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Antimicrobial Susceptibility of 49,319 Pathogens Isolated from Patients in Canadian Hospitals: 12 Years of the CANWARD Study 2007-2018

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Introduction

Antimicrobial resistant Gram-positive organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA, community associated [CA] and healthcare associated [HA]), vancomycin-resistant *Enterococcus species* (VRE), penicillin-resistant *Streptococcus pneumoniae*, and Gram-negative bacilli such as extended spectrum β-lactamase (ESBL) producing *Escherichia coli* and *Klebsiella* species as well as fluoroquinolone-resistant and carbapenem-resistant Enterobacteriaceae and *Pseudomonas aeruginosa* are increasing in prevalence in Canada and around the world (1, 2). Available therapeutic options for the treatment of these antibiotic resistant organisms are limited as these organisms frequently display a multidrug resistant (MDR) and potentially an extremely drug resistant (XDR) phenotype (1, 2).

CANWARD (a collaboration between the Canadian Antimicrobial Resistance Alliance and the National Microbiology Laboratory) is a national ongoing surveillance study which assess pathogens associated with and antimicrobial resistance patterns in respiratory, bacteremic, urinary, and wound/IV site infections in Canadian hospitalized patients on medical/surgical wards, intensive care units, emergency rooms and outpatient clinics.

Materials and Methods

Participating Sites

From January 2007 to October 2018, tertiary-care medical centres in major population centres in 8 of the 10 provinces in Canada were recruited (1, 2). These sites were geographically distributed in a population based fashion.

Bacterial Isolates

Tertiary-care medical centres submitted pathogens from patients attending hospital clinics, emergency rooms, medical and surgical wards, and intensive care units. Each study site was asked to submit clinical isolates (consecutive, one per patient, per infection site) from inpatients and outpatients with respiratory, urine, wound, and bloodstream infections. Isolate identification was performed by the submitting site and confirmed at the reference site as required, based on morphological characteristics and antimicrobial susceptibility patterns. Isolates were shipped on Amies semi-solid transport media to the coordinating laboratory (Health Sciences Centre, Winnipeg, Canada), subcultured onto appropriate media, and stocked in skim milk at -80ºC until minimum inhibitory concentration (MIC) testing was carried out. From 2007-2018, 7718, 5283, 5373, 4960, 3785, 2802, 3511, 3172, 3206, 3126, 3420 and 2963 isolates were collected in each study year (1, 2).

Antimicrobial Susceptibilities

The *in vitro* activity of selected antimicrobials was determined by broth microdilution in accordance with (CLSI) guidelines (3). Antimicrobial minimum inhibitory concentration (MIC) interpretive standards were defined according to CLSI breakpoints (4). The MICs of the antimicrobial agents were determined using 96-well custom designed microtitre plates. These plates contained doubling antimicrobial dilutions in 100µL/well of cation adjusted Mueller-Hinton broth and inoculated to achieve a final concentration of approximately 5 x 10^5 CFU/mL then incubated in ambient air for 24 hours prior to reading. Colony counts were performed periodically to confirm inocula. Quality control was performed using ATCC QC organisms including *S. pneumoniae* 49619, *S. aureus* 29213, *E. faecalis* 29212, *E. coli* 25922, and *P. aeruginosa* 27853.

Results

Table 1. Antimicrobial activity against the most common Gram-positive cocci isolated from Canadian hospitals

