hospital

Hospital type	2019						2018	
	HAI events	HAI patient	Patient-days	Discharged patient	Weighted HAI incidence rate	Weighted HAI incidence proportion (%)	Weighted HAI incidence rate	Weighted HAI incidence proportion (%)
Regional hospital	7,841	6,234	3,318,945	627,416	2.4	1.0	3.4	1.2
General hospital	2,945	2,508	2,305,557	592,309	1.3	0.4	1.2	0.4
Community hospital	113	100	285,008	90,048	0.4	0.1	1.0	0.3
Other MOPH hospital	145	105	45,325	8,388	3.2	1.3	2.9	1.0
Other public hospital	897	729	232,348	31,664	3.9	2.3	3.3	1.7
Private hospital	46	44	101,873	44,655	0.5	0.1	0.7	0.2
Total	**11,987**	**9,720**	**6,289,056**	**1,394,480**	**1.5**	**0.5**	**2.5**	**0.8**

Note: Incidence proportion = (HAI patient/discharged patient)*100

HAI by age groups

- A half of HAI events (52.1%, 6,251 events) occurred in elderly patients >60 years old.
- Around half of paediatric patients with HAI events were newborns (48.8%, 688 of 1,409 events of paediatric patients).

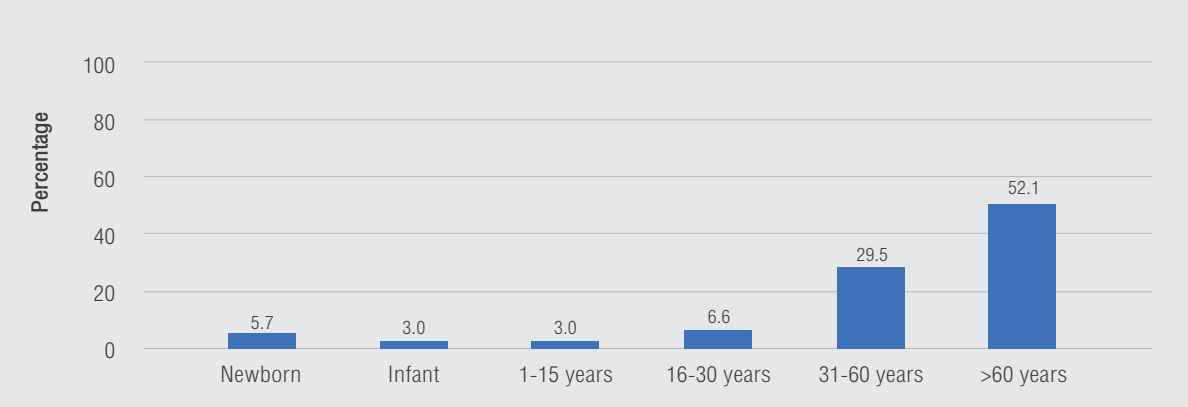


Figure B2.1 Percentage of HAI events by age group

HAI by site of infection

- Defining HAI events by site of infection, in 2019, the top three were respiratory tract infection (48.7%), urinary tract infection (25.4%), and bloodstream infection (10.1%). This list was similar to the top three sites of infection in 2018 B2.2.

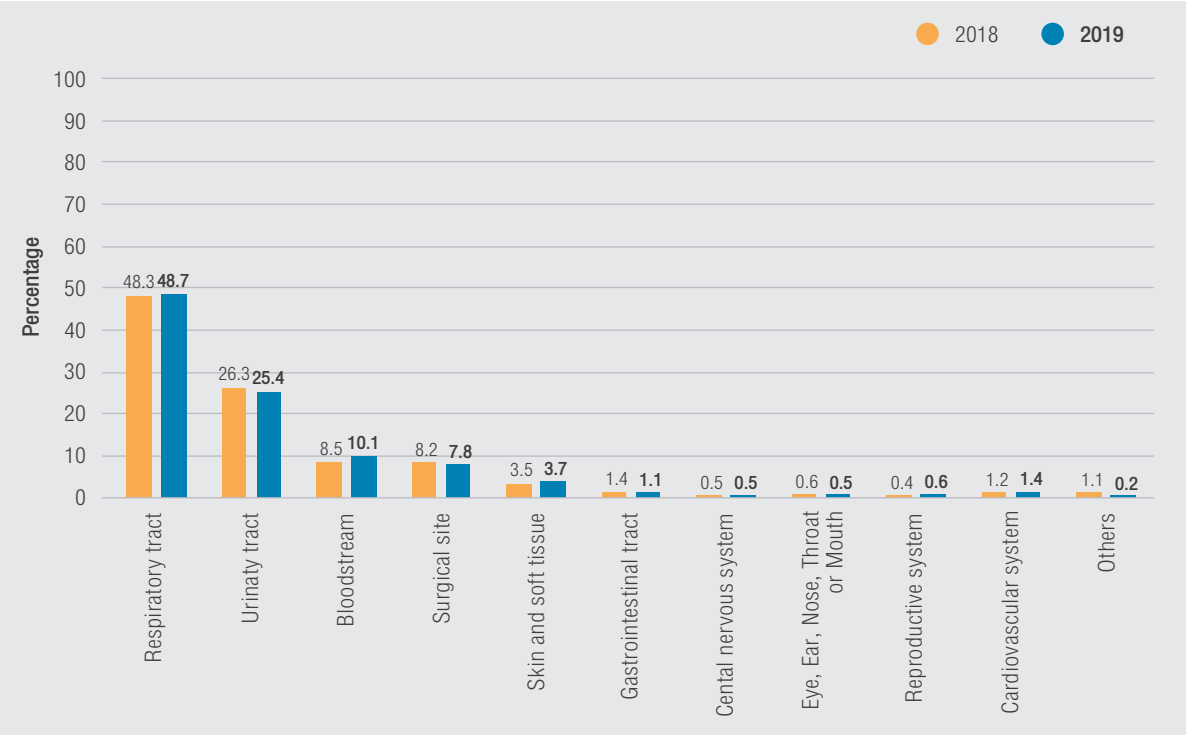


Figure B2.2 Hospital-associated infection by site of infection

- Overall, incidence rate of Ventilator-associated pneumonia (VAP), Central line-associated bloodstream infections (CLABSI), and Catheter-associated urinary tract infections (CAUTI) slightly decreased from 5.5 per 1,000 ventilator-days, 2.2 per 1,000 catheter-days, and 2.1 per 1,000 catheter-days in 2018 to 3.7 per 1,000 ventilator-days, 1.5 per 1,000 catheter-days, and 1.4 per 1,000 catheter-days in 2019. While incidence rate of Surgical Site Infection (SSI) was similar with 0.3 per 100 surgeries. (Table B2.2)
- The VAP incidence rate in other MOPH hospitals had the highest rate accounting for 6.5 per 1,000 ventilator-days while private hospitals had the lowest VAP incidence as 2.2 per 1,000 ventilator-days.
- The CLABSI incidence rate in other MOPH hospitals had highest 3.6 per 1,000 catheter-days while there was no CLABSI incidence rate in private hospitals.
- The CAUTI incidence rate in other public hospitals was at the top at 3.5 per 1,000 catheter-days while private hospitals had lowest incidence rate at 0.3 per 1,000 catheter-days.
- Finally, the incidence proportion of SSI was highest in regional hospitals (0.5 per 100 surgeries) and lowest in community hospitals, other MOPH hospitals and private hospitals (0.1 per 100 surgeries).

Table B2.2 Incidence of invasive device-related HAIs, and site infection by type of hospital

	2019				2018			
	Weighted VAP incidence rate per 1,000 ventilator-days	Weighted CLABSI incidence rate per 1,000 catheter-days	Weighted CAUTI incidence rate per 1,000 cathter-days	Weighted SSI incidence proportion per 100 surgeries	Weighted VAP incidence rate per 1,000 ventilator-days	Weighted CLABSI incidence rate per 1,000 catheter-days	Weighted CAUTI incidence rate per 1,000 catheter-days	Weighted SSI incidence proportion per 100 surgeries
Regional hospital	4.0	1.7	1.6	0.5	6.0	2.7	2.4	0.4
General hospital	3.7	0.9	1.3	0.2	4.2	0.7	1.3	0.2
Community hospital	2.4	3.3	0.5	0.1	6.8	1.2	1.6	0.2
Other MOPH hospital	6.5	3.6	3.4	0.1	3.3	3.0	5.1	0.1
Other public hospital	2.6	1.2	3.5	0.3	4.1	0.9	3.9	0.2
Private hospital	2.2	-	0.3	0.1	5.5	-	1.4	0.2
Total	**3.7**	**1.5**	**1.4**	**0.3**	**5.5**	**2.2**	**2.1**	**0.3**

Causative organisms of HAI

- The top three causative pathogens of HAI were *A. baumannii* (28.0%), *K. pneumoniae* (14.0%), and *E. coli* (12.2%) (Figure B2.3).

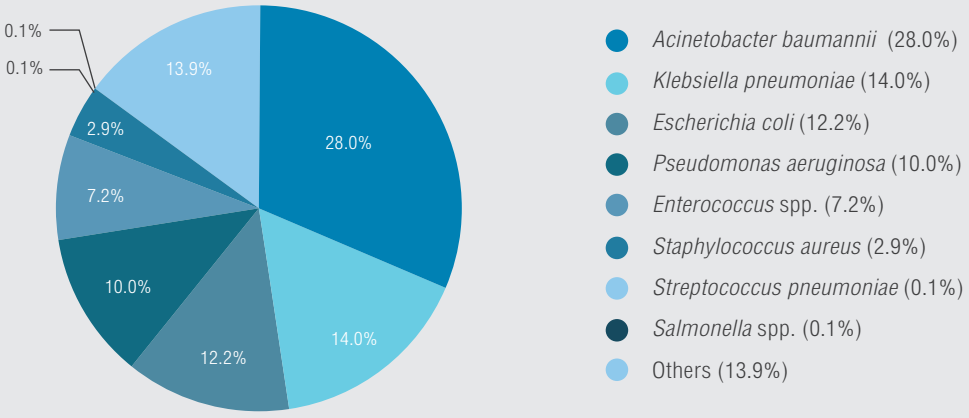


Figure B2.3 Percentage of causative organisms of HAI events by targeted pathogen

B2.2 Antimicrobial resistance in HAI patients[20]

Incidence of AMR in HAI patients

- In 2019, of the total 9,720 HAI patients, there were 4,302 AMR patients with 5,343 AMR reported events (Table B2.3).
- The incidence rate and incidence proportion of AMR infection in 2019 were 0.6 per 1,000 patient-days and 0.2% of total inpatients, respectively, which decreased from 1.4 per 1,000 patient-days and 0.5% of total inpatients in 2018.
- Other public hospitals had the highest AMR incidence rate (1.6 per 1,000 patient-days), and the highest AMR incidence proportion (0.9% of total inpatients). The lowest AMR incidence rate and incidence proportion were in private hospitals as 0.01 per 1,000 patient-days and 0.002% of total inpatients, respectively.

Table B2.3 Incidence rate (per 1,000 patient-days) and incidence proportion (%) of AMR by types of hospital in HAI patients

Hospital type	2019						2018	
	AMR events	AMR patient	Patient-days	Discharged patient	Weighted AMR incidence rate	Weighted AMR incidence proportion (%)	Weighted AMR incidence rate	Weighted AMR incidence proportion (%)
Regional hospital	3,629	2,910	3,318,945	627,416	1.1	0.5	1.8	0.7
General hospital	1,252	1,035	2,305,557	592,309	0.5	0.2	0.9	0.3
Community hospital	26	23	285,008	90,048	0.1	0.0	0.6	0.2
Other MOPH hospital	70	42	45,325	8,388	1.5	0.5	1.7	0.7
Other public hospital	365	291	232,348	31,664	1.6	0.9	1.4	0.8
Private hospital	1	1	101,873	44,655	<0.1*	<0.1**	0.5	0.1
Total	**5,343**	**4,302**	**6,289,056**	**1,394,480**	**0.6**	**0.2**	**1.4**	**0.5**

*0.01, **0.002

Note: Incidence proportion = (AMR patient/discharged patient)*100

AMR in HAI patients by age groups

- Half of AMR events (56.0%, 2,991 of 5,343 events) occurred in elderly patients (age >60 years old).
- Around half of paediatric patients infected with AMR pathogens were newborns (44.1%, 187 of 424 events).

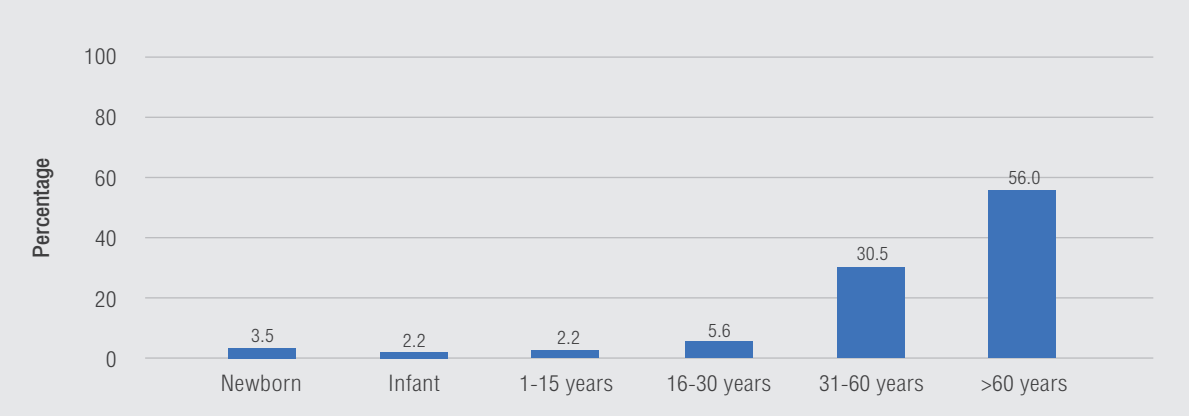


Figure B2.4 Number of AMR events by age group

[20] In this chapter, AMR is defined as the resistance of target bacterial pathogens to at least one of the listed antimicrobials in accordance with the National Strategic Plan on AMR. In case a patient was reported with similar AMR pathogen infection within a 14-day period, a deduplication of AMR events was done.

AMR in HAI patients by site of infection

- Among all AMR events, the top three sites were respiratory tract infection (55.3%), urinary tract infection (26.0%), and bloodstream infection (8.0%).

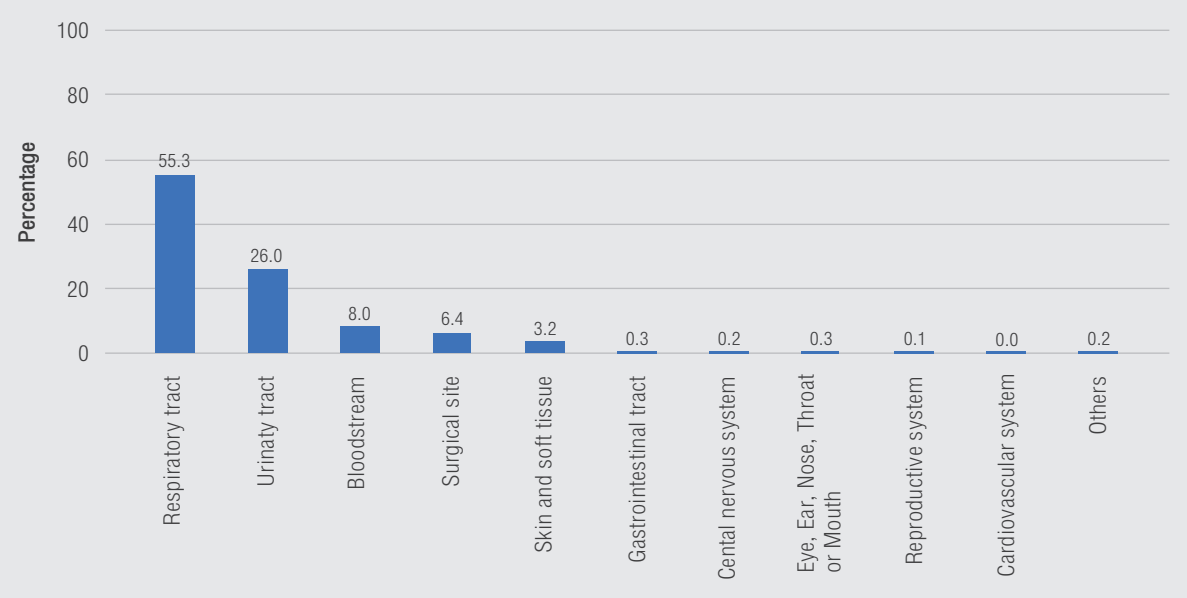


Figure B2.5 Antimicrobial infection by site of infection

AMR in HAI patients by targeted pathogens

- Among the total 5,343 AMR events, *A. baumannii* was the most common pathogen (2,440 events, 45.7%), followed by *K. pneumoniae* (1,239 events, 23.2%), and *E. coli* (1,119 events, 20.9%).
- The results included all targeted pathogens in NSP-AMR which were either community-or hospital-acquired pathogens. Thus, there was no report on *N. gonorrhoeae* and few records of *S. pneumoniae* (3 events) and *Salmonella* spp. (4 events).

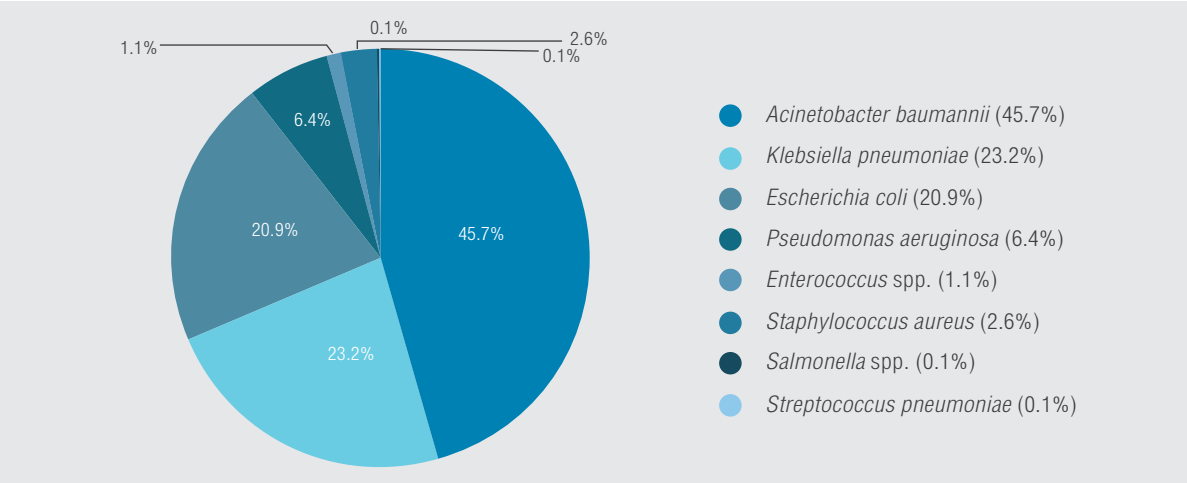


Figure B2.6 Percentage of AMR events in HAI patients by targeted pathogen

Resistance percentage in HAI patients

- Regarding the percentage of AMR causing HAI, 74.0% of *A. baumannii* isolates were resistant (n = 2,539/3,429) to at least one antimicrobial, followed by *E. coli* (72.2%, n = 1,140/1,580) and *K. pneumoniae* (61.9%, n = 1,272/2,054).
- Specifically, most of *A. baumannii* isolates were resistant to carbapenem (74.6%) while carbapenem-resistant *P. aeruginosa* was 23.3% of total isolates. Third generation cephalosporins resistance was common in *K. pneumoniae* and *E. coli,* accounting for 56.4% and 54.4%, respectively.
- *S. aureus* isolates (n = 417) were resistant to methicillin 36.0%. Finally, vancomycin-resistant *Enterococcus* was 6.6% of total reported *Enterococcus* spp. (n = 912).

Table B2.4 Percentage of antimicrobial resistance in targeted pathogens in HAI patients

AMR target	Drug group	Total*	No result	S	I	R	% resistance
A. baumannii	• carbapenem	3,429	35	850	13	2,531	74.6%
	• colistin	3,429	877	2,511	6	35	1.4%
K. pneumoniae	• carbapenem	2,054	68	1,319	12	655	33.0%
	• colistin	2,054	689	1,276	1	88	6.4%
	• 3rd generation cephalosporin	2,054	25	871	13	1,145	56.4%
E. coli	• carbapenem	1,580	75	1,184	5	316	21.0%
	• colistin	1,580	548	998	0	34	3.3%
	• fluoroquinolone	1,580	186	457	55	882	63.3%
	• 3rd generation cephalosporin	1,580	15	705	9	851	54.4%
P. aeruginosa	• carbapenem	1,554	64	1,092	51	347	23.3%
	• colistin	1,554	455	1,092	1	6	0.5%
Enterococcus spp.	• vancomycin	912	39	815	0	58	6.6%
S. aureus	• vancomycin	417	79	329	0	9	2.7%
	• methicillin	417	36	244	0	137	36.0%
S. pneumoniae	• penicillin	24	3	19	0	2	2/24
	• 3rd generation cephalosporin	24	2	20	0	2	2/24
Salmonella spp.	• colistin	17	15	2	0	-	0.0%
	• fluoroquinolone	17	5	7	2	3	3/17
	• 3rd generation cephalosporin	34	20	9	0	5	5/34
N. gonorrhoeae	• 3rd generation cephalosporin	0	-	-	-	-	-

*Count only first isolate pathogen

S = susceptible

I = intermediate

R = resistance

B2.3 Incidence rate of HAI and AMR by ward type

HAI events and AMR events by ward type

- Most incidence of HAI events and AMR events occurred in medicine wards (2.5 per 1,000 patient-days for HAI and 1.3 per 1,000 patient-days for AMR), followed by surgery wards (2.4 per 1,000 patient-days for HAI and 1.0 per 1,000 patient-days for AMR) and mixed wards (2.0 per 1,000 patient-days for HAI and 0.7 per 1,000 patient-days for AMR).
- The incidence rates of HAI and AMR events in ICU wards were higher than non-ICU wards at 6.4 per 1,000 patient-days and 3.1 per 1,000 patient-days, respectively.

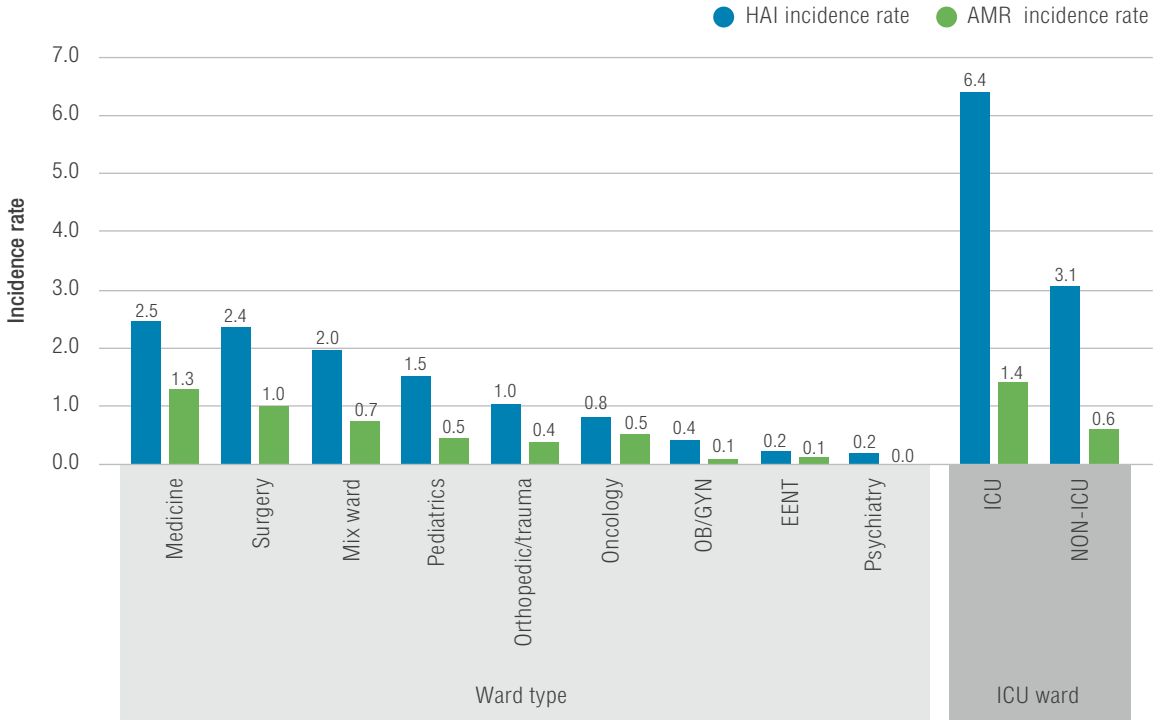


Figure B2.7 Incidence rate (per 1,000 patient-days) HAI and AMR events by ward type

B3. Antimicrobial Resistance in Food-Producing Animals

B3.1 *Escherichia coli*

E. coli isolates from chickens

- High levels of *E. coli* resistance against ampicillin and tetracycline in chicken caeca and chicken meat from slaughterhouses and retail markets were reported in 2019 (Figure B3.1).
- None of the *E. coli* isolates in chicken caeca and chicken meat were resistant to meropenem and ceftazidime in 2019 (Figure B3.1).
- Between 2017 and 2019, the prevalence of AMR in *E. coli* isolated from chicken slightly decreased. However, the *E. coli* isolated from chicken caeca were resistant to ciprofloxacin and gentamicin, and the isolates in chicken meat from retail markets showed resistance to gentamicin (Figure B3.2).

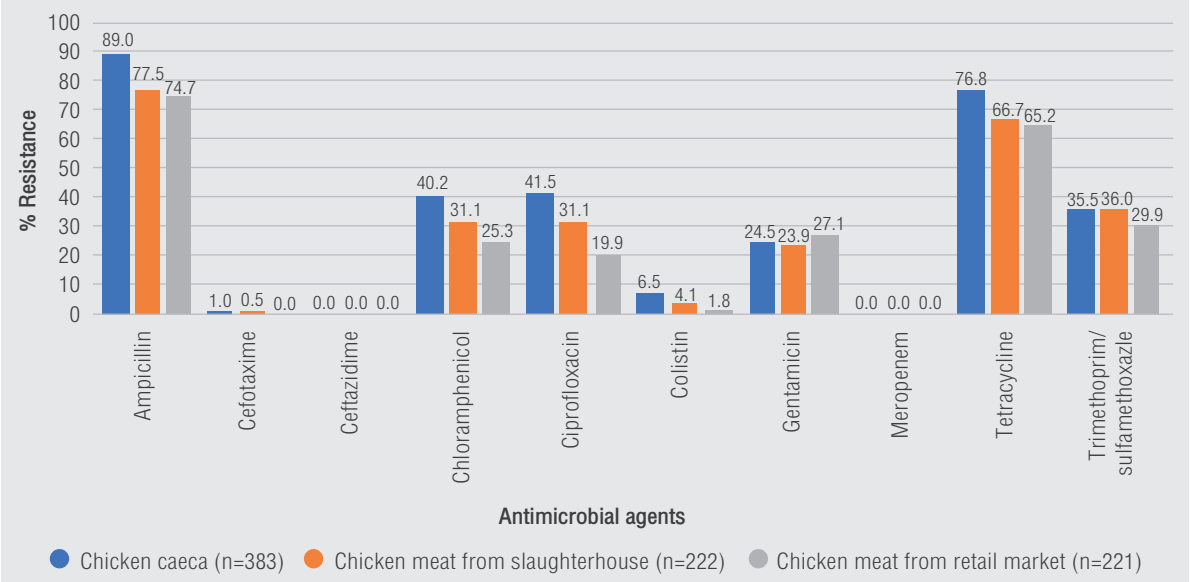


Figure B3.1 Resistance rate (%) among *E. coli* isolates in chicken caeca, and chicken meat from slaughterhouses and retail markets in 2019, Thailand

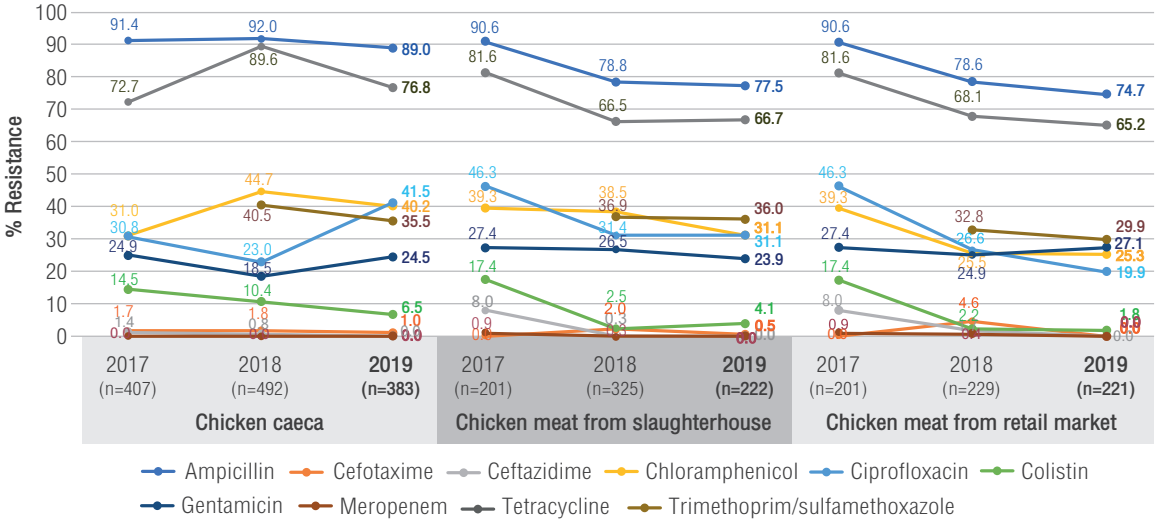


Figure B3.2 Resistance rate (%) among *E. coli* in chicken caeca, and chicken meat from slaughterhouses and retail markets, Thailand (2017-2019)

E. coli isolates from pigs

- High levels of *E. coli* resistance against ampicillin and tetracycline in pig caeca and pork from slaughterhouses and retail markets were reported in 2019 (Figure B3.3).
- None of the *E. coli* isolates in pork from slaughterhouses and retail markets were resistant to meropenem, but low levels of meropenem resistance (0.3%) were detected in pig caeca (Figure B3.3).
- Low levels of AMR (<10.0%) against third generation cephalosporins including cefotaxime and ceftazidime were detected in pig caeca and pork from slaughterhouses and retail markets.
- Between 2017 and 2019, the prevalence of AMR in *E. coli* isolated from pigs slightly declined. However, *E. coli* isolates in pig caeca showed resistance to ciprofloxacin (from 7.5% in 2017 to 27.2% in 2019), and the isolates in pork from retail markets showed resistance to gentamicin (from 15.6% in 2017 to 19.8% in 2019) (Figure B3.4).

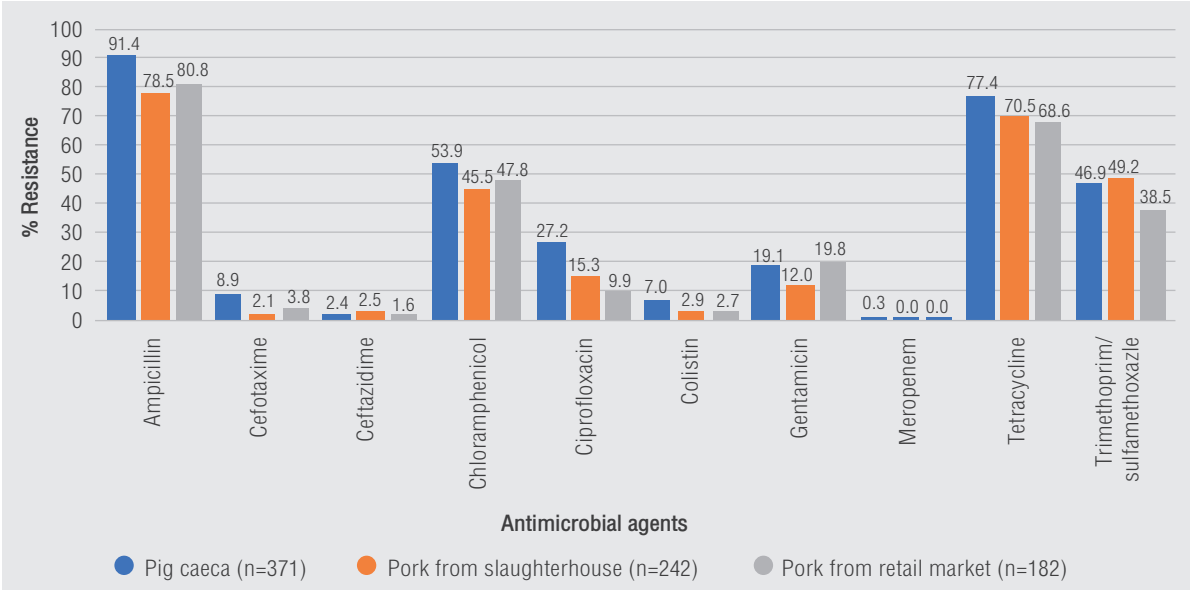


Figure B3.3 Resistance rate (%) among *E. coli* isolates in pig caeca, and pork from slaughterhouses and retail markets in 2019, Thailand

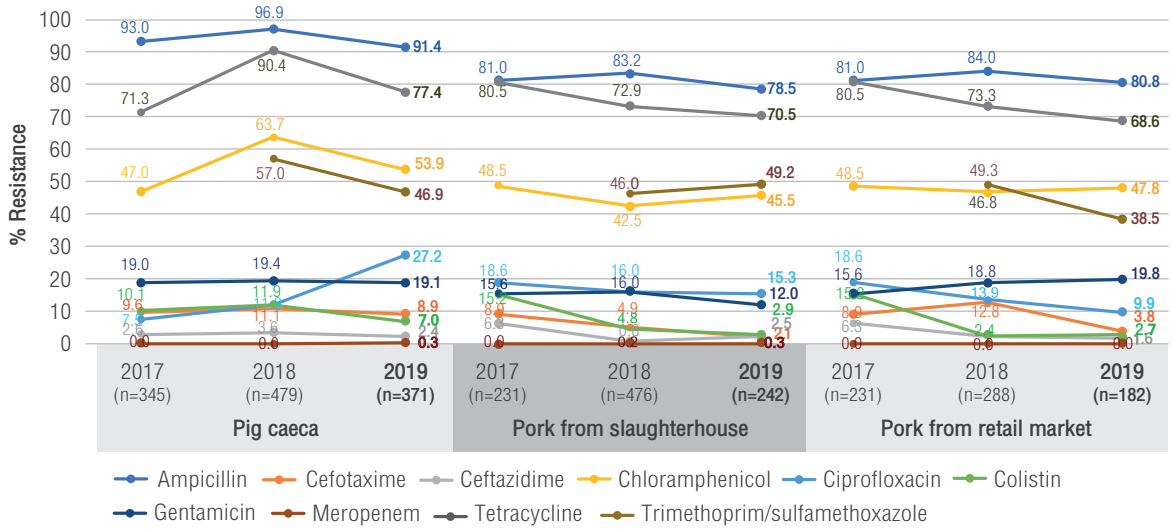


Figure B3.4 Resistance rate (%) among *E. coli* in pig caeca, and pork from slaughterhouses and retail markets, Thailand (2017-2019)

B3.2 *Enterococcus faecium* and *Enterococcus faecalis*

E. faecium and *E. faecalis* isolates from chickens

- High levels of *E. faecium* and *E. faecalis* resistant against erythromycin (90.7%) and tetracycline (85.9%) in chicken caeca were reported in 2019.
- Low levels of AMR (<1.0%) against vancomycin, linezolid, and teicoplanin in chicken caeca were reported in 2019.
- Between 2017 and 2019, the prevalence of AMR *E. faecium* and *E. faecalis* slightly changed.

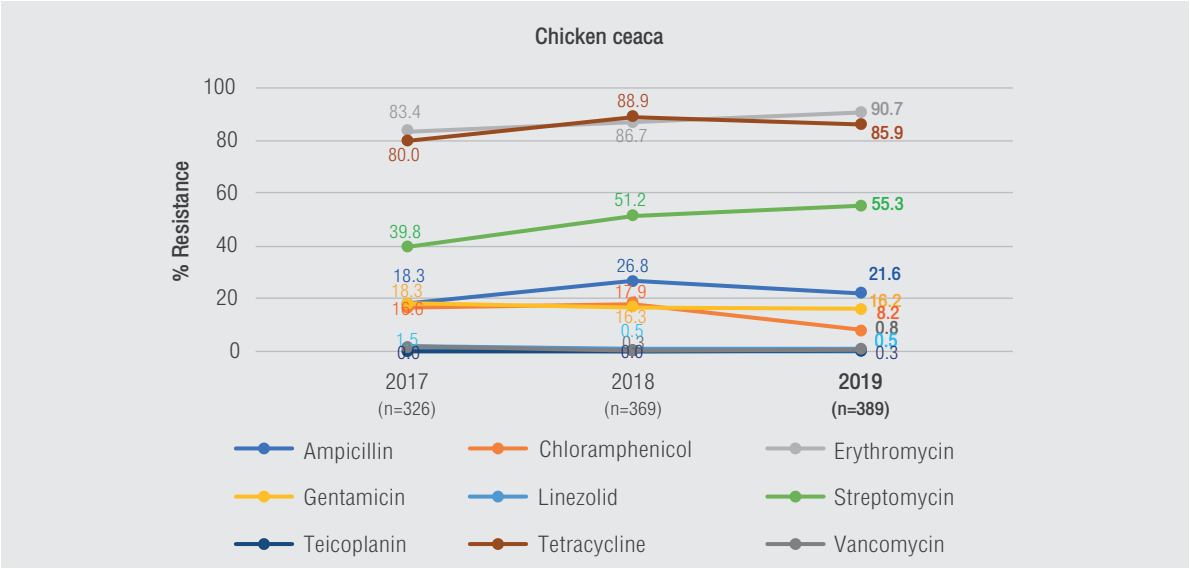


Figure B3.5 Resistance rate (%) among *E. faecium* and *E. faecalis* in chicken caeca (2017-2019)

E. faecium and *E. faecalis* isolates from pigs

- High levels of *E. faecium* and *E. faecalis* resistant against tetracycline (80.4%) and erythromycin (77.9%) in pig caeca were reported in 2019.
- Low levels of AMR against vancomycin (2.0%), linezolid (8.5%), and teicoplanin (0.5%) in pig caeca were detected.
- Between 2017 and 2019, the prevalence of AMR *E. faecium* and *E. faecalis* slightly changed.

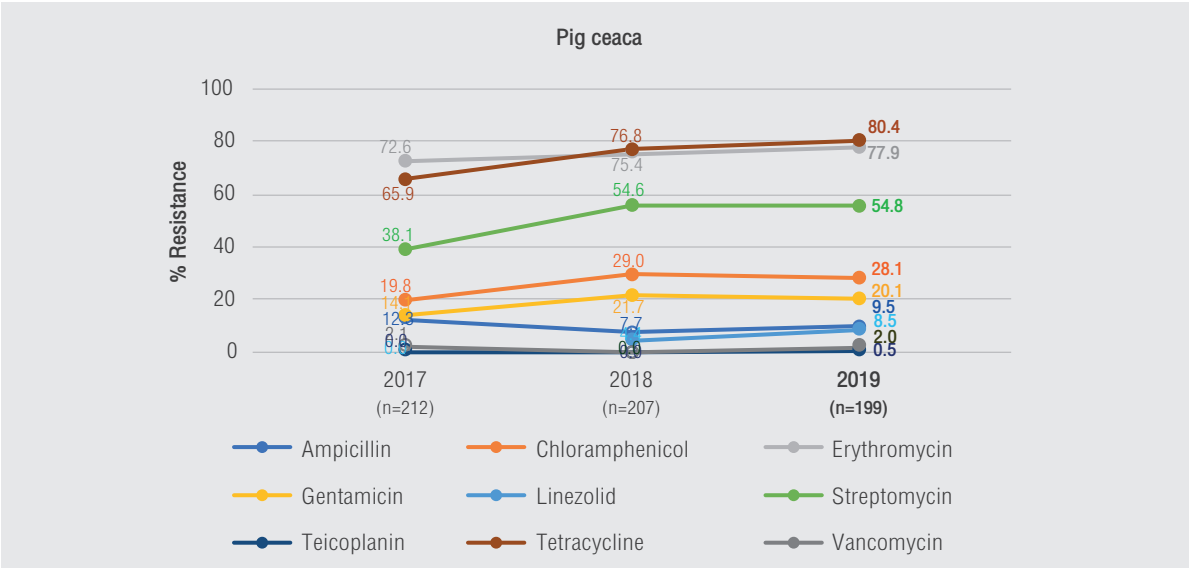


Figure B3.6 Resistance rate (%) among *E. faecium* and *E. faecalis* in pig caeca (2017-2019)

B3.3 *Salmonella* spp.

Salmonella spp. isolates from chickens

- High levels of *Salmonella* spp. resistance against ampicillin and tetracycline in chicken caeca and chicken meat from slaughterhouses and retail markets were reported in 2019 (Figure B3.5).
- No meropenem and colistin resistance was found in *Salmonella* isolated in chicken meat from retail markets, whereas low levels of resistance were detected in chicken caeca and chicken meat from slaughterhouses (Figure B3.5).
- Low levels of AMR (<2.0%) against third generation cephalosporins including cefotaxime and ceftazidime were detected in chicken caeca and chicken meat from slaughterhouses and retail markets (Figure B3.5).
- Between 2017 and 2019, the prevalence of *Salmonella* spp. resistant to ampicillin and tetracycline in chicken significantly declined, whereas the resistant to ciprofloxacin significantly increased (Figure B3.6)

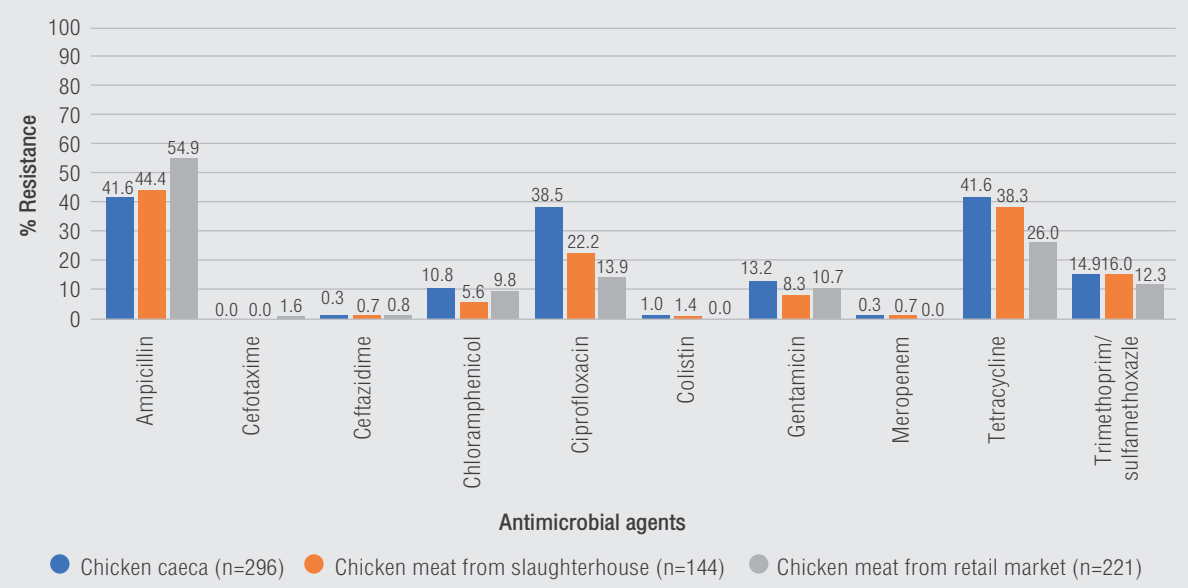


Figure B3.7 Resistance rate (%) among *Salmonella* isolates in chicken caeca, and chicken meat from slaughterhouses and retail markets in 2019, Thailand

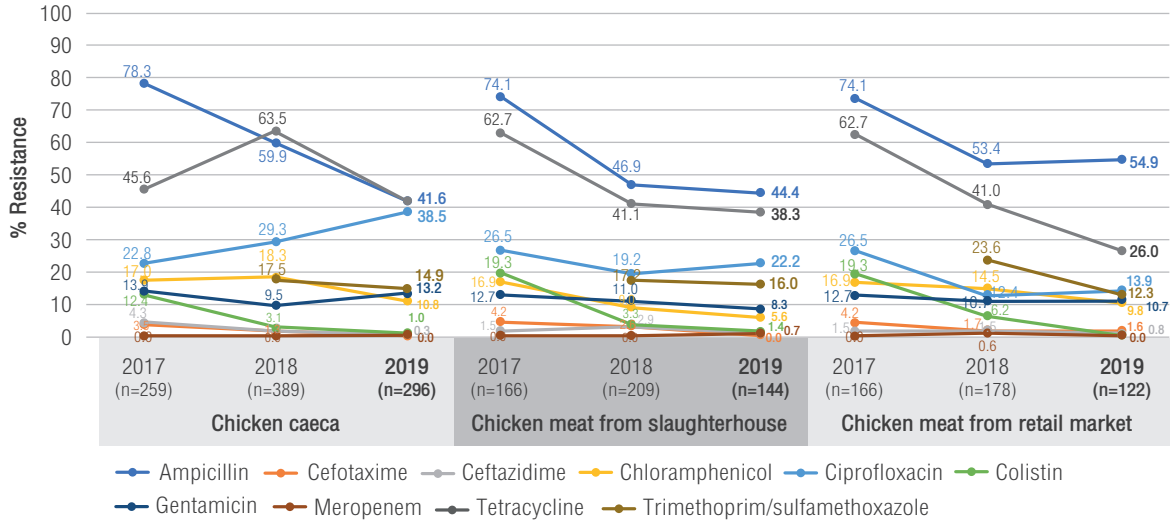


Figure B3.8 Resistance rate (%) among *Salmonella* spp. in chicken caeca, and chicken meat from slaughterhouses and retail markets, Thailand (2017-2019)

Salmonella spp. isolates from pigs

- High levels of *Salmonella* spp. resistance against ampicillin and tetracycline in pig caeca and pork from slaughterhouses and retail markets were reported in 2019 (Figure B3.7).
- None of the *Salmonella* spp. isolates in pork from retail markets were resistant to meropenem, but the low levels of meropenem resistance in pig caeca and pork from slaughterhouses was detected 0.8% and 0.6%, respectively (Figure B3.7).
- None of the *Salmonella* spp. isolates in pork from slaughterhouses were resistant to colistin, whereas the low levels of colistin resistance was detected in pig caeca (2.6%) and pork (0.6%) from retail markets (Figure B3.7).
- Low levels of AMR (<10.0%) against third generation cephalosporins, including cefotaxime and ceftazidime were detected in pig caeca and pork from both slaughterhouses and retail markets (Figure B3.7).
- Between 2017 and 2019, the prevalence of AMR *Salmonella* spp. slightly changed (Figure B3.8).

