American Journal of Infectious Diseases and Microbiology, 2015, Vol. 3, No. 3, 104-111
Available online at http://pubs.sciepub.com/ajidm/3/3/3

DOI:10.12691/ajidm-3-3-3

The Challenge to Interpret Antimicrobial Susceptibility at a Small Community Hospital

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Received January 31, 2015; Revised April 30, 2015; Accepted May 15, 2015

Abstract Objective: We aimed to determine the prevailing resistance rates at a local community hospital for a select group of gram-positive and gram-negative microorganisms for the period 2008-2012. Methods: Aerobic and facultative anaerobic culture isolates representing blood, urine and wounds specimens from all wards were tested at the Microbiology Laboratory, using the MicroScan AutoScan4, to determine antimicrobial susceptibility at the local community hospital. Results: the findings allude to the prevalence of resistance at the institution for the period under review. Conclusion: Resistance trends are speculative at best without the inclusion of molecular characterization of resistance and consumption data. Pharmacists should play a greater role in the determination of resistance by providing the microbiologist with consumption or utilization data, such as the daily defined dose. The inclusion of the daily defined dose in the estimation of resistance would allow clinicians to determine if selective pressure may have contributed to the prevailing resistance rates.

Keywords: *Antimicrobial resistance, Antimicrobial susceptibility, Antimicrobial stewardship, Antibiogram, gram positive organisms, gram negative organisms, antimicrobial agents*

Cite This Article: Patricia Sealy, and William H. Swanston, "The Challenge to Interpret Antimicrobial Susceptibility at a Small Community Hospital." *American Journal of Infectious Diseases and Microbiology*, vol. 3, no. 3 (2015): 104-111. doi: 10.12691/ajidm-3-3-3.

1. Introduction

Surveillance studies conducted by the Centers for Disease Control (CDC) have demonstrated an alarming increase in resistance, which impacted negatively on patient mortality/morbidity and limited the use of antimicrobial agents [1,2,3]. These studies provide information about changes in the spectrum of microbial pathogens and trends in the antimicrobial resistance patterns in infection (both nosocomial and community-acquired) [4,5]. In an era of increasing antimicrobial resistance and a dearth of new antimicrobial agents being developed by the pharmaceutical industry, surveillance studies can be used by microbiologists to develop strategies such as antibiotic heterogeneity [6,7] to preserve the efficacy [8,9,10] of antimicrobial agents. Therefore by extension, clinicians can be alerted and kept abreast of resistance trends in the institution so that informed decisions would be made concerning therapeutic (specifically empiric) options for the management of infectious diseases.

The antibiogram is a tool that can be used to guide clinicians in the treatment of infectious diseases. More importantly, an antibiogram is crucial for microbiologists to monitor resistance trends (and) to assess the efficacy of antimicrobial agents. Since pharmacists are the custodian of pharmaceutical agents at institutions, they should be consulted on the consumption, the daily defined dose calculation, of antimicrobial agents when the analysis of the antibiogram is conducted by the microbiologist and/or infectious diseases clinicians.

Universal health care is practiced in Trinidad and Tobago (TT), where the Healthcare system is divided into five (5) Regional Health Authorities (RHAs); each RHA has one tertiary institution. Although the RHAs expend vast resources on the purchase of antimicrobial agents, antimicrobial surveillance to monitor and control the use (i.e. judicious) of antimicrobial agents is not conducted neither locally (at the level of the institution), regionally (at the RHAs), nor nationally (cumulative data analysis of all RHAs). Deducing susceptibility (or resistance) trends can assist in preserving the life (or efficacy) of antimicrobial agents at the institution. We aimed to determine the resistance patterns of organisms in order to assess the efficacy of antimicrobial agents at the institution for the period 2008 to 2012.

