Pathogens and Their Antimicrobial Resistance Patterns in Emergency Departments (EDs) across Canada: CANWARD 2007-2014

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ABSTRACT

Background: This study assessed the antimicrobial resistance patterns of pathogens causing infections in patients treated in Canadian EDs.

Methods: From 2007 to 2014 inclusive, tertiary care centres across Canada submitted 36,607 bacterial isolates as part of the Canadian Ward Surveillance Study (CANWARD). 9,222 (25.2%) were from patients presenting to EDs. Isolates were collected from blood, urine, wound, and respiratory specimens. Antimicrobial susceptibility testing and MIC breakpoint interpretation was carried out using Clinical and Laboratory Standards Institute (CLSI) guidelines.

Results: Of the 9,222 isolates, 63.4%, 15.5%, 12.2%, and 8.9% were from blood, urine, respiratory, and wound specimens, respectively. The most common organisms were: *E. coli* 29.8%, methicillin-susceptible *Staphylococcus aureus* (MSSA) 14.7%, *Streptococcus pneumoniae* 8.5%, *Klebsiella pneumoniae* 6.4%, *Pseudomonas aeruginosa* 4.3%, and methicillin-resistant *Staphylococcus aureus* (MRSA) 3.9%. 21.1% of *S. aureus* were MRSA (49.6%/45.7% CA/HA-MRSA genotypes). 3.9% of *E. coli* were extended spectrum β-lactamase-producing and 1.3% of *Enterococcus* spp. were vancomycin-resistant. Susceptibility rates (SR) for *E. coli* (blood) were: 100% meropenem (MER), 100% ertapenem (ERT), 98.8% piperacillin-tazobactam (PTZ), 94.0% ceftriaxone (CTR), 91.7% gentamicin, and 80.4% ciprofloxacin. SR for *S. pneumoniae* (respiratory) were: 99.3% CTR, 98.6% levofloxacin (LEV), 93.9% clindamycin (CLD), 90.0% doxycycline (DOX), 86.9% trimethoprim-sulfamethoxazole (SXT), 85.3% penicillin, and 81.4% clarithromycin. SR for MRSA were: 100% linezolid (LZD), 100% daptomycin (DAP), 99.4% vancomycin (VAN), 99.4% tigecycline (TGC), 97.2% SXT, and 54.7% CLD.

Conclusions: *E. coli*, MSSA, *S. pneumoniae*, *K. pneumoniae*, *P. aeruginosa*, and MRSA are the most common pathogens in Canadian EDs. MRSA represents 21.1% of all *S. aureus* infections in EDs (~50/50 split CA and HA genotypes). Against MRSA, SR of >99% were observed for LZD, DAP, VAN, and TGC. MER, ERT, PTZ, CTR were the most active intravenous agents against *E. coli* blood isolates (SR >94.0%). CTR, LEV, CLD, and DOX are the most active agents against respiratory *S. pneumoniae* isolates.

BACKGROUND

The treatment of infectious diseases remains a predominant aspect of care provision in emergency department settings. In addition to varying levels of acuity, limited information, and significant time constraints—the rising proportion of multidrug resistant organisms in the community represent an even further challenge to the ER physician when treating these infections (1,2,3). Antimicrobial stewardship in the ED is often hindered by the frequent need for empiric treatment; given the lack of initial culture data, undifferentiated infections, and/or those presenting with severe illness (1,2,3). CANWARD (an ongoing, annual, national, multicentre study) assesses pathogens causing infections in Canadian hospitals and their antimicrobial resistance patterns. This national surveillance data will hopefully guide and enable emergency room physicians to tailor empiric treatment, optimize clinical outcomes, and foster a culture conducive to antimicrobial stewardship (4).

The 3 main objectives of this study were [1] to determine the pathogens, [2] to assess the activity of antimicrobials, and [3] to determine the prevalence of antimicrobial resistance in these pathogens associated with respiratory, urinary, blood, and wound site infections in Canadian emergency department patients from 2007-2014.

