Original Article

Antimicrobial resistance in pathogens causing nosocomial infections in surgery and intensive care wards in Antananarivo, Madagascar

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Abstract

Background: In developing countries, knowledge of antimicrobial resistance patterns is essential to define empirical therapy.

Methodology: All the surgery and intensive care wards of two hospitals in Antananarivo were included to study the antimicrobial susceptibility of the pathogenic bacteria causing nosocomial infections. A repeated cross-sectional survey was conducted between September 2006 and March 2008, one day per week. Isolates were identified using classical methods, and resistance to antibiotics was assessed according to the recommendations of the Antibiogram Committee of the French Microbiology Society.

Results: Clinical specimens from 706 from 651 patients were collected. Of the 533 bacterial pathogens, 46.7% were *Enterobacteriaceae*, 19.3% were *Staphylococcus aureus*, and 19.1% were pathogens from the hospital environment (*Pseudomonas aeruginosa* and *Acinetobacter baumannii*).Frequencies of resistance were high, particularly in *Enterobacteriaceae*; however, the rate of *Staphylococcus aureus* isolates resistant to oxacillin (13.6 %) was moderate and all these isolates were susceptible to glycopeptids. The percentages of isolates susceptible to ceftazidim were 81.8% for *E. coli*, 60.9% for *Klebsiella*, and 52.5% for *Enterobacter* spp. Resistance to third-generation cephalosporins was due to extended spectrum betalactamases (ESBL). Multivariate analysis showed that diabetes (adjusted OR: 3.9) and use of an invasive procedures (adjusted OR: 3.5) were independent risk factors for resistance to third-generation cephalosporins.

Conclusion: A nationwide surveillance programme is needed to monitor the microbial trends and antimicrobial resistance in Madagascar.

Key words: nosocomial infection, bacterial resistance, Madagascar, surgery wards, intensive care wards

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Introduction

Hospital-acquired infections result in significant morbidity and mortality, and contribute to escalating health care costs [1].The emergence of resistance to antimicrobial agents, despite the availability of newer antibiotics, has become an increasing problem throughout the world, particularly in pathogens causing nosocomial infections [2-4]. For practising physicians, clinical microbiologists and public health officials, knowledge of local antimicrobial resistance patterns is essential for the development of empirical and pathogen-specific therapy. The distribution of pathogens causing nosocomial infections changes with time and varies among hospitals. Information about antimicrobial resistant pathogens is critical for effective decisions to be made on infection control policies, the rational formulation of public health care policies, and the national and international research agendas in this area. Unfortunately, data on endemic antimicrobial resistance are unavailable from many parts of the world, especially from areas where over-the-counter antibiotic use is common.

Few studies have been conducted examining endemic antimicrobial resistance in Madagascar [5,6]. However, observations at the Pasteur Institute of Madagascar, of antimicrobial resistance of bacterial isolated from hospitalized patients, have suggested that it could be a public health problem. This study aimed to identify antimicrobial resistance patterns among bacterial isolates causing nosocomial infection in twelve departments of two hospitals in Antananarivo, the capital city of Madagascar.

Materials and methods

Setting

The study was performed at the hospital Joseph Ravoahangy Andrianavalona (HJRA) and the Soavinandriana hospital (CENHOSOA), Antananarivo, Madagascar. With more than 700 beds, HJRA is the largest hospital in the country and serves as a national university teaching hospital. The CENHOSOA is the country's military hospital, with more than 470 beds. These two hospitals are referral hospitals for a population of approximately 1.5 million in the Antananarivo area.

To target the units most at risk of nosocomial infections, we included a total of 12 wards from the two hospitals: intensive care (n = 2), visceral surgery (n = 5) and trauma units (n = 5).

The Pasteur Institute of Madagascar examines specimens from inpatients and outpatients from a number of hospitals in Antananarivo. Bacteriological cultures are performed on more than 8,500 specimens each year.

Sample methods

For logistical and financial reasons, the study was a repeated cross-sectional survey with systematic sampling. All inpatients presenting a nosocomial infection on a given day each week between September 2006 and March 2008 and in each participating department were recruited to the study. To eliminate duplicates, only one sample was taken per patient and per site.

Nosocomial infection was defined as any infection that occurred more than 48 hours after admission of the patient to hospital. Any patient who had an infection on admission and had not recovered from that episode the day of the survey and any inpatient who had been hospitalized for fewer than three days was not considered a nosocomial infection case. All other inpatients who, on the day of the survey, had signs of infection or were identified as infection cases by the ward doctor were considered to suffering from a nosocomial infection. Only active infections (*i.e.* symptomatic or considered ongoing and needing antimicrobial treatment by medical staff) were included.