2. Methods

Antimicrobial susceptibility testing of aerobic and facultative anaerobic cultures were reported for patient isolates that were processed at the Microbiology Laboratory of the 120-bed community hospital in East

Trinidad for the years 2008 to 2012. Susceptibility testing was performed on the MicroScan AutoScan 4 according to the manufacturer's instructions. The inoculum for the panels were prepared using the MicroScan Prompt System (11). Duplicate isolates were excluded and the interpretation of the susceptibility data was in accordance with the Clinical Laboratory Standards Institute (CLSI) Standards in the M100 S22 document (12). The collated data, specifically isolates from blood, urine and wounds were analysed; the isolates from other specimens (cerebrospinal, pleural and ascitic fluids, and sputum) were very small in number and it was decided to omit them from the individual analysis, although these may be included in the collective specimens. The specimens were representative of all wards and the susceptibility results were subsequently translated into potential antimicrobial agent efficacy against microorganisms. The Control reference strains recommended by the MicroScan manufacturers and used by the laboratory were: *Escherichia coli* ATCC 25922, *Staphylococcus* aureus ATCC 33591; *Staphylococcus aureus* ATCC 25923, *Klebsiella pneumoniae* ATCC 13883, *Klebsiella oxytoca* ATCC49131, *Staphylococcus saprophyticus* ATCC 49907, *Enterobacter aerogenes* ATCC13043, *Enterococcus faecalis* ATCC29212, *Pseudomonas aeruginosa* ATCC 27853, *Proteus vulgaris* ATCC 49132, *Streptococcus* pneumoniae ATCC35088, *Streptococcus* pneumoniae ATCC 33400. Ethics approval was granted by the University Ethics Committee and the Regional Health Agency to conduct this study.

3. Results

3.1. *Escherichia coli*

Resistance rates (Table 1) for collective *E. coli* isolates with amoxicillin-clavulanate, aztreonam, piperacillin-tazobactam, ciprofloxacin, levofloxacillin and gentamycin and tobramycin were generally similar (11 to 33%). For blood isolates, high rates (30 to 52%) were noted for ampicillin, amoxicillin-clavulanate, aztreonam, piperacillin-tazobactam and TMP/SMX. For urine isolates, high rates (22 to 56%) were noted for ampicillin, amoxicillin-clavulanate, ciprofloxacin, levofloxacillin and trimethoprim/sulfamethaxoze (TMP/SMX).In addition, rates were disproportionally higher (26 to 74%) for all agents among wound isolates.

Table 1. Cumulative Resistance Rates (%) from 2008 to 2012 for *E. Coli*

Agents	Collective	Blood	Urine	Wound
	161 – 397 Isolates	14-23 Isolates	244-305 Isolates	72-84 Isolates
	Resistance Rates (%)			
Ampicillin	53-60	52	52-56	74
Amoxicillin-clavulanate	17-33	30-33	22-30	50
Cephalothin	71-94	—	—	—
2-/3-/4-GC	6-20	13-20	< 25	32
Aztreonam	16-23	30-40	12-18	42
Piperacillin-tazobactam	11-20	36-43	9-19	26-40
Ciprofloxacin	25-31	19	21-31	46
Levofloxacin		19-29		
Gentamycin	16-18	21-27	14-21	37
Tobramycin		29	—	
TMP/SMX	35-45	43-47	30-37	53

AWAI, all wards all isolates; Collective: blood, urime, wound and minute amounts of cerebrospinal, pleural, ascitic fluids and sputum
GC: Generation Cephalosporin.

3.2. *Klebsiella pneumoniae*

There was no major difference in resistance rates (9 to 31%, Table 2) among the 2nd, 3rd and 4th generation cephalosporin (GC) agents for all isolates. Similarly, resistance also existed among the fluoroquinolones (18 to 37%) and aztreonam (24-33%). Resistance rates of 22 to 31% was also noted with TMP/SMX and piperacillin-tazobactam.

Table 2. Cumulative Resistance Rates (%) from 2008 to 2012 for *K. pneumonia*

Agents	Collective	Blood	Urine	Wound
	79-202 Isolates	6-11 Isolates	50-114 Isolates	60-80 Isolates
	Resistance Rates (%)			
Amoxicillin-clavulanate	—		25-40	31-33
Cefuroxime	—		15-26	25
Ceftriaxome	11-27	Too	16-22	18
Cefotaxime	19-30		—	—
Ceftazidime	—		20-22	19
Cefepime	9-31	Few	17-20	20
Aztreonam	24-31		24-25	22-33
Piperacillin-tazobactam	22-28	To	17-26	28-30
Ciprofloxacin	25-36		25-36	20-37
Levofloxacin	18-25		19-31	10-33
Gentamycin	—	Interpret	—	14-38
Tobramycin			—	49
TMP/SMX	—		23-31	28

AWAI, All Wards All Isolates; Collective: blood, urine, wound and minute amounts of cerebrospinal, pleural, ascitic fluids and sputum.