REFERENCES

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RESULTS

Table 1. The 20 most common organisms isolated from Canadian EDs

Rank	Organism	n	% of Total
1	*Escherichia coli*	2749	29.8
2	*Staphylococcus aureus*, MSSA	1353	14.7
3	*Streptococcus pneumoniae*	786	8.5
4	*Klebsiella pneumoniae*	588	6.4
5	*Pseudomonas aeruginosa*	394	4.3
6	*Staphylococcus aureus*, MRSA	361	3.9
7	*Streptococcus pyogenes*	290	3.1
8	CNS / *Staphylococcus epidermidis*	262	2.8
9	*Haemophilus influenzae*	251	2.7
10	*Enterococcus faecalis*	244	2.6
11	*Streptococcus agalactiae*	197	2.1
12	*Proteus mirabilis*	174	1.9
13	*Klebsiella oxytoca*	124	1.3
14	*Enterobacter cloacae*	107	1.2
15	*Streptococcus viridans*	104	1.1
16	*Enterococcus* spp.	96	1.0
17	BHS Group A	82	0.9
18	*Staphylococcus hominis*	68	0.7
19	*Serratia marcescens*	63	0.7
20	*Moraxella catarrhalis*	49	0.5
	Other	880	9.5
		9222	

Table 2. Prevalence of common resistance phenotypes isolated from Canadian EDs

Prevalence (%)	n	%
MRSA	361/1714	21.1%
VRE	5/385	1.3%
ESBL *E.coli*	107/2749	3.9%
ESBL *K. pneumoniae*	10/578	1.7%

MRSA - methicillin-resistant *S. aureus* ; VRE – vancomycin-resistant *Enterococcus* spp.;
ESBL - extended spectrum β-lactamase producing

Table 3. Prevalence of MRSA phenotypes isolated from Canadian EDs

MRSA Phenotypes (n)	West	Ontario	Quebec	Maritimes	National
CA-MRSA	109	54	8	8	179
HA-MRSA	42	50	61	12	165
Unique	5	10	2	0	17
Grand Total	156	114	71	20	361
% CA	69.9%	47.4%	11.3%	40.0%	49.6%
% HA	26.9%	43.9%	85.9%	60.0%	45.7%

CA- community associated; HA- healthcare associated

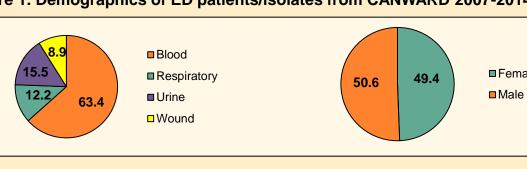**Figure 1. Demographics of ED patients/isolates from CANWARD 2007-2014**

Table 4. Antimicrobial activity of top ED pathogens, by specimen source

Staphylococcus aureus, MSSA - WOUND (n=346)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
Cefoxitin	4	4	1 - 8	99.7		0.3
Ciprofloxacin	0.5	1	0.06 - > 16	93.6	0.6	5.8
Clarithromycin	0.25	> 16	0.25 - > 16	80.0	0.3	19.7
Clindamycin	≤ 0.25	≤ 0.25	≤ 0.25 - > 8	95.7		4.3
Daptomycin	0.25	0.25	0.06 - 0.5	100.0		
Gentamicin	≤ 0.5	≤ 0.5	≤ 0.5 - > 32	98.8		1.2
Linezolid	2	2	0.5 - 4	100.0		
Moxifloxacin	≤ 0.06	0.12	≤ 0.06 - > 16	94.2	0.9	4.9
Tigecycline	0.25	0.25	0.12 - 0.5	100.0		
SXT	≤ 0.12	≤ 0.12	≤ 0.12 - > 8	98.8		1.2
Vancomycin	1	1	≤ 0.25 - 1	100.0		

