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# Antimicrobial Resistance in 18,538 Pathogens from Canadian Hospitals: CANWARD Study 2007-2009


G. G. Zhanel, B. Weshnoweski, R. Vashisht, M. DeCorby, H. Adam, M. R. Mulvey, M. McCracken, K. Nichol, F. Tailor, A. Wierzbowski, P. Simner, P. Lagacé-Wiens, A. Walkty, J. A. Karlowsky, F. Schweizer, Canadian Antimicrobial Resistance Alliance (CARA) and D.J. Hoban

University of Manitoba and National Microbiology Laboratory, Winnipeg, Canada

Dr. G. G. Zhanel
MS673 - 820 Sherbrook Street
Winnipeg, Manitoba, Canada
R3A 1R9
Phone: (204) - 787 - 4902
Fax: (204) - 787 - 4699
Email: ggzhanel@pcs.mb.ca


## ABSTRACT


**Background:** The CANWARD study assessed the pathogens causing infections in Canadian hospitals and their resistance patterns.
**Methods**: In a national surveillance study 2007-2009, inclusive, medical centres from across Canada submitted clinical isolates from patients attending hospital clinics (C), emergency rooms (ER), medical/surgical wards (W) and intensive care units (ICU). Susceptibility testing was performed by CLSI methods.
**Results:** 18,538 isolates, 44.5%, 29.0%, 16.5%, and 10.0% from blood, respiratory, urine and wound specimens, respectively, were collected. Patient demographics were 54.1%/45.9% male/female, 12.6% ≤ 17 yrs, 46.0% 18-64 yrs and 41.4% ≥65 yrs. Isolates were obtained from patients on W 38.6%, ER 26.1%, C 17.9% and ICU 17.4%. Most common pathogens were: *E. coli* 21.2%, *S. aureus* (MSSA) 14.5%, *P. aeruginosa* 8.0%, *S. pneumoniae* (SPN) 7.5%, *K. pneumoniae* 6.1%, MRSA 4.8%, *H. influenzae* 3.7%, *Enterococcus* spp. 3.1% and *Enterobacter cloacae* 2.3%. Resistance rates (RR) for *E. coli* were: 0% ertapenem (ERT), 0% meropenem (MER), 0% tigecycline (TGC), 0.2% amikacin (AMK), 1.1% piperacillin/tazobactam (P/T), 8.5% ceftriaxone (CTR), ciprofloxacin (CIP) 23.0% and 27.2% with cotrimoxazole (T/S). RR for *P. aeruginosa* were: 1.0% colistin, 6.1% AMK, 7.1% MER, 8.1% P/T, 8.8% cefepime, and 21.3% CIP. RR for MRSA were: 0% (0.1% intermediate) vancomycin (VAN), linezolid (LZD) and daptomycin (DAP), 0.7% TGC, 9.7% T/S and 55.9% clindamycin.
**Conclusions:** *E. coli*, MSSA, *P. aeruginosa*, SPN, *K. pneumoniae,* MRSA and *Enterococcus* spp. are the most common pathogens in Canadian hospitals. RR for *E. coli* were lowest with ERT, MER, TGC, AMK and P/T. RR for *P. aeruginosa* were lowest with colistin, AMK, MER and P/T. No resistance occurred in MRSA to LZD and DAP but intermediate resistance of 0.1% with VAN.


## BACKGROUND

Antibiotic resistant pathogens causing infections is a Canadian and global crisis (1,2). Antibiotic resistant pathogens including methicillin-resistant *Staphylococcus aureus* (MRSA, community associated and healthcare- associated), vancomycin-resistant *Enterococcus* species (VRE), penicillin-resistant *Streptococcus pneumoniae* (PRSP), extended spectrum β-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 goal of the CANWARD study was 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).

**Objectives of CANWARD 2007-2009:**

- To determine the pathogens associated with respiratory, urinary, bacteremic and wound/IV site infections in Canadian patients affiliated with hospitals from 2007-2009, 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 2007-2009, inclusive.
- To assess the activity of antimicrobials against respiratory, urinary, bacteremic and wound/IV site pathogens in Canadian patients affiliated with hospitals from 2007-2009, inclusive.