3.3. *Pseudomonas aeruginosa*

Among antimicrobial agents, fluoroquinolones, carbapenems and piperacillin-tazobactam, aminoglycosides (amikacin and tobramycin) were equally efficacious for treating *P. aeruginosa* blood and wound isolates (Table 3). Aztreonam and Gentamycin rates were as high as 50 and 42%, respectively, for collective isolates.

Table 3. Resistance Rates (%) from 2008 to 2012 for *P. aeruginosa*

Agents	Collective	Blood	Urine	Wound
	55-119 Isolates	-	54 Isolates	53-120 Isolates
	Resistance Rates (%)			
Ceftazidime	10-23	Data Not Collate, but Included Among AWAI	17	3-20
Cefepime	12-33		31	14-24
Aztreonam	26-50		47	27-38
Piperacillin-tazobactam	4-24		21	10-18
Ciprofloxacin	17-25		30	18-19
Levofloxacin	12-25		31	18-20
Amikacin	7-15		—	2-18
Gentamycin	15-42		—	7-28
Tobramycin	5-20		24	14
Imipenem	—		26	5-11
Meropenem	2-25		—	—

AWAI, all wards all isolates; Collective: blood, urine, wound and minute amounts of cerebrospinal, pleural, ascitic fluids and sputum.

Table 4. Cumulative Resistance Rates (%) from 2008 to 2012 for Proteus mirabilis

Agents	Collective	Blood	Urine	Wound
	70-89 Isolates	—	16-19 Isolates	49-72 Isolates
	Resistance Rates (%)			
Ampicillin	34-35	Data Not Collated, But Included Among AWAI	The Number of Isolates Too Small (<30) to Assess	37-43
Amoxicillin-clavulanate	18-31			34-36
Cephalothin	19-25			—
Cefuroxime	11-18			8-18
Ceftriaxome	6-11			6
Cefotaxime	6-11			—
Ceftazidime	9-12			3-49
Cefepime	12-21			13-22
Aztreonam	24-38			37-39
Piperacillin-tazobactam	11-27			17-32
Ciprofloxacin	13-24			14-29
Levofloxacin	6-13			6-13
Amikacin	7-11			5-12
Gentamycin	10-14			6-18
Tobramycin	9-15			12
TMP/SMX	16-34			18-42
Ertapenem	4-12			6-15
Imipenem	7-16			6-16
Meropenem	2-33			2

AWAI, all wards all isolates; Collective: blood, urine, wound and minute amounts of cerebrospinal, pleural, ascitic fluids and sputum.

Table 5. Resistance Rates (%) from 2008 to 2012 for *Staphylococcus aureus*

Agents	Collective	Blood	Urine	Wound
	60-134 Isolates	162 Isolates	—	90-144 Isolates
Ampicillin	92-95	87	Data Not Collated, But Included Among AWAI	92-93
Amoxicillin-clavulanate	18-29	25		20-22
Oxacillin	18-27	25		22-45
Piperacillin-tazobactam	12-19	25		13-19
Erythromycin	48-77	31		69-79
Clindamycin	10-21	18		23-29
Ciprofloxacin	23-37	31		30-42
Levofloxacin	23-35	31		34-39
Vancomycin	8-33	0		2-4
Linezolid	3-7	0		5-8
Quinu-/Dalfo-pristin	2-10	—		8
TMP/SMX	8-13	12		11-38

AWAI, all wards all isolates; Collective: blood, urine, wound and minute amounts of cerebrospinal, pleural, ascitic fluids and sputum.

3.4. *Proteus mirabilis*

Ampicillin, amoxicillin-clavulanate, aztreonam, piperacillin-tazobactam and TMP/SMX registered high resistance rates of 27 to 42% (Table 4).

3.5. *Staphylococcus aureus*

The resistance rate for the fluoroquinolones ranged from 23-42% among isolates (Table 5), while that of oxacillin was 25% for blood isolates, but was as high as 45% for wound isolates.

4. Discussion

Surveillance initiatives to standardize microbiological practices at small community hospitals can be challenging to pursue. As a consequence, analysis of resistance rates with precision is equally taxing. The validity of resistance trends considering the arbitrary variations in the number of isolates across years and inconsistent availability of antimicrobial agents at the institution may indeed sully the results.

4.1. *Escherichia coli*

It was difficult to assess with any degree of certainly the resistance rate for blood isolates for *E. Coli* isolates as the actual number was less than 30; none-the-less the rates for aztreonam, piperacilin-tazobactam and the aminoglycosides were similar in wound isolates. Injudicious use or unnecessary prescribing of antimicrobial agents for wound isolates may account for the generally higher resistance rate for these isolates.

