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Review article

The Burden of Multi-drug Resistant *Acinetobacter baumannii* in Nigeria

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Abstract

As a multidrug-resistant and invasive pathogen, *Acinetobacter baumannii* is one of the leading causes of nosocomial infections in the healthcare system. It has been recognized as a causative agent of pneumonia, sepsis, meningitis, urinary tract and wound infections. It is associated with high morbidity, mortality and healthcare costs due to treatment failure. Biomedical databases (Scopus, Medline, Web of Science, EBSCO, Google Scholar and PubMed) were searched and retrieved for all relevant manuscripts published in English. Eighty-six (86) documents were revived from previous researches of four different search engine, with a follow-up full-text evaluation of 35 publications for inclusion. Due to the lack of data on MDR A. *baumannii* in Africa, especially Nigeria, 10 articles were selected for this review. The results of ten selected articles showed that 4084 isolates of A. baumannii causing nosocomial infection were isolated from clinical specimens, of which 287 isolates of A. *baumannii* were detected. Antibiotics tested against identified A. *boumannii* belong to different classes which include: AMK: amikacin; CEF: ceftriaxone; GEN: gentamicin; IPM: imipenem; LVX: levofloxacin; MEM: meropenem; AMP: ampicillin; CIP: ciprofloxacin; AMX amoxicillin; SAL sulbactam and COL: colistin. The highest resistance was to GEN and the lowest to MEM. This review highlighted the burden of multidrug-resistant *Acinetobacter baumannii* to antibiotics in Nigeria. There is a need for continuous surveillance study on antimicrobial resistance in Nigeria, especially in primary healthcare which was abandoned by most researchers.

Keywords: Multi-drug, Resistance, *Acinetobacter baumannii*, Nigeria.

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INTRODUCTION

Acinetobacter baumannii is a Gram-negative coccus, aerobic, non-fermenting and non-motile bacterium that occupies a place in the classification of Acinetobacter. The current taxonomic classification of this bacterium places it in γ-proteobacteria, family Moraxellaceae and order Pseudomonadales (Nemec *et al*., 2016).

It is one of the multidrug-resistant gram-negative bacteria (MDR-GNB) on the global priority list of 12 bacterial families that pose the greatest threat to human health (WHO, 2017). In hospital settings, it can be found in beds, curtains, walls, roofs, medical equipment, medical staff's belongings, running water sinks, telephones, doorknobs, hand sanitizer dispensers, trolleys, trash cans and even computers (Mohammad *et al*., 2018). It does a little harm to healthy people. However, people with weakened immune systems, chronic lung disease, or diabetes may be more susceptible to *A. baumannii* infection (Zeina, 2020). Specific risk factors for developing *A. baumannii* infection include prolonged hospital stay, immunosuppression, advanced age, comorbidities, severe trauma or burns, invasive procedures, and indwelling catheters or mechanical ventilation (Wang *et al*., 2003).

Acinetobacter baumannii causes a range of infections in the hospital and community, including skin and soft tissue infections, urinary tract infections, meningitis, endocarditis, bacteremia, and pneumonia (Dexter *et al*., 2015). *Acinetobacter baumannii* infection is associated with high morbidity, mortality, medical costs, and length of hospital stay due to treatment failure (Silvia, 2008). The resistance of *Acinetobacter baumannii* to different antimicrobials has become a cause of global public health threat due to its resistance to most commercially available antibiotics (Jyoti *et al*., 2014).

