

Original Research Article

Prevalence of multidrug-resistant enterobacterales isolated from 2019 to 2020 in a tertiary hospital in Dakar-Senegal

Abstract

Background: Multi-resistant bacteria have emerged as a global threat to human health. In Africa, there are few data on AMR. The objective of this study was to determine antibiotic resistance profile of enterobacteria strains and prevalence of multidrug-resistant bacteria isolated in a university hospital in the suburbs of Dakar. **Methods:** Enterobacterales were isolated from a wide range of clinical specimens (urine, pus, blood, catheter tip and bronchoalveolar fluid) from inpatients and outpatients at Medical Biology Laboratory of National University Hospital Center of Pikine from November 2019 to October 2020. Enterobacterales were identified using API 20E. Antimicrobial susceptibility testing was performed with ATB G-EU (08) (bio Mérieux®) on all enterobacterales in accordance with CA-SFM/EUCAST 2020 guidelines. **Results:** Of the 3422 different clinical specimens tested, 623 (17.1%) were culture positive. Enterobacteriaceae accounted for 57.6% (n=359) of the strains; *Escherichia coli* and *Klebsiella pneumoniae* were predominant isolates with 53.5% and 20.6% respectively. Seventy-four(%) strains of enterobacterales were ESBL. Antibiotic resistance patterns showed a prevalence of multidrug resistant strains of 32.6%. The most active antibiotics on isolates were imipenem (25%), followed by amikacin (15%), fosfomycin (12%) and piperacillin-tazobactam (10%). **Conclusion:** High rates of ESBL and multidrug-resistant strains were found in both outpatients and inpatients. These results indicate need for an active surveillance system for antimicrobial resistance. Also, the application of good hospital hygiene practices and antibiotic therapy adapted to local data must be adopted.

Key-words : prevalence, ESBL, multidrug-resistant, enterobacterales

Introduction

Antimicrobial resistance (AMR) is a public health problem. The inappropriate use of antibiotics in community and hospital settings has led to appearance of multi-resistant bacteria (MRB). In recent years, the prevalence of MRB has increased worldwide[1]. These MRB cause infections that can lead to increased morbidity, mortality, and healthcare costs. Western sub-Saharan Africa had the highest burden, with 27.3 deaths per 100.000 (20.9–35.3) attributable to AMR and 114,8 deaths per 100 000 (90.4–145.3) associated with AMR [2]. These strains may be of community or healthcare-associated origin. Healthcare-associated

infections are infections that first appear 48 hours or more after hospitalization or within 30 days after having received health care [3].

The increase in bacterial antimicrobial resistance (AMR) is considered as one of the major threats to human health worldwide[4].

Antimicrobials are commonly used in modern medicine and 50% of prescriptions are considered inappropriate. This misuse of antimicrobials is a major cause of increased AMR [5].

To reduce spread of MRBs, one of the preventive measures is based on the fight against cross-transmission by lack of hygiene in the hospital environment at the level of the nursing staff, but also on the screening of asymptomatic carriers who constitute a potential reservoir from which these bacteria can spread [4].

To our knowledge, few data are available on the prevalence of MRB in Senegal, particularly in Dakar and especially in the suburbs.

The objectives of this study were to determine the antibiotic resistance profile of enterobacteria and the prevalence of multi-resistant enterobacteria.

Methodology

This prospective study was conducted at Medical Biology Laboratory of National University Hospital Center of Pikine from November 2019 to October 2020. All inpatients and outpatients with a bacteriological diagnostic sample taken in suspicion of a bacterial infection were included in the study regardless of age and sex. Results of a second bacteriological sample with isolation of same bacteria as previously from a patient already included were not considered. Various specimens (urine, blood, pus, catheter tip, and bronchoalveolar fluid) were plated on appropriate culture media (Müller-Hinton, Chocolate agar, Chapman, thioglycolate broth). These media were incubated in an appropriate atmosphere according to morphological aspect of type of germ observed on microscopic examination after Gram staining.

Identification of enterobacterial strains was performed using the API 20E gallery (bio Mérieux®). Antibiotic susceptibility profiling was performed with the ATB G- EU (08) gallery (bio Mérieux) according to recommendations of CA-SFM/EUCAST version 2020. Several antibiotics were tested: ampicillin, amoxicillin-clavulanic acid, piperacillin, piperacillin + tazobactam, cefalotin, cefuroxime, cefixime, cefotaxime, ceftazidime, cefepime, ertapenem, meropenem, imipenem, nalidixic acid, ofloxacin, levofloxacin, ciprofloxacin, gentamicin, amikacin, tobramycin, tetracycline, fosfomycin and cotrimoxazole. Control strain *E. coli* ATCC 25922 was used for internal quality control.

