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Bacteriological Profile of Infections Encountered in a Pneumology Service in a Moderate-Income Country [Pneumology Department of CHU Cocody (Côte d'Ivoire)]

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Abstract

Introduction: Infections represent a real public health problem aggravating the morbidity and mortality of hospitalized patients. **Methods:** This was a retrospective study with descriptive purposes over a period of 05 years, in the Pneumology Department of the University Hospital of Cocody. **Results:** The average age in our population was 42 years. We observed a male predominance of 64.5%, with a sex ratio of 1.8. Medical history was dominated by HIV infection (23.5%), followed by tuberculosis (15.6%). Concerning lifestyle, smoking was found in 38% of cases. Symptoms progressed chronically in 80% of cases. An infectious syndrome was found in 75% of cases. Microbial culture was positive in 42% of cases. *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* were encountered in 26.4% of cases each, followed by *Echerichia coli* in 10.4% of cases. *Klebsiella pneumoniae* in the first three years topped the list, but gradually. *Pseudomonas aeruginosa* maintained its leadership over the last three years. *Pseudomonas aeruginosa* isolates expressed a resistance rate of 9.8% to ceftazidime and 8.1% to imipenem; to aztreonam (36%), ticarcillin (33.3%) and levofloxacin. These strains were susceptible to fosfomycin (100%), meropenem (96.6%) and amikacin (96%). For isolated strains of *Entero-bacteriaceae*, resistance was observed about ticarcillin (83.3%) and amoxicillin clavulanic acid (71.2%). *Streptococcaceae* showed resistance to tetracycline (69.2%) and erythromycin (50%). Over the years there has been an increase in resistance to amoxicillin-clavulanic acid ceftriaxone. The death rate was 14%. **Conclusion:** The bacterial profile of infections is dominated by germs responsible for nosocomial infection with significant mortality.

Keywords

Bacterial Pleural, Pneumonia, Nosocomial Infection Sub-Saharan Africa, Antibiotic Therapy

1. Introduction

Disease prevention and early detection remains a major public health problem. In a hospital environment, this prevention mainly concerns infections and their mode of transmission: bacterial infections remain the main cause of death in seriously ill patients [1].

The intensive and abusive use of antibiotics leads to the selection of ever more resistant bacterial strains. Antibiotic resistance constitutes one of the most serious threats to global health, food security and development today [2].

These infections lead to prolonged hospitalizations, increased medical expenses, and worsen morbidity and mortality of hospitalized patients.

Certain departments, such as the pulmonology department, are more concerned by the infectious problem as they house immunocompromised subjects and therefore extremely sensitive to infections. Furthermore, bacterial infections are common and represent the second cause of hospitalization in the department. In addition, the first summary evaluation of the bacterial ecosystem of the Pulmonology Department of the Cocody University Hospital (CHU) dates to 1986 [3], which reflects the difficulty of targeting the probabilistic antibiotic therapy proposed since this period.

The study of the bacterial profile in the pulmonology department will allow us to rehabilitate probabilistic antibiotic therapy so we will have a new therapeutic approach to infections and a better predictive response to future resistance. It is with this aim that we carried out this study, the objective of which was to describe the bacterial ecosystem of infections encountered in the pulmonology department.

2. Methodology

2.1. Study Framework

This study took place in the Pulmonology Department of the Cocody University Hospital, in hospitalization. This service is located on the 12th floor of the said university hospital. It has a 42-bed hospitalization unit, a bronchial endoscopy unit, a smoking cessation unit, and a voluntary HIV testing center.

2.2. Type of Study

This was a retrospective study with a descriptive aim over a period of 05 years from September 1, 2016 to August 31, 2021. This period was chosen because during this time we are many infections in the service.

2.3. Study Population

Inclusion criteria

We included in the study all files of patients who were hospitalized during the study period in the Pulmonology department and who benefited from bacteriological research at the Pasteur Institute on a biological sample whatever its nature. The biological sample was pleural effusion or sputum, urinal tip.