Organism (no. tested) / Antimicrobial Agent	% S	% I	% R	MIC (µg/mL) MIC$_{50}$	MIC$_{90}$	Range Min	Range Max
Staphylococcus aureus, MSSA (8243)							
Cefoxitin	99.6		0.4	4	4	0.12	> 32
Ceftobiprole[a]	100.0			≤ 1	≤ 1	≤ 1	2
Ceftriaxone				4	4	≤ 0.25	256
Ciprofloxacin	86.5	3.1	10.4	0.5	4	≤ 0.06	> 16
Clarithromycin	75.7	0.6	23.7	0.25	> 32	≤ 0.03	> 32
Clindamycin	93.6	0.4	5.9	≤ 0.25	≤ 0.25	≤ 0.25	> 8
Daptomycin	99.99		0.01	0.25	0.5	≤ 0.03	2
Doxycycline	98.9	0.8	0.4	≤ 0.12	0.25	≤ 0.12	32
Gentamicin	98.14	0.09	1.77	≤ 0.5	≤ 0.5	≤ 0.5	> 32
Levofloxacin	90.35	0.00	9.28	0.25	1	≤ 0.06	> 32
Linezolid	99.99		0.01	2	4	≤ 0.12	> 16
Moxifloxacin	90.6	0.8	8.6	≤ 0.06	0.25	≤ 0.06	> 16
Nitrofurantoin	99.88	0.03	0.09	16	16	≤ 0.5	256
Telavancin	100.0			0.06	0.06	0.008	0.12
Tigecycline[b]	99.8		0.2	0.12	0.25	≤ 0.03	2
Tobramycin	97.3	0.3	2.5	≤ 0.5	≤ 0.5	≤ 0.5	> 64
Trimethoprim Sulfa	99.5		0.5	≤ 0.12	≤ 0.12	≤ 0.12	> 8
Vancomycin	100.0			1	1	≤ 0.12	2
Staphylococcus aureus, MRSA (2214)							
Cefoxitin	0.2		99.8	> 32	> 32	1	> 32
Ceftobiprole	100.0			≤ 1	≤ 1	≤ 1	4
Ceftriaxone				> 64	> 64	2	> 256
Ciprofloxacin	18.5	0.3	81.2	> 16	> 16	≤ 0.06	> 16
Clarithromycin	16.0	0.4	83.6	> 32	> 32	≤ 0.03	> 32
Clindamycin	56.0	0.0	44.0	≤ 0.12	> 8	≤ 0.12	> 8
Daptomycin	99.9		0.1	0.25	0.5	0.06	4
Doxycycline	97.7	0.9	1.4	≤ 0.12	1	≤ 0.12	16
Gentamicin	93.2	0.3	6.5	≤ 0.5	1	≤ 0.5	> 32
Levofloxacin	16.5		83.5	> 32	> 32	0.12	> 32
Linezolid	100.0			2	4	≤ 0.12	4
Moxifloxacin	19.0	3.8	77.2	8	> 16	≤ 0.06	> 16
Nitrofurantoin	99.8	0.1	0.1	16	16	8	128
Telavancin	100.0			0.06	0.06	0.008	0.12
Tigecycline	98.8		1.2	0.25	0.5	≤ 0.03	2
Tobramycin	61.5	0.8	37.7	≤ 0.5	> 64	≤ 0.5	> 64
Trimethoprim Sulfa	94.4		5.6	≤ 0.12	≤ 0.12	≤ 0.12	> 8
Vancomycin	99.9	0.1		1	1	≤ 0.12	4
Staphylococcus epidermidis (1099)							
Amox-Clav				1	8	≤ 0.06	32
Cefazolin				1	32	≤ 0.5	> 128
Cefepime				4	64	≤ 0.25	128
Cefoxitin				8	> 32	≤ 0.06	> 32
Ceftobiprole				≤ 1	≤ 1	≤ 1	4
Ceftriaxone				8	> 64	≤ 1	> 64
Ciprofloxacin	46.0	1.5	52.6	4	> 16	≤ 0.06	> 16
Clarithromycin	33.7	1.4	64.9	> 32	> 32	≤ 0.03	> 32
Clindamycin	58.1	1.5	40.4	≤ 0.12	> 8	≤ 0.12	> 8
Daptomycin	99.9		0.1	0.25	0.25	≤ 0.03	2
Doxycycline	96.0	1.8	2.2	0.25	1	≤ 0.12	32
Gentamicin	58.7	6.1	35.2	≤ 0.5	> 32	≤ 0.5	> 32
Levofloxacin	47.3	1.1	51.6	4	> 32	0.12	> 32
