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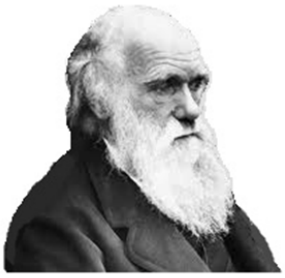

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Antibiotics Evaluation of Bacterial Isolates Associated with Imo State University Microbiology Laboratory and Sub-Offices

Nwakaire Princewill[1], Nnalue Anthony Chinedu[2], Justin Ikechukwu Diaku[3], Ejinwa Confidence Godwin[4,*]

[1] Department of Microbiology, Faculty of Biological Sciences, Imo State University, Owerri, Nigeria

[2] CAS Key Laboratory of Urban Pollutant Conversion, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen, Fujian 361021, China

[3] Department of Chemistry, Faculty of Physical Sciences, Imo State University, Owerri, Nigeria

[4] Department of Pharmaceutical and Medicinal Chemistry, Faculty of Pharmacy, University of Uyo, Akwa Ibom State, Nigeria

*E-mail address: ejinwacg@gmail.com

ABSTRACT

An analysis was carried out to determine the antibiotics evaluation of bacterial isolates associated with Imo State University (IMSU) Microbiology laboratory and sub offices. Swab sticks used for streaking were inoculated unto a freshly prepared nutrient agar, MacConkey agar for bacteria. Identification of bacteria was performed by determining their gram staining properties, biochemical reactions and sugar tests indicating their presence. The microbial isolates obtained from this study were identified to belong to bacteria genus of *Klebsiella* sp., *Escherichia coli*, *Bacillus* sp., *Streptococcus* sp., *Staphylococcus* sp., *Shigella* sp., *Micrococcus* sp., and *Pseudomonas* sp. *Klebsiella* sp. had the highest percentage of occurrence (39.3%) while *Pseudomonas sp* had the least occurrence (1.8%). Bacteria isolates showed the highest percentage of susceptibility to Tarivid (OFX) 21(25%) followed by Augmentin (AU) 13(15.5%), Gentamycin (CN) 10(11.9%), Nalidixic (NA) 9(10.7%), Ceporex (CEP) 7(8.3%), Septrin (SXT) 4(4.8%), Ciprofloxacin (CPX) 3(3.6%) while the lowest percentage of susceptibility was to Streptomycin (S) 1(1.2%). The effectiveness of decontamination ranges from high-level sterilization to simple cleaning with soap and water. Levels of decontamination include Sterilization, Disinfection, Antisepsis, and Cleaning. It is recommended that ethylene oxide gas is used in Sterilization of the air before any analysis is carried out.

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Keywords: Antibiotic susceptibility, Bacterial isolates, IMSU Microbiology laboratory, Sterilization and decontamination, Gram-negative bacteria, Gram-positive bacteria

1. INTRODUCTION

Air, as a non-renewable resource, supplies us with the energy production requirement, oxygen which is essential for our bodies to live [1]. Pollution of the air is the introduction of chemicals, particulate matter or biological materials into the atmosphere, capable of causing discomfort, disease or death to humans, damage to other living organisms including food crops [2].

Since air is an important medium for the spread of infectious and allergic triggers which can result to undesirable effects on human beings, the control of the microbial charge became an important key to define the environmental quality of ambient media surrounding wide human populations which are largely exposed to indoor air during their daily activities.

Indoor air quality (IAQ), as the name implies, is a term used to assess the quality of the air in indoor environments like offices and other building environments [3]. In a normal indoor environment, the quantity of microorganisms should be significantly lower than outdoor levels. Possible sources of biological contamination of indoor air include people, organic dust, various materials stored in buildings, and the air flowing in from the ventilation and air conditioning systems [3].

Wamedo [4], also wrote that, indoor environments are fundamental environmental factors capable of impacting health. Recent studies have shown a gradual interest in indoor microflora [5]. Particular activities like washing, sneezing, coughing, speaking and walking can generate airborne biological particulate matter. Food stuffs, plants indoors and flowerpots, dust, carpets, textiles, wood material and furniture stuffing, occasionally release various fungal spores into the air [6].

Moreover, the environmental factors mainly include temperature, humidity, rate of air movement, air movement, type of building and location, poor design, ventilation system as interior or redesign which supports the growth and multiplication of microorganisms in the indoor atmosphere [2]. Most microbiological processes are done under sterile conditions [7].

