"Antimicrobial Resistance Patterns of Bacteria Isolated from Pharmacy Technicians' Hands in Ghana"

ABSTRACT

Background: Pharmacy technicians play a critical role in healthcare delivery, particularly in developing countries like Ghana. However, there is limited knowledge about the microbial contamination of their hands and the antimicrobial susceptibility patterns of these microbes. This study aimed at investigating the presence of bacteria on the hands of pharmacy technicians in the Upper West region of Ghana and to determine the antimicrobial susceptibility patterns of the isolated organisms.

Methods: A cross-sectional study was conducted from January to April 2019. Hand swabs were collected from pharmacy technicians working in hospital pharmacies, community pharmacies, and over-the-counter medicine shops. Samples were cultured, and isolated bacteria were identified using standard microbiological techniques. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method.

Results: Thirty samples were collected across the three pharmacy categories. The study identified *Bacillus species, Staphylococcus species*, and *Enterobacter species* on the hands of pharmacy technicians. *Bacillus species* were the most prevalent and were generally sensitive to most antibiotics tested. *Staphylococcus species*, however, showed resistance to multiple antibiotics. *Enterobacter species* demonstrated mixed susceptibility patterns.

Conclusion: The study revealed significant microbial contamination on the hands of pharmacy technicians, with some isolates showing alarming antimicrobial resistance patterns. These findings emphasize the need for improved hand hygiene practices and regular antimicrobial susceptibility surveillance among pharmacy technicians to prevent the spread of potentially harmful bacteria in healthcare settings.

KEYWORDS: Antimicrobial, Susceptibility, Bacteria, medicine dispensers, pharmacy technicians, Nosocomial infections.

1.0 INTRODUCTION

In the Upper west regional capital of Ghana, Pharmacy technicians, initially described as non-professionally trained personnel employed to assist doctors and pharmacists in their daily duties, have evolved from mere assistants into influential members of the pharmaceutical world[1]. With the focus of pharmacist training in Ghana centered around the provisions of Great Britain, the role of trained Pharmacy technicians has continued to be crucial in dispensing medications,providing healthcare products, and patient counselling under the supervision of a pharmacist[2].

The significant transformation of Pharmacy technicians reflects the evolution of the pharmacy industry as a whole, encompassing medications, therapies, patients, and insurance [3]. In the past, these individuals were primarily seen as pharmacy assistants, but their position has grown in scope and responsibility over the years [4]. The initial reluctance to hire additional staff for assistance has given way to recognizing the invaluable contributions of Pharmacy technicians, especially as the complexities of the pharmacy landscape have multiplied. Factors such as increased patient numbers, technological advancements, electronic processes, insurance billing, and a wider array of medications have necessitated the professional growth of Pharmacy technicians[4], [5].

As the training of Pharmacy technicians in Ghana expands to meet the growing population and the rising number of disease conditions requiring proficient dispensing skills, their role has extended beyond traditional community and hospital pharmacy settings. Referred to as dispensing technicians, they play a vital part in the pharmacy team, actively involved in the preparation and supply of medicines and healthcare products, while also providing additional advice and guidelines [1]. In addition to medication supply through prescriptions, their responsibilities may involve the production and provision of aseptically prepared medicines, extemporaneous compounding, and the supply of medicines for clinical trials [6].

However, the practice of Pharmacy technicians has recently garnered attention from health scientists due to the potential transmission of disease-causing bacteria. Bacterial multiplication and spread can occur through the hands of Pharmacy technicians, affecting prepared and supplied medicines as well as potentially transmitting pathogens directly to patients through air contamination. This places healthcare providers, including doctors, and nurses, at a higher risk of nosocomial infections caused mainly by *Staphylococcus aureus* and *Enterococcus spp.* [7].

To prevent infections, hand cleansing with antiseptic agents is crucial. Moistening and sanitizing hands with disinfectants, such as liquid chloride solutions, have been identified as one of the most significant measures in reducing pathogen transmission in healthcare facilities[8], [9]. However, the lack of surveillance systems for healthcare-associated infections in most countries, along with the absence of standardized diagnostic criteria, hampers the collection of reliable global information. Nonetheless, studies suggest that hundreds of millions of patients worldwide are affected by healthcare-associated infections each year, with developing countries experiencing a higher frequency compared to developed nations [10], [11].