The growing development of multiple antimicrobial resistance in this *Acinetobacter baumannii* severely limits the treatment options available to infected patients (Maragakis and Perl, 2008). Treatment of infections caused by *Acinetobacter baumannii* is often extremely difficult because it is resistant to most commercially available antibiotics (Manchanda *et al*., 2010). At the same time, the bacterium's ability to rapidly develop resistance has suggested that unless more up-to-date treatment options are created, *A. baumanii* may be closer to the end of the antibiotic treatment period (Giamalarellous *et al*., 2008). The ability of *A. baumannii* to respond to widespread antimicrobial resistance may be due to the effects of lifeforms' normally impermeable outer membranes, efflux pumps, mutations and their environmental introductions on mass resistance (Bonomo and Szabo, 2006; Maragakis and Perl, 2008). If isolates remain susceptible or resistant to antimicrobials (aminoglycosides), carbapenems remain the treatment of choice. However, Asif *et al*. (2018) reported that, 50-60% Carbapenem-resistant *Acinetobacter baumannii* has been reported in Malaysia, 48% in USA, 70%, 92%, and 100% in Chile, Korea, and Portugal, 50% in Singapore, 85% in India, 60-100% in Pakistan. Recently, 85.7% carbapenem-resistant *Acinetobacter baumannii* were recorded from three tertiary hospitals of Kano State metropolis of Northwest Nigeria (Bashir *et al*., 2019).

Literature have shown that there is paucity data to show the magnitude of antibiotics resistance in African continent especially Nigeria due to the lack of surveillance study, proper record keeping (Egwuenu *et al*., 2018). The empirical treatment of bacterial infections is dependent on the selection of the appropriate antibiotics, which are determined by the regional susceptibility profile, key indicators in the genomic evolutionary trend, and the efficacy of the antibiotic commonly prescribed in a specific locality (Ali *et al*., 2017). Therefore, this review was carried out to assess the burden of *Acinetobacter baumannii* in Nigeria.

METHODOLOGY

Search strategy

Biomedical databases (Scopus, Medline, Web of Science, EBSCO, Google Scholar and PubMed) were searched and retrieved for all relevant manuscripts published in English. A search identified publications of epidemiological studies compiling sufficient information on antimicrobial resistance in *Acinetobacter baumannii*. In addition, references cited in these articles were used to find other relevant articles in this review.

Eligibility criteria

If the following standards are met, analysis research is included. (1) The research group is hospitalized (2) at least five species were isolated from clinical specimens (blood, wound, catheterized urine, nasal cannula, tracheal aspirate, bronchoalveolar), *A baumannii* strain lavage based on standard laboratory testing; (3) Mention methods used for antibiotic resistance detection; (4) Report enough data to assay antibiotic-resistant *Acinetobacter baumannii* and report resistance results to at least two antibiotics. No one other than a complete manuscript written in English was deemed eligible for this study.

Global epidemiology of drug-resistant *Acinetobacter baumannii*

Antimicrobial resistance is now a global threat which hinder treatment by healthcare providers. Carbapenem resistance in *Acinetobacter baumannii* is now an emerging problem worldwide (Peleg *et al*., 2008). Surveillance studies have shown an incremental of carbapenem-resistant strains especially in Europe, Northern part of America and Western America over the past decade (Peleg *et al.*, 2008). Numerous outbreaks of carbapenem-resistant *Acinetobacter baumannii* have been reported in hospitals in Northern Europe (Spain, Portugal, France, United Kingdom (UK), Netherlands, Czech Republic, Poland) (Schulte *et al*., 2005; Coelho *et al*., 2006); Dijkshoorn *et al*., 2007; Peleg *et al*., 2008). Southern Europe and the Middle East (Bulgaria, Greece, Italy, Turkey, Lebanon, Israel, Iran, Iraq, and the United Arab Emirates) (Zarrilli *et al*., 2009). North and Latin America (Argentina, Brazil, Chile, and Colombia (Villegas *et al*., 2007; Peleg *et al*., 2008; Merkier *et al*., 2008). Tunisia and South Africa (Poirel et al. 2008; Marais *et al*., 2004). Remote areas such as China, Taiwan, Singapore, Hong Kong, Japan, Korea, Australia, and French Polynesia (Zarrilli *et al*., 2009). In most cases, one or two prevalent strains were