Search for ESBL was performed with the synergy test by placing a third-generation cephalosporin (ceftazidime or cefotaxime) disc opposite an amoxicillin-clavulanic acid disc. Presence of ESBL was shown by a "champagne cork" image. Enterobacteria strains resistant to three families of antibiotics were considered Multi-resistant Bacteria (MRB)[4][Magiorakos and al, 2012].

Data were collected and analyzed with Microsoft Excel software 2022 version.

Results

In this study, 3422 specimens including urine, blood, pus, catheter tip, and bronchoalveolar fluid (BAL) samples were analyzed. The overall isolation rate was 18.2% (Table I).

Table I : Distribution of biological samples and culture isolation rates

Specimens	Number	Isolation rates (%)
Urine	2795	13.8
Blood	362	16.9
Pus	231	63.2
Catheter tip	18	88.9
BAL	16	93.8

A total of 623 bacterial strains were isolated ; 57.6% of isolates were enterobacteria (n=359), 18.3% were non-fermenting Gram-negative bacilli (n=113), 23.8% were Gram-positive cocci (n=148) and 0.48% were anaerobic germs (n=3).

Enterobacteria were mainly *E. coli* (n=192; 53.5%), followed by *K.pneumoniae* (n=74; 20.6%) and *E. cloacae* (n=39; 10.9%). Healthcare-associated strains accounted for 39.6%, compared with 60.4% for community-acquired strains (Table II).

Table II: Distribution of Enterobacterales according to species and hospital department of origin

Bacteria	Origin								Total
	Community	Healthcare-associated infections							
	EC	IM	SUR	AR	PED	ME	GO	NEU	
<i>E. coli</i>	117	27	25	03	06	11	01	02	192
<i>K. pneumoniae</i>	41	12	03	08	03	05	01	01	74
<i>K. oxytoca</i>	05	02	0	0	0	0	0	0	07
<i>E. cloacae</i>	21	02	02	06	07	01	0	0	39
<i>E. aerogenes</i>	02	0	0	0	0	0	0	0	02
<i>P. mirabilis</i>	09	01	0	02	01	0	0	0	13
<i>P. vulgaris</i>	02	0	0	0	0	0	0	0	02
<i>C. freundii</i>	05	1	0	0	0	0	0	0	06
<i>S. enterica</i>	05	03	0	0	01	01	0	0	10
<i>M. morgani</i>	06	0	0	0	0	0	0	0	06
<i>S. marcescens</i>	03	0	01	0	01	0	0	0	05
<i>S. liquefaciens</i>	0	0	0	0	02	0	0	0	02
<i>R. ornithinolytica</i>	1	0	0	0	0	0	0	0	01
Total	217	48	31	19	21	18	02	03	359

EC : External Consultation, IM : Internal Medicine, SUR : Surgery, AR : Anaesthesia Resuscitation, PED : Pediatrics, ME: Medical Emergency, GO : Gynecology Obstetrics, NEU : Neurology.

Antibiotic susceptibility profile of *E. coli* isolates had shown high rates of resistance from 53% to 89.1% to ampicillin, ticarcillin and piperacillin.

Resistance rates greater than 50% were noted for *E. cloacae* and *E. aerogenes* strains with ticarcillin and piperacillin. The combination of amoxicillin and clavulanic acid was more active on *E. coli* than on *K. pneumoniae* (53.1% versus 61.7% resistance).

The piperacillin-tazobactam combination was more active on *Klebsiella* strains (17.3% resistance) than on *E. coli* (20.8% resistance) and *Enterobacter* (34.1% resistance).

Cefoxitin had a better efficacy on *E. coli* and *K. pneumoniae* strains (77.1% and 63%), than third and fourth generation cephalosporins with sensitivity rates of 39.5% to 76%.

Cephalotin was less active on *E. coli* (47.9%) and *K. pneumoniae* (34.6%) strains. ESBL production was noted in 20.6% of the enterobacterial strains (n = 74).

