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Antimicrobial Susceptibility of 36,607 Pathogens Isolated from Patients in Canadian Hospitals: CANWARD Study 2007-2014

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ABSTRACT

Background: CANWARD is a national, annual Health Canada endorsed surveillance study assessing pathogens causing infections in Canadian hospitals and their antimicrobial resistance patterns.

Methods: From 2007 to 2014, 36,607 pathogens were collected from tertiary-care hospitals across Canada. Antimicrobial susceptibility testing was performed using CLSI broth microdilution methods with >45 marketed and investigational agents.

Results: Specimen source composition of the 36,607 isolates was 44.1% blood, 32.0% respiratory, 13.7% urine and 10.2% wound specimens. Patient demographic characteristics were: 54.6/45.4% male/female; 13.0/44.6/42.4% patients aged ≤17/18-64/≥65 years; and 37.8/25.2/19.1/18.0% patients located in medical and surgical wards/emergency rooms/ICUs/clinics. The most common pathogens were: *E. coli* (EC 19.7%), MSSA (16.4%), *P. aeruginosa* (PA 8.7%), *S. pneumoniae* (SPN 6.5%), *K. pneumoniae* (KP 6.1%), MRSA (4.7%), *Enterococcus* spp. (4.0%), and *H. influenzae* (4.0%). Susceptibility rates (SR) for EC were: 99.9% for meropenem (MER) and tigecycline (TGC), 99.7% ertapenem (ERT), 97.7% piperacillin-tazobactam (PTZ), 92.5% ceftriaxone (CTR), 90.4% gentamicin (GEN), 77.2% ciprofloxacin (CIP) and 73.0% TMP-SMX (SXT). SR for PA were: 94.2% colistin, 84.3% PTZ, 83.3% ceftazidime (CAZ), 81.2% MER, 77.6% GEN and 74.1% CIP. SR for MRSA were: 100% for linezolid (LZD) and telavancin (TLV), 99.9% daptomycin (DAP), 99.4% TGC, 99.1% vancomycin, and 93.3% SXT. Rates of resistant organisms between 2007-2014 increased significantly for ESBL-producing EC (3.4%-11.6%) and KP (1.5%-6.5%) as well as VRE (1.8%-7.0%), whereas MRSA rates (26.1%-20.2%) significantly declined.

Conclusions: EC, MSSA, PA, SPN, KP, and MRSA are the most common pathogens in Canadian hospitals. SR for EC were highest for MER, TGC, ERT and PTZ. SR for PA were highest for colistin, PTZ, CAZ and MER. 99-100% of MRSA were susceptible DAP, LZD, TLV, and vancomycin.

INTRODUCTION

Infections caused by antibiotic resistant infections is a Canadian and global crisis (1,2). Resistant pathogens including methicillin-resistant *Staphylococcus aureus* (MRSA, community associated-CA and healthcare associated-HA), vancomycin-resistant *Enterococcus species* (VRE), penicillin-resistant *Streptococcus pneumoniae* (PRSP), extended spectrum B-lactamase (ESBL) producing *Escherichia coli* and *Klebsiella species* and 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 severely limited as these organisms frequently display a multidrug resistant (MDR) phenotype.

The ongoing goal of the CANWARD study is to 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 (W), emergency rooms (ER), outpatient clinics (C) and intensive care units (ICU).

PURPOSE

- To determine the pathogens associated with respiratory, urinary, bacteremic and wound/IV site infections in Canadian patients affiliated with hospitals from 2007-2014, inclusive.
- To determine the prevalence of antimicrobial resistance in pathogens associated with respiratory, urinary bacteremic and wound/IV site infections in Canadian patients affiliated with hospitals from 2007-2014, inclusive.
- To assess the activity of antimicrobials against respiratory, urinary, bacteremic and wound/IV site pathogens in Canadian patients affiliated with hospitals from 2007-2014, inclusive.

MATERIALS & METHODS

Participating Sites:
From January 2007 to December 2014, sentinel hospital sites (12 in 2007, 10 in 2008, 15 in 2009, 14 in 2010, 15 in 2011, 12 in 2012, 15 in 2013, and 13 in 2014) in major population centres in 8 of the 10 provinces in Canada were recruited. These sites were geographically distributed in a population based fashion: (BC [1 site], Alberta [1 site], Saskatchewan [1 site], Manitoba [1 site], Ontario [3-5 sites], Quebec [2-4 sites], Maritimes [1-2 sites]).

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. The medical centres submitted "clinically significant" isolates from patients with a presumed infectious disease. Surveillance swabs, eye, ear, nose and throat swabs, as well as anaerobes, were excluded. 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 -80°C until minimum inhibitory concentration (MIC) testing was carried out. In 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014; 7714, 5283, 5374, 4960, 3788, 2803, 3511, and 3174 isolates were collected, respectively (1,2).