Non-inclusion criteria

We had excluded any unfound patient records; also, any patient file whose bacteriological research was negative and in whom the diagnosis of tuberculosis was retained.

2.4. Progress of the Investigation

Data collection

To carry out this work, we consulted the register and files of patients hospitalized in the Pulmonology Department of the Cocody University Hospital during the study period. We process with an investigation sheet containing the different items. We have listed the files in the filing register. Then we took file by file to complete our investigation sheet.

For the bacteriological aspects we consulted the database of the Pasteur Institute of Côte d'Ivoire. We complete the data with the head of bacteriological service.

Data relating to each patient were collected on an individual computerized form.

2.5. Analysis Settings

The variables studied concerned sociodemographic characteristics (age, sex, profession, marital status), clinical characteristics, bacteriological characteristics (bacterial species and antibiotic sensitivity profile, and evolution).

2.6. Data Analysis

Qualitative variables were presented as a percentage and quantitative variables as a mean ± Standard Deviation.

Data entry, processing and analysis were carried out using EPI INFO software.

2.7. Operational Definitions

During our study, all bacteria with intermediate sensitivity or proven sensitivity were considered resistant.

A bacterium is said to be multi-resistant when it is resistant to at least three different families of antibiotics.

Pneumonia is said to be presumed bacterial when they have a clinical presentation of bacterial pneumonia but without the germ having been isolated; and they are called bacterial when the germ has been identified.

3. Results

During the study period and according to the inclusion criteria of our study, we

collected 302 patient files having been the subject of a bacteriological research out of 2557 files recorded during the period. The frequency is 11.81%.

In our study persons between [15 - 35 years old] are 15%, [36 - 45 years old] 15%, [46 - 65 years old] 65%, upper 65 years olds 5%. The average age in our population was 42 years with extremes between 15 and 87 years. Men represented 64.5% of the sample with a sex ratio of 1.8. The informal sector represented 54.4%, unskilled workers 20.2%, household 5%, manager 1%, students 10%, middle manager 9.4%. The patients came from the medical emergencies of the Cocody University Hospital in 52% of cases. For lifestyle, smoking was encountered at 38%. Medical history was represented by HIV at 23.5% followed by tuberculosis at 15.6%.

Clinically, the symptoms evolved chronically in 80% of cases. Dyspnea was found in 38.6% of cases followed by chest pain in 14.1% of cases. Fever was present in 75% of cases.

Anemia was noted in 78.2% of cases, a biological inflammatory syndrome in 52% of cases then hydro-electrolytic disorders in 49% of cases.

The pathologies selected were represented by bacterial pneumonia in 15% of cases followed by presumed bacterial pleural effusion and presumed bacterial pneumonia in the same proportion at 14% (Figure 1).

However, bacteriological samples were taken at least 72 hours after hospitalization in 61% of cases and the microbial culture was positive in 117 out of 302 patients, in a proportion of 42%. Bacterial culture was 100% (4/4) profitable when done on the drain tip, 72% (13/17) on bronchioloalveolar washing fluid (BAL) and 44% (52/117) on sputum (Figure 2). The polymicrobial character was found in 17% of positive samples with 2 germs in 16% of cases and 3 germs in 1% of cases.