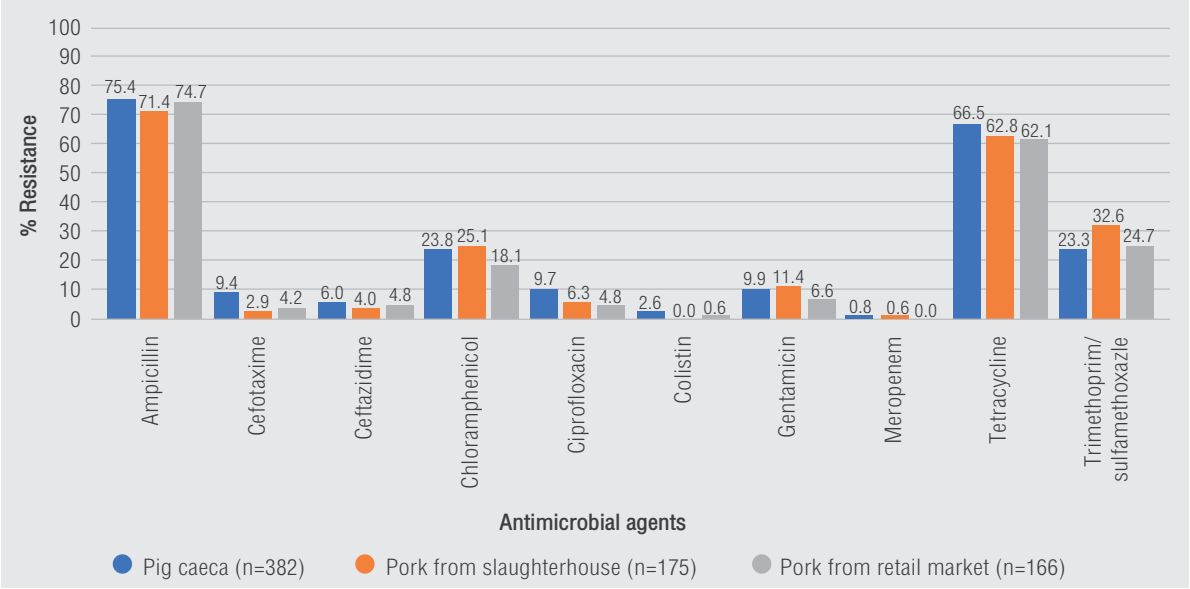


Figure B3.9 Resistance (%) among *Salmonella* spp. isolates in pig caeca, and pork from slaughterhouses and retail markets in 2019, Thailand

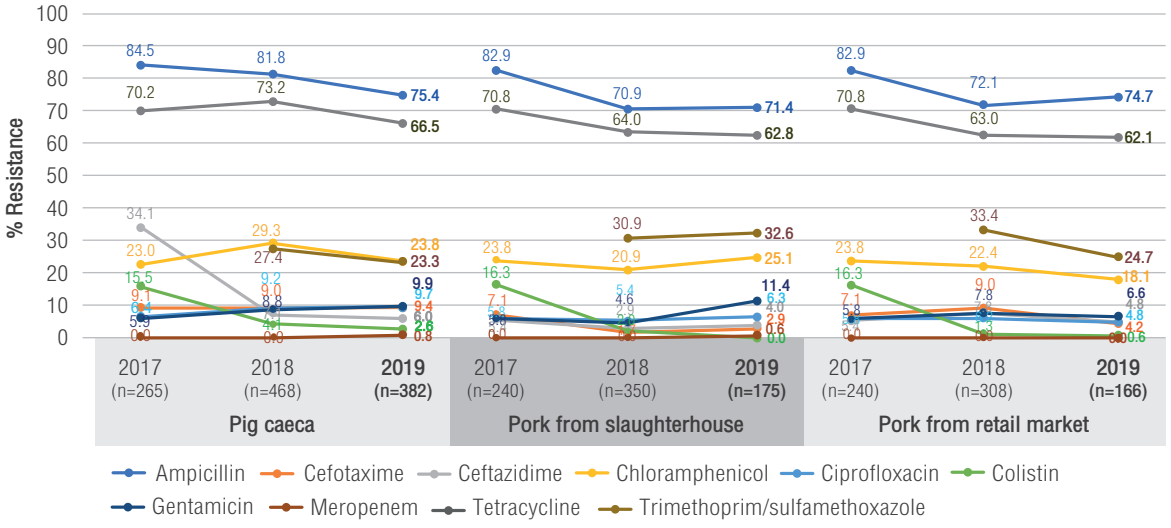


Figure B3.10 Resistance (%) among *Salmonella* spp. in pig caeca, and pork from slaughterhouses and retail markets, Thailand (2017-2019)

B3.4 *Campylobacter coli* and *Campylobacter jejuni*

C. coli and *C. jejuni* isolates from chickens

- High levels of *C. coli* and *C. jejuni* resistance against ciprofloxacin (72.3%) and tetracycline (46.9%) in chicken caeca were reported in 2019.
- The prevalence of AMR in *C. coli* and *C. jejuni* in chicken caeca against ciprofloxacin, gentamicin, streptomycin, and tetracycline increased between 2017 and 2019.

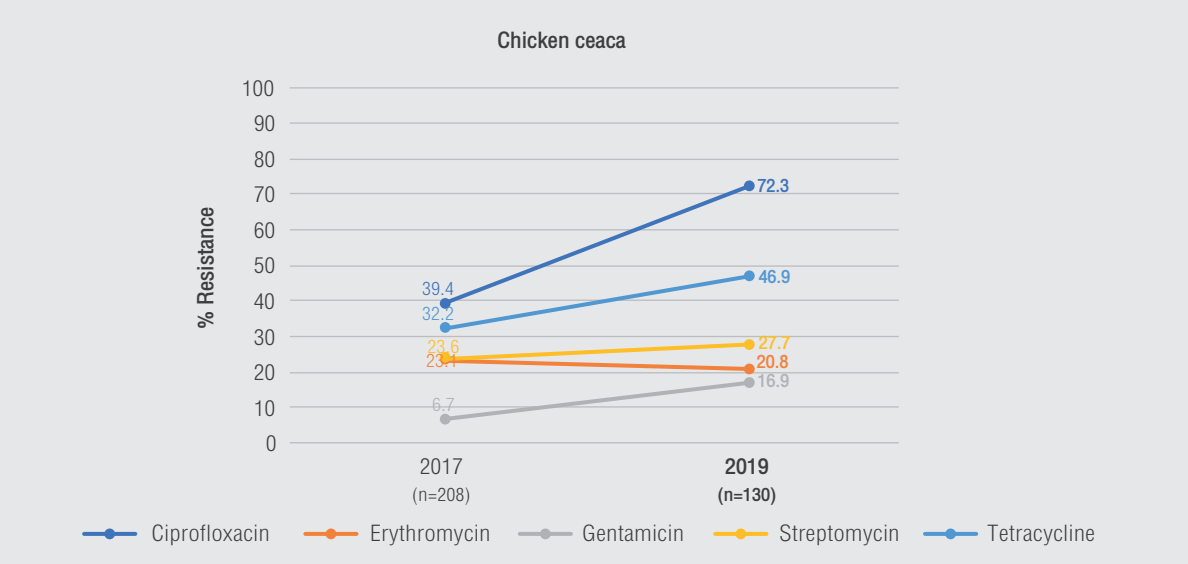


Figure B3.11 Resistance rate (%) among *C. coli* and *C. jejuni* in chicken (2017 and 2019)

C. coli and *C. jejuni* isolates from pigs

- *C. coli* and *C. jejuni* were highly resistant to streptomycin (87.1%), ciprofloxacin (81.1%), erythromycin (72.0%) and tetracycline (69.7%) in pig caeca in 2019.
- The prevalence of AMR in *C. coli* and *C. jejuni* in all tested antimicrobials in pig caeca increased between 2017 and 2019.

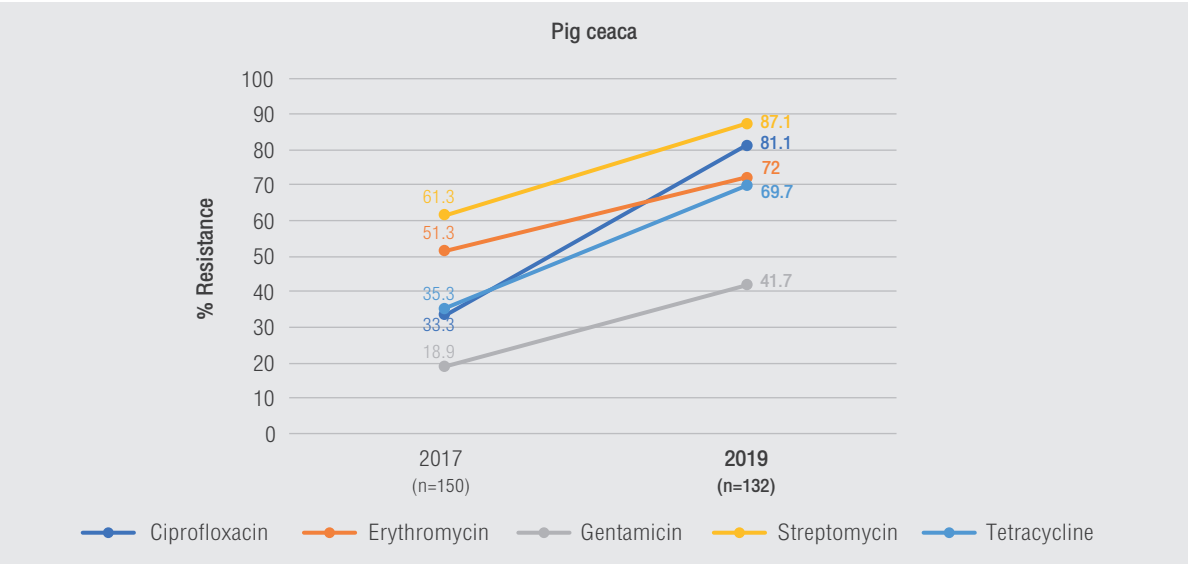


Figure B3.12 Resistance rate (%) among *C. coli* and *C. jejuni* in pigs between 2017 and 2019

SECTION C

KNOWLEDGE AND AWARENESS ON ANTIBIOTIC USE AND AMR

SECTION C:
KNOWLEDGE AND AWARENESS ON ANTIBIOTIC USE AND AMR

C1. Prevalence of antibiotic use, sources and reason for taking antibiotics

- A few respondents (6.3%) reported that they have taken antibiotics in an oral form during the last month with a drop (-1.7%) from the 2017 survey.
- The majority of respondents (98.1%) obtained their last course of antibiotics through healthcare professionals; either via healthcare facilities or retail pharmacists dispensed by licensed pharmacists. Only 1.9% obtained them from other sources such as grocery stores.
- Respondents were most likely to mention flu (43.2%) as a reason for taking antibiotics in the last month, which is defined as inappropriate use. There has been an increase in the proportion of people taking antibiotics for flu (+16.2 percentage points) compared to that reported in the 2017 Health Welfare Survey followed by 32.0% for fever (+12.8%) and 27.2% for a sore throat (+10.4%).

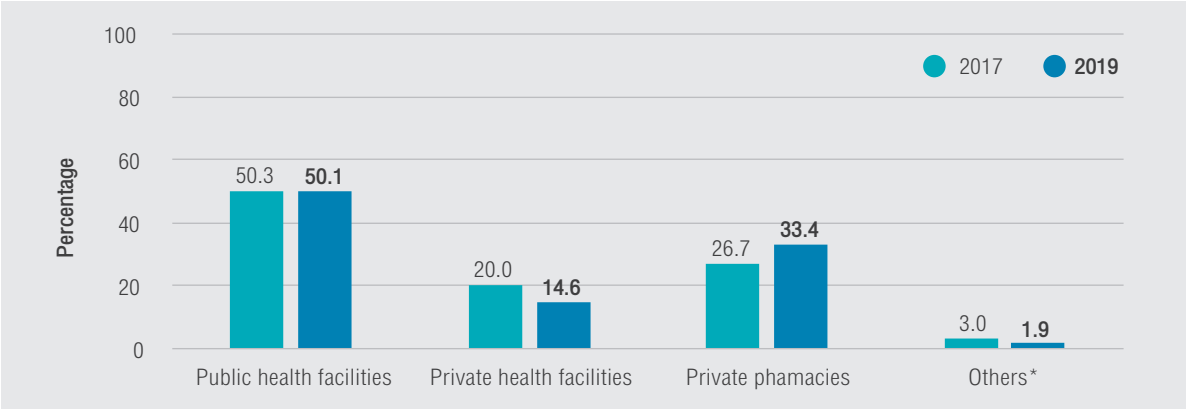


Figure C1.1 Percentages of respondents who received antibiotics classified by sources: comparative findings for 2017 and 2019.

*Others defined as antibiotics provided by non-health professionals e.g. grocery, leftover antibiotics, etc.

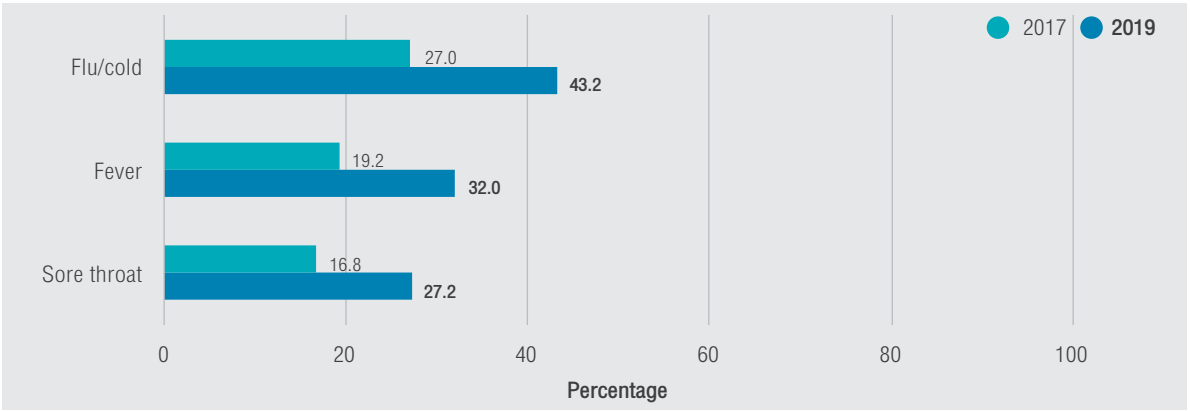


Figure C1.2 Percentages of respondents who received antibiotics classified by reason for taking antibiotics: comparative findings for 2017 and 2019.

Note: Total percentage were more than 100% due to multiple answers.

Other answers such as muscle aches, pharyngitis and others range from 0.3% to 23.8% in 2019 (not showed in the Figure).

C2. Knowledge on antibiotic use and AMR

- Overall, the level of knowledge on AMR and antibiotic use has slightly increased to 24.3% of adults who gave correct answers to more than three out of six true/false statements in 2019 from 23.7% in 2017.
- The proportion of adults who gave correct answers in each statement of knowledge on antibiotic use in 2019 increased from 2017 results, except the statement "Antibiotics are equivalent to anti-inflammatory drugs".
- However, Thai adults still have low levels of knowledge about antibiotic use and AMR. More than half of respondents could not answer correctly to these four statements:
  1. "Antibiotics cannot kill viruses",
  2. "Antibiotics are not effective against colds and flu",
  3. "Antibiotics are not equivalent to anti-inflammatory drugs" and
  4. "Taking antibiotics often has side effects such as diarrhea".

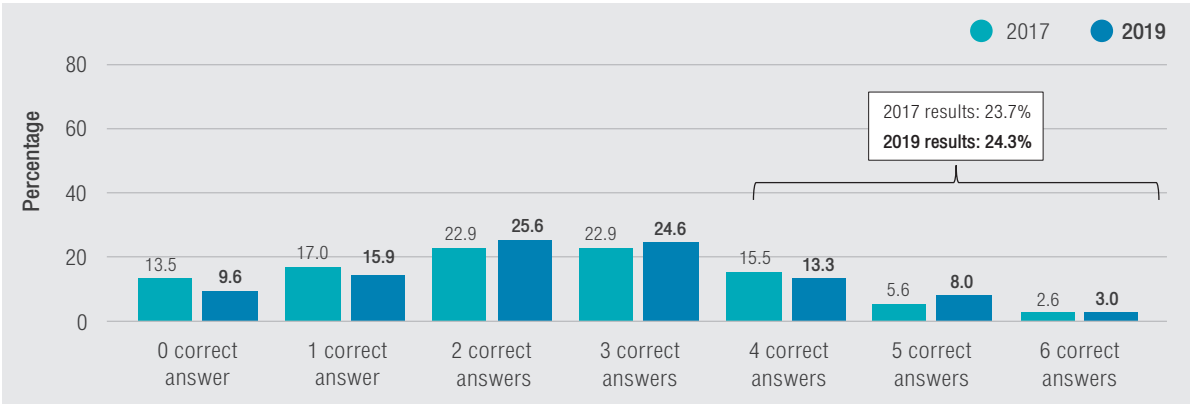


Figure C1.3 Percentages of respondents who gave correct answers: comparative findings for 2017 and 2019

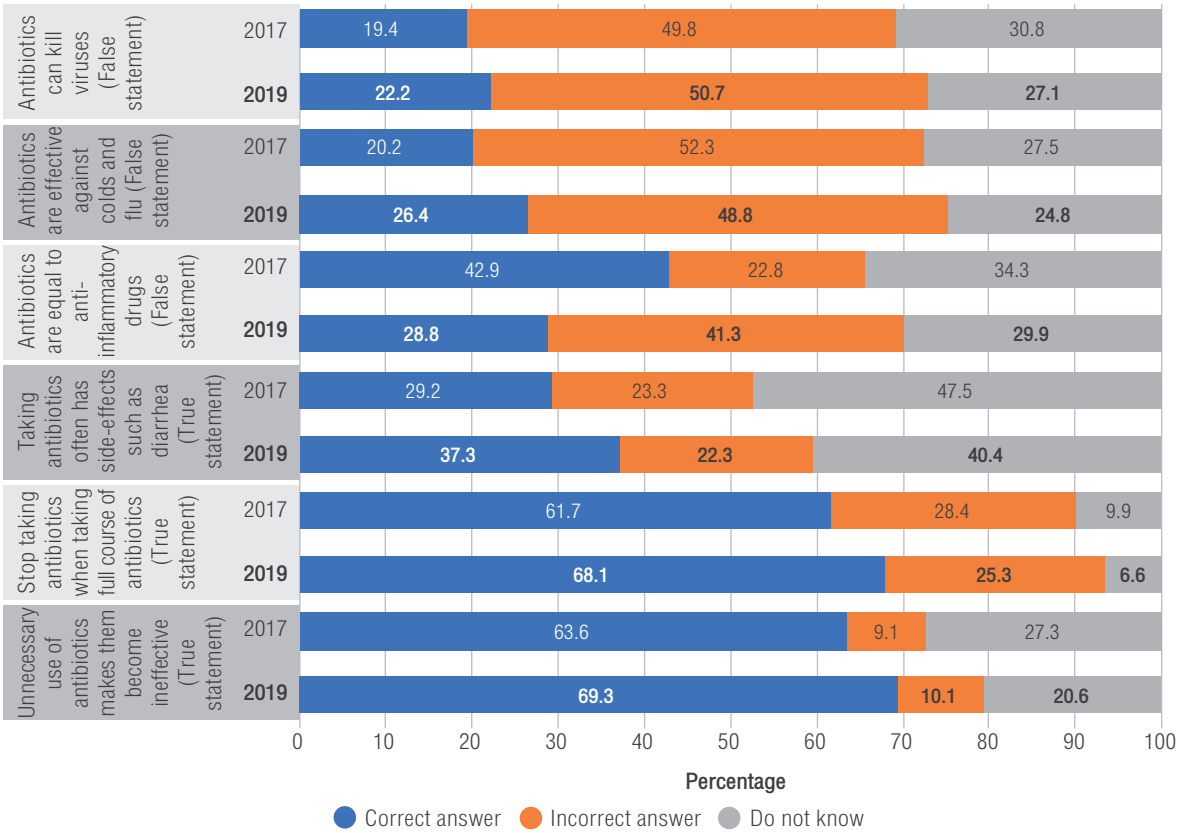


Figure C1.4 Percentage of respondents who gave correct answer in each statement of knowledge on antibiotic use: comparative findings between 2017 and 2019 (%)

C3 Awareness of antibiotic use and AMR

- The overall mean score of Thai adults' awareness of appropriate antibiotic use and AMR was 3.3 out of 5 (Standard Deviation 0.8).
- The majority of respondents correctly recognised the importance of antibiotic use and AMR problems:
  - 89.6% of respondents agreed that "they should use antibiotics only when they are prescribed by a doctor or nurse".
  - 83.7% agreed that "antibiotic resistance is an important problem that should be considered".
- Only one-third of respondents agreed that they should not keep antibiotics for use in the next episode of illnesses.
- The majority of respondents believed that they are not at risk of getting an infection from antibiotic-resistant bacteria, as long as they take antibiotics correctly (83.3%) although this is not, in fact, the case.

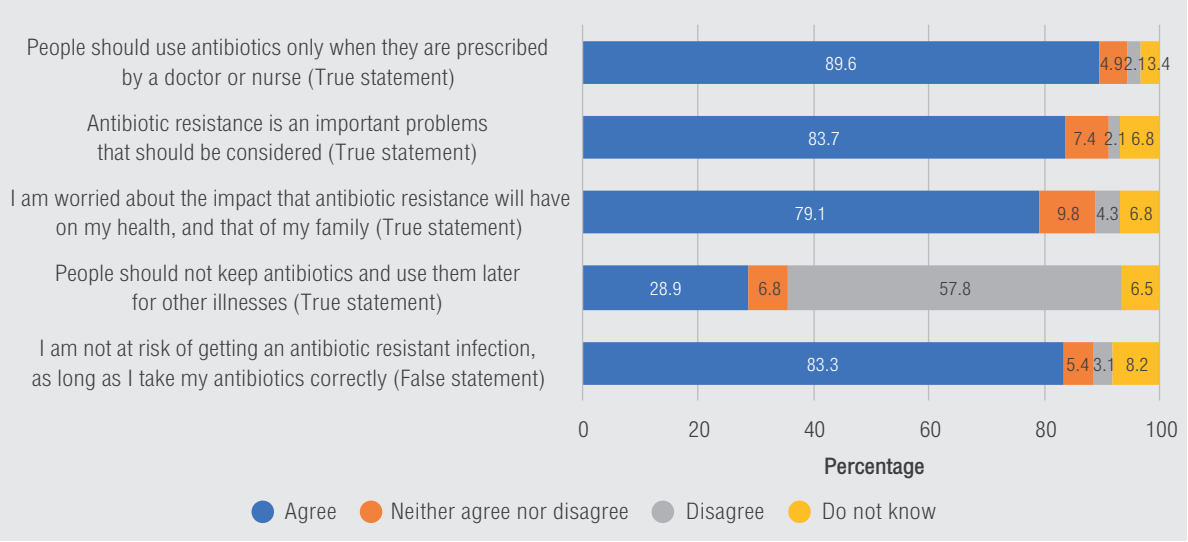


Figure C1.5 Level of agreement by respondents on five statements on awareness of appropriate antibiotic use and AMR in 2019

C4 Public information on antibiotic use and AMR

- During the last 12 months, nearly a quarter of Thai adults (21.5%) received information about the appropriate use of antibiotics and AMR, which increased from the previous survey in 2017 (17.8%).
- The most common source of information about antibiotic use and AMR was through health professionals (82.7%).

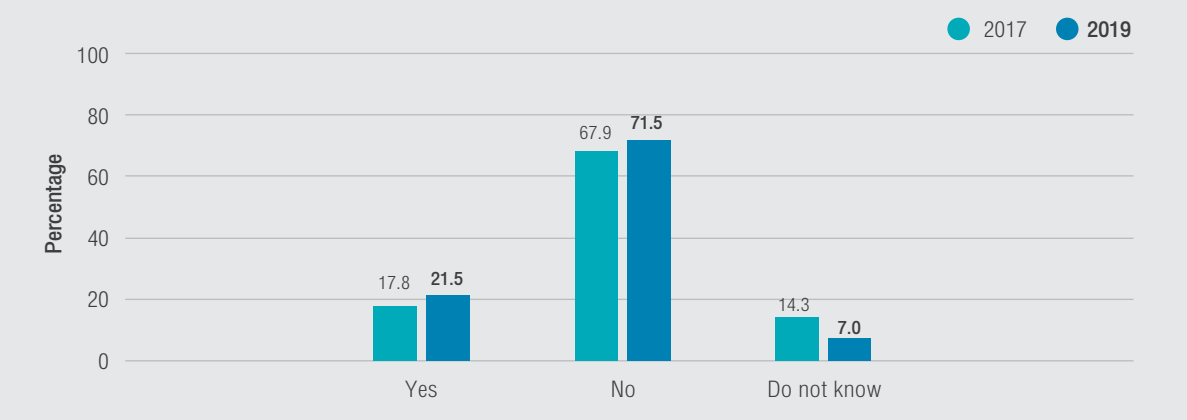


Figure C1.6 Number of respondents who received information about appropriate antibiotic use and AMR in 2019 (% compared to 2017)

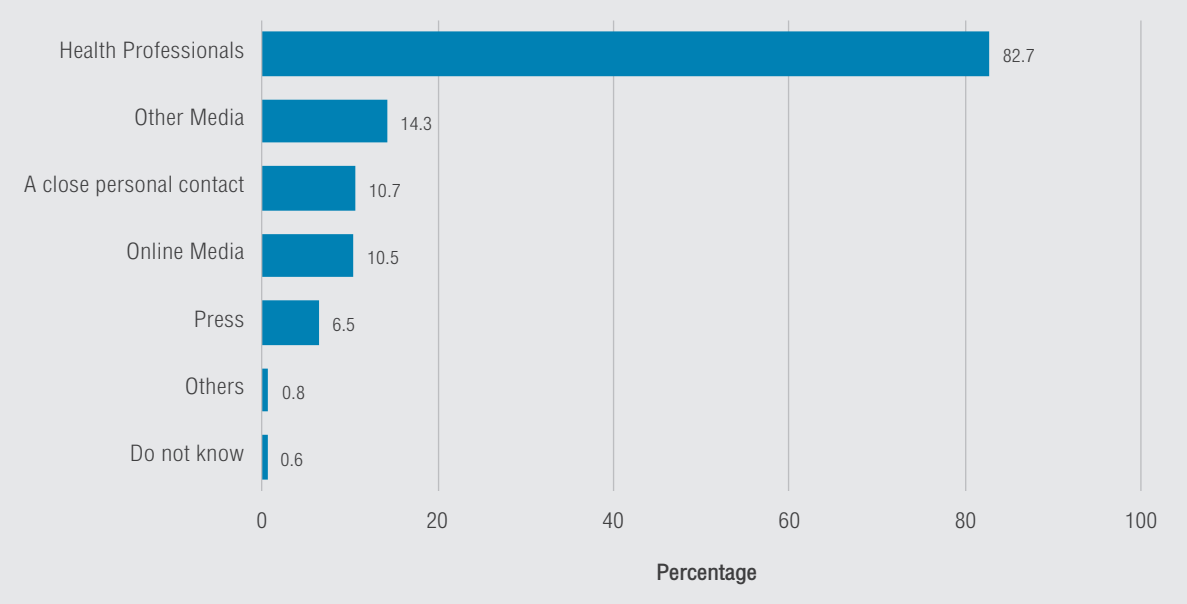


Figure C1.7 Source of information on appropriate use of antibiotics and AMR in the last year (2019)

Note: Total percentages were more than 100% due to multiple answers.

ANNEX

ANNEX

1. ANTIMICROBIAL CONSUMPTION : METHODOLOGY

1.1 Human and Animal Populations

The numbers of human and animal populations in Thailand 2019 were collected, retrieved and verified by various relevant stakeholders to ensure their accuracy. On the basis of populations potentially exposed to antimicrobials, the Figure of each particular population was used as a denominator to calculate the amount of national antimicrobial consumption (AMC).

1.1.1 Human population

In 2018, the mid-year population in Thailand including both Thai citizens and migrants was estimated (Table D1) (2).

Table D1. Human population (2019)

	Male	Female	Total
Citizen	33,904,846	35,720,736	69,625,582
Migrant	3,913,258	3,913,258	
Total	**73,538,840**		

1.1.2 Animal population

Food-producing animal population

The number of food-producing animals was collected and verified through cooperation between the Department of Livestock Development (DLD), Department of Fisheries (DOF), private sector and relevant stakeholders.

For terrestrial food-producing animals, the data were collected and verified from three sources: livestock surveys by regional DLD offices, data records from the E-movement system of DLD, and large-scale producers. As can be seen in Table D2, some of the average weights at the time of treatment (Aw) for certain species were not available in the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC), but were produced in Thailand (3). Consequently, these missing Aw were estimated based on standing weight of these animals (Table D2). Population Correction Unit (PCU) is used as a denominator for AMC in food-producing animals and calculated by applying ESVAC methodology. According to the ESVAC, PCU is assumed to be a surrogate for the animal population at risk of being exposed to antimicrobials (4). However, the PCU in this report was modified from ESVAC, so it is called $PCU_{Thailand}$.

Regarding the aquatic animal population, data were collected from surveys and estimated by the Fisheries Development Policy and Strategy Division of the DOF. The species included were major fishes and shrimps produced from coastal and fresh waters (Table D2). The Figure of aquatic animals are shown in kilogram (kg) of biomass.

Companion animal population

The number of companion animals could not be accurately estimated. Although companion animals, due to its small size of population, are estimated to have much lower AMC than terrestrial food-producing and aquatic animals, the Health Policy and Systems Research on Antimicrobial Resistance (HPSR-AMR) Network plans to collect data on the companion animal population to fill gaps under the One Health approach. Studies have shown the off-label use of antibiotics registered as human antibiotics as the major share of antibiotics used by companion animals (5). Assessment of animal hospital electronic prescription/dispensing database by HPSR-AMR team found feasible to establish AMU in this group in the near future.

Table D2. Food-producing animal population (2019)

Animal category	Aw (kg)	Quantity	PCU (kg)
Terrestrial animals (number of animals)			
Pigs			
Pig breeders	240**	1,211,587	290,780,880.0
Fattening pigs	65**	22,201,488	1,443,096,720.0
Poultry			
Broiler breeder	4*	17,000,000	68,000,000.0
Broilers	1**	1,706,363,843	1,706,363,843.0
Layer breeders	2*	617,051	1,234,102.0
Laying hens	2*	49,533,033	99,066,066.0
Pullets	1.5*	47,056,381	70,584,571.5
Broiler duck breeders	3.5*	321,342	1,124,697.0
Integrated broiler ducks	3.3*	32,134,236	106,042,978.8
Free-market broiler ducks	3.3*	7,345,000	24,238,500.0
Integrated layer ducks	2.5*	6,569,000	16,422,500.0
Free-market layer ducks	2.5*	9,311,504	23,278,760.0
Cattle			
Dairy cows	425**	374,607	159,207,975.0
Dry cows	425*	291,704	123,974,200.0
Beef cows	425**	6,011,000	2,554,675,000.0
Aquatic animals (1,000 tonnes of biomass)			
Coastal aquatic animals		457.28	457,277,885.9
Fresh aquatic animals		486.82	486,817,516.6
Total $PCU_{Thailand}$			**7,632,186,195.8**

*Thailand SAC

**ESVAC

1.2 Method and data source

A1 and A2: Antimicrobial Consumption (FDA)

1.2.1 Overview

In Thailand, oral human antimicrobials and their preparation for external use are classified as dangerous drugs, which must be dispensed only by a licensed pharmacist. In 2019, some oral antimicrobials such as oral antituberculous drugs and injectable antimicrobials were re-classified as special controlled drugs, which require a prescription from a licensed physician (6,7). Some antimicrobials for veterinary use are classified as dangerous drugs, which must be dispensed by a licensed pharmacist or veterinarian without a prescription. In 2019, some veterinary antimicrobials, that is, antibacterials in medicated premix, quinolones and derivatives, cephalosporins, macrolides, and polymyxins were re-classified as specially controlled drugs, which require a prescription before being dispensed (8,9).

According to the NSP-AMR, one of the goals is to reduce human antimicrobial consumption by 20% and veterinary antimicrobial consumption by 30% by 2021. In order to make the goals measurable, the method of monitoring antimicrobial consumption is of substantial importance and that is one of the reasons that Thailand SAC has been developed. Aside from monitoring the national goals, the data from Thailand SAC are useful for both health professionals and policymakers due to the fact that consumption data can help assess the effects of policy implementation, particularly improving the Antimicrobial Stewardship Program (ASP) and law enforcement such as the re-classification of antimicrobials as a specially controlled drugs, which limits the use of antimicrobials only through a licensed physician or an infectious-disease doctor. With some improvements in methodology and data granularity, such useful information can be utilized not only at national, but also at local and regional levels as well to tackle antimicrobial resistance problems in an efficient and practical way.

1.2.2 Data source

According to Drug Act B.E. 2510 (1967) Section 85, all pharmaceutical manufacturers and importers are required by FDA to submit an annual report, which consists of their total production and/or importation volumes of registered products, by 31 March of the following year (10). The data were then electronically retrieved on 31 March 2020 for analysis. In an effort to reach the actual domestic consumption as shown in the scheme of Thailand's drug distribution, the manufacturers and importers, though not mandated by law, were requested to submit their total export volume for subtracting from the total consumption (11).

For human target antimicrobials, Thailand Surveillance on Antimicrobial Consumption (Thailand SAC) covered the core and optional classes of antimicrobials recommended by the World Health Organization (WHO) (12). (Table D3). The unit of measurement was Defined Daily Dose (DDD) as a nominator and the mid-year human population as a denominator, ultimately resulting in DDD/1,000 inhabitants/day (DID). DDD in this report applies the updated version of Anatomical Therapeutic Chemical (ATC)/DDD alterations 2020 which is produced by the WHO Collaborating Centre for Drug Statistics Methodology (13).

For the scope of veterinary target antimicrobials, Thailand SAC covered the list of antimicrobials in line with the World Organisation for Animal Health (OIE) and ESVAC (14) (Table D4).

Table D3. The core and optional classes of target human antimicrobials by WHO

Target human antimicrobials	ATC code
1. Core class	
• Antibacterials for systemic use	J01
• Antibiotics for alimentary tract	A07AA
• Nitroimidazole derivatives	P01AB
2. Optional class	
• Antimycotics for systemic use	J02
• Antifungals for systemic use	D01BA
• Antivirals for systemic use	J05
• Drugs for treatment of tuberculosis	J04A
• Antimalarials	P01B

Table D4. The scope of target antimicrobials intended for use in animals (mainly food-producing animals)

Target veterinary antimicrobials	ATC vet codes
1. Antimicrobial agents for intestinal use	
• Antibiotics	QA07AA
• Sulfonamides	QA07AB
• Other intestinal anti-infectives	QA07AX
2. Antimicrobial agents for intrauterine use	
• Antibiotics	QG01AA, QG01BA
• Sulfonamides	QG01AE, QG01BE
• Antibacterials	QG51AA
• Anti-infectives for intrauterine use	QG51AG
3. Antimicrobial agents for systemic use	QJ01
4. Antimicrobial agents for intramammary use	QJ51

1.2.3 Limitations

A few limitations are addressed. The law did not require pharmaceutical operators to submit export volumes, so not all pharmaceutical manufacturers and importers voluntarily submitted data to the Thai FDA. Consequently, the amount of human antimicrobial consumption might be overestimated. Thailand SAC relies on manufacture and importation data minus the export volume; this has an inevitable disadvantage because the accuracy of the data could be disturbed by the amount of unconsumed stock products. The new regulation requires the pharmaceutical operators to submit the distribution amounts based on sale data in 2020. This requirement will come into effect in the annual report of 2020. Besides, awareness and cooperation from pharmaceutical operators to comply with the new requirement isneeded. Moreover, annual reports to the Thai FDA capture only all legal import and manufacture medicines.

With effort to achieve the actual national consumption Figures, Thai FDA received cooperation from pharmaceutical operators in reporting and improved methodology to capture all antimicrobials, resulting in not only the accurate number of reported registered products but also improved quality of the reports. Along with verification of the registration database from 2017-18, especially related to drug strengths and ATC codes, the differences in consumption data may be derived not only from policies in relation to antimicrobial distribution but from these methodological improvements as well.

1.2.4 Prospect

In order to fully capture antimicrobial consumption, all export values need to be reported and verified with other sources such as port of entry for air, land and sea borders. In doing so, it increases not only the accuracy of the data, but also prevents illegal importation and smuggling along borders. As an unavoidable disadvantage of using total manufacture and import data, the consumption data cannot provide information on how many antimicrobials have been annually used at primary healthcare, retail sector and inpatient hospital care venues, resulting in lack of granularity of data at user level such as age, gender and ward. Therefore, sales data would be more accurate than import, local production and export data, but mandatory reporting for the sales data requires legislative amendments. The new amendment of Ministerial regulations was endorsed and mandatorily requires pharmaceutical operators to electronically submit annual reporting of distribution channels and export volumes of all medicines including antimicrobials. The data on distribution channels are expected to be available in 2022.

For the ultimate goal, antimicrobial consumption at user level should be considered because it reflects the amount of antimicrobials used and policy consequences. However, the acquisition of the data requires a good drug-dispensing system aligned with reliable information systems such as host-to-host services or other timely systems with internal validation.

1.3 Antimicrobial Consumption in Food-Producing Animals (Medicated Feed through Feed Mills)

1.3.1 Overview

More than half of veterinary antimicrobials in Thailand was consumed through medicated feed, which can be produced by either feed mills or farm mixers (15). This pattern was also found in 2018 (16). By law, premix for medicated stuff, as a specially controlled medicine, must be dispensed by either a licensed pharmacist or veterinarian from authorized wholesalers to authorized feed mills (8,9). Then, the production of medicated feed at the feed mill requires a prescription by another licensed veterinarian at farm (17,18).

According to the NSP-AMR, one of the goals is to reduce veterinary antimicrobial consumption by 30% in 2021. In order to achieve the goal and seal the gaps of pharmaceutical supply chains, feed mills are a potential platform for monitoring and evaluation of Thailand Surveillance of Antimicrobial Consumption (SAC). Aside from monitoring the national goal to pragmatic utility, the data from Thailand SAC are useful for both health professionals and policymakers. This is due to the fact that they can help assess the effects of policy implementation, law enforcement, antimicrobial stewardship programmes (ASP), and other relevant interventions. With some improvements in methodology and data granularity, such useful information can be utilized not only at national, but also at local and regional levels as well to tackle antimicrobial resistance problems in an efficient and practical way.

1.3.2 Data source

According to Animal Feed Quality Ccontrol Act B.E. 2558 (2015), all manufacturers and importers are required by DLD to submit an annual report, which consists of their total production and/or importation volumes of feed and medicated feed, by 31 March of the following year (19,20). The data were then electronically retrieved on 31 March 2020 for analysis. “Other” type of animal was not included in the analysis and represented only a small proportion.

Data were derived from 68 feed mills, of which 67 feed mills were large-scale and the other one was small-to-medium-scale producers justified by production capacity (21).

1.3.3 Limitations and prospect

Despite coverage of large-scale feed producers, data on farm mixing of medicated feed were not captured. Inability to segregate data by registered medicated feed and lack of regular on-site verification process could affect reliability and accuracy of input data.

To fully capture veterinary consumption through feed mills, database of medicated feed should be developed and linked to a reporting system for veterinary antimicrobial in feed to facilitate a reporting system for feed mill licensees. Last, regular on-site verification at feed mills should be conducted, which can be facilitated by linkages between the reporting system and specially controlled feed.

2. ANTIMICROBIAL RESISTANCE : METHODOLOGY

2.1 Antimicrobial Resistance in Humans

2.1.1 Overview

Antimicrobial resistance (AMR) in bacterial isolates from human has been increasing in Thailand, especially in Gram-negative bacteria. To date, the data regarding systematic antimicrobial susceptibility is limited. For the surveillance report, we aimed to observe and implement the antimicrobial data into clinical practice.

2.1.2 Method and data sources

Antimicrobial resistance data were collected from 74, 85 and 92 hospitals in Thailand during 2017, 2018 and 2019, respectively, with support from NARST, National Institute of Health, Department of Medical Sciences, The Ministry of Public Health, Thailand. The 2017, 2018 and 2019 gonococcal antimicrobial resistance data were provided by the Department of Disease Control, The Ministry of Public Health, Thailand through Bangrak STIs center, Silom Community Clinic @TropMed and three and six centers of The Office of Disease Prevention and Control, respectively. Data on antimicrobial resistance and MIC values in 2017, 2018 and 2019 were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) susceptibility breakpoints 2017, 2018 and 2019, respectively.

2.1.3 Limitations

- This report did not identify risk factors linked with baseline characteristics of patients and did not show the distribution of isolates from different hospital levels (primary, secondary or tertiary care).
- For most data in this report, all types of specimen were selected for calculation of resistance rate.
- This report did not divide isolates into those from outpatient or inpatient hospital departments including intensive care units.
- Due to the cost of the MIC test, most of the *Staphylococcus aureus* and coagulase-negative *Staphylococcus* spp. isolates were tested by disk diffusion method, instead of the MIC test for vancomycin that is recommended by the CLSI guidelines.
- A two-year analysis of data is insufficient to draw a conclusion of resistant infectious trends in Thailand.
- Colistin susceptibility among gram-negative bacilli in this report was performed by broth microdilution at NARST microbiology laboratory. Therefore, it might not be a good representative of susceptibility patterns in these bacteria. Most clinical microbiology laboratories still lack capacity to perform the test by themselves. Efforts should be made to empower these laboratories to be capable of carrying out the test for both epidemiologic and clinical purposes around the country.

2.1.4 Recommendations

- The data regarding trends towards antimicrobial resistance should be observed for several years in order to assess the evolution and overall situation of antimicrobial resistance problems in Thailand. Findings will contribute substantially to addressing the problem of AMU and AMR and support implementation of effective antimicrobial stewardship policies and infection control programmes.
- Time trends analysis using logistic regression models over a longer period is needed in order to understand how significant changes in the past several years have evolved.

- Systematically combining data on antimicrobial consumption and antimicrobial resistance at patient, hospital, and community levels should be done to allow further analysis of the association between antimicrobial use and the development of resistance.
- Antimicrobial resistance data should be separately analyzed into specimen types (blood, sputum, urine, etc.) or at least sterile and non-sterile sites, and should be stratified by healthcare service sectors, for instance, the proportion of isolates from outpatient departments and inpatient departments including intensive care units.
- Regional antimicrobial resistance rates should be further analyzed and compared.
- Laboratory consideration of MIC testing is very crucial in dose optimization to tackle the antimicrobial resistance problem; thus, MICs of antimicrobial agents against certain bacterial species as suggested by international guidelines should be performed and reported in settings with available resources, for example, in vancomycin for *Staphylococcus aureus.*
- Antimicrobial resistance genes in highly antimicrobial-resistant organisms, (e.g. carbapenem-resistant enterococci, CRE) the carbapenemase genes should be identified and reported. This information may be of value in developing treatment guidelines to suggest reasonable therapeutic options on the essential medicines list.
- Because of the alarming trend of CRE and steady high prevalence of carbapenem-resistant *A. baumannii*, a specific plan at the national level should be constructed and implemented in a systematic manner to alleviate the healthcare burdens caused by these organisms.
- Data on antiviral resistance and antimicrobial resistance in fungi and *Mycobacterium tuberculosis* should be reported in the future.

2.2 Antimicrobial Resistance in Patients with Hospital-associated Infections

2.2.1 Overview

One of the five goals in the National Strategic Plan on Antimicrobial Resistance 2017-2021 (NSP-AMR 2017-2021) is to reduce AMR morbidity by 50.0% by 2021. Currently in Thailand, various departments of the Ministry of Public Health host fragmented AMR monitoring platforms.

Currently, there are two potential platforms to monitor AMR morbidity: 1) the Global Antimicrobial Resistance Surveillance System, Thailand (GLASS-Thailand) hosted by the National Institute of Health; and 2) Hospital Associated Infection Surveillance hosted by the Bamrasnaradura Infectious Disease Institute (BIDI's HAI surveillance).

In 2019, BIDI's HAI surveillance undertook HAI and AMR case-based surveillance in Thailand involving public and private hospitals; 50 hospitals were included in this study. The main objective was to estimate 2019 AMR morbidity and compare with the 2018 results.

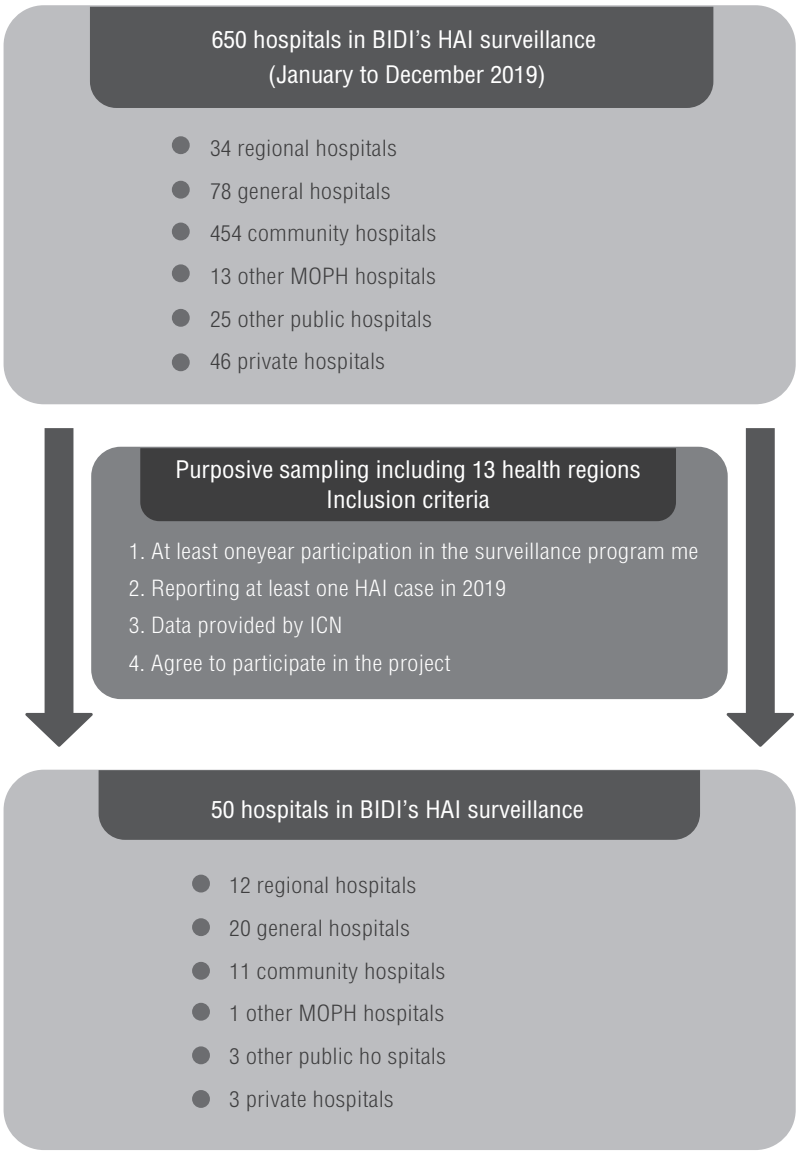
2.2.2 Method and data sources

Study design

This study retrospectively analyzed data from BIDI's hospital-wide surveillance, which included all HAI cases entered during January and December 2019.

All HAI occurring in these hospitals were detected by Infection control ward nurses (ICWNs) and confirmed by Infection control nurses (ICNs) in each hospital using the definition in the Thai Manual of HAI Diagnosis 2018 (22). The data of patients with HAI was manually submitted to the surveillance web portal on a monthly basis. To simplify the data entering process, only the susceptibility data (Susceptible, Intermediate or Resistant) of each drug group reported in laboratory results was collected; as a result, there was no zone size or MIC data. As well as HAI patient data, hospital service profiles such as the number of patient-days, the number of discharged patients and the number of ventilator-days were used as a denominator.

In 2019, 650 hospitals participated in the system. As data verification was needed, only 50 hospitals from 650 hospitals were included in the study. ICNs in these hospitals were requested to retrospectively review and complete any missing data using their hospital database.



Data collection

Data from 50 sampled hospitals, which included both patient records and hospital service profiles, were exported from the database. Then, the verification process was done and records with missing data were verified by local ICNs to fulfill the missing data from their own hospital database. After ICNs completed the missing data, data were rechecked, and the complete data set was analyzed by the research team.

2.2.3 Limitations and Prospect

- The data from the BIDI's surveillance covers only HAI data.
- Purposive sampling of 50 hospitals may limit the interpretation of the HAI and AMR in Thailand. This sampling method was different from the 2018 study which might be limited to the comparison between 2018 and 2019 results.
- AMR pathogens included in this study were based on the NSP-AMR pathogen lists.
- Selected antimicrobials for drug sensitivity testing cover both antimicrobial class (ATC level 4) and antimicrobial active ingredient (ATC level 5).
- Quantity and quality of data submitted in the surveillance programme were verified and validated at hospital level. Lack of colistin susceptibility testing existed in some hospitals (around 30.0% of isolated pathogens).

2.3 AMR in Food-Producing Animals

2.3.1 Overview

In response to the global agenda and Thailand's national strategic plan on AMR 2017–2021, the Department of Livestock Development (DLD) has, since 2017, played an important role in controlling and regulating antimicrobial use in the animal sector, and also initiated the surveillance system on AMR in food-producing animals. The aims of the surveillance system were to monitor the trend of AMR and to promote the prudent use of antimicrobials in farm animals in Thailand. The AMR surveillance was conducted by the ten laboratories under the National Institute of Animal Health (NIAH), Bureau of Quality Control of Livestock Product, and Regional Veterinary Research and Development Center.

2.3.2 Data source

In Thailand, the national surveillance of AMR in food-producing animals was conducted in broiler chickens and pigs because they are the main food-producing animals that are potentially raised with antimicrobials. This surveillance was conducted across the food production chain from slaughter-houses (cecum and meat samples) to retail stores (meat samples). In compliance with the OIE guideline, the sample size was calculated, and a total of 4,608 samples were obtained from all over the country. All the samples were collected by Provincial Livestock Offices and transported to and tested at the DLD laboratories. The target bacteria of AMR surveillance included zoonotic bacteria (*Salmonella* spp., *C. coli* and *C. jejuni*) and indicator bacteria (*E. faecium* and *E. faecalis*, and *E. coli*). Antimicrobial Susceptibility Testing (AST) was performed based on the Clinical and Laboratory Standards Institute (CLSI), International Organization for Standardization (ISO) 20776-1, and the European Committee on Antimicrobial Susceptibility Testing (EUCAST). The tested antimicrobials included:

- Polymyxins (colistin),
- Fluoroquinolones (ciprofloxacin),
- Third generation cephalosporins (cefotaxime and ceftazidime),
- Antibiotics which have been banned or are not used in livestock, but were included for surveillance purposes, including carbapenems (meropenem), amphenicols (chloramphenicol), glycopeptides and lipoglycopeptide (vancomycin and teicoplanin) and oxazolidinones (linezolid)
- Other antibiotic groups used in livestock including sulfonamides, dihydrofolate reductase inhibitors and combinations (sulfamethoxazole and trimethoprim) and aminoglycosides (gentamicin and streptomycin).

