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ORIGINAL ARTICLE

Patient risk factor stratification is essential for the hospital antibiogram

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Abstract

Empiric antimicrobial therapy in hospitalized patients is guided by an institution's cumulative antibiogram, which may not be adequate in giving information on decision-making for optimal treatment in different patient populations. Adding patient risk factors can make it more useful for clinicians in guiding empiric therapy and for antimicrobial stewardship. Cumulative data were obtained for blood culture and urine isolates from the laboratory information system of a tertiary care hospital for 6 months (January to June 2019). Further stratification of organism types and resistance rates on the basis of patient risk factors (Patient Types 1, 2, and 3) was performed and analyzed. *Salmonella* spp. was seen in community-acquired ward patients (Types 1 and 2). *Streptococcus pneumoniae* was seen in Type 1 patients, and *Acinetobacter* spp. was seen in Type 3 patients. Extended-spectrum beta-lactamase-producing gram-negative infection rates were higher in community patients than in hospital patients. Carbapenem-resistant *Enterobacteriaceae* rates were high in Type 3 hospitalized patients. Cumulative blood methicillin-resistant *Staphylococcus aureus* rates were 43% but stratification showed it only in Type 2 and Type 3 ICU patients with 0% in ward patients. Stratified antibiograms based on patient risk factors are valuable for antimicrobial stewardship and help to optimize empiric therapy and increase the understanding of antimicrobial resistance trends.

Keywords: *antimicrobial stewardship; antibiogram; drug resistance; risk factors; India*

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Antimicrobial resistance is increasing worldwide, so it is crucial to monitor the emerging trends in drug resistance at the local hospital level to support decision-making for clinicians, infection control interventions, and antimicrobial resistance containment strategies. Cumulative susceptibility data and derived resistance patterns are used to guide empiric antimicrobial therapy and to detect changes in antibiotic resistance over time, as surveillance of local antibiotic resistance is an integral part of antimicrobial stewardship. In our healthcare facilities, local antimicrobial resistance trend monitoring is commonly performed using an annual summary of susceptibility rates known as a cumulative antibiogram. To ensure applicability to specific patient populations, the Clinical and Laboratory Standards Institute (CLSI) has published guidelines recommending division of susceptibility data by patient location, clinical service, specimen type, and patient population (1).

Clinicians rely on an institution wide cumulative antibiogram that may be skewed because it does not accurately reflect susceptibility rates in different patient populations. Thus, proper history details and patient risk factors, a history of prior admissions, and co-morbid conditions should be included in order to make it meaningful for the clinicians who have to prescribe drugs on the basis of our data.

Standard antibiogram studies segregate only laboratory data. A stratified antibiogram gives clinicians more information than cumulative antibiogram—provides better understanding of resistance patterns to guide optimum empirical therapy and the formulation of an effective local antibiotic policy in hospitals.

Our objective was to compare the hospital-wide cumulative antibiograms of patients with the results of additional stratification of susceptibility data to help with appropriate empiric antibiotic selection and improved surveillance of antimicrobial resistance trends in our institution.

Materials and methods

The antibiogram is assessed 6 monthly in our tertiary care hospital, P. D. Hinduja Hospital and Medical Research

Centre, Mumbai, India, by aggregating the susceptibility data of all isolates from different locations (outpatient, wards, ICU) and sites of infection (blood, urine, lower respiratory tract, intra-abdominal infection) of patients of all ages. For this study, antimicrobial susceptibility data and cumulative antibiogram were analyzed only for blood and urine cultures from the laboratory information system for a period of 6 months from January to June 2019.

The same blood and urine sample data were used to further stratify our antibiogram into community-acquired and hospital-acquired infections by including patient history details and risk factors such as hospitalization of the patient during the previous 90 days, invasive procedures performed during hospitalization, antibiotic exposure in the previous 90 days, and any co-morbid conditions such as immunosuppression, diabetes mellitus, and chronic kidney disease (CKD) (2). On the basis of these risk factors, patients were divided into three types, Types 1, 2, and 3, as shown in Table 1. For every positive blood and urine culture isolate, the patient's contact detail (for outpatients) or admission detail (for inpatients) was noted. Each patient was contacted by phone and asked for history and risk factors. Depending upon these risk factors, patient type (Type 1, 2, or 3) was determined. The patient's admission date was also noted which helped us to evaluate whether the infection was community acquired (within 48 h of admission) or healthcare associated (after 48 h of admission).