Staphylococcus aureus, MSSA - BLOOD (n=830)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
Cefoxitin	4	4	0.12 - 8	99.7		0.3
Ciprofloxacin	0.5	2	≤ 0.06 - > 16	88.9	2.0	9.0
Clarithromycin	0.25	> 16	0.25 - > 16	79.8	0.1	20.1
Clindamycin	≤ 0.25	≤ 0.25	≤ 0.25 - > 8	95.4	0.4	4.2
Daptomycin	0.25	0.25	0.06 - 0.5	100.0		
Gentamicin	≤ 0.5	≤ 0.5	≤ 0.5 - > 32	99.3	0.7	
Linezolid	2	2	0.12 - 4	100.0		
Moxifloxacin	≤ 0.06	0.25	≤ 0.06 - > 16	91.6	0.7	7.7
Tigecycline	0.12	0.25	0.03 - 1	99.9		
SXT	≤ 0.12	≤ 0.12	≤ 0.12 - > 8	99.4		0.6
Vancomycin	1	1	≤ 0.25 - 2	100.0		

Staphylococcus aureus, MRSA - WOUND (n=123)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
Cefoxitin	32	> 32	8 - > 32			100.0
Ciprofloxacin	16	> 16	0.25 - > 16	32.5	0.8	66.7
Clarithromycin	> 16	> 16	≤ 0.25 - > 16	18.0	0.8	81.1
Clindamycin	≤ 0.25	> 8	≤ 0.25 - > 8	81.1		18.9
Daptomycin	0.25	0.25	0.12 - 1	100.0		
Gentamicin	≤ 0.5	1	≤ 0.5 - > 32	93.5	0.8	5.7
Linezolid	2	2	1 - 4	100.0		
Moxifloxacin	2	8	≤ 0.06 - > 16	33.3	5.7	61.0
Tigecycline	0.25	0.25	0.12 - 1	99.2		
SXT	≤ 0.12	≤ 0.12	≤ 0.12 - > 8	97.6		2.4
Vancomycin	1	1	0.5 - 1.5	100.0		

Staphylococcus aureus, MRSA - BLOOD (n=179)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
Cefoxitin	32	> 32	8 - > 32			100.0
Ciprofloxacin	> 16	> 16	0.12 - > 16	22.3	0.6	77.1
Clarithromycin	> 16	> 16	≤ 0.25 - > 16	15.6		84.4
Clindamycin	≤ 0.25	> 8	≤ 0.25 - > 8	54.7		45.3
Daptomycin	0.25	0.5	0.06 - 0.5	100.0		
Gentamicin	≤ 0.5	1	≤ 0.5 - > 32	98.3		1.7
Linezolid	2	2	0.5 - 4	100.0		
Moxifloxacin	2	> 16	≤ 0.06 - > 16	23.5	5.6	70.9
Tigecycline	0.25	0.25	0.12 - 1	99.4		
SXT	≤ 0.12	≤ 0.12	≤ 0.12 - > 8	97.2		2.8
Vancomycin	1	1	≤ 0.25 - 4	99.4	0.6	

Enterococcus spp. - URINE (n=146)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
A/C	0.5	1	0.12 - > 32	-	-	-
Ciprofloxacin	1	> 16	0.25 - > 16	64.4	13.0	22.6
Clarithromycin	1	> 16	≤ 0.25 - > 16	-	-	-
Daptomycin	0.5	2	0.06 - 4	100.0		
Doripenem	4	4	0.12 - > 32	-	-	-
Ertapenem	> 4	> 4	1 - > 4	-	-	-
Levofloxacin	1	> 32	0.5 - > 32	79.7		20.3
Linezolid	2	2	1 - 4	96.5	3.5	
Meropenem	4	8	0.12 - > 32	-	-	-
Moxifloxacin	0.25	16	≤ 0.06 - > 16	-	-	-
Nitrofurantoin	8	8	4 - 64	99.2	0.8	
PTZ	4	4	≤ 1 - > 512	-	-	-
Tigecycline	0.12	0.25	≤ 0.03 - 0.25	-	-	-
Vancomycin	1	1	≤ 0.25 - > 32	99.3		0.7

