

SUPPLEMENT

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Supplementary Table 1. Antimicrobial medications (parenteral, oral/enteral, inhaled) included in the 2015 survey, by World Health Organization Anatomical Therapeutic Chemical (WHO ATC) fourth-level (chemical subgroup) codes.

WHO ATC chemical subgroup code	Antimicrobial medication
Alimentary tract and metabolism	
A01AB	Anti-infectives and antiseptics for local oral treatment Clotrimazole
A02BD	Combinations for eradication of <i>Helicobacter pylori</i> Amoxicillin, clarithromycin, lansoprazole Bismuth subcitrate, metronidazole, tetracycline Bismuth subsalicylate, metronidazole, tetracycline
A07AA	Intestinal anti-infectives, antibiotics Amphotericin B (oral) Colistin (oral) Fidaxomicin (oral) Kanamycin (oral) Neomycin (oral) Nystatin (oral) Polymyxin B (oral) Rifaximin (oral) Streptomycin (oral) Vancomycin (oral)
A07AX	Intestinal anti-infectives, imidazole derivatives Miconazole (oral)
Dermatologicals	
D01BA	Antifungals for dermatologic use, systemic Griseofulvin (oral) Terbinafine (oral)
Anti-infectives for systemic use—Antibacterials	
J01AA	Tetracyclines Doxycycline Minocycline Tetracycline Tigecycline
J01BA	Amphenicols Chloramphenicol
J01CA	Penicillins with extended spectrum Amoxicillin Ampicillin Piperacillin
J01CE	Beta-lactamase sensitive penicillins Benzathine benzylpenicillin Benzylpenicillin (penicillin G, penicillin G potassium, penicillin)

WHO ATC chemical subgroup code	Antimicrobial medication
	Phenoxyethylpenicillin (penicillin V, penicillin V potassium)
J01CF	Beta-lactamase resistant penicillins
	Dicloxacillin
	Nafcillin
	Oxacillin
J01CR	Penicillin combinations, including beta-lactamase inhibitors
	Amoxicillin-clavulanate
	Ampicillin-sulbactam
	Piperacillin-tazobactam
	Ticarcillin-clavulanate
J01DB	First-generation cephalosporins
	Cefadroxil
	Cefalexin
	Cefazolin
J01DC	Second-generation cephalosporins
	Cefaclor
	Cefotetan
	Cefoxitin
	Cefuroxime
J01DD and J01DE	Third- or fourth-generation cephalosporins
	Cefdinir
	Cefditoren
	Cefepime
	Cefixime
	Cefotaxime
	Cefpodoxime
	Ceftazidime
	Ceftazidime-avibactam
	Ceftibuten
	Ceftizoxime
	Ceftriaxone
J01DF	Monobactams
	Aztreonam
J01DH	Carbapenems
	Doripenem
	Ertapenem
	Imipenem-cilastatin
	Meropenem
J01DI	Other cephalosporins and penems
	Ceftaroline
	Ceftolozane-tazobactam
J01EA	Trimethoprim and derivatives
	Trimethoprim

WHO ATC chemical subgroup code	Antimicrobial medication
J01EB	Short acting sulfonamides Sulfisoxazole
J01EE	Combinations of sulfonamides and trimethoprim, including derivatives Sulfamethoxazole and trimethoprim
J01FA	Macrolides Azithromycin Clarithromycin Erythromycin Telithromycin
J01FF	Lincosamides Clindamycin
J01FG	Streptogramins Quinupristin-dalfopristin
J01GA	Streptomycins Streptomycin
J01GB	Other aminoglycosides Amikacin Gentamicin Kanamycin Tobramycin
J01MA	Quinolone antibacterials Ciprofloxacin Gemifloxacin Levofloxacin Moxifloxacin Norfloxacin Ofloxacin
J01XA	Glycopeptide antibacterials Dalbavancin Oritavancin Telavancin Vancomycin (parenteral)
J01XB	Polymyxins Colistin (parenteral, inhaled) Polymyxin B (parenteral)
J01XD	Imidazole derivatives Metronidazole (parenteral) Tinidazole (parenteral)
J01XE	Nitrofurantoin derivatives Nitrofurantoin
J01XX	Other antibacterials Daptomycin Fosfomycin Linezolid

WHO ATC chemical subgroup code	Antimicrobial medication
	Methenamine
	Spectinomycin
	Tedizolid
Anti-infectives for systemic use—Antimycotics	
J02AA	Antibiotics
	Amphotericin B
J02AB	Imidazole derivatives
	Ketoconazole
	Miconazole
J02AC	Triazole derivatives
	Fluconazole
	Isavuconazole
	Itraconazole
	Posaconazole
	Voriconazole
J02AX	Other antimycotics for systemic use
	Anidulafungin
	Caspofungin
	Flucytosine
	Micafungin
Anti-infectives for systemic use—Antimycobacterials	
J04AB	Antibiotics for the treatment of tuberculosis
	Rifabutin
	Rifampin
	Rifapentine
J04AC	Hydrazides for the treatment of tuberculosis
	Isoniazid
J04AK	Other drugs for the treatment of tuberculosis
	Ethambutol
	Pyrazinamide
J04AM	Combinations of drugs for the treatment of tuberculosis
	Isoniazid and rifampin
	Isoniazid, rifampin, pyrazinamide
J04BA	Drugs for the treatment of lepra
	Dapsone
Anti-infectives for systemic use—Antivirals	
J05AB	Nucleosides and nucleotides excluding reverse transcriptase inhibitors
	Acyclovir
	Cidofovir
	Famciclovir