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## RESULTS

### Participating CANWARD 2007-2009 medical centres

| Investigator | Centre | City |
|---|---|---|
| Dr. D. Roscoe | Vancouver Hospital | Vancouver |
| Dr. R. Rennie | University of Alberta Hospital | Edmonton |
| Dr. J. Blondeau | Royal University Hospital | Saskatoon |
| Drs. Hoban / Zhanel | Health Sciences Centre | Winnipeg |
| Dr. Z. Hussain | London Health Sciences Centre | London |
| Dr. C. Lee | St. Joseph's Hospital | Hamilton |
| Dr. S. Poutanen | Mount Sinai Hospital | Toronto |
| Dr. L. Matukas | St. Michael's Hospital | Toronto |
| Dr. F. Chan | Children's Hospital of Eastern Ontario | Ottawa |
| Dr. M. Desjardins | The Ottawa Hospital | Ottawa |
| Dr. V. Loo | Royal Victoria Hospital | Montréal |
| Dr. V. Loo | Montreal General Hospital | Montréal |
| Dr. M. Laverdière | Hôpital Maisonneuve-Rosemont | Montréal |
| Dr. M. Goyette | CHRTR Pavilion Ste. Marie | Trois-Rivières |
| Dr. M. Kuhn | South East Regional Health Authority | Moncton |
| Dr. R. Davidson | Queen Elizabeth II HSC | Halifax |

### Demographics of patients/isolates from CANWARD 2007-2009

| Age Group (yrs) | n | % of Total |
|---|---|---|
| 17 and under | 2336 | 12.6 |
| 18 to 64 | 8525 | 46.0 |
| 65 or greater | 7677 | 41.4 |
| | **18,538** | |

| Gender | n | % of Total |
|---|---|---|
| Female | 8504 | 45.9 |
| Male | 10034 | 54.1 |
| | **18,538** | |

| Specimen Source | n | % of Total |
|---|---|---|
| Blood | 8245 | 44.5 |
| Respiratory | 5378 | 29.0 |
| Urine | 3059 | 16.5 |
| Wounds/IV | 1856 | 10.0 |
| | **18,538** | |

| Ward Type | n | % of Total |
|---|---|---|
| Clinic | 3311 | 17.9 |
| ER | 4847 | 26.1 |
| ICU | 3222 | 17.4 |
| Medical | 5489 | 29.6 |
| Surgical | 1669 | 9.0 |
| | **18,538** | |