Antimicrobial Susceptibilities: Following 2 subcultures from frozen stock, the in vitro activity of selected antimicrobials was determined by broth microdilution in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines (CLSI, 2012 M7-A9). Antimicrobial MIC interpretive standards were defined according to CLSI breakpoints (M100-S24, 2014). Susceptibility testing could not be performed with all agents due to lack of space on the susceptibility panels. Antimicrobial agents were obtained as laboratory grade powders from their respective manufacturers. Stock solutions were prepared and dilutions made as described by CLSI (M7-A9, 2012). The MICs 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.

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RESULTS

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

Organism (n) / Antimicrobial Agent	% S	% I	% R	MIC (μg/mL)		
				MIC_{50}	MIC_{90}	Range
***Staphylococcus aureus*, MSSA (n=5990)**						
Amikacin	99.2	0.4	0.3	4	4	≤ 2 - > 64
Cefoxitin	99.5		0.5	4	4	0.12 - 32
Ciprofloxacin	86.2	3.0	10.8	0.5	4	≤ 0.06 - > 16
Clarithromycin	75.3	0.4	24.3	0.25	> 16	≤ 0.25 - > 16
Clindamycin	93.0	0.4	6.6	≤ 0.25	≤ 0.25	≤ 0.25 - > 8
Daptomycin	100.0			0.25	0.25	≤ 0.06 - 1
Dapsone *				128	128	32 - 256
Doxycycline	99.0	0.7	0.3	≤ 0.25	≤ 0.25	≤ 0.25 - 16
Gentamicin	97.9	0.1	2.0	≤ 0.5	≤ 0.5	≤ 0.5 - > 32
Levofloxacin	90.1	0.3	9.6	0.25	1	≤ 0.06 - > 32
Linezolid	99.98		0.02	2	2	≤ 0.12 - 8
Moxifloxacin	90.3	0.7	9.0	≤ 0.06	0.25	≤ 0.06 - > 16
Nitrofurantoin	100.0			16	16	≤ 0.5 - 32
Tigecycline	99.9			0.12	0.25	≤ 0.03 - 1
Tobramycin	97.2	0.2	2.6	≤ 0.5	≤ 0.5	≤ 0.5 - > 64
Trimethoprim Sulfa	99.4		0.6	≤ 0.12	≤ 0.12	≤ 0.12 - > 8
Vancomycin	100.0			1	1	≤ 0.25 - 2
***Staphylococcus aureus*, MRSA (n=1707)**						
Amikacin	68.2	21.8	10.1	16	64	≤ 2 - > 64
Cefoxitin	0.1		99.9	> 32	> 32	1 - > 32
Ciprofloxacin	16.0	0.3	83.7	> 16	> 16	0.12 - > 16
Clarithromycin	14.4	0.4	85.2	> 16	> 16	≤ 0.25 - > 16
Clindamycin	52.8	0.1	47.2	≤ 0.25	> 8	≤ 0.25 - > 8
Daptomycin	99.9		0.1	0.25	0.5	0.06 - 2
Dapsone *				128	256	16 - 512
Doxycycline	97.6	0.8	1.5	≤ 0.12	1	≤ 0.12 - 16
Gentamicin	92.2	0.3	7.5	≤ 0.5	1	≤ 0.5 - > 32
Levofloxacin	14.1		85.9	> 32	> 32	0.12 - > 32
Linezolid	100.0			2	2	≤ 0.12 - 4
Moxifloxacin	16.7	3.2	80.2	8	> 16	≤ 0.06 - > 16
Nitrofurantoin	100.0			16	16	8 - 32
Tigecycline	99.1			0.25	0.5	≤ 0.03 - 2
Tobramycin	56.7	0.7	42.6	1	> 64	≤ 0.5 - > 64
Trimethoprim Sulfa	93.3		6.7	≤ 0.12	≤ 0.12	≤ 0.12 - > 8
Vancomycin	99.9	0.1		1	1	≤ 0.25 - 4
***Staphylococcus epidermidis* (n=775)**						
Amikacin	95.2	2.9	2.0	≤ 2	16	≤ 2 - > 64