detected in a given hospital (Zarrilli *et al*., 2009). Over the past three decades, it has become a major care-related infectious agent, with high morbidity and mortality, especially in immunocompromised populations (Punpanich *et al*., 2012). In Morocco, a retrospective study by Elouennass *et al*. (2008) from 2002 to 2005 showed that, *Acinetobacter baumannii* represented 13.63 % of clinical isolates from blood cultures in the intensive care units (ICUs) and in another Moroccan study represented 6.74 % Multidrug resistance *Acinetobacter baumannii* (Lahsoune *et al*., 2007). The prevalence of Acinetobacter infection varies depending on the geographical and socioeconomic status of the patients (Ntusi *et al*., 2012). In an international study in ICUs, the Acinetobacter infections rate was 19.2% in Asia; 17.1% in Eastern Europe; 14.8% in Africa; 13.8% in Central and South America; 5.6% in Western Europe; 4.4% in Oceania and 3.7% in North America (Vincent *et al*., 2009). It is 15% in South African HIV-positive patients (Ntusi *et al*., 2012). Thirteen percent (13%) in Canadian burn care units (Simor *et al*., 2002). Indeed this bacterium generally showed resistance to different classes antibiotics. Literature have shown that, *Acinetobacter baumannii* resistance rate varies from 31.8 to 92.1% to ceftazidime; 8.8 to 89.9% to imipenem, 12.2 to 89.9% to Piperacillin / Tazobactam, 28.8 to 91.6% to fluoroquinolones and 30 to 90.3% to aminoglycosides (Ntusi *et al*., 2012). But colistin is often the only effective treatment option whereas some Acinetobacter strains develop resistance to carbapenem (Ntusi *et al*., 2012). Resistance to colistin was estimated to 5.3% in the United States Queenan *et al*. (2012); 2.7% in South Africa (Ntusi *et al*. (2012); 1.2% in India (Jaggi, 2012) and 0.9% in Tunisia (Khalifa, 2010) and 0.5% in Saudi Arabia (Al-Mously and Hakawi 2013). In Morocco, the Acinetobacter's antibiotic resistance rates were up to 50.3 to 68.7% for ceftazidime, 23.8 to 42.6% for the imipenem, 17 to 77.5% for aminoglycosides, 65 to 68% for ciprofloxacin and no clinical isolates were resistant to colistin I'm (Lahsoune *et al*., 2007; Elouennass *et al.*, 2003).

Regional surveillance of multidrug-resistant *Acinetobacter baumannii* in Nigeria.

There is paucity of information on the true extent of the multidrug-resistant *Acinetobacter baumannii* burden in Nigeria, as drug resistance surveillance was carried out in few states. There is a lack of accurate and reliable data on antimicrobial resistance (AMR), especially antibiotics resistance (ABR), for many common and serious infectious diseases that are important to public health in the countries, such as meningitis, pneumonia, and bloodstream infections (WHO, 2014). This review summarize the current information available on the antibiotics resistant of *A. baumannii* within country according the region:

South East Region

The Geometric Area of Southeast Nigeria consists of five states; Abia, Anambra, Eboni, Enugu and Imo. However, Victor *et al*. (2014) reported that, A total of 155 lactose-free fermenters were isolated from patients at Imo University Hospital, of which 14 (9.0%) were Acinetobacter spp. Eleven (79.0%) of 14 Acinetobacter spp were *A. baumannii*, while 2 (14.0%) were *A. lwoffii* and 1 (7.0%) *A. calcoaceticus*. All the isolates were resistant to Amoxicillin-clavulanate, Ceftriaxone, Ciprofloxacin, Ofloxacin, gentamicin and Ampicillin-sulbactam; while susceptibility to Meropenem, Amikacin and Levofloxacin were 64.3%, 50.0% and 35.7% respectively. A similar study was carried out at Alex Ekwueme - Federal University Teaching Hospital Abakaliki in Ebony where a total of only 23 *A. baumannii* (6%) were obtained from 385 clinical samples collected from 87 patients including 48 men and 39 women admitted to various AE-FETHA hospital wards. The age of the patient varies from 20-79 years. The most common contaminated areas (*A. baumannii* infection) were catheter urine (8/8%) and wound swabs (7/8%). The highest rates of resistance were observed with cefuroxime (96%), tetracycline (96%), sulfamethoxazole / trimethoprim (96%) and ofloxacin (91%). Meropenem and imipenem were found to be the most sensitive or effective antibiotics against *A. baumannii* with 91% and 78% respectively (Ikechukwu *et al.*, 2021).