Linezolid	100.0			0.5	1	≤ 0.12	4
Moxifloxacin	47.8	8.9	43.3	1	> 16	≤ 0.06	> 16
Pip-Tazo				≤ 1	16	≤ 1	128
Telavancin				0.06	0.12	0.004	0.5
Tigecycline	99.3		0.7	0.12	0.5	≤ 0.03	1
Tobramycin				≤ 0.5	32	≤ 0.5	> 64
Trimethoprim Sulfa	60.9		39.1	1	8	≤ 0.12	> 8
Vancomycin	100.0			1	2	≤ 0.25	4
Streptococcus pneumoniae (2868)							
Amox-Clav	97.8	1.4	0.8	≤ 0.06	0.12	≤ 0.06	16
Ceftobiprole	99.9			≤ 0.06	≤ 0.06	≤ 0.06	1
Ceftriaxone	99.5	0.4	0.1	≤ 0.12	≤ 0.12	≤ 0.06	4
Cefuroxime	93.2	1.9	4.9	≤ 0.25	≤ 0.25	≤ 0.25	> 16
Chloramphenicol	98.0		2.0	2	4	≤ 0.12	32
Ciprofloxacin	97.1		2.9	1	2	≤ 0.06	> 16
Clarithromycin	78.5	3.3	18.1	≤ 0.03	4	≤ 0.03	> 32
Clindamycin	92.6	0.5	6.8	≤ 0.12	≤ 0.12	≤ 0.12	> 64
Daptomycin				≤ 0.06	0.12	≤ 0.06	0.5
Doxycycline	86.6	1.2	12.2	≤ 0.25	2	≤ 0.25	> 16
Ertapenem	99.0	1.0	0.0	≤ 0.06	0.12	≤ 0.06	4
Imipenem	93.4	4.7	1.9	≤ 0.03	≤ 0.03	≤ 0.03	1
Levofloxacin	99.0	0.2	0.8	1	1	≤ 0.06	16
Linezolid	100.0		0.0	1	1	≤ 0.12	4
Meropenem	95.2	3.1	1.7	≤ 0.06	≤ 0.06	≤ 0.06	2
Moxifloxacin	99.1	0.4	0.4	0.12	0.25	≤ 0.06	8
Penicillin	82.6	13.0	4.4	≤ 0.03	0.25	≤ 0.03	> 8
Pip-Tazo				≤ 1	≤ 1	≤ 1	8
Telavancin				0.015	0.015	≤ 0.002	0.06
Tigecycline	99.7		0.3	0.03	0.06	≤ 0.015	0.25
Trimethoprim Sulfa	85.2	6.1	8.7	≤ 0.12	2	≤ 0.12	> 8
Vancomycin	100.0			≤ 0.25	≤ 0.25	≤ 0.25	1
Streptococcus agalactiae (792)							
Amox-Clav				≤ 0.06	≤ 0.06	≤ 0.06	0.25
Ceftobiprole				≤ 0.06	≤ 0.06	≤ 0.06	≤ 0.06
Ceftriaxone	100.0			≤ 0.12	≤ 0.12	≤ 0.06	0.5
Cefuroxime				≤ 0.25	≤ 0.25	≤ 0.25	0.5
Chloramphenicol	96.8	2.9	0.2	4	4	0.5	16
Ciprofloxacin				0.5	1	0.25	> 16
Clarithromycin	66.1	3.6	30.3	≤ 0.03	> 32	≤ 0.03	> 32
Clindamycin	81.1	0.8	18.1	≤ 0.12	> 64	≤ 0.12	> 64
Daptomycin	100.0			0.25	0.25	≤ 0.03	1
Doxycycline				8	16	≤ 0.25	> 16
Ertapenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06	0.12
Imipenem				≤ 0.03	≤ 0.03	≤ 0.03	0.12
Levofloxacin	96.3		3.7	0.5	1	0.25	> 32
Linezolid	97.4		2.6	1	2	≤ 0.12	4
Meropenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06	0.12
Moxifloxacin				0.12	0.25	≤ 0.06	16
Penicillin	99.8		0.2	0.06	0.12	≤ 0.03	0.25
Pip-Tazo				≤ 1	≤ 1	≤ 1	≤ 1
Telavancin	100.0			0.06	0.06	0.015	0.12
Tigecycline	99.8		0.2	0.06	0.12	≤ 0.015	1
Trimethoprim Sulfa				≤ 0.12	≤ 0.12	≤ 0.12	1
Vancomycin	100.0			0.5	0.5	≤ 0.25	1
Streptococcus pyogenes (724)							