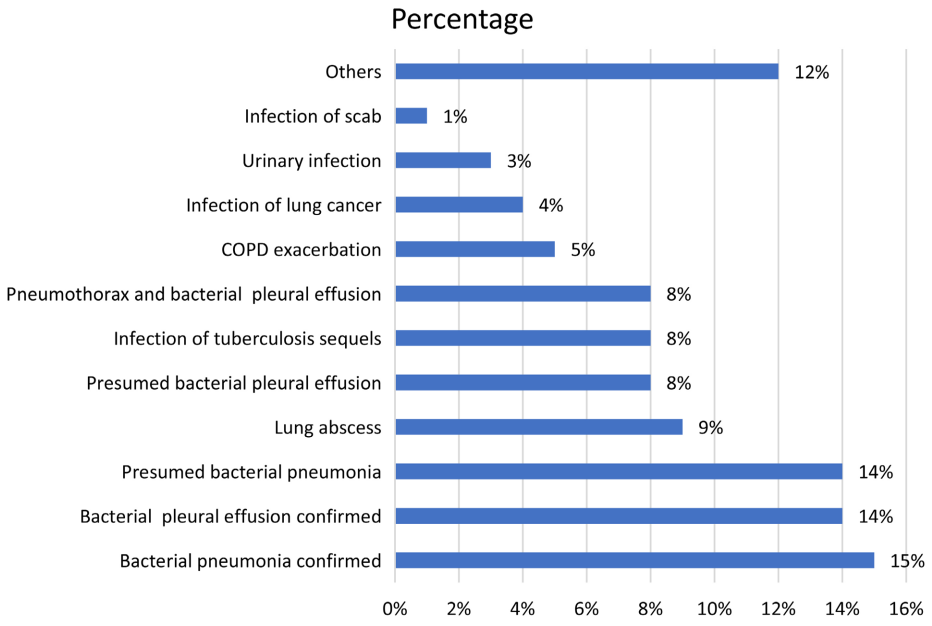

Figure 1. Distribution of patient files according to the diagnosis retained.

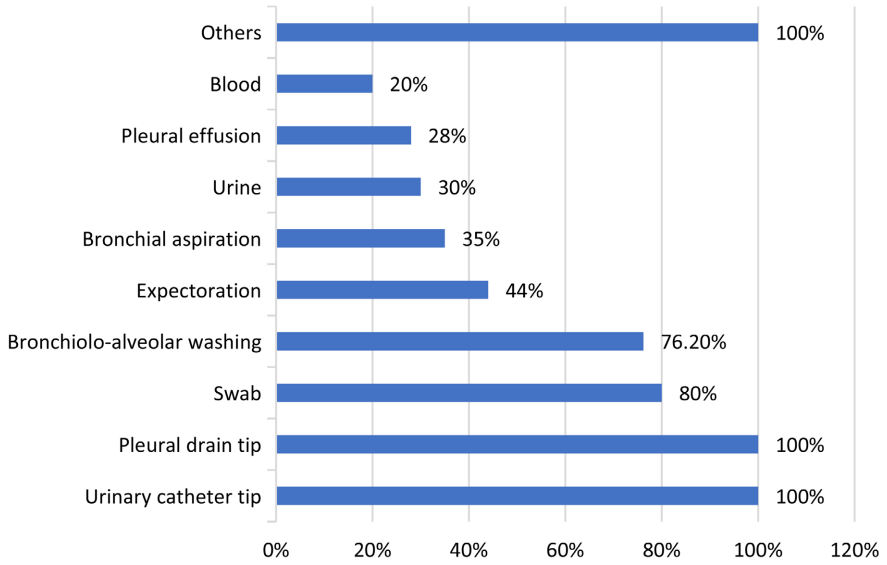

Figure 2. Distribution of patient files according to the profitability of the sample. Others (05): joint fluid, skin abscess, foot wound, mandibular cellulitis.

3.1. Microbial Profile

The distribution by family showed the predominance of *enterobacteria* which represented 49.1% of the isolates, followed by non-fermentative Gram-negative bacilli (BGN) at 29.1%, then *staphylococcaceae* at 12.7% and finally *streptococcaceae* at 11.3%.

The overall study of species found *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* in the same proportion at 26.4% followed by *Escherichia coli* at 10.4% (**Figure 3**).

The distribution by family showed the predominance of enterobacteria which represented 49.1% of the isolates, followed by non-fermentative Gram-negative bacilli (BGN) at 29.1%, then *staphylococcaceae* at 12.7% and finally *streptococcaceae* at 11.3%.

The overall study of species found *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* in the same proportion at 26.4% followed by *Escherichia coli* at 10.4% (**Figure 3**).

3.2. Distribution of Germs According to the Years

During the first three years we observed that Klebsiella pneumoniae was at the top of the list, but that Pseudomonas aeruginosa gradually remained the leader over the last three years of study (**Figure 4**).