Amox-Clav				1	8	≤ 0.06 - 32
Cefazolin				1	64	≤ 0.5 - > 128
Cefepime				4	> 32	≤ 1 - > 32
Cefoxitin				8	> 32	≤ 0.06 - > 32
Ceftriaxone				> 4	> 4	≤ 1 - > 4
Ciprofloxacin	44.9	1.6	53.6	4	> 16	≤ 0.06 - > 16
Clarithromycin	32.7	1.2	66.2	> 16	> 16	≤ 0.25 - > 16
Clindamycin	55.0	1.3	43.8	≤ 0.25	> 8	≤ 0.25 - > 8
Daptomycin	100.0			0.12	0.25	≤ 0.06 - 1
Dapsone *				128	512	32 - > 512
Doripenem				1	16	≤ 0.12 - > 32
Doxycycline	95.7	2.9	1.5	0.25	1	≤ 0.25 - 32
Ertapenem				4	> 32	≤ 0.06 - > 32
Gentamicin				≤ 0.5	> 32	≤ 0.5 - > 32
Levofloxacin	44.2	1.6	54.2	4	> 32	0.12 - > 32
Linezolid	100.0			0.5	1	≤ 0.12 - 4
Meropenem				2	32	≤ 0.12 - > 32
Moxifloxacin	46.9	6.9	46.2	1	> 16	≤ 0.06 - > 16
Pip-Tazo				≤ 1	32	≤ 1 - 128
Tigecycline				0.12	0.5	≤ 0.03 - 1
Tobramycin	59.3	12.8	27.8	2	64	≤ 0.5 - > 64
Trimethoprim Sulfa	59.4		40.6	1	8	≤ 0.12 - > 8
Vancomycin	100.0			1	2	≤ 0.25 - 4
***Streptococcus pneumoniae* (n=2366)**						
Amox-Clav	97.8	1.2	0.9	≤ 0.06	0.12	≤ 0.06 - 16
Ceftriaxone [a]	99.3	0.5	0.2	≤ 0.12	≤ 0.12	≤ 0.12 - 4
Cefuroxime	93.6	1.8	4.6	≤ 0.25	0.5	≤ 0.25 - > 16
Chloramphenicol	98.5		1.5	2	4	≤ 0.12 - 32
Ciprofloxacin				1	2	≤ 0.06 - > 16
Clarithromycin	79.3	3.6	17.2	≤ 0.03	4	≤ 0.03 - > 32
Clindamycin	92.9	0.6	6.5	≤ 0.12	≤ 0.12	≤ 0.12 - > 8
Daptomycin				0.06	0.12	-
Doripenem	99.9		0.1	≤ 0.06	0.06	≤ 0.06 - 2
Doxycycline	86.8	1.3	11.9	≤ 0.25	1	≤ 0.25 - > 16
Ertapenem	98.9	1.1	0.0	≤ 0.06	0.12	≤ 0.06 - 4
Imipenem	93.6	4.2	2.3	≤ 0.03	≤ 0.03	≤ 0.03 - 1
Levofloxacin	98.9	0.2	0.9	1	1	≤ 0.06 - 32
Linezolid	100.0			1	1	≤ 0.12 - 2
Meropenem	95.1	3.0	1.9	≤ 0.06	≤ 0.06	≤ 0.06 - 2
Moxifloxacin	99.0	0.5	0.5	0.12	0.25	≤ 0.06 - 8
Penicillin [b]	82.6	12.9	4.5	≤ 0.03	0.25	≤ 0.03 - > 8
Pip-Tazo				≤ 1	≤ 1	≤ 1 - 8
Tigecycline	99.8			≤ 0.03	0.06	≤ 0.03 - 0.25
Trimethoprim Sulfa	84.9	6.3	8.9	≤ 0.12	2	≤ 0.12 - > 8
Vancomycin	100.0			≤ 0.25	0.25	≤ 0.25 - 1
***Streptococcus agalactiae* (n=599)**						
Amox-Clav				≤ 0.06	≤ 0.06	≤ 0.06 - 0.25
Ceftriaxone	100.0			≤ 0.12	≤ 0.12	≤ 0.12 - 0.25
Cefuroxime				≤ 0.25	≤ 0.25	≤ 0.25 - 0.5
Chloramphenicol	97.2	2.8		4	4	0.5 - 8
Ciprofloxacin				0.5	1	0.25 - > 16
Clarithromycin	70.5	4.3	25.3			-
Clindamycin	83.3	1.0	15.7	≤ 0.12	> 8	≤ 0.12 - > 8
Daptomycin	100.0			0.25	0.25	≤ 0.06 - 0.5
Dapsone *				32	256	16 - 256
Doripenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06 - ≤ 0.06
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	97.1		3.0	1	1	0.25 - > 32
Linezolid	100.0			1	2	≤ 0.12 - 2
Meropenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06 - 0.12
Moxifloxacin				0.12	0.25	≤ 0.06 - 4