WHO ATC chemical subgroup code	Antimicrobial medication
	Ganciclovir
	Valacyclovir
	Valganciclovir
J05AC	Cyclic amines
	Rimantadine
J05AD	Phosphonic acid derivatives
	Foscarnet
J05AH	Neuraminidase inhibitors
	Oseltamivir
	Peramivir
	Zanamavir
J05AP	Direct acting antivirals for the treatment of hepatitis C infections
	Ribavirin ^a
Nervous system—Anti-Parkinson drugs	
N04BB	Adamantane derivatives
	Amantadine
Antiparasitic products, insecticides and repellents—Antiprotozoals	
P01AB	Nitroimidazole derivatives
	Metronidazole (oral)
	Tinidazole (oral)
P01CX	Other antiprotozoal agents against leishmaniasis and trypanosomiasis
	Pentamidine

^aRibavirin was included only if used for an indication other than treatment of hepatitis C.

Supplementary Table 2. Characteristics of hospitals participating in the 2015 survey.

Characteristic	No. (%), N=199
Antimicrobial stewardship team – no. (%)	158 (79.4)
In place for <4 years at the time of the survey	89 (44.7)
In place for ≥4 years at the time of the survey	69 (34.7)
Full or partial salary support for ≥1 antimicrobial stewardship team member(s) ^a	72/158 (45.6)
Physician antimicrobial stewardship team participation ^a	151/158 (95.6)
Infectious diseases	136 (86.1)
Other physician	70 (44.3)
Pharmacist antimicrobial stewardship team participation ^a	157/158 (99.4)
Infectious diseases	72 (45.6)
Other pharmacist	124 (78.5)
Antimicrobial consumption monitoring	157 (78.9)
Hospital-wide	148 (74.4)
Specific patient units or other monitoring	37 (18.6)
Antimicrobial stewardship practices, any	196 (98.5)
Pre-authorization	139 (69.9)
Audits of selected antimicrobials	167 (83.9)
Feedback of audit results to prescribers	132 (66.3)
Automatic stop orders	79 (39.7)
Guidelines for switching from parenteral to oral antimicrobials	158 (79.4)
Guidelines for surgical prophylaxis	190 (95.5)
Guidelines for treatment of common infections	173 (86.9)
Required indication documentation	77 (38.7)
Required documentation of treatment duration	43 (21.6)
Antimicrobial consumption data reported to front-line providers or clinical leaders	52 (26.1)
Hospital-wide or unit-specific antibiogram made available to prescribers	189 (95.0)
Prescriber training requirement at least annually	12 (6.0)

^aAmong 158 hospitals with antimicrobial stewardship teams.

Supplementary Table 3. Characteristics of patients in the 2015 survey who were receiving antimicrobial medications compared with those not receiving antimicrobial medications.

Characteristic	All patients, N=12,299	Patients on antimicrobial medications, N=6084	Patients not on antimicrobial medications, N=6215	P value^{a,b}
Sex – no. (%)				0.17
Female	6822 (55.5)	3337 (54.8)	3485 (56.1)	
Male	5476 (44.5)	2747 (45.2)	2729 (43.9)	
Missing data	1 (<0.1)	0	1 (<0.1)	
Age category – no. (%)				<0.001
<1 year	1339 (10.9)	228 (3.7)	1111 (17.9)	
1-17 years	527 (4.3)	279 (4.6)	248 (4.0)	
18-24 years	457 (3.7)	195 (3.2)	262 (4.2)	
25-44 years	1951 (15.9)	881 (14.5)	1070 (17.2)	
45-64 years	3211 (26.1)	1817 (29.9)	1394 (22.4)	
65-84 years	3756 (30.5)	2105 (34.6)	1651 (26.6)	
≥85 years	1058 (8.6)	579 (9.5)	479 (7.7)	
Race – no. (%)				<0.001
American Indian or Alaska Native	142 (1.2)	80 (1.3)	62 (1.0)	
Asian	312 (2.5)	147 (2.4)	165 (2.7)	
Black or African-American	2007 (16.3)	922 (15.2)	1085 (17.5)	
Multiple races or other unspecified race	615 (5.0)	279 (4.6)	336 (5.4)	
Native Hawaiian or other Pacific Islander	41 (0.3)	17 (0.3)	24 (0.4)	
White	8161 (66.4)	4224 (69.4)	3937 (63.3)	
Missing data	1021 (8.3)	415 (6.8)	606 (9.8)	
Ethnicity – no. (%)				<0.005
Hispanic or Latino	977 (7.9)	451 (7.4)	526 (8.5)	
Not Hispanic or Latino	7991 (65.0)	4069 (66.9)	3922 (63.1)	
Missing data	3331 (27.1)	1564 (25.7)	1767 (28.4)	
Primary payer – no. (%)				<0.001
Medicaid	2446 (19.9)	1045 (17.2)	1401 (22.5)	
Medicare	4952 (40.3)	2771 (45.5)	2181 (35.1)	
No charge	11 (0.1)	5 (0.1)	6 (0.1)	
Other	309 (2.5)	158 (2.6)	151 (2.4)	
Private	3850 (31.3)	1807 (29.7)	2043 (32.9)	
Self-pay	430 (3.5)	169 (2.8)	261 (4.2)	
Missing data	301 (2.4)	129 (2.1)	172 (2.8)	
Body mass index category ^c – no. (%)				
Normal	3601 (29.3)	1981 (32.6)	1620 (26.1)	0.14
Overweight	2887 (23.5)	1528 (25.1)	1359 (21.9)	0.16
Obese	3846 (31.3)	2074 (34.1)	1772 (28.5)	0.88