The study of the profile of bacterial resistance to the main antibiotics

For non-fermentative Gram-negative bacilli (*Pseudomonas* +++), *Pseudomonas aeruginosa* isolates had expressed a resistance rate of 9.8% for ceftazidime and 8.1% to imipenem. But we also noted resistance to aztreonam (36%), ticarcillin (33.3%) and levofloxacin (31.8%). On the other hand, these strains were sensitive to fosfomycin (100%), meropenem (96.6%) and amikacin (96%).

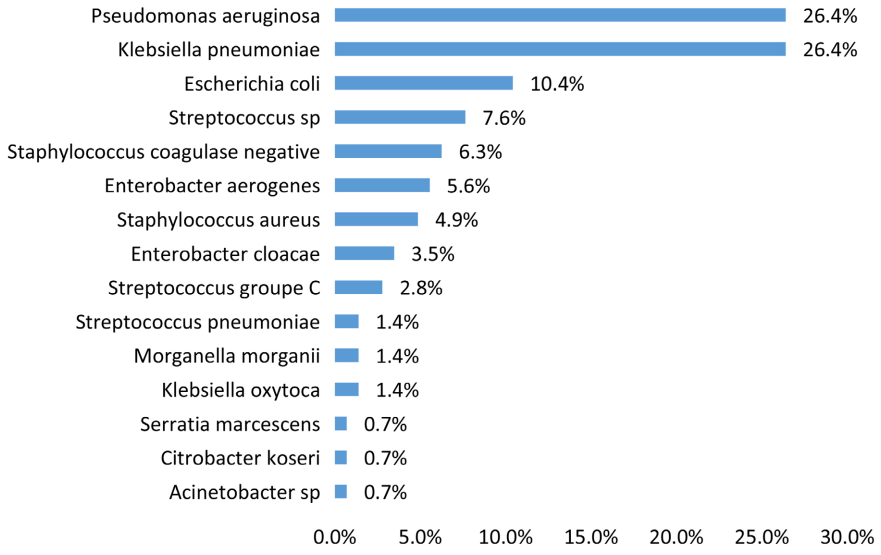

Figure 3. Distribution of patient files according to species.

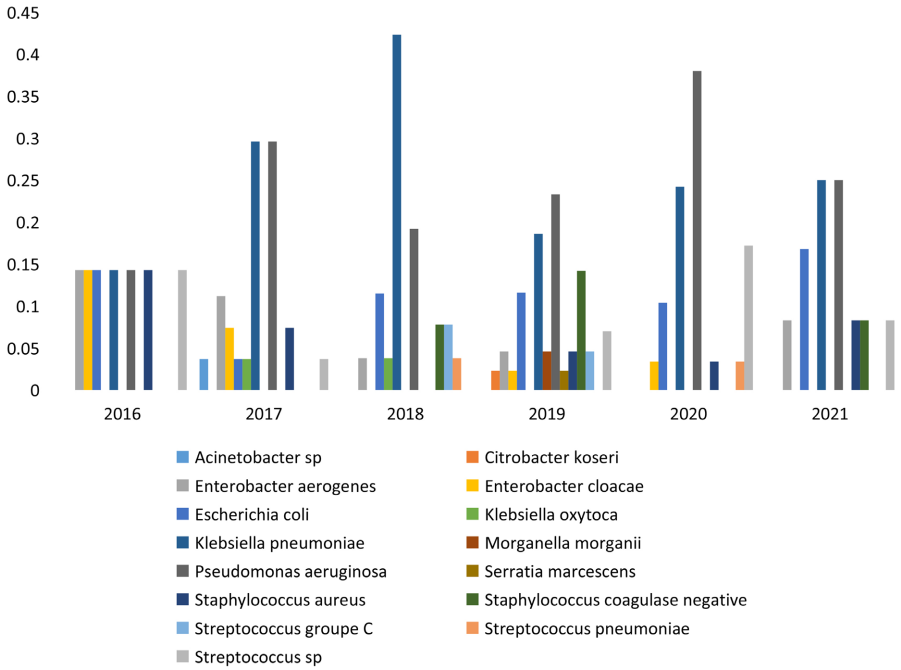

Figure 4. Distribution of patient files according to bacterial species over the years.