Penicillin	100.0			0.06	0.12	≤ 0.03 - 0.12
Pip-Tazo				≤ 1	≤ 1	≤ 1 - ≤ 1
Tigecycline	99.7			0.06	0.12	≤ 0.03 - 1
Trimethoprim Sulfa				≤ 0.12	0.25	≤ 0.12 - 1
Vancomycin	100.0			0.5	0.5	≤ 0.25 - 1
***Streptococcus pyogenes* (n=547)**						
Amox-Clav				≤ 0.06	≤ 0.06	≤ 0.06 - 0.5
Ceftriaxone	99.8		0.2	≤ 0.12	≤ 0.12	≤ 0.12 - 1
Cefuroxime				≤ 0.25	≤ 0.25	≤ 0.25 - 0.5
Chloramphenicol	98.8	1.2		2	4	0.5 - 8
Ciprofloxacin				0.5	1	≤ 0.06 - 8
Clarithromycin	89.1	2.1	8.8	≤ 0.03	0.5	≤ 0.03 - > 32
Clindamycin	98.4		1.6	≤ 0.12	≤ 0.12	≤ 0.12 - > 8
Daptomycin	100.0			0.06	0.12	≤ 0.06 - 0.25
Dapsone *				32	512	4 - >512
Doripenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06 - 0.12
Doxycycline				≤ 0.25	0.5	≤ 0.25 - 16
Ertapenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06 - 0.12
Imipenem				≤ 0.03	≤ 0.03	≤ 0.03 - 0.06
Levofloxacin	99.8	0.2		0.5	1	≤ 0.06 - 4
Linezolid	99.6		0.4	1	1	≤ 0.12 - 4
Meropenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06 - 0.12
Moxifloxacin				0.12	0.25	≤ 0.06 - 0.5
Penicillin	100.0			≤ 0.03	≤ 0.03	≤ 0.03 - 0.12
Pip-Tazo				≤ 1	≤ 1	≤ 1 - ≤ 1
Tigecycline	100.0			0.03	0.06	≤ 0.03 - 0.25
Trimethoprim Sulfa				≤ 0.12	≤ 0.12	≤ 0.12 - > 8
Vancomycin	100.0			0.5	0.5	≤ 0.25 - 1
***Enterococcus faecalis* (n=1059)**						
Amox-Clav				0.5	1	≤ 0.06 - 32
Ciprofloxacin	60.1	10.0	29.9	1	> 16	0.25 - > 16
Clarithromycin				2	> 16	≤ 0.25 - > 16
Daptomycin	100.0			0.5	1	≤ 0.06 - 4
Dapsone *				256	512	8 - > 512
Doripenem				4	4	≤ 0.06 - > 32
Doxycycline	37.8	41.4	20.8	8	16	≤ 0.12 - 32
Ertapenem				8	16	0.25 - > 32
Levofloxacin	65.6	1.1	33.3	2	> 32	0.25 - > 32
Linezolid	96.3	3.8		2	2	0.5 - 4
Meropenem				4	8	≤ 0.06 - > 32
Moxifloxacin				0.25	16	≤ 0.06 - > 16
Nitrofurantoin	99.6	0.4		8	8	2 - 64
Pip-Tazo				4	8	≤ 1 - 512
Tigecycline	98.0			0.12	0.25	≤ 0.03 - 1
Trimethoprim Sulfa				≤ 0.12	0.5	≤ 0.12 - > 8
Vancomycin	100.0			1	2	0.25 - 4
***Enterococcus faecium* (n=400)**						
Amox-Clav				> 32	> 32	≤ 0.06 - > 32
Ciprofloxacin	7.1	1.8	91.1	> 16	> 16	0.25 - > 16
Clarithromycin				> 16	> 16	≤ 0.03 - > 16
Daptomycin	100.0			1	2	≤ 0.03 - 4
Dapsone *				512	> 512	64 - > 512
Doripenem				> 32	> 32	0.12 - > 32
Doxycycline	80.0	5.4	14.6	1	16	≤ 0.12 - 32
Ertapenem				> 4	> 4	0.5 - > 4
Levofloxacin	9.5	1.3	89.2	> 32	> 32	1 - > 32
Linezolid	90.1	9.6	0.3	2	2	≤ 0.12 - 16
Meropenem				> 32	> 32	0.25 - > 32
Moxifloxacin				> 16	> 16	0.12 - > 16
Nitrofurantoin	41.9	27.9	30.2	64	128	4 - 256
Pip-Tazo				> 512	> 512	≤ 1 - > 512
Tigecycline				0.12	0.12	≤ 0.03 - 2
Trimethoprim Sulfa				0.25	> 8	≤ 0.12 - > 8
Vancomycin	76.9		23.1	1	> 32	≤ 0.25 - > 32