Characteristic	All patients, N=12,299	Patients on antimicrobial medications, N=6084	Patients not on antimicrobial medications, N=6215	P value^{a,b}
Missing data	1965 (16.0)	501 (8.2)	1464 (23.6)	--
Hospital size category – no. (%)				0.18
Small (<150 beds)	3975 (32.3)	2014 (33.1)	1961 (31.6)	
Medium (150-399 beds)	5629 (45.8)	2758 (45.3)	2871 (46.2)	
Large (≥400 beds)	2695 (21.9)	1312 (21.6)	1383 (22.3)	
Location of patient in hospital on the survey date – no. (%)				<0.001
Critical care unit	1834 (14.9)	960 (15.8)	874 (14.1)	
Mixed acuity unit	228 (1.9)	103 (1.7)	125 (2.0)	
Newborn/special care nursery	456 (3.7)	24 (0.4)	432 (7.0)	
Specialty care area	60 (0.5)	39 (0.6)	21 (0.3)	
Step-down unit	547 (4.4)	263 (4.3)	284 (4.6)	
Ward (not nursery)	9174 (74.6)	4695 (77.2)	4479 (72.1)	
Central line in place on survey date – no. (%)				<0.001 ^d
Any	2081 (16.9)	1438 (23.6)	643 (10.3)	
One line	1716 (14.0)	1182 (19.4)	534 (8.6)	
More than one line	217 (1.8)	156 (2.6)	61 (1.0)	
Unknown number of lines	148 (1.2)	100 (1.6)	48 (0.8)	
None	10,175 (82.7)	4626 (76.0)	5549 (89.3)	
Missing data	43 (0.3)	20 (0.3)	23 (0.4)	
Urinary catheter in place on survey date – no. (%)				<0.001 ^d
Yes	2299 (18.7)	1627 (26.7)	672 (10.8)	
No	9959 (81.0)	4434 (72.9)	5525 (88.9)	
Missing data	41 (0.3)	23 (0.4)	18 (0.3)	
Ventilator in place on survey date – no. (%)				<0.001 ^d
Yes	586 (4.8)	432 (7.1)	154 (2.5)	
No	11,683 (95.0)	5633 (92.6)	6050 (97.3)	
Missing data	30 (0.2)	19 (0.3)	11 (0.2)	
Median days from admission to survey (IQR)	3 (1-6)	3 (1-6)	2 (1-6)	<0.001
Median hospital length of stay, days (IQR)	5 (3-11)	6 (3-13)	4 (2-10)	<0.001 ^e
Outcome of hospitalization – no. (%)				<0.001 ^f
Died	358 (2.9)	241 (4.0)	117 (1.9)	
Survived	11,927 (97.0)	5839 (96.0)	6088 (98.0)	

Characteristic	All patients, N=12,299	Patients on antimicrobial medications, N=6084	Patients not on antimicrobial medications, N=6215	P value^{a,b}
Still in hospital 6 months after survey	8 (0.1)	2 (<0.1)	6 (0.1)	
Missing data	6 (0.1)	2 (<0.1)	4 (0.1)	

^aChi square test unless otherwise indicated.

^bComparison excludes patients with missing data unless otherwise indicated.

^cBody mass index (BMI) categories were generated using reported or calculated body mass index for patients ≥ 2 years of age. BMI was considered missing for children < 2 years of age, even if BMI was reported. Normal weight among adults was BMI < 25 ; overweight $25 \leq \text{BMI} < 30$; and obese BMI ≥ 30 . Normal weight among children ≥ 2 years was BMI $< 85^{\text{th}}$ percentile for age and sex; overweight BMI between the 85^{th} and 95^{th} percentile for age and sex; and obese BMI $\geq 95^{\text{th}}$ percentile for age and sex.

^dComparison includes patients with missing data.

^eMedian 2-sample test. Data on hospital length of stay missing for 9 patients (2 on antimicrobial medications and 7 not on antimicrobial medications).

^fComparison includes patients who were known to have survived or died during the hospitalization; patients still in the hospital and those with unknown outcome were excluded.

Supplementary Table 4. Percentages of patients on antimicrobial medications in different inpatient locations in the 2015 survey, among locations with ≥50 patients surveyed.

Location	Total no. of patients	No. of patients on antimicrobial medications	Percentage of patients on antimicrobial medications (95% CI)
Critical care			
Medical-surgical	775	489	63.1 (59.7-66.4)
Neonatal level III	326	83	25.5 (21.0-30.6)
Medical	185	123	66.5 (59.5-73.0)
Neonatal level II/III	155	27	17.4 (12.1-24.0)
Pediatric medical-surgical	94	60	63.8 (53.8-73.1)
Surgical	75	55	73.3 (62.5-82.4)
Neurosurgical	55	28	50.9 (37.8-63.9)
Cardiothoracic	53	36	67.9 (54.5-79.4)
Ward			
Medical-surgical	2937	1702	58.0 (56.2-59.7)
Medical	1728	920	53.2 (50.9-55.6)
Surgical	1050	610	58.1 (55.1-61.1)
Telemetry	717	305	42.5 (39.0-46.2)
Post-partum	535	104	19.4 (16.3-23.0)
Stepdown	526	253	48.1 (43.9-52.4)
Labor, delivery, recovery, post-partum	464	110	23.7 (20.0-27.7)
Newborn nursery	373	11	2.9 (1.6-5.1)
Orthopedic	373	249	66.8 (61.9-71.4)
Pediatric medical-surgical	297	143	48.1 (42.5-53.8)
Hematology-oncology	209	127	60.8 (54.0-67.2)
Labor and delivery	170	61	35.9 (28.9-43.3)
Pediatric medical	121	59	48.8 (39.9-57.6)
Neurology	98	42	42.9 (33.3-52.8)
Neurosurgical	87	26	29.9 (21.0-40.1)
Special care nursery	83	13	15.7 (9.0-24.7)
Pediatric hematology-oncology	58	36	62.1 (49.1-73.8)
Pulmonary	53	32	60.4 (46.9-72.8)
Other locations			
Mixed acuity adult	165	76	46.1 (38.6-53.7)
Solid organ transplant	50	35	70.0 (56.3-81.5)