Amoxicillin/clavunate serves as the surrogate marker for tracking penicillinase or AmpC hyper-production in *E. coli*isolates [13,14]. Resistance among *E. coli* isolates to β-lactams (ampicillin and amoxicillin-clavunate in particular) may be indicative of penicillinase and or AmpC hyperproduction suggestive of the presence of β-lactamase enzymes. As a consequence, the generally preferred (cephalosproins, fluoroquinolones, aminopenicillins) and/or alternative (aztreonam, gentamycin or TMP/SMX) options for treating *E. coli* infections may not be appropriate empiric choices in the absence of conducting susceptibility tests. Cephalosporin activity across generations (2^{nd}, 3^{rd}, and 4^{th}) alludes to insignificant surrogate markers for extended spectrum β-lactamase (ESBL) activity; the resistant pattern may likely be class mediated as cefepime does not demonstrate enhanced activity against *E. coli* over the 3GCs. Resistance with fluoroquinolones may be a mediated phenomenon that is well documented in the literature. Also, TMP/SMX should not be used empirically to treat lower urinary tract infections in the inpatient setting specifically [15]. The high resistance observed with wound isolates must be queried as clinicians have been known to prescribe antibiotics unnecessarily for wound infections that need not be so treated, thereby creating selective pressure because of injudicious use.

4.2. *Klebsiella pneumoniae*

The fluoroquinolones and aztreonam agents are the preferred or alternative therapies for treating *klebsiella pneumniae* infections. Trimethoprim/sulfamethaxoze (TMP/SMX) has been known to be ineffective for treating systemic *Klebsiella* infections, and the anti-pseudomonal penicillins has limited anti-klebsiella activity. The patterns of resistance observed with these agents, as with *E. coli*, allude to the presence of penicillinase hyperproduction and extended spectrum betalactamase (ESBL). Enhanced ESBL activity is well documented among the cephalosporin class of antibiotics to *K. pneumniae*, as well as to *E. coli*.

In 2010, the Clinical and Laboratory Standards Institute (CLSI) lowered the *Enterobacteriaceae* susceptibility breakpoints of cefazolin, cefotaxime, ceftizoxime and ceftriaxone (from 8 μg/ml to 1 μg/ml) and for ceftazidime and aztreonam (from 8 μg/ml to 4 μg/ml) [14]. CLSI eliminated the need to perform ESBL screening and confirmatory tests, except if needed for infection control or epidemiological purposes. Some authors report that the revised breakpoints may not detect ESBL-producing strains [17,18]. Hence, it should be recognized that (all) ESBL producing strains of Enterobacteriaceae may be reported as resistant to cefazolin, cefotaxime and ceftriaxone using the new CLSI breakpoints, while a number of ESBL containing *P. mirabilis* and *E. coli* strains may be reported as susceptible to ceftazidime, cefepime and aztreonam, likely due to the high prevalence of CTX-M type ESBLs. [19]. Carbapenemase-producing Enterobacteriaceae can be missed by automated testing systems and should be tested manually. The potential for multidrug resistance exists.

Multidrug resistance (MDR) is defined as non-susceptibility to at least one agent in three or more antimicrobial categories [20]. Extreme drug resistance (XDR) is defined as non-susceptibility to at least one agent in all but two or fewer antimicrobial categories (i.e. bacterial isolates remain susceptible to only one or two categories). Pandrug resistance (PDR) is defined as non-susceptibility to all agents in all anti-microbial categories (i.e. no agents tested susceptible for that organism). It is important to monitor the resistance rates to the fluoroquinolones, aminoglycosides, monobactam and β-lactam/β-lactamamse inhibitors for potential MDR-*Klebsiella* [21]. Resistance to fluoroquinolones and TMP/SMX is frequently observed among ESBL producers [22,23]. Although the prevalence of ESBL may be insignificant, its presence may be a good marker of the MDR phenotype.