Table D5. Responsible organisation, sampling details, and antimicrobial susceptibility testing

The responsible agency	1. National Institute of Animal Health 2.Bureau of Quality Control of Livestock Product 3.Regional Veterinary Research and Development Center 4.Division of Animal Feed and Veterinary Products Control	
Target animal	Broiler chicken and pigs	
Target specimen/sample and responsible organisation	Cecum of chicken and pigs were performed by National Institute of Animal Health, and Regional Veterinary Research and Development Center	Chicken meat and pork were performed by Bureau of Quality Control of Livestock Product, and RegionalVeterinary Research and Development Center
Sampling location	Slaughterhouses	Slaughterhouses and retailers
Target bacterial isolates	*E. coli* *Salmonella* spp. *E.faecium* and *E. faecalis* *C. coli* and *C. jejuni*	*E. coli* *Salmonella* spp.
Antibiotics Susceptibility Testing	MIC determination: Broth microdilution, manual method and automated MIC device	
Reference	WHO, OIE, FAO, CLSI, EUCAST and ISO 20776-1	
Drug panel for AST	All class of antibiotics for testing pathogen reference from CLSI, EUCAST and European Food Safety Authority (EFSA)	

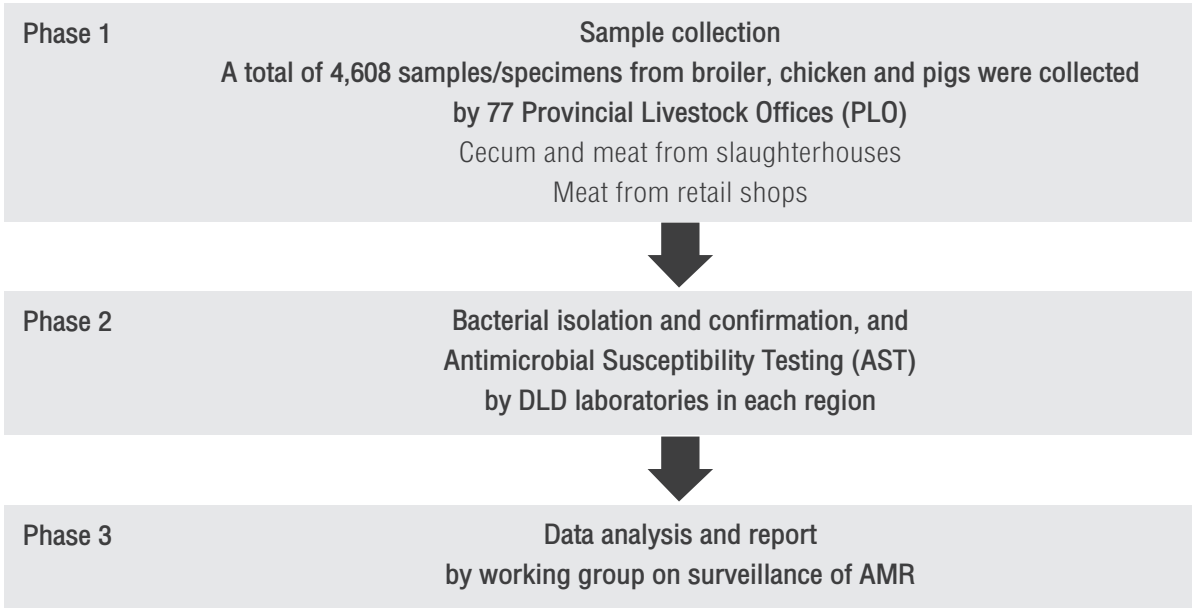


Figure D1. Process of sample collection, microbiological testing, and data analysis

2.3.3 Limitations and Prospect

The number of *C. coli* and *C. jejuni* isolates were insufficient to reach the target sample size, so it may affect the result of AMR surveillance. As *Campylobacter* spp. are fastidious bacteria, sample processing and bacterial identification techniques are of importance.

Some antimicrobials included in the panel might be found to be resistant, but they have been banned in livestock (vancomycin and chloramphenicol), and were not available for animals (teicoplanin), or used as a representative drug of an antimicrobial class (ciprofloxacin for fluoroquinolones). Consequently, careful interpretation on AMR results is advised. Lastly, this preliminary phase of AMR surveillance in food-producing animals were mainly focused only on phenotypic characterization of AMR. Genetic resistance determinants should be further performed for implementing an efficient AMR surveillance system.

In the next phase, the DLD has planned to include Extended Spectrum Beta- Lactamase (ESBL) phenotypic screening in the surveillance panel and improve the quality of bacterial identification, especially for *C. coli* and *C. jejuni* to increase the proper sample size for analysis and interpretation.

The surveillance of AMR indicated the current situation of AMR in the animal sector. For Critically Important Antimicrobials (CIA), the use of cephalosporins (3^{rd} and 4^{th} generation), polymyxins, and macrolides should be restricted in food-producing animals. Despite a low resistance rate of CIA, the routine surveillance of AMR in chicken and pigs should be implemented to monitor AMR bacteria in food-producing animals throughout the food chain. Moreover, the study of resistance determinants is needed to strengthen AMR capacity in Thailand.

3. KNOWLEDGE AND AWARENESS ON ANTIBIOTIC USE AND AMR : METHODOLOGY

3.1 Knowledge and Awareness on antimicrobial use and AMR

3.1.1 Overview

The Thailand National Strategic Plan on AMR 2017-2021 was endorsed by the Cabinet in August 2016. One of the five goals is to increase public knowledge of antibiotics and awareness on AMR by 20.0% before 2021.

In 2017, the National Statistical Office (NSO) and the International Health Policy Program (IHPP) of the Ministry of Public Health, Thailand jointly developed an antimicrobial resistance module and integrated it into the HWS, which is a national representative cross-sectional household interview survey carried out biennially by the NSO. The AMR module aims to assess the use of antibiotics, levels of knowledge and awareness about antibiotic use and AMR, and sources of information on the appropriate use of antibiotics and AMR among the Thai population. This evidence is essential to assess progress in implementing the NSP-AMR.

3.1.2 Methods

A stratified two-stage sampling approach was used. The first stratum was all 77 provinces (including Bangkok); the second stratum in each province has two sub-strata, namely urban and rural areas. Enumeration areas (EA) for urban and rural were calculated based on proportional probability to the size of the population and 1,990 sample EAs were selected. From the sampling frame in each of the selected EAs, 16 and 12 households were systematically randomly selected from urban and rural EAs. The total of 27,762 and 27,900 households were selected in 2017 and 2019, respectively, and face-to-face interviews were conducted with Thai adults aged 15 years or above.

The AMR module has four sections:

I. Prevalence of antibiotic use, sources, and reason for taking antibiotics

II. Knowledge about appropriate antibiotic use and antimicrobial resistance

III. Awareness of appropriate antibiotic use and antimicrobial resistance

IV. Public information about appropriate antibiotic use and antimicrobial resistance.

The AMR module was modified from the “Antimicrobial Resistance: Eurobarometer Survey” and “Antibiotic resistance: multi-country public awareness survey” with additional questions on knowledge of antibiotic use and AMR specifically designed to suit the national context.

The AMR module had four sections. The first section asked about the use of antibiotics in the last month, the sources of antibiotics, and the reasons for using them. The second section asked about knowledge of antibiotic use and AMR, which was assessed using true/false statements and one question. Section three asked about awareness of the importance of appropriate antibiotic use and AMR (inserted in 2019). The last session explored whether respondents had received information during the last twelve months about antibiotics and AMR and the sources of such information. (Table D6)

Table D6. AMR module embedded in 2019 HWS

	Contents	Choices of answer
I. USE OF ANTIBIOTICS, SOURCE OF ANTIBIOTICS, AND REASON FOR TAKING ANTIBIOTICS		
AB1	Have you taken any antibiotics orally such as tablets, powder or syrup in the last month?	• Yes • No • Do not know
AB2 (IF 'YES' to AB1)	Where did you obtain the last course of antibiotics that you used?	• Health center • Community hospital • General or regional hospital • University hospital • Other public hospital • Private hospital • Private clinic • Pharmacy • Online • Grocery store • Some left over from the previous treatment (your own and others) • Mobile medical Unit • Others (Specify)
AB3 (IF 'YES' to AB1)	What were the symptoms for last taking the antibiotics that you used?	• Sore throat • Cough • Fever • Loose stool • Headache • Muscle aches • Pustule/purulent wound • Fresh wound/bleeding wound • Dysuria • Leukorrhea • Toothache • Others (Specify) • No symptom • Do not know
AB4 (IF 'YES' to AB1)	What were the illnesses for last taking the antibiotics that you used?	• Pneumonia • Bronchitis • Pharyngitis/tonsillitis • Flu/cold • Diarrhea • Bloody diarrhea/dysentery • Skin infection/wound infection • Cystitis/pyelonephritis • Vaginitis/pelvic inflammatory disease • Acute otitis media/sinusitis • Gingivitis/periodontitis • Others (Specify) • No illness

	Contents	Choices of answer
II. KNOWLEDGE OF APPROPRIATE ANTIBIOTIC USE AND AMR		
AB5_1	Please tell me whether you think it is true or false.	• True • False • Do not know
AB5_2	Please tell me whether you think it is true or false.	• True • False • Do not know
AB5_3	Please tell me whether you think it is true or false.	• True • False • Do not know
AB5_4	Please tell me whether you think it is true or false.	• True • False • Do not know
AB5_5	Please tell me whether you think it is true or false.	• True • False • Do not know
AB 6	When do you think you should stop taking antibiotics once you have begun a course of treatment?	• When your illness is better • When you get full course of antibiotics (from doctor's or health professional's recommendation) • Others (Specify) • Do not know
III. AWARENESS OF THE IMPORTANCE OF APPROPRIATE ANTIBIOTIC USE AND AMR		
AB7_1	How much do you agree with following statements: People should use antibiotics only when they are prescribed by a doctor or nurse	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree
AB7_2	How much do you agree with following statements: People should not keep antibiotics and use them later for other illnesses	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree
AB7_3	How much do you agree with following statements: If I take antibiotics inappropriately, it induces antimicrobial resistance	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree
AB7_4	How much do you agree with following statements: Antibiotic resistance is one of the problems that should be considered	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree
AB7_5	How much do you agree with following statements: I am worried about the impact that antibiotic resistance will have on my health, and that of my family	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree

	Contents	Choices of answer
AB7_6	How much do you agree with following statements: I am not at risk of getting an antibiotic resistant infection, as long as I take my antibiotics correctly	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree
IV. PUBLIC INFORMATION ABOUT APPROPRIATE USE OF ANTIBIOTICS AND AMR		
AB8	In the last 12 months, do you remember getting any information about not taking antibiotics unnecessarily, for example for a cold or the flu, or information on antimicrobial resistance?	• Yes • No • Do not know
AB9 (IF 'YES' to AB8)	Whom did you get this information about not taking antibiotics unnecessarily? (Multiple answers possible)	• Leaflet/poster • Newspaper • Radio • TV • Internet/social media • Family members/Friends • Doctor • Nurse • Pharmacist • Another health professional • Others (Specify) • Do not know
I. USE OF ANTIBIOTICS, SOURCE OF ANTIBIOTICS AND REASON FOR TAKING ANTIBIOTICS		
AB1	Have you taken any antibiotics orally such as tablets, powder or syrup in the last month?	• Yes • No • Do not know
AB2 (IF 'YES' to AB1)	Where did you obtain the last course of antibiotics that you used?	• Health center • Community hospital • General or regional hospital • University hospital • Other public hospital • Private hospital • Private clinic • Pharmacy • Online • Grocery store • Some left over from the previous treatment (your own and others) • Mobile medical Unit • Others (Specify)

	Contents	Choices of answer
AB3 (IF 'YES' to AB1)	What were the symptoms for last taking the antibiotics that you used? (Multiple answers possible)	• Sore throat • Cough • Fever • Loose stool • Headache • Muscle aches • Pustule/purulent wound • Fresh wound/bleeding wound • Dysuria • Leukorrhea • Toothache • Others (Specify) • No symptom • Do not know
II. KNOWLEDGE OF APPROPRIATE ANTIBIOTIC USE AND AMR		
AB4_1	Please tell me whether you think it is true or false.	• True • False • Do not know
AB4_2	Please tell me whether you think it is true or false.	• True • False • Do not know
AB4_4	Please tell me whether you think it is true or false.	• True • False • Do not know
AB5_4	Please tell me whether you think it is true or false.	• True • False • Do not know
AB4_5	Please tell me whether you think it is true or false.	• True • False • Do not know
AB 5	When do you think you should stop taking antibiotics once you have begun a course of treatment?	• When your illness is better • When you get full course of antibiotics (from doctor's or health professionals recommendation) • Others (Specify) • Do not know
III. AWARENESS OF THE IMPORTANCE OF APPROPRIATE ANTIBIOTIC USE AND AMR		
AB6_1	How much do you agree with following statements: People should use antibiotics only when they are prescribed by a doctor or nurse	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree • Do not know
AB6_2	How much do you agree with following statements: People should not keep antibiotics and use them later for other illnesses	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree • Do not know

	Contents	Choices of answer
AB6_3	How much do you agree with following statements: If I take antibiotics inappropriately, it induces antimicrobial resistance	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree • Do not know
AB6_4	How much do you agree with following statements: Antibiotic resistance is one of the problems that should be considered	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree • Do not know
AB6_5	How much do you agree with following statements: I am worried about the impact that antibiotic resistance will have on my health, and that of my family	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree • Do not know
AB6_6	How much do you agree with following statements: I am not at risk of getting an antibiotic resistant infection, as long as I take my antibiotics correctly	• Strongly disagree • Slightly disagree • Neither agree nor disagree • Slightly agree • Strongly agree • Do not know
IV. PUBLIC INFORMATION ABOUT APPROPRIATE USE OF ANTIBIOTICS AND AMR		
AB7	In the last 12 months, do you remember getting any information about not taking antibiotics unnecessarily, for example for a cold or the flu, or information on antimicrobial resistance?	• Yes • No • Do not know
AB8 (IF 'YES' to AB7)	Whom did you get this information about not taking antibiotics unnecessarily? (Multiple answers possible)	• Leaflet/poster • Newspaper • Radio • TV • Internet/social media • Family members/Friends • Doctor • Nurse • Pharmacist • Another health professional • Others (Specify) • Do not know

The content validity was assessed by experts on the logic and clarity of the content. The pilot testing of the revised questionnaire was conducted with a sample of 30 individuals in order to improve the reliability of questions. These 30 individuals were randomly selected in Banmoh hospital, Saraburi Province on 1 August 2018. There was a minor amendment to the questionnaire after piloting.

3.1.3 Data analysis

Data were analyzed using STATA/IC (version 14.2). Descriptive measures were presented in populational weight percentages.

4. Health Policy and Systems Research on Antimicrobial Resistance (HPSR-AMR) Network members

MINISTRY OF PUBLIC HEALTH

International Health Policy Program

Viroj Tangcharoensathien
Angkana Lekagul
Supapat Kirivan
Anond Kulthanmanusorn
Hathairat Kosiyaporn
Wanwisa Kaewkhankhaeng
Saowapa Khotchalai
Oranat Rueangna

Food and Drug Administration

Charunee Krisanaphan
Varavoot Sermsinsiri
Nithima Sumpradit
Kritsada Limpananont
Chutamas Luangaroonchai
Pischa Lusanandana
Chaiporn Pumkam
Sitanan Poonpolsub
Pongsathid Virungrojint

Bamrasnaradura Infectious Diseases Institute

Weerawat Manosuthi
Visal Moolasart
Lantharita Charoenpong
Varaporn Thienthong
Ratchanu Charoenpak

National Institute of Health of Thailand, Department of Medical Sciences

Noppavan Janejai
Wantana Paveenkittiporn
Aekkawat Unahalekhaka
Pimrata Leethongdee

MINISTRY OF AGRICULTURE AND COOPERATIVES

Department of Livestock Development

Rakthai Ngampak
Pacharee Thongkamkoon
Lertchai Jintapitaksakul
Thanida Harintharanon
Sasi Jareonpoj

Watcharachai Narongsak
Julaporn Srinha
Thammarath Sujit
Supaporn Wongsrichai
Suchana Sukklad
Somsajee Sivilaikul
Passawee Pakpong
Thanawan Na Thalang

Department of Fisheries
Janejit Kongkumnerd
Thitiporn Laoprasert
Chanotit Nakmanoch
Jutamas Auewongaree
Siriwimon thamgandee

MINISTRY OF DIGITAL ECONOMY AND SOCIETY

National Statistical Office of Thailand
Apichart Thunyahan
Waree Maneepiphatkamol

Faculty of Pharmaceutical Sciences, Chulalongkorn University
Rungpetch Sakulbumrungsil
Sang Usayaporn

Faculty of Pharmacy, Silpakorn University
Inthira Kanchanaphibool

Faculty of Pharmaceutical Sciences, Khon Kaen University
Nussaraporn Kessomboon

Faculty of Pharmaceutical Sciences, Prince of Songkla University
Khunjira Udomaksorn

Faculty of Veterinary Science, Mahidol University
Walasinee Sakcamduang
Boonrat Chantong
Sarin Suwanpakdee
Anuwat Wiratsudakul

Thai Feed Mill Association
Boonyita Rujtikumporn
Wichai Thermphonboon
Chaiwat Suvanatad
Sompong Harnuthaikij
Krisada Rithichaidumrongkul

Yamuna Patthong
Sureemas Nitikanchana
Pranee Pirompud

Animal Health Products Association
Nackanun Chitaroon
Panitan Suwannapetch
Eagaluk Theerakornsakul
Varisara Jirathitivong

INTERNATIONAL PARTNERS

World Health Organization Country Office, Thailand
Richard Brown
Phiangjai Boonsuk

Food and Agriculture Organization of the United Nations
Kachen Wongsathapornchai
Mary Joy Gordoncillo
Katinka de Balogh
Yin Myo Aye

USAID/Regional Development Mission for Asia
Daniel Schar
Sudarat Damrongwatanapokin
Karoon Chanachai

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International Health Policy Program, Ministry of Public Health, Thailand

Thailand's One Health Report on Antimicrobial Consumption and Antimicrobial Resistance in 2020

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Published by:
International Health Policy Program, Ministry of Public Health, Thailand

Address:
Ministry of Public Health,
Tiwanon Rd. Nonthaburi 11000, Thailand
Phone: +66 (0) 2590-2366-7
Fax: +66 (0) 2590-2385

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Correspondence:
Any correspondence relating to this report should be sent by e-mail to: hpsr_amr@ihpp.thaigov.net

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Foreword

On behalf of the National Steering Committee on Antimicrobial Resistance, I welcome the publication of Thailand's One Health Report on Antimicrobial Consumption and Antimicrobial Resistance 2020.

In 2016, Thailand's first National Strategic Plan on Antimicrobial Resistance 2017-2021 (NSP-AMR) was endorsed by the Cabinet. In response to the strategic goals of NSP-AMR, the One Health Report on Antimicrobial Consumption and Antimicrobial Resistance has been produced to monitor antimicrobial consumption and antimicrobial resistance in humans and animals, and knowledge and public awareness on antimicrobial resistance since 2017.

Regarding the strategic goals, by 2021, we need to reduce morbidity attributable to antimicrobial resistance by 50.0%; reduce antimicrobial consumption by 20.0% in the human sector and 30.0% in the animal sector; and increase the proportion of the population shown to have a predefined basic level of knowledge and awareness of antimicrobial resistance by 20.0%.

This year, the report provides data in 2020, and compares it with 2017 baseline data for the monitoring of NSP-AMR (2017-2021) strategic goals. The overall consumption of human antimicrobials was 46.3 Defined Daily Doses/1000 inhabitants/day (-15.2% from 2017) and the overall consumption of veterinary antimicrobials was 421.5 mg/$PCU_{Thailand}$ (-36.0% from 2017).

We thank the members of the Health Policy and Systems Research on Antimicrobial Resistance (HPSR-AMR) Network, led by the International Health Policy Program, Ministry of Public Health, Thailand for their contribution to the development of this report. This report was produced through a collaborative process involving professionals working in the human and animal health sectors in Thailand.

We fully believe that cross-sectoral cooperation based on the One Health approach can effectively address antimicrobial resistance.

Dr. Paisarn Dunkum
Secretary-General
Food and Drug Administration
Ministry of Public Health

Dr. Supakit Sirilak
Director-General
Department of Medical Sciences
Ministry of Public Health

Dr. Opart Karnkawinpong
Director-General
Department of Disease Control
Ministry of Public Health

Dr. Sorravis Thaneto
Director-General
Department of Livestock Development
Ministry of Agriculture and Cooperatives

Mr. Mesak Pakdeekong
Director-General
Department of Fisheries
Ministry of Agriculture and Cooperatives

Mr. Athapol charoenchasa
Director-General
Pollution Control Department
Ministry of Natural Resources and Environment

On behalf of the National Steering Committee on Antimicrobial Resistance

Contributor

Editor in Chief:
Viroj Tangcharoensathien

Editorial team:
Angkana Lekagul
Supapat Kirivan
Wanwisa Kaewkhankhaeng
Saowapa Khotchalai
Wimonrat Tanomsridachchai

	Data sources	Authors	Expert reviewers
SECTION A ANTIMICROBIAL CONSUMPTION			
A1: **Antimicrobial Consumption in Humans**	Food and Drug Administration, Ministry of Public Health	Supapat Kirivan Charunee Krisanaphan Kritsada Limpananont Chutamas Luangaroonchai Pongsathid Virungrojint	Khunjira Udomaksorn Inthira Kanchanaphibool Nussaraporn Kessomboon Rungpecth Sakulbumrungsil
A2: **Antimicrobial Consumption in Food-Producing Animals**			Nackanun Chitaroon Natthasit Tansakul
A3: **Antimicrobial Consumption in Food-Producing Animals (Medicated Feed through Feed Mills)**	Department of Livestock Development, Ministry of Agriculture and Cooperatives	Supapat Kirivan Julaporn Srinha Somsajee Sivilaikul Porjai Rattanapanadda Suchana Sukklad Passawee Pakpong	Boonyita Rujtikumporn Natthasit Tansakul
SECTION B ANTIMICROBIAL RESISTANCE			
B1. **Antimicrobial Resistance in Humans**	National Antimicrobial Resistance Surveillance Center Thailand (NARST), National Institute of Health, Department of Medical Sciences, Ministry of Public Health Department of Disease Control, Ministry of Public Health	Sang Usayaporn Ratchanu Charoenpak Abhisit Prawang Noppavan Janejai Wantana Paveenkittiporn Aekkawat Unahalekhaka Pimrata Leethongdee	Chanwit Tribuddharat Lantharita Charoenpong Angkana Lekagul
B2. **Antimicrobial Resistance in Patients with Hospital-associated Infections**	Bamrasnaradura Infectious Disease Institute, Department of Disease Control, Ministry of Public Health	Wanwisa Kaewkhankhaeng Anond Kulthanmanusorn Weerawat Manosuthi Visal Moolasart Lantharita Charoenpong	Kumthorn Malathum Suvaporn Anugulruengkitt Angkana Lekagul
B3. **Antimicrobial resistance in Food-Producing Animals**	Department of Livestock Development, Ministry of Agriculture and Cooperatives	Saowapa Khotchalai Angkana Lekagul Julaporn Srinha Supaporn Wongsrichai Thanawan Na Thalang	Sanpech Angkititrakul Saharuetai Jeamsripong

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ABBREVIATIONS AND ACRONYMS

AMC	Antimicrobial consumption
AMR	Antimicrobial resistance
API	Active pharmaceutical ingredient
AST	Antimicrobial Susceptibility Testing
ATC	Anatomical Therapeutic Chemical
ATCvet	Anatomical Therapeutic Chemical classification system for veterinary medicinal products
AWaRe	Access, Watch, Reserve classification of antibiotics
Aw	Average weight at the time of treatment
BLI	Beta-lactamase inhibitor
CAUTI	Catheter-associated urinary tract infections
CIA	Critically important antimicrobials
CLABSI	Central line-associated bloodstream infections
CLSI	Clinical and Laboratory Standards Institute
CRPA	Carbapenem-resistant *Pseudomonas aeruginosa*
CRE	Carbapenem-resistant *Enterococci*
DDD	Defined Daily Dose
DID	Defined Daily Doses/1000 inhabitants/day
DLD	Department of Livestock Development, Ministry of Agriculture and Cooperatives
DOF	Department of Fisheries, Ministry of Agriculture and Cooperatives
EFSA	European Food Safety Authority
ESAC-Net	European Surveillance of Antimicrobial Consumption Network
ESVAC	European Surveillance of Veterinary Antimicrobial Consumption
EUCAST	European Committee on Antimicrobial Susceptibility Testing
FAO	Food and Agriculture Organization
FDA	Thai Food and Drug Administration
HPSR-AMR	Health Policy and Systems Research on Antimicrobial Resistance
HAI	Hospital-Associated Infections
I	Intermediate
ICN	Infection control nurse
ICWN	Infection control ward nurse
ISO	International Organization for Standardization
IHPP	International Health Policy Program
MIC	Minimal Inhibitory Concentration
MOPH	Ministry of Public Health
MRCNS	Methicillin-resistant coagulase-negative *Staphylococcus*
MRSA	methicillin-resistant *Staphylococcus aureus*
NARST	National Surveillance System for Antimicrobial Resistance
NSP-AMR	National Strategic Plan on Antimicrobial Resistance
NIAH	National Institute of Animal Health
OIE	World Organisation for Animal Health
PCU	Population correction unit
PLO	Provincial Livestock Offices
R	Resistant

S	Susceptible
SAC	Surveillance of Antimicrobial Consumption
SD	Standard deviation
SDD	Strains susceptible-dose dependent
SSI	Surgical site infection
VAP	Ventilator-associated pneumonia
VRE	Vancomycin-resistant *Enterococcus*
WHO	World Health Organization

GLOSSARY

Antimicrobial consumption (AMC)

Antimicrobial consumption is the quantity of consumption of antimicrobial drugs, which is measured at the national level as the quantity of its production plus imports minus the quantity of its exports. AMC is expressed as the number of Defined Daily Doses (DDDs) per 1,000 inhabitants per day for human antimicrobials, and milligram per Population Correction Unit, modified by Thailand (mg/$PCU_{Thailand}$) for food-producing animals.

Antimicrobial resistance (AMR)

Antimicrobial resistance is the ability of microbes (e.g. bacteria, viruses and fungi) to grow or survive even after exposure to antimicrobial agents at concentrations that are normally sufficient to inhibit or kill that particular strain of microbe. In this report, AMR predominantly means AMR in bacteria.

Antituberculous drug

Antituberculous drugs in Thailand Surveillance of antimicrobial consumption (Thailand SAC) are drugs used solely for treatment of tuberculosis; however, this may or may not include certain groups of drugs such as macrolides, fluoroquinolones and ansamycins due to their other indications for non-mycobacterial infections.

Antimicrobial agent

Antimicrobial agents are substances with antimicrobial properties or the ability to inhibit growth or metabolic processes in microbes (e.g. bacteria, viruses and fungi). They are obtained from living organisms or through synthesis. In this report, antimicrobial agents predominantly refer to antibacterial agents; except for the human antimicrobial consumption chapters in which antimicrobial agents cover antimicrobials of all origins, antivirals, antifungals, antimycotics, antituberculous drugs, and antimalarials.

Antibiotics

Antibiotics are antimicrobial medicines with bactericidal properties, (including those with the ability to stop bacterial growth), obtained from living organisms or through synthesis. Examples include penicillin, amoxicillin, tetracycline, norfloxacin and azithromycin. The terms microbicide (microbe killer), antibacterial medicines and antibiotics are used interchangeably.

Bacteria

Bacteria are one of the major groups of microorganisms or microbes, some of which can infect and cause diseases in humans and animals. A range of descriptive terms are used. Bacteria cultivated in a laboratory are referred to as isolates, capable of causing disease are referred to as pathogens (pathogens that are transmissible between animals and humans are zoonotic), and those that are normally resident on or in humans or animals without causing disease are referred to as commensals or colonizers.

Critically Important Antimicrobials

In this report, the Critically Important Antimicrobials (CIA) refers to the list of CIA for human medicine defined by the World Health Organization[1]. It ranks medically important antimicrobials for risk management of antimicrobial resistance due to non-human use. It was developed for cautious use in mitigating the human health risks associated with antimicrobial use (AMU) in both humans and food-producing animals.

One Health

A concept promoting a 'whole of society' approach to attain optimal health for people and animals, and a healthy environment.

Surveillance

Surveillance means a continuing process of collecting, collating and analysing data and communicating information to all relevant actors. It involves the generation and timely provision of information that can inform appropriate decision-making and action.

Susceptible

A category which implies that isolates are inhibited by the usually achievable concentrations of antimicrobial agent when the recommended dosage (dosage regimen) is used for achieving therapeutic effects at the site of infection (1).

Susceptible-dose dependent (SDD)

A category defined by a breakpoint that implies the susceptibility of an isolate is dependent on the dosing regimen that is used in the patient. In order to achieve levels that are likely to be clinically effective against isolates for which the susceptibility testing results are in the SDD category, it is necessary to use a dosing regimen (i.e., higher doses, more frequent doses, or both) that results in higher drug exposure than the dose that was used to establish the susceptible breakpoint.

Intermediate

A category which includes isolates with antimicrobial agent MICs that approach usually attainable blood and tissue levels and for which response rates may be lower than those for susceptible isolates, leading to less success rates of treatment (1).

Resistant

A category that implies that isolates are not inhibited by the usually achievable concentrations of the antimicrobial agent with normal dosage regimen and/or demonstrate MICs/zone diameters that fall in the range where specific microbial resistance mechanisms (e.g., β-lactamases) are likely to do and that clinical efficacy against the isolate has not been shown reliably in treatment studies (1).

Non-susceptible

A category used for isolates for which only a susceptible breakpoint is designated because of the absence or rare occurrence of resistant strains. This includes isolates for which the antimicrobial agent minimum inhibitory concentrations (MICs) are above a susceptible breakpoint or their zone diameters fall below the value indicated for the susceptible.

[1] World Health Organization. Critically important antimicrobials for human medicine, 6th revision. Geneva, 2019.

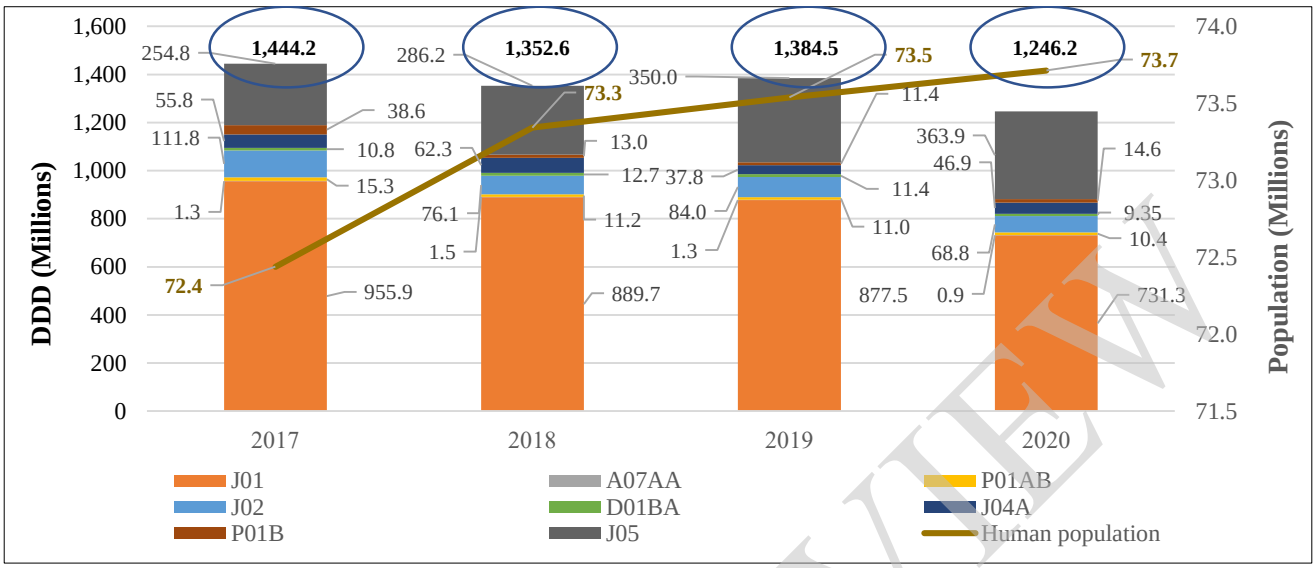
HIGHLIGHTS

Data on monitoring and evaluation of the Goals of Thailand's National Strategic Plan on Antimicrobial Resistance 2017-2021

Indicator	Data			
	2017	2018	2019	2020
A. Antimicrobial consumption in humans and animals				
Antimicrobial consumption in humans (Defined Daily Doses/1,000 inhabitants/day, DID)	54.6 (baseline)	50.5 (-7.5%)	51.6 (-5.6%)	46.3 (-15.2%)
Antimicrobial consumption in food-producing animals (mg/$PCU_{Thailand}$)	658.7 (baseline)	522.0 (-20.8%)	336.3 (-49.0%)	421.5 (-36.0%)
Antibacterial Consumption in Food-Producing Animals through Medicated Feed Produced by Feed mills (tonnes of API)(only pigs and poultry)	-	-	1,055.9 (baseline)	1,086.2 (+2.9%)
B. AMR in humans and animals				
Percentage of carbapenem-resistant *Acinetobacter baumannii* (CRAB)				
- AMR in humans, lab-based surveillance (NARST)	69.8	68.2	69.7	71.6
- AMR in patients with hospital-associated Infections	-	89.8	74.6	87.8
Percentage of carbapenem-resistant Enterobacteriaceae (CRE)				
- AMR in humans, lab-based surveillance (NARST) [*Escherichia coli, Klebsiella pneumoniae*]	2.4, 10.1	2.8, 12.3	3.3, 12.5	3.4, 12.6
- AMR in patients with hospital-associated Infections [*Escherichia coli, Klebsiella pneumoniae*]	-	12.2, 36.8	21.0, 33.0	27.0, 44.7
Percentage of *Escherichia coli* resistant to 3rd-generation cephalosporin				
- AMR in humans, lab-based surveillance (NARST)	44.0	42.7	43.9	41.4
- AMR in patients with hospital-associated infections	-	69.4	54.4	71.8
- AMR in chicken caeca (cefotaxime, ceftazidime)	1.7, 1.4	1.8, 0.8	1.0, 0.0	1.8, 0.3
- AMR in pig caeca (cefotaxime, ceftazidime)	9.6, 2.6	11.1, 3.6	8.9, 2.4	13.6, 3.2
Percentage of methicillin-resistant *Staphylococcus aureus* (MRSA)				
- AMR in humans, lab-based surveillance (NARST)	9.6	8.1	9.4	6.5
- AMR in patients with hospital-associated Infections	-	33.8	36.0	29.4
C. Public knowledge on AMR (percent)	23.7 (baseline)	-	24.3 (↑ 0.6 percentage point)	-

I. Antimicrobial Consumption in Humans[2]

Human antimicrobial consumption (Defined Daily Doses, DDDs) and population in Thailand (including migrants) (Millions)

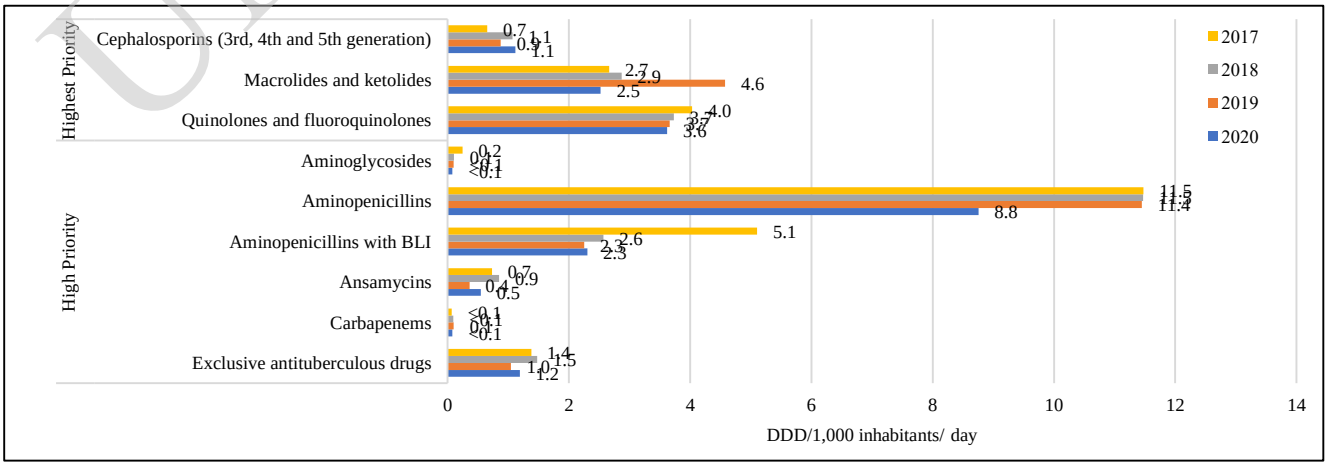


J01, antibacterials for systemic use; A07AA, antibiotics for alimentary tract; P01AB, nitroimidazole derivatives; J02, antimycotics for systemic use; D01BA, antifungals for systemic use; J04A, drugs for treatment of tuberculosis; P01B, antimalarials; J05, antivirals for systemic use

Top 10 antimicrobials for humans in 2020 and their consumption from 2017-2020 (DDDs/1,000 inhabitants/day, DID)

Rank in 2020	Antimicrobial agent	Consumption (DDD/1,000 inhabitans/day)			
		2020	2019	2018	2017
1	Amoxicillin	6.6	9.2	9.3	10.1
2	Emtricitabine, tenofovir disoproxil and efavirenz	2.8	2.5	1.8	1.3
3	Lamivudine	2.5	1.8	2.5	2.6
4	Tetracycline	2.4	2.3	3.7	3.4
5	Amoxicillin and beta-lactamase inhibitor	2.3	2.3	2.6	5.1
6	Ampicillin	2.2	2.2	2.2	1.4
7	Ketoconazole	2.0	2.4	2.1	3.7
8	Tenofovir disoproxil	1.6	1.6	0.2	0.1
9	Norfloxacin	1.6	1.4	1.4	2.0
10	Doxycycline	1.6	2.0	2.2	2.4

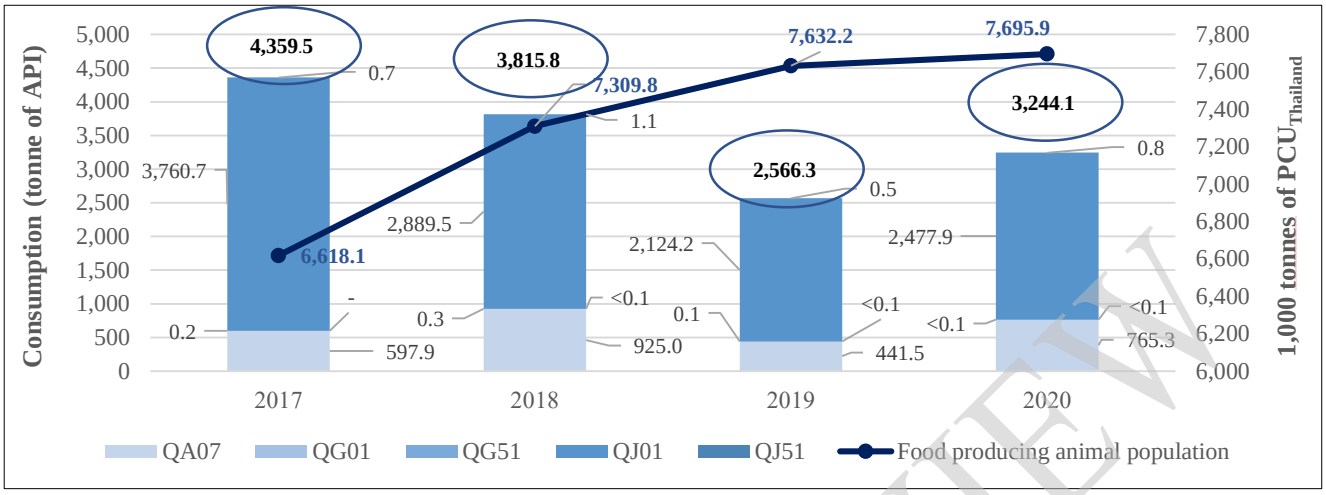
Human Antimicrobial Consumption Classified by WHO Critically Important Antimicrobials DDDs/1,000 inhabitants/day, DID)



[2] Data source: Thailand Surveillance of Antimicrobial Consumption

II. Antimicrobial Consumption in Food-Producing Animals[3]

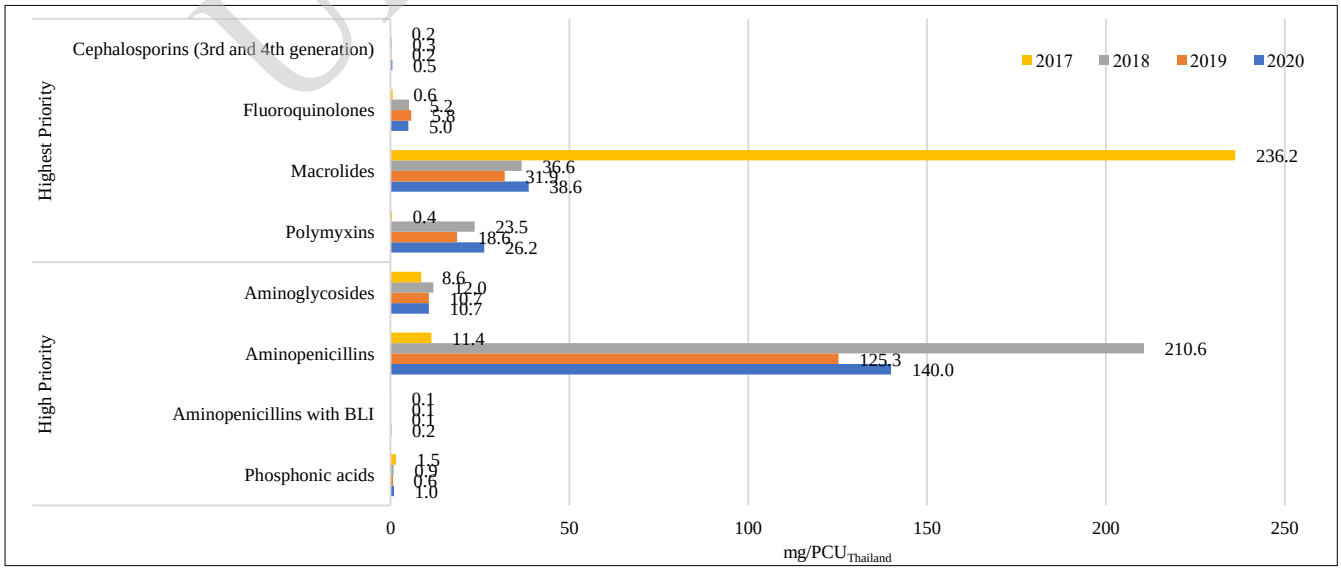
Antimicrobial consumption in food-producing animals (tonnes of active pharmaceutical ingredient, API) and food-producing animal population (1,000 tonnes of PCU$_{Thailand}$)



Top 10 antimicrobials for food-producing animals in 2020 and their consumption in 2017, 2018 and 2019 (mg/PCUThailand)

Rank in 2020	Antimicrobial agent	mg/PCU$_{Thailand}$			
		2020	2019	2018	2017
1	Amoxicillin	139.8	125.1	210.4	11.4
2	Chlortetracycline	57.1	44.8	42.8	52.9
3	Tiamulin	45.6	36.2	60.2	7.7
4	Bacitracin	45.6	18.4	14.6	10.5
5	Colistin	26.2	18.6	23.5	0.4
6	Tilmicosin	25.6	16.3	16.7	8.9
7	Halquinol	22.2	14.8	80.5	73.3
8	Doxycycline	14.5	13	14.6	19.1
9	Tylosin	8.2	8.8	14.3	223.7
10	Neomycin	5.5	6	7.8	5.9

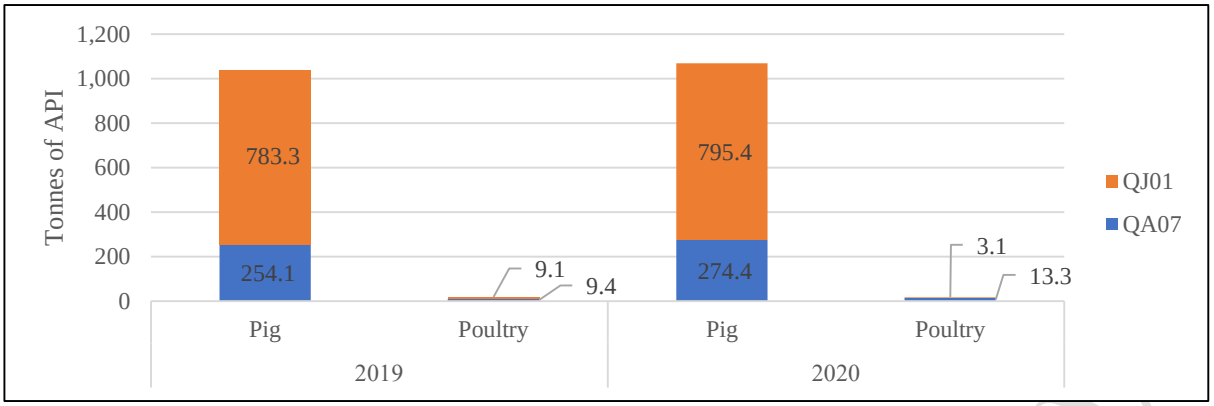
Antimicrobial consumption in food-producing animals classified by WHO Critically Important Antimicrobials (mg/PCU$_{Thailand}$)



[3] Data source: Thailand Surveillance of Antimicrobial Consumption

III. Antibacterial Consumption in Food-Producing Animals (Medicated Feed through Feed Mills)[4]

Antibacterial consumption in medicated feed by species of food-producing animals in 2019 (tonnes of active pharmaceutical ingredient, API)

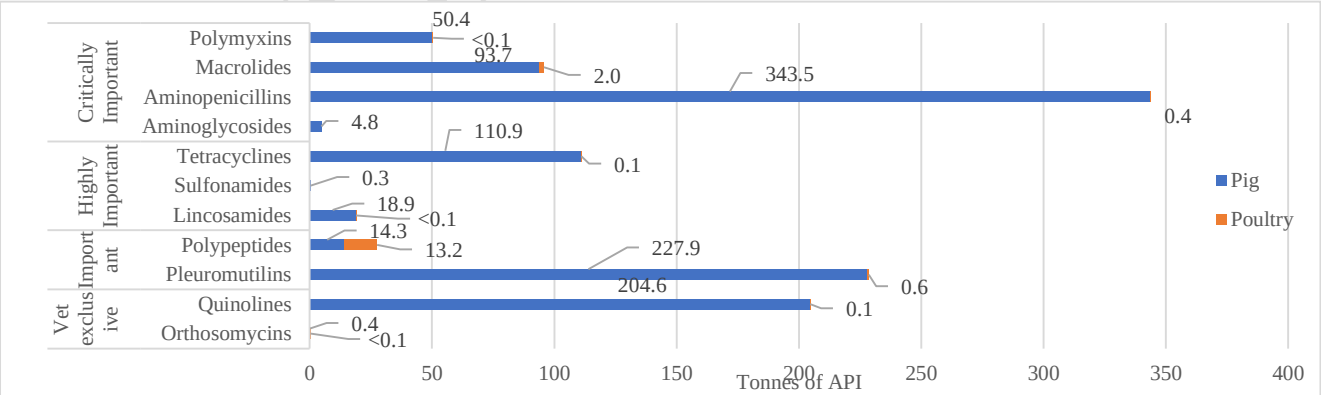


QA07, antimicrobial agents for intestinal use; QJ01, antimicrobial agents for systemic use

Top 10 antibacterials used in medicated feed for pigs and poultry in 2020 (tonnes of API)

Rank	Pigs		Poultry	
	Antibacterials	Tonnes of API	Antibacterials	Tonnes of API
1	Amoxicillin	343.5	Bacitracin	13.2
2	Tiamulin	227.9	Tilmicosin	1.2
3	Halquinol	204.6	Tylvalosin	0.8
4	Chlortetracycline	84.7	Tiamulin	0.6
5	Tilmicosin	83.0	Amoxicillin	0.4
6	Colistin	50.4	Doxycycline	<0.1
7	Doxycycline	21.8	Halquinol	<0.1
8	Lincomycin	18.9	Kitasamycin	<0.1
9	Bacitracin	14.3	Chlortetracycline	<0.1
10	Tylvalosin	4.9	Colistin	<0.1

Antibacterial consumption in medicated feed for pigs and poultry by WHO Critically Important Antimicrobials and chemical class in 2020 (tonnes of API)[5]

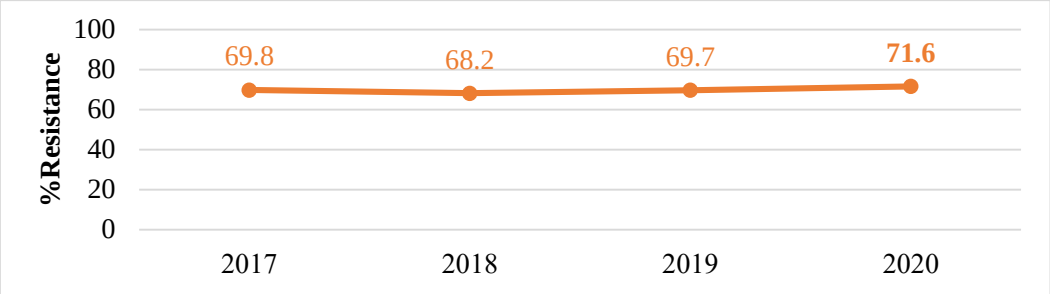


[4] Data source: Thailand Surveillance of Antimicrobial Consumption

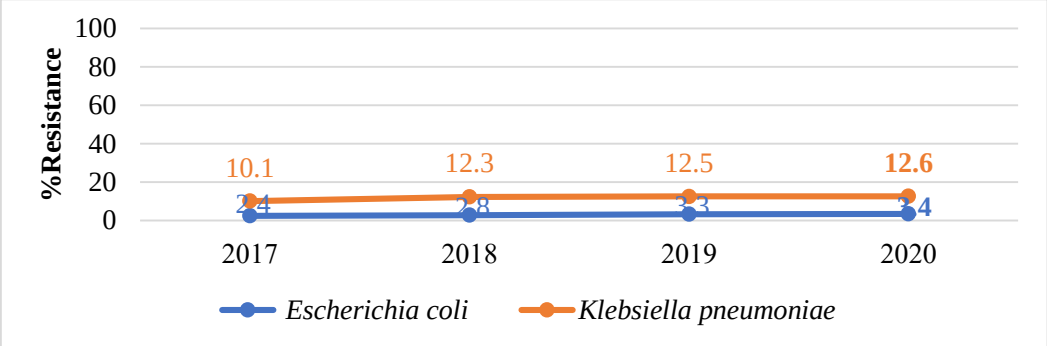
[5] Antimicrobials with less than 0.1 tonnes of API for both pigs and poultry (non-CIA penicillins, phosphoglycolipids and aminoclyclitols) are not shown.