Despite the critical role of pharmacy technicians in healthcare delivery, there is a notable gap in current knowledge regarding the microbial contamination of their hands and the antimicrobial susceptibility patterns of these microbes, particularly in developing countries like Ghana. While studies have been conducted on hand hygiene and bacterial contamination among other healthcare workers such as doctors and nurses[12], [13], pharmacy technicians have been largely overlooked. This gap is particularly concerning given the increasing responsibilities of pharmacy technicians and their frequent contact with both medications and patients. Furthermore, there is limited data on the potential role of pharmacy technicians in the spread of antimicrobial-resistant organisms within healthcare and community settings in Ghana.

The number of Pharmacy technicians has been steadily increasing in the region since the introduction of dispensing technology at the Dr. HillaLimann Technical University (formerly Wa Polytechnic) in 2013. This advancement has led to improved pharmaceutical service delivery, prompting pharmaceutical shops to replace medicine counter assistants and non-pharmacy staff with Pharmacy technicians to promote better pharmaceutical practices in the region [14]. However, concerns arise regarding their practice methods, as their service delivery could potentially contribute to disease transmission through the spread of bacteria [14].

This research aims to address the pressing issues surrounding pathogen transmission by pharmacy technicians in the Upper westregional capital and to explore the antimicrobial susceptibility pattern of some selected pathogens isolated from the palms of Pharmacy technicians. The study of bacterial contamination and drug resistance in pharmacy technicians is of paramount importance for several reasons. Firstly, pharmacy technicians serve as a critical interface between healthcare systems and patients, handling medications and interacting directly with the public. Their role in medication dispensing and healthcare product provision places them in a unique position where they could potentially become vectors for pathogen transmission if proper hygiene practices are not maintained. Secondly, the hands of healthcare workers, including pharmacy technicians, have been identified as a significant source of nosocomial infections. Understanding the microbial flora present on technicians' hands and their antimicrobial resistance patterns is crucial for developing effective infection control strategies. Lastly, in the context of the global antimicrobial resistance crisis, identifying resistant strains in community and healthcare settings is vital for public health surveillance and intervention planning.

2.0 METHODOLOGY

2.1 Study setting

The Upper West region is located in the northwestern part of Ghana, covering an area of approximately 18,476 square kilometers. It is the least populous region in Ghana, with an estimated population of about 900,000 as of 2021. The region's capital and largest city is Wa. Healthcare facilities in the Upper West region consist of a mix of public and private institutions. The region has one major referral hospital, the Upper West Regional Hospital in Wa, which serves as the primary tertiary care center. Additionally, there are several district hospitals, health centers, and Community-based Health Planning and Services (CHPS) compounds spread across the region's 11 districts. The pharmaceutical sector in the region has seen significant growth in recent years, with an increasing number of community pharmacies and over-the-counter medicine shops.

2.2 Study Design

The study followed a cross-sectional pattern involving the collection of palm swabs from pharmacy technicians from January to April 2019. The researchers included pharmacy technicians operating within the Upper West regional capital during the study period. There was no age restriction, and the participation of the individuals was voluntary as informed consent was obtained from each of them.

2.3 Inclusion Criteria and Exclusion Criteria

Authorized pharmacy technicians previously called dispensers operating within the regional capital were included in this study. Pharmacy technicians who were not part of the dispensing process as well as those who did not give their consent were excluded from this study.

2.4 Sample Collection and Inoculation

The sample for this study was collected using a stratified random sampling method in which swabs were taken from technicians according to their operation unit category. Samples were classified into those operating in hospitals pharmacies, community pharmacies, and over the counter (OTC) medicines seller's shops. The sample size was determined by taking a record of all technicians within the regional capital taking into consideration all the above-mentioned categories. Samples were collected by taking hand swabs of pharmacy technicians in the various units using a sterile cotton swab stick that was moistened with sterile normal saline. The sample was immediately transported to the Microbiology laboratory of Dr. HillaLimann Technical University and inoculated onto brain heart infusion broth, MacConkey broth and Selenite cystine F broth and incubated overnight at 37^0C. The number of samples taken from each category was determined by the availability of technicians and the willingness to partake in the study.