Data were collected from questionnaires filled out by two senior medical epidemiologists training in hospital infection studies from the Institut Pasteur of Madagascar, who used case notes and the ward doctor as sources of information. For each patient included, the following information was recorded: age, sex, date of admission, ward, admitting diagnosis, site and symptoms of infection on admission, recovery from admitting infection, underlying disease, history of past hospitalization, history of invasive devices used, history of antibiotic treatment before admission, treatment during hospitalization (antibiotic therapy, invasive devices used), site and symptoms of infection on day of survey, date of clinical sampling, and site of surgery if any. Clinical specimens were collected before antimicrobial treatment for microbiology analysis and the study investigation form was completed with the results of the laboratory diagnosis and data of antimicrobial susceptibility.

Laboratory methods

The specimens, from deep pus, surgical wounds or urinary tract infection (UTI), were cultured at 37°C overnight. Blood samples were collected using a conventional blood culture bottle (Hemoline performance diphasique; BioMérieux), cultured at 37°C and were observed twice a day for seven days.

Bacterial isolates were identified using standard microbiological methods, as previously described [6,7]. The susceptibility of bacterial isolates to antibiotics was tested using the disc diffusion method, as described by the Antibiogram Committee of the French Microbiology Society [8]. Antibiotic discs were obtained from Biorad, Marne la Coquette, France.

The antibiotics tested were recommended by the CASFM. The zone of inhibition was measured after 24 hours at 37°C. To detect extended spectrum betalactamases (ESBL), discs of ceftazidim and cefotaxim were placed 30 mm from an amoxicillin-clavulanate (20/10 µg) disc. An increased zone of inhibition between the clavulanate disc and any one of the third-generation cephalosporin discs indicated the presence of an ESBL. The distance between the discs could be reduced when the synergy was not easily observed as in cephalosporinase-producing strains. Cefoxitin discs were used to test for resistance to methicillin in *Staphylococcus aureus*.

S. aureus ATCC 25923, *Escherichia coli* ATCC 25922, and *Pseudomonas aeruginosa* ATCC 27853 were included as control strains. Criteria for susceptibility or resistance followed the CASFM guidelines [8]. The isolates showing intermediate resistance were grouped together with resistant isolates for the purpose of data analysis. The resistance rate was calculated as the number of non-susceptible isolates divided by the total number of isolates.

Statistical methods

Data were analysed using Statistica Software, version 5.5 (Statsoft Corporation, OK, USA). Proportions for categorical variables were compared using χ^2 tests, although Fisher's exact test was employed for small amounts of data. $P < 0.05$ was considered significant, using two-sided comparisons. A multivariate model was performed using backward stepwise analysis for multi-resistance concerning *Enterobacteriaceae* and *S. aureus.*

Ethical clearance

The study was approved by the Ministry of Health and the National Ethics Committee of Madagascar. For each confirmed infection case, treatment was instituted according to the laboratory results reported to each care ward.

Results

During the study period, 706 clinical specimens were collected from 651 inpatients, of whom 487 (74.8%) were hospitalized in HJRA and 164 (25.2%) in CENHOSOA. Only one specimen was collected for 601 patients (92.3%), two for 45 patients (6.9%) and three specimens for 5 patients (0.8%). The sex ratio (M/F) was 1.25 (55.4% male and 44.6% female). Clinical specimens were positive for at least one pathogen in 57.1% (n = 403) of cases. The majority of clinical specimens were obtained from surgical wounds (64.0%, 452/706), deep layer pus (19.1%, 135/706), and blood cultures (9.1%, 64/706).

Bacterial isolates

A total of 533 bacterial pathogens causing nosocomial infections were recorded during the study period, of which 68.9% (n = 367) were Gram-negative and 31.1% (n = 166) Gram-positive bacteria. The most frequently encountered bacterial pathogens were *Enterobacteriaceae* [46.7%, n = 249: (*Escherichia coli*, *Klebsiella pneumoniae*, *Enterobacter cloacae*, M*organella. morganii*, *Proteus mirabilis, Klebsiella oxytoca*,*Enterobacter . sakazakii*)], *Staphylococcus aureus* (19.3%, n = 103), and bacterial pathogens from the hospital environment (19.1%, n=102:*Pseudomonas aeruginosa* and *Acinetobacter baumannii*).