Southwest Region

The region consists of six states; Ekiti, Ogun, Ondo, Osun and Oyo. Consistent with the descriptive cross-sectional study conducted by Ike *et al*. (2014) in 8 major tertiary hospitals in southwestern Nigeria. From April 2011 to May 2013, a total of 1002 specimens were collected, of which 72 strains of *Acinetobacter baumannii* were isolated from clinical sources. Susceptibility patterns were determined on 34 antimicrobials belonging to 13 classes of antibiotics using disc diffusion method and results interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. All isolates were resistant to ≥14 antimicrobial agents tested which includes amoxicillin, amoxicillin-clavulanate, ampicillin, cefpodoxime, ceftazidime, ceftriaxone, cefuroxime, and cloxacillin. High rates of resistance to erythromycin (98.6%) were observed. Cefazolin (97.2%); aztreonam (93.1%); tetracycline (91.7%); cephalotin, trimethoprim-sulfamethoxazole (90.3%); kanamycin (88.5%); gentamicin, ticarcillin (86.1%); piperacillin, cefoxitin (87.5%), nitrofurantoin (81.9%); chloramphenicol (80.3%); ofloxacin (66.7%); and colistin (63.9%). A high rate of carbapenem resistance was also recorded against meropenem (77.8%) and imipenem (56.9%). The lowest resistance was observed to azithromycin (37.9%); ciprofloxacin, polymyxin B (40.3%); and amikacin (43.1%). Furthermore, individual research from the region was also carried out. Recently, a study by Fasuyi *et al*. (2020) showed that, a total of 18 (12.8%) isolates were identified as *A. baumannii* from 140 wounded patients admitted to Federal Medical Center, Abeokuta. All isolates (100%) were resistant to antimicrobials; sulfamethoxazole/trimethoprim (96%) and ofloxacin (91%), and imipenem (98%). However, a similar study was conducted in Ladoke Akintola University Teaching Hospital, Osogbo. A total of 150

specimens were collected, detecting 8 *A. baumannii* and was most common in patients in the 51-60 age group (36%); the male patients (63.6%) were infected more frequently than their female colleagues. Patients (72.7%) in the intensive care unit (ICU) were the most infected with this organism. The isolates showed 100% resistance to amikacin and ciprofloxacin and 90.9% to both ceftriaxone and ceftazidime, while resistance to the other antibiotics used in this study were: piperacillin (81.8%), imipenem (72.7%), gentamycin (72.2%), and meropenem (63.6%). However, none of the isolates were resistant to colistin (Odewale *et al*., 2016).

Further analysis of *A. baumannii* at Lagos University Teaching Hospital shows that a total of 58 (3%) isolates from all clinical specimens received by the laboratory in 2001 were *A. baumannii*. Fifty eight 58 (5.5%) isolates of all 1051 non-lactose fermenters Gram-negative bacteria (NLF-GNB) were identified, and caused 4.6% out of 1261 nosocomial infections. Thirty-seven (63%) and 17 (30%) Acinetobacter isolates were from wound infection and UTI respectively. All infections were acquired nosocomially and were related to the host's immune system, body defenses, surgery, or urinary catheterization. *A. baumannii* was the dominant bacterial species reported in that study. However, there was an apparent male dominance over females with a ratio of 1.9:1 in the infections, particularly from 45 years and above. One hundred percent (100%) and 96.6% of the *A. baumannii* isolates were susceptible to cefoperazone-sulbactam and travofloxacin respectively (Victor *et al.*, 2012).