The aim of this research is to determine the in-vitro evaluation of bacterial isolates associated with IMSU Microbiology Laboratory and sub-offices, with specific objectives to enumerate bacteria in the laboratory, isolate bacteria from sub-offices, identify and characterize isolates through morphological and biochemical tests, evaluate their anti-biogram, assess their frequency of occurrence in the environment, and recommend control measures for these organisms.

2. EXPERIMENTAL (MATERIALS AND METHODS)

2. 1. Study Area

Imo State University is in Owerri, which is the capital of Imo State, Nigeria, set in the heart of Igbo land. It has an estimated population of about 750,000 people as of 2006 and is approximately 100 square kilometers (40 sq mi) in area. It lies between Latitude 5°10’ and 5°51’ North and Longitude 6°35’ and 7°28’ [8].

2. 2. Sterilization Technique

Materials like glass wares (culture plates, pipettes, Test-tubes), media, diluents and solutions were sterilized first at 121 °C for 15 minutes before being used. Wire loop and inoculation needle were sterilized by flaming to red hot in a Bunsen burner. Sterilization of containers used for the sample collection and transportation were done by soaking and rinsing in 2.5% acid alcohol. While the L-shaped glass spreader (hockey stick-like glass rod) was first dipped in the acid alcohol first and then flamed in the Bunsen burner to remove the alcohol and as well sterilize the glass rod.

2. 3. Preparation of Media

Nutrient Agar, mannitol salt Agar, MacConkey Agar media were used in this study. These media used were prepared according to the manufacturer's instructions.

2. 3. 1 Nutrient Agar Medium Preparation

According to the manufacturer (Antec in the United Kingdom), twenty-eight grams (28g) of the powder was weighed out and added to one liter of distilled water. It was allowed to soak for ten minutes and was swirled to simulate mixing. The mixture was sterilized at 121 °C for 15 minutes using autoclave and was then cooled to 47 °C, mixed well and poured into sterile Petri dishes.

2. 4. Microbiological Analysis

2. 4. 1. Sampling of Microbes

A total of seven (7) samples were collected in total. Three swab samples were collected from microbiology lab which includes Lab door hand knob, incubator knob, lab bench while four samples were collected from the sub offices which includes office door I table, office door 2 table, office 1 hand knob and 2 hand knob. The method used was as described by Chessbrough, [6]. Each sample was collected by swabbing a 4 cm section using sterile saline soaked cotton swab stick. Sample was collected in duplicate; the first swab was inoculated into buffer peptone water and used tor enumeration of total viable bacteria whereas the other was taken in buffer peptone water for enrichment of inoculums, while the air sampling was performed by settling a media plate on the areas of sampling for 5 minutes. All samples were transported to the laboratory for further microbiological examination.

2. 5. Identification of Isolates

According to the method described by Chessbrough [6], for the identification of micro-organisms, visually distinct colonies from agar plate were picked and gram - stained smears were examined under oil immersion microscope. Following the staining reactions and observed morphological features, these colonies were then streaked onto their primary media and incubated at the optimum temperature for growth for 24-48 hours for bacteria.

2. 5. 1. Cultural Characteristics

The organisms were characterized by the properties they showed on culture media. This includes: Shape (Circular, Irregular, Rhizoid), Size, Elevation (flat, raised, convex, umbonate),

Edge (entire, undulated, lobate, dentate, rhizoid), Colony surface (smooth, rough, dull, wrinkled, glistening or granular), Optical characteristics (transparent, translucent or opaque), Pigmentation (white, red, pink, light, yellow, straw yellow, deep yellow, orange etc) and Consistency: - tested by touching with a sterile wire loop (Butyrous, viscid, granulsar).

2. 5. 2. Gram Staining

The smears of the test organisms were made on grease-free glass slides, air dried and heat fixed by passing the reverse side of the slide over Bunsen burner 3-5 times. The smears were stained with crystal violet for 30-60 seconds and washed with gram's iodine solution and left for 60 seconds. The slides were decolourized with 95% ethanol until no blue colour was seen. They were counter stained with carbol fuchsin for 30 seconds. And finally washed off with tap water, blotted dry and then observed under microscope. The preparation was first examined with 40X objective to see the distribution of the stained organisms and then with oil immersion objection (100X) to observe the bacteria.

2. 6. Biochemical Tests

Catalase Test: This was done according to Chessbrough, [6], with the aid of a wire loop, test organism was emulsified with a loop-full of hydrogen peroxide on a glass slide. Effervescence caused by the liberation of free oxygen as gas bubbles, indicated the presence of catalase in the test culture [6].