These enterobacteriales kept a good sensitivity to carbapenems, amikacin, gentamicin and fosfomycin with resistance rates ranging from 2.1% to 36.6% contrary to tetracycline and cotrimoxazole with resistance rates ranging from 51.2% to 69.8% (Table III).

Table III : Antibiotic resistance rate of most isolated enterobacteriales

Antibiotics	% Resistance		
	<i>E. coli</i> (n=192)	<i>K. pneumoniae-K. oxytoca</i> (n=81)	<i>E. cloacae-E. aerogenes</i> (n=41)
Ampicillin	89,1	-	-
Amox-acclav	53,1	61,7	-
Ticarcillin	89,1	-	56,1
Piperacillin	89,1	-	53,7
Pip - tazo	20,8	17,3	34,1
Cephalotin	52,1	65,4	-
Cefoxitin	22,9	37	-
Ceftazidim	28,1	60,5	51,2
Cefepim	24	46,9	41,5
Ertapenem	2,6	3,7	19,5
Meropenem	2,6	3,7	19,5
Imipenem	2,1	3,7	19,5
Nalidixic acide	58,3	49,4	51,2
Ciprofloxacin	41,7	45,7	53,7
Tobramycin	27,1	48,1	19,5
Gentamicin	18,8	18,5	17,1
Amikacin	3,6	9,9	22
Tetracyclin	52,6	56,8	51,2
Fosfomycin	12,7	16	36,6
Cotrimoxazol	69,8	59,3	51,2

Analysis of resistance patterns showed that 32.6% (n=117/359) of strains were multidrug-resistant enterobacteria (MRE), including 60 community strains and 57 hospital strains. MRE consisted of *E. coli* (n=55), *K. pneumoniae* (n=34), *K. oxytoca* (n=2), *E. cloacae* (n=17), *E. aerogenes* (n=2), *M. morgani* (n=2), *C. freundii* (n=2), *S. marcescens* (n= 1), *S. liquefaciens* (n= 1), and *R. ornithinolytica* (n=1) (Table IV).

Table IV : Distribution of MRE according to their community and hospital origins

Bacteria	MRE origin						Total
	Community	Healthcare-associated infections					
	EC	IM	SUR	AR	PED	ME	
<i>E. coli</i>	31	10	9	2	1	2	55
<i>K. pneumoniae</i>	16	5	2	6	2	3	34
<i>K. oxytoca</i>	1	1	0	0	0	0	2
<i>E. cloacae</i>	8	2	1	2	3	1	17
<i>E. aerogenes</i>	1	0	0	0	1	0	2
<i>C. freundii</i>	1	1	0	0	0	0	2
<i>M. morgani</i>	2	0	0	0	0	0	2
<i>S. marcescens</i>	0	0	0	0	1	0	1
<i>S. liquefaciens</i>	0	0	0	0	1	0	1
<i>R. ornithinolytica</i>	0	0	0	1	0	0	1
Total	60	19	12	11	9	6	117

ESBL production was found in 45.3% of MRE (n = 53) including *E. coli* (n=24), *K. pneumoniae* (n=18) and *E. cloacae* (n=6).

Majority of MRE (75.2%, n=88) were resistant to both β -lactams, quinolones and aminoglycosides. Some MRE were still sensitive to some antibiotics. Piperacillin-tazobactam combination was active on 70.6% of *K. pneumoniae* strains. Carbapenems, amikacin and fosfomycin were more active against *E. coli* and *K. pneumoniae* than *E. cloacae*. Gentamicin is more active on *K. pneumoniae*(70,5%) than *E. coli*(54,5%) and *E. cloacae*(52,9%) (Table V).

Table V : Antibiotic susceptibility profile of the 3 main MRE

Antibiotics	% Resistance EMR		
	<i>E. coli</i> (n=55)	<i>K. pneumoniae</i> (n=34)	<i>E. cloacae</i> (n=17)
Piperacillin-tazobactam	38,2	70,6	41,2
Ertapenem	90,9	91,2	52,9
Meropenem	90,9	91,2	52,9
Imipénème	92,7	91,2	52,9
Amikacine	89,1	79,4	58,8
Gentamicine	54,5	70,5	52,9
Fosfomycine	87,3	82,4	41,2

Discussion

The main objective of this study was to determine the prevalence of multi-resistant enterobacteria isolated from 2019 to 2020 in medical biology laboratory of university hospital of Pikine, in the periphery of Dakar.