Forty-five (77.6%) susceptible to cefotaxime, 49 (84.5%) to ampicillin-sulbactam, 34 (58.6%) to ceftazidime, 38 (65.6%) to ticarcillin-clavulanic acid, and 41 (70.7 %) on ciprofloxacin. Overall, Acinetobacter spp showed multiple resistance to the range of antibiotics tested (Iregbu *et al*., 2002). Similarly, a study conducted at Lagos State Special Hospital reported that fourteen percent (14%) of the 100 patients admitted to the study developed *A. baumannii* infection, 12 (86%) of those isolated strains were recovered from tracheal aspiration, 1 (7%) from urine and 1 (7%) from blood. Only the duration of endotracheal intubation, specifically a period of 8–14 days, was an independent risk factor for Acinetobacter. All isolates were 100% resistance to ceftriaxone, ciprofloxacin, ofloxacin and gentamicin. Nine (64.3%) of the isolates were sensitive to Meropenem, including (50%) sensitive to amikacin and five (35.7%) sensitive to levofloxacin (Victor, 2012).

In early 2020, a study conducted by University College Hospital, Ibadan, Nigeria reported that, thirty-seven (37) bacterial isolates. *Acinetobacter baumannii* caused 26 (70.3%) infections, mainly among surgical patients. Fifteen (40.5%) from blood and nine (24.3%) from wound biopsy (smear). The sensitivity of *A. baumannii* to meropenem and levofloxacin was 61.5% and 69.2% respectively, but the susceptibility of *Acinetobacter haemolyticus* and *Acinetobacter iwoffii* was 100% to ampicillin sulbactam, quinolones, meropenem and piperacillin/tazobactam, and 88.9% to 100.0% aminoglycosides. Ten (27.0%) and 5 (13.5%) *A. baumannii* were identified as MDR and XDR, respectively (Hannah *et al*., 2020).

Northwest Region

A study conducted at 3 tertiary hospitals in Kano State; Aminu Kano Teaching Hospital (AKTH), Murtala Muhammed Specialist Hospital (MMSH), and Muhammad Abdullahi Waseh Specialist Hospital (MAWSH). Of the 401 samples collected, 138 samples (34.4%) were positive for suspected bacterial isolates, 14 (10.1%) of which were identified to be *A. baumannii* using biochemical and API 20NE methods. Isolation confirmation using sequencing showed that 9 (6.5%) of the suspected Acinetobacter spp were *A. baumannii*. The susceptibility test result showed that *A. baumannii* isolates were highly resistant to ampicillin/salbactam 13 (92.8%) and least resistant to ciprofloxacin 2 (14.3%) and amikacin 3 (21.4). The results of their finding concluded that presence of *A. baumannii* species that are resistant to common antibiotics are associated with a longer duration of hospitalization in the three hospitals studied (Bashir *et al*., 2019).

Similarly, a cross-sectional study conducted by Shuaibu *et al*. (2015) in 7 major hospitals distributed in North-West Nigeria reported that, *A. baumannii* infection was 11%, 9%, 6%, 4%, 12% 5% and 3% from Sokoto, Kaduna, Katsina, Kebbi, Kano State, Jigawa and Zamfara respectively. All isolates were tested and showed resistance to erythromycin (92.1%); cefazolin (85.6%); aztreonam (77.1%); tetracycline (74.8%); cephalothin, kanamycin (65.5%); gentamicin (65.1%); piperacillin, cefoxitin (63.5%), nitrofurantoin (61.9%); chloramphenicol (59.3%); ofloxacin (56.9%); and colistin (53.8%). However, high rates of carbapenem resistance were also recorded compared to meropenem (87.8%) and imipenem (76.9%). The least resistance was observed from azithromycin (33.9%); ciprofloxacin, polymyxin B (30.2%); and amikacin (28.1%). This review observed that, there is paucity of data on *Acinetobater baumannii* research in the northern part of the country, few or no records have been found in the north-eastern region, including the Federal Capital Territory (FCT) and other south-eastern states (Abia, Anambra, Enugu) **Fig.1.**

Table 1. Baseline characteristics of included research articles on *A. baumannii* in Nigeria