2.5 Bacteria Identification and Isolation

The presence of bacteria was determined by inspection for bacteria growth and morphology on the agar plates. Separate colonies of bacteria were aseptically isolated onto differential media and biochemical reagents for identification and further examination. Mannitol salt agar(Oxoid, UK) was used to detect the presence of *Staphylococcus aureus* from Brain heart infusion broth while MacConkey agar (Oxoid, UK)was used for lactose fermenting bacteria such as *Escherichia coli and Klebsiella species* growing in MacConkey broth(Oxoid, UK).Salmonella Shigella agar (Oxoid, UK)was used for selective isolation of *Salmonella species* from Selenite cystine F broth. A series of biochemical tests such as the Indole test, Citrate test, Urease test, and Triple Sugar Iron (TSI) test were conducted on the cultures to identify and confirm the Gram-negative bacterial isolates while Gram stain, catalase and coagulase test were performed on Gram-positive isolates[15]. To ensure the accuracy and reliability of the biochemical tests performed in the study, two quality control organisms were employed: *Escherichia coli* (*E. coli*) ATCC 25922 and

Klebsiella pneumoniae (*K. pneumoniae*) NCTC 13442, as recommended by the Clinical and Laboratory Standards Institute in their 2021 guidelines [16].

Comment [H1]: CLSI (2021) *Performance Standards for Antimicrobial Susceptibility Testing*, 31st ed.

2.6 Antibiotics susceptibility testing

Antibiotic sensitivity was tested using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar according to CLSI antibiotic disk susceptibility testing guidelines [17]. The procedure was carried out by initiallysuspending bacterial isolate in sterile saline to match the turbidity of a 0.5 McFarland standard. This standardized inoculum was then evenly spread onto Mueller-Hinton agar plates using a sterile cotton swab to ensure a uniform bacterial lawn. After allowing the inoculum to dry for approximately 3-5 minutes, commercially prepared antibiotic discs were placed on the agar surface using sterile forceps, with a maximum of 8 discs per 90 mm plate to prevent overlapping of inhibition zones.

The antibiotics tested included those commonly used for treating infections caused by the isolated organisms, such as penicillin, amoxicillin, ciprofloxacin, erythromycin, and tetracycline for Gram-positive bacteria, and ciprofloxacin, ceftazidime, amikacin, and imipenem for Gram-negative bacteria. The complete list of antibiotics used is provided in the "List of Antimicrobial Agents Used" section of the manuscript.

Following disc placement, the plates were inverted and incubated at 37^0C for 18-24 hours in ambient air. After incubation, the diameter of each zone of inhibition was measured in millimeters using a calibrated ruler. The results were interpreted as susceptible or resistant based on the CLSI breakpoint criteria for each antibiotic [17].

Quality control was ensured by testing *Escherichia coli* ATCC 25922 and *Staphylococcus aureus* ATCC 25923 alongside the participants isolates. The study proceeded with result interpretation only after confirming that the quality control strains produced inhibition zone diameters within the acceptable ranges specified by CLSI guidelines.

3.1 RESULTS

This study set out to investigate the presence of *E. coli*, *Klebsiella species*, *Salmonella species* and *Staphylococcus species* amongst palms of pharmacy technicians in Wa municipality. Interestingly, only *Staphylococcus species* in conjunction with *Bacillus species* and *Enterobacter species* were identified during the study period. The samples were distributed among three different pharmacy units (Figure 1). The majority of the organisms isolated belonged to the genus *Bacillus* and most were isolated from the 'over-the-counter shops' (Figure 2).

