

SPECIAL ARTICLE

Intensive Care Antimicrobial Resistance Epidemiology (ICARE) Surveillance Report, Data Summary from January 1996 through December 1997

A report from the National Nosocomial Infections Surveillance (NNIS) System*

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The Intensive Care Antimicrobial Resistance Epidemiology project has established laboratory-based surveillance for antimicrobial resistance and antimicrobial use at a subset of hospitals participating in the National Nosocomial Infections Surveillance system. These data illustrate that, for most antimicrobial resistant organisms studied, rates of resistance were highest in the intensive care unit areas and lowest in the outpatient areas. For most of the antimicrobial agents, the rate of use was highest in the intensive care unit areas in parallel to the pattern seen for resistance. These comparative data on antimicrobial use and resistance among similar areas (ie, intensive care unit or other inpatient areas) can be used as a benchmark by participating hospitals to focus their efforts at addressing antimicrobial resistance. (AJIC Am J Infect Control 1999;27:279-84)

This report is a summary of the data collected by participating hospitals in the Intensive Care Antimicrobial Resistance Epidemiology (ICARE) project from January 1996 through December 1997 and supplements previously published data.¹ Monitoring antimicrobial use and resistance can aid the infection control community in determining how to focus its efforts in reducing the emergence and spread of antimicrobial-resistant pathogens.² The data in this report can serve as a tool for such efforts.

The Centers for Disease Control and Prevention's Hospital Infections Program, in cooperation with the Rollins School of Public Health at Emory University, began Project ICARE at a subset of hospitals participating in the intensive care unit (ICU) component of the National Nosocomial Infections Surveillance (NNIS) system.³ Data collected in Project ICARE hospitals include antimicrobial susceptibilities for select organisms processed by the microbiology laboratory and

antimicrobial agents used throughout the hospital. The identity of the 41 participating hospitals providing data in this report is confidential.

Microbiology data

Microbiology data included antimicrobial susceptibility test results on all nonduplicate clinical isolates processed by the laboratory during each study month. A duplicate isolate was defined as an isolate of the same species of bacteria with the same antimicrobial susceptibility pattern in the same patient, whatever the site of isolation, during each month.

Susceptible, intermediate, and resistant isolates of selected organisms were stratified by hospital area for each month, for 12 sentinel antimicrobial-resistant organisms (Tables 1A and 1B). All isolates fitting the selected organism-antimicrobial combinations, whether responsible for hospital-acquired or community-acquired infection or for colonization, were reported to Project ICARE by participating hospitals. Hospitals used National Committee for Clinical Laboratory Standards interpretive standards for minimum inhibitory concentration or zone diameter testing standards to report numbers of susceptible, intermediate, or resistant organisms.^{4,5} In addition to the data collected, clinical isolates were collected from each hospital to verify reported resistance.

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*See Appendix B.

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Table 1A. Antimicrobial resistance rates and key percentiles for inpatient non-ICUs, outpatient units, and all ICUs combined at Project ICARE hospitals, phase 2, January 1996 through December 1997