### Activity of various antimicrobials against select pathogens from CANWARD 2007-2009

| Organism (n) / Drug | % S | % I | % R | $MIC_{50}$ | $MIC_{90}$ | Range Min | Range Max |
|---|---|---|---|---|---|---|---|
| ***Escherichia coli* (3930)** | | | | | | | |
| Amikacin | 99.54% | 0.31% | 0.15% | ≤ 2 | 4 | ≤ 2 | > 64 |
| Amoxicillin Clavulanic Acid | 94.31% | 4.67% | 1.03% | 4 | 8 | ≤ 0.06 | > 32 |
| Cefazolin | 32.82% | 33.79% | 33.38% | 2 | 32 | ≤ 0.5 | > 128 |
| Cefepime | 96.59% | 1.91% | 1.50% | ≤ 1 | ≤ 1 | ≤ 1 | > 32 |
| Cefoxitin | 91.83% | 3.57% | 4.60% | 4 | 8 | ≤ 0.06 | > 32 |
| Ceftazidime | 95.60% | 0.45% | 3.95% | ≤ 0.5 | 1 | ≤ 0.5 | > 32 |
| Ceftobiprole* | 93.00% | 0.36% | 6.64% | ≤ 1 | ≤ 1 | ≤ 1 | > 32 |
| Ceftriaxone | 91.07% | 0.46% | 8.47% | ≤ 1 | ≤ 1 | ≤ 1 | > 64 |
| Ciprofloxacin | 76.69% | 0.31% | 23.00% | ≤ 0.06 | > 16 | ≤ 0.06 | > 16 |
| Colistin | | NBD | | 0.5 | 1 | ≤ 0.06 | > 16 |
| Doripenem | 100.00% | | | ≤ 0.12 | ≤ 0.12 | ≤ 0.12 | 0.5 |
| Ertapenem | 99.96% | 0.04% | | ≤ 0.06 | ≤ 0.06 | ≤ 0.06 | 4 |
| Gentamicin | 89.67% | 0.36% | 9.97% | ≤ 0.5 | 8 | ≤ 0.5 | > 32 |
| Levofloxacin | 77.00% | 0.66% | 22.34% | ≤ 0.06 | 16 | ≤ 0.06 | > 32 |
| Meropenem | 100.00% | | | ≤ 0.12 | ≤ 0.12 | ≤ 0.12 | 1 |
| Moxifloxacin | | NBD | | ≤ 0.06 | > 16 | ≤ 0.06 | > 16 |
| Nitrofurantoin | 96.53% | 2.37% | 1.10% | 16 | 32 | ≤ 0.5 | > 256 |
| Piperacillin Tazobactam | 97.61% | 1.30% | 1.09% | 2 | 4 | ≤ 1 | > 512 |
| Tigecycline* | 99.87% | 0.13% | | 0.5 | 1 | 0.06 | 4 |
| Trimethoprim Sulfa | 72.85% | | 27.15% | ≤ 0.12 | > 8 | ≤ 0.12 | > 8 |
| ***Pseudomonas aeruginosa* (1476)** | | | | | | | |
| Amikacin | 89.09% | 4.81% | 6.10% | 8 | 32 | ≤ 2 | > 64 |
| Cefepime | 75.20% | 15.99% | 8.81% | 4 | 16 | ≤ 1 | > 32 |
| Ceftazidime | 84.82% | 4.15% | 11.03% | 4 | 32 | ≤ 0.5 | > 32 |
| Ceftobiprole | | NBD | | 4 | 16 | ≤ 1 | > 32 |
| Ceftriaxone | 22.22% | 44.72% | 33.06% | 32 | > 64 | ≤ 1 | > 64 |
| Ciprofloxacin | 70.05% | 8.60% | 21.34% | 0.5 | 8 | ≤ 0.06 | > 16 |
| Colistin | 90.92% | 8.06% | 1.02% | 2 | 2 | ≤ 0.06 | > 16 |
| Doripenem | 83.88% | | 16.12% | 0.5 | 4 | ≤ 0.12 | > 32 |
| Ertapenem | | NBD | | 8 | > 32 | 0.06 | > 32 |
| Gentamicin | 67.48% | 15.79% | 16.73% | 4 | 16 | ≤ 0.5 | > 32 |
| Levofloxacin | 63.48% | 12.06% | 24.46% | 1 | 16 | ≤ 0.06 | > 32 |
| Meropenem | 88.55% | 4.40% | 7.05% | 0.5 | 8 | ≤ 0.12 | > 32 |
| Moxifloxacin | | NBD | | 4 | > 16 | ≤ 0.06 | > 16 |
| Piperacillin Tazobactam | 91.94% | | 8.06% | 4 | 64 | ≤ 1 | > 512 |
| Tigecycline | | NBD | | > 16 | > 16 | 0.25 | > 16 |
| Trimethoprim Sulfa | | NBD | | 8 | > 8 | ≤ 0.12 | > 8 |
| ***Klebsiella pneumoniae* (1128)** | | | | | | | |
| Amikacin | 99.47% | 0.18% | 0.35% | ≤ 2 | ≤ 2 | ≤ 2 | > 64 |
| Amoxicillin Clavulanic Acid | 96.22% | 3.33% | 0.46% | 2 | 8 | 0.5 | > 32 |
| Cefazolin | 36.88% | 43.09% | 20.04% | 2 | 8 | ≤ 0.5 | > 128 |
| Cefepime | 97.96% | 0.44% | 1.60% | ≤ 1 | ≤ 1 | ≤ 1 | > 32 |
| Cefoxitin | 92.66% | 3.90% | 3.44% | 4 | 8 | 0.12 | > 32 |
| Ceftazidime | 97.33% | 0.30% | 2.38% | ≤ 0.5 | 1 | ≤ 0.5 | > 32 |
| Ceftobiprole* | 96.10% | 0.71% | 3.19% | ≤ 1 | ≤ 1 | ≤ 1 | > 32 |
| Ceftriaxone | 95.48% | 0.62% | 3.90% | ≤ 1 | ≤ 1 | ≤ 1 | > 64 |
| Ciprofloxacin | 91.76% | 1.24% | 7.00% | ≤ 0.06 | 0.5 | ≤ 0.06 | > 16 |
| Colistin | | NBD | | 0.5 | 1 | ≤ 0.06 | > 16 |
| Daptomycin | | NBD | | > 16 | > 16 | 2 | > 16 |
| Doripenem | 99.82% | | 0.18% | ≤ 0.12 | ≤ 0.12 | ≤ 0.12 | 4 |
| Ertapenem | 99.77% | | 0.23% | ≤ 0.06 | ≤ 0.06 | ≤ 0.06 | 16 |
| Gentamicin | 96.72% | 0.53% | 2.75% | ≤ 0.5 | ≤ 0.5 | ≤ 0.5 | > 32 |
| Levofloxacin | 93.71% | 1.77% | 4.52% | ≤ 0.06 | 1 | ≤ 0.06 | > 32 |
| Meropenem | 100.00% | | | ≤ 0.12 | ≤ 0.12 | ≤ 0.12 | 4 |
| Moxifloxacin | | NBD | | 0.12 | 1 | ≤ 0.06 | > 16 |
| Nitrofurantoin | 35.92% | 32.04% | 32.04% | 64 | 128 | 2 | > 256 |
| Piperacillin Tazobactam | 96.54% | 1.33% | 2.13% | 2 | 8 | ≤ 1 | > 512 |
| Tigecycline* | 95.57% | 3.63% | 0.80% | 1 | 2 | 0.25 | 16 |
| Trimethoprim Sulfa | 90.78% | | 9.22% | ≤ 0.12 | 2 | ≤ 0.12 | > 8 |