Six hundred and twenty-three bacterial strains were isolated from different pathological products with an isolation rate of 18.2%. Enterobacterales accounted for 57.6% of isolates (n=359). *E. coli* and *K. pneumoniae* were the most frequently isolated bacteria with 53.5% and 20.6% respectively. Predominance of these two bacterial pathogens has been reported in other studies [6], this could be explained by predominance of uropathogenic isolates which represented 59.8% of which these two strains were the majority. Preponderance of uropathogenic enterobacteria is often reported in microbiology laboratories where urine is by far most analyzed specimen [7,8,9]. Majority of enterobacterales strains were of community origin (58.9%), which could be explained by the greater number of outpatient samples than inpatients.

Antibiotic susceptibility testing showed that 90% of *E. coli* strains were resistant to ampicillin, ticarcillin and piperacillin compared to 55% of *E. cloacae* isolates for ticarcillin and piperacillin. *E. coli*, *K. pneumoniae* and *E. cloacae* strains had shown piperacillin-tazobactam resistance rates of 20.8%, 17.3% and 34.1% respectively. A study carried out in Dakar showed a resistance of 69.3% to piperacillin-tazobactam in *E. cloacae* [10].

The resistance rates of *E. coli* and *K. pneumoniae* with amoxicillin-clavulanic acid combination were 53.1% and 61.7% respectively. A meta-analysis of ten studies conducted in Cameroon had reported *E. coli* resistance rates to amoxicillin ranging from 59.7% to 89.7% and to amoxicillin-clavulanic acid ranging from 48.9% to 75.9%; while *K. pneumoniae* resistance rates to amoxicillin ranged from 84.9% to 98.3% [11]. A hospital study conducted in 2019 in northern India of uropathogenic *E. coli* isolates (n=145) had reported amoxicillin and amoxicillin-clavulanic acid resistance rates of 81.37% and 75.86%, respectively [8].

Third generation cephalosporins were ineffective on half of the strains while cefoxitin showed better activity on *E. coli* and *K. pneumoniae* isolates by 77.1% and 63% respectively. This trend was described on strains of enterobacteria isolated from different pathological products collected in two university hospitals in Khartoum, Sudan, with resistance rates to *E. coli* and *K. pneumoniae* with cefoxitin of 7.2% and 16.7%, respectively, and with ceftazidime of 39.1% and 47.2%, respectively [12]. Enterobacterales isolated during this study were

predominantly susceptible to carbapenems. *E. coli* and *K. pneumoniae* isolates showed 90% susceptibility to imipenem and meropenem while *E. cloacae* isolates were 80% susceptible.

A study carried out in Senegal in 2016 showed 45.2% in *E. coli* and 27.4% in *K. pneumoniae* isolated mainly in urine (58%) and pus (19.3%)[13].

However, overuse of carbapenems in therapy could lead to the emergence of carbapenem-resistant Enterobacteriaceae either by acquisition of carbapenem hydrolyzing betalactamases by the strains or by a combination of a plasmidmediated beta-lactamase AmpC and mutation of an outer membrane protein[14,15], thus posing a real threat to antibiotic therapy.

ESBL production was demonstrated in 20.6% of strains (n=74). Variable prevalence rates have been reported in West Africa. In Mauritania, prevalence rate of ESBL found was 12.8% among 522 uropathogenic enterobacteria isolated from January to June 2014 [16]. In Ivory Coast, a rate of 58.8% of ESBL had been found in 153 enterobacteria isolated from various pathological products [17] while in Burkina Faso 58% of the 308 enterobacteria analyzed were ESBL producers[18]. These ESBL have been described throughout the world. Thus, in France a surveillance of antibiotic resistance carried out in 2019 in 19 at 327 hospital laboratories had reported an ESBL rate of 6.6% [19]. In Nepal, a hospital study in Kathmandu of 268 strains of *E. coli* and *K. pneumoniae* had reported 34.5% rate of ESBL-producing strains [20].

The strains isolated in our study had shown resistance rates of 47%, 53% and 60% respectively to ciprofloxacin, tetracycline and cotrimoxazole. They were however sensitive to amikacin (89%), gentamicin (82%) and fosfomicin (78.3%).

The analysis of susceptibility profiles showed that 117 strains (32.6%) were multi-resistant (resistant to at least three families of antibiotics) of which 53 strains (71.6%) were ESBL producers. This multiresistance phenomenon in enterobacteria is due to the acquisition of genes hosted by integrons, transposons, or plasmids [21].