Antimicrobial-resistant pathogen	No. tested	Pooled mean	No. units	Resistance rates at key percentiles				
				10th	25th	50th	75th	90th
Inpatient non-ICU								
MRSA	15,978	31.9	40	13.9	19.0	33.2	43.1	49.2
Methicillin-resistant CNS	11,988	60.4	39	43.2	57.0	60.6	66.5	72.1
Vancomycin-resistant <i>Enterococcus</i>	14,669	7.3	39	0.0	1.3	3.5	9.0	17.0
Ciprofloxacin-resistant <i>Pseudomonas aeruginosa</i>	10,312	17.6	40	8.3	12.6	18.2	23.3	30.2
Imipenem-resistant <i>P aeruginosa</i>	8350	9.4	37	3.3	5.1	8.5	11.7	17.6
Ceftazidime-resistant <i>P aeruginosa</i>	10,461	7.2	39	2.1	3.8	6.4	11.3	15.0
Piperacillin-resistant <i>P aeruginosa</i>	8423	8.3	37	2.7	4.3	7.4	11.6	14.3
Cef3-resistant <i>Enterobacter</i> spp	4351	22.3	40	9.0	12.1	22.4	28.7	34.7
Cef3-resistant <i>Klebsiella pneumoniae</i>	7030	3.7	39	0.0	0.0	1.1	4.3	7.4
Cef3-resistant <i>Escherichia coli</i>	19,188	0.8	39	0.0	0.0	0.5	1.1	1.8
Quinolone-resistant <i>E coli</i>	17,836	1.4	39	0.0	0.2	1.0	1.6	2.7
Penicillin-resistant pneumococcus	1830	10.4	37	0.9	4.5	9.1	18.2	30.9
Outpatient								
MRSA	12,580	17.7	36	7.1	10.8	19.6	27.9	33.3
Methicillin-resistant CNS	8120	44.5	35	33.3	40.8	45.0	50.4	59.5
Vancomycin-resistant <i>Enterococcus</i>	8285	2.5	35	0.0	0.3	1.9	4.2	7.1
Ciprofloxacin-resistant <i>P aeruginosa</i>	5871	20.0	36	12.2	16.0	19.8	25.2	32.3
Imipenem-resistant <i>P aeruginosa</i>	4420	6.2	33	1.4	3.0	4.8	8.8	11.4
Ceftazidime-resistant <i>P aeruginosa</i>	5784	5.1	36	0.0	1.3	4.2	8.5	12.2
Piperacillin-resistant <i>P aeruginosa</i>	5028	6.0	33	0.0	1.6	4.2	6.8	14.3
Cef3-resistant <i>Enterobacter</i> spp	2265	10.1	34	2.6	4.8	8.2	11.4	18.8
Cef3-resistant <i>K pneumoniae</i>	5434	1.4	35	0.0	0.0	0.5	1.9	6.7
Cef3-resistant <i>E coli</i>	32,618	0.2	36	0.0	0.0	0.0	0.5	1.0
Quinolone-resistant <i>E coli</i>	28,314	0.7	35	0.0	0.0	0.4	1.1	1.9
Penicillin-resistant pneumococcus	1818	9.8	31	0.8	4.4	9.1	16.7	22.2
ICU								
MRSA	4303	35.9	77	11.4	20.1	36.8	53.8	65.2
Methicillin-resistant CNS	3959	76.0	70	59.4	66.7	77.1	83.9	87.0
Vancomycin-resistant <i>Enterococcus</i>	2750	10.4	65	0.0	0.0	5.6	14.8	19.2
Ciprofloxacin-resistant <i>P aeruginosa</i>	3398	16.5	71	4.2	7.7	10.7	21.1	33.3
Imipenem-resistant <i>P aeruginosa</i>	2968	11.4	65	0.0	1.9	10.2	15.8	24.0
Ceftazidime-resistant <i>P aeruginosa</i>	3373	10.4	69	0.0	2.0	7.5	15.2	24.5
Piperacillin-resistant <i>P aeruginosa</i>	2966	12.3	64	0.0	2.5	9.1	15.9	25.0
Cef3-resistant <i>Enterobacter</i> spp	1881	25.3	57	9.1	16.7	25.2	38.5	58.8
Cef3-resistant <i>K pneumoniae</i>	1711	3.7	53	0.0	0.0	0.0	5.6	10.0
Cef3-resistant <i>E coli</i>	2676	0.9	69	0.0	0.0	0.0	0.0	3.6
Quinolone-resistant <i>E coli</i>	2465	1.4	64	0.0	0.0	0.0	1.1	7.7
Penicillin-resistant pneumococcus	270	9.6	16	0.0	0.0	0.0	24.4	47.1

MRSA, Methicillin-resistant *Staphylococcus aureus*; CNS, coagulase-negative *Staphylococcus*; Cef3, ceftazidime, cefotaxime, or ceftriaxone; Quinolone, ciprofloxacin or ofloxacin.