IV. Antimicrobial Resistance in Humans[6]

Percentage of Carbapenem-resistant *Acinetobacter baumannii* (CRAB) in 2017-2020

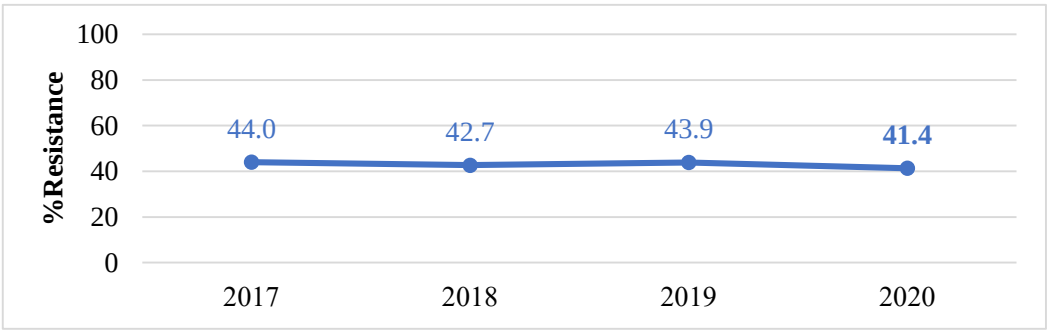


Percentage of Carbapenem-resistant Enterobacterales (CRE) in 2017-2020

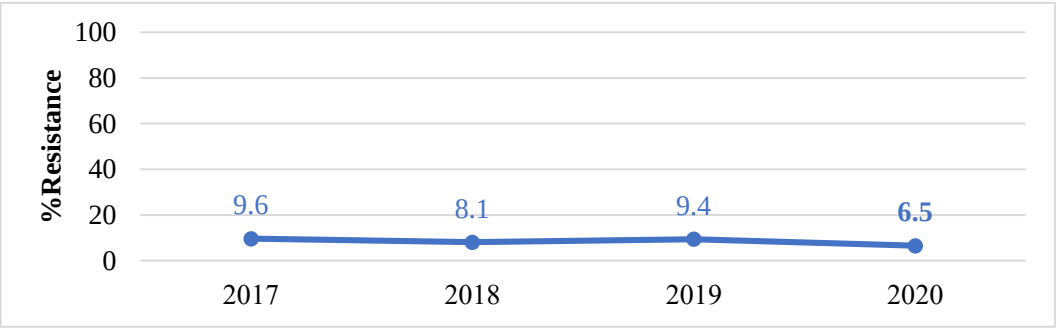


Note: Carbapenem-resistant Enterobacterales (CRE) included *Klebsiella pneumoniae* and *Escherichia coli*.

Percentage of *Escherichia coli* with 3rd-generation cephalosporin resistance in 2017-2020



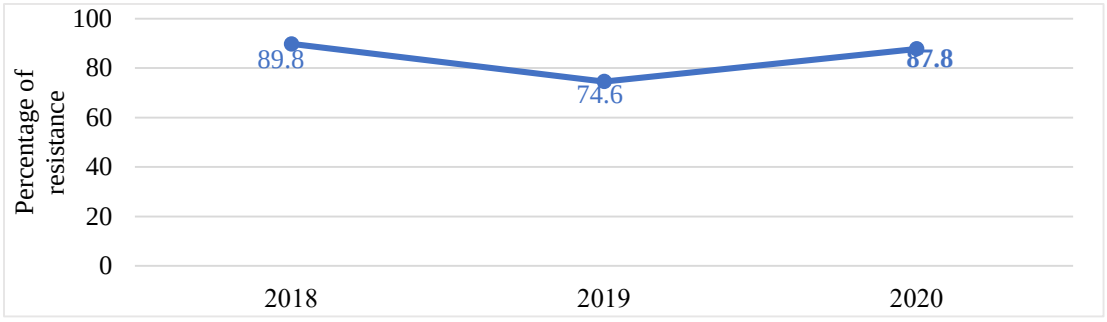
Percentage of Methicillin-resistant *Staphylococcus aureus* (MRSA) in 2017-2020



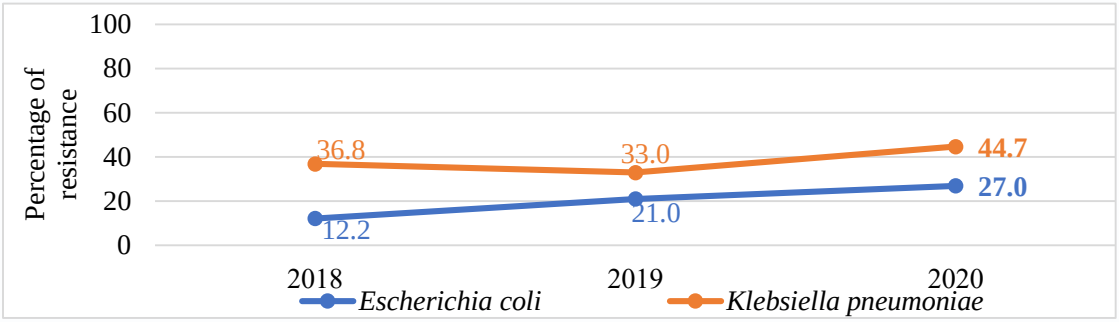
[6] Data source: National Antimicrobial Resistance Surveillance Center Thailand (NARST), National Institute of Health, Department of Medical Sciences, and Department of Disease Control

V. Antimicrobial Resistance in Patients with Hospital-Associated Infections[7]

Percentage of Carbapenem-Resistant *Acinetobacter baumannii* (CRAB) in patients with hospital-associated infections in 2018-2020

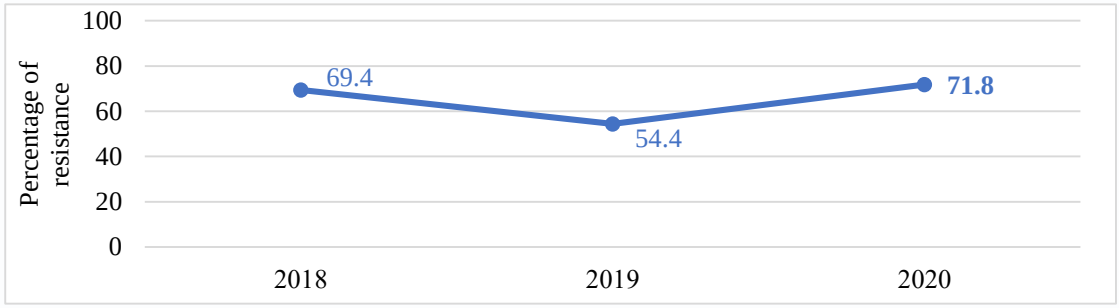


Percentage of Carbapenem-Resistant Enterobacteriaceae (CRE) in patients with hospital-associated infections in 2018-2020

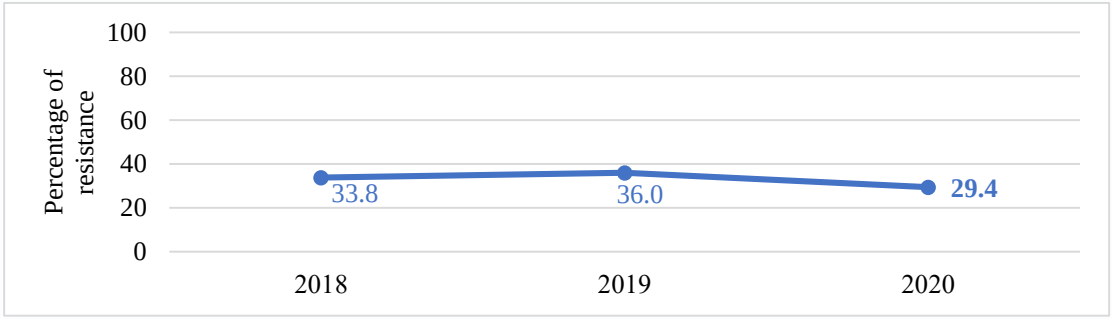


Note: Carbapenem-Resistant Enterobacteriaceae (CRE) included *Klebsiella pneumoniae* and *Escherichia coli*.

Percentage of *Escherichia coli* with 3rd-generation cephalosporin resistance in patients with hospital-associated infections in 2018-2020



Percentage of Methicillin-resistant *Staphylococcus aureus* (MRSA) in patients with hospital-associated infections in 2018-2020

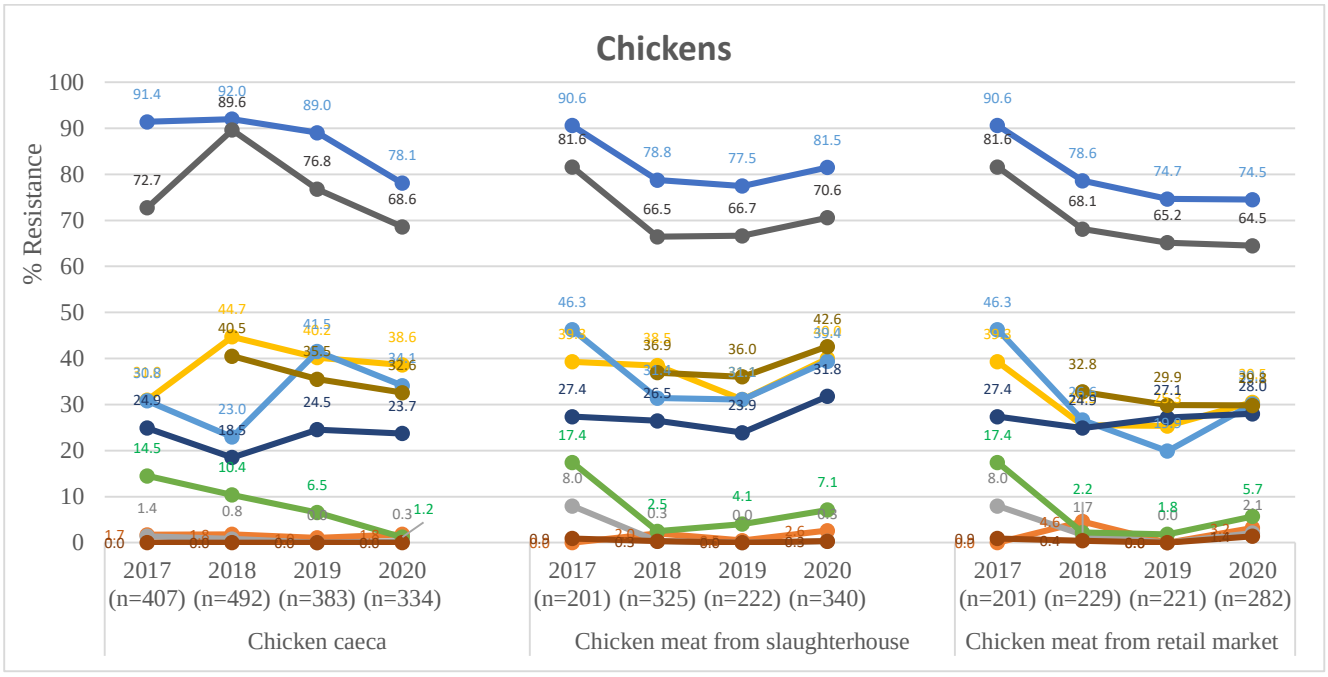


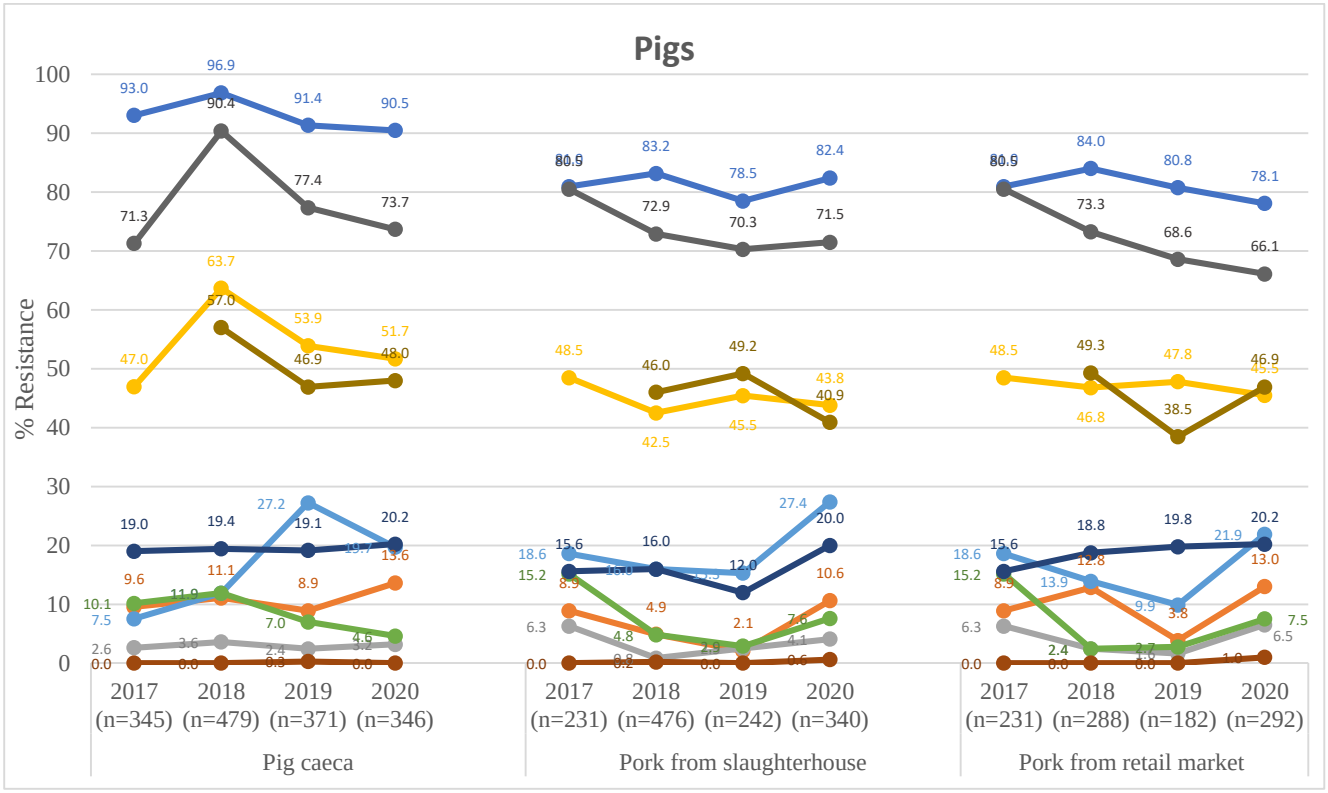
[7] Data source: Surveillance of Hospital-associated Infection, Bamrasnaradura Infectious Disease Institute

VI. Antimicrobial Resistance in Food-Producing Animals[8]

Escherichia coli

Percentage of antimicrobial resistance of *E. coli* (2017-2020)



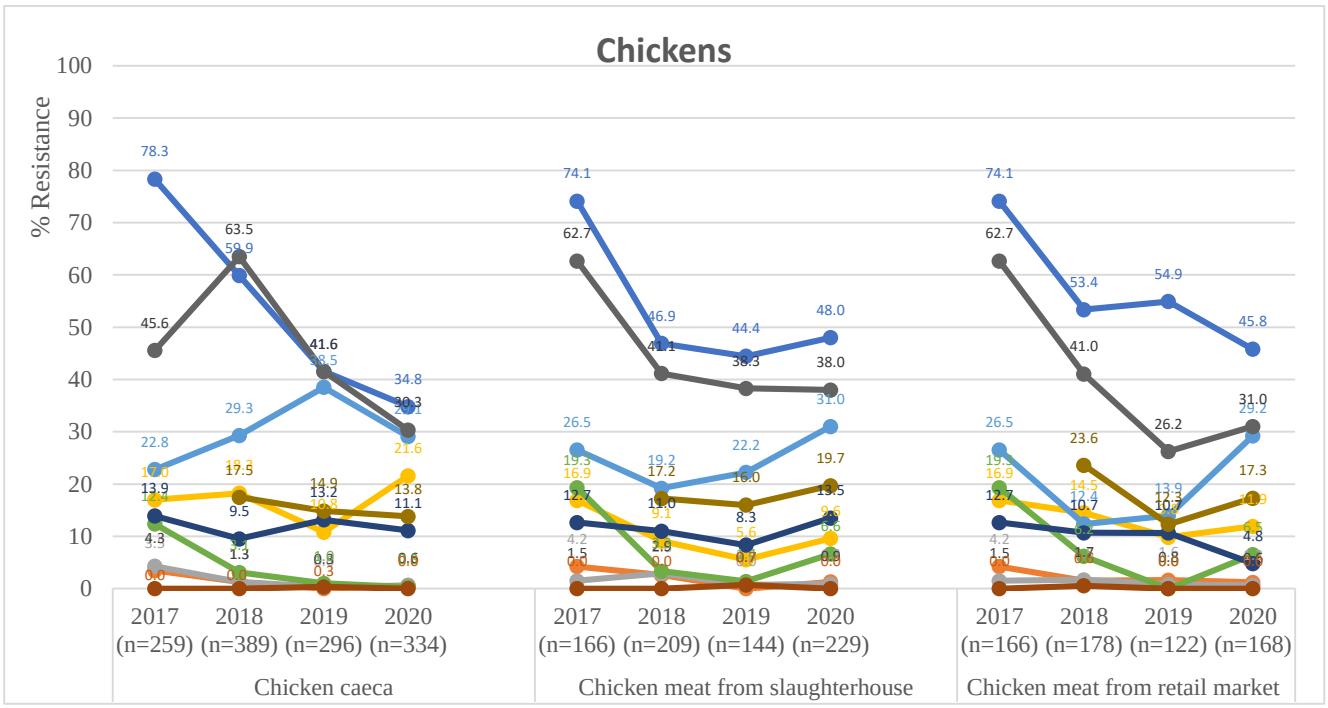


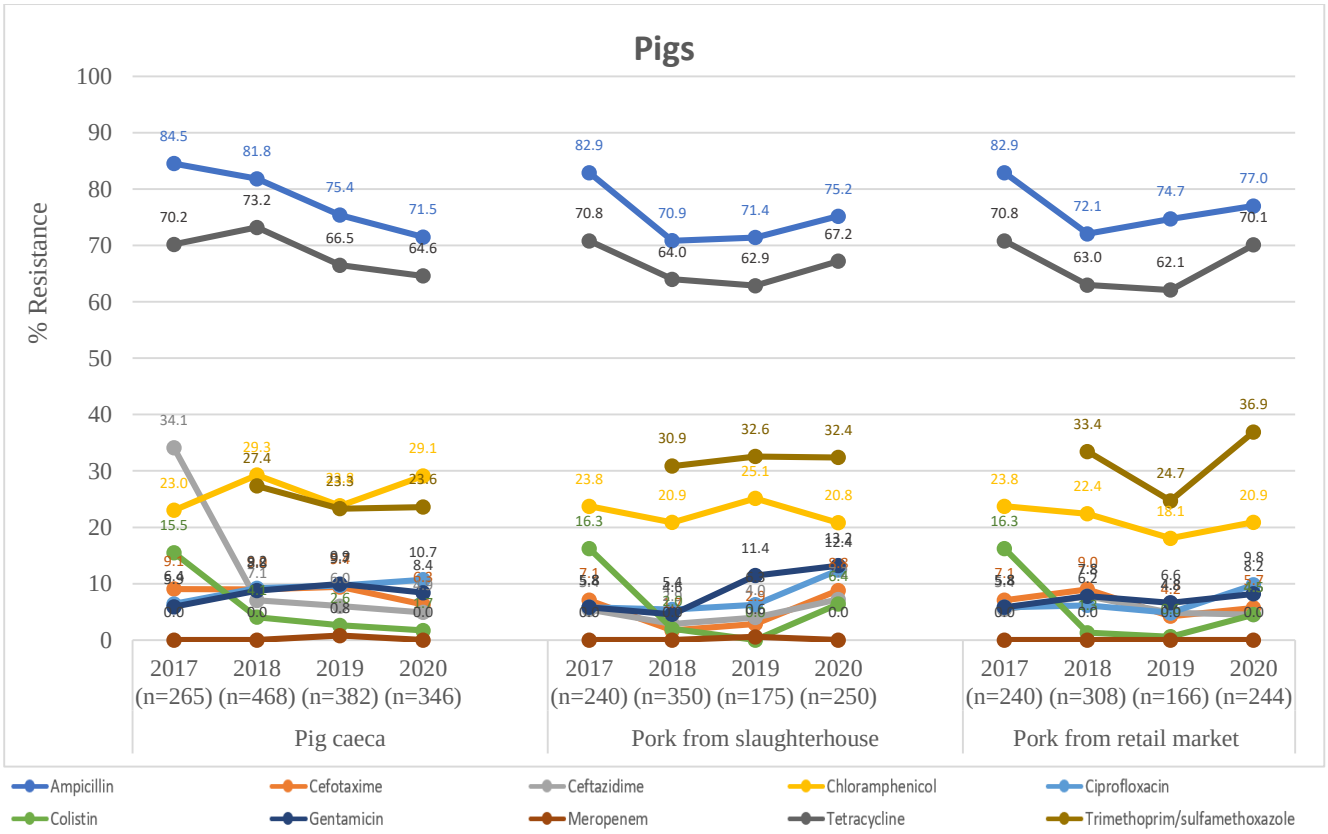
Note: Number of isolates differs between source and years

[8] Data source: Department of Livestock Development

***Salmonella* spp.**

Percentage of antimicrobial resistance of *Salmonella* spp. (2017-2020)

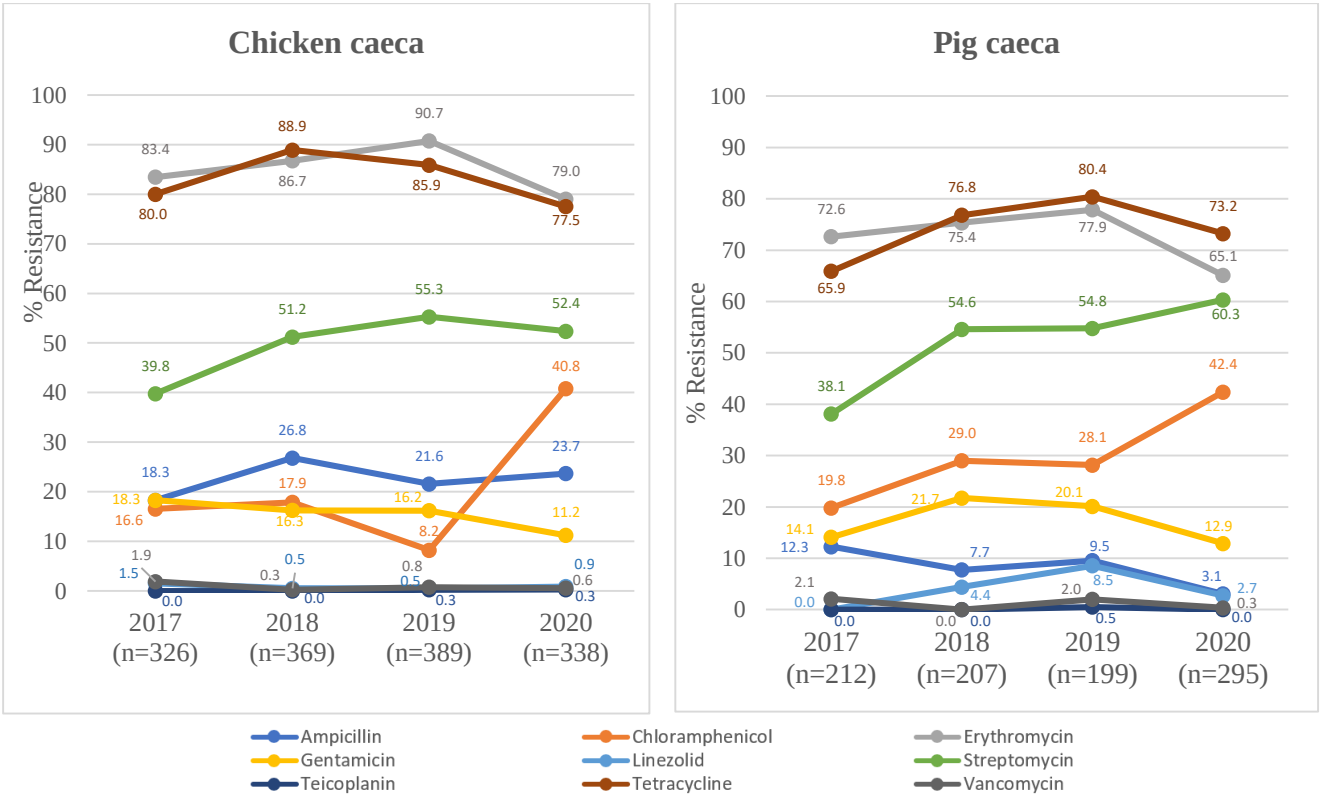




Note: Number of isolates differs between source and years

***Enterococcus* spp.**

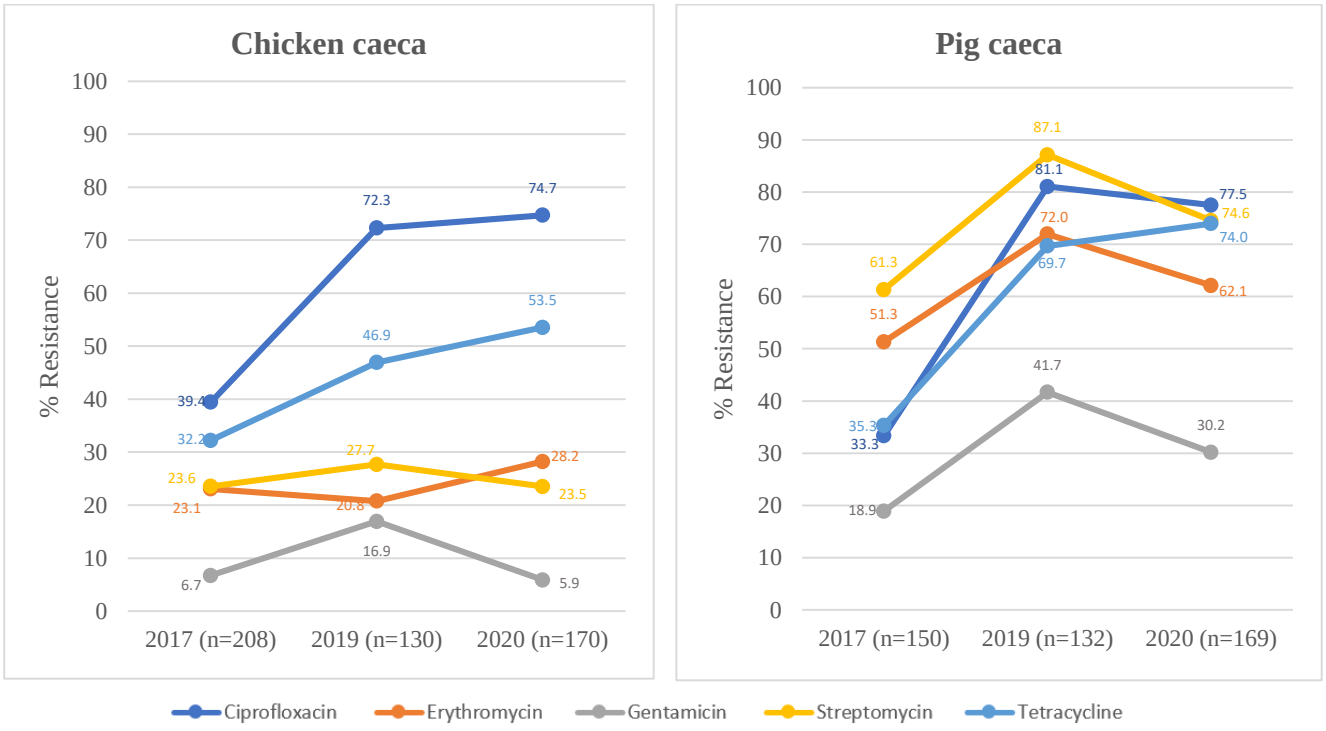
Percentage of antimicrobial resistance of Enterococcus spp. (2017-2020)



Note: Number of isolates differs between years

***Campylobacter* spp.**

Percentage of antimicrobial resistance of *Campylobacter* spp. (2017-2020)



Note: Number of isolates differs between years

SECTION A: ANTIMICROBIAL CONSUMPTION

A1: Antimicrobial Consumption in Humans

A1.1 Overall consumption

- The overall consumption of human antimicrobials in Defined Daily Doses (DDDs) within the scope of the study has decreased to 1,246,167,240.1 DDDs (-13.7% from 2017-20) (Figure A1.1). However, the population in Thailand has increased to 73,713,236.0 (+1.8% from 2017-20). As a result, the national indicator for human antimicrobial consumption has decreased to 46.3 Defined Daily Doses/1000 inhabitants/day (DID) (-15.2% from 2017-20).
- Overall, from 2017 to 2020, the majority of decrease in consumption came from antibacterial for systemic use (J01) (-9.0 DID, -24.8% from 2017-20), which was the main group of consumed antimicrobials in the core class (98.5%) and overall (58.7%), and from antimycotics for systemic infections (J05) (-1.7 DID, -39.5% from 2017-20), the third contributor to the overall consumption (5.5%).
- On the contrary, the only group with increased consumption was antivirals for systemic use (J05) (+3.5 DID, +40.3% from 2017-20).

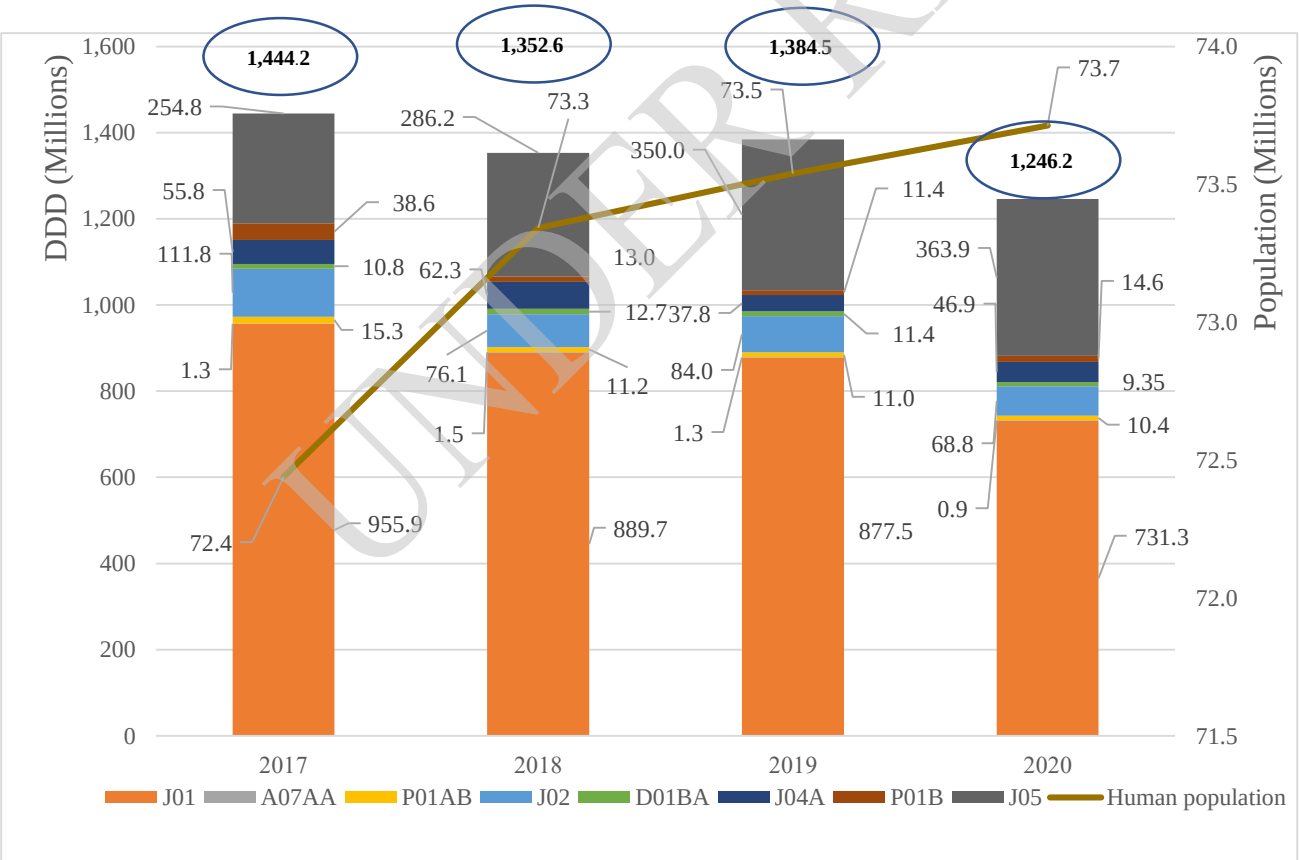


Figure A1.1 Consumption of target human antimicrobials (Defined Daily Doses, DDDs) classified by WHO Anatomical Therapeutic Chemical Classification (ATC) code, from 2017 to 2020

J01, antibacterials for systemic use; A07AA, antibiotics for alimentary tract; P01AB, nitroimidazole derivatives; J02, antimycotics for systemic use; D01BA, antifungals for systemic use; J04A, drugs for treatment of tuberculosis; P01B, antimalarials; J05, antivirals for systemic use

A1.2 Core and optional class breakdowns

Overall consumption of core class with highest proportion

As the major contributor to total human antimicrobial consumption (58.7% in 2020), the profile of antibacterials for systemic use (J01) still had penicillins (J01C) (48.4% of J01 in 2020) and tetracyclines (J01A) (14.9% of J01 in 2020), as the main consumption groups in J01 (Figure A1.2). The decrease of J01 (-9.0 DID from 2017-20) mainly came from decrease in J01C (-5.7 DID from 2017-20) and in J01A (-1.8 DID from 2017-20). In contrast to the decreased counterpart, only antimicrobial group in J01 was other antibacterials (J01X) (+0.2 DID from 2017-20). Similar to the top-two J01 groups, the two most consumed antibacterial for systemic use in 2019 by ATC level 5 were amoxicillin (J01CA04) (6.6 DID, 24.2% of J01 consumption) and tetracycline (2.4 DID, 9.0% of J01 consumption) (Figure A1.3).

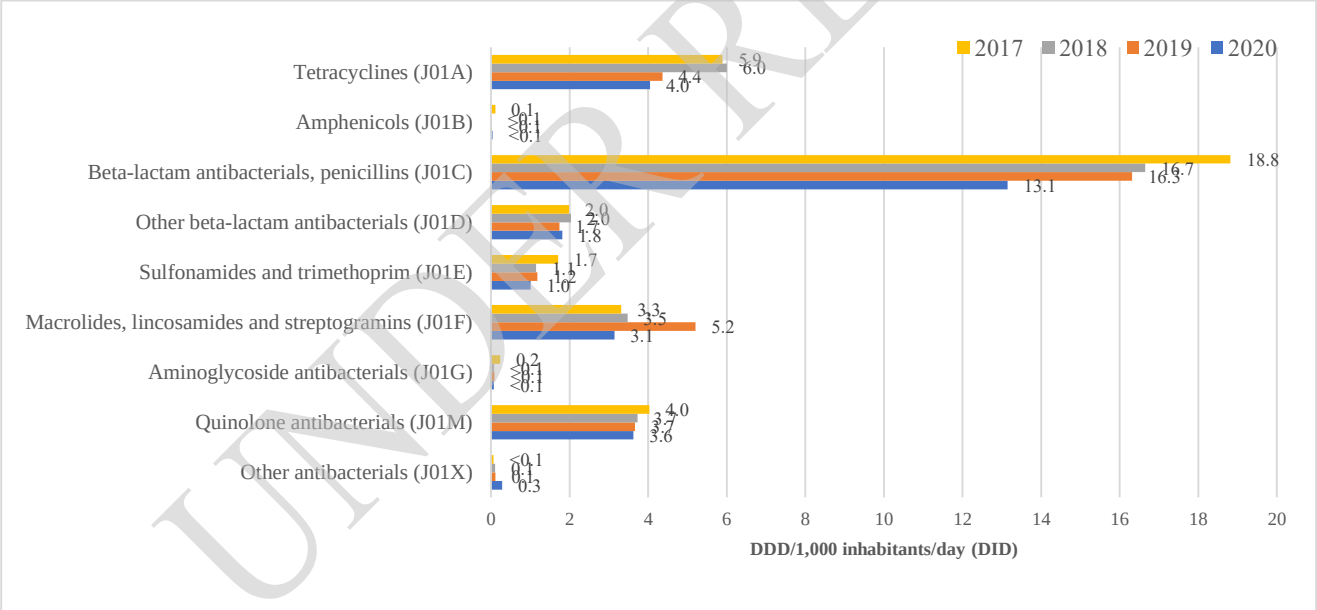


Figure A1.2 Consumption of human antimicrobials indicated for systemic use (J01) classified by ATC level 3, (DDD/1,000 inhabitants/day, DID), from 2017 to 2020

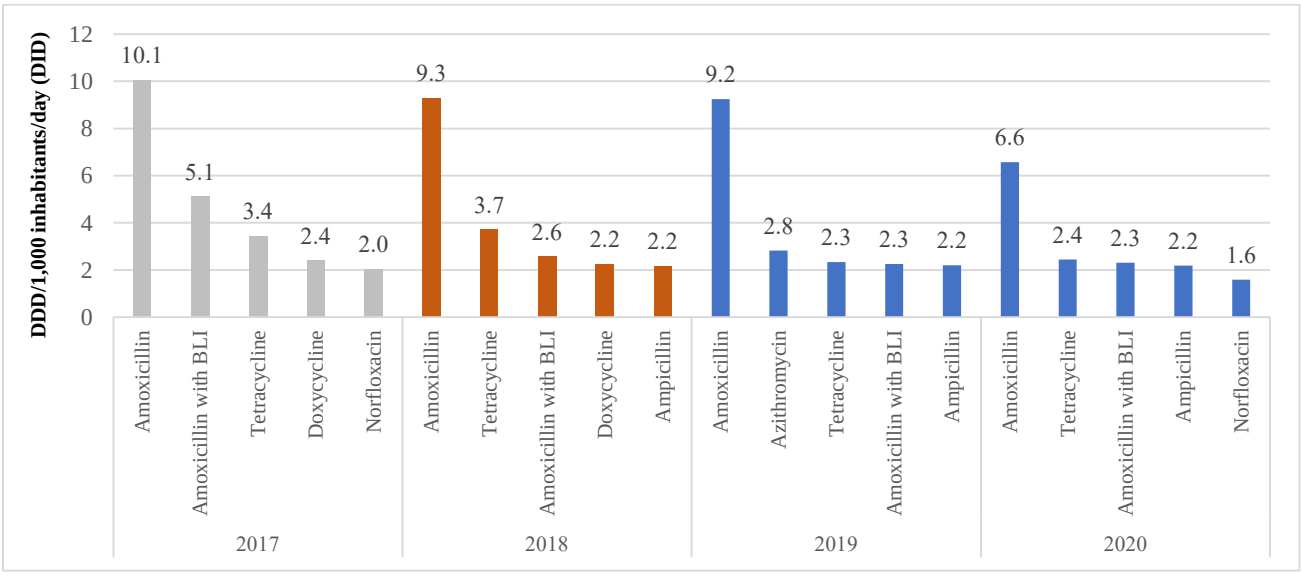


Figure A1.3 Consumption of the top-five antibacterials indicated for systemic use (J01) classified by ATC level 5 (DDD/1,000 inhabitants/day, DID), from 2017 to 2020

Overall consumption of the other core classes

As the second rank in core class, nitroimidazole derivatives (P01AB) were decreased to 0.4 DID (-0.2 DID from 2017-20) (Figure A1.1). The most consumed nitroimidazole in 2020 by ATC level 5 was metronidazole (P01AB01) (0.4 DID, 93.5% of P01AB consumption. The intestinal anti-infectives (A07AA) were consumed with annual fluctuations. The intestinal anti-infective most consumed in 2019 by ATC level 5 was nystatin (A07AA02) (<0.1 DID, 74.5 % of A07AA consumption).

Overall consumption of optional classes

Antivirals for systemic use (J05) (ranked second in overall consumption and first in the optional class) have been increasingly consumed to 13.5 DID (+3.9 DID from 2017-20). The consumptions of other optional classes, on the other hand, were decreased from 2017-20 (-1.7 DID for J02, -0.06 DID for D01BA, -0.4 DID for J04A, and -0.9 DID for P01B) (Figure A1.1).

Consumption of the top-five antimicrobials in the optional classes classified by ATC level 5

- For antivirals for systemic use (J05), the most consumed antiviral in 2020 was still the combination of emtricitabine, tenofovir disoproxil and efavirenz (J05AR06) (2.8 DID, 20.5% of J05 consumption) (Figure A1.4). Lamivudine still ranked second in 2019 (2.5 DID, 18.4% of J05 consumption), and remained in the top-three antivirals consumed from 2017 to 2020 with an increase in consumption (+0.7 DID from 2019).

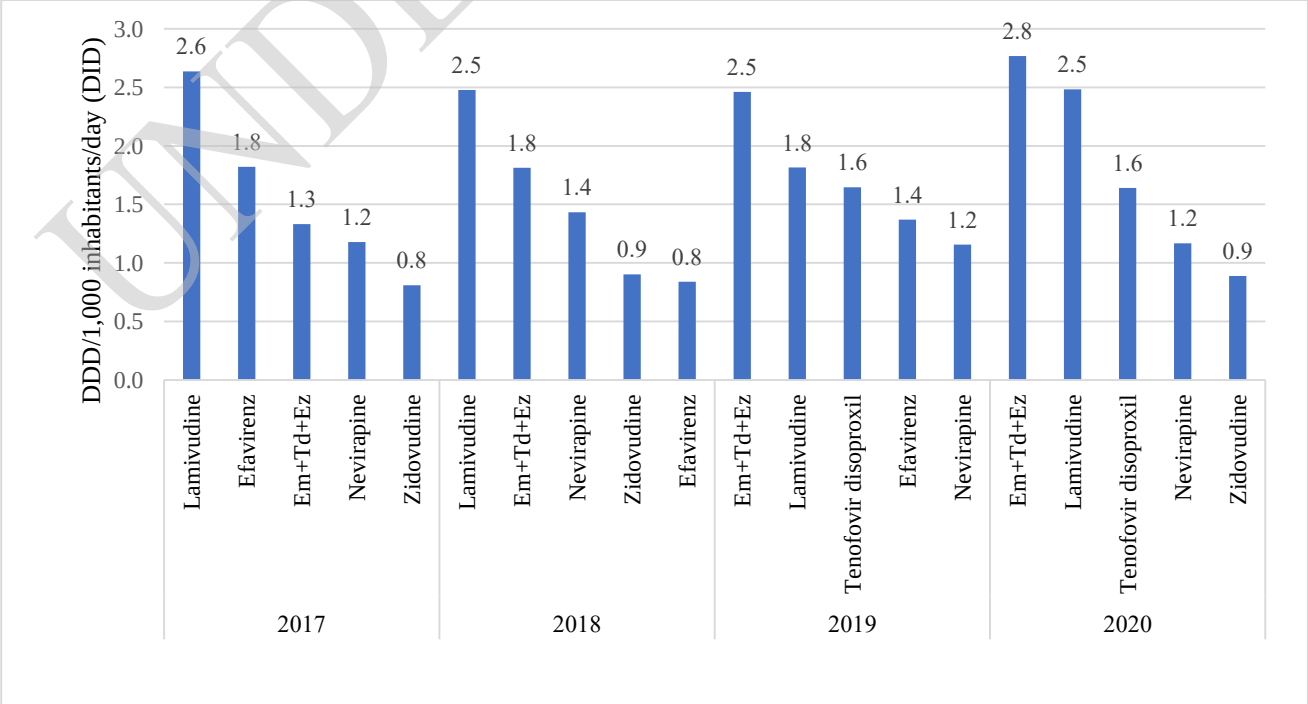


Figure A1.4 Consumption of the top-five antivirals indicated for systemic use (J05) classified by ATC level 5 (DDD/1,000 inhabitants/day, DID) from 2017 to 2020

Em, emtricitabine; Td, tenofovir disoproxil; Ez, efavirenz

- From 2017 to 2020, the top-two antituberculous drugs remained isoniazid (INH) (>35% of J04A consumption) and rifampicin (RIF) (>25% of J04A consumption) (Figure A1.5). Isoniazid was consumed 0.7 DID in 2020 with an increase from 2019 (+0.08 DID). Rifampicin was consumed 0.5 DID in 2020 with an increase from 2019 (+0.2 DID). Pyrazinamide (PZA) and ethambutol (EMB) still remained among the top five antituberculous drugs from 2017 and 2020.