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

Organism (n) / Antimicrobial Agent	% S	% I	% R	MIC (μg/mL)		
				MIC_{50}	MIC_{90}	Range
***Escherichia coli* (n=7224)**						
Amikacin	99.7	0.2	0.1	≤ 2	4	≤ 2 - > 64
Amox-Clav				4	16	≤ 0.06 - > 32
Cefazolin	70.4	12.3	17.3	2	16	≤ 0.5 - > 128
Cefepime	95.5	2.0	2.5	≤ 1	≤ 1	≤ 1 - > 32
Cefoxitin	92.4	3.8	3.9	4	8	≤ 0.06 - > 32
Ceftazidime	94.1	0.7	5.2	≤ 0.5	1	≤ 0.5 - > 32
Ceftriaxone	92.5	0.3	7.2	≤ 1	≤ 1	≤ 1 - > 64
Ciprofloxacin	77.2	0.2	22.5	≤ 0.06	> 16	≤ 0.06 - > 16
Colistin				0.25	0.5	≤ 0.06 - > 16
Dapsone *				512	> 512	128 - > 512
Doripenem	99.97	0.01	0.01	≤ 0.12	≤ 0.12	≤ 0.12 - 16
Ertapenem	99.7	0.2	0.1	≤ 0.06	≤ 0.06	≤ 0.06 - > 32
Gentamicin	90.4	0.4	9.2	≤ 0.5	4	≤ 0.5 - > 32
Levofloxacin	78.8	0.7	20.6	≤ 0.06	16	≤ 0.06 - > 32
Meropenem	99.99		0.01	≤ 0.12	≤ 0.12	≤ 0.12 - 32
Moxifloxacin				≤ 0.06	> 16	≤ 0.06 - > 16
Nitrofurantoin	96.1	2.5	1.4	16	32	≤ 1 - > 256
Pip-Tazo	97.7	1.1	1.2	2	4	≤ 1 - > 512
Tigecycline	99.9	0.1		0.25	0.5	0.06 - 4
Trimethoprim Sulfa	73.0		27.0	≤ 0.12	> 8	≤ 0.12 - > 8
ESBL *E. coli* (n=403)						
Amikacin	97.0	2.5	0.5	2	8	≤ 2 - > 64
Amox-Clav				8	16	1 - > 32
Cefazolin		0.3	99.8	> 128	> 128	4 - > 128
Cefepime	29.0	31.4	39.7	8	> 32	≤ 1 - > 32
Cefoxitin	81.4	9.7	8.9	8	16	0.5 - > 32
Ceftazidime	33.7	8.0	58.3	16	> 32	≤ 0.5 - > 32
Ceftriaxone	2.5	1.0	96.5	> 64	> 64	≤ 0.25 - > 64
Ciprofloxacin	11.9	0.5	87.6	> 16	> 16	≤ 0.06 - > 16
Colistin				0.5	1	≤ 0.06 - > 16
Doripenem	99.8		0.3	≤ 0.12	≤ 0.12	≤ 0.12 - 16
Ertapenem	97.5	1.0	1.5	≤ 0.06	0.25	≤ 0.06 - > 32
Gentamicin	55.3	1.5	43.2	1	> 32	≤ 0.5 - > 32
Levofloxacin	12.9	1.3	85.8	16	32	≤ 0.06 - > 32
Meropenem	99.8		0.3	≤ 0.12	≤ 0.12	≤ 0.12 - 32
Moxifloxacin				16	> 16	≤ 0.06 - > 16
Nitrofurantoin	90.2	6.8	3.1	16	32	≤ 1 - 256
Pip-Tazo	92.6	4.7	2.7	4	16	≤ 1 - > 512
Tigecycline	99.8	0.3		0.5	1	0.12 - 4
Trimethoprim Sulfa	32.5		67.5	> 8	> 8	≤ 0.12 - > 8
***Pseudomonas aeruginosa* (n=3175)**						
Amikacin	91.8	3.7	4.5	4	16	≤ 2 - > 64
Amox-Clav				> 32	> 32	≤ 0.06 - > 32
Cefazolin				> 128	> 128	≤ 0.5 - > 128
Cefepime	80.9	12.9	6.1	4	16	≤ 1 - > 32
Cefoxitin				> 32	> 32	1 - > 32
Ceftazidime	83.3	5.5	11.2	4	32	≤ 0.5 - > 32
Ceftriaxone				16	> 64	≤ 1 - > 64
Ciprofloxacin	74.1	8.5	17.5	0.25	8	≤ 0.06 - > 16
Colistin	94.2	4.4	1.4	1	2	≤ 0.06 - > 16
Dapsone *				> 512	> 512	128 - > 512
Doripenem	84.3	6.3	9.4	0.5	4	≤ 0.12 - > 32
Ertapenem				8	> 32	0.06 - > 32
Gentamicin	77.6	10.2	12.2	2	16	≤ 0.5 - > 32
Levofloxacin	63.5	12.1	24.5	1	16	≤ 0.06 - > 32
Meropenem	81.3	7.1	11.7	0.5	8	≤ 0.12 - > 32
Moxifloxacin				4	> 16	≤ 0.06 - > 16
Nitrofurantoin				> 256	> 256	16 - > 256