Coagulase Test: According to Chessbrough [6], this was carried out using slide test method. A colony of the test organism was emulsified on drop of physiological saline on a glass slide to make a thick suspension. A drop of plasma was then added to the suspension and mixed gently.

Methyl Red-Voges Proskauer (MR-VP) Test: According to Chessbrough [6], 15 g of MR VP broth was weighed and dissolved in 1 litre of distilled water. The medium contains Peptone - 7.0 g, Dextrose -5.0 g and K_2hp04 5.0 g. The medium was autoclaved after distributing into test tube. After cooling, the isolates were inoculated into the test tubes in duplicates and then incubated for 48 hours at 37%.

Methyl Red Test: To about 5ml of the broth culture, a few drops of methyl red solution was added. A red color indicated positive methyl red test (which showed that the organism can produce acid from glucose phosphate) while negative test was indicated when the color is yellow.

Voges Proskauer Test: To the remaining portion of the broth culture, 3 mL of 5% alpha-naphthol and I mL of 40% potassium hydroxide were added, vortexed and then observed for color formation. A pink color (or red color) within 2-5 minutes showed a positive VP reaction.

Oxidase Test: This was performed by placing 2 to 3 drops of 1% solution of tetramethtyl-Pphenylenediamine dihydrochloride (TMPPEH) onto a filter paper in a Petri-dish. Smear of the test organism was made on the filter paper using an inoculating loop. The appearance of a purple color indicated a positive reaction [6].

Citrate Utilization Test: This test was carried out using simmons citrate agar method. The medium was prepared according to the manufactured directions. 5-10 ml portions were dispensed in test tubes and sterilized at 121 °C for 15 minutes. They were kept in slanting positions to set. The slope surface was inoculated with test isolates and incubated at 37 °C for

4-7 days. Utilization of citrate resulted in an alkaline reaction which was indicated by color changing from green to blue and growth of organism, while negative test retained the green color without any growth of the isolate [6].

Motility Test: Stab culture technique was used. With the use of a sterile straight wire loop, the test bacterial isolate was picked and inoculated by making a straight-line stab into a semisolid medium so that the stab stopped at about the centre of the medium. The medium was then incubated. Motility was detected by migration of the bacteria from the stab line and diffusion into the medium causing turbidity and rendering it opaque, while non-motile organisms give confined growth to the path of inoculation i.e. the stab line [6].

Indole test: The medium, peptone water (tryptone 2% sodium chloride 0.5%, final pH 7.2) was used for the test. This was dispensed in 5ml amounts in test-tubes and sterilized by autoclaving for 15 minutes at 121 °C. After sterilization, the medium was inoculated with test organisms and incubated at 37 °C for 24-72 hours. 0.5 ml kovac's reagent was added and the tubes were shaken gently and allowed to stand. The appearance of red color indicates the presence of indole [6].

Sugar Fermentation Test: The medium used here was basal medium, which was composed of 10g of tryptone, 5g of NaCl, 2.5 ml of 1% of bromoresol purple and 1 litre of distilled water. The components were added to the distilled water and dissolved by steaming. Tae 1% bromoresol purple was also added and the colour changed to purple. The solution was then distributed into test tubes each provided with an inverted Durham tube; and care was taken to ensure that no gas was in the inverted vials. The test tubes were then covered with cotton wool and foil paper and sterilized at 121 °C for 15 minutes. The sugars which included, glucose, lactose, fructose and sucrose were weighed out in lg amount each and dissolved in 10mls of distilled water respectively. The sugars solutions were sterilized at 121 °C for 15 minutes. After sterilization, the sugars were distributed aseptically in the test tubes containing the basal medium. After this, the tubes were incubated with the test isolates and then incubated at 37 °C for about 5-7 days. After incubation, the change of color of the basal medium from purple to yellow indicates acid production and the presence of gas bubble inside the inverted Durham tubes showed gas production [6].