NBD - No breakpoints defined
* Interpretive breakpoints defined by Health Canada (ceftobiprole) or FDA (tigecycline)
** Based on oxacillin susceptibility
# Tetracycline breakpoints used to interpret MIC values

| Organism (n) / Drug | % S | % I | % R | $MIC_{50}$ | $MIC_{90}$ | Range Min | Range Max |
|---|---|---|---|---|---|---|---|
| ***Staphylococcus aureus* (MSSA) (2697)** | | | | | | | |
| Amikacin | 99.00% | 0.48% | 0.52% | 4 | 8 | ≤ 2 | > 64 |
| Amoxicillin Clavulanic Acid | 100.00% | | | 0.5 | 1 | ≤ 0.06 | 4 |
| Cefazolin | 99.96% | | 0.04% | 0.5 | 1 | ≤ 0.5 | 32 |
| Cefepime | 99.85% | 0.11% | 0.04% | 4 | 4 | ≤ 1 | 128 |
| Cefoxitin | 99.55% | | 0.45% | 4 | 4 | 0.12 | 16 |
| Ceftazidime | 31.38% | 67.43% | 1.18% | 16 | 16 | ≤ 0.25 | > 32 |
| Ceftobiprole* | 100.00% | | | ≤ 1 | ≤ 1 | ≤ 1 | 2 |
| Ceftriaxone | 99.70% | 0.26% | 0.04% | 4 | 4 | ≤ 1 | 256 |
| Ciprofloxacin | 85.47% | 3.37% | 11.16% | 0.5 | 4 | ≤ 0.06 | > 16 |
| Clarithromycin | 74.94% | 0.33% | 24.73% | 0.25 | > 16 | ≤ 0.25 | > 16 |
| Clindamycin | 91.77% | 0.56% | 7.68% | ≤ 0.25 | ≤ 0.25 | ≤ 0.25 | > 8 |
| Daptomycin | 100.00% | | | 0.12 | 0.25 | ≤ 0.06 | 1 |
| Doripenem | | NBD | | ≤ 0.12 | ≤ 0.12 | ≤ 0.12 | 1 |
| Gentamicin | 97.55% | 0.07% | 2.37% | ≤ 0.5 | 1 | ≤ 0.5 | > 32 |
| Levofloxacin | 90.10% | 0.33% | 9.57% | 0.25 | 1 | ≤ 0.06 | > 32 |
| Linezolid | 100.00% | | | 2 | 2 | ≤ 0.12 | 4 |
| Meropenem | 100.00% | | | 0.12 | 0.25 | ≤ 0.12 | 4 |
| Moxifloxacin | 90.36% | 0.59% | 9.05% | ≤ 0.06 | 0.25 | ≤ 0.06 | > 16 |
| Piperacillin Tazobactam | 99.93% | | 0.07% | ≤ 1 | ≤ 1 | ≤ 1 | 32 |
| Tigecycline* | 99.81% | | | 0.25 | 0.25 | ≤ 0.03 | 1 |
| Trimethoprim Sulfa | 99.26% | | 0.74% | ≤ 0.12 | ≤ 0.12 | ≤ 0.12 | > 8 |
| Vancomycin | 100.00% | | | 1 | 1 | ≤ 0.25 | 2 |
| ***Streptococcus pneumoniae* (1391)** | | | | | | | |
| Amoxicillin Clavulanic Acid | 98.62% | 0.87% | 0.51% | ≤ 0.06 | 0.12 | ≤ 0.06 | 8 |
| Ceftobiprole | | NBD | | ≤ 0.06 | 0.06 | ≤ 0.06 | 0.5 |
| Ceftriaxone | 99.42% | 0.36% | 0.22% | ≤ 0.12 | 0.12 | ≤ 0.12 | 4 |
| Cefuroxime | 94.27% | 1.89% | 3.85% | ≤ 0.25 | 0.5 | ≤ 0.25 | > 16 |
| Ciprofloxacin | | NBD | | 1 | 2 | ≤ 0.06 | > 16 |
| Clarithromycin | 81.25% | 4.29% | 14.46% | ≤ 0.03 | 2 | ≤ 0.03 | > 32 |
| Clindamycin | 93.53% | 0.58% | 5.89% | ≤ 0.12 | ≤ 0.12 | ≤ 0.12 | > 8 |