Pharmacy data

The pharmacy data included in-hospital use of selected oral and parenteral antimicrobial agents in grams. For purpose of analysis, grams of antimicrobials were converted into number of defined daily doses (DDDs) used each month in each hospital area. A DDD is the typical number of grams of an antimicrobial used per day in a typical adult (Appendix C).^{6,7} Antimicrobial use was stratified by route of administration and hospital area. Because outpatient antimicrobial use could not be estimated reliably from hospital pharmacy records, we did not collect data on outpatient antimicrobial use.

Finally, antimicrobials with similar spectrum or clinical indications were grouped (Appendix C).^{1,6}

Statistical methods

To provide comparative feedback of data to the individual hospitals, the individual resistance rates were calculated at each institution, by hospital area. Data from each of the hospitals' areas were pooled during the entire study period beginning in January 1996 for at least 12 consecutive months. To calculate a single rate for each hospital area, we divided the number of resistant isolates by the total number of isolates for which susceptibility testing had been performed. Resistance rates and key

Table 1B. Antimicrobial resistance for pediatric and coronary care ICUs at Project ICARE hospitals, phase 2, January 1996 through December 1997

Antimicrobial-resistant pathogen	Pediatric ICUs			Coronary care ICUs		
	No. tested	Pooled mean	No. units	No. tested	Pooled mean	No. units
MRSA	227	5.7	5	447	28.4	13
Methicillin-resistant CNS	203	73.9	7	452	66.4	12
Vancomycin-resistant <i>Enterococcus</i>	56	3.6	3	257	3.1	10
Ciprofloxacin-resistant <i>P aeruginosa</i>	191	3.7	6	224	13.8	9
Imipenem-resistant <i>P aeruginosa</i>	135	17.8	5	135	10.4	6
Ceftazidime-resistant <i>P aeruginosa</i>	196	12.8	6	228	7.5	9
Piperacillin-resistant <i>P aeruginosa</i>	135	17.0	5	151	11.3	6
Cef3-resistant <i>Enterobacter</i> spp	69	36.2	3	85	17.6	4
Cef3-resistant <i>K pneumoniae</i>	32	0.0	2	176	2.8	9
Cef3-resistant <i>E coli</i>	45	0.0	2	336	0.6	11
Quinolone-resistant <i>E coli</i>	44	0.0	2	329	0.6	13
Penicillin-resistant pneumococcus	73	20.5	4	14	7.1	1

MRSA, Methicillin-resistant *Staphylococcus aureus*; CNS, coagulase-negative *Staphylococcus*; Cef3, ceftazidime, cefotaxime, or ceftriaxone; Quinolone, ciprofloxacin or ofloxacin.

percentile distributions were calculated for a particular hospital area only if ≥10 isolates were tested for susceptibility. To compare rates between hospital areas, a pooled mean resistance rate for each antimicrobial-resistant organism combination was calculated by pooling the data from all ICARE hospitals for each hospital area.

To control for the population at risk for receiving antimicrobial agents, we expressed use as a usage density rate: number of DDDs per 1000 patient-days (DDD/1000 patient-days). Use of antimicrobial agents was determined at each hospital, by hospital area. The pooled number of grams of each antimicrobial agent used, by hospital area, was divided by the number of grams per DDD for the specific antimicrobial agent, then divided by the pooled number of patient-days in the corresponding hospital area, and multiplied by 1000 to derive the number of DDDs per 1000 patient-days.

Participating hospitals

Forty-one hospitals reported data from 108 adult ICUs (20 coronary care, 12 cardiothoracic, 19 medical intensive care, 27 combined medical-surgical, 19 general-surgical, 6 neurosurgical, 5 others) for a median of 12 months (interquartile range 9-18 months). Forty hospitals reported data from non-ICU inpatient areas a median of 12 months (interquartile range 12-20 months) of data, and 38 reported data from the outpatient areas for a median of 12 months (interquartile range 12-18 months). Ten of these hospitals reported data on pediatric ICUs (median 12 months, range 6-24 months). Each Table summarizes the pooled mean rates and key percentile distributions for antimicrobial resistance and usage.