Streptococcus pneumoniae - BLOOD (n=466)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
A/C	≤ 0.06	≤ 0.06	≤ 0.06 - 8	98.1	1.3	0.6
Ceftriaxone	≤ 0.12	≤ 0.12	≤ 0.12 - 2	99.8	0.2	
Cefuroxime	≤ 0.25	≤ 0.25	≤ 0.25 - 16	95.7	1.1	3.2
Ciprofloxacin	1	2	≤ 0.06 - 4	99.4		0.6
Clarithromycin	≤ 0.03	4	≤ 0.03 - > 32	79.7	2.4	17.9
Clindamycin	≤ 0.12	≤ 0.12	≤ 0.12 - > 8	94.0	0.4	5.6
Doripenem	≤ 0.06	0.06	≤ 0.06 - 1	100.0		
Doxycycline	0.25	0.5	≤ 0.25 - 16	89.8	0.6	9.5
Ertapenem	≤ 0.06	≤ 0.06	≤ 0.06 - 2	99.1	0.9	
Levofloxacin	0.5	1	≤ 0.06 - 2	100.0		
Linezolid	1	1	≤ 0.12 - 2	100.0		
Meropenem	≤ 0.06	≤ 0.06	≤ 0.06 - 1	97.4	0.9	1.7
Moxifloxacin	0.12	0.25	≤ 0.06 - 0.5	100.0		
Penicillin	≤ 0.03	0.12	≤ 0.03 - 4	88.2	9.1	2.7
PTZ	≤ 1	≤ 1	≤ 1 - 4	-	-	-
Tigecycline	≤ 0.03	0.06	≤ 0.03 - 0.06	100.0		
SXT	≤ 0.12	1	≤ 0.12 - > 8	88.0	6.4	5.6
Vancomycin	≤ 0.25	0.25	≤ 0.25 - 1	100.0		

Streptococcus pneumoniae - RESPIRATORY (n=282)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
A/C	≤ 0.06	0.12	≤ 0.06 - 8	98.6	0.7	0.7
Ceftriaxone	≤ 0.12	0.12	≤ 0.12 - 2	99.3	0.7	
Cefuroxime	≤ 0.25	≤ 0.25	≤ 0.25 - 16	95.4	1.4	3.2
Ciprofloxacin	1	2	≤ 0.06 - > 16	96.4		3.6
Clarithromycin	≤ 0.03	2	≤ 0.03 - > 32	81.4	5.4	13.2
Clindamycin	≤ 0.12	≤ 0.12	≤ 0.12 - > 8	93.9	1.1	5.0
Doripenem	≤ 0.06	0.06	≤ 0.06 - 2	99.3		0.7
Doxycycline	0.25	0.25	≤ 0.25 - 16	90.0	1.1	8.9
Ertapenem	≤ 0.06	≤ 0.06	≤ 0.06 - 2	99.6	0.4	
Levofloxacin	0.5	1	≤ 0.06 - 32	98.6		1.4
Linezolid	0.5	1	≤ 0.12 - 2	100.0		
Meropenem	≤ 0.06	0.06	≤ 0.06 - 1	96.8	1.4	1.8
Moxifloxacin	0.12	0.25	≤ 0.06 - 8	98.2	0.4	1.4
Penicillin	≤ 0.03	0.25	≤ 0.03 - 8	85.3	10.4	4.3
PTZ	≤ 1	≤ 1	≤ 1 - 8	-	-	-
Tigecycline	≤ 0.03	0.06	≤ 0.03 - 0.25	99.3		0.7
SXT	≤ 0.12	1	≤ 0.12 - > 8	86.9	6.7	6.4
Vancomycin	≤ 0.25	0.25	≤ 0.25 - 0.5	100.0		