Table 1 shows the bacteria most frequently isolated from the various specimen types, considered together or separately. The frequency of bacteria isolates differed between care units ($p < 0.01$; Table 2). *E. coli* were more frequent in visceral surgery units (41.2%, n = 47), *S. aureus* in trauma units (25.7%, n = 92), and *Klebsiella Spp.* (18.0%, n = 11) and *Pseudomonas spp.* (16.4%, n = 10) in intensive care units.

Antimicrobial susceptibility

Tables 3 and 4 show the frequency of antimicrobial susceptibility of the most frequently isolated Gram-negative and Gram-positive bacteria, respectively. The susceptibility of different strains to antibiotics showed that the resistance rates of gram-negative bacilli (resistant plus intermediate) were 90.5% for amoxicillin (229/253), 58.7% for co-trimoxazol (249/424), 26.7% for ceftazidim (97/365) and 15.9% for imipenem (28/176).

Enterobacteriaceae, especially *K. pneumonia*, displayed multiple resistance to many antimicrobials tested but were uniformly susceptible to imipenem (100.0%). Of the 249 *Enterobacteriaceae*, 58 (23.3%) were resistant to third-generation cephalosporins; ESBL production was confirmed in 53 (91.4%), and five (8.6%) overproduced Amp-C betalactamase.

P. aeruginosa showed a moderate rate of resistance against antipseudomonal penicillins (piperacillin 12.8%, ticarcillin 31.9%) and all strains were susceptible to ceftazidim. *A. baumannii* were much more resistant; 74.5% of strains were resistant to ticarcillin, 85.1% to chloramphenicol, 62% to ceftazidim and 44.7% to imipenem.

The rates of *S. aureus* resistant to oxacillin (MRSA) were moderate (13.6%). All staphylococcal isolates were susceptible to vancomycin.

Enterobacteriaceae *risk factors for resistance to third-generation cephalosporins*

In univariate analysis (table 5), the risk factors for acquiring resistance to third-generation cephalosporins in *Enterobacteriaceae* were as follows: coming from care unit (OR: 1.9; 95%CI: [1.1-3.7]), having diabetes (OR: 3.5; 95% CI [1.3-9.6]), invasive procedures during hospitalization (OR: 3.1; 95% CI [1.2-7.2]) and urinary catheterisation (OR: 2.2; 95% CI [1.1-4.5]). Neither blood catheterisation (OR: 7.5; 95% CI [0.95-59.3]) nor use of antibiotics (OR: 1.03; 95% CI [0.48 -2.2]) were significant risk factors.

Variables giving p-values less than 0.20 in univariate analysis were analysed using multiple logistic regression. In multivariate analysis, coming from care unit (adjusted OR 2.78; 95% CI [1.25-6.25]), having diabetes (adjusted OR: 3.7; 95% CI [1.3-11.2]) and past invasive procedure (adjusted OR:

3.6; 95% CI [1.1-11.9]) were independent risk factors for acquired multiple resistance.

Table 1. Frequency of pathogenic bacterial isolates from different types at Antananarivo, Madagascar.

Organism	**Surgical wounds**		**Deep pus***		**Blood**		**Other****		**Overall**	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Gram-negative isolates										
E. coli	68	(27.4)	12	(17.9)	1	(5.6)	7	(20.6)	88	(23.9)
Klebsiella spp.	26	(10.5)	9	(13.4)	8	(44.4)	4	(11.8)	47	(12.8)
Proteus mirabilis	11	(4.5)	5	(7.5)	0	---	3	(8.8)	19	(5.2)
Pr. Providencia - M. morganii	22	(8.9)	10	(14.9)	0	---	7	(20.6)	39	(10.6)
Enterobacter spp.	31	(12.5)	7	(10.4)	0	---	2	(5.9)	40	(10.9)
Other *Enterobacteriaceae*	13	(5.2)	1	(1.5)	1	(5.5)	1	(2.9)	16	(4.4)
Pseudomonas spp.	37	(14.9)	6	(9.0)	2	(11.1)	7	(20.6)	52	(14.2)
Acinetobacter	32	(12.9)	13	(19.4)	3	(16.7)	2	(5.9)	50	(13.6)
Other GNB	8	(3.2)	4	(6.0)	3	(16.7)	1	(2.9)	16	(4.4)
Subtotal, Gram-negative isolates	***248***	***(46.5)***	***67***	***(12.6)***	***18***	***(3.4)***	***34***	***(6.4)***	***367***	***(68.9)***
Gram-positive isolates										
Staphylococcus aureus	75	(66.4)	18	(60.0)	0	---	10	(62.5)	103	(62.0)
St. Coagulase neg.	0	---	0	---	5	(71.4)	4	(25.0)	9	(5.4)
Enterococci	24	(21.2)	3	(10.0)	1	(14.3)	2	(12.5)	30	(18.1)
Streptococcus spp	14	(12.4)	9	(30.0)	1	(14.3)	0	---	24	(14.5)
Subtotal, Gram-positive isolates	***113***	***(21.2)***	***30***	***(5.6)***	***7***	***(1.3)***	***16***	***(3.0)***	***166***	***(31.1)***
Total	**361**	**(67.7)**	**97**	**(18.2)**	**25**	**(4.7)**	**50**	**(9.4)**	**533**	**(100.0)**