4.3. *Pseudomonas aeruginosa*

Given that the fluoroquinolones, carbapenems, piperacillin-tazobactam, aminoglycosides were equally efficacious for treating *P. aeruginosa* isolates, they may be selected over aztreonam and gentamicin (Table 3). However, the 4GC, cefepime, should not be the initial choice for the empiric treatment of *P. aeruginosa* infections compared with the 3GC, ceftazidime. The mechanisms of resistance, as suggested by the surveillance antibiotic for cefepime may include Amp C hyperproduction and reflux, together with reduced permeability with gentamicin. The use of anti-pseudomonas agents (cefepime, aztreonam and gentamicin) by clinicians as empiric therapy in patients not suspected of a *Pseudomonas* infection increases the likelihood of collateral damage within the hospital. The pharmacy should monitor the use of these agents.

4.4. *Proteus mirabilis*

Although most antibiotics may be effective against the uropathogen *P. mirabilis*, ampicillin, amoxicillin-clavulanate, aztreonam, piperacillin-tazobactam and TMP/SMX may not be appropriate empiric choices for treating these infections (Table 4).

The correlation between ampicillin and the combination product (amoxicillin-clavulanate) provides surrogate evidence for the hyperproduction of beta-lactamase within *P. mirabilis* pathogens. Hyperproduction of β-Lactamase creates exponentially large concentrations of the enzyme that render suicidal agents such as clavulanate and tazobactam ineffective. Decreasing amoxicillin use may decrease *P. mirabilis* resistance. Additionally, cefepime, the 4GC, is less efficacious that 1-/2-/3-GC possibly because of selective pressure probably brought on due to injudicious use (not planned cycling or rotation). Again, the possible mechanism of action for resistance with the ceplalosporin agents may be the incidence of penicillinase or AmpC hyperproduction. The similarity in the susceptibilities across generation reveals surrogate evidence for extended spectrum cephalosporinase activity.

4.5. *Staphylococcu saureus*

Certain antibiotics like the fluoroquinolones have been implicated in MRSA development; therefore the use of fluoroquinoloes, with resistance ranging from 23-42% among isolates, Table 5, should be monitored.

Resistance observed with oxacillin alludes to the existence of methicillin-resistant *Staphylococcus aureus* (MRSA). There may be a potential for vancomycin resistant *Staphylococcus aureus* (VRSA) (even vancomycin intermediate *Staphylococcus aureus*, VISA), although small, at the institution given the cumulative data. Suitable alternative therapies, in addition to vancomycin for treating hospital-acquired MRSA include linezolid, quinu-/dalfo-pristin, with TMP-SMX reserved for community acquired-MRSA. Consideration may be given to the use of a cefoxitin disk screen, which is purported to be a better predictor of MRSA and a more potent inducer of mecA than the penicillins [24]. This screen also has equal sensitivity but improved specificity for coagulase-negative *Staphylococcus spp*. There may also be a subpopulation of resistant cells, heterogeneous VISA (hVISA), which are considered to be precursors of VRSA. As many as 0.5%–20% of MRSA have been reported as hetero-resistant in the literature [25]. These strains are difficult to detect by conventional (disk diffusion or by standard minimum inhibitory concentration [MIC]) methods. Standard MIC techniques do not detect a rise in vancomycin MICs from 1 µg/mL to 2 µg/mL or from 2 µg/mL to 4 µg/mL, which may be of clinical significance [26]. Indeed, hVISA and VISA strains should not be treated with vancomycin despite a modest rise in MICs.

According to the CDC, laboratories that use automated methods that are not validated for VRSA detection should also include a vancomycin screen agar plate for enhanced detection of VRSA [27]. If possible, laboratories should incorporate the vancomycin agar screen plate for testing all *S. aureus* microorganisms. Laboratories using disk diffusion to determine vancomycin susceptibility should consider adding a second method for VISA detection, such as the vancomycin screen plate which is useful for detecting VISA (MIC = 8 µg/ml). Reliable detection of VISA (MIC = 4 µg/ml) may require a non-automated MIC method. A vancomycin-/intermediate–resistant (VI/VR) result for staphylococci isolate should be verified by repeating a validated MIC method along with organism identification.

Finally, the CDC advises clinical laboratories to save (all) vancomycin-resistant enterococci (VRE), MRSA, and VRSA isolated from patients whenever VRSA is suspected or confirmed [28]. This is necessary because genetic material can be exchanged from VRE to MRSA in the emergence of VRSA. Following confirmation of VRSA, the CDC recommends that the three isolate types (VRE, MRSA, and VRSA) be shared with public health departments. While performing the confirmatory susceptibility tests, the patient's primary caregiver, patient-care personnel, and infection-control personnel should be notified regarding the presumptive identification of VRSA so that appropriate infection control precautions (isolation) can be promptly initiated. These processes may be applicable in our setting.