Region	State	Study Location	No. of specimen collected	No. of isolates tested	Method of Antibiotics test	References
Southeast	Imo	Imo University Teaching Hospital	155	14	K-B disc diffusion	Victor *et al*., 2014
Southeast	Ibonyi	Alex Ekwue Federal University Teaching Hospital	385	23	K-B disc diffusion	Ikechukwu *et al*., 2021
Southwest	Abeokuta	8 different hospitals of the southwest Nigeria	1002	72	K-B disc diffusion	Ike *et al*., 2014
Southwest	Ogun	Federal Medical Center Abeokuta	140	18	K-B disc diffusion	Fasuyi *et al.*, 2020
Southwest	Osun	Ladoke Akintola University Teaching Hospital Osogbo	150	8	K-B disc diffusion	Odewale *et al*., 2016
Southwest	Lagos	Lagos University Teaching Hospital	1051	53	K-B disc diffusion	Iregbu *et al*., 2002
Southwest	Lagos	Lagos State Specialist Hospital	100	14	K-B disc diffusion	Victor *et al.*, 2012
Southwest	Oyo	University College Hospital Ibadan	_	26	K-B disc diffusion	Hannah *et al.*, 2012
Northwest	Kano	3 Tertiary Hospital (AKTH, MMSH and MAWSH)	401	9	K-B disc diffusion	Bashir *et al*., 2019
Northwest	Sokoto Kaduna Katsina Kebbi Kano Jigawa Zamfara	7 Major Hospital of the Northwest Nigeria	700	50	K-B disc diffusion	Shuaibu *et al*., 2015

Table 2. Summary of antimicrobials tested against *A. baumannii* in different studies

Antibiotics											References
AMK	**CEF**	**GEN**	**IPM**	**LVX**	**MEM**	**AMP**	**CIP**	**AMX**	**SAL**	**COL**	
√	√	√		√	√	√	√	√	√		Victor *et al*., 2014
√	√	√	√		√	√	√		√		Ikechukwu *et al*., 2021
√	√	√	√		√	√	√			√	Ike *et al*., 2014
√	√		√	√			√			√	Fasuyi *et al.*, 2020
√		√	√		√		√				Odewale *et al*., 2016
	√	√	√	√		√	√		√		Iregbu *et al*., 2002
√		√		√	√		√				Victor *et al*., 2012
				√	√	√	√		√		Hannah *et al.*, 2012
√	√	√	√	√		√	√	√	√	√	Bashir *et al*., 2019
√		√	√		√		√			√	Shuaibu *et al*., 2015

Key: AMK: Amikacin; CEF: Ceftriaxone; GEN: Gentamicin; IPM: Imipenem; LVX: Levofloxacin; MEM: Meropenem; AMP: Ampicillin; CIP: Ciprofloxacin; AMX Amoxicillin; SAL: Lactam; COL: Colistin.

Table 3. Subgroup *A. baumannii* resistance to different antibiotics across Nigeria

Class of Drug	Total number of *A. baumannii* tested	Resistance n (%)
ß-lactam		
Imepenem	7	5 (71.4)
Meropenem	7	3 (42.9)
Salbuctam	5	4 (80.0)
Cephalosporin		
Ceptriazone	6	4 (66.7)
Aminoglycosides		
Gentamicin	8	8 (100.0)
Amikacin	8	6 (75.0)
Fluoroquinolones		
Ciprofloxacin	10	8 (80.0)
Levofloxacin	6	5 (83.3)
Penicillins		
Ampicillin	6	4 (66.6)
Amoxicillin	2	2 (100.0)
Polymyxin		
Colistin	4	3 (75.0)