* except surgical wounds
**burn, urinary tract, respiratory tract

Table 2. Frequency of pathogenic bacterial isolates from different units at Antananarivo, Madagascar.

	Trauma units		**Intensive units Care**		**Visceral surgery units**	
	n	(%)	n	(%)	n	(%)
E. coli	37	(10.3)	4	(6.6)	**47**	**(41.2)**
Klebsiella spp.	25	(7.0)	**11**	**(18.0)**	11	(9.7)
Proteus mirabilis	14	(3.9)	3	(4.9)	2	(1.8)
Pr. providencia - M. morganii	34	(9.5)	2	(3.3)	3	(2.6)
Enterobacter spp.	30	(8.4)	3	(4.9)	7	(6.1)
Other *Enterobacteriaceae*	12	(3.4)	3	(4.9)	1	(0.9)
Pseudomonas spp.	38	(10.6)	**10**	**(16.4)**	4	(3.5)
Acinetobacter	33	(9.2)	6	(9.9)	11	(9.7)
Other GNB	10	(2.8)	5	(8.2)	1	(0.9)
Staphylococcus aureus	**92**	**(25.7)**	1	(1.6)	10	(8.8)
Coagulase neg. St.	1	(0.3)	7	(11.5)	1	(0.9)
Enterococci	17	(4.8)	4	(6.6)	9	(7.9)
Streptococcus spp	15	(4.2)	2	(3.3)	7	6.1)
Total	**358**	**(67.2)**	**61**	**(11.4)**	**114**	**(21.4)**

Table 3. Percentage of gram-negative bacterial isolates resistant to antimicrobial agents (number of tested isolates in brackets).

Gram-negative	***E. coli***	***Klebsiella spp.***	***Enterobacter spp.***	***Proteus***	**Other**	**Pseudomonas**	**A*cinetobacter***
	(88)	**(47)**	**(40)**	***Mirabilis*** **(19)**	**Enterob*** **(55)**	**spp. (52)**	**spp. (50)**
Drugs	%	%	%	%	%	%	%
Amoxicillin	82.9	100.0	100.0	68.4	98.2	---	---
Ticarcillin	82.9	100.0	47.5	47.4	43.6	32.7	72.0
Cefotaxime	18.2	39.1	47.5	0.0	20.0	---	---
Ceftazidime	18.2	39.1	47.5	0.0	20.0	1.9	62.0
Imipenem	0.0	0.0	0.0	---	0.0	1.9	44.0
Gentamicin	28.4	42.3	45.0	0.0	25.5	7.7	76.0
Tobramycine	39.8	48.9	47.5	11.1	30.9	15.3	46.0
Amikacin	1.1	8.5	15.0	0.0	5.4	5.8	46.0
Nalidixic acid	64.8	46.8	50.0	15.8	50.9	---	---
Ciprofloxacin	52.3	40.4	32.5	5.3	40.0	3.9	72.0
Co-trimoxazole	82.9	76.1	47.5	52.6	69.1	92.0	87.5

*Other *enterobacteriaceae*: *M. morganii, P. vulgaris, Providencia sp., C. freundii, Pantoa sp.*

Table 4. Percentage of Gram-positive bacterial isolates resistant to antimicrobial agents (number of tested isolates in brackets).