Resistance to the macrolides, erythromycin, was as high as 79% among wound isolates and 31% in blood isolates with substantial resistance to Clindamycin (29% in wounds and 18% in blood isolates). We may suspect the presence of strains of macrolide-resistant *S. aureus* and coagulase-negative *Staphylococcus spp* that are capable of inducing the transferrable macrolide-lincosamide-streptogramin B resistance (detected using the D-test), leading to clindamycin treatment failures [29,30,31,32].

4.6. *Enterococcus faecalis* and *Enterococcus faecium*

Neither *E. faecalis* nor *E. faecium* were observed for the period of observation. It is established in the literature that *E. faecium isolates* (the more virulent species) should not exceed 20% of the total number of *Enterococcus* isolates. Surveillance antibiotics, such as gentamicin and fluoroquinolones should be added to the panel for detecting *Enterococcus* species. Gentamicin can be used to test for high level aminoglycoside resistance in enterococci [33]. The presence of high-level aminoglycoside resistance would indicate a lack of synergistic effect when an aminoglycoside is combined with a cell-wall inhibitor. The existence of an Antibiotic Stewardship Committee can selectively recommend screening of newly admitted or high-risk patients (e.g., intensive care, oncology, and surgery patients) who are determined to be at greater risk for VRE colonization [34]. Colonized patients with VRE do not have clinical signs or symptoms of infection while infected VRE patients show clinical signs or symptoms of disease, a distinction that is important in VRE screening. Patients may be colonized in the gastrointestinal tract and occasionally in the urinary tract. VRE colony counts are similar in the stool of colonized or infected patients. It should be noted that if the hospital VRE rate is based solely on VRE isolated from clinical cultures (infected patients), the facility may be adequately reporting the infection rate, but may be underestimating the true burden (and therefore potential transmissibility) of VRE in the facility. Therefore, screening for patients colonized by VRE provides information about potential sources of illness with the

goal being to identify as many colonized patients as possible so that infection control measures can be implemented to decrease transmission and reduce the number of patients infected with VRE.

In addition, CLSI recommends performing a vancomycin MIC test, and also motility and pigment production tests to distinguish species with acquired resistance (*van*A and *van*B) from those with *van*C intrinsic resistance. Identification of VRE to the species level would confirm whether an isolate has intrinsic (*van*C) or acquired resistance (*van*A or *van*B). Knowledge of the type of resistance is critical for infection control purposes; *van*A and *van*B genes are transferable and can lead to clonal spread from organism to organism (and from patient to patient). In contrast, *van*C genes are not transferable, have been rarely associated with serious infections, and have not been associated with outbreaks.

4.7. *Staphylococcus epidermidis*

Coagulase negative staphylococcus (CNS) species have been associated with increasing numbers of hospital-acquired infections. Patients at risk may have invasive devises (catheters) and/or may be immunocompromised. Some species are more resistant to commonly used antimicrobial agents than others. Identification to the species level can aid in the recognition of outbreaks and in tracking resistance trends.

Although susceptibilities to vancomycin were high at the institution, isolates with decreased susceptibility to vancomycin can be difficult to detect using the disk diffusion (Kirby-Bauer) testing and MicroScan rapid panel methods. Consequently, *S. epidermidis* (SE) isolates with vancomycin MICs of 8-16 µg/ml (intermediate to resistant) would be important to detect. All clinical isolates with decreased susceptibility to glycopeptides have been oxacillin-resistant and resistant to many other commonly used therapeutic agents. In fact, both oxacillin-resistant SE and isolates with reduced susceptibility to vancomycin can show heteroresistance. In general, MicroScan conventional panels and Etest can detect staphylococci with decreased susceptibility to vancomycin when the isolates being tested are incubated for a full 24 hours before reading. The institution is, therefore, encouraged to tract suspected SE to differentiate between contamination, colonization and true infection.