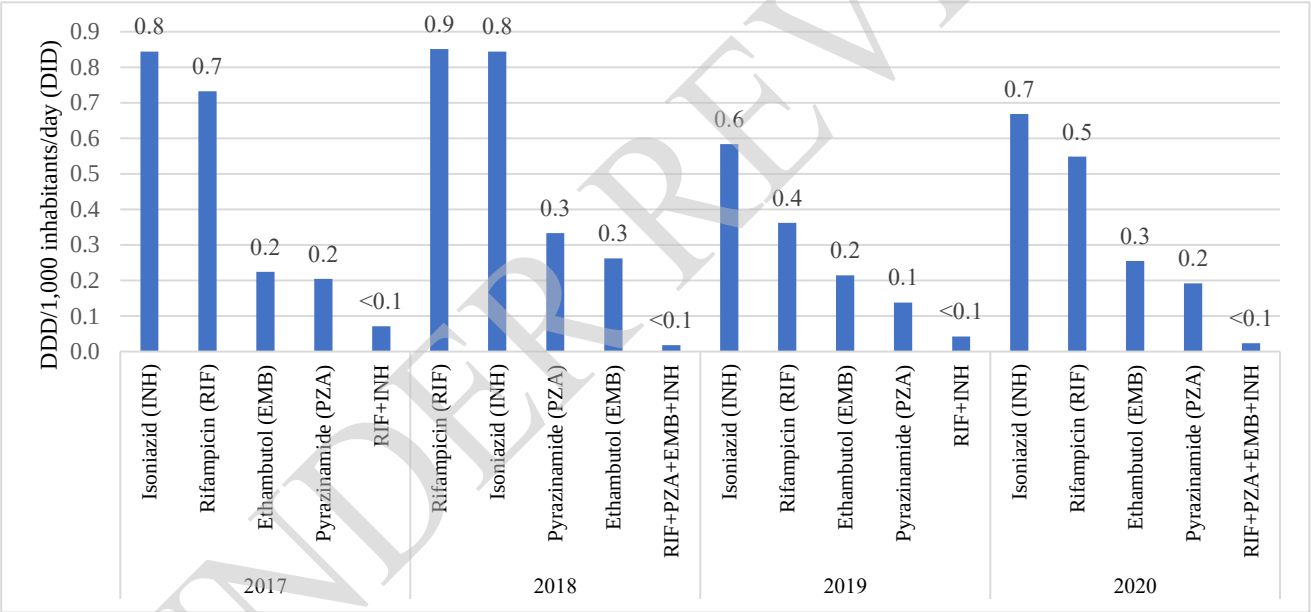


Figure A1.5 Consumption of the top-five antituberculous drugs for systemic use (J04A) classified by ATC level 5 (DDD/1,000 inhabitants/day, DID), 2019 compared with 2017 and 2020

A1.3 Consumption of Critically Important Antimicrobials (CIA)

- Consumption profile of human antimicrobials remained Non-CIA-dominant from 2017 to 2020. However, by proportion of CIA consumption, the highest priority CIA increased from 13.5% in 2017 to 15.7% of total in 2020 (Figure A1.6).

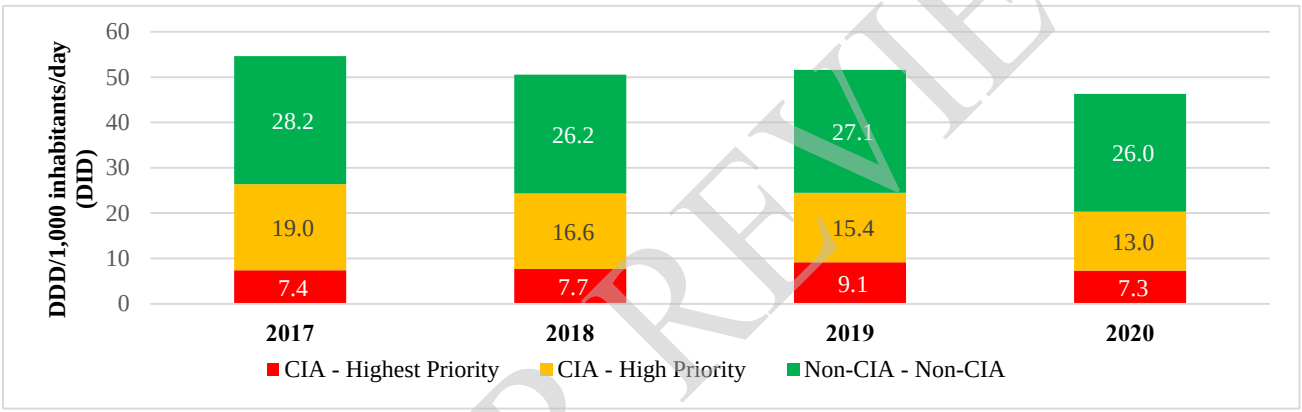


Figure A1.6 Comparative proportional consumption profile of Critically Important Antimicrobials (CIA) in humans from 2017 to 2020 (Non-CIA includes other antimicrobials in the scope of study, which are not categorized as CIA) (DDDs/1,000 inhabitants/day, DID)

- In the highest priority CIA, the consumption has decreased from 7.4 in 2017 to 7.3 DID in 2020 (Figure A1.7). The major contributor to this decrease was quinolones and fluoroquinolones (-0.4 DID from 2017-20), and macrolides including ketolides (-0.1 DID from 2017-20). The two main quinolones consumed in 2020 were norfloxacin (-0.5 DID from 2017-20) and ciprofloxacin (+0.06 DID from 2017-20). For macrolides and ketolides, the majority of decrease came from roxithromycin (-0.2 DID from 2017-20) and clarithromycin (-0.08 DID from 2017-20). In contrast to highest priority CIA, the consumption of the high priority CIA has decreased from 19.0 DID in 2017 to 13.0 DID in 2020 (Figure A1.6). The major contributors for this decrease were aminopenicillins (-2.7 DID from 2017-20) and aminopenicillins with beta-lactamase inhibitor (BLI) (-2.8 DID from 2017-20). The top-two antimicrobials in the high priority CIA with a large decrease DID were amoxicillin (-3.5 DID from 2017-20) and amoxicillin with beta-lactamase inhibitor (-2.8 DID from 2017-20).

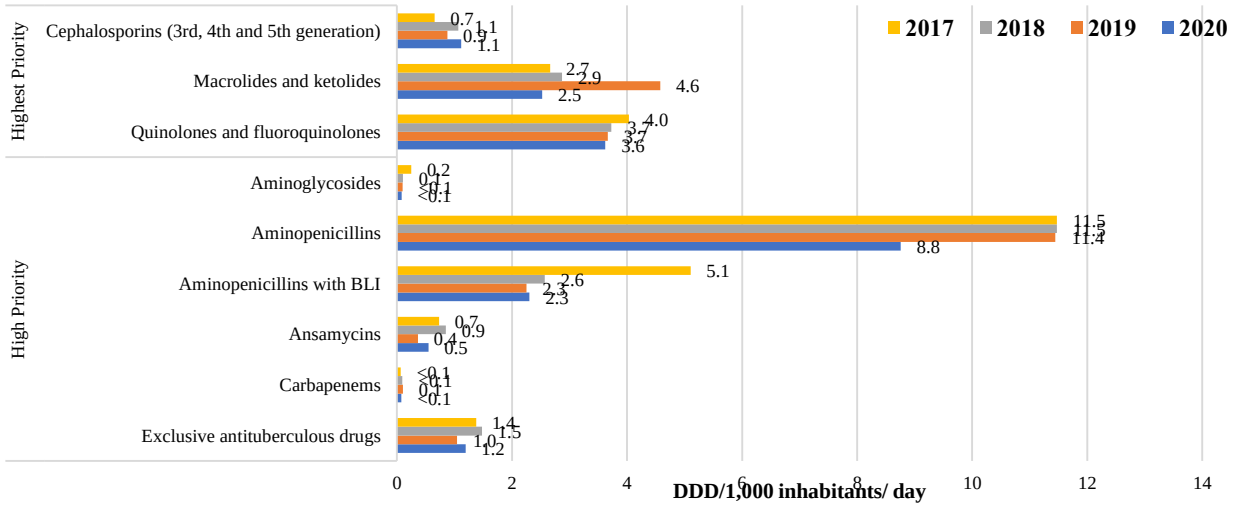


Figure A1.7 Consumption of Critically Important Antimicrobials classified by class of antimicrobials, from 2017 to 2020 (DDDs/1,000 inhabitants/day, DID)

Antimicrobial groups with less than 0.1 DID for 4 consecutive years (2017-20) were not shown (highest priority – polymyxins, and glycopeptides and lipoglycopeptides; high priority – phosphonic acid derivatives, oxazolidinones, glycycyclines, and antipseudomonal penicillins)

A1.4 Consumption of Antimicrobials on AWaRe List

- Classified by WHO Access, Watch, Reserve classification of antibiotics (AWaRe), the overall trend has access (A) and watch (Wa) antibacterials as the main groups of consumption (Figure A1.8). The consumption of antimicrobials on the access list has decreased (-9.5 DID from 2017-20). On the other hand, the consumption on the watch has fluctuated from 2017-20 with a decrease (-0.6 DID from 2017-20).

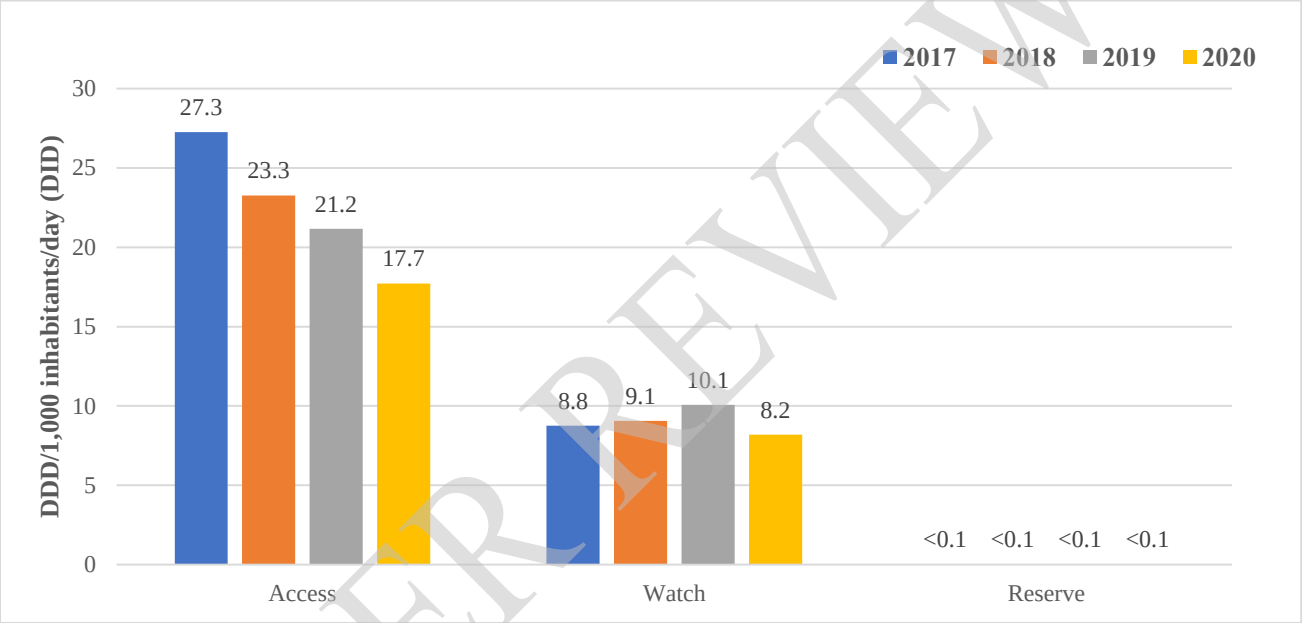


Figure A1.8 Consumption of antimicrobials by AWaRe classification from 2017 to 2020 (excluding antimicrobials by ATC level 5 not listed or recommended by AWaRe classification)

- On the watch list, the most antimicrobial consumed was norfloxacin despite a decrease (-0.5 DID from 2017-20) (Figure A1.9). The other top-five antimicrobials on this list in 2020 were roxithromycin (-0.2 DID from 2017-20), ciprofloxacin (+0.06 DID from 2017-20), ceftriaxone (+0.5 DID from 2017-20) and azithromycin (+0.2 DID from 2017-20).

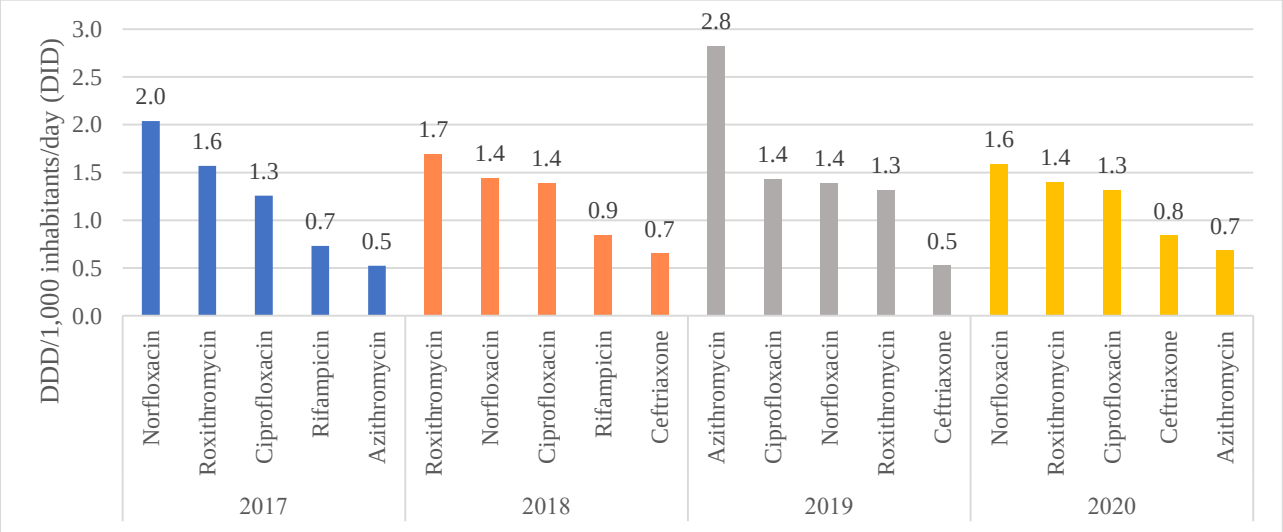


Figure A1.9 Consumption of top five antimicrobials on the Watch list by AWaRe classification from 2017 to 2020

A2: Antimicrobial Consumption in Food-producing Animals

A2.1 Overall consumption

- Overall, the numerator (tonnes of active pharmaceutical ingredient (API)) tended to decreasewhile the denominator (estimated food-producing animal population) was likely to increase (Figure A2.1). From 2017 to 2020, the amount of API consumed in food-producing animals decreased by 25.6% while the Population Correction Unit modified by Thailand's methodology ($PCU_{Thailand}$) in 2020 increased by 16.3%, from estimated terrestrial food-producing animals (18.0% increase) and projected aquatic animals (3.9% increase). As a result, the national consumption indicator in 2020 was 421.5 mg/$PCU_{Thailand}$, which decreased by 36.0% from 2017.
- The majority of consumption in 2020 still belonged to antibacterials for systemic use (QJ01; 76.4%), followed by intestinal anti-infectives (QA07; 23.6%). Hence, the decrease in the national indicator was derived from decreases in QA07 by 10.1% and QJ01 by 43.3% from 2017 to 2020. For the minority group of consumption (QG01, QG51, and QJ51; <0.1% each), the same decreasing pattern was also found.

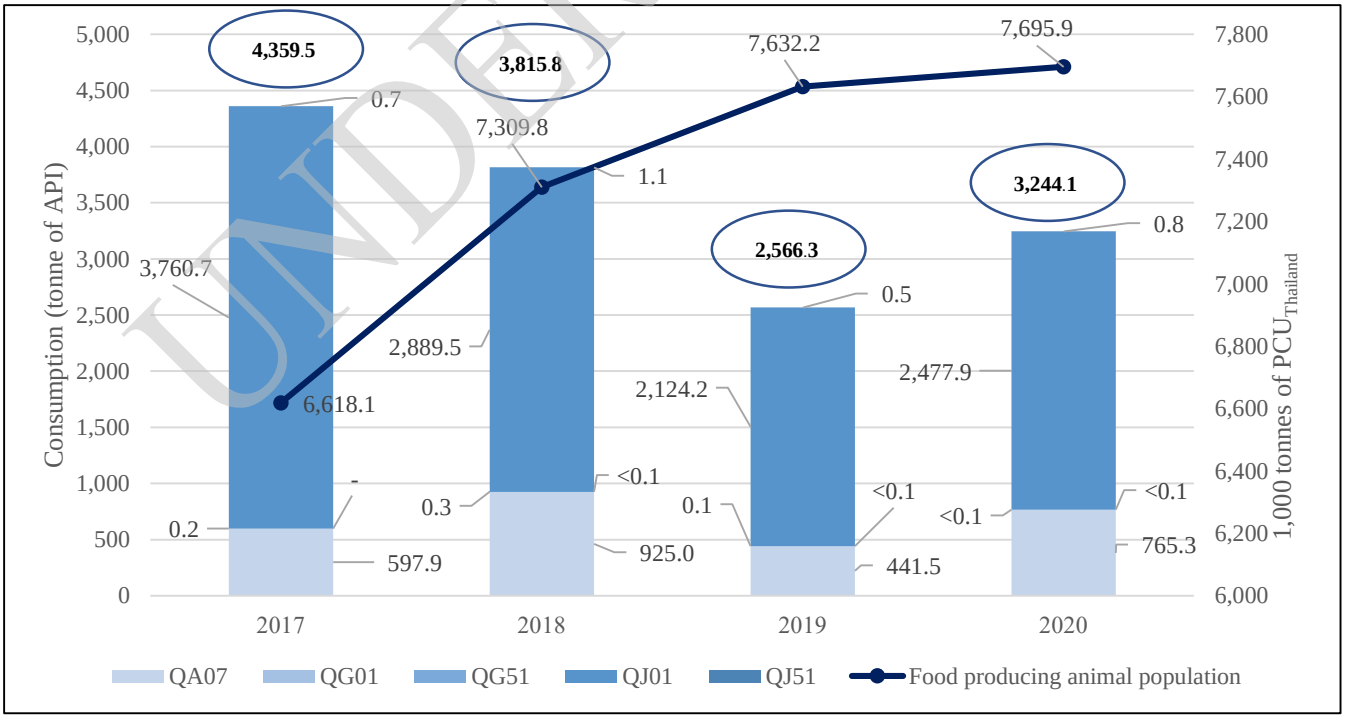


Figure A2.1 Consumption of veterinary antimicrobials classified by Anatomical Therapeutic Chemical classification system for veterinary medicinal products (ATCvet) code, from 2017 to 2020

QA07, antimicrobial agents for intestinal use; QG01, Gynecological antiinfectives and antiseptics; QG51, antiinfectives and antiseptics for intrauterine use; QJ01, antimicrobial agents for systemic use; QJ51, antimicrobial agents for intramammary use

A2.2 Consumption breakdown by chemical class of antimicrobials and dosage form

- **Consumption by ATC vet code**
  - When comparing antibacterials for systemic use (QJ01) from 2017 to 2020, the most consumed QJ01 profile had shifted from dominance of macrolides (QJ01F) and sulfonamides (QJ01E) in 2017 to penicillins (QJ01C) and tetracyclines (QJ01A) in 2018, 2019 and 2020 (Figure A2.2).
  - The majority of QJ01 consumption came from QJ01C (44.1%), followed by QJ01A (23.8% and other antibacterials (QJ01X) (14.7%). However, the decrease in QJ01 came from decreases in QJ01E (217.9 mg/PCU$_{Thailand}$ from 2017-20) and QJ01F(-196.6 mg/PCU$_{Thailand}$ from 2017-20).
  - The most consumed of antibacterials in QJ01C was amoxicillin (QJ01CA04) (139.8 mg/PCU$_{Thailand}$, 98.4% of QJ01C consumption). The second rank was procaine benzylpenicillin (QJ01CE09) (1.0 mg/ PCU$_{Thailand}$, 0.7% QJ01C consumption).

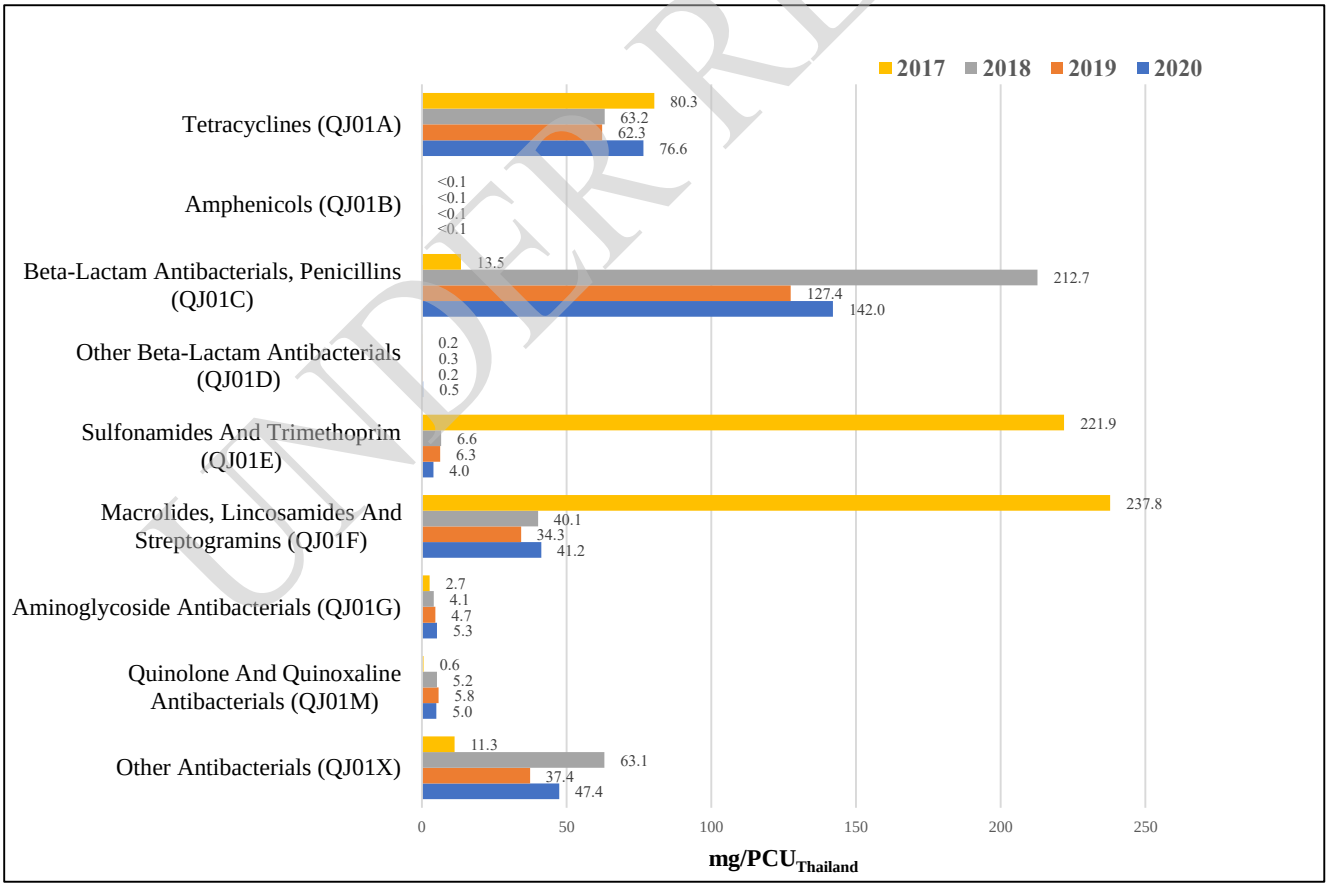


Figure A2.2 Consumption of veterinary antimicrobials indicated for systemic use classified by ATC level 3, from 2017 to 2020

- **Consumption by chemical class**
  - Comparing consumption profiles by chemical class from 2017 to 2020, the profile was shifted from macrolides-in 2017 to penicillins-dominant consumption in 2018-20 (Figure A2.3). But, the most difference in percentage from 2017 to 2020 was found in polymyxins (+25.7 mg/PCU$_{Thailand}$).
  - The two antimicrobial groups with most increase were penicillins (+128.5 mg/PCU$_{Thailand}$ from 2017-20) and pleuromutilins (+37.9 mg/PCU$_{Thailand}$ from 2017-20). However, when compared with 2017, the two antimicrobial classes with most decrease in consumption in 2020 were sulfonamides (-218.0 mg/PCU$_{Thailand}$) and macrolides (-197.6 mg/PCU$_{Thailand}$). Both of these antimicrobial classes were the top two classes with highest consumption in 2017.
  - Despite ranked among top three of overall consumption, tetracyclines were consumed with a fluctuation from 80.3 mg/PCU$_{Thailand}$ in 2017 to 76.6 mg/PCU$_{Thailand}$ in 2020.

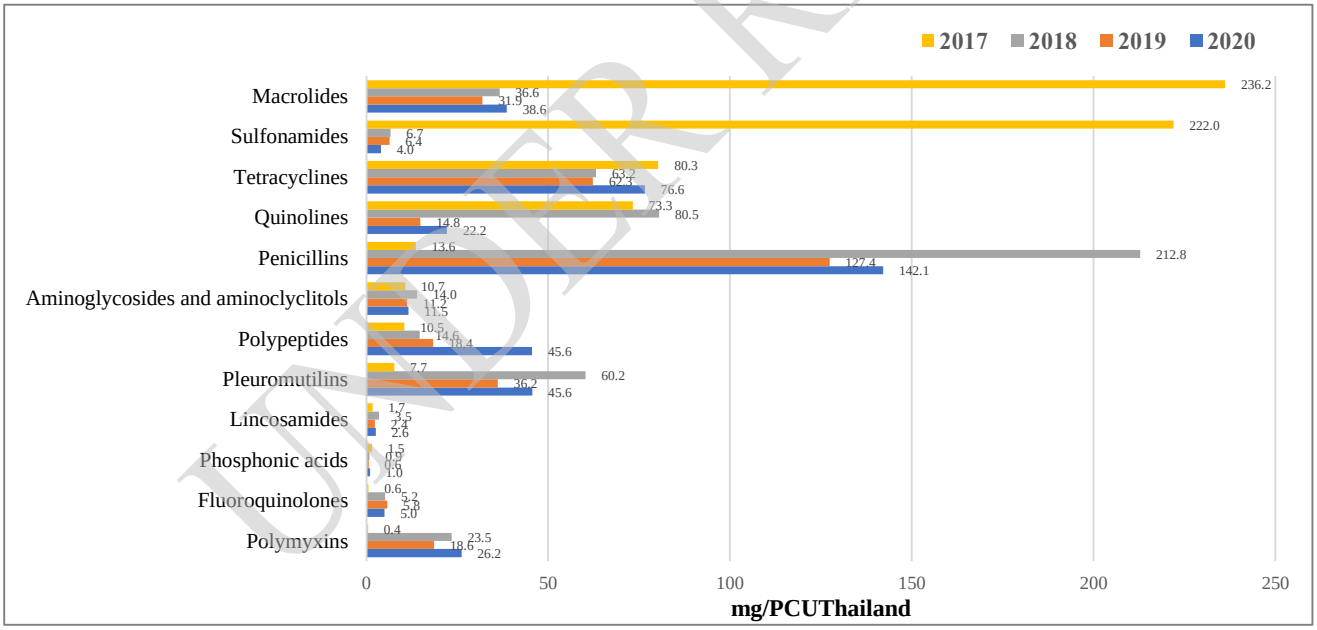


Figure A2.3 Consumption of veterinary antimicrobials by class of antimicrobials, from 2017 to 2020

- **Consumption by route of administration and pharmaceutical dosage form**
  - For 2020, the main consumption still belonged to premix, followed by oral powder and injection, respectively (Figure A.2.4).

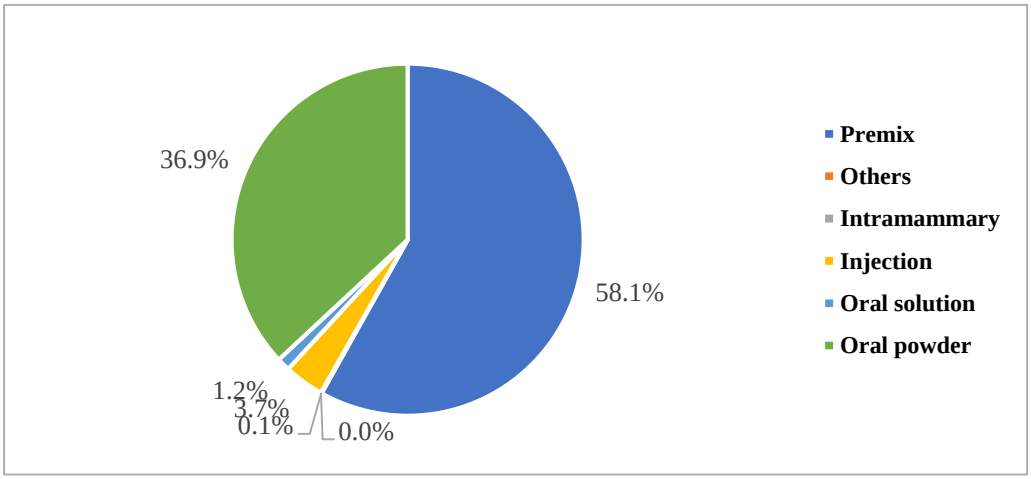


Figure A2.4 Proportional consumption of veterinary antimicrobials by route of administration and pharmaceutical dosage form in 2020

A 2.3 Consumption of Critically Important Antimicrobials (CIA)

- Overall, the consumption profile was shifted to more proportion of CIA in 2018 and 2019 (Figure A2.5). It was due to the fact that the consumption of CIA decreased by 14.2% (from 2017-20), but highly important antimicrobials decreased by 72.2% (from 2017-20). Moreover, the proportion of CIA consumption was shifted from highest priority in 2017 (91.7% of CIA consumption, -70.4% from 2017-20) to high priority (68.4% of CIA consumption, +603.1% from 2017-20).
- For highest priority CIA, the consumption had decreased over the four years (Figure A2.5). The decreasing trend was derived from constant drops in macrolide consumption (197.6 mg/PCU$_{Thailand}$ from 2017-20), mainly from tylosin (-215.5 mg/PCU$_{Thailand}$ from 2017-20) (Figure A2.6). Ranked second in proportion of highest priority CIA, polymyxins had a fluctuation (0.4 mg/PCU$_{Thailand}$ in 2017 to 26.2 mg/PCU$_{Thailand}$ in 2020), solely from colistin.
- For high priority CIA, the consumption had increased overall (Figure A2.6). The main contributing class to this increase was aminopenicillins (+128.6 mg/PCU$_{Thailand}$ from 2017-20), mainly from amoxicillin (+128.4 mg/PCU$_{Thailand}$ from 2017-20) (Figure A2.6). The second rank in this priority with similar trend was aminoglycosides, mainly from gentamicin (+1.2 mg/PCU$_{Thailand}$ from 2017-20) and kanamycin (+1.2 mg/PCU$_{Thailand}$ from 2017-20).

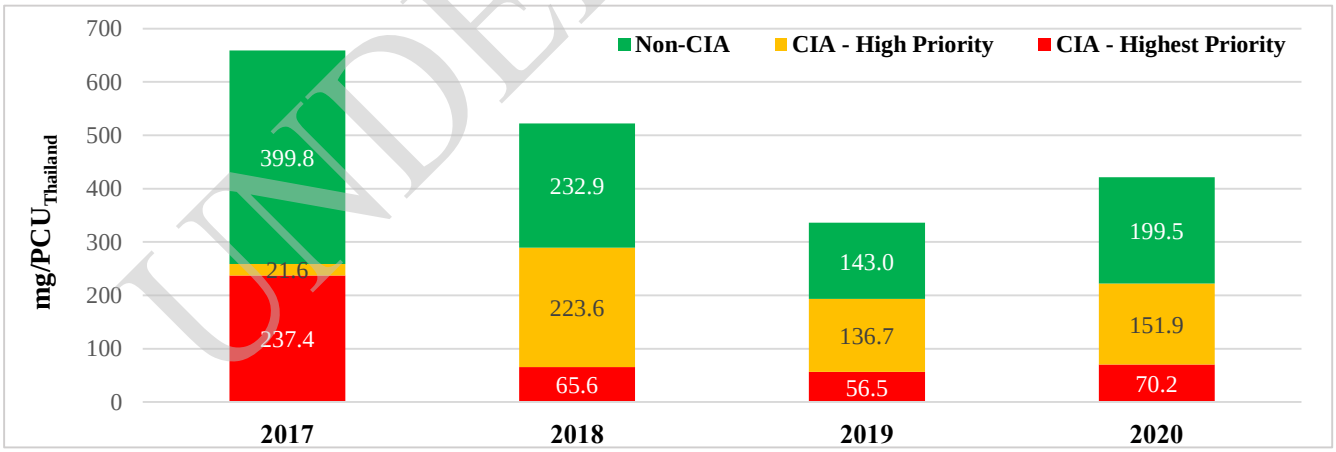


Figure A2.5 Comparative proportional consumption profile of critically important antimicrobials in food-producing animals from 2017 to 2020

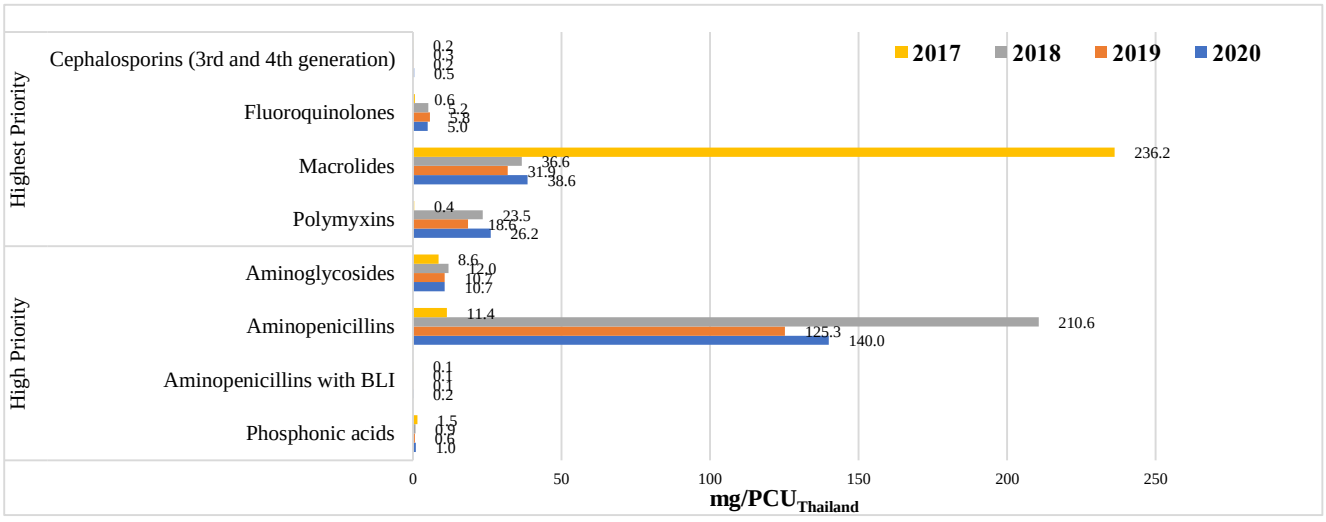


Figure A2.6 Consumption profile of CIA in food-producing animals from 2017 to 2020

A3: Antimicrobial Consumption in Food-Producing Animals (Medicated Feed through Feed Mills)

A 3.1 Overall consumption

- Overall, antibacterial consumption (ABC) through medicated feed in pigs was significantly more than that of poultry. The gap between the two species in 2020 remained the same due to a slight increase of ABC in pigs (+3.1% from 2019) and a slight decrease of ABC in poultry (-11.2% from 2019) (Figure A3.1).
- Classified by ATC vet code level 2 and animal species in 2020, pigs mostly consumed antibacterials for systematic (QJ01) (74.4% of pig ABC, +1.5% from 2019) and for intestinal infections (QA07) (25.6% of pig ABC, +8.0% from 2019).
- Poultry, on the other hand, mainly consumed QA07 (81.0% of poultry ABC, +41.9% from 2019) and QJ01 (19.0% of poultry ABC, -65.8% from 2019) (Figure A3.1).

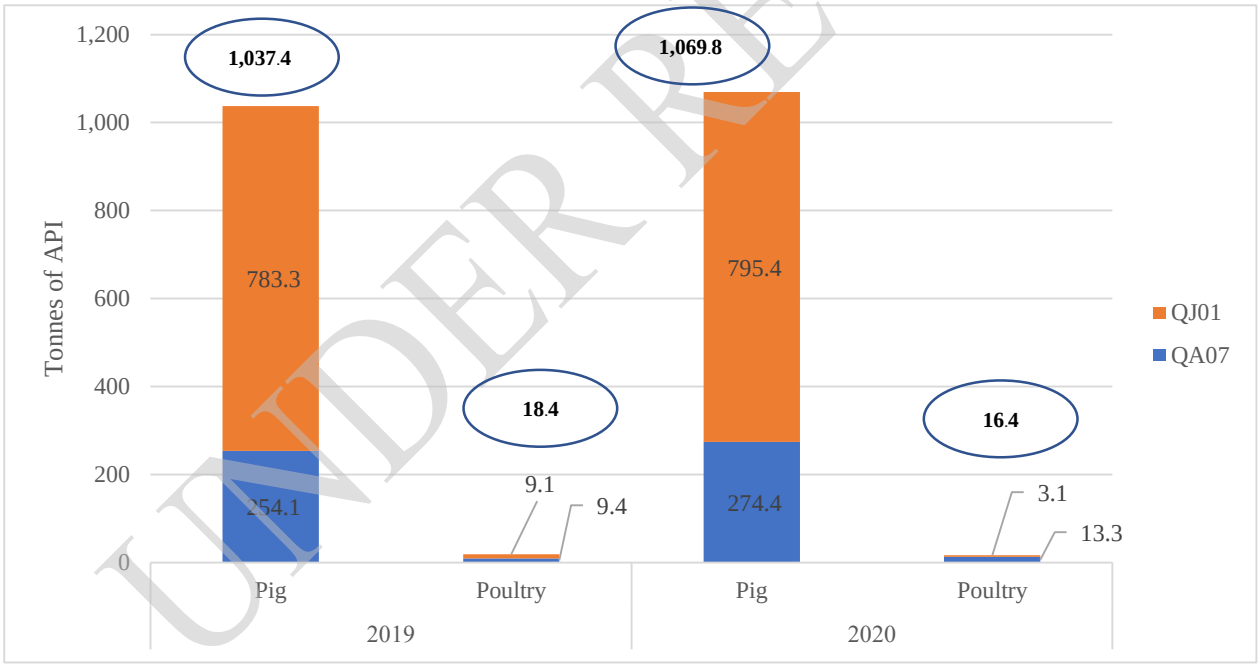


Figure A3.1 Antibacterial consumption through medicated feed by ATC vet code level 2 and animal species from 2019 to 2020

A 3.2 Consumption by chemical class of antibacterials and animal species

- ABC profiles in medicated feed of pigs and poultry were different in the profile of chemical class (Figure A3.2).
- Through more than 70% in medicated feed 2020, pigs consumed top-three antibacterial classes: penicillins (32.1% of pig ABC), pleuromutilins (21.3%) and quinolines (19.1% of pig ABC) (Figure A3.2). The top-three antibacterials came from top one of each the three classes: amoxicillin (343.5 tonnes), tiamulin (227.9 tonnes) and halquinol (204.6 tonnes). Amoxicillin was most consumed by piglets (167.2 tonnes), followed by pig breeders (101.9 tonnes).
- For poultry ABC in medicated feed, the top three antibacterials were polypeptides (80.5% of poultry ABC), macrolides (12.2% of poultry ABC) and pleuromutilins (3.9% of poultry ABC) (Figure A3.3). The top-three antibacterials most consumed by poultry were bacitracin (13.2 tonnes), tilmicosin (1.2 tonnes) and tylvalosin (0.8 tonnes). Bacitracin was most consumed by broiler (5.1 tonnes), followed by broiler breeders (2.3 tonnes).

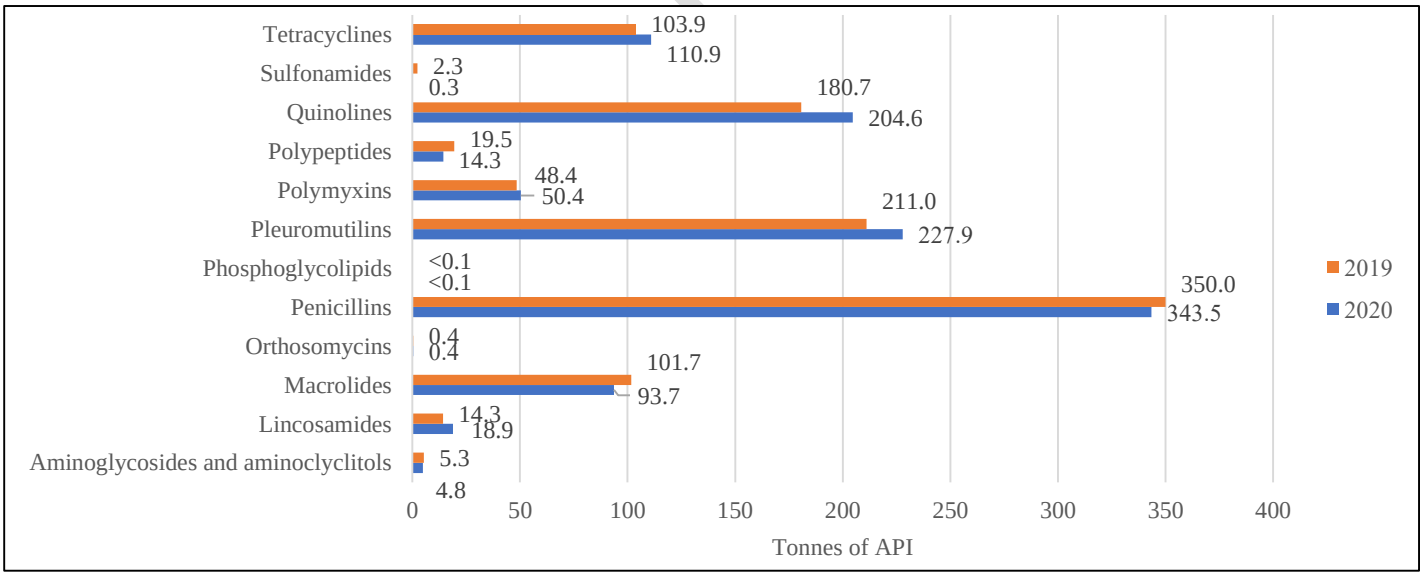


Figure A3.2 Antibacterial consumption through medicated feed in feed mills by chemical class in pigs from 2019 to 2020*

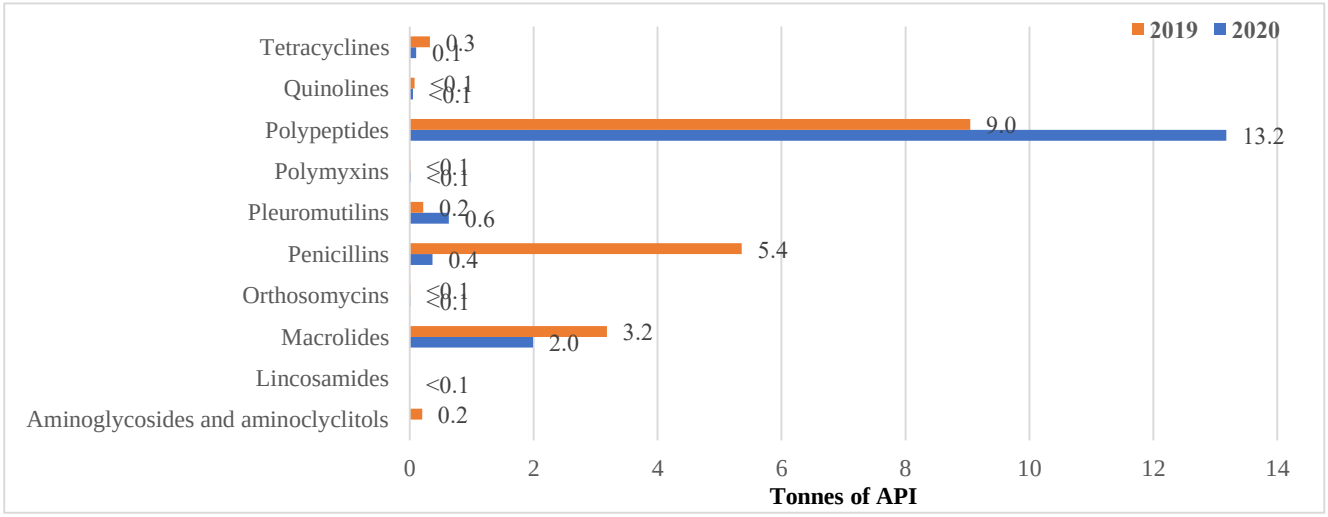


Figure A3.3 Antibacterial consumption through medicated feed in feed mills by chemical class in poultry from 2019 to 2020

*Sulfonamides includes sulfonamides and dihydrofolate reductase; aminoglycosides does not include aminocyclitols

A 3.3 Consumption of critically Important antimicrobials by animal species

- Classified by human CIA, the consumption profiles through medicated feed in feed mills between pigs and poultry were similar in 2020 (Figure A3.4). Pigs mainly consumed CIAs at 716.7 tonnes (55.4% of pig ABC) and important antimicrobials at 242.3 tonnes (84.4% of poultry ABC) while poultry principally consumed important antimicrobials at 13.8 tonnes (50.2%), and CIAs at 2.4 tonnes (14.5% of poultry ABC) (Figure A3.3).
- For CIA in 2020, pigs mainly consumed aminopenicillins (343.5 tonnes) and macrolides (93.7 tonnes) (Figure A3.5). The main CIA consumer in pigs were piglets (239.1 tonnes), followed by pig breeders (115.5 tonnes) and fattening pigs (137.9 tonnes). The two most consumed CIAs in pigs were amoxicillin (343.5 tonnes), and tilmicosin (83.0 tonnes).
- For poultry in 2020, they mainly consumed CIA in macrolides (2.0 tonnes) and aminopenicillins (0.4 tonnes). The main CIA consumers in poultry were broiler breeder (1.9 tonnes) and layers (1.0 tonnes). The two most consumed CIAs were macrolides: tilmiconsin (1.2 tonnes) and tylvalosin (0.8 tonnes).

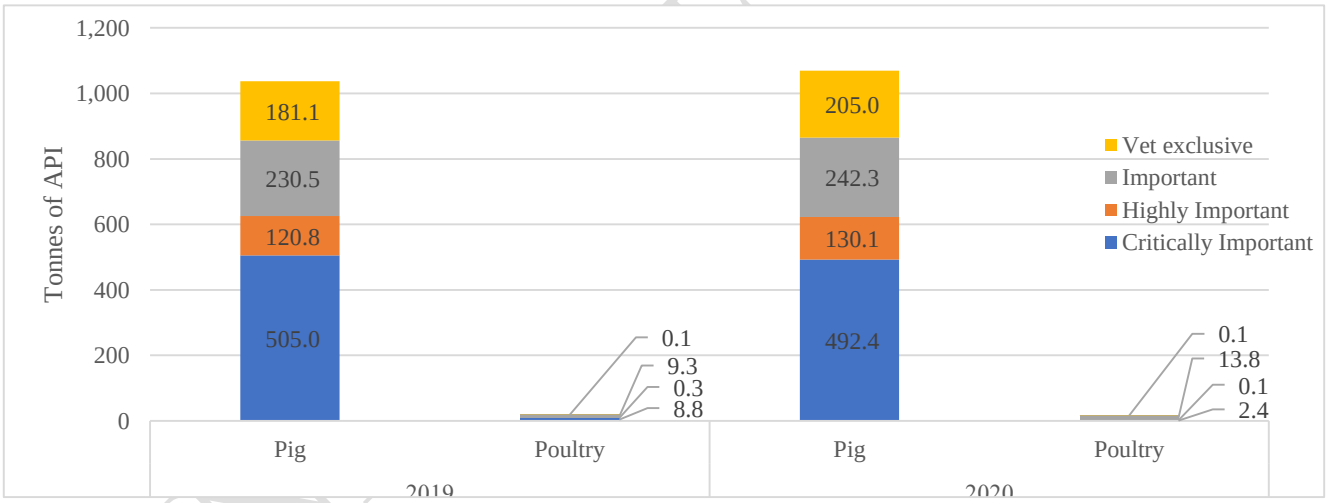


Figure A3.4 Antimicrobial consumption by type of WHO CIA through medicated feed in feed mills by chemical class and animal species from 2019 to 2020*

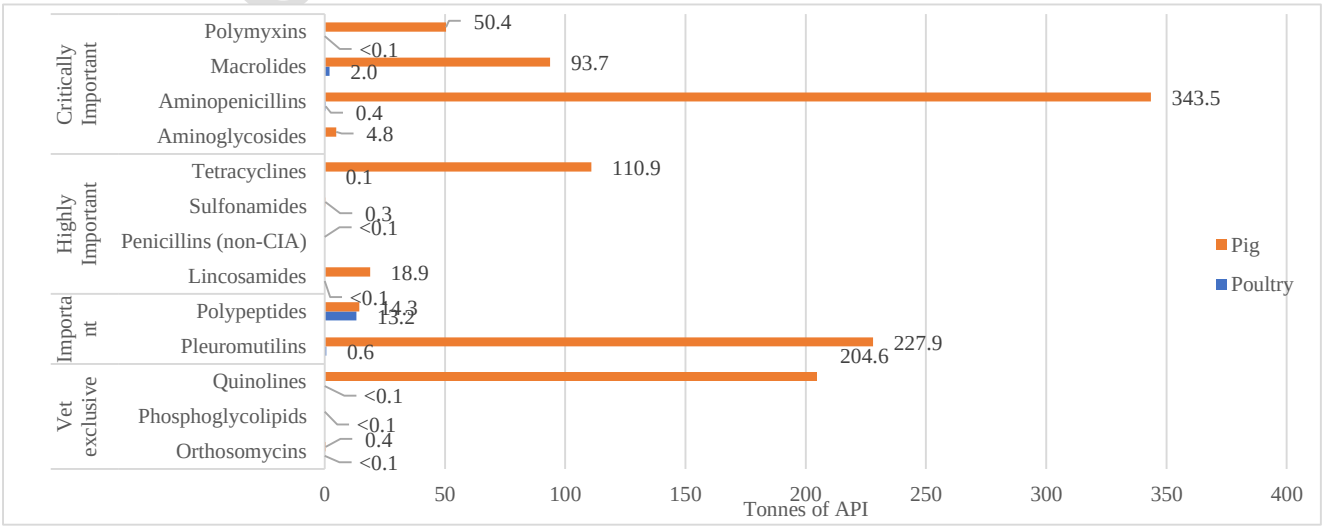


Figure A3.5 Antimicrobial consumption by type of WHO CIA through medicated feed in feed mills by chemical class in pigs from 2019 to 2020

*Sulfonamides includes sulfonamides and dihydrofolate reductase; aminoglycosides does not include aminocyclitols

SECTION B: ANTIMICROBIAL RESISTANCE

B1: Antimicrobial Resistance in Humans

B1.1 Gram-negative bacteria

Acinetobacter calcoaceticus-baumannii complex (*A. calcoaceticus-baumannii* complex)

Given the highest prevalence of *Acinetobacter baummanii* in clinical specimens tested in laboratories where accurate species can be performed and its virulence properties, the *Acinetobacter calcoaceticus-baumannii* complex is considered as *A. baumannii* in this report.