Resistance rates

Table 1A lists the rates of resistance for each of the specified antimicrobial resistant organisms for each

area of the hospital: inpatient non-ICU, outpatient, and all ICUs combined. However, rates for coronary care units and pediatric ICUs are not listed in Table 1A because these units had significantly different rates than other ICUs (Table 1B). Because <10 units reported sufficient numbers of tested isolates in these ICUs, no percentile distributions are displayed. Because patient-mix and severity of illness influence rates of antimicrobial resistance, comparison of rates within each of the listed hospital areas may facilitate interhospital comparison. For most of the organisms studied, the highest resistance rates occurred among isolates from ICU patients followed in decreasing order by rates among isolates from non-ICU inpatients and rates among isolates from outpatients.

Antimicrobial usage

Table 2 represents an expansion of previously published data on the relative rates of antimicrobial use in different hospital areas.¹ Overall, the median rate of antimicrobial use was higher in adult ICU areas than in non-ICU areas for most antimicrobial agents measured. In general, rates of use differed among different types of ICUs. Specific rates and percentile distributions are provided for coronary, medical, medical-surgical, general-surgical, and cardiothoracic ICUs. The number of units reporting from the neurosurgical, burn, respiratory, and trauma ICUs was insufficient to provide data in this report.

Comparisons

If you would like to compare your hospital's rates with the rates in this report, you must first collect information from your hospital in accordance with the methods described for Project ICARE in this report and elsewhere (www.sph.emory.edu/ICARE/prot.html).¹

Table 2. Antimicrobial usage rates (DDD/1000 patient-days) and key percentiles for inpatient non-ICUs, and each specific ICU type at Project ICARE hospitals, phase 2, January 1996 through December 1997