| Daptomycin | | NBD | | 0.06 | 0.12 | | |
| Doripenem | | NBD | | ≤ 0.06 | 0.06 | ≤ 0.06 | 2 |
| Doxycycline# | 93.16% | 2.84% | 4.00% | ≤ 0.25 | 1 | ≤ 0.25 | > 16 |
| Ertapenem | 99.85% | 0.07% | 0.07% | ≤ 0.06 | 0.12 | ≤ 0.06 | 4 |
| Levofloxacin | 99.06% | 0.15% | 0.80% | 1 | 1 | ≤ 0.06 | 32 |
| Linezolid | 100.00% | | | 0.5 | 1 | ≤ 0.12 | 2 |
| Meropenem | 96.37% | 2.54% | 1.09% | ≤ 0.06 | ≤ 0.06 | ≤ 0.06 | 2 |
| Moxifloxacin | 98.98% | 0.29% | 0.73% | 0.12 | 0.25 | ≤ 0.06 | 8 |
| Penicillin | 81.06% | 14.51% | 4.43% | ≤ 0.03 | 0.25 | ≤ 0.03 | > 8 |
| Piperacillin Tazobactam | | NBD | | ≤ 1 | ≤ 1 | ≤ 1 | 8 |
| Telithromycin | 100.00% | | | 0.008 | 0.03 | ≤ 0.008 | 0.5 |
| Tigecycline* | 98.55% | | | 0.03 | 0.06 | ≤ 0.03 | 0.5 |
| Trimethoprim Sulfa | 85.61% | 6.33% | 8.06% | ≤ 0.12 | 1 | ≤ 0.12 | > 8 |
| Vancomycin | 99.93% | | 0.07% | ≤ 0.25 | 0.25 | ≤ 0.25 | 2 |
| ***Staphylococcus aureus* (MRSA) (889)** | | | | | | | |
| Amikacin | 56.47% | 28.12% | 15.41% | 16 | 64 | ≤ 2 | > 64 |
| Amoxicillin Clavulanic Acid | | | 100%** | 16 | 32 | 1 | > 32 |
| Cefazolin | | | 100%** | 64 | > 128 | 1 | > 128 |
| Cefepime | | | 100%** | > 32 | > 32 | 4 | > 32 |
| Cefoxitin | | | 100%** | > 32 | > 32 | 1 | > 32 |
| Ceftazidime | | | 100%** | > 32 | > 32 | 16 | > 32 |
| Ceftobiprole* | 100.00% | | | 1 | 2 | ≤ 1 | 4 |
| Ceftriaxone | | | 100%** | > 64 | > 64 | 2 | > 64 |
| Ciprofloxacin | 13.39% | 0.22% | 86.39% | > 16 | > 16 | 0.25 | > 16 |
| Clarithromycin | 11.70% | 0.11% | 88.19% | > 16 | > 16 | ≤ 0.25 | > 16 |
| Clindamycin | 43.98% | 0.11% | 55.91% | > 8 | > 8 | ≤ 0.25 | > 8 |
| Daptomycin | 100.00% | | | 0.12 | 0.25 | 0.06 | 1 |
| Doripenem | | NBD | | 4 | 32 | ≤ 0.12 | > 32 |
| Ertapenem | | | 100%** | 8 | > 32 | 0.25 | > 32 |
| Gentamicin | 89.31% | | 10.69% | ≤ 0.5 | 32 | ≤ 0.5 | > 32 |
| Levofloxacin | 14.06% | | 85.94% | > 32 | > 32 | 0.12 | > 32 |
| Linezolid | 100.00% | | | 2 | 2 | ≤ 0.12 | 4 |
| Meropenem | | | 100%** | 8 | 32 | 0.12 | > 32 |
| Moxifloxacin | 14.06% | 1.01% | 84.93% | 8 | > 16 | ≤ 0.06 | > 16 |
| Nitrofurantoin | 100.00% | | | 16 | 16 | 8 | 32 |
| Piperacillin Tazobactam | | | 100%** | 64 | 128 | ≤ 1 | 512 |
| Tigecycline* | 99.33% | | | 0.25 | 0.5 | 0.06 | 1 |
| Trimethoprim Sulfa | 90.33% | | 9.67% | ≤ 0.12 | 1 | ≤ 0.12 | > 8 |
| Vancomycin | 99.89% | 0.11% | | 1 | 1 | ≤ 0.25 | 4 |