For the isolated enterobacteria strains, the highest level of resistance was observed against ticarcillin (83.3%) then with the amoxicillin-clavulanic acid combination was 71.2%. These strains were sensitive to imipenem (98.4%) and amikacin (98.1%).

Staphylococcus showed resistance to cefotaxime at 42.8% and to oxacillin at 11.7%. On the other hand, all our strains were sensitive to vancomycin and levofloxacin.

Streptococcus showed high resistance to tetracycline (69.2%) and erythromycin (50%).

3.3. The Evolution of Bacterial Resistance to Antibiotics

All bacterial strains showed resistance to amoxicillin and clavulanic acid. This resistance was relatively stable around 60% during the first four years of study with an increase of up to 80% during the last two years of study. Years 2018 and 2020 were the years in which we recorded the highest percentage of ofloxacin resistance at 63.6% and 50% respectively. The bacterial strains had demonstrated increased resistance to ceftriaxone with an increase of up to 66% during the last two years of study (**Figure 5**).

Furthermore, as a treatment received in hospitalization, dual antibiotic therapy was the combination frequently observed at 45.7%. Before the antibiogram, the most frequent probabilistic antibiotic molecule was (51%) amoxicillin-clavulanic acid. After the antibiogram, antibiotic therapy was adapted in 93.21% of cases.

The average length of patient hospitalization days was 34.26 in patients with a positive bacteriological culture.

Exit was authorized in 82% of cases. However, there was a death rate of 14%.

4. Discussion

Our study was a retrospective study based on the analysis of medical records and laboratory data of hospitalized patients. It presented as an essential limitation its retrospective nature which does not allow the analysis of a certain number of data such as the community or nosocomial nature of our infections.

The average age in our population was 42 years. This result was like that found by Abdelkarim S. in 2015 in Morocco [4] who found an average age of 40, but it differs from that found by Aseray N. *et al.* in Nantes in 2008 with an average age of 71 years [5]. This observed difference could be due to our much younger general population.

We observed a male predominance of 64.5%. Male predominance was found in the study by Njall C. *et al.* in 2013 in Cameroon [6] while Davakan T. *et al.* in

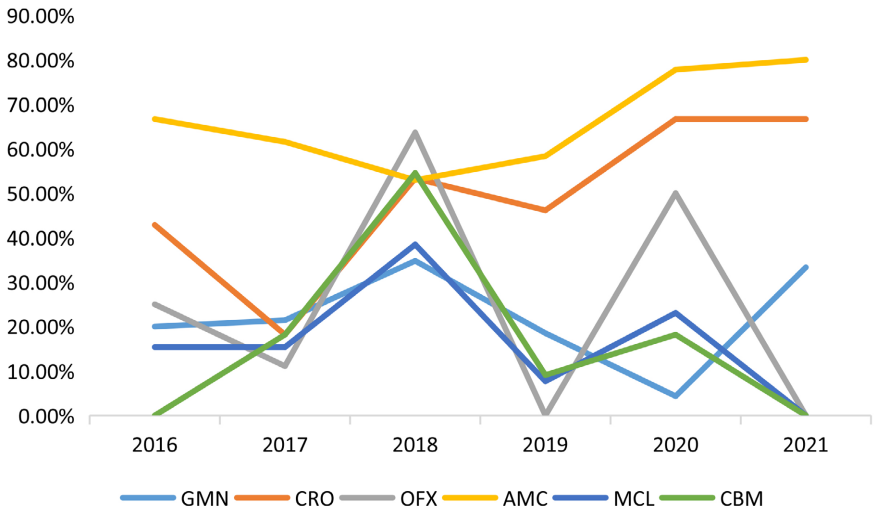

Figure 5. Evolution of antibiotic resistance over time.

2018 in Benin [7] found a female predominance.

Most of our patients worked in the informal sector (54.4%), which reflects the low level of our developing countries.