Supplementary Table 5. Multivariable log binomial regression model of patient and hospital factors associated with receipt of antimicrobial medications, 2015 survey (N=12,299).

Variable*	Total no. of patients	No. of patients on antimicrobial medications	Adjusted relative risk	95% confidence interval	P value
Patient group ^a					
Group A	1772	1130	20.30	12.17–37.79	<.0001
Group B	4441	2614	21.97	13.18–40.87	<.0001
Group C	3965	1926	18.76	11.25–34.89	<.0001
Group D	1144	338	12.26	7.30–22.91	<.0001
Group E	432	64	5.92	3.37–11.40	<.0001
Group F	545	12	Ref	Ref	Ref
Urinary catheter ^b	2299	1627	1.27	1.22–1.32	<0.0001
Central line ^b	2081	1438	1.20	1.16–1.25	<0.0001
Ventilator ^b	586	432	1.09	1.04–1.14	0.0004
Length of hospitalization					
3–5 days or >25 days	4996	2440	1.12	1.07–1.18	<0.0001
6–25 days	4375	2569	1.19	1.13–1.25	<0.0001
≤2 days	2928	1075	Ref	Ref	Ref
Race					
American Indian, Asian, Multiple, Other, White	9230	4730	1.08	1.04–1.12	0.0002
Black, Pacific Islander, Unknown	3069	1354	Ref	Ref	Ref
Annual hospital discharges					
<14,000 or >30,000	8172	4189	1.06	1.02–1.10	0.0011
14,000–30,000	4127	1895	Ref	Ref	Ref
Region					
South, Midwest	5695	2930	1.05	1.02–1.08	0.0016

Variable*	Total no. of patients	No. of patients on antimicrobial medications	Adjusted relative risk	95% confidence interval	P value
West, Northeast	6604	3154	Ref	Ref	Ref
Primary payer					
Medicaid, Medicare, Private, Other, Unknown	11858	5910	1.15	1.04–1.28	0.0103
Self-pay, No charge	441	174	Ref	Ref	Ref

*Other variables that were tested but not significantly associated with antimicrobial use were: patient characteristics (sex, ethnicity, weight category, time from admission to survey, outcome, and survey month [May–June vs. July–September]); time of initial survey data collection (day of survey vs. retrospective); and hospital characteristics (bed size, urban vs. rural, teaching status, infection preventionist and healthcare epidemiologist staffing, selected infection prevention practices, and selected antimicrobial stewardship characteristics).

^aGroup A: patients in non-neonatal critical care units, oncology wards, or other specialty care areas. Group B: patients in adult medical-surgical, surgical, gerontology, genitourinary, orthopedic or pulmonary wards. Group C: patients in other wards, mixed age or mixed acuity units, or step down units. Group D: patients >0.125 years in antenatal, mother-baby units (labor and delivery, labor/deliver/recovery/postpartum or postpartum wards), or infants ≤1 week old in neonatal critical or special care units. Group E: infants >1 week old in neonatal critical or special care units, or infants >3 days old but ≤0.125 years old in mother-baby units or newborn nursery. Group F: infants in newborn nursery ≤3 days old.

^bPatients with unknown device presence were grouped with patients without devices.

Supplementary Table 6. Antimicrobial medications administered to patients in the 2015 survey (fourth- and fifth-level World Health Organization Anatomical Therapeutic Chemical classification).

Antimicrobial medication	No. of antimicrobial medications (%), N=10,612
Third or fourth generation cephalosporins	1531 (14.4)
Ceftriaxone	1010
Cefepime	380
Ceftazidime	62
Cefotaxime	38
Cefdinir	18
Cefpodoxime	16
Cefixime	6
Ceftazidime-avibactam	1
Glycopeptides	1258 (11.9)
Vancomycin (parenteral)	1258
Fluoroquinolones	1241 (11.7)
Levofloxacin	798
Ciprofloxacin	397
Moxifloxacin	45
Ofloxacin	1
First generation cephalosporins	1206 (11.4)
Cefazolin	1117
Cephalexin	82
Cefadroxil	7
Penicillin combinations, including beta-lactamase inhibitors	1093 (10.3)
Piperacillin-tazobactam	827
Ampicillin-sulbactam	158
Amoxicillin-clavulanate	108
Imidazole derivatives	501 (4.7)
Metronidazole (parenteral)	501
Carbapenems	445 (4.2)
Meropenem	306
Ertapenem	110
Imipenem	29
Macrolides	436 (4.1)
Azithromycin	391
Erythromycin	40
Clarithromycin	5
Triazole derivatives	367 (3.5)
Fluconazole	296
Voriconazole	42
Posaconazole	20
Itraconazole	7
Isavuconazole	2
Intestinal antibiotics	315 (3.0)
Vancomycin (oral)	139