### Most common pathogens overall, and by infectious site

Overall

| Rank | Organism | n | % of Total |
|---|---|---|---|
| 1 | *E. coli* | 3934 | 21.2 |
| 2 | *S. aureus* - MSSA | 2700 | 14.6 |
| 3 | *P. aeruginosa* | 1477 | 8.0 |
| 4 | *S. pneumoniae* | 1463 | 7.9 |
| 5 | *K. pneumoniae* | 1130 | 6.1 |
| 6 | *S. aureus* - MRSA | 889 | 4.8 |
| 7 | CNS / *S. epidermidis* | 888 | 4.8 |
| 8 | *H. influenzae* | 728 | 3.9 |
| 9 | *Enterococcus* sp. | 585 | 3.2 |
| 10 | *E. cloacae* | 424 | 2.3 |
| 11 | *E. faecalis* | 393 | 2.1 |
| 12 | *S. pyogenes* | 305 | 1.6 |
| 13 | *S. agalactiae* | 291 | 1.6 |
| 14 | *P. mirabilis* | 289 | 1.6 |
| 15 | *K. oxytoca* | 272 | 1.5 |
| 16 | *S. marcescens* | 252 | 1.4 |
| 17 | *S. maltophilia* | 245 | 1.3 |
| 18 | *M. catarrhalis* | 198 | 1.1 |
| 19 | *Viridans Strep* | 165 | 0.9 |
| 20 | *E. faecium* | 152 | 0.8 |
| | Other | 1758 | 9.5 |
| TOTAL | | **18,538** | |