Pip-Tazo	84.3	8.4	7.3	4	64	≤ 1 - > 512
Tigecycline				16	> 16	0.12 - > 16
Trimethoprim Sulfa				8	> 8	≤ 0.12 - > 8
***Klebsiella pneumoniae* (n=2242)**						
Amikacin	99.7	0.1	0.2	≤ 2	≤ 2	≤ 2 - > 64
Amox-Clav				2	8	0.5 - > 32
Cefazolin	83.0	6.3	10.8	1	8	≤ 0.5 - > 128
Cefepime	97.1	1.2	1.7	≤ 1	≤ 1	≤ 1 - > 32
Cefoxitin	91.4	4.0	4.6	4	8	0.12 - > 32
Ceftazidime	96.2	0.3	3.5	≤ 0.5	1	≤ 0.5 - > 32
Ceftriaxone	95.0	0.5	4.5	≤ 1	≤ 1	≤ 1 - > 64
Ciprofloxacin	92.8	1.3	5.9	≤ 0.06	0.5	≤ 0.06 - > 16
Colistin				0.5	1	≤ 0.06 - > 16
Dapsone *				512	> 512	256 - > 512
Doripenem	99.9		0.1	≤ 0.12	≤ 0.12	≤ 0.12 - 8
Ertapenem	99.5	0.3	0.3	≤ 0.06	≤ 0.06	≤ 0.06 - 32
Gentamicin	96.9	0.2	2.9	≤ 0.5	≤ 0.5	≤ 0.5 - > 32
Levofloxacin	93.8	1.8	4.5	≤ 0.06	1	≤ 0.06 - > 32
Meropenem	99.82	0.04	0.13	≤ 0.12	≤ 0.12	≤ 0.12 - 16
Moxifloxacin				0.12	1	≤ 0.06 - > 16
Nitrofurantoin	35.3	31.4	33.3	64	128	2 - > 256
Pip-Tazo	97.0	1.1	1.9	2	8	≤ 1 - > 512
Tigecycline	95.4	3.8	0.8	1	2	0.06 - 16
Trimethoprim Sulfa	90.4		9.6	≤ 0.12	2	≤ 0.12 - > 8
***Enterobacter cloacae* (n=879)**						
Amikacin	99.9		0.1	≤ 2	2	≤ 2 - > 64
Amox-Clav				> 32	> 32	2 - > 32
Cefazolin	2.4	1.1	96.5	> 128	> 128	1 - > 128
Cefepime	95.4	3.8	0.8	≤ 1	2	≤ 1 - 64
Cefoxitin	9.8	4.9	85.3	> 32	> 32	2 - > 32
Ceftazidime	78.8	1.1	20.1	0.5	> 32	≤ 0.5 - > 32
Ceftriaxone	73.9	2.1	24.0	≤ 1	> 64	≤ 1 - > 64
Ciprofloxacin	93.5	1.6	4.9	≤ 0.06	0.25	≤ 0.06 - > 16
Colistin				0.5	> 16	≤ 0.06 - > 16
Dapsone *				512	> 512	256 - > 512
Doripenem	99.4	0.2	0.3	≤ 0.12	0.12	≤ 0.12 - > 32
Ertapenem	92.0	4.9	3.2	≤ 0.06	0.5	≤ 0.06 - > 32
Gentamicin	97.6	0.1	2.3	≤ 0.5	≤ 0.5	≤ 0.5 - > 32
Levofloxacin	94.8	3.8	1.4	≤ 0.06	0.5	≤ 0.06 - 32
Meropenem	99.4	0.3	0.2	≤ 0.12	0.12	≤ 0.12 - > 32
Moxifloxacin				≤ 0.06	0.5	≤ 0.06 - > 16
Nitrofurantoin	47.0	38.9	14.1	64	128	2 - > 256
Pip-Tazo	85.4	8.2	6.4	2	64	≤ 1 - > 512
Tigecycline	94.5	3.3	2.2	1	1	0.25 - 16
Trimethoprim Sulfa	91.9		8.1	≤ 0.12	1	≤ 0.12 > 8
***Proteus mirabilis* (n=555)**						
Amikacin	99.6	0.4		2	4	≤ 2 - 32
Amox-Clav				1	4	0.5 - > 32
Cefazolin	3.6	55.9	40.5	4	8	1 - > 128
Cefepime	100.0			≤ 1	≤ 1	≤ 1 - 2
Cefoxitin	96.4	2.3	1.3	4	4	1 - > 32
Ceftazidime	99.1	0.2	0.7	≤ 0.5	≤ 0.5	≤ 0.5 - 32
Ceftriaxone	98.0	0.9	1.1	≤ 1	≤ 1	≤ 1 - 16
Ciprofloxacin	86.9	5.6	7.6	≤ 0.06	2	≤ 0.06 - > 16
Colistin				> 16	> 16	≤ 0.06 - > 16
Dapsone *				512	> 512	256 - > 512
Doripenem	100.0			0.12	0.25	≤ 0.12 - 1
Ertapenem	100.0			≤ 0.06	≤ 0.06	≤ 0.06 - 0.25
Gentamicin	95.3	1.1	3.6	1	2	≤ 0.5 - > 32
Levofloxacin	90.3	3.8	5.9	0.12	2	≤ 0.06 - > 32
Meropenem	100.0			≤ 0.12	0.12	≤ 0.12 - 0.5
Moxifloxacin				0.5	16	≤ 0.06 - > 16