The trends in carbapenem-resistant *Acinetobacter* were steady at around 70.0%. Meanwhile, an increasing trend in resistance was observed for ampicillin/sulbactam from 62.2% in 2019 to 71.8% in 2020 (+9.6%).

The proportion of colistin resistance in 2020 was 2.2%, decreasing from 2.7% in 2019 (-0.5%) as a result of changing colistin breakpoints in 2020. The minimum inhibitory concentration 90 (MIC_{90}) of colistin in 2020 <1.0 mg/L, decreased from 2.0 mg/L in 2019.

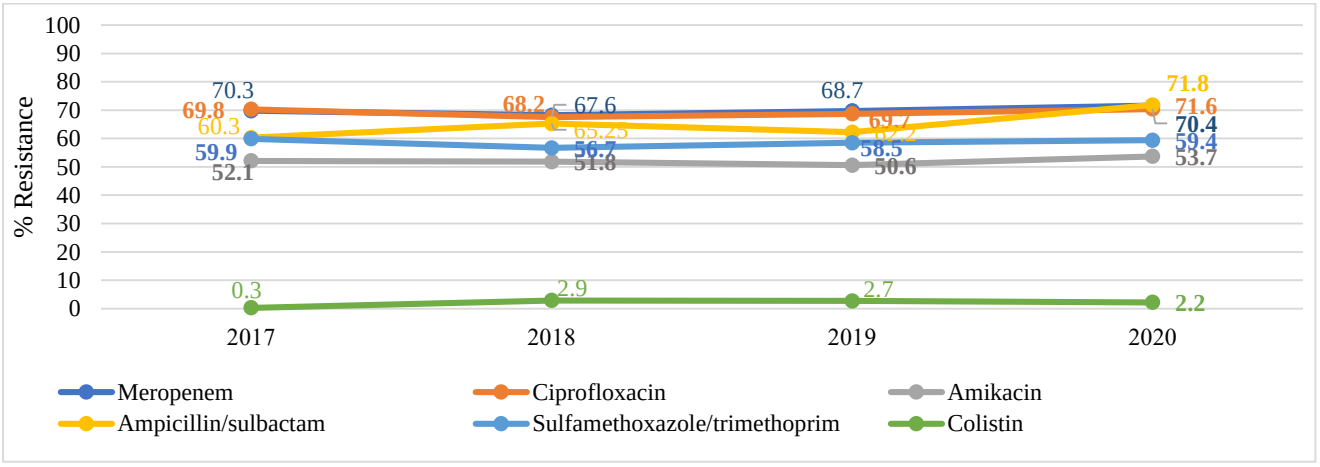
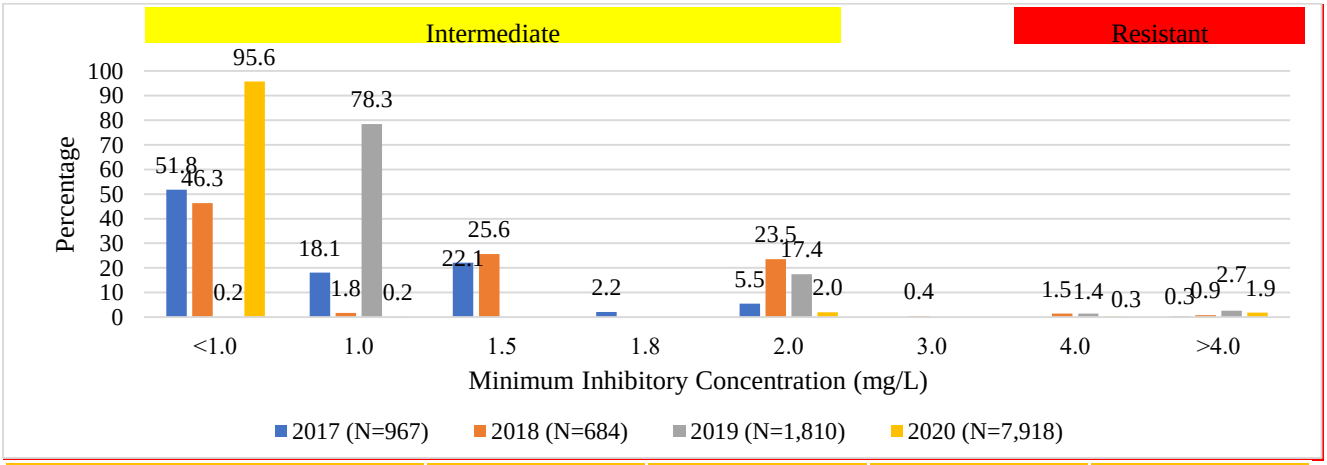


Fig B1.1 Percent resistance among *Acinetobacter calcoaceticus-baumannii* complex (2017-2020)
Note: In 2020, *Acinetobacter calcoaceticus-baumannii* complex resistance to colistin using MIC ≥ 4.0



Colistin MIC by Sensititre® (number of hospitals)	2017 (7)	2018 (6)	2019 (5)	2020 (8)
MIC_{50} (mg/L)	<1.0	1.5	1.0	<1.0
MIC_{90} (mg/L)	1.5	2.0	2.0	<1.0

Fig B1.2 MIC distribution of colistin for *Acinetobacter calcoaceticus-baumannii* complex (2017-2020)

***Pseudomonas aeruginosa* (*P. aeruginosa*)**

The recent trends in carbapenem-resistant *P. aeruginosa* (CRPA) remained steady in 2020 at 19.4% and 22% resistance for meropenem and imipenem, respectively.

A considerably decreasing trend in colistin resistance was observed among isolates of *P. aeruginosa* from 2.2% in 2019 to 1.1% in 2020, because of the breakpoint change from >2.0 to >4.0 mg/L. Additionally, the colistin MIC_{90} value over the three-year period were steady at 2.0 mg/L, which were intermediate range.

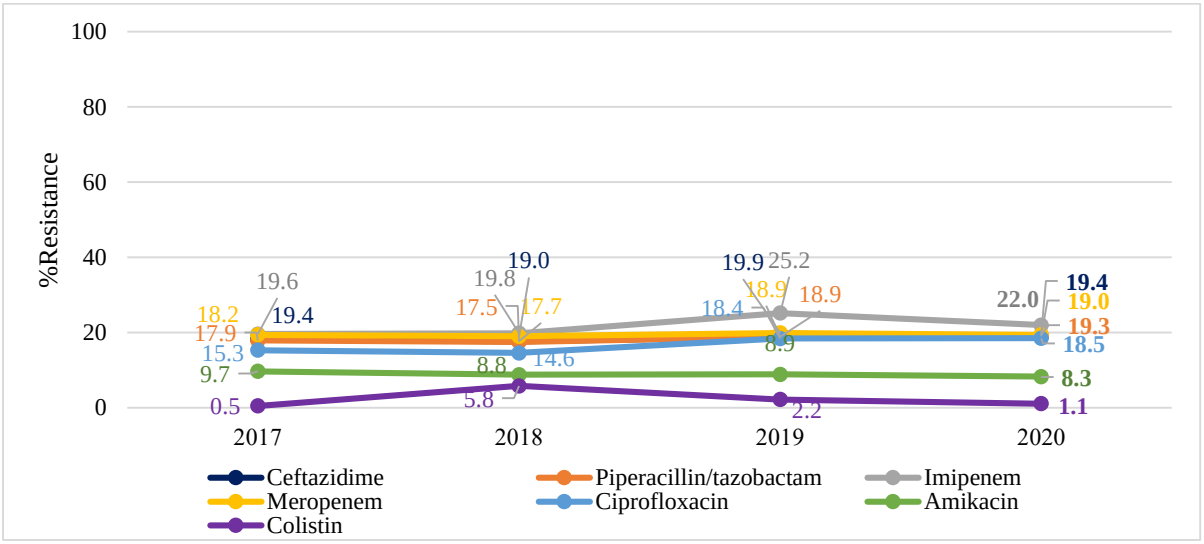


Fig B1.3 Percent resistance among *Pseudomonas aeruginosa* (2017-2020)

Note: In 2020, *Pseudomonas aeruginosa* resistance to colistin using MIC ⩾ 4.0

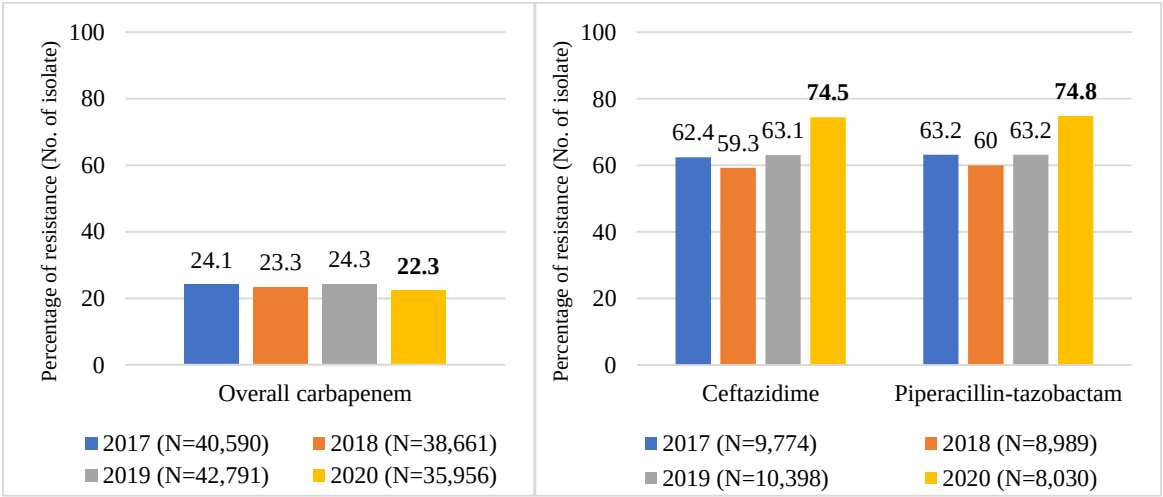
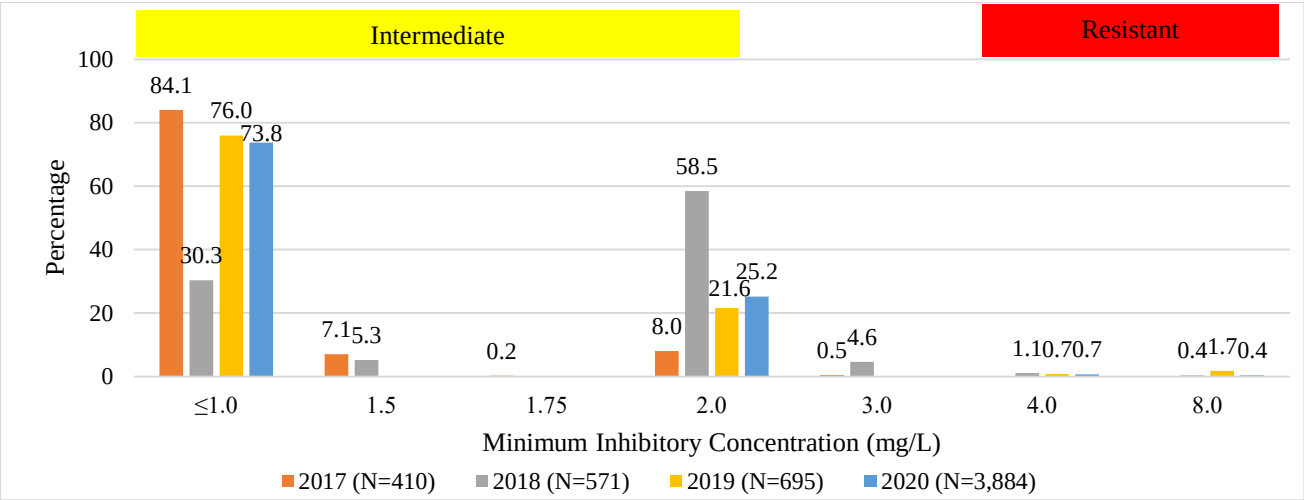


Fig B1.4 Percent resistance among carbapenem-resistant *Pseudomonas aeruginosa* (2017-2020)



Colistin MIC by Sensititre® (number of hospitals)	2017 (7)	2018 (6)	2019 (5)	2020 (8)
MIC_{50} (mg/L)	≤1.0	2.0	⩽1.0	⩽1.0
MIC_{90} (mg/L)	1.5	2.0	2.0	2.0

Fig B1.5 MIC distribution of colistin for *Pseudomonas aeruginosa* (2017-2020)

***Escherichia coli* (*E. coli*)**

Between 2019- 2020, the proportion of third- generation cephalosporin resistant *E. coli* has slightly changed from 43.9% in 2019 to 41.4% in 2020.

The proportion of fluoroquinolone resistant *E. coli* accounted for 60.0% in 2019-2020 increased from 50.5% in 2018 (+10%)

Regarding carbapenem-resistant Enterobacterales (CRE), *E coli* resistance rate for carbapenems in 2020 was 3.4%, which was the same rate as in 2019.

In 2020, over 6,000 isolates were tested for colistin MIC by Sensititre®, which demonstrated the majority of *E. coli* isolates were susceptible to colistin, the MIC_{90} was ⩽1.0 mg/L.

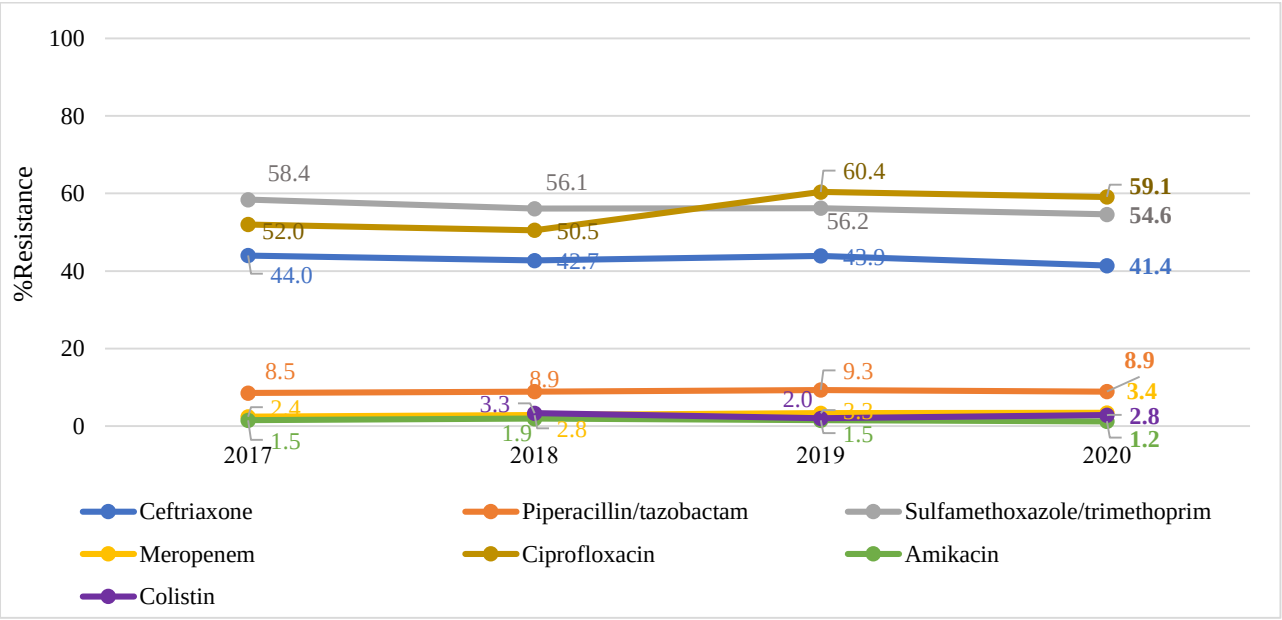
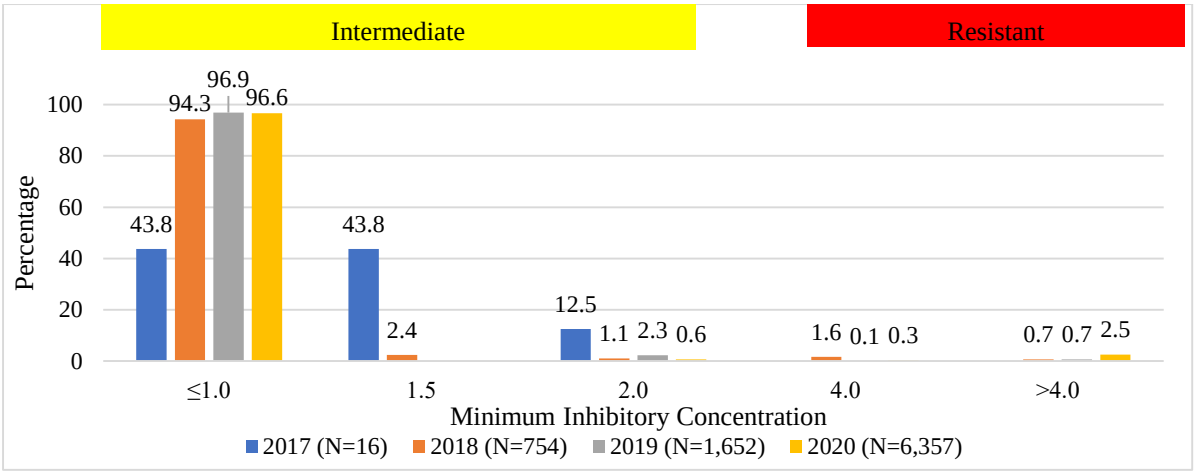


Fig B1.6 Percent resistanceamong *Escherichia coli* (2017-2020)



Colistin MIC by Sensititre® (number of hospitals)	2017 (4)	2018 (4)	2019 (4)	2020 (5)
MIC_{50} (mg/L)	1.5	≤1.0	≤1.0	≤1.0
MIC_{90} (mg/L)	2.0	≤1.0	≤1.0	≤1.0

Fig B1.7 MIC distribution of colistin for *Escherichia coli* (2017-2020)

***Klebsiella pneumoniae* (*K. pneumoniae*)**

The proportion of third-generation cephalosporin resistant *K. pneumoniae* in 2019 stayed at the same rate as 2019 at around 40.0%.

The proportion of fluoroquinolone resistant *K. pneumoniae* was slightly decreased from 48.8% in 2019 to 45.8% in 2020 (-3.0%)

The overall trend in carbapenem-resistant *K. pneumoniae* has remained steady at 12.6% in 2020.

The proportion of colistin-resistant *K. pneumoniae* in 2020 slightly increased to 4.3%. among over 5,400 tested isolates, while MIC_{90} maintained at ⩽1.0 mg/L.

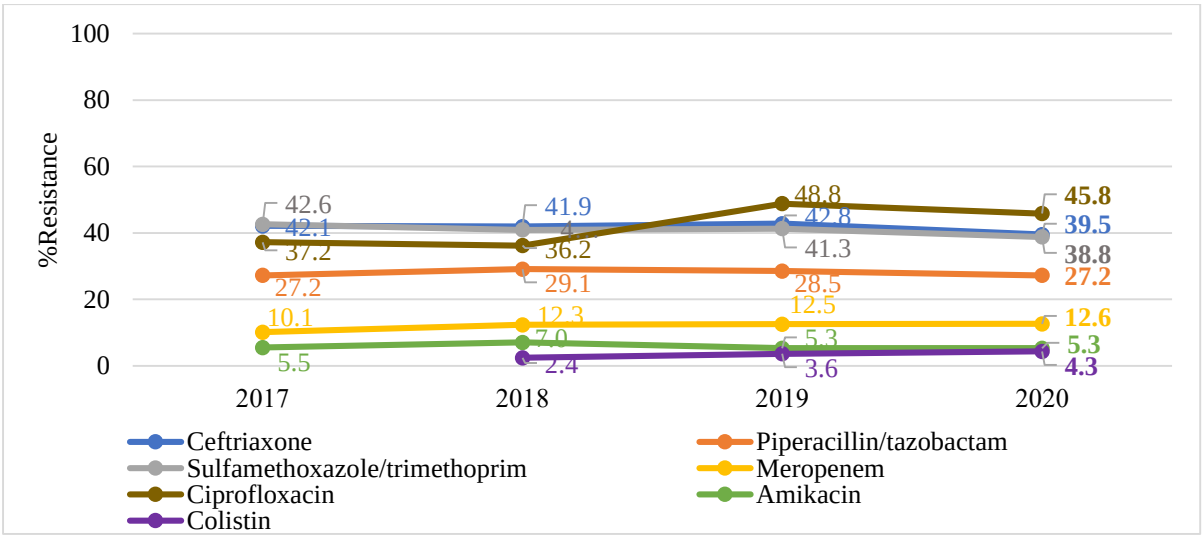
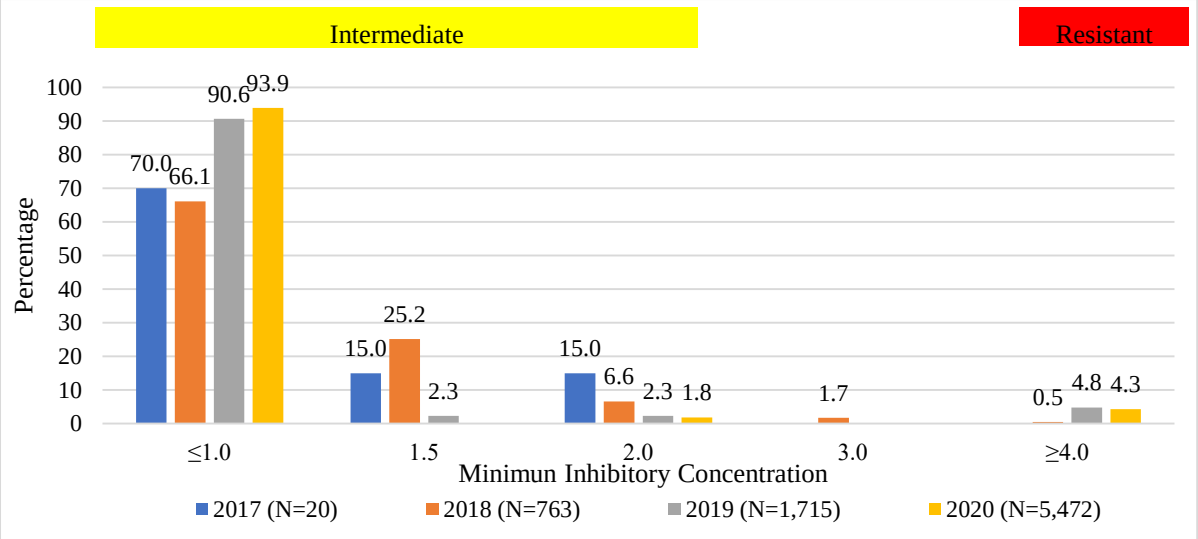


Fig B1.8 Resistance (%) among *Klebsiella pneumoniae* (2017-2020)
Note: In 2020, *Klebsiella pneumoniae* resistance to colistin using MIC ⩾ 4.0



Colistin MIC by Sensititre® (number of hospitals)	2017 (4)	2018 (6)	2019 (5)	2020 (9)
MIC_{50} (mg/L)	≤1.0	≤1.0	≤1.0	≤1.0
MIC_{90} (mg/L)	2.0	1.5	≤1.0	≤1.0

Fig B1.9 MIC distribution of colistin for *Klebsiella pneumoniae* (2017-2020)

B1.2 Gram-positive bacteria

Staphylococcus aureus (*S. aureus*)

The proportion of methicillin-resistant *Staphylococcus aureus* (MRSA) has been decreasing gradually from 9.6% in 2017 to 6.5% in 2020. On the other hand, the proportion of methicillin-resistant coagulase-negative *Staphylococcus* (MRCNS) has been increasing since 2017 at 53.2%, which accounted for 64.3% in 2020. Methicillin resistance rate in coagulase-negative *Staphylococcus* spp. has been seen considerably larger than *Staphylococcus aureus* in Thailand. None of the isolates in 2020 were resistant to vancomycin.

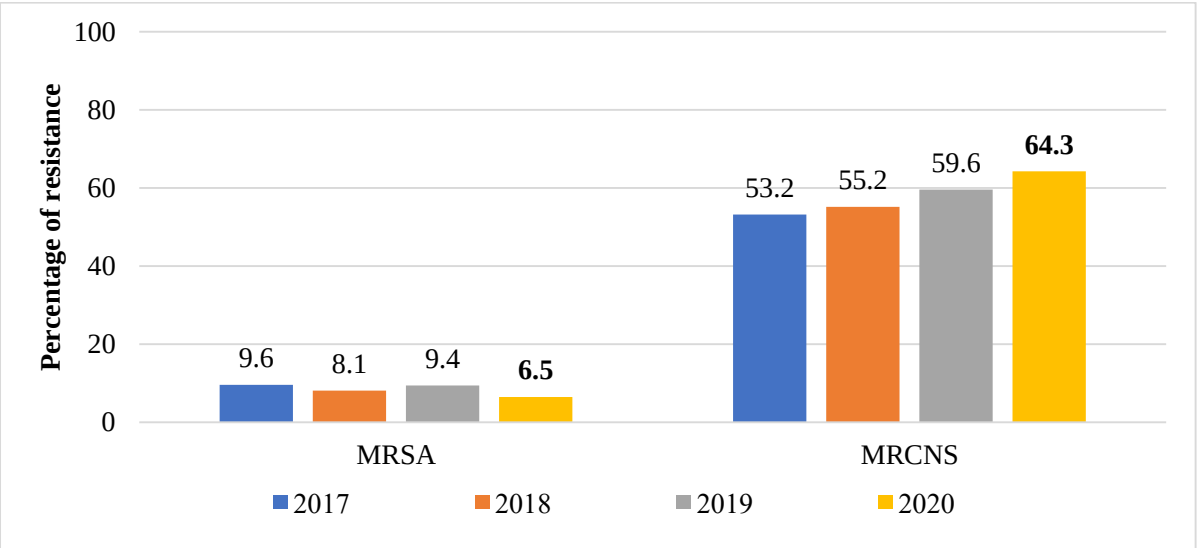


Fig B1.10 Percentage of methicillin resistance among *Staphylococcus aureus* (MRSA) and coagulase-negative staphylococci (MRCNS) (2017-2020)

***Enterococcus* spp.**

Ampicillin-resistant *Enterococcus faecalis* was found in around 5.2% of all isolates tested. *Enterococcus faecium* was, nonetheless, resistant to ampicillin a lot more than 90%. In addition, the percentage of vancomycin-resistant enterococcus (VRE) isolates was found in approximately 0.9% of *E. faecalis* and 7.3% of *E. faecium*.

Furthermore, other enterococci were not identified to the species level, thus, they were labeled as *Enterococcus* spp. Among 8,710 isolates tested, about 7.1% of them were resistant to vancomycin in 2020.

In 2020, a large number of *Enterococcus* spp. isolates were tested by broth microdilution method. The susceptibility data of VRE in 2020 were somewhat similar to isolates that tested by disk diffusion method.

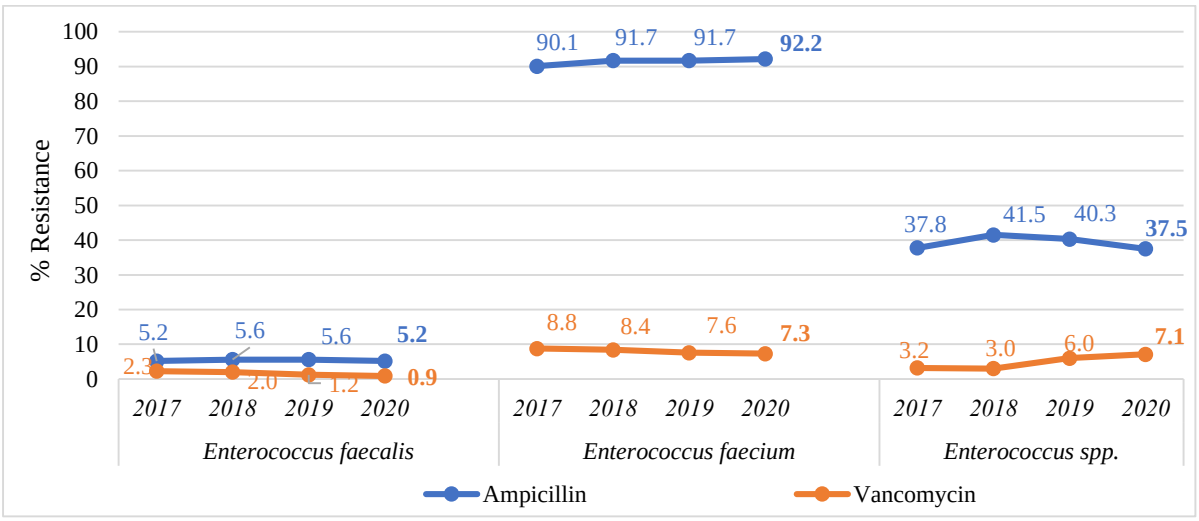


Fig B1.11 Percent resistance among *Enterococcus faecalis*, *Enterococcus faecium*, *Enterococcus* spp. (2017-2019)

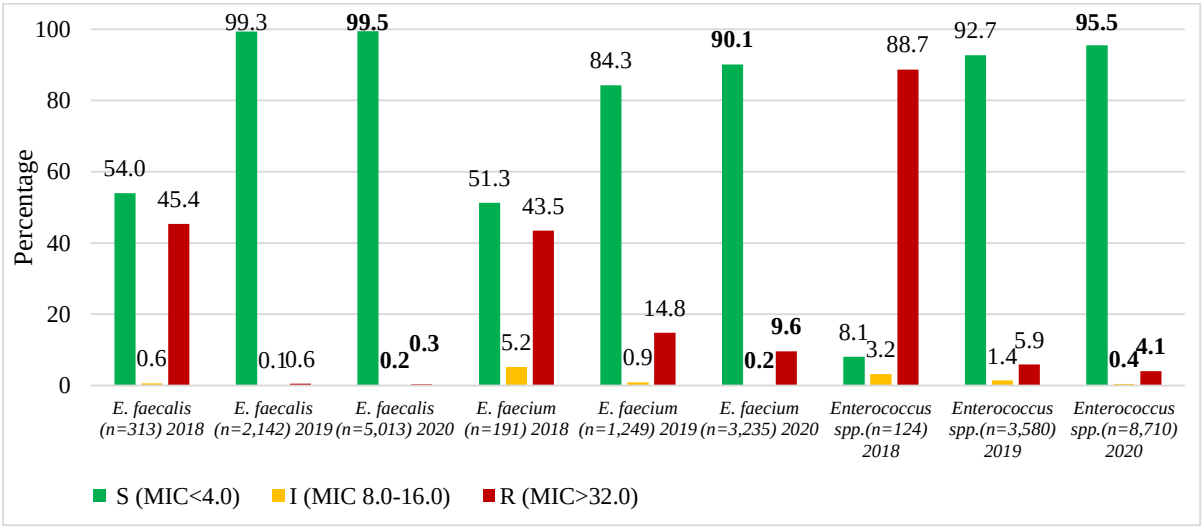


Fig B1.12 Percentage of susceptible, intermediate and resistance to vancomycin among *Enterococcus faecalis*, *Enterococcus faecium*, *Enterococcus* spp., 2018-2020

***Streptococcus pneumoniae* (*S. pneumoniae*)**

For non-cerebrospinal fluid (CSF) samples, the proportion of penicillin non-susceptible *S. pneumoniae* (PNSP) including *S. pneumoniae* with intermediate level of penicillin resistance remained at 6.7% in 2020, which minimally decreased as they were 7.2% in 2019 (-0.5%). For cephalosporin resistance in 2020, approximately 3.4 and 8.9% were intermediate-resistant to ceftriaxone and cefotaxime, respectively.

For CSF samples, approximately 16.7% were resistant to penicillin in 2020. None of the isolates were resistant to ceftriaxone and cefotaxime. This implies that penicillin should not be used for empirical treatment of acute bacterial meningitis in Thailand.

Table B1.1 The proportion (%) of antimicrobial resistance in *Streptococcus pneumoniae*

Drug	% Resistant (number isolates)				E-test, (number isolates)							
					Meningitis				Non-meningitis			
	2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
Penicillin*	65.8	63.4	64.3	53.8	50.0	57.1	88.9	33.3	10.0	5.62	7.2	6.4
	(371)	(366)	(1,276)	(788)	(2)	(7)	(9)	(6)	(369)	(359)	(1,267)	(956)
Cefotaxime*	-	-	-	-	0.0	0.0	-	0.0	0.0	0.98	6.9	8.9
					(11)	(3)		(4)	(144)	(209)	(663)	(404)
Levofloxacin*	0.9	1.0	1.2	1.4	-	-	-	-	-	-	-	-
	(1,437)	(1,750)	(2,383)	(1,109)								

*Interpretation by minimum inhibitory concentration test

B1.3 Other antimicrobial-resistant bacteria

Non-typhoidal *Salmonella* spp.

Determination of ciprofloxacin susceptibility for non-typhoidal *Salmonella* from extraintestinal isolates showed that 5.9% was ciprofloxacin resistant in 2020 tested by the conventional disk diffusion method which slightly decreased as they were 6.1% in 2019 (-0.2%).

The overall trends of third-generation cephalosporin resistance in *Salmonella* spp. have been stable around 12.0% -15.1%.

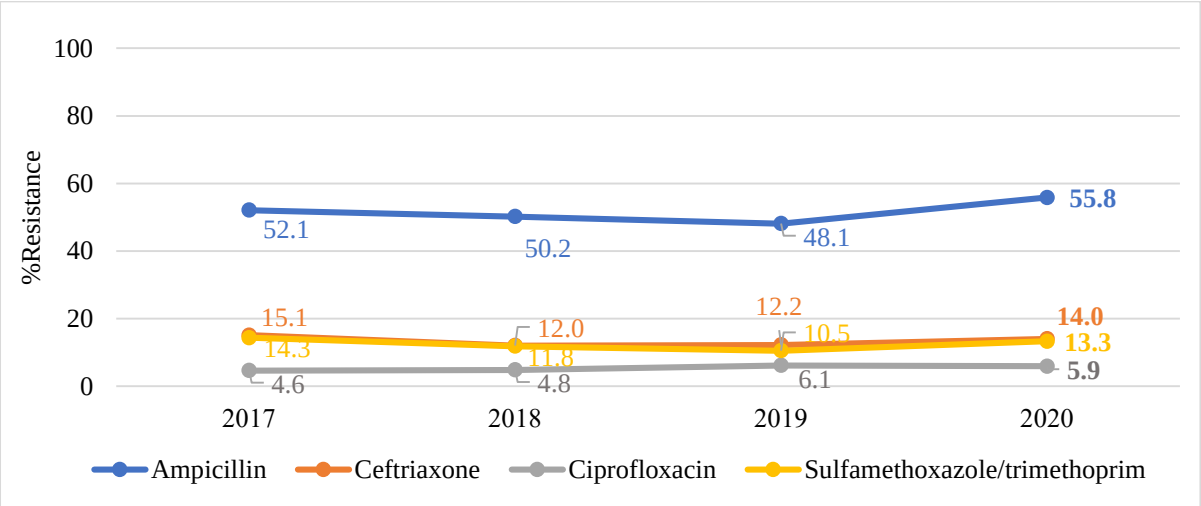


Fig B1.13 Percent resistance among Non-typhoidal *Salmonella* spp. from extraintestinal isolates (2017-2020)

***Neisseria gonorrhoeae* (*N. Gonorrhoeae*)**

N. gonorrhoeae isolates showed a hundred percent of resistance to penicillin. In addition, 94.7% of *N. gonorrhoeae* isolates were non-susceptible to ciprofloxacin and 96.9% of those were non-susceptible to tetracycline in 2020.

However, no resistance to cefixime or ceftriaxone has been reported during 2017- 2020. Additionally, all isolates have remained susceptible to azithromycin in 2020.

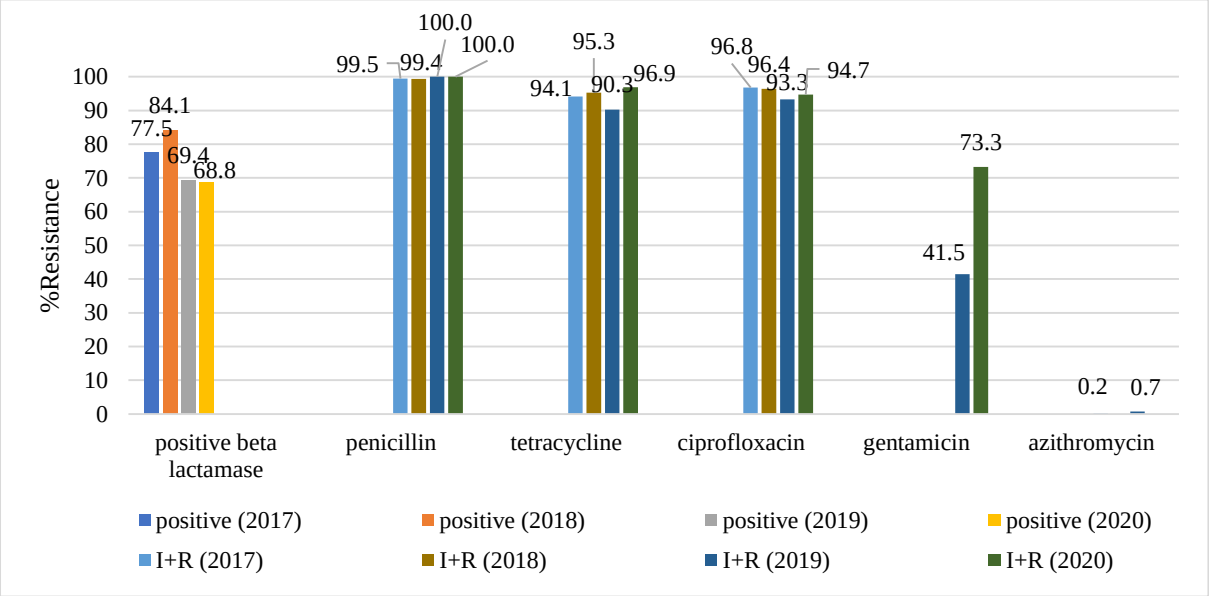


Fig B1.14 Resistance (%) among *Neisseria gonorrhoeae* (2017-2019)
positive: enzyme β-lactamase was detected.
I+R: resistance or non-susceptible

B1.4 Empirical therapy combinations

The data in the table B1.2 and B1.3 showed the combination regimens for empirical therapy of *A. baummanii*, carbapenem-resistant *E. coli* and carbapenem-resistant *K. pneumoniae* infection according to susceptibility pattern of antimicrobials in 2019-2020. These data were based on a criterion which was at least 1 antimicrobial of both antimicrobial combinations had been reported as susceptible, will be counted into susceptible regimens.

The regimen of empirical therapy for infection should be considered when it shows more than 80.0% susceptible. The recommendation of appropriate combination regimens for empirical therapy in patient who is suspected of *A. baummanii* or carbapenem-resistant *E. coli* or *K. pneumoniae* infection is colistin + co-trimoxazole, colistin +Fosfomycin, and colistin + amikacin, respectively. These tables only provide the data on susceptibility aspect, therefore pharmacokinetic properties and adverse drug reactions should be taken into consideration.

Table B1.2 Susceptible levels (%) among diagnostic isolates of *A. baumannii*

Empiric therapy combinations	**2019 (N)**	**2020 (N)**
Colistin + Meropenem	98.6 (707)	97.8 (8,832)
Colistin + Imipenem	99.3 (675)	97.8 (8,816)
Colistin + Gentamicin	97.6 (484)	94.9 (445)
Colistin + Amikacin	98.9 (731)	97.8 (7,128)
Colistin + Sulbactam	99.9 (931)	99.0 (1,859)
Colistin + Co-trimoxazole	99.2 (499)	99.5 (6,129)

Table B1.3 Susceptible levels (%) among diagnostic isolates of Carbapenem-resistant Enterobacterales (CRE)

Antibiotic	***E. coli***		***K. pneumoniae***	
	2019 (N=3,514)	**2020 (N=2,764)**	**2019 (N=9,570)**	**2020 (N=6,468)**
Amikacin	91.3 (2,787)	89.3 (2,309)	77.8 (6,507)	65.6 (4,033)
Gentamicin	39.2 (1,005)	37.7 (946)	67.7 (4,641)	65.3 (4,303)
Fosfomycin	90.3 (495)	93.1 (421)	69.7 (796)	71.5 (647)
Empiric combination therapy				
Meropenem + Amikacin	91.7 (2,801)	89.6 (2,318)	78.3 (6,553)	66.1 (4,062)
Meropenem + Gentamicin	45.3 (1,161)	43.5 (1,090)	70.5 (4,831)	68.5 (4,514)
Meropenem + Colistin	97.6 (847)	97.5 (588)	90.2 (2,012)	92.0 (1,859)
Meropenem + Fosfomycin	91.2 (500)	93.6 (423)	73.0 (834)	76.5 (692)
Colistin + Amikacin	99.8 (838)	99.7 (1,183)	97.1 (2,107)	99.3 (805)
Colistin + Gentamicin	97.8 (668)	98.4 (1,159)	96.1 (1,682)	98.9 (806)
Colistin + Fosfomycin	99.8 (2,527)	99.3 (148)	96.5 (462)	97.8 (305)
Amikacin + Fosfomycin	98.8 (512)	98.8 (402)	89.3 (897)	97.3 (778)
Gentamicin+ Fosfomycin	92.9 (468)	92.7 (497)	84.8 (833)	96.9 (1,670)

B2: Antimicrobial Resistance in Patients with Hospital-associated Infections

B2.1 Hospital-associated infection

- **Incidence of Hospital-Associated Infections (HAI)**
  - Overall, in 2020, total 11,030 HAI events were reported in 8,979 patients from 50 hospitals. The incidence rate (per 1,000 patient-days) and incidence proportion (%) of HAI by year and type of hospital are shown in Table B2.1.
  - The incidence rate and incidence proportion of HAI increased from 1.5 per 1,000 patient-days and 0.5% of total inpatients in 2019 to 1.8 per 1,000 patient-days and 0.7% of total inpatients in 2020.
  - In 2020, other public hospitals had the highest HAI incidence rate (3.5 per 1,000 patient-days) and incidence proportion 1.7% of total inpatients. The lowest HAI incidence rate and incidence proportion were found in community hospitals at 0.3 per 1,000 patient-days and 0.1% of total inpatients.

Table B2.1 Incidence rate (per 1,000 patient-days) and incidence proportion (%) of HAI by type of hospital

Hospital type	2020						2019		2018	
	HAI patient	HAI events	Patient-days	Discharged patient	Weighted HAI incidence rate	Weighted HAI incidence proportion (%)	Weighted HAI incidence rate	Weighted HAI incidence proportion (%)	Weighted HAI incidence rate	Weighted HAI incidence proportion (%)
Regional hospital	5,843	7,270	3,135,154	593,194	2.3	1.0	2.4	1	3.4	1.2
General hospital	2,350	2,798	2,143,871	995,253	1.3	0.2	1.3	0.4	1.2	0.4
Community hospital	75	84	272,209	86,141	0.3	0.1	0.4	0.1	1	0.3
Other MOPH hospital	80	109	33,962	6,198	3.2	1.3	3.2	1.3	2.9	1.0
Other public hospital	607	740	208,452	34,957	3.5	1.7	3.9	2.3	3.3	1.7
Private hospital	24	29	81,669	30,613	0.4	0.1	0.5	0.1	0.7	0.2
Total	**8,979**	**11,030**	**5,875,317**	**1,746,356**	**1.5**	**0.4**	**1.5**	**0.5**	**2.5**	**0.8**

- **HAI by age groups**
  - HAI events were found in elderly patients (age >60 years old) (51.7%, 5,705 events) more than other age groups (Figure B2.1).
  - In 2020, almost of paediatric patients (newborn, infant, 1-15 years) with HAI events were newborn 5.9% (652 events).

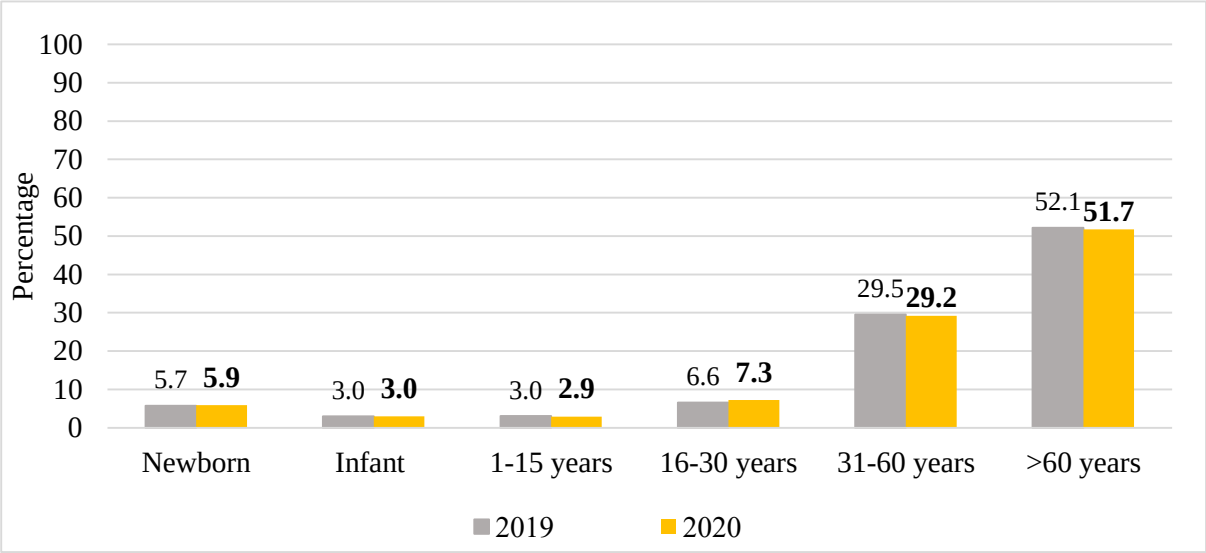


Figure B2.1 Percentage of HAI events by age group

Note: Data in 2018 was not available.

- **HAI by site of infection**
  - In 2020, the top three sites of HAI infection were respiratory tract infection (49.5%), urinary tract infection (25.3%), and bloodstream infection (10.4%). The 2020 profile was similar to 2019 and 2018 (Figure B2.2).