The study was approved by the Institutional Ethics Committee.

Results

Cumulative data

Our cumulative organism data for 6 months (January to June 2019) showed 317 isolates for blood culture in wards and ICU collectively, of which 155 were ward isolates and 162 were ICU isolates. The most common organisms in wards were *Escherichia coli* (32%), followed by *Salmonella* spp. (9%), *Klebsiella pneumoniae* (8%), *Staphylococcus aureus* (all MSSA) (6%), and *Enterococcus* spp. (6%); in the ICU, the most common organisms were *K. pneumoniae* (20%) and *E. coli* (20%), followed by *Enterococcus* spp. (6%), *Pseudomonas aeruginosa* (5%), and *S. aureus* (4%).

Similarly, the total number of isolates was 432 for urine cultures in wards and ICU collectively, of which 315 were ward isolates and 117 were ICU isolates. Urine isolates from wards were mainly *E. coli* (44%), *K. pneumoniae* (19%), *P. aeruginosa* (8%), *Enterococcus* spp. (5%), and *Proteus mirabilis* (3%) and those from ICU were mainly *E. coli* (32%), *K. pneumoniae* (16%), *Enterococcus* spp. (5%), *P. aeruginosa* (5%), and *P. mirabilis* (3%).

Stratified data

Further stratification of the most common organisms based on cumulative data was performed on the basis of patient risk factors, and the results were different as shown in Table 2.

Resistance rates in blood and urine isolates are shown in Tables 3 and 4, respectively, with cumulative data in the left column and stratified data in the remaining columns.

Discussion

Inclusion of different patient types based on risk factors at our hospital was transformative to the hospital antibiogram.

The most common blood culture isolates in wards and in ICU as per cumulative data were *E. coli,* followed by *Salmonella* spp. and *K. pneumoniae*. Further stratification showed that community-acquired *Salmonella* spp. was the common organism in Type 1 and Type 2 community-acquired infections and not in Type 3 and hospital-acquired infections, which our cumulative data were not able to differentiate. In ICU, *Streptococcus pneumoniae* was seen in Type 1 patients and *Acinetobacter* spp. was seen in Type 3 patients. This lent clarity about common organisms in certain patient types.

Our ESBL rates in blood and urine in wards and ICU were almost the same as shown by cumulative data, while risk factor stratification showed that ESBL rates were higher in community patients than in hospital patients as hospital CRE rates could have masked the actual ESBL rates.

Table 1. Patient types classified on the basis of risk factors

Patient risk factors (2)	Patient type 1	Patient type 2	Patient type 3
Hospitalization in last 90 days	No	Yes	Yes
Invasive procedures during hospitalization	Not applicable	No	Yes
Antibiotics received in last 90 days	No	≤2	≥3
Co-morbid conditions	No	≤2	≥3*
Criteria to be fulfilled	All	Any 1	Any 1

*Patients with malignancy/CKD (on hemodialysis) are considered patient Type 3.

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Table 2. Most common organisms based on stratification by patient risk factors