Antibiotic Susceptibility Test: The antimicrobial susceptibility test was performed by using disc diffusion according to Bauer et al. [9], on Muller-Hinton agar medium. This test was carried out using simmons citrate agar method. The medium was prepared according to the manufactured directions. 5-10 mL portions were dispensed in test tubes and sterilized at 121 °C for 15 minutes. They were kept in slanting positions to set. The slope Surface were inoculated with test isolates and incubated at 37 °C for 4-7 days. The following antibiotic were used: Nalidixic (30 mcg), Tarivid (30 mcg), Reflacine (30 mcg), Augmentin (30 mg), Gentamycin (30 mcg), Cerporex (30 mcg), Septrin (30 mg), Ampicilin (30 mcg) and ciprofloxacin (5 mcg) (Abtek biological Ltd, UK). The pure culture of each isolate was incubated in nutrient broth and incubated at 37 °C for 24 hrs. The growth was standardized by diluting the culture with normal saline to match the turbidity of 1.5×10^8 cfu/ml (0.5McFarland standards). The 0. 1 ml was collected and spread on the surface of Muller Hinton agar (Oxoid ltd Basingstoke, UK) Using sterile glass rod. The antibiotic disc was placed carefully to make good contact with the agar surface using sterile forceps and sufficiently separated from each other in order to prevent overlapping of the zones of inhibition. The agar plates were left on the bench for 30 minutes to allow for diffusion of the antibiotics and were incubated at 37 °C for 24 hrs and results were

interpreted as sensitive and resistant. Isolates resistance to least five antibiotics were selected as multi-drug resistance (MDR). Results were recorded by measuring the zone of incubation and comparing with the CLSI susceptibility.

3. RESULTS AND DISCUSSION

3. 1. Identification and characterization of Bacterial Isolates

Table 1. Morphological and Biochemical Test of Bacteria Isolate.

Morphology	Catalase	Coagulase	Citrate	Indole	Methyl red	Motility	Oxidase	Glucose	Lactose	Suspected Organism
Yellow, Glassy, round, Cocci in Clusters, +ve	+	+	+	+	+	+	+	+	+	*Staphyloccus* sp
Cream, Smooth, Irregular, short Rod in single, ve	+	+	+	+	+	+	+	+	+	*Escherichia coli*
Gray-white Round, opaque, Flat, drying, Mrdium-size Colony, - ve	+	+	+	+	+	+	+	+	+	*Bacillus* sp.
Greyish white Single, in pairs, Or in short chains and sometimes in Clusters, - ve	+	+	+	+	+	+	+	+	+	*Proteus* sp.
Cream, Smooth, Irregular, short Rod in Single. +ve	+		+			+		+	+	*Klebsiella* sp.
Grennish coloration, cocci shaped, transclecent, +ve								+	+	*Streptococcus* sp.

Pearlescent, appearance an grape-like or tortilla like oour, -ve	+				+	+	+			*Pseuomonas* sp.

Table 1: The microbial isolates obtained from this study were identified to belong to bacteria genus of *Klebsiella* sp, *Escherichia coli*, *Bacillus* sp, *Streptococcus* sp., *Staphylococcus* sp, *Micrococcus* sp, and *Pseudomonas* sp. Bacterial species were identified according to their different features and their biochemical characterization at IMSU Microbiology Lab and sub-offices. *Staphylococcus* sp. were round yellow and glassy colonies and cocci in clusters, while *Escherichia coli* was cream, smooth, irregular colonies with short rods. *Bacillus* sp. reported as gray-white, flat, drying colonies, and *Proteus* sp. exhibited greyish-white colonies in short chains or clusters.

Klebsiella sp. was seen as cream, smooth, irregular colonies of short rods, and fellow S. were identified by their greenish cocci-shaped colonies and *Pseudomonas* sp. had a pearlescent, grape-like appearance. Depending on biochemical tests, the following characteristics were confirmed in most isolates: catalase positivity and varying abilities to ferment sugars. These findings ultimately present an extensive picture of bacterial richness and resilience that is critical to understanding the dynamics of contamination and to the development of antimicrobial strategies in the laboratory environment.

Table 2. Frequency of Occurrence of Bacteria Isolate

Samples	**Isolates**						
	***Staphylococcus* sp.**	***Escherichia coli***	***Proteus* sp.**	***Bacillus* sp.**	***Klebsiella* sp.**	***Streptococcus* sp.**	***Pseudomonas* sp.**
Al	0(0)	2(9.5)	2(22.2)	1(10)	3(9.09)	0(0)	0(0)
A2	0(0)	7(33.3)	1(11.1)	1(10)	10(30.3)	0(0)	0(0)
Bl	2(28.5)	2(9,5)	0(0)	2(20)	9(27.2)	0(0)	0(0)
B2	1(14.2)	5(23.8)	1(11.1)	3(30)	1(3.03)	0(0)	0(0)
C	0(0)	4(19.0)	3(33,3)	0(0)	5(15.1)	0(0)	0(0)
D	3(42,8)	1(4.7)	0(0)	1(10)	2(6.06)	3(100)	1(100)
E	1(14.2)	0(0)	2(22.2)	2(20)	3(9.09)	0(0)	0(0)
Total	7(8.3%)	21(25%)	9(10.7%)	10(11.9%)	33(39.3%)	3(2.2%)	1(1.8%)