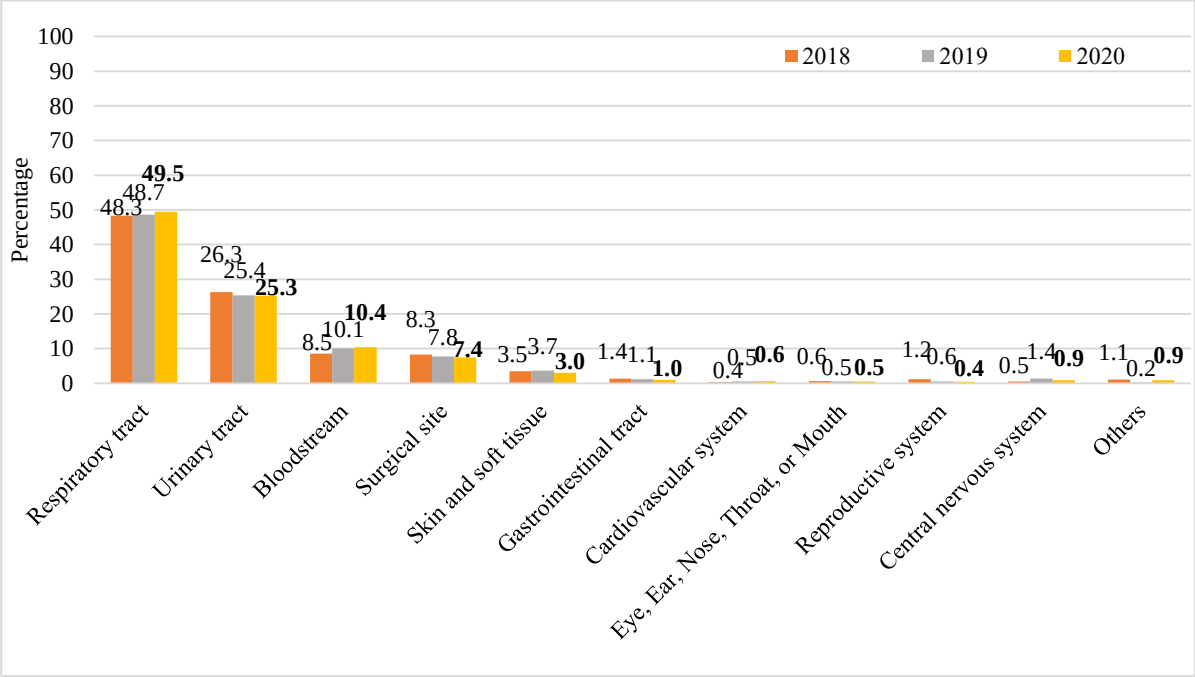


Figure B2.2 Hospital-associated infection by site of infection

- Overall, incidence rate of ventilator-associated pneumonia (VAP), central line-associated bloodstream infections (CLABSI), and catheter-associated urinary tract infections (CAUTI) slightly decreased from 3.7 per 1,000 ventilator-days, 1.5 per 1,000 catheter-days, and 1.4 per 1,000 catheter-days in 2019 to 3.7 per 1,000 ventilator-days, 1.5 per 1,000 catheter-days, and 1.3 per 1,000 catheter-days in 2020. While incidence rate of surgical site infection (SSI) decreased from 0.3 per 100 surgeries in 2019 to 0.2 per 100 surgeries in 2020. (Table B2.2)
- The VAP incidence rate in other MOPH hospitals had the highest rate accounting for 8.7 per 1,000 ventilator-days while community hospitals had lowest VAP incidence as 1.2 per 1,000 ventilator-days.
- The CLABSI incidence rate in other MOPH hospitals had the highest rate as 8.9 per 1,000 catheter-days while there was no CLABSI incidence rate in community and private hospitals.
- The CAUTI incidence rate in other MOPH hospitals and other public hospitals were 3.3 per 1,000 catheter-days while community hospital and private hospitals had lowest incidence rate at 0.2 per 1,000 catheter-days.
- Finally, the incidence rate of SSI was highest in regional hospitals (0.5 per 100 surgeries) while there was no SSI incidence rate in community hospitals.

Table B2.2 Incidence of invasive device-related HAIs, and surgical site infection (weighted incidence rate) by type of hospital

	2020				2019				2018			
	VAP	**CLABSI**	**CAUTI**	**SSI**	**VAP**	**CLABSI**	**CAUTI**	**SSI**	**VAP**	**CLABSI**	**CAUTI**	**SSI**
Regional hospital	4.0	1.7	1.6	0.5	4.0	1.7	1.6	0.5	6.0	2.7	2.4	0.4
General hospital	3.4	0.9	1.2	0.2	3.7	0.9	1.3	0.2	4.2	0.7	1.3	0.2
Community hospital	1.2	0.0	0.2	0.0	2.4	3.3	0.5	0.1	6.8	1.2	1.6	0.2
Other MOPH hospital	8.7	8.9	3.3	0.1	6.5	3.6	3.4	0.1	3.3	3.0	5.1	0.1
Other public hospital	2.9	1.4	3.3	0.2	2.6	1.2	3.5	0.3	4.1	0.9	3.9	0.2
Private hospital	3.6	0.0	0.2	0.4	2.2	0.0	0.3	0.1	5.5	0.0	1.4	0.2
Total	**3.5**	**1.5**	**1.3**	**0.2**	**3.7**	**1.5**	**1.4**	**0.3**	**5.5**	**2.2**	**2.1**	**0.3**

Note: Ventilator-associated pneumonia (VAP), Central line-associated bloodstream infections (CLABSI), Catheter-associated urinary tract infections (CAUTI), and Surgical site infection (SSI)

- **Causative organisms of HAI**
  - The top three causative pathogens of HAI in 2020 were *A. baumannii* (30.3%), *K. pneumoniae* (14.8%), and *E. coli* (11.8%). This profile was similar to the top three in 2019 and 2018 (Figure B2.3).

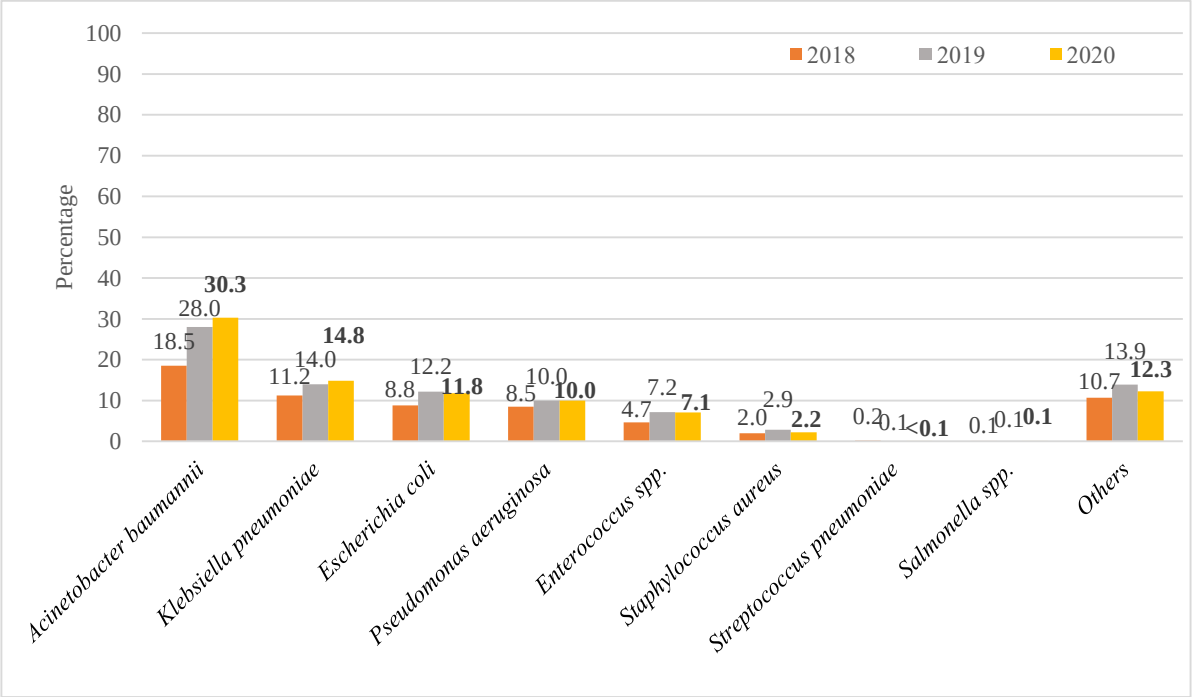


Figure B2.3 Causative organisms of HAI events by targeted pathogen
Note: Others are not targeted pathogen.

B2.2 Antimicrobial resistance[9]

- **Incidence of AMR in HAI patients**
  - In 2020, of the total 11,030 HAI events and 8,979 HAI patients there were 5,854 AMR reported events (53.1% of total HAI events) in 4,721 AMR patients (52.6% of total HAI patients) (Table B2.3).
  - The incidence rate and incidence proportion of AMR infection in 2020 were 0.7 per 1,000 patient-days and 0.2% of total inpatients, which slightly increased from 0.6 per 1,000 patient-days and 0.2% of total inpatients in 2019.
  - Other MOPH hospitals had the highest AMR incidence rate (1.5 per 1,000 patient-days).
  - The lowest AMR incidence rate was found in community hospitals and private hospitals as 0.1 per 1,000 patient-days while the lowest AMR incidence proportion was found in community hospitals as 0.02%.

[9] In this chapter, AMR is defined as the resistance of target bacterial pathogens to at least one of the listed antimicrobials (*Acinetobacter baumannii, Klebsiella pneumoniae, Escherichia coli, Pseudomonas aeruginosa, Enterococcus* spp., *Staphylococcus aureus, Streptococcus pneumoniae, Salmonella* spp., and *Neisseria gonorrhoeae*) in accordance with the National Strategic Plan on AMR (2016-2020). In case a patient was reported with similar AMR pathogen infection within a 14-day period, a deduplication of AMR events was done.

Table B2.3 Incidence rate (per 1,000 patient-days) and incidence proportion (%) of AMR by type of hospital

Hospital type	2020						2019		2018	
	AMR patient	AMR events	Patient-days	Discharged patient	Weighted AMR incidence rate	Weighted AMR proportion	Weighted AMR incidence rate	Weighted AMR proportion	Weighted AMR incidence rate	Weighted AMR proportion
Regional hospital	3,185	3,935	3,135,154	593,194	1.3	0.5	1.1	0.5	1.8	0.7
General hospital	1,274	1,589	2,143,871	995,253	0.7	0.1	0.5	0.2	0.9	0.3
Community hospital	15	17	272,209	86,141	0.1	<0.1+	0.1	0.0	0.6	0.2
Other MOPH hospital	34	52	33,962	6,198	1.5	0.5	1.5	0.5	1.7	0.7
Other public hospital	203	249	208,452	34,957	1.2	0.6	1.6	0.9	1.4	0.8
Private hospital	10	12	81,669	30,613	0.1	<0.1++	<0.1*	<0.1**	0.5	0.1
Total	**4,721**	**5,854**	**5,875,317**	**1,746,356**	**0.7**	**0.2**	**0.6**	**0.2**	**1.4**	**0.5**

Note: +0.02, ++ 0.03, *0.01, **0.002

- **AMR in HAI patients by age groups**
  - Half of AMR events in 2020 (55.5%, 3,248 of 5,856 events) occurred in elderly patients (age >60 years old).
  - Almost half of paediatric patients infected (newborn, infant, 1-15 years) with AMR pathogens were newborn 3.6% (208 events).

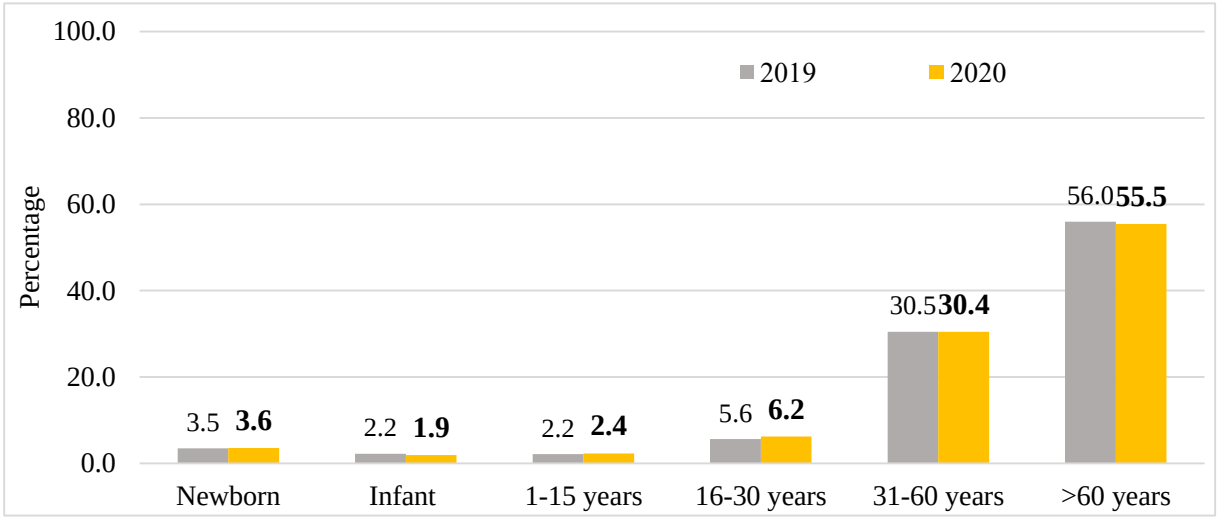


Figure B2.4 Number of AMR events by age group

Note: Data in 2018 was not available

- **AMR in HAI patients by site of infection**
  - Among all AMR events, the top three sites were respiratory tract infection (59.3%), urinary tract infection (23.1%), and bloodstream infection (7.5%). These sites of infection were similar to the top three in 2019 (Figure B2.5).

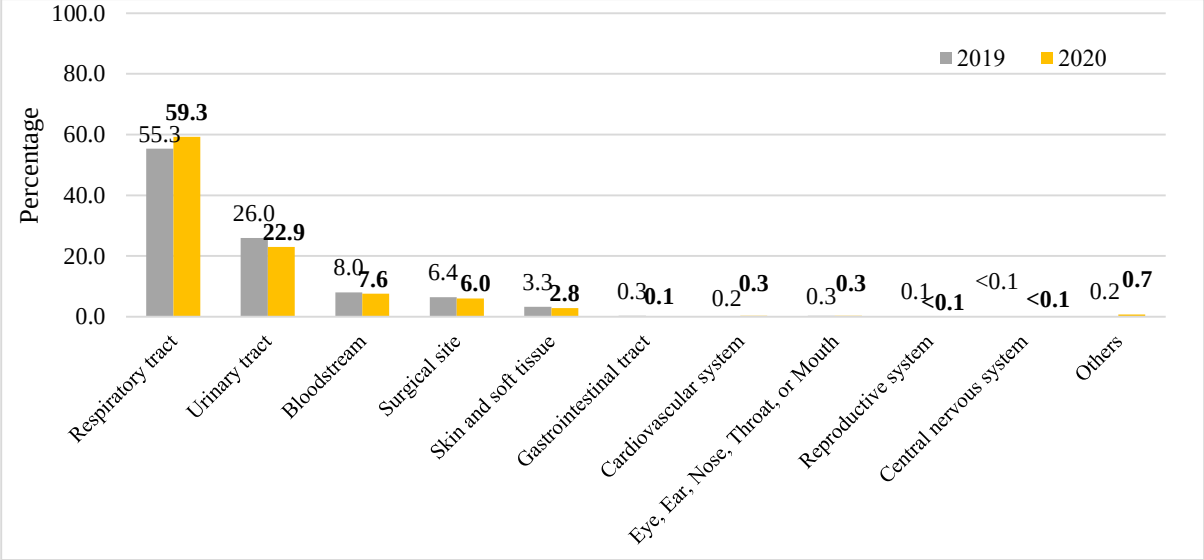


Figure B2.5 Antimicrobial infection by site of infection

Note: Reproductive system was 0.04% in 2019. Central nervous system was 0.04% and 0.03% in 2019 and 2020, respectively.

Note: Data in 2018 was not available

- **Target AMR pathogen in HAI patients**
  - In 2020, among the total 5,856 AMR events, *A. baumannii* was the most common pathogen (2,848 events, 48.6%), followed by *K. pneumoniae* (1,482 events, 25.3%), and *E. coli* (981 events, 16.8%).
  - This result, *Salmonella* spp. was low of AMR event (1 event, <0.1%) while there was no penicillin resistant *Streptococcus pneumoniae* in 2020 (Figure B2.6).

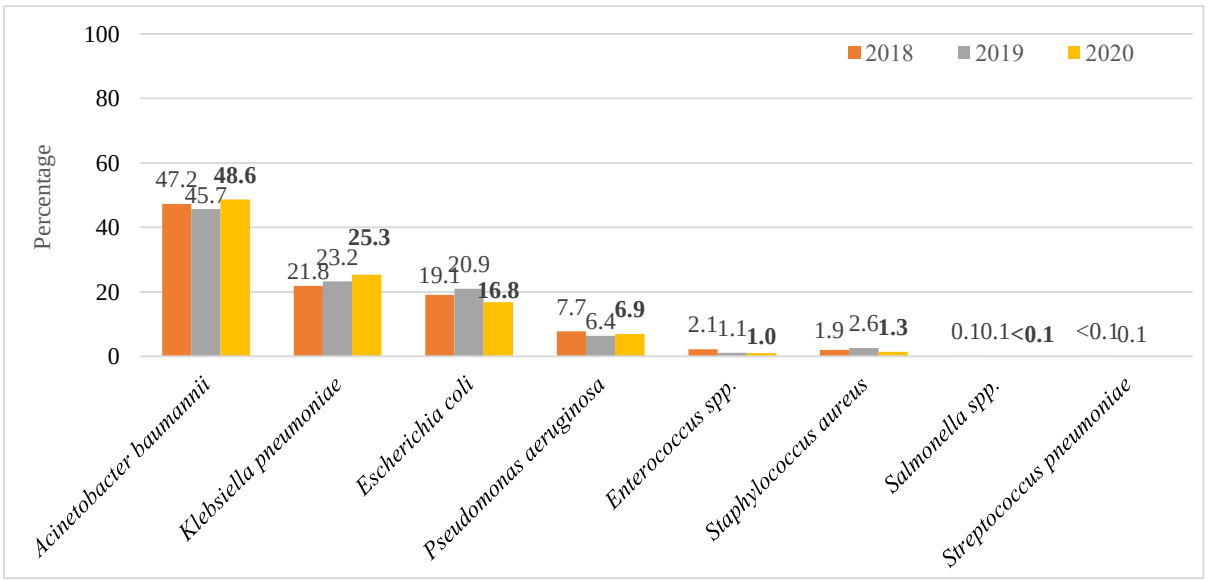


Figure B2.6 AMR events by targeted pathogen

- **Resistance percentage in HAI patients**
  - In 2020, percentage of AMR causing HAI, 87.8% of *A. baumannii* isolates (n = 2,939/3,448) were resistant to at least one antimicrobial, followed by *K. pneumoniae* (79.3%, n = 1,140/1,580) and *E. coli* (71.8%, n = 905/1,261), increased from 2019 in particular.
  - Trend of carbapenem resistance in *A. baumannii* (87.8%), *K. pneumoniae* (44.7%), *E. coli* (27.0%) and *P. aeruginosa* (31.2%), are also increased from the data in 2019.
  - More than two third of *K. pneumoniae* and *E. coli isolates were* resistant to third generation cephalosporins which were 79.3% and 71.8%, respectively. These resistance percentage were higher than the percentage in 2018 and 2019.
  - In 2020, none of *S. aureus* isolates (n = 235) was resistant to vancomycin and none of *S. pneumoniae* (n = 1) was resistant to penicillin and third generation cephalosporins.
  - Vancomycin-resistant *Enterococcus* increased from 6.6% in 2019 to 8.5% in 2020 (n = 717).

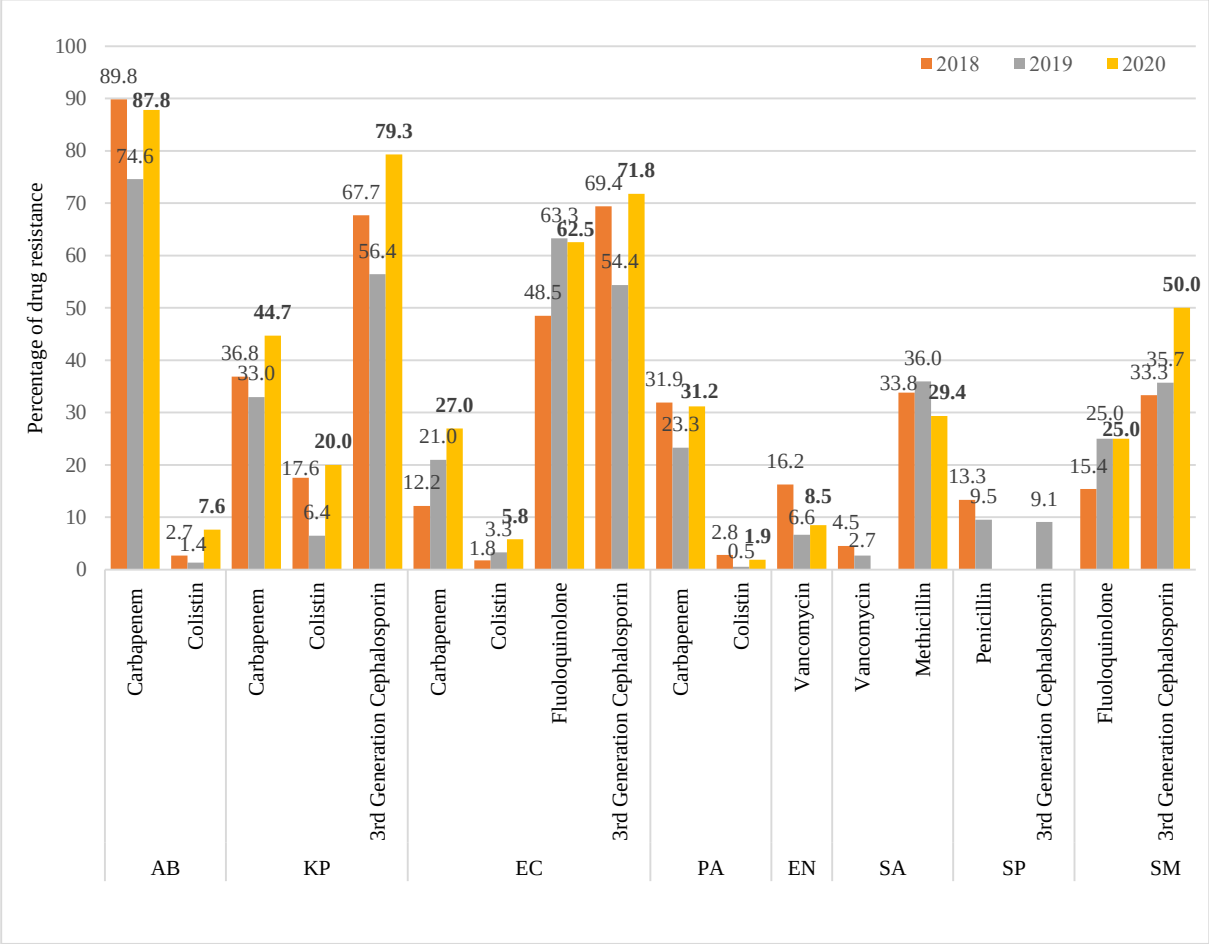


Figure B2.7 Percentage of drug resistance in targeted pathogens

Note: AB: *A. baumannii*, KP: *K. pneumoniae*, EC: *E. coli*, PA: *P. aeruginosa*, EN: *Enterococcus spp.*, SA: *S. aureus*, SP: *S. pneumoniae*, SM: *Salmonella spp.*

Note: *Salmonella* spp. was not resistant to colistin in 2018, 2019, and 2020.

*Count only first isolate pathogen

B2.3 Incidence rate by ward type

- **HAI events and AMR events by ward type**

- In 2020, most incidence of HAI events and AMR events occurred in medicine wards (2.4 per 1,000 patient-days for HAI and 1.4 per 1,000 patient-days for AMR), followed by surgery wards (2.3 per 1,000 patient-days for HAI and 1.2 per 1,000 patient-days for AMR) and mixed wards (1.3 per 1,000 patient-days for HAI and 0.7 per 1,000 patient-days for AMR). These results were common top three of incidence rate HAI and AMR events similar to 2019.
- In 2020, the incidence rates of HAI events and AMR events in ICU wards were higher than non-ICU wards at 6.3 per 1,000 patient-days for HAI and 3.5 per 1,000 patient-days for AMR, respectively (Figure B2.8).

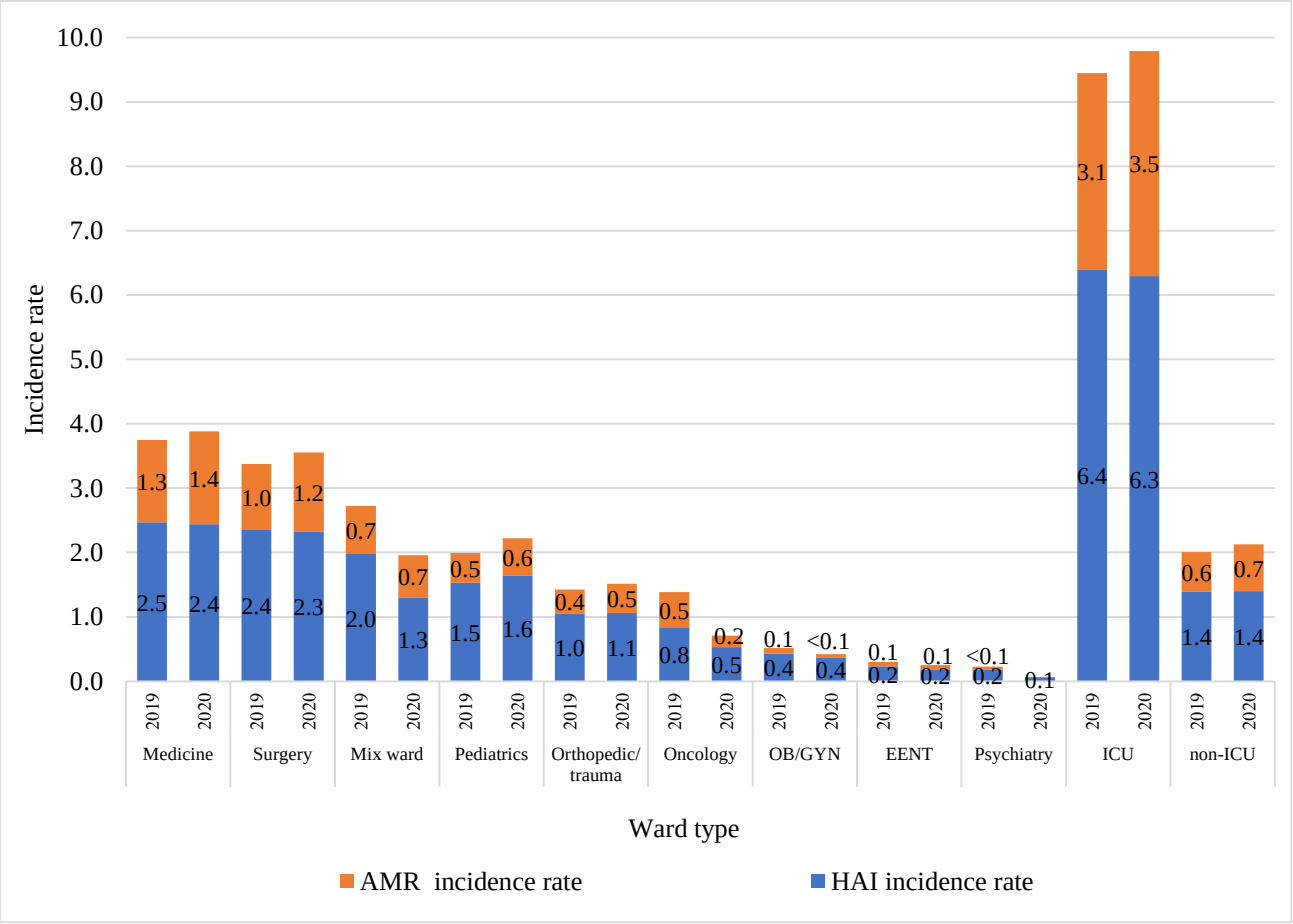


Figure B2.8 Incidence rate (per 1,000 patient-days) HAI and AMR events by ward type

Note: OB/GYN was 0.05 per 1,000 patient-days for AMR in 2020. Psychiatry was 0.05 per 1,000 patient-days for AMR in 2019 and none AMR events by ward type in 2020.

Note: Data in 2018 was not available

B3: Antimicrobial Resistance in Food-Producing Animals

B3.1 *Escherichia coli*

- ***E. coli* isolates from chickens**
  - High levels of *E. coli* resistance against ampicillin and tetracycline in chicken caeca and chicken meat from slaughterhouses and retail markets were reported in 2020.
  - None of the *E. coli* isolates in chicken caeca was resistant to meropenem in 2020, but low levels of meropenem resistance were detected in chicken meat from slaughterhouses (0.3%) and retail markets (1.4%).
  - Low levels of resistance (<4.0%) against third generation cephalosporins (e.g., cefotaxime, ceftazidime) were detected in chicken caeca and chicken meat from slaughterhouses and retail markets.
  - Between 2017-2020, the prevalence of AMR in *E. coli* isolates from chickens slightly decreased in tested antimicrobials, except ciprofloxacin and gentamicin. Resistance to ciprofloxacin and gentamicin in chicken meat from slaughterhouses and retail markets and resistance to gentamicin in chicken caeca of *E. coli* isolates increased.
  - The resistant *E. coli* to colistin from chicken caeca remarkably declined 92% from 14.5% in 2017 to 1.2% in 2020.

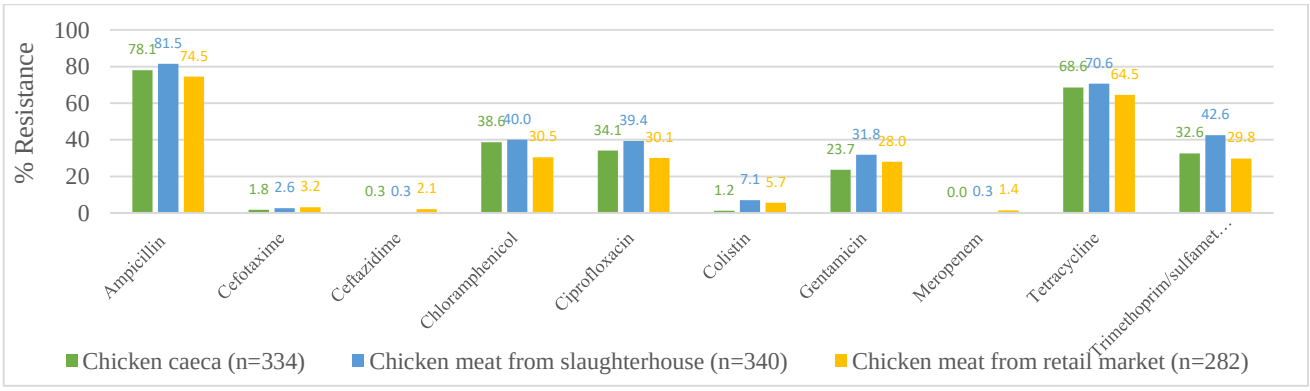


Figure B3.1 Resistance rate (%) of *E. coli* isolates in chicken caeca, and chicken meat from slaughterhouses and retail markets in 2020

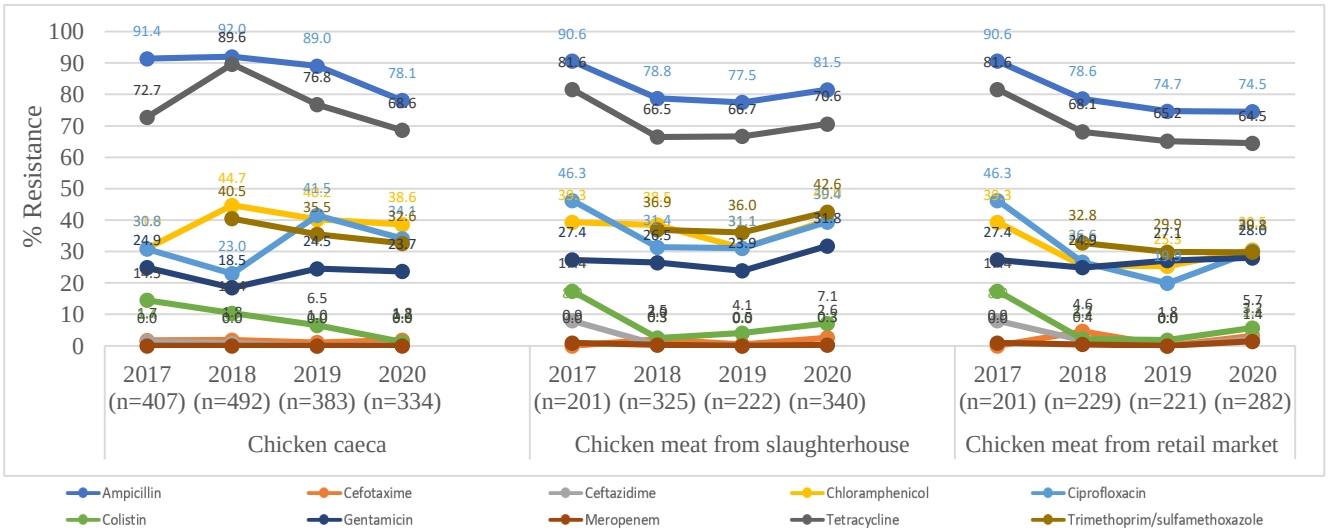


Figure B3.2 Resistance rate (%) among *E. coli* in chicken caeca, and chicken meat from slaughterhouses and retail markets, Thailand (2017-2020)

- ***E. coli* isolates from pigs**
  - High levels of *E. coli* resistance against ampicillin, tetracycline, chloramphenicol, and trimethoprim/sulfamethoxazole in pig caeca and pork from slaughterhouses and retail markets were reported in 2020.
  - None of the *E. coli* isolates in pig caeca was resistant to meropenem in 2020. However, low levels of meropenem resistance were detected in pork from slaughterhouses (0.6%) and retail markets (1.0%).
  - Prevalence of AMR against third generation cephalosporins (e.g., cefotaxime, ceftazidime) varied. Resistance to cefotaxime (10.6-13.6%) was higher than that of ceftazidime (3.2-6.5%) in pig caeca and pork from slaughterhouses and retail markets in 2020.
  - Between 2017-2020, the prevalence of resistant *E. coli* isolates from pigs slightly declined in tested antimicrobials, except ciprofloxacin and gentamicin. The increase resistance to ciprofloxacin were examined in *E. coli* isolates in pork from slaughterhouses (from 18.6% in 2017 to 27.4% in 2020) and pork from retail markets (from 18.6% in 2017 to 21.9% in 2020). Similarly, the isolates in pork from retail markets increased resistance to gentamicin from 15.6% in 2017 to 20.2% in 2019.
  - The decrease resistance to colistin was examined 54% in *E. coli* isolated from pig caeca from 10.1% in 2017 to 4.6% in 2020.

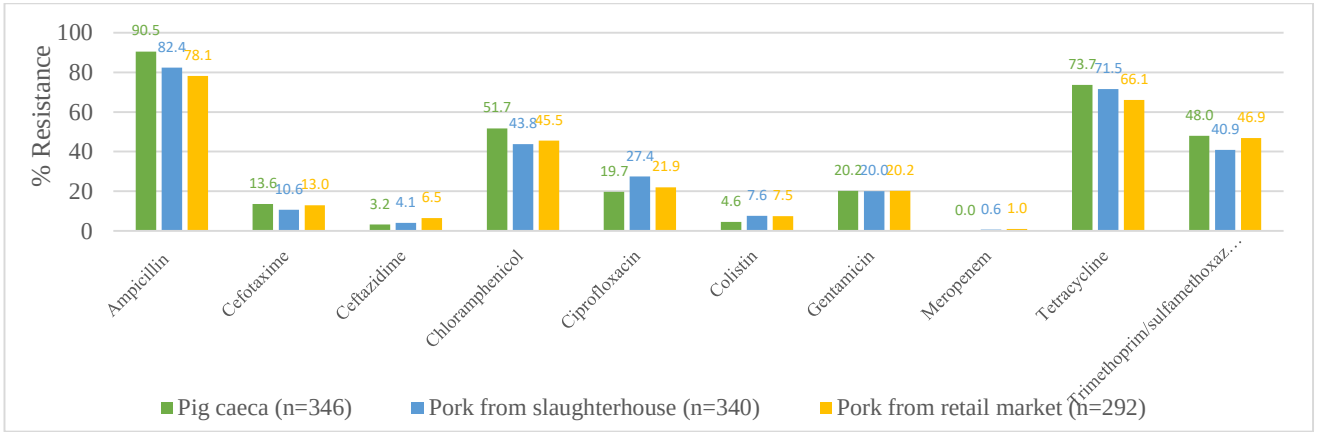


Figure B3.3 Resistance rate (%) of *E. coli* isolates in pig caeca, and pork from slaughterhouses and retail markets in 2020

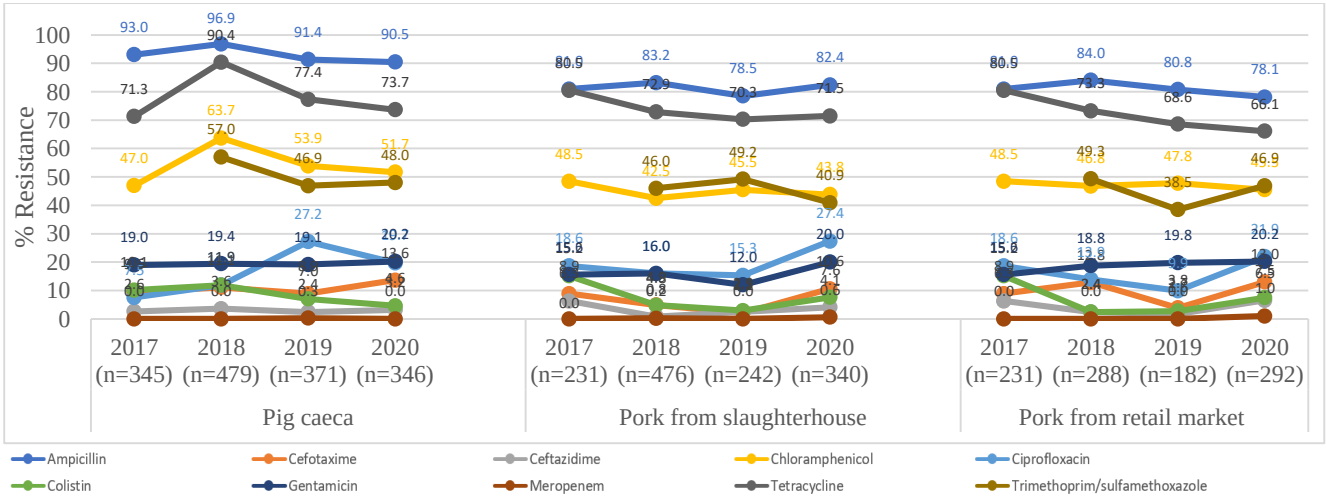


Figure B3.4 Resistance rate (%) among *E. coli* in pig caeca, and pork from slaughterhouses and retail markets, Thailand (2017-2020)

B3.2 *Salmonella* spp.

- ***Salmonella* isolates from chickens**
  - High levels of *Salmonella* spp. resistance against ampicillin and tetracycline in chicken caeca and chicken meat from slaughterhouses and retail markets were reported in 2020.
  - No meropenem resistance was found in *Salmonella* isolated from all type of samples in 2020.
  - In 2020, low levels of resistance (<2%) against third generation cephalosporins (e.g., cefotaxime, ceftazidime) were detected in chicken caeca and chicken meat from slaughterhouses and retail markets.
  - Between 2017-2020, the prevalence of *Salmonella* spp. resistant to ampicillin and tetracycline in chickens significantly declined, while the resistant to ciprofloxacin continuously increased.
  - From 2017 to 2020, colistin resistant *Salmonella* spp. significantly declined 98% in chicken caeca, and 66% in chicken meat from both slaughterhouses and retail markets.

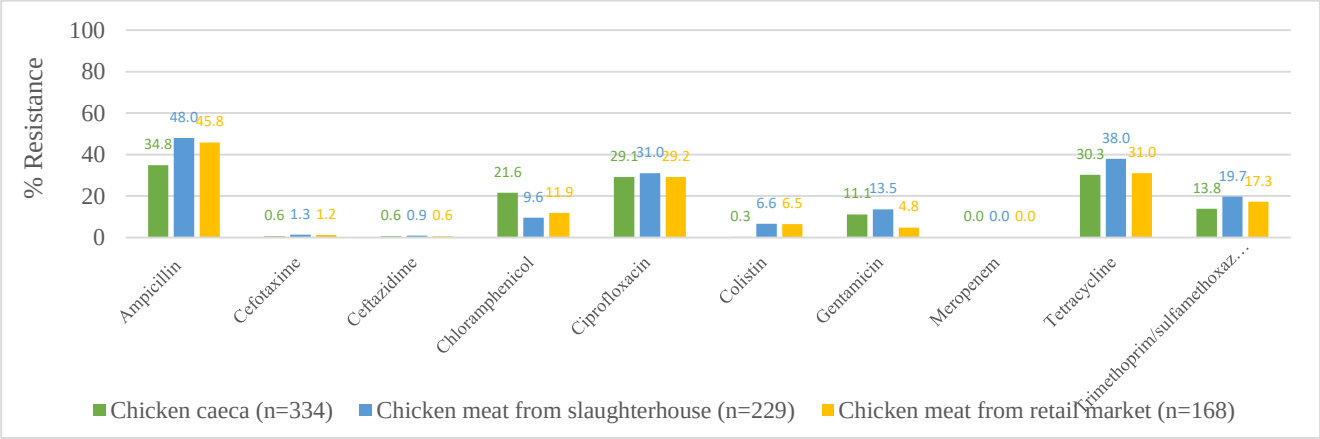


Figure B3.5 Resistance rate (%) of *Salmonella* isolates in chicken caeca, and chicken meat from slaughterhouses and retail markets in 2020

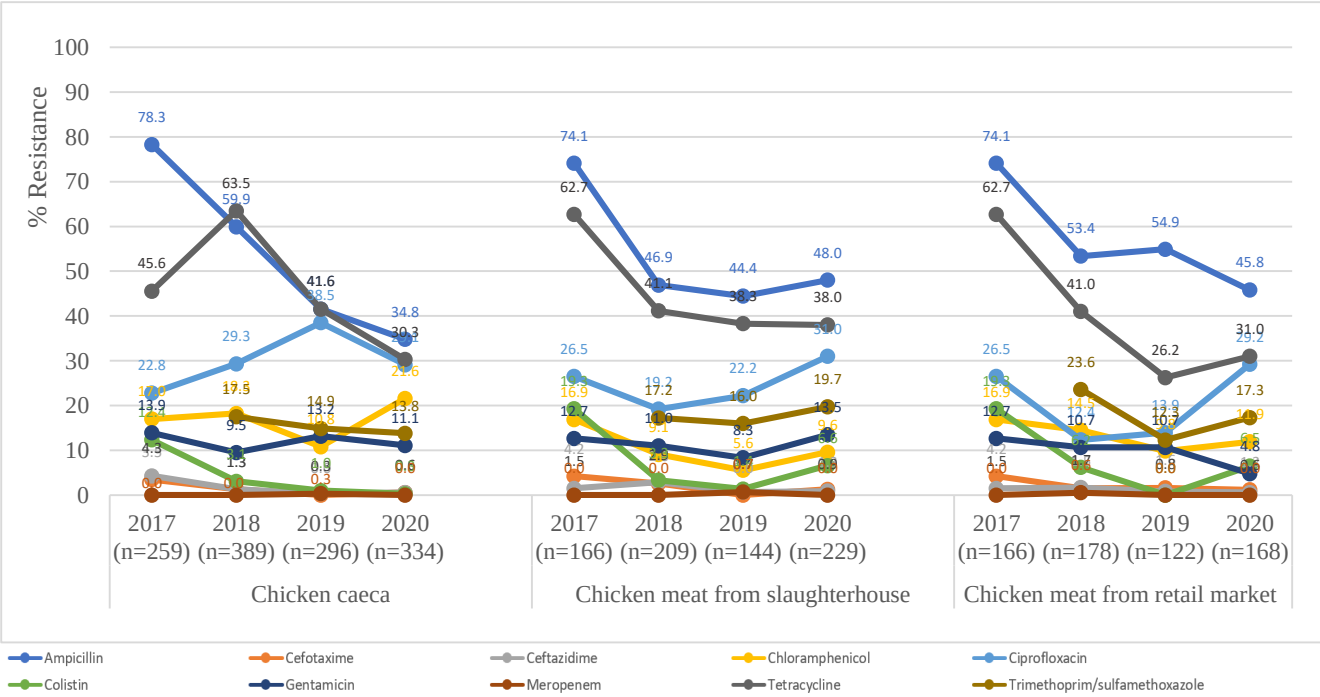


Figure B3.6 Resistance rate (%) among *Salmonella* spp. in chicken caeca, and chicken meat from slaughterhouses and retail markets, Thailand (2017-2020)

- ***Salmonella* isolates from pigs**
  - High levels of *Salmonella* spp. resistance against ampicillin and tetracycline in pig caeca and pork from slaughterhouses and retail markets were reported in 2020.
  - No meropenem resistance was examined in *Salmonella* isolated from all type of samples.
  - In 2020, low levels of resistance (<9%) against third generation cephalosporins (e.g., cefotaxime, ceftazidime) were detected in pig caeca and pork from both slaughterhouses and retail markets.
  - Between 2017-2020, the prevalence of *Salmonella* spp. resistant to ampicillin and tetracycline in pigs significantly declined, while the resistance to ciprofloxacin notably increased.
  - From 2017 to 2020, colistin resistant *Salmonella* spp. significantly declined 89% in pig caeca, followed by 70% in pork from retail markets and 61% in pork from slaughterhouses.

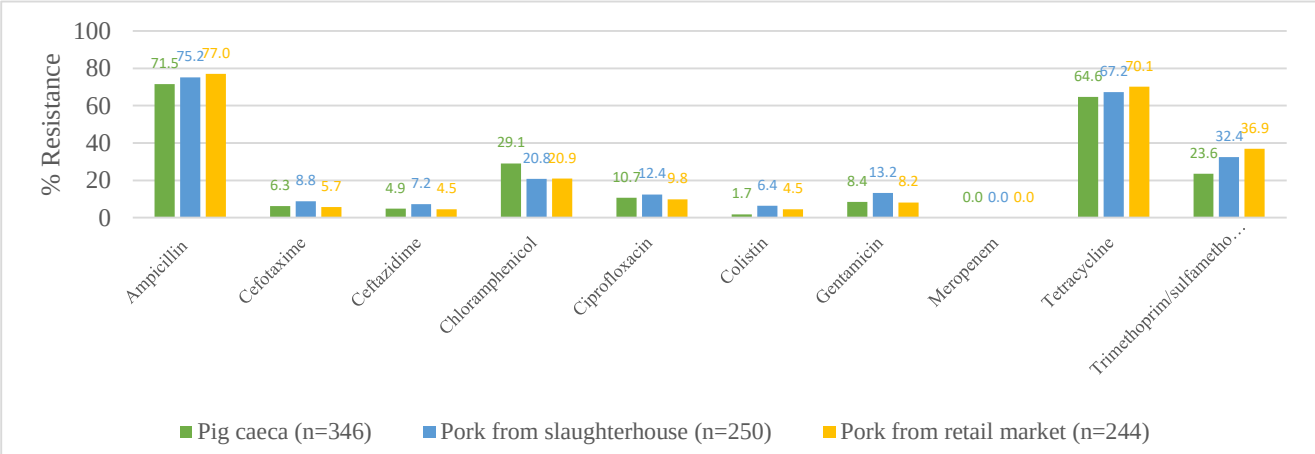


Figure B3.7 Resistance (%) of *Salmonella* isolates in pig caeca, and pork from slaughterhouses and retail markets in 2020

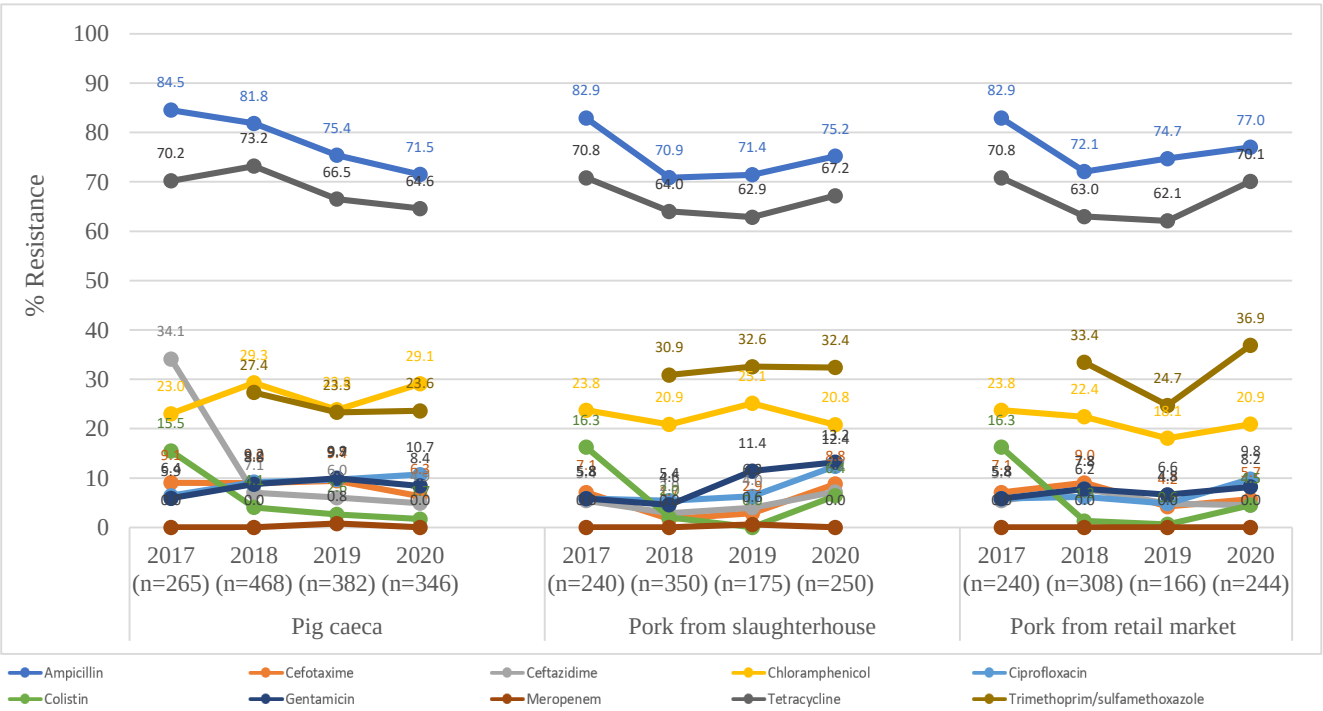


Figure B3.8 Resistance (%) among *Salmonella* spp. in pig caeca, and pork from slaughterhouses and retail markets, Thailand (2017-2020)

B3.3 *Enterococcus* spp.