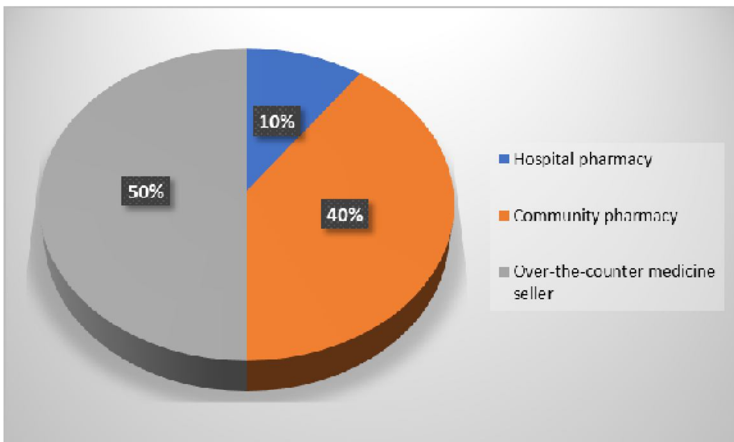

Figure 1: Distribution of samples across the various units

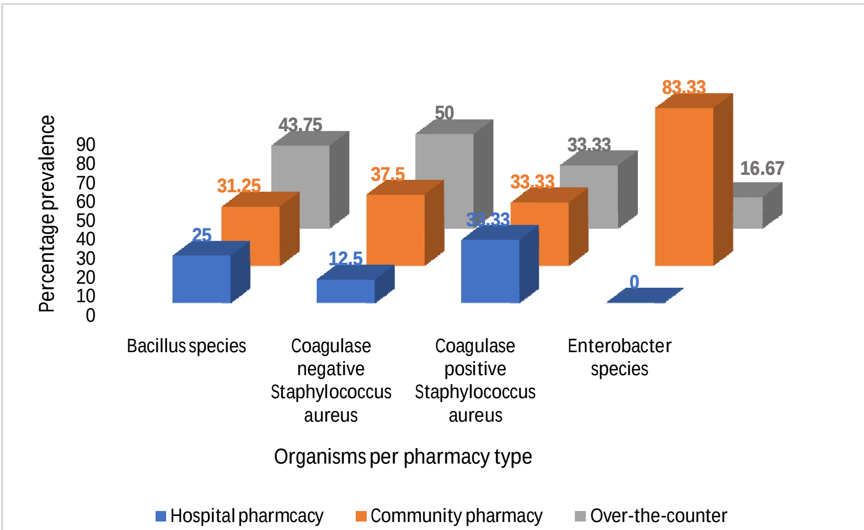

Figure 2: Organisms Isolated Per Location Of Sampling

The genus *Bacillus* was sensitive to most of the antibiotics used in the test except ciprofloxacin (CL/5), Penicillin G (P/10), Erythromycin (EM/30) and Piperacillin (PT/100) (Figure 3). On the other hand, both coagulase negative and coagulase positive *Staphylococcus* isolates showed resistance to the antibiotics used (Figure 3). The *Enterobacter spp.* was sensitive to half of the antibiotics tested and resistant to the other half (Figure 4)

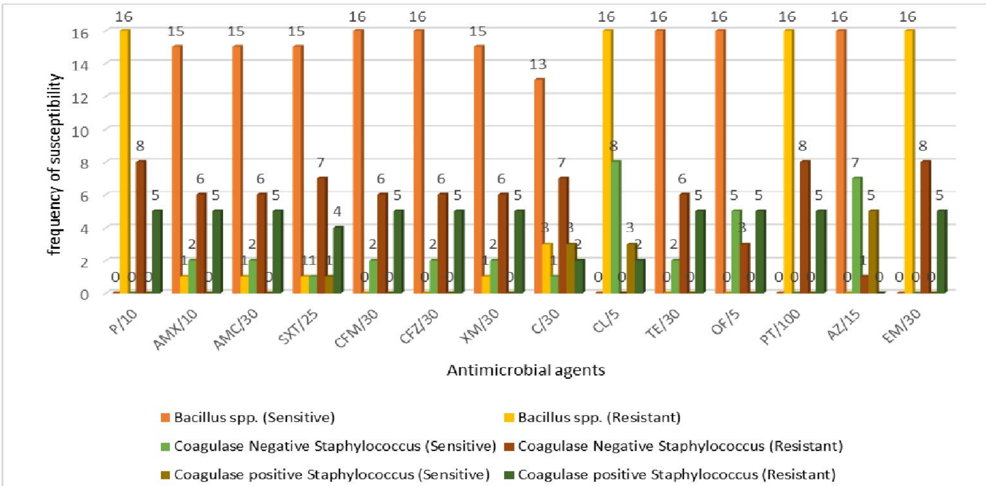

Figure 3: Distribution of antimicrobial susceptibility pattern displayed by Gram-positive organisms isolated