Antimicrobial agent(s)*	No. DDD	Pooled mean	Rate of use at key percentiles				
			10th	25th	50th	75th	90th
Inpatient non-ICU (n = 40)							
Penicillin group	36,672	8.6	1.8	3.0	5.2	9.7	14.9
Ampicillin group	282,143	65.8	41.2	51.6	65.8	81.5	103.8
Antipseudomonal penicillins	67,909	15.8	3.0	9.0	14.8	22.0	32.5
Antistaphylococcal penicillins	58,850	13.7	2.9	4.0	11.2	16.3	23.2
First-generation cephalosporins	329,808	76.9	43.7	60.2	78.9	104.4	120.9
Second-generation cephalosporins	210,651	49.1	19.6	27.4	41.9	64.8	78.0
Third-generation cephalosporins	333,796	77.8	34.5	52.3	77.4	113.8	141.1
Imipenem	26,045	6.1	0.3	1.4	4.5	9.1	16.7
Aztreonam	13,396	3.1	0.1	0.9	2.0	4.3	8.5
Fluoroquinolones	168,261	39.2	17.5	28.2	38.7	56.8	63.1
Trimethoprim/sulfamethoxazole	183,245	42.7	0.6	22.2	27.6	50.1	104.8
Vancomycin (oral)	9436	2.2	0.1	0.5	1.3	2.5	6.2
Vancomycin (parenteral)	116,293	27.1	13.0	16.4	20.8	29.2	56.9
Coronary care ICUs (n = 20)							
Penicillin group	318	5.2	0.0	0.4	3.7	8.1	15.9
Ampicillin group	2335	38.1	5.8	21.6	41.3	56.8	92.8
Antipseudomonal penicillins	1491	24.4	0.5	2.3	15.0	44.7	92.0
Antistaphylococcal penicillins	1219	19.9	0.0	2.0	13.2	28.1	44.0
First-generation cephalosporins	5615	91.7	9.1	26.5	39.5	59.7	330.5
Second-generation cephalosporins	2982	48.7	2.7	8.3	21.3	44.6	61.1
Third-generation cephalosporins	5296	86.5	21.2	41.8	87.3	146.2	171.7
Imipenem	394	6.4	0.0	0.0	3.2	8.9	24.7
Aztreonam	389	6.4	0.0	0.0	1.3	7.5	14.6
Fluoroquinolones	2639	43.1	3.5	16.2	33.8	58.0	104.6
Trimethoprim/sulfamethoxazole	1710	27.9	0.0	5.2	14.0	46.7	82.2
Vancomycin (oral)	286	4.7	0.0	0.0	0.0	0.5	1.2
Vancomycin (parenteral)	2141	35.0	9.2	15.5	25.6	48.3	108.9
Cardiothoracic ICUs (n = 12)							
Penicillin group	95	2.7	0.0	0.0	0.0	3.6	4.8
Ampicillin group	959	27.1	5.3	10.0	25.7	38.6	45.8
Antipseudomonal penicillins	989	28.0	0.7	8.4	22.5	44.4	51.0
Antistaphylococcal penicillins	397	11.2	0.0	0.0	2.4	8.0	18.6
First-generation cephalosporins	9596	271	74.6	196.1	305.0	430.8	465.4
Second-generation cephalosporins	1898	53.6	0.7	6.4	20.5	61.3	141.1
Third-generation cephalosporins	2942	83.1	16.5	28.0	74.6	90.5	120.7
Imipenem	523	14.8	0.0	0.8	4.5	16.7	37.5
Aztreonam	313	8.9	0.0	0.0	0.9	4.3	7.8
Fluoroquinolones	1692	47.8	7.8	14.9	31.4	55.5	86.2
Trimethoprim/sulfamethoxazole	345	9.7	0.0	0.0	3.4	8.8	13.6
Vancomycin (oral)	101	2.9	0.0	0.0	0.0	0.1	0.4
Vancomycin (parenteral)	4606	130	24.8	53.7	85.6	171.1	198.0
Medical ICUs (n = 19)							
Penicillin group	493	8.5	0.0	1.5	4.6	13.4	20.3
Ampicillin group	6692	115	39.4	56.2	96.9	100.6	206.6
Antipseudomonal penicillins	5103	87.6	2.7	28.0	80.3	119.4	180.1
Antistaphylococcal penicillins	1492	25.6	0.7	4.3	20.4	35.9	46.2
First-generation cephalosporins	1925	33.1	17.1	22.7	33.5	41.5	70.3
Second-generation cephalosporins	3121	53.6	7.2	13.9	51.0	69.0	102.0
Third-generation cephalosporins	12,129	208	74.8	140.4	173.7	275.8	382.5
Imipenem	1439	24.7	0.0	3.0	16.7	35.9	54.5
Aztreonam	431	7.4	0.0	0.2	5.4	6.7	24.1
Fluoroquinolones	4438	76.2	19.3	45.0	76.7	105.5	117.6
Trimethoprim/sulfamethoxazole	2792	47.9	0.0	14.6	35.5	51.3	95.7
Vancomycin (oral)	60	1.0	0.0	0.0	0.0	1.2	2.7
Vancomycin (parenteral)	4939	84.8	27.4	41.3	59.1	114.3	157.2