From finding in Table 2 *Klebsiella* sp. was found to be the most prevalent 33(39.3%) followed by *Escherichia coli* 21(25%), *Bacillus* sp. 10(11.9%), *Proteus* sp. 9(10.7%), *Staphylococcus* sp. 7(8.3%), *Streptococcus* sp. 3(2.2%) and *Pseudomonas* sp. 1(1.8%). From the analysis, IMSU Microbiology Laboratory and its sub-offices recorded diverse species of bacteria namely, *Staphylococcus* sp., *Escherichia coli*, *Proteus* sp., *Bacillus* sp., *Klebsiella* sp., *Streptococcus* sp. and *Pseudomonas* sp. Morphologically, the isolates were initially characterized during culturing as yellow glassy colonies, cream smooth colonies and greyish-white clusters. Biochemical tests were employed to confirm their identities. *Klebsiella* sp. (39.3%) was the most common and *Pseudomonas* sp. (1.8%) was the least common. Frequency distribution for *Klebsiella* sp. which prevailed in most of the individual sample sites indicating that this isolate is harder or possibly more adaptable to the environment from where the sample was collected. These findings illuminate microbial diversity and prevalence patterns relevant for mitigating contamination or infection risk in the laboratory.

Table 3. Percentage Resistance of Isolates to Antibiotics

Samples	CEP	OFX	NA	CN	AUG	CPX	SXT	S	PN
Staphylococcus sp .(7)	0(0)	3(12%)	2(10%)	0(0)	1(7.9%)	0(0)	0(0)	0(0)	0(0)
Escherichia coli (21)	2(16%)	7(29%)	5(26%)	4(50%)	2(15.3%)	1(33.3)	0(0)	0(0)	0(0)
Proteus sp. (9)	2(16%)	3(12%)	1(5%)	1(12.5%)	3(23%)	0(0)	1(25%)	0(0)	0(0)
Bacillus sp. (10)	1(8%)	1(4%)	2(10%)	3(37.5%)	2(15.3%)	0(0)	0(0)	1(100)	0(0)
Klebsiella sp. (33)	3(25%)	10(41%)	9(47%)	1(12.5%)	5(38.4%)	2(66.6)	3(100%)	0(0)	0(0)
Streptococcus sp. (3)	3(25%)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Pseudomonas sp. (1)	1(8%)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Total	12(14.1%)	24(28.2%)	19(22.3%)	8(9.4%)	13(15.2%)	3(3.5%)	4(4.7%)	1(1.1%)	0(0)

Key: Gentamycin (CN), Augumentin(AU), Nalidixic (NA), Ceporex (CEP), Septrin (SXT), pefloxaacin (PEF), Ciprofloxacin (CPX), Ampilicin (PN), Streptomycin (S) and Tarivid (OFX).

Table 3 showed that all that isolates showed the highest percentage of susceptibility on Tarivid (OFX) 24(28.2%) followed by Augumentin (AU) 13(15.2%), Gentamycin (CN) 8(9.4%), Nalidixic (NA) 19(22.3%), Ceporex (CEP) 12(14.1%), Septrin (SXT) 4(4.7%), Ciprofloxacin (CPX) 3(3.5%) while the lowest percentage of susceptibility Streptomycin (S) 1(1.1%).

Table 3 ranges of resistance profiles of isolates from IMSU Microbiology Laboratory. *Staphylococcus* sp. showed little resistance, and no resistance at all to most antibiotics, indicating that it is susceptible to most standard treatments. In contrast, Ofloxacin (29%), Nalidixic acid (26%) and Gentamicin (50%) exerted moderate antimicrobial effects against *Escherichia coli*, highlighting its potential for adaptation.

Proteus sp. had significantly less resistant but had high resistant to Amoxicillin-clavulanic acid (23%), Septrin (25%). *Bacillus* sp. with high resistance (37.5) towards gentamicin while it has low resistance towards other antibiotics. *Klebsiella* sp. showed the highest resistance rates, especially against to Nalidixic acid (47%) and Ofloxacin (41%) and Ciprofloxacin (66.6%) implying its strong antibiotic defence mechanisms. *Streptococcus* sp. and *Pseudomonas* sp. presenting with minimal resistance, while *Streptococcus* sp. showing resistance to just a few antibiotics. Ultimately, these conclusions highlight improvement areas for antibiotic stewardship program implementation to guide emerging resistance through both clinical and laboratory settings.