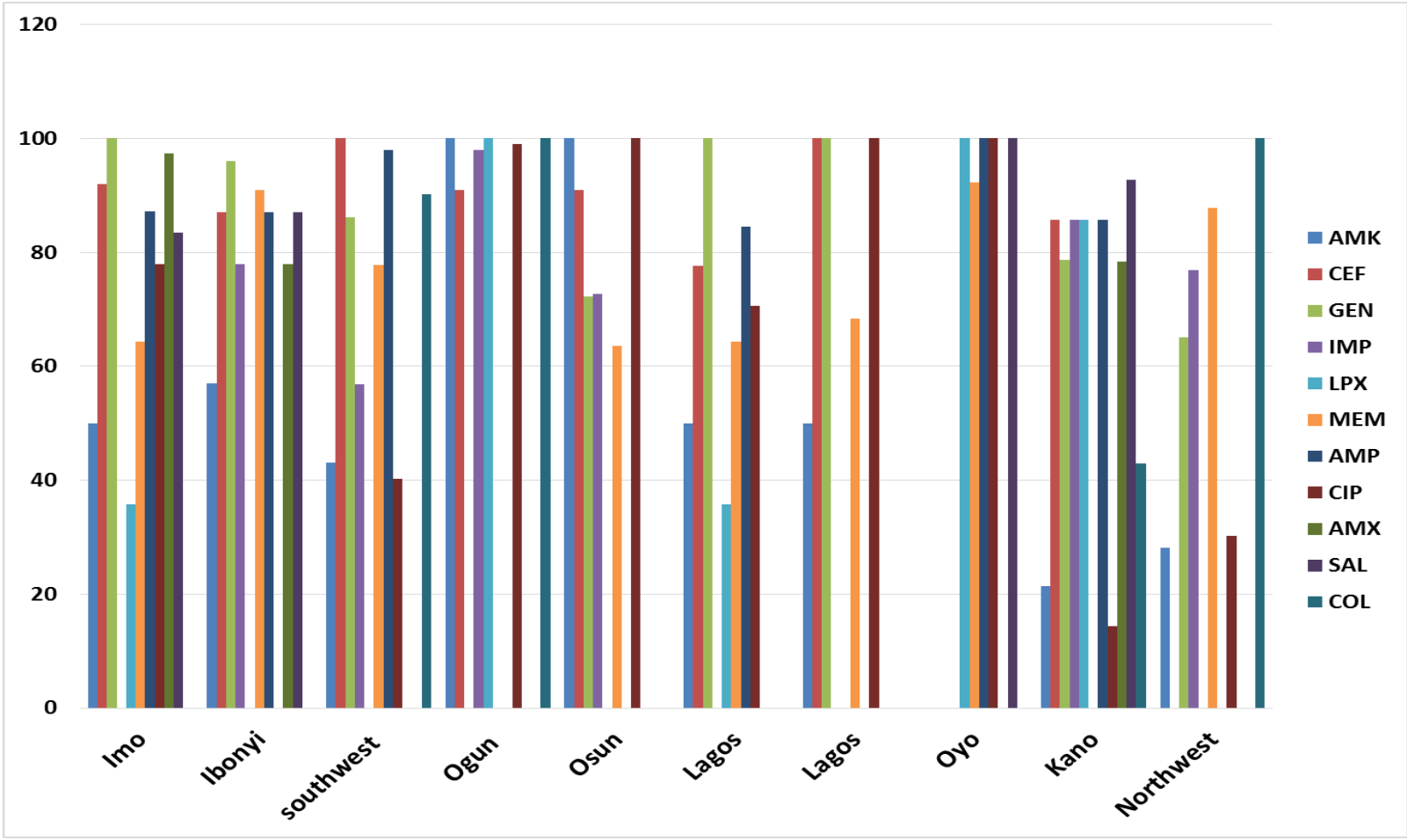

Figure 1. State / Study Area

Key: AMK: Amikacin; CEF: Ceftriaxone; GEN: Gentamicin; IPM: Imipenem; LVX: Levofloxacin; MEM: Meropenem; AMP: Ampicillin; CIP: Ciprofloxacin; AMX Amoxicillin; SAL Lactam; COL: Lolistin.

RESULTS

Research options

Eighty-six (86) articles were revived from four different search engine, while 35 publications were subsequently evaluated for enrollment. Conclusively, 10 articles was chosen for inclusion in this review.