In spite of fact that MRE were resistant to several families of antibiotics, some molecules were still effective on these strains: imipenem (78.9%), amikacin (75.8%), fosfomicin (70.3%) and piperacillin-tazobactam (50%). A retrospective study conducted at LeDantec University Hospital from January to December 2011 on 44 β -lactamase-secreting *K. pneumoniae* strains had shown a 41% resistance rate to amikacin and 2.2% to imipenem while no resistance was observed with fosfomicin [22]. Similarly, rates of 0.2% and 19% for imipenem and fosfomicin, respectively, were reported with the study conducted at Fann university hospital on 89 uropathogenic ESBL isolated from January to June 2017[9].

A study conducted in Asia Pacific from 2008 to 2014 on 2728 ESBL strains reported an imipenem resistance rate of 92.1% [23].

Conclusion

High rate of ESBL and MRE was found from outpatient and inpatient. This highlights a need for active surveillance systems, good antibiotic practices and good hospital hygiene. Based on our findings presented in this paper, it will be interesting and important to study the ESBL and MRE in a molecular level. This will highlight the genes responsible for antibiotic resistance.

References

1. Worthington RJ, Melander C. Combination approaches to combat multidrug-resistant bacteria. *Trends Biotechnol.* 2013;31(3):177-84. doi:10.1016/j.tibtech.2012.12.006.
2. Salehi, B., Abu-Darwish, M. S., Tarawneh, A. H., Cabral, C., Gadetskaya, A. V., Salgueiro, L., ... & Sharifi-Rad, M. Antimicrobial resistance collaborators global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet.*2022;399:629-655
3. Revelas A. Healthcare-associated infections: A public health problem. *Niger Med J.* 2012;53(2):59-64
4. Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. *Clin Microbiol Infect.* 2012.18:268-81
5. Holmes AH, Moore LSP, Sundsfjord A et al. Understanding the mechanisms and drivers of antimicrobial resistance. *Lancet.*2016;387(10014):176–187. doi :10.1016/S0140-6736(15)00473-0
6. Marzouk, M., Toumi, N., Hassine, ABH, Ali, MH et Boukadida, J. Profil et sensibilité aux antibiotiques de 5187 bactéries uropathogènes en Tunisie. *Médecine et Maladies Infectieuses.*2016;6(46),330-332
7. Sbiti M, Lahmadi K, Louzi L. Profil épidémiologique des entérobactéries uropathogènes productrices de bêta-lactamases à spectre élargi. *Pan Afr Med J.* 2017;28(1). Doi: 10.11604/pamj.2017.28.29.11402

8. Jain R, Pal N, Hooja S. Prevalence of β -lactamase production and multi-drug resistance among uropathogenic *Escherichia coli* isolates at a tertiary care hospital of North-western India. *Asian J Med Sci* .2021, 12(7). doi: 10.3126/ajms.v12i7.35
9. Niang AA, Ka R, Sarr H, Diop AF, Dièye BF, Ba-Diallo A, D Diallo F, Lo S, Ka M, Diagne R, Dia ML, Cissé MF, Sow AI. Caractérisation phénotypique des Bactéries uropathogènes isolées au CHNU de Fann à Dakar. *Uro'Andro*.2020;2,2:56-60
10. Seck, A., Ndiaye,B., Diop, A., Ndao, M., Fall, C., Dieng, A.,Diallo, T.A., Mahou, C. and Dubrous, P. Prevalence and Resistance Profile of MuenchenCefotaximase (CTX-M) Group 1 Extended Spectrum Beta-Lactamase (ESBL)-Producing Uropathogenic *Escherichia coli* Strains in Dakar, Senegal. *Open Journal of Medical Microbiology*. 2023;13:137-145
11. Mouiche MMM, Moffo F, Akoachere JFT, Nnode HON, Mapiefou NP, ValantineNgum V, Wade A, Djuikwo-Teukeng FF, Toghousa DGT, Zambou HR, Feussom JMK, Le Breton M and Awah-Ndukum J. Antimicrobial resistance from a one health perspective in Cameroon: a systematic review and meta-analysis. *BMC Public Health*. 2019;19(1):1135. Doi.org/10.1186/s12889-019-7450-5
12. Moglad Ehssan H. Antibiotics profil, prevalence of Extending-SpectrumBeta-Lactamase (ESBL), and Multidrug-Resistant Enterobacteriaceae from Different Clinical Samples in Khartoum State, Soudan. *Int J Microbiol*.2020:8898430
13. Camara M, Mane MT, Ba-Diallo A, Dieng A, Diop-Ndiaye H, Karam F, et al. Extended-Spectrum Beta-Lactamase- and Carbapenemase-Producing Enterobacteriaceae Clinical Isolates in a Senegalese Teaching Hospital: A Cross Sectional Study. *Asian Journal of Medical Research*.2017;11:1600-1605
14. G. and Bouall.gue O. Imipenem Resistance in *Klebsiella pneumoniae* Is Associated to the Combination of Plasmid-Mediated CMY-4 AmpC β -Lactamase and Loss of an Outer Membrane Protein. *Microbial Drug Resistance*.2012;18:479-483. <https://doi.org/10.1089/mdr.2011.0214>
15. Nordmann P, Naas T, and Poirel, L. Global Spread of Carbapenemase-Producing Enterobacteriaceae . *Emerging Infectious Diseases*.2011;17:1791-1798. <https://doi.org/10.3201/eid1710.110655>
16. Hailaji NSM, Ould Salem ML, Ghaber SM. La sensibilité aux antibiotiques des bactéries uropathogènes dans la ville de Nouakchott-Mauritanie. *Pro Urol*. 2016;26:346-352. Doi.org/10.1016/j.purol.2016.04.004