Blood

| Rank | Organism | n | % of Total |
|---|---|---|---|
| 1 | *E. coli* | 1856 | 22.5 |
| 2 | *S. aureus* - MSSA | 1101 | 13.4 |
| 3 | *CNS / S. epidermidis* | 784 | 9.5 |
| 4 | *K. pneumoniae* | 600 | 7.3 |
| 5 | *S. pneumoniae* | 470 | 5.7 |
| 6 | *E. faecalis* | 360 | 4.4 |
| 7 | *S. aureus* - MRSA | 356 | 4.3 |
| 8 | *P. aeruginosa* | 333 | 4.0 |
| 9 | *E. cloacae* | 193 | 2.3 |
| 10 | *S. viridans* | 162 | 2.0 |
| 11 | *S. pyogenes* | 159 | 1.9 |
| 12 | *C. albicans* | 150 | 1.8 |
| 13 | *S. agalactiae* | 142 | 1.7 |
| 14 | *E. faecium* | 140 | 1.7 |
| 15 | *K. oxytoca* | 132 | 1.6 |
| 16 | *S. marcescens* | 107 | 1.3 |
| 17 | *P. mirabilis* | 98 | 1.2 |
| 18 | *C. glabrata* | 50 | 0.6 |
| 19 | *S. mitis* | 48 | 0.6 |
| 20 | *BHS gr G* | 47 | 0.6 |
| | Other | 957 | 11.6 |
| TOTAL | | **8245** | |

Respiratory

| Rank | Organism | n | % of Total |
|---|---|---|---|
| 1 | *S. pneumoniae* | 996 | 18.5 |
| 2 | *S. aureus* - MSSA | 912 | 17.0 |
| 3 | *P. aeruginosa* | 870 | 16.2 |
| 4 | *H. influenzae* | 687 | 12.8 |
| 5 | *S. aureus* - MRSA | 293 | 5.4 |
| 6 | *E. coli* | 226 | 4.2 |
| 7 | *K. pneumoniae* | 202 | 3.8 |
| 8 | *M. catarrhalis* | 193 | 3.6 |
| 9 | *S. maltophilia* | 188 | 3.5 |
| 10 | *E. cloacae* | 121 | 2.2 |
| 11 | *S. marcescens* | 115 | 2.1 |
| 12 | *K. oxytoca* | 79 | 1.5 |
| 13 | *H. parainfluenzae* | 59 | 1.1 |
| 14 | *P. mirabilis* | 39 | 0.7 |
| 15 | *Enterococcus* spp. | 37 | 0.7 |
| 16 | *S. agalactiae* | 36 | 0.7 |
| 17 | *E. aerogenes* | 33 | 0.6 |
| 18 | *S. pyogenes* | 30 | 0.6 |
| 19 | *A. baumannii* | 22 | 0.4 |
| 20 | *A. xylosoxidans* | 16 | 0.3 |
| | Other | 224 | 4.2 |
| TOTAL | | **5378** | |

Urine

| Rank | Organism | n | % of Total |
|---|---|---|---|
| 1 | *E. coli* | 1696 | 55.4 |
| 2 | *Enterococcus spp.* | 403 | 13.2 |
| 3 | *K. pneumoniae* | 274 | 9.0 |
| 4 | *P. mirabilis* | 122 | 4.0 |
| 5 | *P. aeruginosa* | 100 | 3.3 |
| 6 | *CNS / S. epidermidis* | 58 | 1.9 |
| 7 | *E. cloacae* | 54 | 1.8 |
| 8 | *S. agalactiae* | 52 | 1.7 |
| 9 | *K. oxytoca* | 46 | 1.5 |
| 10 | *S. aureus* - MSSA | 45 | 1.5 |
| 11 | *S. aureus* - MRSA | 35 | 1.1 |
| 12 | *C. freundii* | 29 | 0.9 |
| 13 | *M. morganii* | 24 | 0.8 |
| 14 | *C. koseri* | 14 | 0.5 |
| 15 | *S. saprophyticus* | 14 | 0.5 |
| 16 | *S. marcescens* | 12 | 0.4 |
| 17 | *E. aerogenes* | 10 | 0.3 |
| 18 | *Klebsiella spp.* | 8 | 0.3 |
| 19 | *E. faecalis* | 6 | 0.2 |
| 20 | *P. vulgaris* | 5 | 0.2 |
| | Other | 52 | 1.7 |
| TOTAL | | **3059** | |