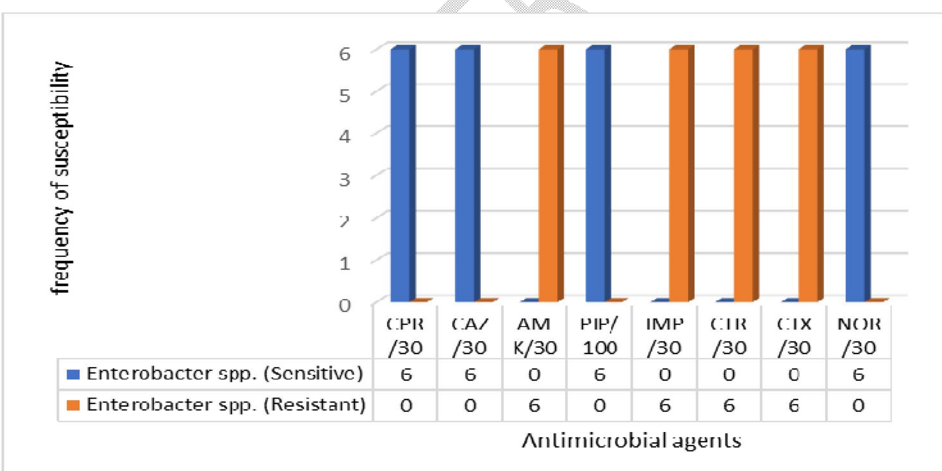

Figure 4: Showing antimicrobial susceptibility pattern of *Enterobacter species*

3.2 DISCUSSION

Thirty (30) samples were taken from all three (3) operation categories (community pharmacy, hospital pharmacy and over-the-counter medicine sellers' shops) for this study. The study intended to have taken an equal number of samples from each operation category; however, due to the bureaucracy involved in the acquisition of permission to take samples from the public-owned hospital, it could not go as planned. As such, samples were randomly taken based on the availability and the willingness to partake in the study, with three (3) of the samples taken from hospital pharmacies, twelve (12) of them from community pharmacies and the remaining fifteen (15) taken from over-the-counter medicine sellers. As a result of unequal sampling, it is difficult to determine which category has the highest contamination rate. However, the presence of microbes across all sampling units indicates potential risk of transmission of microbes to the health workers as well as to the clients who use the facility.

Amongst all the four (4) organisms initially targeted by this study, only *Staphylococcus spp.* was found to be present on the hands of pharmacy technicians; *Escherichia coli, Klebsiella spp.* and *Salmonella* spp. were not found to contaminate the hands of Pharmacy technicians. This corroborates to the findings of Asim *et, al.* 2015 [14], which also showed greater contamination of the hands of healthcare givers in Eastern India by *Staphylococcus spp.* Other organisms worth mentioning (*Bacillus spp.* and *Enterobacter spp*.) were also found to contaminate the palms of Pharmacy technicians. *Bacillus spp.* was the most abundant organism isolated in this study. *Bacillus spp., coagulase negative and coagulase positiveStaphylococcus* were distributed across all three (3) categories, while *Enterobacter spp.* was found mainly among the community pharmacy and the over-the-counter medicine sellers and this could be a result of less sampling from the hospital pharmacy. It can be argued that, the comparatively high number of *Staphylococcus spp.* isolates found on the palms of over-the-counter medicine dispensers compared to the other groups could be due to lack of training and supervision of pharmacy technicians as received in hospital and community pharmacy settings coupled with less strict regulations on hygiene in the areas of over-the-counter medicine sellers.Although it has been reported that most *Bacillus* spp. pose no significant health dangers and are rather opportunistic, a few *Bacillus sp* groups are pathogenic to humans and animals[18] causing deadly infections such as anthrax (in the case of *B. anthracis*)in humans and livestock [19] and food poisoning similar to staphylococcal food poisoning [20]. *Bacillus spp.* are also known to cause some systemic and local infections which include but are not limited to fulminant bacteremia, endophthalmitis, pneumonia, and gas gangrene-like cutaneous infections in immunocompromised persons such as neonates and patients sustaining traumatic or surgical wounds [20], [21] who are also persons most likely to patronize the services of pharmacy units. Its infection can necessitate prolonged hospitalization involving expensive antimicrobial agents.

Staphylococcus spp. which is of greater concern in this study causes a wide range of infections, of which most are caused by *Staphylococcus aureus.* Although *Staphylococcus aureus* is a common member of the human microflora, it can produce disease through two different mechanisms. One is based on the ability of the organisms to multiply and spread widely in tissues, and the other is based on the ability of the organisms to produce extracellular enzymes and toxins. Infections based on the multiplication of organisms are a significant problem in hospitals and other healthcare facilities[22] . Multiplication in tissues can result in manifestations such as boils, skin sepsis, post-operative wound infections, enteric infections and septicaemia.