Amox-Clav				≤ 0.06	≤ 0.06	≤ 0.06	1
Ceftobiprole				≤ 0.06	≤ 0.06	≤ 0.06	0.5
Ceftriaxone	100.0			≤ 0.12	≤ 0.12	≤ 0.06	0.25
Cefuroxime				≤ 0.25	≤ 0.25	≤ 0.25	1
Chloramphenicol	97.1	2.6	0.3	2	4	0.5	32
Ciprofloxacin				0.5	1	≤ 0.06	> 16
Clarithromycin	89.4	1.9	8.7	≤ 0.03	0.5	≤ 0.03	> 32
Clindamycin	98.0		2.0	≤ 0.12	≤ 0.12	≤ 0.12	> 64
Daptomycin	100.0			0.06	0.12	≤ 0.03	0.25
Doxycycline				≤ 0.25	0.5	≤ 0.25	> 16
Ertapenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06	1
Imipenem				≤ 0.03	≤ 0.03	≤ 0.03	0.25
Levofloxacin	99.8		0.2	0.5	1	≤ 0.06	16
Linezolid	99.3		0.7	1	2	≤ 0.12	4
Meropenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06	0.25
Moxifloxacin				0.12	0.25	≤ 0.06	4
Penicillin	100.0			≤ 0.03	≤ 0.03	≤ 0.03	0.12
Pip-Tazo				≤ 1	≤ 1	≤ 1	4
Telavancin	100.0			0.03	0.06	0.015	0.06
Tigecycline	100.0			0.03	0.06	≤ 0.015	0.25
Trimethoprim Sulfa				≤ 0.12	≤ 0.12	≤ 0.12	> 8
Vancomycin	100.0			0.5	0.5	≤ 0.12	1
Enterococcus faecalis (1424)							
Amox-Clav				0.5	1	≤ 0.06	32
Ceftobiprole				≤ 1	≤ 1	≤ 1	> 16
Ciprofloxacin	62.5	10.8	26.7	1	> 16	≤ 0.06	> 16
Clarithromycin				2	> 32	≤ 0.03	> 32
Daptomycin	88.8	11.2		0.5	2	≤ 0.03	4
Doripenem				4	4	0.12	16
Doxycycline	36.6	41.3	22.1	8	16	≤ 0.12	32
Ertapenem				16	16	0.25	> 32
Imipenem				1	2	0.25	8
Levofloxacin	63.9	1.8	34.4	2	> 32	0.5	> 32
Linezolid	91.4	8.6		2	2	0.5	4
Meropenem				4	8	≤ 0.06	> 32
Moxifloxacin				0.25	16	≤ 0.06	> 16
Nitrofurantoin	99.5	0.5		8	16	≤ 0.5	64
Pip-Tazo				4	4	≤ 1	> 512
Tigecycline	98.1		1.9	0.12	0.25	≤ 0.03	1
Tobramycin				16	> 64	≤ 0.5	> 64
Vancomycin	100.0			1	2	0.25	4
Enterococcus faecium (572)							
Amox-Clav				> 32	> 32	≤ 0.06	> 32
Ceftobiprole				> 16	> 16	≤ 1	> 16
Ciprofloxacin	6.9	1.6	91.5	> 16	> 16	0.25	> 16
Clarithromycin				> 32	> 32	≤ 0.03	> 32
Daptomycin	58.9	40.9	0.2	1	2	≤ 0.03	8
Doripenem				> 32	> 32	0.12	> 32
Doxycycline	69.9	7.3	22.8	1	16	≤ 0.12	32
Ertapenem				> 32	> 32	0.5	> 32
Imipenem				> 32	> 32	0.12	> 32
Levofloxacin	5.1		95.0	> 32	> 32	1	> 32
Linezolid	88.8	10.6	0.5	2	4	≤ 0.12	16
Meropenem				> 32	> 32	0.25	> 64
Moxifloxacin				> 16	> 16	0.12	> 16
Nitrofurantoin	37.3	31.2	31.6	64	128	≤ 0.5	> 512
Pip-Tazo				> 512	> 512	≤ 1	> 512
Tigecycline	98.9		1.1	0.12	0.12	≤ 0.03	2
Tobramycin				64	> 64	4	> 64
Vancomycin	76.8	0.2	23.0	1	> 32	≤ 0.12	> 32