Sample type	Location type	Infection acquired type	Patient types based on risk factors (refer to Table 1)		
			Patient type 1	Patient type 2	Patient type 3
Blood	Wards	Community acquired (within 48 h of admission)	1. *Salmonella* spp. 2. *E. coli*	1. *E. coli* 2. *Salmonella* spp. 3. *K. pneumoniae* 4. *S. aureus* 5. *P. aeruginosa*	1. *E. coli* 2. *Klebsiella* spp. 3. *Pseudomonas* spp. 4. *Enterococcus* spp. 5. *S. aureus*
		Hospital acquired (after 48 h of admission)	*	1. *E. coli* 2. *Proteus* spp. 3. *S. aureus* 4. *Streptococcus* spp.	1. *E. coli* 2. *Klebsiella* spp. 3. *Pseudomonas* spp. 4. *S. aureus* 5. *Enterococcus* spp.
	ICU	Community acquired	1. *Streptococcus pneumoniae* 2. *E. coli* 3. *K. pneumoniae*	1. *E. coli* 2. *Salmonella* spp. 3. *S. aureus* 4. *Enterococcus* spp.	1. *E. coli* 2. *Klebsiella* spp. 3. *Acinetobacter* spp. 4. *S. aureus* 5. *Burkholderia cepacia*
		Hospital acquired	*	1. *E. coli* 2. *Acinetobacter* spp. 3. *Enterococcus* spp.	1. *E. coli* 2. *Klebsiella* spp. 3. *Pseudomonas* spp. 4. *Candida* spp. 5. *Enterococcus* spp. 6. *Enterobacter* spp.
Urine	Wards	Community acquired	1. *E. coli* 2. *Klebsiella* spp. 3. *Enterococcus* spp. 4. *Pseudomonas* spp. 5. *Salmonella* spp.	1. *E. coli* 2. *Candida* spp. 3. *Pseudomonas* spp. 4. *Klebsiella* spp. 5. *Enterococcus* spp.	1. *E. coli* 2. *Klebsiella* spp. 3. *Pseudomonas* spp. 4. *Enterococcus* spp. 5. *Acinetobacter* spp.
		Hospital acquired	*	1. *E. coli* 2. *Klebsiella* spp. 3. *Enterococcus* spp. 4. *Proteus* spp. 5. *Candida* sp.	1. *E. coli* 2. *Klebsiella* spp. 3. *Pseudomonas* spp. 4. *Providencia* spp. 5. *Enterobacter* spp.
	ICU	Community acquired	1. *K. pneumoniae* 2. *Candida* spp.	1. *E. coli* 2. *Candida* spp. 3. *K. pneumoniae* 4. *Pseudomonas* spp. 5. *Streptococcus* spp.	1. *E. coli* 2. *Candida* spp. 3. *K. pneumoniae* 4. *Enterococcus* spp. 5. *Morganella morganii* 5. *S. aureus*
		Hospital acquired		1. *E. coli* 2. *K. pneumoniae* 3. *Candida* spp. 4. *Pseudomonas* spp. 5. *Enterococcus* spp.	1. *K. pneumoniae* 2. *E. coli* 3. *Candida* spp. 4. *Pseudomonas* spp. 5. *Enterococcus* spp.

*Type 1 patients have not been hospitalized and therefore cannot have hospital-acquired infection.

CRE rates in ward blood isolates were 20% and 37% in ICU as per the cumulative data. When we stratified it further, CRE rates were higher in Type 3 patients, while they were nil in the blood isolates of Type 1 and Type 2 patients. The same pattern was also seen in urine isolates. CRE coverage is important in Type 3 patients with multiple risk factors and not in other patient types; our cumulative antibiogram did not differentiate patient types because it extrapolates CRE rates for whole wards and ICU populations. On the basis of this observation, we can change our antibiotic policy to add colistin with carbapenem in Type 3 hospitalized patients.

Cumulative VRE rates in blood isolates in wards and ICU were 22% and 10%, respectively. Our stratified data showed that VRE rates were around 20% in Type 3 patients in wards and 50% in Type 3 community-acquired ICU patients, although numbers were lower. Similarly, our cumulative blood MRSA rates were 43%, while stratification showed

Table 3. Resistance rates in blood isolates

Resistance rates in blood gram-negative bacilli (GNB) isolates (cumulative %)	Wards (stratified %)				
	Community-acquired infection			Hospital-acquired infection	
	Type 1	Type2	Type3	Type2	Type3
Extended-spectrum beta-lactamase(ESBL)-producing organisms (37%)	Nil	73%	35%	75%	33%
Carbapenem-resistant *Enterobacteriaceae* (CRE) (20%)	Nil	Nil	23%	Nil	28%
Vancomycin resistant enterococci (VRE) (22%)	Nil	Nil	25%	Nil	20%
Methicillin-resistant *Staphylococcus aureus* (MRSA) (Nil)	Nil	Nil	Nil	Nil	Nil
Resistance rates in blood GNB isolates (cumulative %)	ICU (stratified %)				
	Community-acquired infection			Hospital-acquired infection	
	Type 1	Type 2	Type 3	Type2	Type3
ESBL (36%)	33%	55%	35%	25%	16%
CRE (37%)	Nil	Nil	41.2%	Nil	38.7%
VRE (10%)	Nil	Nil	50%	Nil	Nil
MRSA (43%)	Nil	50%	50%	Nil	33%