Majority of the *Bacillus spp.* isolated showed greater sensitivity to most of the antibiotics tested contrary to *Staphylococcus spp.* which resisted most of the antibiotics tested against them. This high level of antimicrobial resistance of *Staphylococcus spp.* is not strange because of the continued spread of methicillin-resistant *S. aureus* (MRSA) over the past several decades in both human and animal species[23].This is still very worrisome as it continues to compound the menace of multidrug resistant strains of *Stap1hylococcus species* from the pharmacy units.

4.0 CONCLUSION AND RECOMMENDATIONS

This study investigated the prevalence and antimicrobial susceptibility patterns of targeted bacterial species isolated from the palms of pharmacy technicians in the Upper West Region of Ghana. The results revealed alarming levels of microbial contamination likely stemming from insufficient hand hygiene practices. Although the intended target organisms like *Escherichia coli, Klebsiella species*, and *Salmonella species* were not identified, the isolation of

Staphylococcus species, *Bacillus species*, and *Enterobacter species* points to potential risks of pathogen transmission to healthcare workers and patients through improper hand cleansing.

The high prevalence of *Bacillus species* across all pharmacy categories sampled is worrying given the ability of some strains to cause dangerous infections, especially in vulnerable populations that commonly utilize pharmacies. However, most *Bacillus* isolates displayed susceptibility to the panel of antibiotics tested. In contrast, the isolated *Staphylococcus species* exhibited multidrug resistance, compounding the ongoing spread of treatment-resistant strains in healthcare settings.

The findings emphasize the urgent need for reinforced handwashing protocols and stringent hygiene monitoring, especially in over-the-counter medicine shops where regulations may be less strict.Additionally, regular surveillance of antimicrobial susceptibility patterns will be vital to guide interventions for infection control and prevention. More stringent regulations may be warranted, especially for over-the-counter medicine shops. Overall, this study provides valuable insights into mitigating risks from nosocomial pathogens in community and hospital pharmacies to protect wider public health. Enhanced training and supervision of pharmacy technicians will be key to improving pharmaceutical hygiene practices in this region and beyond.Future research should focus on evaluating the effectiveness of various hand hygiene interventions specific to pharmacy settings. Longitudinal studies tracking changes in microbial flora and resistance patterns over time would provide valuable insights into the dynamics of bacterial contamination. Additionally, investigating the potential impact of contaminated hands on medication safety and patient outcomes would further elucidate the clinical significance of these findings.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

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LIST OF ANTIMICROBIAL AGENTS USED

Gram positive agents

1. P/10 = PENICILLIN –G 10 micrograms
2. AMX/10 = AMOXICILLIN 10 micrograms
3. AMC/30 = AMOXICILLIN + CLAUVOLANIC ACID 30 micrograms
4. SXT/25 = COTRIMOXAZOLE 25 micrograms
5. CFM/30 = CEPHALEXIN 30 micrograms
6. CFZ/30 = CEFAZOLIN 30 micrograms
7. XM/30 = CEFUROXIME 30 micrograms
8. C/30 = CHLORAMPHENICOL 30 micrograms
9. CL/5 = CIPROFLOXACIN 5 micrograms
10. TE/30 = TETRACYCLINE 30 micrograms
11. OF/5 = OFLOXACIN 5 micrograms
12. PT/100 = PIPERACILLIN 100 micrograms

13. AZ/15 = AZYTHROMYCIN 15 micrograms

14. EM/30 = ERYTHROMYCIN 30 micrograms

Gram negative agents

1. CPR/30 = CIPROFLOXACIN 30 micrograms
2. CAZ/30 = CEFTAZIDIME 30 micrograms
3. AMK/30 = AMIKACIN 30 micrograms
4. IMP/30 = IMIPENEM 30 micrograms
5. CTR/30 = CEFTRIAXONE 30 micrograms
6. CTX/30 = CEFOTAXIME 30 micrograms
7. NOR/30 = NORFLOXACIN 30 micrograms
8. PIP/100= PIPERACILLIN 100 micrograms