Amox-Clav, Amoxicillin-Clavulanate; Pip-Tazo, Piperacillin-Tazobactam

[a] For tigecycline, FDA breakpoints applied.
[b] For ceftobiprole, Health Canada breakpoints applied. Not all isolates tested with ceftobiprole.

Table 2. Antimicrobial activity against the most common Gram-negative bacilli isolated from Canadian hospitals

Organism (no. tested) / Antimicrobial Agent	% S	% I	% R	MIC (µg/mL) MIC$_{50}$	MIC$_{90}$	Range Min	Range Max
Escherichia coli (9591)							
Amikacin	99.6	0.2	0.1	≤2	4	≤2	> 64
Amox-Clav	83.4	11.7	4.9	4	16	≤ 0.06	> 32
Cefazolin	69.9	11.7	18.4	2	32	≤ 0.5	> 128
Cefepime	94.3	2.4	3.4	≤ 1	≤ 1	≤ 1	> 32
Cefoxitin	92.0	4.3	3.8	4	8	≤ 0.06	> 32
Ceftazidime	92.7	1.1	6.1	≤ 0.25	2	≤ 0.25	> 32
Ceftobiprole[a]	93.3	0.2	6.5	≤ 1	≤ 1	≤ 1	> 16
Ceftol-Tazo	99.4	0.2	0.5	0.25	0.5	≤ 0.12	> 64
Ceftriaxone	91.1	0.3	8.6	≤ 1	≤ 1	≤ 1	> 64
Ciprofloxacin	74.5	1.4	24.0	≤ 0.06	> 16	≤ 0.06	> 16
Colistin	99.7		0.3	0.25	0.5	≤ 0.06	> 16
Doxycycline	72.4	6.0	21.6	2	32	0.25	> 32
Ertapenem	99.7	0.2	0.2	≤ 0.06	≤ 0.06	≤ 0.06	> 32
Gentamicin	90.7	0.4	8.9	≤ 0.5	2	≤ 0.5	> 32
Imipenem	99.90	0.06	0.04	0.25	0.25	≤ 0.03	> 32
Levofloxacin	76.7	1.6	21.7	≤ 0.06	16	≤ 0.06	> 32
Meropenem	99.98		0.02	≤ 0.12	≤ 0.12	≤ 0.12	> 32
Moxifloxacin				≤ 0.06	> 16	≤ 0.06	> 16
Nitrofurantoin	97.2	1.8	0.9	16	32	≤ 0.5	> 512
Pip-Tazo	97.4	1.3	1.4	2	4	≤ 1	> 512
Tigecycline[b]	99.97	0.03		0.25	0.5	≤ 0.03	4
Tobramycin	91.6	3.2	5.3	≤ 0.5	4	≤ 0.5	> 64
Trimethoprim Sulfa	73.2		26.8	≤ 0.12	> 8	≤ 0.12	> 8
ESBL *E. coli* (674)							
Amikacin	97.6	2.1	0.3	2	8	≤ 1	> 64
Amox-Clav	49.8	37.9	12.3	16	32	1	> 32
Cefazolin		0.1	99.9	> 128	> 128	4	> 128
Cefepime	27.2	30.0	42.9	8	> 64	≤ 1	> 64
Cefoxitin	79.2	12.2	8.6	8	16	0.5	> 32
Ceftazidime	30.4	11.0	58.6	16	> 32	≤ 0.5	> 32
Ceftobiprole	3.1	1.7	95.2	> 16	> 16	≤ 1	> 16
Ceftol-Tazo	96.7	1.2	2.0	0.25	1	≤ 0.12	> 64
Ceftriaxone	1.8	1.3	96.9	> 64	> 64	≤ 0.25	> 64
Ciprofloxacin	10.5	0.6	88.9	> 16	> 16	≤ 0.06	> 16
Colistin	99.5		0.5	0.25	1	≤ 0.06	8
Doxycycline	31.2	15.6	53.3	16	> 32	0.25	> 32
Ertapenem	97.6	1.2	1.2	≤ 0.06	0.25	≤ 0.06	> 32
Gentamicin	62.0	1.5	36.5	1	> 32	≤ 0.5	> 32
Imipenem	99.8		0.2	0.25	0.25	0.06	8
Levofloxacin	11.6	1.3	87.1	16	32	≤ 0.06	> 32
Meropenem	99.9		0.1	≤ 0.12	≤ 0.12	≤ 0.12	32
Moxifloxacin				16	> 16	≤ 0.06	> 16
Nitrofurantoin	92.2	5.2	2.5	16	32	≤ 1	256
Pip-Tazo	92.4	4.3	3.3	4	16	≤ 1	> 512
Tigecycline	99.9	0.1		0.5	1	0.12	4
Tobramycin	56.2	7.4	36.4	4	32	≤ 0.5	> 64
Trimethoprim Sulfa	32.8		67.2	> 8	> 8	≤ 0.12	> 8
Klebsiella pneumoniae (3061)							
Amikacin	99.7	0.1	0.2	≤ 1	2	≤ 1	> 64
Amox-Clav	92.8	3.9	3.4	2	8	≤ 0.06	> 32
Cefazolin	82.5	6.0	11.5	1	8	≤ 0.5	> 128
Cefepime	95.6	1.6	2.8	≤ 1	≤ 1	≤ 1	> 32
Cefoxitin	91.1	3.9	5.0	4	8	0.12	> 32
Ceftazidime	95.0	0.5	4.5	≤ 0.25	1	≤ 0.25	> 32
Ceftobiprole	94.3	0.5	5.2	≤ 1	≤ 1	≤ 1	> 16
Ceftol-Tazo	97.6	0.4	2.0	0.25	0.5	≤ 0.12	> 64
Ceftriaxone	93.9	0.4	5.7	≤ 1	≤ 1	≤ 1	> 64
Ciprofloxacin	87.0	3.7	9.3	≤ 0.06	0.5	≤ 0.06	> 16