Wounds / IV

| Rank | Organism | n | % of Total |
|---|---|---|---|
| 1 | *S. aureus* - MSSA | 641 | 34.5 |
| 2 | *S. aureus* - MRSA | 205 | 11.0 |
| 3 | *P. aeruginosa* | 173 | 9.3 |
| 4 | *E. coli* | 153 | 8.2 |
| 5 | *S. pyogenes* | 113 | 6.1 |
| 6 | *Enterococcus* spp. | 97 | 5.2 |
| 7 | *S. agalactiae* | 61 | 3.3 |
| 8 | *E. cloacae* | 56 | 3.0 |
| 9 | *K. pneumoniae* | 53 | 2.9 |
| 10 | *CNS / S. epidermidis* | 45 | 2.4 |
| 11 | *P. mirabilis* | 30 | 1.6 |
| 12 | *E. faecalis* | 19 | 1.0 |
| 13 | *BHS gr G* | 19 | 1.0 |
| 14 | *S. marcescens* | 18 | 1.0 |
| 15 | *K. oxytoca* | 15 | 0.8 |
| 16 | *S. maltophilia* | 14 | 0.8 |
| 17 | *E. aerogenes* | 11 | 0.6 |
| 18 | *M. morganii* | 10 | 0.5 |
| 19 | *C. freundii* | 9 | 0.5 |
| 20 | *E. faecium* | 9 | 0.5 |
| | Other | 105 | 5.7 |
| TOTAL | | **1856** | |

## MATERIALS & METHODS

**Participating Sites:** Sentinel hospital sites (12 in 2007, 10 in 2008, 15 in 2009) in major population centres in 8 of the 10 provinces in Canada were recruited (see Results and references 1 and 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. From January 2007 through December 2009, inclusive, 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 were excluded. We also excluded anaerobic organisms. 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, and 2009, 7881, 5282, and 5375 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, 2006 M7-A7 and M100-S16). Antimicrobial minimum inhibitory concentration (MIC) interpretive standards were defined according to CLSI breakpoints (CLSI, 2010). 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-A7, 2006). The MICs of the antimicrobial agents for the isolates 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 105 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; *S. pneumoniae* 49619, *S. aureus* 29213, *E. faecalis* 29212, *E. coli* 25922, and *P. aeruginosa* 27853.

## CONCLUSIONS

- Of the 18,538 pathogens obtained, the most common were: *E. coli* 21.6%, *S. aureus* (MSSA) 14.6%, *P. aeruginosa* 8.0%, *S. pneumoniae* 7.9%, *K. pneumoniae* 6.1%, MRSA 4.8%, *H. influenzae* 3.9% and *Enterococcus* spp. 3.2%.
- Isolates were obtained from blood (44.5%), respiratory (29.0%), urine (16.5%) and wound specimens (10%) from patients on W 38.6% (29.6% medical/9.0% surgical), ER 26.1%, C 17.9% and ICU 17.4%.
- Susceptibility rates for *E. coli* were: 100% doripenem and meropenem, 99.9% ertapenem, 99.9% tigecycline, 99.5% amikacin, 97.6% piperacillin/tazobactam (P/T), 96.6% cefepime, 95.6% ceftazidime, 93.0% ceftobiprole, 91.1% ceftriaxone, 73.3% gentamicin, 72.9% trimethoprim/sulfamethoxazole (T/S), and 76.7% ciprofloxacin.
- Susceptibility rates for *P. aeruginosa* were: 91.9% piperacillin/tazobactam, 90.9% colistin, 89.1% amikacin, 88.6% meropenem, 83.9% doripenem, 84.8% ceftazidime, 70.1% ciprofloxacin and 67.5% gentamicin.
- Susceptibility rates for MRSA were: 100% ceftobiprole, daptomycin and linezolid, with 99.9% vancomycin, 99.3% tigecycline, 90.3% T/S, 44.0% clindamycin, 13.4% ciprofloxacin, and 11.7% for clarithromycin.

## REFERENCES


1. Zhanel GG, *et al*. Prevalence of antimicrobial resistant pathogens in Canadian hospitals: Results of the Canadian ward surveillance study (CANWARD 2007). *Can J Infect Dis Med Microbiol* 2009; 20 (Suppl A): 9-19.
2. Zhanel GG, *et al*. Antimicrobial susceptibility of 6,685 isolated from Canadian hospitals: CANWARD 2007. *Can J Infect Dis Med Microbiol* 2009; 20 (Suppl A): 20-30.



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