Antimicrobial medication	No. of antimicrobial medications (%), N=10,612
Nystatin	91
Rifaximin	78
Fidaxomicin	4
Neomycin	3
Nucleoside and nucleotide antivirals	284 (2.7)
Acyclovir	194
Valacyclovir	56
Valganciclovir	20
Ganciclovir	9
Famciclovir	5
Lincosamides	271 (2.6)
Clindamycin	271
Penicillins with extended spectrum	242 (2.3)
Ampicillin	177
Amoxicillin	62
Piperacillin	3
Aminoglycosides	199 (1.9)
Gentamicin	158
Tobramycin	28
Amikacin	13
Nitroimidazole derivatives	195 (1.8)
Metronidazole (oral)	195
Tetracyclines	189 (1.8)
Doxycycline	170
Minocycline	11
Tigecycline	7
Tetracycline	1
Combinations of sulfonamides and trimethoprim, including derivatives	187 (1.8)
Trimethoprim-sulfamethoxazole	187
Second generation cephalosporins	129 (1.2)
Cefoxitin	57
Cefuroxime	41
Cefotetan	29
Cefaclor	1
Cefprozil	1
Other antibacterials	123 (1.2)
Linezolid	74
Daptomycin	46
Fosfomycin	2
Methenamine	1
Other antimycotics for systemic use	79 (0.7)
Micafungin	66
Caspofungin	8
Anidulafungin	5

Antimicrobial medication	No. of antimicrobial medications (%), N=10,612
Beta-lactamase sensitive penicillins	68 (0.6)
Benzylpenicillin (penicillin G, penicillin G potassium, penicillin)	63
Phenoxymethylpenicillin (penicillin V, penicillin V potassium)	5
Monobactams	61 (0.6)
Aztreonam	61
Beta-lactamase resistant penicillins	39 (0.4)
Nafcillin	24
Oxacillin	15
Drugs for treatment of tuberculosis	36 (0.3)
Rifampin	36
Other cephalosporins and penems	28 (0.3)
Ceftaroline	27
Ceftolozane-tazobactam	1
Nitrofurantoin derivatives	25 (0.2)
Nitrofurantoin	25
Other drugs for treatment of tuberculosis	12 (0.1)
Ethambutol	8
Pyrazinamide	4
Hydrazides	11 (0.1)
Isoniazid	11
Other antifungals	10 (0.1)
Amphotericin B	10
Other antimicrobials^a	31 (0.2)

^aIncludes dapsons (9), clotrimazole (5), trimethoprim (4), pentamidine (3), colistin (3), erythromycin ethylsuccinate and sulfisoxazole acetyl (2), terbinafine (1), amantadine (1), amoxicillin/clarithromycin/lansoprazole (1), foscarnet (1), ketoconazole (1).

Supplementary Table 7. Percentages of patients on common antimicrobial groups, by patient age group, 2011 vs. 2015, among 148 hospitals that participated in the 2011 and 2015 surveys. Table displays the top five antimicrobial groups overall, in both surveys combined, for each age group.

Age group	Antimicrobial group	2011 survey Patients receiving antimicrobial group, no. (%)	2015 survey Patients receiving antimicrobial group, no. (%)
≤3 months	Extended-spectrum penicillins	87/901 patients (9.7)	76/893 patients (8.5)
	Aminoglycosides	73 (8.1)	60 (6.7)
	Third or fourth generation cephalosporins	44 (4.9)	34 (3.8)
	Glycopeptides, parenteral	29 (3.2)	13 (1.5)
	Intestinal anti-infectives	18 (2.0)	9 (1.0)
4-11 months	Third or fourth generation cephalosporins	12/83 patients (14.5)	13/104 patients (12.5)
	Extended-spectrum penicillins	9 (10.8)	4 (3.8)
	First generation cephalosporins	8 (9.6)	13 (12.5)
	Glycopeptides, parenteral	7 (8.4)	7 (6.7)
	Penicillin combinations, including beta-lactamase inhibitors	4 (4.8)	7 (6.7)
1-4 years	Glycopeptides, parenteral	21/148 patients (14.2)	8/121 patients (6.6)
	Third or fourth generation cephalosporins	19 (12.8)	10 (8.3)
	Penicillin combinations, including beta-lactamase inhibitors	15 (10.1)	12 (9.9)
	First generation cephalosporins	12 (8.1)	14 (11.6)
	Lincosamides	11 (7.4)	12 (9.9)
5-12 years	Third or fourth generation cephalosporins	25/145 patients (17.2)	29/143 patients (20.3)
	Glycopeptides, parenteral	16 (11.0)	14 (9.8)
	Lincosamides	12 (8.3)	12 (8.4)
	First generation cephalosporins	11 (7.6)	16 (11.2)
	Macrolides	11 (7.6)	9 (6.3)
13-17 years	Third or fourth generation cephalosporins	16/155 patients (10.3)	16/152 patients (10.5)
	Penicillin combinations, incl. beta-lactamase inhibitors	14 (9.0)	13 (8.6)
	First generation cephalosporins	14 (9.0)	11 (7.2)