Concerning the origin, 80% of the patients had already stayed in another department before being admitted to a pulmonology hospitalization. This could account for the possibility of a poly-infection with nosocomial and community germs.

Medical history was dominated by HIV at 23.5%. This rate was much higher than that of the general population, but close to that found in 2018 by Davakan T *et al.* in Benin [7]. HIV-AIDS immunosuppression is the essential driving force favoring the occurrence of respiratory bacterial infection. In addition, HIV infection, sometimes with its opportunistic conditions, constitutes the essential risk factor for community-acquired bacterial pneumonia [8]. It is very prevalent with a proportion of 58% [9].

Smoking, which is also a factor in immunosuppression of the tracheobronchial tract, favoring bacterial infections, was observed in 38% of cases. It is a real public health problem with a prevalence of 20.3% of the general population.

Concerning the diagnosis chosen, bacterial pneumonia was the most represented at 15%. This result agrees with those of Koffi N [10] and several other African authors [11] [12] who report that bacterial pneumonia was the second cause of hospitalization after tuberculosis.

Bacterial culture was positive in 42% of cases. The result is like those found in a meta-analysis on the microbiological diagnosis of community pneumonia; it emerged that the etiological diagnosis was only made in approximately 50% of cases, although with large variations between studies [13].

Infections are therapeutic emergencies that require the initiation of probabilistic antibiotic therapy without delay. For this, most of these samples were taken in hospital and were taken from patients already on antibiotic therapy, which could have reduced the profitability of the cultures.

Cultures are more profitable when it comes to bronchiolo-alveolar washing fluid compared to sputum with a positivity rate of 76% and 44% respectively. In literature, difference is also observed; BAL culture sensitivity ranges from 42 to 93%, with a mean of 73%. As for the Cyto-Bacteriological Examination of Sputum, according to a meta-analysis, the sensitivity of the direct examination varies from 15% to 100% in the diagnosis of community pneumonia. This variability can be explained by different characteristics of the populations studied, by the prior administration of antibiotics and depending on the reference test used [14].

In our series, 83% of cultures isolated a single germ, but in 17% of cases, several germs were found, including two germs in 16% of cases and three germs in 1% of cases. Quartin A. found polymicrobial flora in 50.4% of nosocomial pneumonia [15]. In our study, this profile could be linked to the fact that the patients had been admitted to various departments before their hospitalization on

the one hand and on the other hand to the fact of their relatively long hospital stay exposing them to nosocomial infection.

The distribution by families showed the predominance of *Enterobacteria* which represented 49.1% of the isolates, followed by non-fermentative Gram Negative Bacilli at 29.1%, then *staphylococcus* at 12.7% and finally *streptococcus* at 11.3%.

The main bacterial were *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* encountered in the same proportion in 26.4% of cases, followed by *Escherichia coli* in 10.4% of cases. These results differ from those of Coulibaly N. and Duchasin [3] according to this preliminary study in 1986 which found *Streptococcocus pneumoniae* as the most frequent germ 31% but also from those of Njall *et al.* in 2013 in Cameroon [6]: *Escherichia coli* (23.1%), followed by *Acinetobacter baumani* (15.4%), *Pseudomonas aeruginosa* (15.4%), and *Staphylococcus aureus* (15.4%).

Data from the SENTRY surveillance program, a multinational study, indicated that the first 6 etiological agents often involved: *Staphylococcus aureus* 28%, *Pseudomonas aeruginosa* 21.8%, *Klebsiella sp* 9.8%, *Escherichia coli* 6.9%, *Acinetobacter sp* 6.8%, and *Enterobacter sp* (6.3%) caused 80% of all infections [16].

This diversity encountered in these different studies may be since bacterial ecology varies greatly from one country to another, from one city to another and even from one service to another. This heterogeneous distribution of germs responsible for infection is explained by the difference in the type of microbiological analysis leading to the diagnosis, by the existence of prior systemic antibiotic therapy, by the type of patient studied (medical, surgical, or traumatic), the existence of comorbidity, the length of stay in the department and the invasive procedures the patient received.