Nitrofurantoin		9.6	90.4	128	256	64 - > 256
Pip-Tazo	100.0			≤ 1	≤ 1	≤ 1 - 8
Tigecycline	9.7	36.2	54.1	8	16	0.5 - > 16
Trimethoprim Sulfa	83.6		16.4	≤ 0.12	> 8	≤ 0.12 - > 8
***Klebsiella oxytoca* (n=556)**						
Amikacin	99.8		0.2	≤ 2	2	≤ 2 - > 64
Amox-Clav				2	16	1 - > 32
Cefazolin	25.6	21.6	52.8	8	> 128	≤ 0.5 - > 128
Cefepime	97.9	1.7	0.4	≤ 1	≤ 1	≤ 1 - > 64
Cefoxitin	97.1	1.4	1.4	2	4	0.5 - > 32
Ceftazidime	98.5	0.4	1.1	≤ 0.5	0.5	≤ 0.5 - > 32
Ceftriaxone	91.0	1.8	7.2	≤ 1	1	≤ 1 - > 64
Ciprofloxacin	97.1	1.1	1.8	≤ 0.06	≤ 0.06	≤ 0.06 - > 16
Colistin				0.25	1	≤ 0.06 - > 16
Dapsone *				512	> 512	256 - > 512
Doripenem	100.0			≤ 0.12	≤ 0.12	≤ 0.12 - 1
Ertapenem	99.6		0.4	≤ 0.06	≤ 0.06	≤ 0.06 - 2
Gentamicin	98.0	0.7	1.3	≤ 0.5	≤ 0.5	≤ 0.5 - > 32
Levofloxacin	97.8	0.7	1.5	≤ 0.06	0.25	≤ 0.06 - > 32
Meropenem	100.0			≤ 0.12	≤ 0.12	≤ 0.12 - 1
Moxifloxacin				0.12	0.25	≤ 0.06 - > 16
Nitrofurantoin	80.2	18.3	1.6	32	64	4 - 128
Pip-Tazo	88.5	0.7	10.8	2	128	≤ 1 - > 512
Tigecycline	99.5	0.4	0.2	0.5	1	0.06 - 8
Trimethoprim Sulfa	95.3		4.7	≤ 0.12	0.25	≤ 0.12 - > 8
***Stenotrophomonas maltophilia* (n=537)**						
Amikacin				> 64	> 64	≤ 2 - > 64
Amox-Clav				> 32	> 32	2 - > 32
Cefazolin				> 128	> 128	2 - > 128
Cefepime				32	> 32	≤ 1 - > 32
Cefoxitin				> 32	> 32	4 - > 32
Ceftazidime	23.4	8.9	67.7	> 32	> 32	1 - > 32
Ceftriaxone				> 64	> 64	4 - > 64
Ciprofloxacin				2	16	≤ 0.06 - > 16
Colistin				8	> 16	0.25 - > 16
Dapsone *				16	64	8 - 64
Doripenem				> 32	> 32	≤ 0.12 - > 32
Ertapenem				> 32	> 32	0.12 - > 32
Gentamicin				32	> 32	≤ 0.5 - > 32
Levofloxacin	66.9	12.8	20.3	2	8	≤ 0.06 - > 32
Meropenem				> 32	> 32	≤ 0.12 - > 32
Moxifloxacin				0.5	4	≤ 0.06 - > 16
Nitrofurantoin				> 256	> 256	32 - > 256
Pip-Tazo				256	> 512	≤ 1 - > 512
Tigecycline				2	8	0.25 - 16
Trimethoprim Sulfa	86.1		13.9	0.5	8	≤ 0.12 - > 8
***Acinetobacter baumannii* (n=144)**						
Amikacin	95.2		4.8	≤ 2	4	≤ 2 - > 64
Amox-Clav				16	32	0.25 - > 32
Cefazolin				> 128	> 128	32 - > 128
Cefepime	85.5	4.3	10.3	4	32	≤ 1 - > 64
Cefoxitin				> 32	> 32	8 - > 32
Ceftazidime	80.8	5.8	13.3	8	32	1 - > 32
Ceftriaxone	45.5	44.8	9.7	16	32	1 - > 64
Ciprofloxacin	91.7	1.4	6.9	0.25	1	≤ 0.06 - > 16
Colistin	97.8		2.2	1	2	0.25 - > 16
Doripenem	95.9		4.1	0.25	1	≤ 0.12 - > 32
Ertapenem				4	16	0.12 - > 32
Gentamicin	93.1	1.4	5.5	≤ 0.5	2	≤ 0.5 - > 32
Levofloxacin	92.2		7.8	0.12	1	≤ 0.06 - > 16
Meropenem	93.8	2.1	4.1	0.5	2	≤ 0.12 - > 32
Moxifloxacin				≤ 0.06	0.25	≤ 0.06 - > 16
Nitrofurantoin				> 256	> 256	128 - > 256
Pip-Tazo	83.5	8.3	8.3	2	64	≤ 1 - > 128
Tigecycline				0.5	1	0.12 - > 16
Trimethoprim Sulfa	89.0		11.0	0.25	4	≤ 0.12 - > 8