4. DISCUSSION

Study results indicate clearly that the microorganisms isolated from the microbiology laboratory and sub offices were mainly from the surfaces. The microbial isolates obtained from this study identified bacteria as *Pseudomonas* sp., *Escherichia coli, Proteus* sp., *Klebsiella* sp., *Streptococcus* sp., *Staphylococcus* sp. and *Bacillus* sp. Therefore, *Klebsiella* sp. has the highest percentage of occurrence with 39.3%, *Escherichia coli* 25%, *Bacillus* sp. 11.9%, *Proteus* sp. 10.7%, *Staphylococcus* sp. 8.3% occurrence while *Pseudomonas* sp. had 1.8% occurrence in Table 2.

This finding goes to show the ubiquity of microbes, even in air. Isolation of microorganisms at the laboratory and sub-office clearly shows microbial isolation and contamination can take place no matter the area of isolation. People occupying or visiting enclosed spaces play an important role in the creation of surface and air micro-flora. Enclosed rooms and offices have the potential of placing human occupants at higher risk than the outdoors. Enclosed spaces trap aerosols and allow them to buildup to potentially infectious levels.

Bacteria species like *Staphylococcus* sp. are found on human skin scales [10]. *S. aureus* are emitted from 57 the nasopharynx of normally healthy individuals when the person talks, and are commonly found in air, water, the skin [11].

Pseudomonas sp. has been reportedly associated with wet surfaces of air- conditioning systems, cooling coils, drain pans and sump pumps [12]. Poppert, [13] reported the isolation and characterization of thirty-one microorganisms from different laboratory locations including walls, tables and floor. *Corynebacterium* sp. and *Pseudomonas* sp. were predominant. Liberto [14], identified *Bacillus* sp. and *Corynebacteria* sp. as contaminants in the laboratory cabinets. During the period when air conditioners are on, doors are always shut, the windows are closed, and it becomes difficult for ultraviolet rays of sunlight to penetrate. With the recent rise in the almost new phenomenon of "community acquired nosocomial infections" there is the need for caution in enclosed rooms.

The isolated and identified bacteria have been implicated as causal agents of food spoilage, diseases of animals and man. They are especially harmful as opportunistic pathogens in immune-compromised individuals, the aged and children. The pollution of the environment by pathogenic or opportunistic bacteria is an important factor affecting health. Diseases such as allergy, rhinitis, bronchial asthma, respiratory tract infection may develop in occupants, or they may serve as latent hosts. The disease caused by these microorganisms is contacted through inhalation of these microbes and their spores [15-16].

4. CONCLUSIONS

This study points to the interconnected nature of influencers of indoor air micro flora. Human occupancy, activity and ventilation. This study shows that human activity, number of persons indoor, activities going on, and ventilation all affect the number and types of microbes present indoors. Though, air has no nutrients that support the growth of microorganisms, the microflora of air consists of organisms found temporarily in air or carried by dust particle and bio aerosols. Some microorganisms present in air are harmless; there are also pathogenic organisms in air. This study reveals the wide variety of bacterial isolates from patients attending the IMSU Microbiology Laboratory, and their varying resistance to several antibiotics. *Klebsiella* sp. was found to be most widely, whereas *Escherichia coli* followed, but other species were detected in low percentages. Antibiotic resistance testing showed high levels of resistance among isolates, especially in *Klebsiella* sp., to widely used antibiotics. Such findings highlight the importance of better hygiene practices, targeted interventions, and antimicrobial stewardship programs to ameliorate the hazards posed by resistant bacterial strains and ensure effective infection control in similar settings.

Recommendation

Special attention should be given to the elimination and reduction of these pathogenic microbes from indoor air. The use of highly efficient particulate air filters and immunization have been used to control the spread of these airborne diseases. Obviously, the presence of a good ventilation system inside buildings eliminates to some extent the influence of indoor and outdoor sources. Proper ventilation helps to dilute the negative effects of indoor air. Adequate sterilization, disinfection, antisepsis. It is recommended that ethylene oxide gas be applied in the microbiology laboratory periodically to sterilize the air in the laboratory.

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