Colistin	97.8		2.2	0.5	1	≤ 0.06	> 16
Doxycycline	80.2	4.6	15.2	2	16	≤ 0.12	> 32
Ertapenem	99.0	0.3	0.6	≤ 0.06	≤ 0.06	≤ 0.06	> 32
Gentamicin	96.6	0.2	3.2	≤ 0.5	≤ 0.5	≤ 0.5	> 32
Imipenem	98.8	0.6	0.7	0.25	0.5	0.06	> 32
Levofloxacin	87.5	4.5	8.1	≤ 0.06	1	≤ 0.06	> 32
Meropenem	99.6	0.1	0.3	≤ 0.03	0.06	≤ 0.03	> 32
Moxifloxacin				0.12	1	≤ 0.06	> 16
Nitrofurantoin	41.9	34.0	24.1	64	128	1	> 512
Pip-Tazo	96.3	1.4	2.3	2	8	≤ 1	> 512
Tigecycline	95.5	3.8	0.7	1	2	0.06	> 16
Tobramycin	95.2	2.2	2.6	≤ 0.5	≤ 0.5	≤ 0.5	> 64
Trimethoprim Sulfa	89.6		10.4	≤ 0.12	4	≤ 0.12	> 8
Stenotrophomonas maltophilia (841)							
Cefepime				32	> 64	≤ 0.25	> 128
Ceftazidime	23.7	7.1	69.2	> 32	> 32	0.5	> 32
Ceftobiprole				> 16	> 16	≤ 1	> 16
Ceftol-Tazo				32	> 64	≤ 0.12	> 64
Ciprofloxacin				2	16	≤ 0.06	> 16
Colistin				8	> 16	0.12	> 16
Doxycycline				2	8	0.25	> 32
Levofloxacin	66.8	12.9	20.3	2	8	≤ 0.06	> 32
Moxifloxacin				1	4	≤ 0.06	> 16
Nitrofurantoin				> 512	> 512	32	> 512
Tigecycline				1	4	0.12	16
Trimethoprim Sulfa	97.7		2.3	0.25	1	≤ 0.12	> 8
Acinetobacter baumannii (202)							
Amikacin	95.0		5.0	≤ 2	4	≤ 2	> 64
Cefepime	83.3	6.3	10.3	4	32	≤ 0.25	> 128
Ceftazidime	78.5	9.0	12.4	8	32	1	> 32
Ceftobiprole				≤ 1	4	≤ 1	> 16
Ceftol-Tazo				0.5	8	≤ 0.12	> 64
Ceftriaxone	44.6	45.0	10.4	16	64	1	> 256
Ciprofloxacin	92.1	1.0	6.9	0.25	1	≤ 0.06	32
Colistin	97.9		2.1	1	2	0.25	> 16
Gentamicin	91.1	2.0	6.9	≤ 0.5	2	≤ 0.5	> 32
Levofloxacin	92.2		7.8	0.12	1	≤ 0.06	> 16
Meropenem	93.6	2.0	4.5	0.5	2	0.06	> 32
Moxifloxacin				≤ 0.06	0.25	≤ 0.06	> 16
Nitrofurantoin				512	> 512	128	> 512
Pip-Tazo	80.7	9.9	9.4	2	64	≤ 1	> 512
Tigecycline				0.5	2	0.12	> 16
Trimethoprim Sulfa	89.6		10.4	≤ 0.12	4	≤ 0.12	> 8
Pseudomonas aeruginosa (4522)							
Amikacin	91.9	3.5	4.6	4	16	≤ 1	> 64
Cefepime	81.4	12.2	6.4	4	16	≤ 0.25	> 128
Ceftazidime	81.0	6.5	12.5	4	32	≤ 0.25	> 32
Ceftobiprole				4	16	≤ 1	> 16
Ceftol-Tazo	97.7	1.1	1.2	0.5	2	≤ 0.12	> 64
Ciprofloxacin	66.4	9.8	23.9	0.25	4	≤ 0.06	> 16
Colistin	95.5		4.5	1	2	≤ 0.06	> 16
Gentamicin	80.7	8.7	10.6	2	16	≤ 0.5	> 32
Imipenem	66.5	10.4	23.1	2	16	≤ 0.03	> 32
Levofloxacin	52.9	10.6	36.5	1	16	≤ 0.06	> 32
Meropenem	80.5	6.6	12.8	0.5	8	≤ 0.03	> 64
Moxifloxacin				2	> 16	≤ 0.06	> 16
Nitrofurantoin				> 512	> 512	≤ 0.5	> 512
Pip-Tazo	82.7	8.9	8.4	4	64	≤ 1	> 512
Tigecycline				16	> 16	0.25	> 16
Tobramycin	93.1	1.4	5.4	≤ 0.5	2	≤ 0.5	> 64
Trimethoprim Sulfa				8	> 8	≤ 0.12	> 8
Enterobacter cloacae (1183)							
Amikacin	100.0			≤ 2	≤ 2	≤ 2	16
Cefepime	94.7	4.2	1.1	≤ 0.25	2	≤ 0.25	> 64
Ceftazidime	77.3	1.1	21.6	0.5	> 32	≤ 0.25	> 32
Ceftobiprole	86.6	3.9	9.5	≤ 1	2	≤ 1	> 16
Ceftol-Tazo	83.8	4.5	11.7	0.25	8	≤ 0.12	> 64
Ceftriaxone	73.2	2.0	24.9	≤ 1	> 64	≤ 1	> 64
Ciprofloxacin	92.6	0.9	6.5	≤ 0.06	0.12	≤ 0.06	> 16
Colistin	81.4		18.6	0.5	> 16	≤ 0.06	> 16
Ertapenem	90.8	5.6	3.6	0.06	0.5	≤ 0.03	> 32
Gentamicin	97.6	0.2	2.2	≤ 0.5	≤ 0.5	≤ 0.5	> 32