Escherichia coli - BLOOD (n=1810)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
Amikacin	≤ 2	4	≤ 2 - > 64	99.7	0.2	0.1
A/C	4	16	0.25 - > 32	89.8	7.6	2.6
Aztreonam	≤ 0.12	0.25	≤ 0.12 - > 64	93.8	0.9	5.3
Cefazolin	2	8	0.5 - > 128	74.4	12.7	12.9
Cefepime	≤ 1	≤ 1	≤ 1 - > 32	96.2	2.0	1.7
Cefoxitin	4	8	0.25 - > 32	95.0	2.5	2.4
Ceftazidime	≤ 0.5	0.5	≤ 0.5 - > 32	94.9	0.4	4.7
Ceftriaxone	≤ 1	≤ 1	≤ 1 - > 64	94.0	0.2	5.7
Ciprofloxacin	≤ 0.06	> 16	≤ 0.06 - > 16	80.4	0.1	19.4
Colistin	0.25	0.5	≤ 0.06 - > 16	-	-	-
Doripenem	≤ 0.12	≤ 0.12	≤ 0.12 - 0.25	100.0		
Ertapenem	≤ 0.06	≤ 0.06	≤ 0.06 - 2	99.8	0.1	0.1
Gentamicin	≤ 0.5	1	≤ 0.5 - > 32	91.7	0.2	8.2
Meropenem	≤ 0.12	≤ 0.12	≤ 0.12 - 0.25	100.0		
Moxifloxacin	≤ 0.06	16	≤ 0.06 - > 16	-	-	-
Nitrofurantoin	16	32	≤ 1 - 256	96.3	2.6	1.0
PTZ	≤ 1	4	≤ 1 - 512	98.8	0.8	0.4
Tigecycline	0.25	0.5	0.12 - 2	100.0		
SXT	≤ 0.12	> 8	≤ 0.12 - > 8	72.8		27.2

Escherichia coli - URINE (n=878)

Drug	MIC50	MIC90	MIC Range	% S	% I	% R
Amikacin	≤ 2	4	≤ 2 - 16	100.0		
A/C	4	16	0.06 - > 32	88.8	8.9	2.3
Aztreonam	≤ 0.12	0.5	≤ 0.12 - > 64	93.4	1.5	5.1
Cefazolin	2	8	0.5 - > 128	77.0	9.9	13.1
Cefepime	≤ 1	≤ 1	≤ 1 - > 32	96.9	1.3	1.8
Cefoxitin	4	8	0.06 - > 32	94.0	2.6	3.4
Ceftazidime	≤ 0.5	0.5	≤ 0.5 - > 32	96.1	0.3	3.7
Ceftriaxone	≤ 1	≤ 1	≤ 1 - > 64	95.7	0.2	4.1
Ciprofloxacin	≤ 0.06	> 16	≤ 0.06 - > 16	85.3		14.7
Colistin	0.25	0.5	≤ 0.06 - > 16	-	-	-
Doripenem	≤ 0.12	≤ 0.12	≤ 0.12 - 0.25	100.0		
Ertapenem	≤ 0.06	≤ 0.06	≤ 0.06 - 0.25	100.0		
Gentamicin	≤ 0.5	1	≤ 0.5 - > 32	93.1	0.3	6.6
Meropenem	≤ 0.12	≤ 0.12	≤ 0.12 - 0.12	100.0		
Moxifloxacin	≤ 0.06	16	≤ 0.06 - > 16	-	-	-
Nitrofurantoin	16	32	≤ 1 - 256	97.9	1.4	0.7
PTZ	≤ 1	4	≤ 1 - > 512	98.7	0.7	0.6
Tigecycline	0.25	0.5	0.06 - 4	99.9	0.1	
SXT	≤ 0.12	> 8	≤ 0.12 - > 8	78.2		21.8

' – ' indicates no defined CLSI breakpoints
Tigecycline breakpoints defined by US FDA
A/C – amoxicillin-clavulanate
PTZ – piperacillin-tazobactam
SXT – trimethoprim-sulfamethoxazole

MATERIALS & METHODS

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CONCLUSIONS

- *E. coli*, MSSA, *S. pneumoniae*, *K. pneumoniae*, *P. aeruginosa*, and MRSA are the most common pathogens isolated from Canadian emergency departments.

- MRSA represents 21.1% of all *S. aureus* infections in EDs (with a nearly 50/50 split between community-acquired and hospital acquired genotypes).

- Against MRSA, susceptibility rates of >99% were observed for LZD, DAP, VAN, and TGC. Wound MRSA isolates exhibited 18.9% resistance to CLD and 2.4% resistance to SXT.

- MER, ERT, PTZ, CTR were the most active intravenous agents against *E. coli* blood isolates (susceptibility >94.0%), while urinary *E. coli* isolates exhibited 21.8% resistance to SXT and 14.7% resistance to CIP—both common empiric oral agents prescribed in the ED.

- CTR, LEV, A/C, and DOX are the most active agents against respiratory *S. pneumoniae* isolates.