Drugs	***S. aureus*** **(103)**	**CNS*** **(9)**	**Enterococci** **(30)**	**Streptococci** **(24)**
	%	%	%	%
Penicillin	92.2	77.8	---	
Ampicillin	---	---	16.7	4.2
Oxacillin	13.6	22.2	93.3	8.7
Tetracyclin	59.2	33.3	65.5	56.5
Erythromycin	19.4	44.4	70.0	12.5
Lincomycin	5.8	33.3	90.0	12.5
Pristinamycin	1.0	11.1	73.3	8.3
Ciprofloxacin	5.8	33.3	20.0	8.3
Gentamicin	3.9	33.3	10.0	4.3
Vancomycin	0.0	0.0	3.3	0.0
Teicoplanin	0.0	0.0	3.3	0.0

* CNS: coagulase negative *Staphylococcus*

As described in other studies, organisms associated with surgical site infections vary with the type of procedure and the anatomical location of the infections may become apparent only after patients are discharged, as observed previously in Thailand [10].

Risk factors for resistance to oxacillin in S. Aureus

In univariate analysis (table 6), no risk factors were found for resistance to oxacillin except age.

Discussion

In countries where resources are limited, surgical site infections remain a major cause of nosocomial infections [9]. This study therefore mainly targeted surgery units. The study presents evident limitations but, since samples were collected by staff from the Pasteur Institute of Madagascar to ensure their rapid delivery to the laboratory, it was not possible to collect samples more than once a week from each unit.

Unfortunately, we were not able to determine the prevalence of nosocomial infections. Although we knew the number of patients present the days of the sampling, we did not know how many were hospitalized for more than 48 hours. However, the prevalence rate would have been very difficult to estimate since in Madagascar, as in many developing countries hospital stays are short and nosocomial operation, with a predominance of *S. aureus* observed in trauma units and of enterobacteria in visceral surgery. We observed a similar rate of *S. aureus* infections to that found (approximately 20.0%) in a literature review [11]. Similarly to the results found in Cameroon [12], the percentage of *E. coli* infection in our study was greater than that in other developing countries [13-15].

This study provides insights into the problem of resistance in bacterial pathogens in Antananarivo, Madagascar. Our results demonstrated that, in general, isolates have high rates of resistance to antibiotics commonly used in developing countries. We also found a high rate of resistance to penicillins, first generation cephalosporins and cotrimoxazol. Therefore, cheap antibiotics such as amoxicillin, tetracyclin and cotrimoxazol are now of limited benefit in the treatment of infections in Madagascar. These results, probably due to overuse of broad-spectrum antibiotics, confirm those of previous studies [6,7].

The high level of ciprofloxacin resistance among *E. coli*, and more generally *Enterobacteriaceae*, rules out the use of ciprofloxin as empirical treatment when invasive infections due to these pathogens are

Table 5. Risk factors for nosocomial infection with *Enterobacteriaceae* resistant to third-generation cephalosporins in Antananarivo.

		Enterobacteriaceae			
		All	Resistant	OR	OR adjusted
	(%)	n = 218	n = 57	[95%CI]	[95%CI]
Age	mean	37.6	37.2	0.99	
	95%CI	[34.9 - 40.2]	[32.4 - 42.0]	[0.98-1.01]	
Sex	Male	129 (59.4)	35 (61.4)	0.89	
	Female	88 (40.5)	22 (38.6)	[0.48-1.67]	
Wards	Trauma	123 (56.4)	28 (49.1)	0.67	
	Others	95 (43.6)	29 (50.9)	[0.36-1.23]	
Coming from					
	Home	143 (65.6)	31 (54.4)	0.51	0.38
	Other care unit	75 (34.4)	26 (45.6)	[0.27-0.95]	[0.16-0.94]
Hospitalization last 12 months		41 (18.8)	12 (21.1)	1.36	
				[0.63-2.95]	
Antibiotic last month		49 (22.5)	7 (12.3)	0.42	0.20
				[0.17-1.01]	[0.05-0.82]
Diabetes		18 (8.2)	9 (15.8)	3.51	5.16
				[1.28-9.59]	[1.35-19.8]
Past invasive devices used		21 (9.6)	10 (17.5)	3.05	3.90
				[1.21-7.21]	[0.88-17.3]
Current hospitalization					
	Urinary catheter	85 (39.0)	32 (56.1)	2.24	1.76
				[1.13-4.46]	[0.67-4.65]
	Invasive devices	169 (77.5)	49 (86.0)	2.21	1.64
				[0.92-5.32]	[0.58-4.53]
	Venous catheter	153 (70.2)	49 (86.0)	7.53	4.01
				[0.95-59.3]	[0.47-34.1]
	Deep surgery	72 (33.0)	25 (43.9)	1.55	0.91
				[0.79-3.03]	[0.34-2.45]
	Antibiotic treatment	175 (80.3)	46 (80.7)	1.03	1.64
				[0.48-2.23]	[0.58-4.63]

suspected. The rate of resistance to third-generation cephalosporins is also worrisome because the alternative treatment (carbapenem) has limited availability in Antananarivo. This rate is similar to or even lower than that described in other developing countries [13-16] but higher than rates in developed countries [17-19].