Age group	Antimicrobial group	2011 survey	2015 survey
		Patients receiving antimicrobial group, no. (%)	Patients receiving antimicrobial group, no. (%)
	Lincosamides	11 (7.1)	8 (5.3)
	Glycopeptides, parenteral	10 (6.5)	10 (6.6)
18-44 years	First generation cephalosporins	188/1777 patients (10.6)	209/1768 patients (11.8)
	Glycopeptides, parenteral	153 (8.6)	161 (9.1)
	Fluoroquinolones	131 (7.4)	115 (6.5)
	Penicillin combinations, including beta-lactamase inhibitors	129 (7.3)	126 (7.1)
	Third or fourth generation cephalosporins	105 (5.9)	129 (7.3)
45-64 years	Glycopeptides, parenteral	347/2486 patients (14.0)	328/2433 patients (13.5)
	Fluoroquinolones	331 (13.3)	286 (11.8)
	Penicillin combinations, including beta-lactamase inhibitors	295 (11.9)	259 (10.6)
	First generation cephalosporins	258 (10.4)	270 (11.1)
	Third or fourth generation cephalosporins	248 (10.0)	301 (12.4)
65-84 years	Fluoroquinolones	471/2732 patients (17.2)	414/2797 patients (14.8)
	Third or fourth generation cephalosporins	368 (13.5)	441 (15.8)
	Glycopeptides, parenteral	322 (11.8)	349 (12.5)
	Penicillin combinations, including beta-lactamase inhibitors	284 (10.4)	308 (11.0)
	First generation cephalosporins	247 (9.0)	292 (10.4)
≥85 years	Third or fourth generation cephalosporins	157/856 patients (18.3)	142/758 patients (18.7)
	Fluoroquinolones	154 (18.0)	99 (13.1)
	Penicillin combinations, including beta-lactamase inhibitors	91 (10.6)	55 (7.3)
	Glycopeptides, parenteral	82 (9.6)	61 (8.0)
	First generation cephalosporins	43 (5.0)	63 (8.3)

Supplementary Table 8. Percentages of patients on antimicrobial medications by patient location, 2011 vs. 2015, 148 hospitals. Table displays the top five ranked antimicrobial groups overall, in both surveys combined.

Inpatient location and antimicrobial group	2011 survey		2015 survey	
	Total no. of patients	No. of patients on antimicrobial medications (%)	Total no. of patients	No. of patients on antimicrobial medications (%)
Adult critical care	955	610 (63.9)	921	573 (62.2)
Glycopeptides, parenteral		189 (19.8)		178 (19.3)
Penicillin combinations, including beta-lactamase inhibitors		177 (18.5)		165 (17.9)
Third or fourth generation cephalosporins		135 (14.1)		151 (16.4)
Fluoroquinolones		159 (16.6)		111 (12.1)
First generation cephalosporins		84 (8.8)		94 (10.2)
Adult non-critical care ^a	6294	3382 (53.8)	6143	3406 (55.5)
Fluoroquinolones		924 (14.7)		801 (13.0)
Third or fourth generation cephalosporins		739 (11.7)		849 (13.8)
Glycopeptides, parenteral		708 (11.2)		717 (11.7)
First generation cephalosporins		573 (9.1)		641 (10.4)
Penicillin combinations, including beta-lactamase inhibitors		618 (9.8)		570 (9.3)
Pediatric critical care	96	66 (68.8)	109	70 (64.2)
Third or fourth generation cephalosporins		16 (16.7)		20 (18.3)
First generation cephalosporins		13 (13.5)		22 (20.2)
Glycopeptides, parenteral		20 (20.8)		15 (13.8)
Penicillin combinations, including beta-lactamase inhibitors		14 (14.5)		10 (9.2)
Aminoglycosides		14 (14.5)		2 (1.8)
Pediatric non-critical care	469	244 (52.0)	470	241 (51.3)
Third or fourth generation cephalosporins		73 (15.6)		68 (14.5)
First generation cephalosporins		34 (7.2)		34 (7.2)
Penicillin combinations, including beta-lactamase inhibitors		28 (6.0)		37 (7.9)
Glycopeptides, parenteral		36 (7.7)		27 (5.7)

Inpatient location and antimicrobial group	2011 survey		2015 survey	
	Total no. of patients	No. of patients on antimicrobial medications (%)	Total no. of patients	No. of patients on antimicrobial medications (%)
Lincosamides		29 (6.2)		27 (5.7)
Neonatal critical care	337	108 (32.0)	372	85 (22.8)
Extended spectrum penicillins		55 (16.3)		50 (13.4)
Aminoglycosides		56 (16.6)		42 (11.3)
Third or fourth generation cephalosporins		18 (5.3)		19 (5.1)
Glycopeptides, parenteral		24 (7.1)		11 (3.0)
Triazoles		9 (2.7)		9 (2.4)
Neonatal non-critical care	396	24 (6.1)	344	21 (6.1)
Extended spectrum penicillins		15 (3.8)		18 (5.2)
Aminoglycosides		10 (2.5)		16 (4.7)
Third or fourth generation cephalosporins		8 (2.0)		2 (0.6)
Intestinal anti-infectives		5 (1.3)		1 (0.3)
Glycopeptides, parenteral		2 (0.5)		0
Mother-baby units	728	167 (22.9)	798	188 (23.6)
First generation cephalosporins		78 (10.7)		97 (12.2)
Beta-lactamase sensitive penicillins		52 (7.1)		31 (3.9)
Extended spectrum penicillins		17 (2.3)		37 (4.6)
Lincosamides		14 (1.9)		16 (2.0)
Aminoglycosides		10 (1.4)		17 (2.1)

^aExcludes 20 patients (8 in the 2011 survey and 12 in the 2015 survey) in mixed age locations.

Supplementary Table 9. Ten most common antimicrobial medications given for no documented rationale or for non-infection-related reasons.