Resistance profile for isolated *A. baumannii*

A total of 4084 clinical specimens were collected in all the studies, of which 287 strains of *Acinetobacter baumannii* were identified. The highest resistance was reported to gentamicin (GEN) and the lowest to meropenem (MEM) across all the regions Fig.1

Quality assessment and characteristics of this review

Table 1. Describe baseline characteristics of included studies, region; States; location, number of isolates tested and method of antibiotic testing. Most of the selected studies used Kirby-Bauer disk diffusion (K-B) to test for antimicrobial resistance. Table 2 summarizes the antimicrobial agents tested against *A. baunmanii* isolates in the included studies. Antibiotics tested from different structural classes include: AMA: amikacin; CEF: ceftriazone; GEN: gentamicin; IPM: imipenem; LVX: levofloxacin; MEM: meropenem; AMP ampicillin; CIP: ciprofloxacin; AMX amoxicillin; Sulbactam SAL and COL: colistin. Table 3: showed a summary of the subgroup and overall prevalence of resistance to 11 antimicrobial according to the studied areas. The classes of antibiotics tested includes ß-lactam, Cephalosporin, Aminoglycosides, Fluoroquinolones, Penicillins and polymyxin.

DISCUSSION

Antibiotics resistance in Nigeria become a grave health problem, with increasing rates of resistance in most clinically important bacteria (Ike *et al*., 2014). To our knowledge, this is the first review to investigate antimicrobial resistance in *A. baumannii* patients in Nigeria. Regards to 287 strains of *Acinetobacter baumannii* isolated from clinical specimens of hospital admitted patients in Nigeria from 2002-2021, we found an increase of 28% resistance rate to habitually used antibacterial agents. Subclass analyzes implied an increase of *A. baumannii* antibiotics resistance over time.

Regarding resistance to aminoglycosides, the resistance results indicated that Nigerian patients infected with *Acinetobacter baumannii* had the highest risk of GEN resistance, independent of time. Compared to other common antibiotics, consistently high resistance to GEN was found between 48% and 61% during 2002–2021 (Xiao *et al*., 2011). In the past decade (2000-2009), *A. baumannii* had a high rate of resistance to GEN, however, the results of study shows that GEN resistance is still widespread in the in

recent years. Subclass comparisons suggest that the near-significant trend in GEN resistance decline may be attributable to the effective control for GEN use at the time, compared to previous resistance profile.

However, rate of GEN resistance has risen sharply over the last few years. Therefore, reduction in the utilizing of this antibacterial agent have to be considered when treating patients for whom resistance testing results are unknown, and aminoglycosides, due to their low resistance potential, should be considered when considering the use of aminoglycosides. AMK can be the first choice.

The accelerating rate of carbapenem-resistant *Acinetobacter baumannii* isolated from critically ill patients poses a threat to antibiotic curative in Nigeria. In this analysis, IPM and MEM resistance to *Acinetobacter baumannii* were reported to be on average 28% and 24.4% respectively. The synergy of multiple chromosomal resistance mechanisms mainly leads to carbapenem resistance (Zeina, 2020). Carbapenems show remarkable stability against most β-lactamases without high toxicity and are therefore currently the main choice for severe Gram-negative bacterial infections (Asif *et al*., 2018). Despite the overall results showing increased resistance, in the absence of drug susceptibility testing, carbapenems can still be considered as first-line treatment for severe infections because of their potent antimicrobial action. However, the results of this study showed relatively high susceptibility to carbapenems compared to other antibiotics.

It should be noted the importance of drug control in the management of patients requires continuous evaluation of clinical specimens and carefully monitor antimicrobial resistance to help physicians choose the best treatment options for infected patients and avoid treatment failure. In addition, effective antibacterial control programs should be inaugurated. Each ward should adopt a monitoring system and should be thoroughly disinfected on a regular basis.

We acknowledge some key limitations of this study. There is limited research carried on elsewhere in Nigeria in more recent times. Medications used for patient management may vary by region, and dosing patterns may vary according to local physician prescriptions. And, those drugs they use may come from multiple drug-makers. Furthermore, we noted publication bias when analyzing combined resistance to CIP.

Conclusively, the increase in resistant strains of *Acinetobacter baumannii* isolated from clinical specimen's remains a challenges for patients in many parts of Nigeria especially those are immunocompromised. Therefore, it is prudent to continuously monitor the isolated *Acinetobacter baumannii* and develop a more effective antibiotic dosing regimen to avoid treatment failure. At the same time, more research are encouraged to better monitor resistance patterns and clarify treatment options especial in rural areas or primary healthcare which was abandoned.

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