The high prevalence of *A. baumanii* (8.8%, n = 47) and *P. aeruginosa* (8.8%, n = 47) may have been exacerbated by failure of infection control in the hospitals. The overall rate of antibiotic resistance in *A. baumanii* was higher than that in *P. aeruginosa*; this observation contrasts with previous results founds in South Africa [16]. Resistance to carbapenem (imipenem) in *A. baumanii* was 45.7%, but 0.0% in *P. aeruginosa*. This high rate of resistance to carbapenem in *A. baumanii* in our study is striking given that this antibiotic is rarely prescribed in Madagascar. This result may be due to the clonal spread of a multi-resistant strain of *A. baumanii*. The prevalence of fluoroquinolon resistance was also lower in *P. aeruginosa* than *A.*

baumanii (2.2% vs. 76.1%). The high levels of antibiotic resistance throughout the study period in isolates of *A. baumanii* are of great concern because the limited choice of treatments threatens the successful management of these infections. None of the currently available single agents that we tested relatively low, this rate was higher than that observed in a previous study, in which the rate of oxacillin resistance among 68 strains isolated from nosocomial infections between 2001 and 2005 was 4.4% [6]. We did not observe resistance to vancomycin or teicoplanin. These antibiotics are not yet used in

Table 6. Risk factors for nosocomial infection with MRSA in Antananarivo.

		Staph. Aureus	MRSA	p-value
	(%)	n = 103	n = 14	
Age	Mean	27.9	18.5	0.045
	95%CI	[24.1 - 31.6]	[8.9 - 28.0]	
Sex				
	Male	63 (61.2)	8 (57.1)	0.77
	Female	39 (38.8)	6 (42.9)	
Wards				
	Trauma unit	92 (89.3)	13 (92.9)	0.90
	Others	11 (10.7)	1 (7.1)	
Coming from				
	Home	77 (74.8)	12 (85.7)	0.43
	Other care unit	26 (25.2)	2 (14.3)	
Hospitalization last 12 months		22 (21.4)	3 (21.4)	0.70
Antibiotic last 3 months		33 (32.0)	2 (14.3)	0.18
Diabetes		3 (2.9)	0 -	0.98
Past invasive devices used		11 (10.7)	2 (14.3)	0.94
Current hospitalization				
	Invasive devices	64 (62.1)	10 (71.4)	0.36
	Venous Catheter	59 (57.3)	11 (78.6)	0.78
	Deep Surgery	24 (23.3)	3 (21.4)	0.66
	Oxacilline treatment	6 (5.8)	1 (7.1)	0.64

performed adequately to be considered as a suitable empirical monotherapy. Combination therapy should therefore be used until susceptibility results are available. In contrast, rates of resistance in *P. aeruginosa* in Antananarivo are much lower than those described in most countries [13-16,17,18].

The prevalence of MRSA varies greatly throughout the world, as a function of geographical region, site of infection and whether the infection is nosocomial or community-based. In this study, the rate of MRSA (14.6%) was much lower than in most countries [13-16,17]. However, despite being Madagascar because they are too expensive.

Patients admitted to hospitals in tropical regions of Africa are at increased risk of nosocomial infection. However, an accurate assessment of this risk is difficult due to a lack of published data. The main risk factors may be poor health care facilities, high microbial levels in the hospital and community environment, and uncertain health status among patients. The increasing number of reports of multi-resistant bacteria is evidence of poor hospital sanitation. In this study, invasive procedures were identified as a major risk factor. Health care workers

and patients must be educated about the importance of hand-washing, not performing unnecessary injections and transfusions and ensuring that these procedures are carried out in aseptic conditions, isolating patients with communicable diseases, handling waste products safely, and using antimicrobials properly.

We identified diabetes as a risk factor for infection by enterobacteria resistant to third-generation cephalosporins. This observation could be explained by the fact that people with diabetes are more likely to be treated or hospitalised than other patients.

Conclusion

Our findings demonstrate the widespread problem of antibiotic resistance among nosocomial pathogens in two hospitals in Madagascar. Continued surveillance is necessary to guide appropriate empirical therapy for these infections. It is imperative that all professionals take an active role in infection control within their establishments. More resources should be provided to encourage good antibiotic practice and good hygiene in hospitals.

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