Antimicrobial medications for no documented rationale (no., %) N=265	Antimicrobial medications for non-infection-related reasons (no., %) N=78
Fluconazole (20, 7.5)	Rifaximin (48, 61.5)
Cefazolin (19, 7.2)	Erythromycin (18, 23.1)
Nystatin (19, 7.2)	Doxycycline (3, 3.8)
Ciprofloxacin (18, 6.8)	Azithromycin (2, 2.6)
Levofloxacin (18, 6.8)	Metronidazole, parenteral (2, 2.6)
Acyclovir (16, 6.0)	Ciprofloxacin (1, 1.3)
Piperacillin-tazobactam (14, 5.3)	Ketoconazole (1, 1.3)
Ceftriaxone (14, 5.3)	Fluconazole (1, 1.3)
Metronidazole, parenteral (14, 5.3)	Dapsone (1, 1.3)
Vancomycin, parenteral (11, 4.2)	Other (1, 1.3)

Supplementary Table 10. Rationale for antimicrobial use, 2011 vs. 2015, among 148 hospitals participating in both surveys. Note that antimicrobial medications could have been administered for more than one rationale.

Rationale	2011 survey No. of antimicrobial medications (%), N=8110	2015 survey No. of antimicrobial medications (%), N=8091
Treatment of active infection	6228 (76.8)	6167 (76.2)
Surgical prophylaxis	991 (12.2)	1013 (12.5)
Medical prophylaxis	522 (6.4)	698 (8.6)
Non-infection-related	34 (0.4)	63 (0.8)
No documented rationale	376 (4.6)	197 (2.4)

Supplementary Table 11. Patients receiving antimicrobial medications for treatment of active infections, by infection onset location, 2015 survey.

Infection onset location^a	No. of patients receiving antimicrobial medications for treatment of active infection (%), N=4476
Community	3433 (76.7)
Survey hospital	802 (17.9)
Long-term care facility	301 (6.7)
Other healthcare facility	102 (2.3)
Multiple onset locations	6 (0.13)
Unknown onset location	41 (0.92)

Numbers sum to more than 100% because each patient could have received antimicrobial medications for infections with different onset locations.

^aMultiple onset locations could be reported for each infection.

Supplementary Table 12. Antimicrobial medications given to treat infections at different therapeutic sites, by location of infection onset, 2015 survey.

Therapeutic site	Community-onset infections, no. of antimicrobial medications (%), N=6052	Survey hospital-onset infections, no. of antimicrobial medications (%), N=1325	Long term care facility-onset infections, no. of antimicrobial medications (%), N=628	Other healthcare facility ^a -onset infections, no. of antimicrobial medications (%), N=199	Infections with unknown onset location, no. of antimicrobial medications (%), N=63	Infections with multiple onset locations, no. of antimicrobial medications (%), N=10	Total no. of antimicrobial medications (%), N=8138
Pneumonia	1520 (25.1)	423 (31.9)	260 (41.4)	96 (48.2)	8 (12.7)	4 (40.0)	2311 (28.4)
Skin or soft tissue	1153 (19.1)	102 (7.7)	102 (16.2)	17 (8.5)	11 (17.5)	5 (50.0)	1390 (17.1)
Urinary tract	1048 (17.3)	198 (14.9)	192 (30.6)	19 (9.5)	9 (14.3)	0	1466 (18.0)
Undetermined	549 (9.1)	222 (16.8)	73 (11.6)	36 (18.1)	9 (14.3)	0	889 (10.9)
Gastrointestinal ^b	487 (8.0)	39 (2.9)	21 (3.3)	3 (1.5)	0	0	550 (6.8)
Lower respiratory ^c	433 (7.2)	44 (3.3)	23 (3.7)	4 (2.0)	6 (9.5)	0	510 (6.3)
Bloodstream	405 (6.7)	122 (9.2)	48 (7.6)	27 (13.6)	5 (7.9)	0	607 (7.5)
Intraabdominal	313 (5.2)	60 (4.5)	22 (3.5)	11 (5.5)	3 (4.8)	1 (10.0)	410 (5.0)
Bone or joint	265 (4.4)	12 (0.9)	15 (2.4)	4 (2.0)	6 (9.5)	0	302 (3.7)
Hepatobiliary	199 (3.3)	11 (0.8)	6 (1.0)	10 (5.0)	2 (3.2)	0	228 (2.8)
Ear, eye, nose, mouth, throat	164 (2.7)	64 (4.8)	1 (0.2)	0	0	0	229 (2.8)
<i>Clostridioides difficile</i>	131 (2.2)	91 (6.9)	26 (4.1)	6 (3.0)	0	0	254 (3.1)
Central nervous system	121 (2.0)	11 (0.8)	9 (1.4)	3 (1.5)	0	0	144 (1.8)
Reproductive	90 (1.5)	27 (2.0)	4 (0.6)	0	1 (1.6)	0	122 (1.5)
Cardiovascular	52 (0.9)	6 (0.5)	3 (0.5)	2 (1.0)	0	0	63 (0.8)
Disseminated	39 (0.6)	1 (0.1)	0	2 (1.0)	1 (1.6)	0	43 (0.5)
Unknown	23 (0.4)	4 (0.3)	0	1 (0.5)	5 (7.9)	0	33 (0.4)

Numbers in columns may sum to more than 100% because antimicrobial medications could be given for multiple different infections.

^aOther healthcare facilities included facilities that were not long-term care facilities and not the survey hospital, such as long-term acute care hospitals, rehabilitation facilities, other acute care hospitals, and dialysis centers.

^bOther than *Clostridioides difficile*.

^cOther than pneumonia.

Supplementary Table 13. Surgical prophylaxis duration by operative procedure category, 2015 survey. If multiple antimicrobials with different reported durations were given to a patient as prophylaxis for a single surgical procedure type, the longest duration was used.