Table 2 continued

Antimicrobial agent(s)*	No. DDD	Pooled mean	Rate of use at key percentiles				
			10th	25th	50th	75th	90th
Medical-surgical ICUs (n = 27)							
Penicillin group	940	7.6	0.0	0.3	2.0	7.6	38.2
Ampicillin group	11,414	92.2	30.1	48.3	98.1	136.0	160.7
Antipseudomonal penicillins	7240	58.5	19.8	29.5	46.7	76.2	100.0
Antistaphylococcal penicillins	2829	22.8	0.0	4.9	14.3	23.9	60.5
First-generation cephalosporins	15,480	125	30.2	53.4	85.1	179.9	257.8
Second-generation cephalosporins	8539	69.0	7.4	23.2	47.4	72.4	103.9
Third-generation cephalosporins	23,961	194	94.0	125.3	200.7	273.6	322.1
Imipenem	3858	31.2	0.7	7.5	25.0	47.5	66.3
Aztreonam	1664	13.4	0.2	2.6	8.5	19.4	36.2
Fluoroquinolones	9945	80.3	9.6	36.7	64.4	101.3	134.9
Trimethoprim/sulfamethoxazole	5051	40.8	0.0	4.1	23.2	61.6	95.5
Vancomycin (oral)	513	4.1	0.0	0.0	0.8	3.2	14.7
Vancomycin (parenteral)	8379	67.7	25.6	38.7	53.2	81.3	134.2
Surgical ICUs (n = 19)							
Penicillin group	827	15.0	0.0	0.8	5.6	14.5	49.5
Ampicillin group	5968	109	49.8	72.4	97.5	150.6	197.9
Antipseudomonal penicillins	3456	62.9	2.9	25.2	58.0	89.7	138.8
Antistaphylococcal penicillins	1489	27.1	1.6	8.8	14.2	35.6	50.3
First-generation cephalosporins	11,635	212	94.7	143.3	195.2	365.5	557.2
Second-generation cephalosporins	3283	59.8	21.3	31.2	53.3	84.7	103.4
Third-generation cephalosporins	9089	165	95.6	102.8	142.8	206.6	249.8
Imipenem	1880	34.2	0.0	7.4	18.4	49.4	66.3
Aztreonam	713	13.0	1.4	5.8	10.9	13.4	36.1
Fluoroquinolones	4015	73.1	25.9	46.5	69.1	105.5	122.4
Trimethoprim/sulfamethoxazole	1961	35.7	1.7	9.9	17.9	33.3	68.7
Vancomycin (oral)	152	2.8	0.0	0.0	0.4	3.5	12.6
Vancomycin (parenteral)	6439	117	42.0	54.8	87.6	155.3	207.5
Pediatric ICUs (n = 10)							
Penicillin group	165	6.9	0.8	2.1	5.0	9.7	11.2
Ampicillin group	874	36.6	8.4	24.6	42.3	59.2	66.3
Antipseudomonal penicillins	357	14.9	0.0	0.7	5.4	24.0	47.7
Antistaphylococcal penicillins	574	24.0	3.0	12.1	22.3	27.4	65.2
First-generation cephalosporins	1019	42.6	7.8	14.4	39.4	74.9	126.3
Second-generation cephalosporins	696	29.1	5.5	11.1	25.5	48.6	70.7
Third-generation cephalosporins	4044	169	56.3	88.9	164.3	263.0	390.7
Imipenem	115	4.8	0.0	0.0	1.1	8.0	14.6
Aztreonam	64	2.7	0.0	0.0	0.0	0.1	12.3
Fluoroquinolones	193	8.1	0.0	0.5	5.0	7.9	26.5
Trimethoprim/sulfamethoxazole	374	15.6	0.0	0.0	4.5	10.1	61.5
Vancomycin (oral)	127	5.3	0.0	0.0	0.0	2.7	24.1
Vancomycin (parenteral)	1272	53.2	9.5	14.8	47.2	77.7	105.9

*Groupings and DDDs of agents are published previously.^{1,6}

In addition, for comparisons of antimicrobial use to be valid, utilization of similar DDDs as used in this report are necessary (Appendix C).^{1,6} For example, your pharmacy may report 130 g of parenteral vancomycin used during 400 patient-days in 3 months in your medical ICU. The rate of usage is determined by dividing 130 g by 2 DDD/g and dividing by 400 patient-days, then multiplying by 1000, resulting in 162.5 DDD/1000 patient-days. For the medical ICU, this value is above the 90th percentile, which may be interpreted as high compared with the rest of ICARE medical ICUs. In general, a high rate of resistance or use (>90th percentile) does not necessarily define a problem—it only suggests

an area for further investigation. Such investigation may include a review of vancomycin orders to determine the degree of appropriateness or necessity. Similarly, a low rate (<10th percentile) for use or resistance may be the result of inadequate reporting of pharmacy data or detection of resistant isolates.