4.8. Limitation

We recognize the inconsistency (missing years and types of microorganisms) in the cumulative data relative to the types of culture (blood, urine and wound) during the period of observation. This was also compounded by the inconsistency either in the availability and/or reporting of select antimicrobial agents; linezolid, tobramycin or quinu-/dalfo-pristin that are not available on formulary; nitrofurantion standard which was used for *E. coli*, *K. pneumoniae* and *Enterobacter spp*. analysis of blood and urine specimens, but was not included in this analysis as the number of specimens was either less than 30 for the year under review or the information was available for one year only. Potentially, there may be other unaccounted-for variables that can affect the results. These variables may include changes in the severity-of-illness parameters, and nursing home admissions. Also, isolates that were processed manually (which occurs periodically when the automated system breaks down) would not be reflected in the cumulative data for the period of observation. In addition, no confirmatory test for vancomycin resistance routinely exists in the Laboratory. Hence the data as presented may underestimate the true level of antimicrobial resistance among all isolates/cultures processed at the clinical laboratory. Changes in reporting and testing from one year to the next minimize the ability to compare data for trend analysis. Results may also be misleading when agents are tested on different groups of isolates in the dataset (e.g. an antimicrobial agent tested only against urine compared with an antimicrobial agent tested against organisms from all sites).

4.9. Recommendation

The healthcare system of TT is divided into five (5) existing RHAs. The compilation of surveillance data from each RHA would facilitate tracking of national (cumulative RHA data) versus regional (each RHA) susceptibility data. Therefore, all clinical laboratories operating in the island should be mandated to submit cumulative susceptibility data to the Surveillance Unit of the Ministry of Health for determination of national and regional susceptibility data and to compare these results with the international community.

Although the evaluation and reporting of systemic and urinary isolates separately provides more useful data (ICU and non-ICU isolates), it may not be useful for small community hospitals; the resistance data for many isolates (*Acetinobacter spp., Enterobacter spp., Staphylococcus saprophyticus, and Streptococcus agalactiae*) were not included in this report as the number of isolates were small (<30). Since antimicrobial susceptibility rates are calculated from the results of patient samples processed by the clinical laboratory, the values of these estimates for guiding policy decisions must accurately represent the patient population of interest. Susceptibility rates may also be biased due to frequent sampling of patients with treatment failures following prior antimicrobial therapy and/or patients with prolonged medical histories of recent hospitalizations.

5. Conclusion

It may be opportune to institute an Antimicrobial Stewardship Program so that policies may be established for determining the appropriate use of antimicrobial agents in order to preserve the life or efficacy of antimicrobial agents and to minimize the effect of selective pressure. For example, it may be assumed that in an attempt to control for the resistance observed with any antimicrobial agent (e.g. gentamycin), uncontrolled (undue) pressures may have been placed on other agents with a similar spectrum (aerobic gram negative) of activity. At this institution, undue pressure (might however or) may be provoked because of fluctuation in availability (i.e. unsustainable) of supply. Intervention strategies to limit the spread of resistance may be warranted and could be adopted by the Antimicrobial Steward Committee.

A more robust analysis would require the routine tracking of cultures consistently across years. For some isolates (e.g. *Enterobacter cloacae or Staphylococcus*

saprophyticus) however, the number may be too small to warrant an independent analysis and especially for specific areas of the hospital (Pediatrics or ICU). For this reason, the antibiogram may have to be prepared for the entire year (annually) rather than semi-annually for the entire hospital, or it may be necessary to combine data on the organism over more than 12 consecutive months or data for more than one species within a genus (*Enterobacter spp.*). It would also be important to differentiate colonization from infection (urine and wound cultures) to determine if treatment with antimicrobial agents for some microorganisms (*Acetinobacter spp*.) may be warranted. It is therefore necessary to train and alert clinical staff when such decisions are deemed necessary, particularly for empiric therapy.

Sponsoring Information

The authors are not sponsored or supported financially by an organization.

Statement of Competing Interests

The authors have no competing interests.

List of Abbreviations

Centers for disease control: CDC, Trinidad and Tobago: TT, Regional Health Authority: RHA, Trimethoprim/Sulfamethoxazole: TMP/SMX, Extended spectrum β-Lactamase: ESBL, Clinical and Laboratory Standards Institute: CLSI, Multi Drug Resistance: MDR, extreme drug resistance: XDR, pandrug resistance: PDR, Generation Cephalosporin: GC, methicillin-resistant Staphylococcus aureus: MRSA, Vancomycin-resistant Staphylococcus aureus: VRSA, heterogeneous Vancomycin-intermediate Staphylococcus aureus: hVISA, Minimum inhibitory concentration: MIC, Vancomycin Resistant Enterococci: VRE, *Staphylococcus epidermidis*: SE, Intensive care unit: ICU.

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