S, susceptible; I, intermediate; R, resistant ; * Not all isolates tested with dapsone; FDA approved breakpoints used for tigecycline; Colistin (Polymyxin E); Amox-Clav = amoxicillin-clavulanate; Pip-Tazo=piperacillin-tazobactam; Trimethoprim Sulfa = trimethoprim-sulfamethoxazole; ESBL = extended spectrum ß-lactamase-producing; [a] CLSI, non-meningitis breakpoints used; [b] CLSI penicillin-v breakpoints used

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

Rank	Organism	n	% of Total
1	*Escherichia coli*	7,224	19.7
2	*Staphylococcus aureus,* MSSA	5,990	16.4
3	*Pseudomonas aeruginosa*	3,175	8.7
4	*Streptococcus pneumoniae*	2,366	6.5
5	*Klebsiella pneumoniae*	2,242	6.1
6	*Staphylococcus aureus,* MRSA	1,707	4.7
7	*Haemophilus influenzae*	1,460	4.0
8	*CNS* / Staphylococcus epidermidis*	1,426	3.9
9	*Enterococcus faecalis*	1,059	2.9
10	*Enterobacter cloacae*	879	2.4
11	*Streptococcus agalactiae*	599	1.6
12	*Enterococcus, non-speciated*	580	1.6
13	*Klebsiella oxytoca*	556	1.5
14	*Proteus mirabilis*	555	1.5
15	*Serratia marcescens*	553	1.5
16	*Streptococcus pyogenes*	547	1.5
17	*Stenotrophomonas maltophilia*	537	1.5
18	*Candida albicans*	459	1.3
19	*Enterococcus faecium*	400	1.1
20	*Moraxella catarrhalis*	390	1.1
	Other	3,903	10.7
		36,607	

*CNS – coagulase negative staphylococci

Bacterial Isolates Collected

36,607 clinical isolates were collected for CANWARD 2007-2014.

- 16,150 (44.1%) were from blood, 11,712 (32.0%) from respiratory sources, 5,001 (13.7%) were from urine and 3,744 (10.2%) were from wounds
- 19,977 (54.6%) collected from male patients; 16,627 (45.4%) female patients
- 4,749 (13.0%) from patients ≤17 years of age, 16,329 (44.6%) 18-64 years, and 15,526 (42.4%) ≥ 65 years
- 10,762 (29.4%) were from patients on medical wards, 9,222 (25.2%) from emergency rooms, 6,977 (19.1%) from intensive care units, 6,574 (18.0%) from hospital clinics, and 3,072 (8.4%) from surgical wards

CONCLUSIONS

- Of the 36,607 pathogens obtained, the most common were: *E. coli* 19.7%, *S. aureus* (MSSA) 16.4%, *P. aeruginosa* 8.7%, *S. pneumoniae* 6.5%, *K. pneumoniae* 6.1%, MRSA 4.7%, *H. influenzae* 4.0% and *Enterococcus* spp. (*E. faecalis* and *E. faecium*) 4.0%.
- Isolates were obtained from blood (44.1%), respiratory (32.0%), urine (13.7%) and wound specimens (10.2%) from patients on wards 37.8% (29.4% medical/8.4% surgical), ER 25.2%, C 18.0% and ICU 19.1%.
- Susceptibility rates for *E. coli* were: 99.9% MER, 99.9% DOR and TGC, 99.7% ERT, 99.7% amikacin, 97.7% PTZ, 95.5% cefepime, 94.1% CAZ, 92.5% CTR, 90.4% GEN, 77.2% CIP and 73.0% SXT.
- Susceptibility rates for *P. aeruginosa* were: 94.2% colistin, 91.8% amikacin, 84.3% doripenem, 84.3% PTZ, 83.3% CAZ, 81.3% MER, 77.6% GEN and 74.1% CIP.
- Susceptibility rates for MRSA were: 100% linezolid, 99.9% daptomycin, 99.9% vancomycin, 99.1% tigecycline, 93.3% SXT, 52.8% clindamycin, 16.0% ciprofloxacin and 14.4% for clarithromycin.

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