Antimicrobial use is an important factor influencing the emergence of antimicrobial resistance, but it is only one of several important factors.⁸⁻¹⁰ However, the best method to monitor use is not known. Provision of ICARE data is one attempt to aid the infection control community in such efforts. Although we have made attempts to provide meaningful comparative rates, problems with

comparisons still exist. For example, specialized patient populations cared for on non-ICU wards who require unique or intensive therapy with specific agents in some hospitals may skew usage and resistance rates in these hospitals. Attempts to address these specialized patient populations, such as hematology-oncology or hemodialysis patients, are being made in the current phase (phase 3) of ICARE. Likewise, the laboratory-based reporting of all isolates done in Project ICARE parallels the type of reports many clinical microbiology laboratories generate, and minimizes data collection burden, but whether infection is associated with the isolate is uncertain. Regardless, these data do serve as a tool for the infection control community to roughly assess antimicrobial use and resistance in their hospitals.

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APPENDIX A.

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APPENDIX B

ICARE PERSONNEL

Rachel M. Lawton, MPH; Scott K. Fridkin, MD; Christine D. Steward, MPH; Jonathan R. Edwards, MS; Erica R. Pryor; John E. McGowan Jr, MD; Lennox K. Archibald, MD; Robert P. Gaynes, MD; Fred C. Tenover, PhD; Sarah C. Pichette, MPH; Jasmine Mohammed, MPH; Elise Felicione, MPH; Susannah Hubert; and Project ICARE Hospitals.

APPENDIX C.

CLASS, GROUPING AND DEFINED DAILY DOSE (DDD) OF ANTIMICROBIAL AGENTS, PHASE 2 ICARE

Class	Group	Antimicrobial agent	DDD	
β-lactams	Penicillin group	Penicillin G	12 × 106 U	
		Procaine Pen. G	2.4 × 106 U	
		Pen. G benzathine	1.2 × 106 U	
	Ampicillin group	Penicillin V	1 g	
		Ampicillin (parenteral)	4 g	
		Ampicillin (oral)	2 g	
		Ampicillin/sulbactam	6 g	
		Amoxicillin (oral)	1.5 g	
	Antistaphylococcal penicillins (Methicillin group)	Amoxicillin/clav. acid (oral)	1.5 g	
		Methicillin	4 g	
		Nafcillin	4 g	
		Oxacillin	4 g	
		Cloxacillin (oral)	2 g	
	Antipseudomonal penicillins	Dicloxacillin (oral)	2 g	
		Piperacillin	18 g	
		Piperacillin/tazobactam	13.5 g	
		Mezlocillin	18 g	
		Ticarcillin	18 g	
	First-generation cephalosporins	Ticarcillin/clav. acid	12.4 g	
		Cefazolin	3 g	
		Cephalothin	4 g	
		Cefadroxil (oral)	2 g	
		Cephalexin (oral)	2 g	
		Second-generation cephalosporins	Cefotetan	2 g
			Cefmetazole	4 g
			Cefoxitin	4 g
			Cefuroxime	3 g
			Cefuroxime axetil (oral)	1 g
	Third-generation cephalosporins	Cefaclor (oral)	1 g	
		Cefotaxime	3 g	
		Ceftazidime	3 g	
		Ceftizoxime	3 g	
		Ceftriaxone	1 g	
Cefixime (oral)		0.4 g		
Cefoperazone		4 g		
Imipenem cilastatin		2 g		
Other β-lactams	Aztreonam	4 g		
	Vancomycin (parenteral)	2 g		
Glycopeptides	Vancomycin (oral)	1 g		
	Fluoroquinolones	Ciprofloxacin (parenteral)	0.8 g	
Trimethoprim/sulfamethoxazole	Ciprofloxacin (oral)	1.5 g		
	Ofloxacin (parenteral)	0.8 g		
	Ofloxacin (oral)	0.8 g		
	Trimethoprim component (oral)	0.32 g		
	Trimethoprim component (IV)	0.84 g		