However, our study allows us to draw some observations. First, *Klebsiella pneumoniae* was at the top of the list during the first three years of the study, but was gradually overtaken by *Pseudomonas aeruginosa* which remained the leader in recent years. We are witnessing an emergence of nosocomial infections. *Pseudomonas aeruginosa* were for the most part multi-resistant strains due to the resistance expressed to imipenem (8.1%), ceftazidime (9.8%), aztreonam (36%), ticarcillin (33.3%) and levofloxacin (31.8%). It is time for us to question the quality of care we provide given that nosocomial infection is an indicator of poor quality of care [17]. Hospital hygiene must be questioned, from simple hand washing to the most invasive medical procedures. These results could also reflect the hygiene and maintenance of our hospitalization services characterized by insufficient quality and frequency of bio cleaning, disinfection, and sterilization.

Our bacterial strains showed increased resistance to amoxicillin-clavulanic acid. Resistance was relatively stable around 60% during the first four years with an increase of up to 80% during the last two years. It could be explained by the fact that the amoxicillin-clavulanic acid combination is the most used antibiotic

in probabilistic treatments (51%), moreover its use has increased since the advent of the Covid 19 pandemic. fact that it is part of the therapeutic strategy in force in Côte d'Ivoire.

Bi-antibiotic therapy was the most frequent combination (45.7%) and the adaptation of this therapy after antibiogram improved patient survival. This same observation was made by Coulibaly *et al.* in 2014 in Mali [18] while in France in 2008, Asseray *et al.* described monotherapy as the most used regimen (72%). It could be explained by the fact that in our context, patients seen in a specialized environment present serious signs justifying dual antibiotic therapy. There was a high mortality rate of 14%, due to difficulties in accessing care, delays in consultation, and the high cost of antibiotics; but also because of the debilitated situation caused by HIV, smoking, and alcoholism, which will add to the picture given that they are poor prognostic factors.

5. Conclusion

The study of the bacterial ecosystem of infections encountered in the Pulmonology Department of the Cocody University Hospital carried out from September 1, 2016 to August 31, 2021 based on the analysis of the medical files of hospitalized patients allowed us to note that we are gradually tending towards the change in the bacterial ecosystem dominated by multi-resistant *Pseudomonas aeruginosa* which is an indicator of nosocomial infections. Bacteria are becoming increasingly resistant to probabilistic antibiotics. Faced with these results, emphasis should be placed on urgently adopting a certain number of measures to prevent the spread of multi-resistant bacteria.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Organisation Mondiale de la Santé (OMS) (2017) L'OMS publie une liste de bactéries contre lesquelles il est urgent d'avoir de nouveaux antibiotiques [en ligne]. https://www.who.int/fr/news/item/27-02-2017-who-publishes-list-of-bacteria-for-which-new-antibiotics-are-urgently-needed

[2] World Health Organization (WHO) (2014) Antimicrobial Resistance: Global Report on Surveillance 2014 [en ligne]. http://www.who.int/drugresistance/documents/surveillancereport/en/

[3] Coulibaly, N., Duchassin, M., Darracq, M., Rey, J. and Lamarque, G. (1986) Etude de la bioclinique dans le traitement des pneumopathies bactériennes hospitalières à Abidjan. *Medecine d'Afrique Noire*, **33**, 61-65.

[4] Shimi, A., Touzani, S., Elbakouri, N., Bechri, B., Derkaoui, A. and Khatouf, M. (2015) Les pneumopathies nosocomiales en réanimation de CHU Hassan II de Fès. *Pan African Medical Journal*, **22**, 285. https://doi.org/10.11604/pamj.2015.22.285.7630

[5] Asseray, N., Bleher, Y., Poirier, Y., Hoff, J., Boutoille, D., Bretonniere, C., *et al.*

(2009) L'antibiothérapie aux urgences, évaluation par une approche qualitative et quantitative. *Médecine et Maladies Infectieuses*, **39**, 203-208. https://doi.org/10.1016/j.medmal.2008.10.020

[6] Njall, C., Adiogo, D., Bita, A., Ateba, N., Sume, G., Kollo, B., *et al.* (2013) Écologie bactérienne de l'infection nosocomiale au service de réanimation de l'hôpital Laquintinie de Douala, Cameroun. *Pan African Medical Journal*, **14**, 140. https://doi.org/10.11604/pamj.2013.14.140.1818

[7] Davakan, T.A., Kakpo-Zannou, R. and Allabi, A.C. (2018) Analyse de l'antibiothérapie dans le service de médecine polyvalente de l'hôpital de zone d'ABOMEY-CALAVI/ SO-AVA. *J sci pharm boil*, **19**, 38-46.