Imipenem	95.6	2.9	1.5	0.5	1	0.06	> 32
Levofloxacin	92.9	1.2	5.9	≤ 0.06	0.5	≤ 0.06	32
Meropenem	99.5	0.3	0.2	≤ 0.12	≤ 0.12	≤ 0.12	> 32
Moxifloxacin				≤ 0.06	0.5	≤ 0.06	> 16
Nitrofurantoin	40.6	42.6	16.9	64	128	1	> 512
Pip-Tazo	84.6	8.4	7.0	2	64	≤ 1	> 512
Tigecycline	95.1	3.1	1.7	0.5	1	0.12	16
Trimethoprim Sulfa	92.4		7.6	≤ 0.12	1	≤ 0.12	> 8
Proteus mirabilis (727)							
Amikacin	99.4	0.6		2	4	≤ 1	32
Amox-Clav	95.5	1.4	3.1	1	4	0.5	> 32
Cefazolin	3.7	59.3	37.0	4	8	1	> 128
Cefepime	99.7	0.2	0.2	≤ 1	≤ 1	≤ 1	16
Cefoxitin	96.3	2.5	1.2	4	4	≤ 0.06	> 32
Ceftazidime	98.8	0.5	0.7	≤ 0.5	≤ 0.5	≤ 0.5	32
Ceftobiprole	99.3	0.2	0.5	≤ 1	≤ 1	≤ 1	16
Ceftol-Tazo	99.7	0.3		0.5	0.5	≤ 0.12	4
Ceftriaxone	97.9	1.0	1.1	≤ 1	≤ 1	≤ 1	> 64
Ciprofloxacin	83.2	0.8	16.0	≤ 0.06	2	≤ 0.06	> 16
Doxycycline	0.8	0.6	98.6	> 32	> 32	4	> 32
Ertapenem	99.8	0.2		≤ 0.06	≤ 0.06	≤ 0.06	1
Gentamicin	94.4	1.2	4.4	1	2	≤ 0.5	> 32
Imipenem	47.1	30.3	22.7	2	4	0.12	16
Levofloxacin	79.3	3.1	17.6	0.12	2	≤ 0.06	> 32
Meropenem	100.0			0.06	0.12	≤ 0.03	1
Moxifloxacin				0.5	16	≤ 0.06	> 16
Pip-Tazo	99.7	0.3		≤ 1	≤ 1	≤ 1	64
Tobramycin	95.0	2.0	3.1	≤ 0.5	2	≤ 0.5	> 64
Trimethoprim Sulfa	83.1		16.9	≤ 0.12	> 8	≤ 0.12	> 8
Klebsiella oxytoca (795)							
Amikacin	99.9		0.1	≤ 1	2	≤ 1	> 64
Amox-Clav	87.9	5.2	6.9	2	16	1	> 32
Cefazolin	24.8	20.3	54.9	8	> 128	≤ 0.5	> 128
Cefepime	97.8	1.5	0.7	≤ 1	≤ 1	≤ 1	> 32
Cefoxitin	96.3	2.1	1.7	2	8	0.5	> 32
Ceftazidime	98.3	0.1	1.6	≤ 0.25	1	≤ 0.25	> 32
Ceftobiprole	86.7	1.9	11.4	≤ 1	8	≤ 1	> 16
Ceftol-Tazo	99.1	0.7	0.2	0.25	0.5	≤ 0.12	32
Ceftriaxone	90.2	1.6	8.2	≤ 0.25	1	≤ 0.25	> 64
Ciprofloxacin	96.2	0.8	3.0	≤ 0.06	≤ 0.06	≤ 0.06	> 16
Colistin	98.3		1.7	0.25	1	≤ 0.06	> 16
Doxycycline	93.7	2.5	3.8	1	2	0.25	> 32
Ertapenem	99.9	0.0	0.1	≤ 0.06	≤ 0.06	≤ 0.06	2
Gentamicin	98.1	0.4	1.5	≤ 0.5	≤ 0.5	≤ 0.5	> 32
Imipenem	100.0			0.25	0.5	0.12	1
Levofloxacin	94.9	1.8	3.3	≤ 0.06	0.25	≤ 0.06	> 32
Meropenem	100.0			≤ 0.03	0.06	≤ 0.03	1
Moxifloxacin				≤ 0.06	0.25	≤ 0.06	> 16
Nitrofurantoin	85.9	12.2	1.9	32	64	4	256
Pip-Tazo	88.8	1.0	10.2	2	128	≤ 1	> 512
Tigecycline	99.4	0.5	0.1	0.5	1	0.06	8
Tobramycin	98.9	0.2	0.9	≤ 0.5	≤ 0.5	≤ 0.5	64
Trimethoprim Sulfa	95.7		4.3	≤ 0.12	≤ 0.12	≤ 0.12	> 8
Klebsiella aerogenes (309)							
Amikacin	100.0			≤ 1	2	≤ 1	8
Cefepime	98.5	0.8	0.8	≤ 1	≤ 1	≤ 1	16
Ceftazidime	73.9	2.6	23.5	0.5	> 32	≤ 0.25	> 32
Ceftobiprole	98.6		1.4	≤ 1	≤ 1	≤ 1	> 16
Ceftol-Tazo	87.9	6.4	5.8	0.25	4	≤ 0.12	32
Ceftriaxone	72.8	0.7	26.6	≤ 0.25	32	≤ 0.25	> 64
Ciprofloxacin	91.8	2.3	5.9	≤ 0.06	0.25	≤ 0.06	> 16
Colistin	98.2		1.8	0.25	0.5	0.12	> 16
Ertapenem	92.3	4.9	2.8	0.12	0.5	≤ 0.03	> 32
Gentamicin	99.7		0.3	≤ 0.5	≤ 0.5	≤ 0.5	32
Levofloxacin	92.2	1.1	6.7	≤ 0.06	0.5	≤ 0.06	16
Meropenem	99.3	0.3	0.3	0.06	0.12	≤ 0.03	32
Moxifloxacin				0.12	1	≤ 0.06	16
Nitrofurantoin	17.8	52.5	29.7	64	128	8	512
Pip-Tazo	85.2	12.2	2.6	4	32	≤ 1	256
Tigecycline	97.0	2.3	0.7	1	2	0.06	8
Trimethoprim Sulfa	97.7		2.3	≤ 0.12	0.5	≤ 0.12	> 8