Table 4. Resistance rates in urine isolates

Resistance rates in urine gram-negative bacilli (GNB) isolates (cumulative %)	Wards (stratified %)				
	Community-acquired infection			Hospital-acquired infection	
	Type1	Type 2	Type 3	Type 2	Type 3
Extended-spectrum beta-lactamase (ESBL)-producing organisms (37%)	22%	50%	24%	36%	18%
Carbapenem-resistant *Enterobacteriaceae* (CRE) (24%)	Nil	Nil	24	3%	48%
Vancomycin-resistant enterococci (VRE) (18%)	Nil	25%	33%	Nil	Nil
Methicillin-resistant *Staphylococcus aureus* (MRSA) (Nil)	Nil	Nil	Nil	Nil	Nil
Resistance rates in urine GNB isolates (cumulative %)	ICU (stratified %)				
	Community-acquired infection			Hospital-acquired infection	
	Type 1	Type 2	Type 3	Type 2	Type 3
ESBL (34%)	98%	29%	6%	17%	19%
CRE (30%)	Nil	Nil	45%	Nil	39%
VRE (50%)	Nil	Nil	Nil	Nil	66.6%
MRSA (Nil)	Nil	Nil	Nil	Nil	Nil

that this was seen only in Type 2 and Type 3 ICU patients. Our observation of 6 months data hints at how clinical stratification can help us with antimicrobial stewardship by including risk factors and relevant history of patients in our antibiogram. These early data on patient stratification with risk factors and relevant history are vital to the understanding and implementation of antibiogram.

Limitations

As our study included 6 months antibiogram data, numbers are small and statistical analysis could not be performed. We therefore do not know if the difference between cumulative and stratified antibiograms is significant, but certainly a difference is observable and warrants further investigation.

Conclusions

Clinicians' reliance on institution wide antibiograms that do not accurately reflect susceptibility rates in certain patient groups might lead to inappropriate empiric antibiotic prescribing. Usual antibiogram studies have only laboratory data, but our study went further and incorporated relevant patient-related clinical history and other factors to stratify susceptibility data.

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Stratifying the antibiogram by incorporating patient risk factors is a valuable antibiotic stewardship tool that helps in appropriate empiric antibiotic selection and improved surveillance of antimicrobial resistance trends. Such stratification is key to antimicrobial stewardship program (3).

Disclosure statement

Camilla Rodrigues is a Scientific Advisory Board member and has received speaker honoraria from Pfizer, Sanofi and Biomerieux; and has received speaker honoraria from B Braun, Becton Dickinson , Cipla, Glenmark, Novartis, and Cepheid. Anjali Shetty is an Advisory Board member for Bharat Biotech and has received honoraria from Pfizer.

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References

1. Hindler JF, Stelling J. Analysis and presentation of cumulative antibiograms: a new consensus guideline from the Clinical and Laboratory Standards Institute. Clin Inf Dis 2007; 44: 867–73. doi: 10.1086/511864
2. Slavcovici A, Streinu-Cercel A, Tatulescu D, Radulescu A, Mera S, Marcu C et al. The role of risk factors ('Carmeli score') and infective endocarditis classification in the assessment of appropriate empirical therapy. Therapeut Pharmacol Clin Toxicol 2009; 13(1): 52–6.
3. Swami SK, Banerjee R. Comparison of hospital-wide and age and location – stratified antibiograms of *S. aureus*, *E. coli*, and *S. pneumoniae*: age- and location-stratified antibiograms. Springerplus 2013; 2(1): 63. doi: 10.1186/2193-1801-2-63

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