[8] Horo, K., Koffi, N., Kouassi, B., N'gom, A.S., Kenmogné, K., Ahui, B.J.M., *et al.* (2004) Facteurs de décès par pneumopathie aigue comlmunautaire en milieu africain à Abidjan. *Revue des Maladies Respiratoires*, **1**, 10-13. https://doi.org/10.1016/S0761-8425(04)71779-9

[9] Horo, K., Gode, C.V., Ahui, J.M.B., Kouassi, A.B., Djereke, G.B., Cardenat, M., *et al.* (2009) Pneumonies communautaires d'allure bactérienne chez le sujet infecté par le VIH: étude préliminaire prospective. *Revue de Pneumologie Clinique*, **65**, 137-142. https://doi.org/10.1016/j.pneumo.2009.03.004

[10] Pneumopathies aigues d'allure bacterienne chez le sujet agé - Bibliotheque Virtuelle-MESRS [Internet]. http://inveniov1.uvci.edu.ci/record/2042/files/?ln=en

[11] Zoubga, A.Z., Ouedraogo, M., Drabo, Y.J., Boncoungou, K., Ki, C., Ouedraogo, S.M., *et al.* (2000) Aspects épidémiologiques, cliniques et thérapeutiques des pneumopathies aiguës bactériennes dans le service de pneumologie du centre Hospitalier National Sanou Souro de Bobo-Dioulasso. *Medecine d'Afrique Noire*, **47**, 470-472.

[12] Kayantao, D., Koné, A., Tchameni, R.P., M'Baye, O., Diallo, S., Sissoko, B., *et al.* (2001) Aspects épidémiologiques, cliniques et évolutifs des pneumopathies bactériennes à l'hôpital du point G à Bamako. *MedAfr Noire*, **48**, 427-431.

[13] Péan, Y. (2011) Diagnostic microbiologique des pneumopathies communautaires. *Médecine et Maladies Infectieuses*, **41**, H2-H4. https://doi.org/10.1016/S0399-077X(11)70002-6

[14] Dahyot, S., Lemee, L. and Pestel-Caron, M. (2017) Description et place des techniques bactériologiques dans la prise en charge des infections pulmonaires. *Revue des Maladies Respiratoires*, **34**, 1098-1113. https://doi.org/10.1016/j.rmr.2016.07.007

[15] Quartin, A.A., Scerpella, E.G., Puttagunta, S. and Kett, D.H. (2013) A Comparison of Microbiology and Demographics among Patients with Healthcare-Associated, Hospital-Acquired, and Ventilator-Associated Pneumonia: A Retrospective Analysis of 1184 Patients from a Large, International Study. *BMC Infectious Diseases*, **13**, Article Number: 561. https://doi.org/10.1186/1471-2334-13-561

[16] Nair, G.B. and Niederman, M.S. (2013) Nosocomial Pneumonia: Lessons Learned. *Critical Care Clinics*, **29**, 521-546. https://doi.org/10.1016/j.ccc.2013.03.007

[17] Durocher, A. (2005) L'infection nosocomiale comme indicateur de (non) qualité des soins: L'exemple de la réanimation (Commentaire). *Sciences Sociales et Santé*, **23**, 59-68. https://doi.org/10.3406/sosan.2005.1659

[18] Coulibaly, Y., Konate, A., Kone, D. and Bougoudogo, F. (2014) Étude de la prescription des antibiotiques en milieu hospitalier malien. *Rev Mali Infect Microbiol.*, **3**, 2-8.