Amox-Clav, Amoxicillin-Clavulanate; Ceftol-Tazo, Ceftolozane-Tazobactam; Pip-Tazo, Piperacillin-Tazobactam; ESBL, extended-spectrum ß-lactamase
[a] For tigecycline, FDA breakpoints applied.
[b] For ceftobiprole, Health Canada breakpoints applied. Not all isolates tested with ceftobiprole.

Results

Table 3. The 20 most common organisms isolated from Canadian hospitals

Rank	Organism	N	% Total
1	*Staphylococcus aureus*	10,457	21.2
	MSSA	8,243	16.7
	MRSA	2,214	4.5
2	*Escherichia coli*	9,591	19.4
3	*Pseudomonas aeruginosa*	4,522	9.2
4	*Klebsiella pneumoniae*	3,061	6.2
5	*Streptococcus pneumoniae*	2,868	5.8
6	*Haemophilus influenzae*	2,030	4.1
7	CNS / *Staphylococcus epidermidis*	1,770	3.6
8	*Enterococcus faecalis*	1,424	2.9
9	*Enterobacter cloacae*	1,183	2.4
10	*Stenotrophomonas maltophilia*	841	1.7
11	*Klebsiella oxytoca / Raoultella spp.*	795	1.6
12	*Streptococcus agalactiae*	792	1.6
13	*Serratia marcescens*	765	1.6
14	*Proteus mirabilis*	727	1.5
15	*Streptococcus pyogenes*	724	1.5
16	*Enterococcus*, non-speciated	583	1.2
17	*Enterococcus faecium*	572	1.2
18	*Candida albicans*	522	1.1
19	*Moraxella catarrhalis*	520	1.1
20	*Haemophilus parainfluenzae*	348	0.7
	Other	5,224	10.6
	Total	**49,319**	

Table 4. Demographics of patients / isolates from CANWARD (n=49,319)

Demographic Variable	N	% of Total
Gender[a]		
Female	22,368	45.4
Male	26,947	54.6
Age Group[b]		
≤ 17 years	6,236	12.6
18 - 64 years	21,703	44.0
≥ 65 years	21,377	43.4
Specimen Source		
Blood	21,255	43.1
Respiratory	16,751	34.0
Urine	6,293	12.7
Wound	5,020	10.2
Ward Type[c]		
Clinic	8,935	18.1
ER	12,119	24.6
ICU	9,299	18.9
Medical	14,894	30.2
Surgical	4,055	8.2

[a] Gender unknown for 4 isolates
[b] Age unknown for 3 isolates
[c] Patient location unknown for 17 isolates

Conclusions

1. Of the 49,319 pathogens obtained, the most common were: *S. aureus* 21.2% (MSSA 16.7% / MRSA 4.5%), *E. coli* 19.4%, *P. aeruginosa* 9.2%, *K. pneumoniae* 6.2%, *S. pneumoniae* 5.8%, *H. influenzae* 4.1% and *Enterococcus* spp. (*E. faecalis* and *E. faecium*) 4.0%.
2. Isolates were obtained from blood (43.1%), respiratory (34.0%), urine (12.7%) and wound specimens (10.2%) from patients on wards 38.4% (30.2% medical/8.2% surgical), ER 24.6%, ICU 18.9%, and clinics 18.1%.
3. Susceptibility rates for *E. coli* were: 99.9% meropenem, and tigecycline, 99.7% ertapenem, 99.6% amikacin, 99.4% ceftolozane-tazobactam, 97.4% piperacillin-tazobactam, 94.3% cefepime, 93.3% ceftobiprole, 91.1% ceftriaxone, 90.7% gentamicin, 74.5% ciprofloxacin, and 73.2% trimethoprim-sulfamethoxazole.
4. Susceptibility rates for *P. aeruginosa* were: 97.7% ceftolozane-tazobactam, 95.5% colistin, 91.9% amikacin, 82.7% piperacillin-tazobactam, 81.0% ceftazidime, 80.7% gentamicin, 80.5% meropenem, and 66.4% ciprofloxacin.
5. Susceptibility rates for MRSA were: 100% ceftobiprole, linezolid and telavancin, 99.9% daptomycin and vancomycin, 98.8% tigecycline, 94.4% trimethoprim-sulfamethoxazole, 56.0% clindamycin, 18.5% ciprofloxacin and 16.0% for clarithromycin.

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