17. Gadou V, Guessennd NK, Toty AA, Diene SM, Rolain J-M, Djaman JA, Dosso M. First Detection of Aminoglycosides Resistance Genes *aa(6)-Ib*, *ant(2'')-I* and *aad* in Enterobacteriaceae Producing Extended-Spectrum Beta-Lactamases in Abidjan (Côte d'Ivoire). *Int J Microbiol Res.*2018;10, 5:1171-1174
18. Ouédraogo AS, Sanou M, Kissou A, Sanou S, Somlaré H, Kaboré F, Poda A, Aberkane S, Bouzinbi N, Sanou I, Nacro B, Sangaré L, Christian C, Decré D, Ouédraogo R, Jean PH, Godreuil S. (2016). High prevalence of extended-spectrum β -lactamase producing Enterobacteriaceae among clinical isolates in Burkina Faso. *BMC Infect Dis.* 2016;16(1):326.doi : 10.1186/s12879-016-1655-3
19. Guillard, F., Merens, A., Dortet, L., Janvier, F., Lebrun, C., Yin, N., ... &Héry-Arnaud, M. (2019). Évaluation de la prévalence de la résistance aux antibiotiques chez les entérobactéries isolées de prélèvements urinaires dans les services d'urgence de France. *Médecine et Maladies Infectieuses.* 2019 ;49(4):S111-S112.
20. Krishus N, Narayan D-P, Bibhusan N, Ankit B, Rikesh B , Ram K-S , Binod L , Dwij Raj B and Bharat J. Extended spectrum beta-lactamase and metallo beta-lactamase production among Escherichia coli and Klebsiella pneumoniae isolated from different clinical samples in a tertiary care hospital in Kathmandu, Nepal. *Ann Clin Microbiol Antimicrob.* 2017;16:62 Doi 10.1186/s12941-017-0236-7.
21. Muylaert A, Mainil JG. (2012) Résistances bactériennes aux antibiotiques : les mécanismes et leur « contagiosité ». *Ann Med Vet.* 2012;156:109-123.
22. Camara M, Diop-Ndiaye H, Ba-Diallo A, Karam F, Mbow M, Faye A, Diop M, Diagne Samb A, Toupane M, Mbengue AS, Toure-Kane NC, Mboup S, Gaye-Diallo A. Epidémiologie des souches de Klebsiella pneumoniae productrices de β -lactamases a spectre élargi dans un hôpital universitaire au Senegal. *CAMES SANTE.* 2013;1(2)
23. Shio-Shin J and Po-Ren H. Distribution of ESBLs, AmpC b-lactamases and carbapenemases among Enterobacteriaceae isolates causing intra-abdominal and urinary tract infections in the Asia-Pacific region during 2008–14: results from the Study for Monitoring Antimicrobial Resistance Trends. *J AntimicrobChemother.* 2017;72:166-171 doi:10.1093/jac/dkw398.