Operative procedure category	No. of procedures for which patients received surgical prophylaxis (%), N=1188	No. of procedures for which patients received antimicrobial medications given solely for surgical prophylaxis (%), N=1153	No. of procedures for which surgical prophylaxis was ≤24 hours (%), N=869	No. of procedures for which surgical prophylaxis was >24 hours (%), N=238	No. of procedures for which surgical prophylaxis was unknown duration (%), N=46
Other surgery	178 (15.0)	169 (14.7)	119 (13.7)	44 (18.5)	6 (13.0)
Knee replacement	153 (12.9)	152 (13.2)	129 (14.8)	18 (7.6)	5 (10.9)
Hip replacement	123 (10.4)	121 (10.5)	110 (12.7)	9 (3.8)	2 (4.4)
Cesarean section	113 (9.5)	113 (9.8)	98 (11.3)	9 (3.8)	6 (13.0)
Open reduction fracture	96 (8.1)	92 (8.0)	63 (7.3)	26 (10.9)	3 (6.5)
Laminectomy	50 (4.2)	50 (4.3)	37 (4.3)	10 (4.2)	3 (6.5)
Spinal fusion	48 (4.0)	48 (4.2)	39 (4.5)	7 (2.9)	2 (4.4)
Abdominal surgery	35 (3.0)	30 (2.6)	20 (2.3)	5 (2.1)	5 (10.9)
Colon surgery	33 (2.8)	32 (2.8)	21 (2.4)	10 (4.2)	1 (2.2)
Gastric surgery	30 (2.5)	28 (2.4)	18 (2.1)	9 (3.8)	1 (2.2)
Appendix surgery	29 (2.4)	23 (2.0)	15 (1.7)	8 (3.4)	0
Cardiac surgery	26 (2.2)	26 (2.3)	12 (1.4)	12 (5.0)	2 (4.4)
Gall bladder surgery	26 (2.2)	23 (2.0)	16 (1.8)	6 (2.5)	1 (2.2)
Coronary artery bypass graft with chest and donor site incisions	21 (1.8)	21 (1.8)	13 (1.5)	7 (2.9)	1 (2.2)
Abdominal hysterectomy	21 (1.8)	21 (1.8)	19 (2.2)	1 (0.4)	1 (2.2)
Craniotomy	20 (1.7)	20 (1.7)	10 (1.2)	10 (4.2)	0
Pacemaker surgery	20 (1.7)	19 (1.7)	13 (1.5)	6 (2.5)	0
Small bowel surgery	16 (1.3)	15 (1.3)	11 (1.3)	4 (1.7)	0
Thoracic surgery	16 (1.3)	16 (1.4)	14 (1.6)	1 (0.4)	1 (2.2)
Breast surgery	15 (1.3)	15 (1.3)	6 (0.7)	7 (2.9)	2 (4.4)
Vaginal hysterectomy	13 (1.1)	13 (1.1)	11 (1.3)	2 (0.8)	0
Kidney surgery	11 (0.9)	11 (1.0)	8 (0.9)	3 (1.3)	0

Operative procedure category	No. of procedures for which patients received				
	No. of procedures for which patients received surgical prophylaxis (%), N=1188	antimicrobial medications given solely for surgical prophylaxis (%), N=1153	No. of procedures for which surgical prophylaxis was ≤24 hours (%), N=869	No. of procedures for which surgical prophylaxis was >24 hours (%), N=238	No. of procedures for which surgical prophylaxis was unknown duration (%), N=46
Ventricular shunt	11 (0.9)	11 (1.0)	5 (0.6)	6 (2.5)	0
Carotid endarterectomy	10 (0.8)	10 (0.9)	9 (1.0)	1 (0.4)	0
Herniorrhaphy	9 (0.8)	9 (0.8)	8 (0.9)	1 (0.4)	0
Prostate surgery	8 (0.7)	8 (0.7)	5 (0.6)	2 (0.8)	1 (2.2)
Bile duct, liver or pancreatic surgery	6 (0.5)	6 (0.5)	4 (0.5)	2 (0.8)	0
Ovarian surgery	6 (0.5)	6 (0.5)	5 (0.6)	0	1 (2.2)
Peripheral vascular bypass surgery	6 (0.5)	6 (0.5)	4 (0.5)	2 (0.8)	0
Abdominal aortic aneurysm repair	5 (0.4)	5 (0.4)	3 (0.4)	2 (0.8)	0
Amputation of limb	5 (0.4)	5 (0.4)	4 (0.5)	1 (0.4)	0
Rectal surgery	5 (0.4)	5 (0.4)	3 (0.4)	2 (0.8)	0
Shunt for dialysis	4 (0.3)	4 (0.3)	2 (0.2)	1 (0.4)	1 (2.2)
Coronary artery bypass graft with chest incision only	4 (0.3)	4 (0.3)	3 (0.4)	1 (0.4)	0
Kidney transplant	4 (0.3)	4 (0.3)	3 (0.4)	1 (0.4)	0
Refusion of spine	4 (0.3)	4 (0.3)	3 (0.4)	1 (0.4)	0
Thyroid or parathyroid surgery	4 (0.3)	4 (0.3)	4 (0.5)	0	0
Liver transplant	2 (0.2)	2 (0.2)	1 (0.1)	0	1 (2.2)
Neck surgery	1 (0.1)	1 (0.1)	1 (0.1)	0	0
Spleen surgery	1 (0.1)	1 (0.1)	0	1 (0.4)	0