- ***Enterococcus* isolates from chickens**
  - High levels of *Enterococcus* spp. resistance against erythromycin (79.0%) and tetracycline (77.5%) in chicken caeca were reported in 2020. However, resistance to these antimicrobials declined in 2020 in comparison to 2019.
  - Low levels of resistance (<2%) against vancomycin, linezolid, and teicoplanin were reported in chicken caeca in 2020.
  - Between 2017 and 2020, the prevalence of resistant *Enterococcus* spp. to chloramphenicol significantly increased.

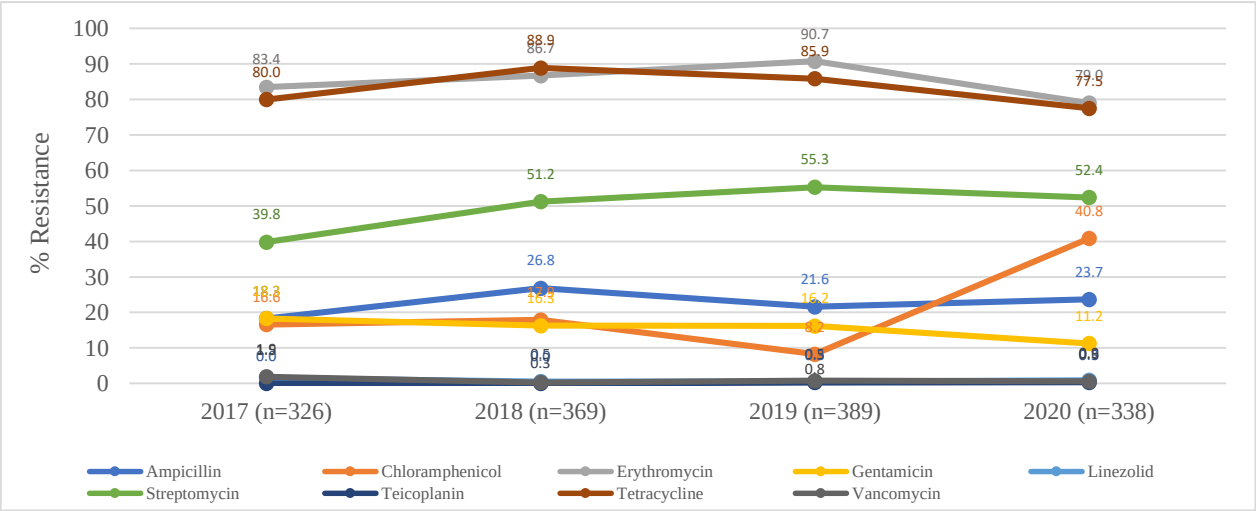


Figure B3.9 Resistance rate (%) of *Enterococcus* spp. in chicken caeca (2017-2020)

- ***Enterococcus* isolates from pigs**
  - High levels of *Enterococcus* spp. resistance against tetracycline (73.2%) and erythromycin (65.1%) were reported in pig caeca in 2020. However, the decrease resistance to those antimicrobials was examined in 2020 in comparison to 2019.
  - Low levels of resistance to vancomycin (0.3%) and linezolid (2.7%) were detected in pig caeca. None teicoplanin resistance was found in *Enterococcus* isolates from pig caeca in 2020.
  - Between 2017 and 2020, the prevalence of *Enterococcus* spp. resistant to chloramphenicol and streptomycin significantly increased.

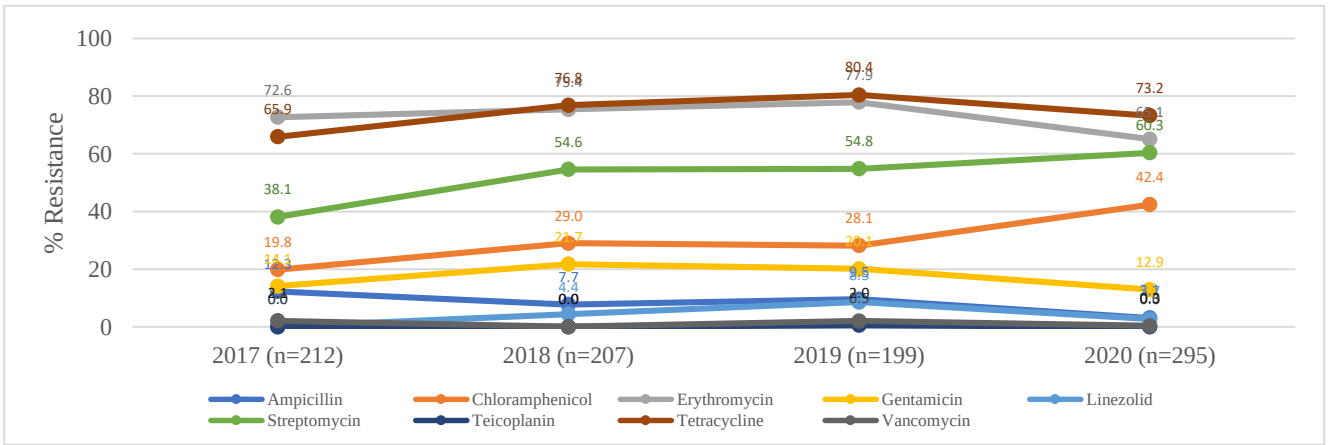


Figure B3.10 Resistance rate (%) of *Enterococcus* spp. in pig caeca (2017-2020)

B3.4 *Campylobacter* spp.

- ***Campylobacter* isolates from chickens**
  - High levels of *Campylobacter* spp. resistance against ciprofloxacin (74.7%) and tetracycline (53.5%) were reported in chicken caeca in 2020.
  - The prevalence of resistant *Campylobacter* spp. in chicken caeca against ciprofloxacin, erythromycin, and tetracycline increased between 2017 and 2020. The reduction of resistance to streptomycin and gentamicin was observed in *Campylobacter* isolated from chicken caeca.

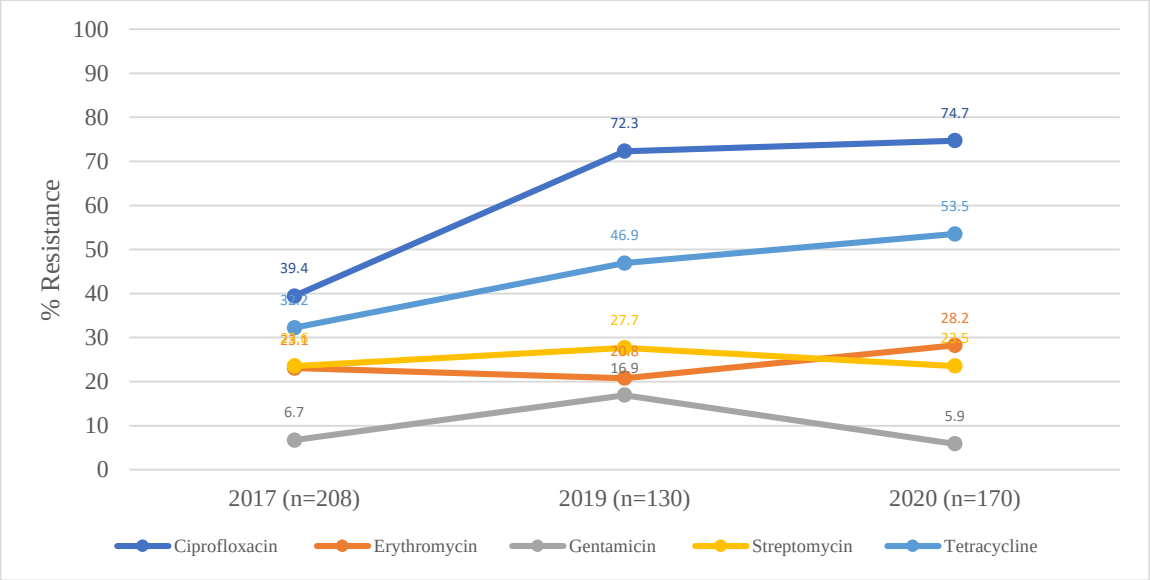


Figure B3.11 Resistance rate (%) of *Campylobacter* spp. in chicken (2017 and 2020)

- ***Campylobacter* isolates from pigs**
  - *Campylobacter* spp. were highly resistant to ciprofloxacin (77.5%), streptomycin (74.6%), and tetracycline (74.0%) in pig caeca in 2020.
  - The prevalence of resistant *Campylobacter* spp. in all tested antimicrobials in pig caeca increased from 2017 to 2020. However, *Campylobacter* spp. resistance to ciprofloxacin, erythromycin, gentamycin, and streptomycin decreased from 2019 to 2020.

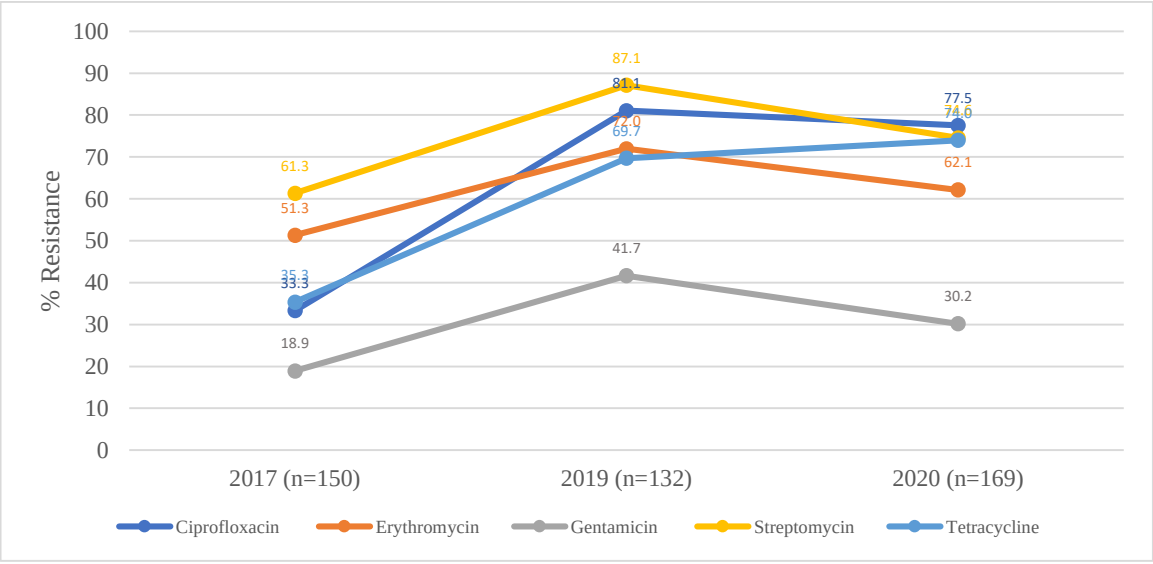


Figure B3.12 Resistance rate (%) of *Campylobacter* spp. in pigs (2017 and 2020)

ANNEX

1. ANTIMICROBIAL CONSUMPTION: METHODOLOGY

1.1 Human and Animal Populations

The number of human populations in 2020 was retrieved from World development indicator (2). The number of animal populations in 2020 was collected, retrieved and verified by various relevant stakeholders to ensure their accuracy. On the basis of populations potentially exposed to antimicrobials, the figure of each particular population was used as a denominator to calculate the amount of national antimicrobial consumption.

1.1.1 Human population

In 2020, the mid-year population in Thailand was calculated for the particular reporting year, while the number of migrants was estimated in the latest reporting year. (Table D1). Both data were from World development indicator (2).

Table D1. Human population (2020)

Population (reporting year)	**Male**	**Female**	**Total**
Citizen (2020)	33,966,060	35,833,918	69,799,978
Migrant (2015)	3,913,258		3,913,258
Total			**73,713,236**

1.1.2 Animal population

The number of food-producing animals was collected and verified through cooperation between the Department of Livestock Development (DLD), Department of Fisheries (DOF), private sector and relevant stakeholders. For terrestrial food-producing animals, the data were collected and verified from three sources: 1) livestock surveys by district and provincial DLD offices, 2) data records from the E-movement system of DLD, and 3) large-scale livestock producers.

The weights for each animal category based on the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) were used in the calculation. It is the theoretical weight at the likely time for treatment. For farmed fish, the fish biomass live-weight slaughtered is used to calculate the total PCU (ref). However, the weight of certain species was raised as food-producing animals in Thailand are not available or not relevant to the local context (3). Consequently, Aw were estimated based on standing weight of these animal species including broiler breeder, layer breeder, laying hen, pullet, broiler duck breeder, broiler duck, layer duck and dry cow (Table D2). Population Correction Unit (PCU) is used as a denominator for AMC in food-producing animals and calculated by applying ESVAC methodology. According to the ESVAC, PCU is assumed to be a surrogate for the animal population at risk of being exposed to antimicrobials (4).

For the aquatic animal population, data were collected from surveys and estimated by the Fisheries Development Policy and Strategy Division, Department of Fisheries. The estimation were done using estimated annual amount of fishes or shrimps raised in a particular area and the size of the area. The species included were major fishes and shrimps produced from coastal and fresh waters (Table D2). The figures of aquatic animals are shown in biomass. The PCU used as a denominator in this report was modified from ESVAC by combining both PCU from terrestrial animals and biomass from aquatic animals, so it is called $PCU_{Thailand}$.

Table D2. Food-producing animal population (2020)

Food-producing animal category			
Terrestrial animals (number of animals)	**Weight (kg)**	**Head count**	**PCU (kg)**
Pigs			
Pig breeders	240**	1,206,566	289,575,840
Fattening pigs	65**	22,050,733	1,433,297,645
Poultry			
Broiler breeder	4*	17,518,500	70,074,000
Broilers	1**	1,757,871,998	1,757,871,998
Layer breeders	2*	670,493	1,340,986
Laying hens	2*	49,778,787	99,557,574
Pullets	1.5*	41,749,950	62,624,925
Broiler duck breeders	3.5*	344,208	1,204,728
Integrated broiler ducks	3.3*	34,420,840	113,588,772
Free-market broiler ducks	3.3*	15,741,011	51,945,336
Integrated layer ducks	2.5*	9,114,559	22,786,398
Free-market layer ducks	2.5*	6,602,297	16,505,743
Cattle			
Dairy cows	425**	320,613	136,260,525
Dry cows	425*	386,623	164,314,775
Beef cows	425**	6,230,140	2,647,809,500
Aquatic animals		**1,000 tonnes of biomass**	**PCU (kg)**
Coastal aquatic animals	-	413,648	413,648,000
Freshwater aquatic animals	-	413,455	413,455,000
	Total $PCU_{Thailand}$		**7,695,861,744**

*Thailand SAC
**ESVAC

1.2 Antimicrobial Consumption in Humans and Food-producing Animals

1.2.1 Overview

In Thailand, oral human antimicrobials and their preparation for external use are classified as dangerous drugs, which must be dispensed only by a licensed pharmacist. In 2019, some oral antimicrobials such as oral antituberculous drugs and injectable antimicrobials were classified as special controlled drugs, which require a prescription from a licensed physician (5). Some veterinary antimicrobials are classified as dangerous drugs, which must be dispensed by a licensed pharmacist or veterinarian without a prescription requirement. In 2019, some veterinary antimicrobials (antibacterials in medicated premix, quinolones and derivatives, cephalosporins, macrolides, and polymyxins) are classified as specially controlled drugs, which require a prescription before being dispensed (6,7).

According to the NSP-AMR, one of the goals is to reduce human antimicrobial consumption by 20% and veterinary antimicrobial consumption by 30% by 2021 (8). In order to make the goals measurable, the methodology of monitoring antimicrobial consumption is of substantial importance and that is one of the reasons that Thailand SAC has been developed. Aside from monitoring the national goals, the data from Thailand SAC are useful for both health professionals and policymakers because consumption data can help assess the effects of policy implementation, particularly improving the Antimicrobial Stewardship Program and law enforcement such as the re-classification of antimicrobials. With some improvements in methodology and data granularity, such useful information can be utilised not only at national, but also at local and regional levels to tackle antimicrobial resistance problems in an efficiently practical way.

1.2.2 Data source

According to Drug Act B.E. 2510 (1967) Section 85 including its amendments, all pharmaceutical manufacturers and importers are required by FDA to submit an annual report, which consists of their total produced, imported, and/or exported volumes of registered products, by 31 March of the following year (9,10). The data were then electronically retrieved on 31 March 2021 for analysis. The assumption that domestic consumption equals the amount of manufactures and imports subtracted by that of exports (11).

For human target antimicrobials, it covers the core and optional classes of antimicrobials recommended by the World Health Organization (12) (Table D3). The unit of measurement was DDD/1,000 inhabitants/day (DID), computed from Defined Daily Dose (DDD) as a numerator and the mid-year human population as a denominator. The standard of DDDs in this report applies the latest version of Anatomical Therapeutic Chemical (ATC)/DDD alterations, which is produced by the WHO Collaborating Centre for Drug Statistics Methodology (13).

For the scope of veterinary target antimicrobials, Thailand SAC covered a list of target antimicrobials in alignment with the World Organisation for Animal Health and ESVAC (3,14) (Table D4).

Table D3. The core and optional classes of target human antimicrobials suggested by WHO

Target human antimicrobials	ATC code
1. Core class	
Antibacterials for systemic use	J01
Antibiotics for alimentary tract	A07AA
Nitroimidazole derivatives	P01AB
2. Optional class	
Antimycotics for systemic use	J02
Antifungals for systemic use	D01BA
Antivirals for systemic use	J05
Drugs for treatment of tuberculosis	J04A
Antimalarials	P01B

Table D4. The scope of target antimicrobials intended for use in food-producing animals

Target veterinary antimicrobials	ATC vet codes
1. Antimicrobial agents for intestinal use	
Antibiotics	QA07AA
Sulfonamides	QA07AB
Other intestinal anti-infectives	QA07AX
2. Antimicrobial agents for intrauterine use	
Antibiotics	QG01AA, QG01BA
Sulfonamides	QG01AE, QG01BE
Antibacterials	QG51AA
Anti-infectives for intrauterine use	QG51AG
3. Antimicrobial agents for systemic use	QJ01
4. Antimicrobial agents for intramammary use	QJ51

1.2.3 Limitations

A few limitations are addressed. Thailand SAC relies on the concept that domestic consumption equals to manufacture and importation data minus the export volume. This concept has an inevitable disadvantage that the accuracy of the data could be disturbed by the amount of stock finished products not consumed. As a result, some efforts have been made to pass a new regulation requiring the pharmaceutical operators to submit the distribution amounts based on sale data in 2020. This requirement will come into effect in the annual report of 2022. Besides, awareness and compliance of pharmaceutical operators with the new requirement is needed. Moreover, annual reports to FDA capture only all legal import and manufacture medicines.

With effort to achieve the actual national consumption f, Thai FDA have received cooperation from pharmaceutical operators in reporting and advances methodology to capture all antimicrobials, resulting in not only more accurate amounts of reported registered products but also improvements in data quality. Along with verification of the registration database from 2017-19, especially related to drug strengths and ATC codes, the differences in annual consumption data may be derived not only from policies in relation to antimicrobial distribution but from these methodological improvements as well as

systematic verification, which requires pharmaceutical operators of any registered antimicrobials with a change of more than 150% compared to the previous year will be asked to verify whether the amount of finished products reported was accurate or not.

1.2.4 Prospect

In order to fully capture antimicrobial consumption, all export values need to be reported and verified with other sources such as port of entry for air, land and sea borders. In doing so, it increases not only the accuracy of the data, but also prevents illegal importation and smuggling along borders. As an unavoidable disadvantage of estimating domestic consumption in this report, the consumption data cannot provide information on how many antimicrobials have been annually used at primary healthcare, retail and inpatient hospital care sectors, resulting in lack of data granularity at user level such as age, gender and ward. Therefore, sales data would be more accurate than import, local production and export data, but mandatory reporting for the sales data requires legislative amendments. An amendment of Ministerial regulations was endorsed and mandatorily requires pharmaceutical operators to electronically submit annual reporting of distribution channels and export volumes of all medicines including antimicrobials (10). For the ultimate goal, antimicrobial consumption at user level should be considered because it reflects antimicrobial use at point of service, the real selective pressure on AMR, and policy consequences. However, the acquisition of the data requires a good drug-dispensing system aligned with reliable seamless information systems from upstream to downstream of the pharmaceutical supply chains.

1.3 Antimicrobial Consumption in Food-Producing Animals (Medicated Feed through Feed Mills)

1.3.1 Overview

Given the limitations of Thailand SAC, data are not available to disaggregate by animal species. In 2017, the working group decided to collect data of antimicrobial used in medicated feed (medicated premix) which can divided the amount of antimicrobial use by animal species. More than half of veterinary antimicrobials in Thailand was consumed through medicated feed, which can be produced by either feed mills or farm mixers (15,16). By law, medicated premixes containing antibacterial(s) have been classified as specially controlled medicine and must be dispensed by a licensed pharmacist or requires a prescription from a veterinarian (17,18). Therefore, veterinary prescription is needed for feed mills before medicated feed production, and for farmers who produce farm-mixed medicated feed on farms (19).

According to the NSP-AMR, one of the goals is to reduce veterinary antimicrobial consumption by 30% in 2021 (8). In order to achieve the goal and close the gaps of pharmaceutical supply chains, feed mills are a potential platform for monitoring and evaluation in Thailand SAC. Aside from monitoring the national goal to pragmatic utility, the data from Thailand SAC may be useful for both health professionals and policymakers. This is because that they can help assess the effects of policy implementation, law enforcement, antimicrobial stewardship program, and other relevant interventions imposed at national level.

1.3.2 Data source

According to Animal Feed Quality Control Act B.E. 2558 (2015), all feel mills and feed importers are required by DLD to submit an annual report, which consists of their total production and/or importation volumes of feed and medicated premix, by 31 March of the following year (20,21). The data were electronically retrieved on 31 March 2021 for analysis. "Other" type of animal including any other species than poultry and pigs was excluded in the analysis and the past data suggested that it represented only a small proportion. Data were derived from 73 feed mills (22).

1.3.3 Limitations and prospect

Despite coverage of large-scale feed producers, data on farm mixing of medicated feed were not captured. Data are not disaggregated by different registered medicated feed. No regular on-site verification process could affect reliability and accuracy of input data.

1.3.4 Prospect

To fully capture veterinary consumption through feed mills, database of medicated feed should be developed and linked to a reporting system for veterinary antimicrobials in feed to facilitate a reporting system for feed mill licensees. Regular on-site verification at feed mills should be conducted, which can be facilitated by linkages between the reporting system and specially controlled feed.

2. ANTIMICROBIAL RESISTANCE

2.1 Antimicrobial Resistance in Humans: lab-based surveillance

2.1.1 Overview

A Antimicrobial resistance (AMR) in bacterial isolates from human in Thailand has been increasing, especially in Gram-negative bacteria. To date, the data regarding systematic antimicrobial susceptibility is limited. For the surveillance report, we aimed to observe and implement the antimicrobial data into clinical practice.

2.1.2 Method and data sources

Antimicrobial resistance data were collected from 74, 85, 92 and 83 hospitals in Thailand during 2017, 2018, 2019 and 2020, respectively, with support from NARST, National Institute of Health, Department of Medical Sciences, The Ministry of Public Health, Thailand. The 2017, 2018, 2019 and 2020 gonococcal antimicrobial resistance data were provided by the Department of Disease Control, Ministry of Public Health, Thailand through Bangrak STIs center, Silom Community Clinic @TropMed and three and six centers of The Office of Disease Prevention and Control, respectively. Data on antimicrobial resistance and MIC values in 2017, 2018, 2019 and 2020 were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) susceptibility breakpoints 2017, 2018, 2019 and 2020, respectively.

The percentage of antimicrobial resistance was calculated which the numerator was the number of resistant isolates and denominator was total number of tested isolates for all specimen types.

Note: nearly all antimicrobial resistance data in this chapter, intermediate category was classified as resistance, unless otherwise specified.

2.1.3 Limitation

- This report did not identify risk factors linked with baseline characteristics of patients and did not show the distribution of isolates from different hospital levels (primary, secondary or tertiary care).
- For most data in this report, all types of specimens were selected for calculation of resistance rate.
- This report did not divide isolates into those from outpatients, inpatients, or hospital departments including intensive care units.
- Due to the cost of the MIC test, most *Staphylococcus aureus* and coagulase- negative *Staphylococcus* spp. isolates were tested by disk diffusion method, instead of the MIC test for vancomycin that is recommended by the CLSI guidelines.
- Because the colistin MIC breakpoints was modified in CLSI 2020 that MIC value of ≤2 and ≥ 4 mg/L were defined as intermediate and resistant, respectively with no susceptible breakpoint, the percentage of colistin resistance in 2020 was demonstrated from only MIC value ≥ 4 mg/L. As the resistance data in the previous years were demonstrated from MIC value >2 mg/L which intermediate category were included. Therefore, interpretation for antimicrobial susceptibility should be noted between 2018-2019 and 2020.

2.1.4 Recommendations

- Covid-19 situation has impacted on working conditions and might impact on antimicrobial resistance data in 2020.
- The data regarding trends towards antimicrobial resistance should be observed for several years in order to assess the evolution and overall situation of antimicrobial resistance problems in Thailand. Findings will contribute substantially to addressing the problem of AMU and AMR and support implementation of effective antimicrobial stewardship policies and infection control programs.
- Time trends analysis using logistic regression models over a longer period is needed in order to understand how significant changes in the past several years have evolved.
- Systematically combining data on antimicrobial consumption and antimicrobial resistance at patient, hospital, and community levels should be done to allow further analyses of the association between antimicrobial use and the development of resistance.
- Antimicrobial resistance data should be separately analyzed into specimen types (blood, sputum, urine, etc.) or at least sterile and non-sterile sites, and should be stratified by healthcare service sectors, for instance, the proportion of isolates from outpatient departments and inpatient departments including intensive care units.
- Regional antimicrobial resistance rates should be further analyzed and compared.
- Laboratory consideration of MIC testing is very crucial in dose optimization to tackle the antimicrobial resistance problem; thus, MICs of antimicrobial agents against certain bacterial species as suggested by international guidelines should be performed and reported in settings with available resources, for example, in vancomycin for *Staphylococcus aureus*.
- Antimicrobial resistance genes in highly antimicrobial-resistant organisms, (e.g. carbapenem-resistant Enterobacterales, CRE) the carbapenemase genes should be identified and reported. This information may be of value in developing treatment guidelines to suggest reasonable therapeutic options on the essential medicines list.
- Because of the alarming trend of CRE and steady high prevalence of carbapenem-resistant *A. baumannii*, a specific plan at the national level should be constructed and implemented in a systematic manner to alleviate the healthcare burdens caused by these organisms, especially improving health services with tightened infection prevention and control.
- Data on antiviral resistance and antimicrobial resistance in fungi and *Mycobacterium tuberculosis* should be reported in the future.
- The greater number of isolates, the more accurate data will be seen. Efforts should be made to empower laboratories to be capable of carrying out the tests for both epidemiologic and clinical purposes around the country.

2.2 Antimicrobial Resistance in Patients with Hospital-associated Infections

2.2.1 Overview

Antimicrobial Resistance Surveillance System is one of the six strategies of the National Strategic Plan on Antimicrobial Resistance 2017-2021 (NSP-AMR 2017-2021). One of five goals in the NSP-AMR 2017-2021 is to reduce AMR morbidity by 50% by 2021. However, various departments of the Ministry of Public Health host fragmented AMR monitoring platforms. Currently, there are two potential platforms to monitor AMR morbidity: 1) the Global Antimicrobial Resistance Surveillance System, Thailand (GLASS-Thailand) hosted by the National Institute of Health; and 2) Hospital Associated Infection Surveillance hosted by the Bamrasnaradura Infectious Diseases Institute (BIDI's HAI surveillance).

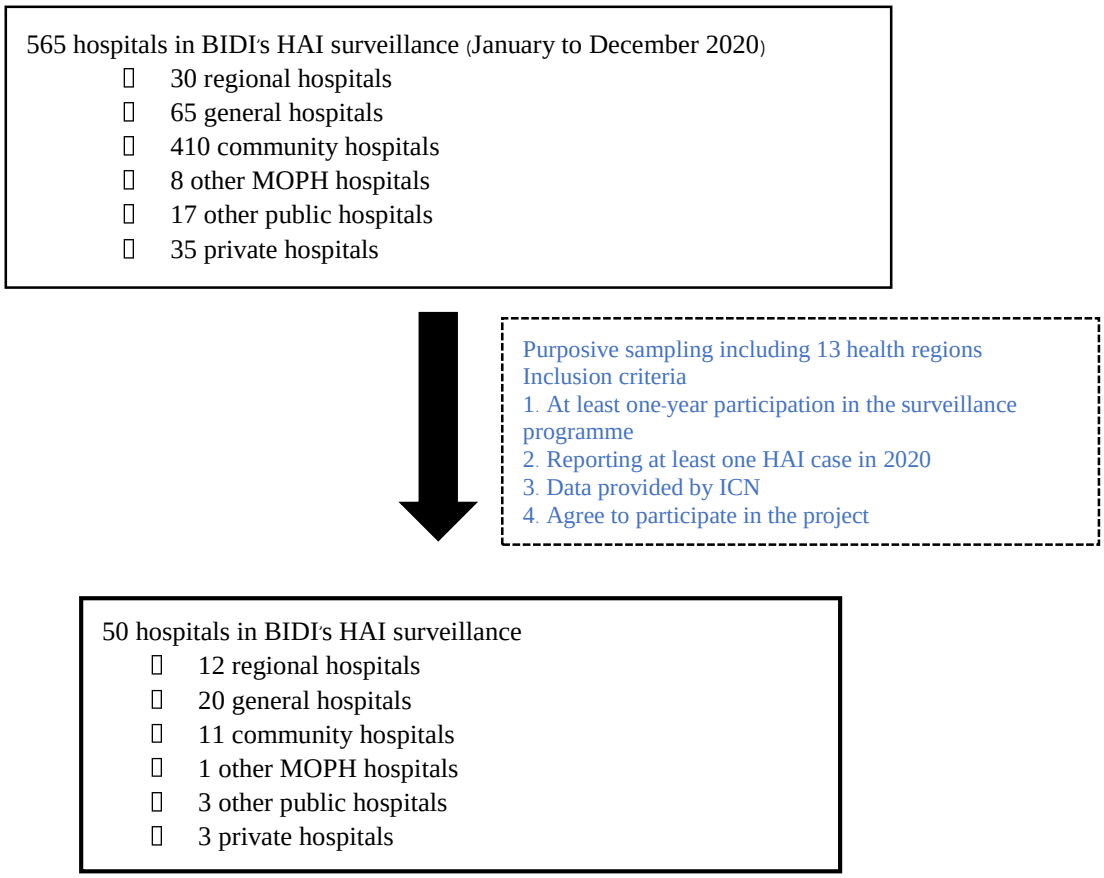
Since 2018, BIDI's HAI surveillance have undertaken HAI and AMR case-based surveillance in Thailand involving public and private hospitals; 50 hospitals were included in this study in 2020. In this report, the main objective of the analysis was to estimate 2020 AMR morbidity and compare with the 2018 and 2019 results.

2.2.2 Method and data sources

Data from BIDI's hospital-wide surveillance were analysed including all HAI cases entered in the surveillance system during January and December 2020. All HAI cases occurring in the hospitals were detected by infection control ward nurses (ICWNs) and confirmed by infection control nurses (ICNs) in each hospital using the definition in the Thai Manual of HAI Diagnosis 2018.[10] Data of patients with HAI were manually submitted to the surveillance web portal on a monthly basis. Antimicrobial susceptibility data (susceptible, intermediate or resistant) of HAI patients reported in laboratory results was collected. In addition, hospital service profiles such as the number of patient-days, the number of discharged patients and the number of ventilator-days were used as a denominator.

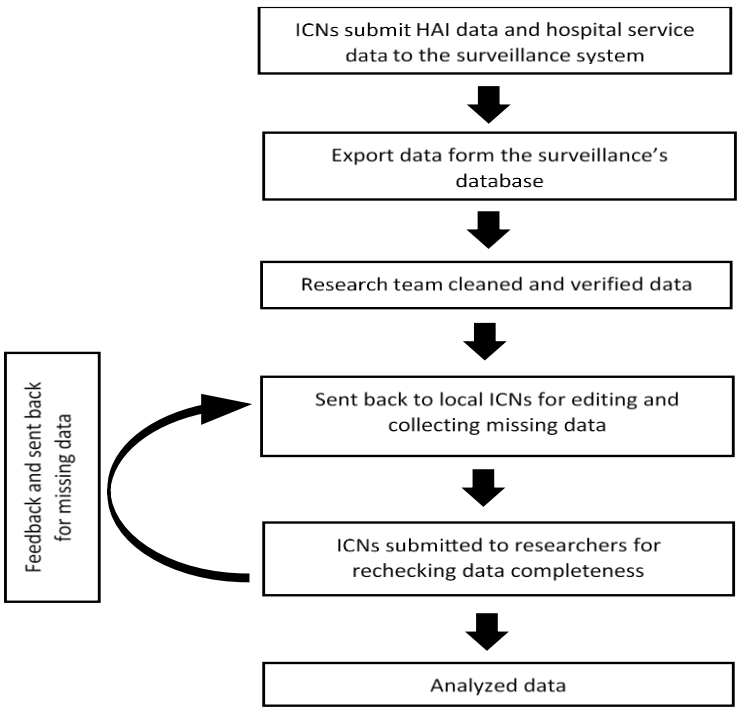
In 2020, 565 hospitals participated in the surveillance system. Of 565 hospitals, data from 50 hospitals were included in the analysis. ICNs in these hospitals were requested to retrospectively review and complete any missing data using their hospital database. Data was verified by researchers.

[10] Hospital-associated Infections (HAI) are infections that occur in hospital. It is infected at date of event (DOE) after hospital admission days 3. HAI are including neonatal infections and infections that can pass through the baby. The diagnosis included clinically diagnosed and culture confirmed, in addition included patients receipted and not receipted antibiotic treatment (Bamrasnaradura Infectious Diseases Institute. Manual of HAI diagnosis (คู่มือวินิจฉัยการติดเชื้อในโรงพยาบาล), 2018)



Data collection

Data from 50 sampled hospitals including both patient records and hospital service profiles, were exported from the database. Then, all patient records were verified with local ICNs to fulfill the missing data from their own hospital database. After ICNs completed the missing data, data were rechecked, and the complete data set was analysed by the research team.



2.2.3 Limitations and Prospect

- The data from the BIDI's surveillance cover only HAI data. There are still lack of community associated infection (CAI) data, that demonstrated cover about the data of incidence rate of infection and data antimicrobial infection in Thailand. By definition, the BIDI system will not have data of community-acquired infection. It has to be a separate system for community AMR surveillance. Furthermore, type of organisms and patterns of resistance among community-acquired infection are different from those causing HAI. Therefore, target pathogens will be different and route causes of MDR are also different.
- Purposive sampling of 50 hospitals may limit the interpretation of the HAI and AMR in Thailand. We do not know whether hospitals with a strong surveillance system that are capable of providing AMR-HAI data are also have strong preventive efforts in parallel. If so, we could expect that the actual AMR-HAI might be much higher since all other hospitals would be unable to recognize AMR problem in their hospitals and response appropriately.
- AMR pathogens (9 pathogens) in this study are the pathogens that are defined in the AMR strategic plan. Therefore, may not cover all of the pathogens isolated and identified from patients in hospitals.
- Antimicrobials agents for drug sensitivity testing in this study were cover both class of antibiotic (ATC level 4) and type of antibiotic (ATC level 5), that were the limitation to interpreting results. Next study may be assigned only type of antibiotic to interpret result.
- Pandemic of coronavirus (COVID-19) affected to quantity and quality of data submission and verification data onsite of the surveillance program.
- In this year, the quantity and quality of data from the BIDI's surveillance program were verified and validated at only hospital level, lack of verified and validated of data by program owners or researchers.
- In some hospitals, clinical microbiology laboratories are still lack capacity to colistin susceptibility testing. Due to limitations on equipment and laboratory standards determination of colistin resistance requiring broth/ microbroth dilution cannot be performed.

2.3 AMR in Food-Producing Animals

2.3.1 Overview

In response to the global agenda and Thailand's national strategic plan on AMR 2017–2021, the Department of Livestock Development has played a key role in controlling and regulating antimicrobial use in animal sector, and initiated the surveillance system on AMR in food-producing animals since 2017. The AMR surveillance system aimed to monitor the trend of AMR for promoting the prudent use of antimicrobials in food-producing animals and food safety in Thailand. The AMR surveillance has been conducted in nine laboratories under the National Institute of Animal Health, Bureau of Quality Control of Livestock Product, and Regional Veterinary Research and Development Center.

2.3.2 Data source

The specimens for AMR monitoring were collected from broiler chickens and pigs based on the main food-producing animals in Thailand. The sample collection was performed across the food production chain from slaughterhouses (cecum and meat samples) to retails (meat samples). In compliance with the OIE guideline, the sample size was calculated, and a total of 4,608 samples were obtained from 77 provinces. All the samples were collected by Provincial Livestock Offices and transported to the laboratories for further analysis.

The target bacteria of national AMR surveillance included

1) Zoonotic bacteria: *Salmonella* spp., *Campylobacter* spp.
2) Indicator bacteria: *Enterococcus* spp., and *E. coli*

Antimicrobial susceptibility testing (AST) was performed based on the Clinical and Laboratory Standards Institute (CLSI), International Organization for Standardization (ISO) 20776-1, and the European Committee on Antimicrobial Susceptibility Testing (EUCAST).

The tested antimicrobials included:

- Critically important antimicrobials (CIA): polymyxins (colistin), fluoroquinolones (ciprofloxacin), and third generation cephalosporins (cefotaxime and ceftazidime),
- Some antimicrobials, which have been banned or do not used in livestock, were included in this study for surveillance purposes, including carbapenems (meropenem), amphenicols (chloramphenicol), glycopeptides and lipoglycopeptide (vancomycin and teicoplanin), and oxazolidinones (linezolid)
- Other antimicrobial groups used in livestock including sulfonamides, dihydrofolate reductase inhibitors and combinations (sulfamethoxazole and trimethoprim), and aminoglycosides (gentamicin and streptomycin).

Table D5. Responsible organisation, sampling details, and antimicrobial susceptibility testing

The responsible agency	1. National Institute of Animal Health 2. Bureau of Quality Control of Livestock Product 3. Regional Veterinary Research and Development Center 4. Division of Animal Feed and Veterinary Products Control	
Target animal	Broiler chickens and pigs	
Target specimen/ sample and responsible organisation	- Cecum of chicken and pigs - National Institute of Animal Health, and Regional Veterinary Research and Development Center	- Chicken meat and pork - Bureau of Quality Control of Livestock Product, and Regional Veterinary Research and Development Center
Sampling location	Slaughterhouses	Slaughterhouses and retail markets
Target bacterial isolates	*E. coli* *Salmonella* spp. *Enterococcus* spp. *Campylobacter* spp.	*E. coli* *Salmonella* spp.
Antibiotics susceptibility testing	MIC determination: Broth microdilution, Conventional method and automated MIC device	
Reference	WHO, OIE, FAO, CLSI, EUCAST and ISO 20776-1	
Drug panel for AST	All class of antibiotics for testing pathogen reference from CLSI, EUCAST and European Food Safety Authority (EFSA)	

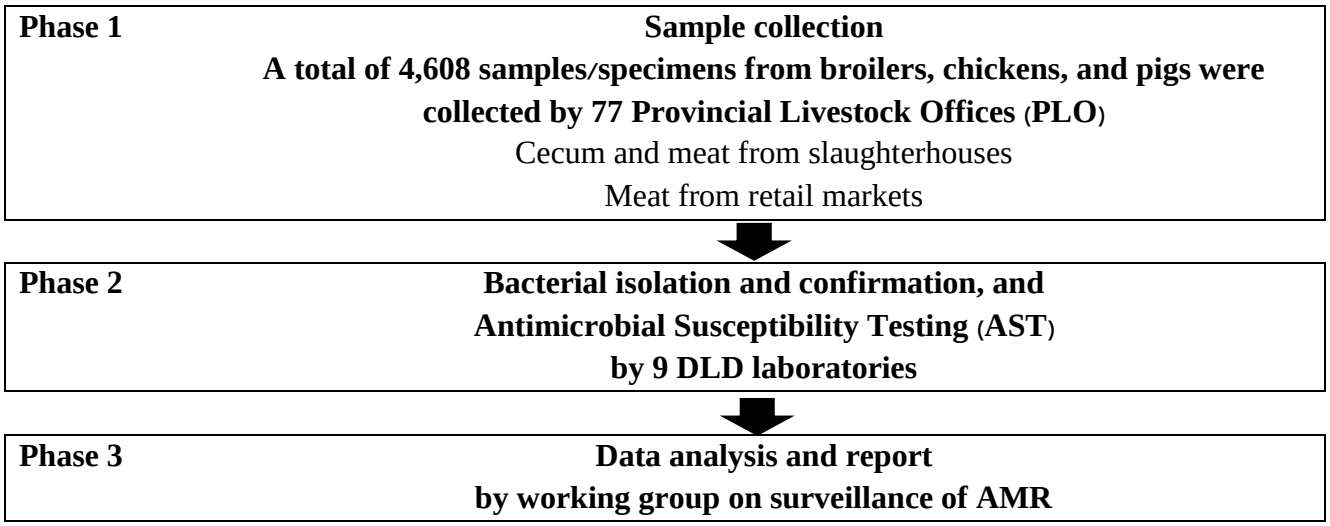


Figure D1. Process of sample collection, microbiological testing, and data analysis

2.3.3 Limitations and Prospect

Some antimicrobials included in this antibiotic panel were resistant in different rates, even though they have been banned in livestock for a long time (vancomycin and chloramphenicol), unavailable for animals (teicoplanin) or used as a representative drug of antimicrobial class (ciprofloxacin for fluoroquinolones). Consequently, careful interpretation on these AMR results should be advised. The AMR surveillance in food-producing animals were mainly focused on phenotypic characterization of AMR. Genetic characterization of AMR and their resistant determinants should be further performed on AMR surveillance to support efficient control and prevention of AMR. In the next phase, the DLD has been planned to include Extended Spectrum Beta- Lactamase (ESBL) phenotypic screening test in the surveillance panel.

The surveillance of AMR indicated the current situation of AMR in the animal sector. For Critically Important Antimicrobials, the use of cephalosporins (3^{rd} and 4^{th} generation), polymyxins, and macrolides should be restricted in food-producing animals. Despite a low resistance rate of antimicrobials from the CIA list, the routine surveillance of AMR in chickens and pigs should be implemented to monitor AMR bacteria in food-producing animals throughout the food production chain. Moreover, further studies of resistance determinants are needed to strengthen AMR capacity in Thailand.

3. Health Policy and Systems Research on Antimicrobial Resistance (HPSR-AMR) Network members

MINISTRY OF PUBLIC HEALTH
International Health Policy Program
Viroj Tangcharoensathien
Angkana Lekagul
Supapat Kirivan
Wimonrat Tanomsridachchai
Anond Kulthanmanusorn
Hathairat Kosiyaporn
Wanwisa Kaewkhankhaeng
Saowapa Khotchalai
Oranat Rueangna

Food and Drug Administration
Charunee Krisanaphan
Varavoot Sermsinsiri
Nithima Sumpradit
Kritsada Limpananont
Chutamas Luangaroonchai
Pischa Lusanandana
Chaiporn Pumkam
Sitanan Poonpolsub
Pongsathid Virungrojint

Bamrasnaradura Infectious Diseases Institute
Weerawat Manosuthi
Visal Moolasart
Lantharita Charoenpong
Varaporn Thienthong
Winnada Kongdejsakda
Ratchanu Charoenpak

National Institute of Health of Thailand, Department of Medical Sciences
Noppavan Janejai
Wantana Paveenklttlporn
Aekkawat Unahalekhaka
Pimrata Leethongdee

Division of AIDS and STIs, Department of Disease Control
Rossaphorn kittiyaowaman
Pongsathorn Sangprasert
Natnaree Girdthep

MINISTRY OF AGRICULTURE AND COOPERATIVES
Department of Livestock Development
Rakthai Ngampak
Pacharee Thongkamkoon
Lertchai Jintapitaksakul
Thanida Harintharanon
Sasi Jareonpoj
Watcharachai Narongsak
Julaporn Srinha
Thammarath Sujit
Supaporn Wongsrichai
Suchana Sukklad
Somsajee Sivilaikul
Passawee Pakpong
Thanawan Na Thalang
Porjai Rattanapanadda

Department of Fisheries
Janejit Kongkumnerd
Thitiporn Laoprasert
Chanotit Nakmanoch
Jutamas Auewongaree
Siriwimon thamgandee

MINISTRY OF DIGITAL ECONOMY AND SOCIETY
National Statistical Office of Thailand
Apichart Thunyahan
Waree Maneepiphatkamol

MINISTRY OF NATURAI RESOURCES AND ENVIRONMENT
Water Quality Management Division, Pollution Control Department
Chaiyut Sanghaisuk
Wimolporn Wainipee
Chaowalit Jangaksorn

ACADEMIA
Faculty of Pharmaceutical Sciences, Chulalongkorn University
Rungpetch Sakulbumrungsil
Sang Usayaporn

Faculty of Pharmacy, Silpakorn University
Inthira Kanchanaphibool

Faculty of Pharmaceutical Sciences, Khon Kaen University
Supon Limwattananon

Nussaraporn Kessomboon

Faculty of Pharmaceutical Sciences, Prince of Songkla University
Khunjira Udomaksorn

Faculty of Veterinary Science, Mahidol University
Walasinee Sakcamduang
Boonrat Chantong
Sarin Suwanpakdee
Anuwat Wiratsudakul

Faculty of Public Health, Mahidol University
Fuangfa Utrarachkij
Chayaporn Saranpuetti
Peeraya Ekchariyawat
Neunghatai Supa
Yuwanda Thongpanich
Pramualchai Ketkhao

Faculty of Veterinary Science, Chulalongkorn University
Saharuetai Jeamsripong

Faculty of Veterinary Medicine,Kasetsart University
Natthasit Tansakul

Faculty of Veterinary Medicine, Khon Kaen University
Sunpetch Angkititrakul

Faculty of Medicine Ramathibodi Hospital, Mahidol University
Kumthorn Malathum

Faculty of Medicine Siriraj Hospital
Chanwit Tribuddharat

Faculty of Science, Mahidol University
Parinda Thayanukul

PRIVATE SECTOR
Thai Feed Mill Association
Boonyita Rujtikumporn
Wichai Thermphonboon
Chaiwat Suvanatad
Sompong Harnuthaikij
Krisada Rithichaidumrongkul
Yamuna Patthong

Sureemas Nitikanchana
Pranee Pirompud

Animal Health Products Association
Nackanun Chitaroon
Panitan Suwannapetch
Eagaluk Theerakornsakul
Varisara Jirathitivong

INTERNATIONAL PARTNERS
World Health Organization Country Office, Thailand
Richard Brown
Phiangjai Boonsuk

Food and Agriculture Organization of the United Nations
Kachen Wongsathapornchai
Mary Joy Gordoncillo
Katinka de Balogh
Yin Myo Aye

USAID/Regional Development Mission for Asia
Daniel Schar
Karoon Chanachai

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