

Bacteriological Investigation of the Infectious Risks in a Semi-Public Biomedical Laboratory in Benin (West Africa)

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Abstract

Biomedical analysis laboratories represent a particular sector of healthcare systems whereby professionals are especially exposed to high infectious risks. This study assessed the level of hygiene in the biomedical laboratory of a regional semi-public hospital from May 18th to August 18th, 2015. A checklist of good laboratory practices was set based on the laboratory inspection checklist of the World Health Organisation. The laboratory was divided into two sub-sections A1 and A2. 91 swabs were collected from the two sections. All these samples were then subjected to bacteriological analysis. Hygiene was less observed in section A1 than section A2. Similarly, the framework, the wastes management and technical arrangements are in contradiction with biosecurity rules. After incubation, 55 samples were infected. Coagulase negative *Staphylococcus* (57.58%) were the most commonly isolated bacteria from hands. Cell phones were essentially contaminated by *Pseudomonas aeruginosa*, *Enterobacter cloacae*, *Klebsiella pneumoniae* and *Acinetobacter spp* in equal proportions of 25%. *Escherichia coli* were the most isolated bacteria from work surfaces (83.33%). All door knobs were contaminated by *Escherichia coli* (100%). Almost all these isolated bacteria were multidrug resistant. Due to the importance of laboratories in the sanitary system of hospitals, urgent and appropriate measures must be taken to mitigate the risk of infections among professionals.

Keywords: bacteria, biomedical laboratories, infectious risks, multidrug resistance

1. Introduction

The whole world is facing rapidly and increasingly uncertain changes. New infectious agents and unknown diseases have emerged (Wilson & Chosewood, 2009). Often separated from hospitalization services, a biomedical analysis laboratory provides an important diagnostic help. It is a place for pathological materials manipulation where professionals are frequently exposed to infectious risks. These risks are related to daily handling of human biological products, pathogen micro-organism and chemical products. Indeed, the biomedical analysis laboratory receives every day, organics products that may harbour potential pathogens for humans. The analysis requires in most cases the use of various chemicals and physical agents. All these activities are constant hazards to the laboratory personnel and its immediate environment (Rhame, 1998; Vesley et al., 2001; Munoz-Price et al., 2012). Technicians, engineers, doctors, chemists, researchers and surface technicians are all exposed (Méité et al., 2007).

The risk of infection in laboratories is relatively well known for mycobacteria, virus of hepatitis B and C, human immunodeficiency and haemorrhagic fevers. But, this risk is less or not known for the others bacteria and

especially multidrug-resistant bacteria. These bacteria through biological products from clinical services invade the laboratory's environment every day. It thus promotes close contact between staff and those germs.

This could be a risk of infection for the users of this place if they neglect biosafety measures (Kouamé, 2009; Trick et al., 2003; Misgana et al., 2014).

In Benin, despite the efforts of several biomedical analysis laboratories involved in the quality process, limited scientific data exist regarding the status of bacteriological risks that people are exposed to when they attend these environments.

This study aimed to assess the bacteriological risk to the personnel working in a biomedical laboratory. Firstly, the level of adequacy of the laboratory with the minimum hygiene rules was assessed. The sensitivity of bacteria identified in the compartments of the laboratory to antibiotics was then tested.

2. Materials and Methods

2.1 Materials

The study was conducted from May 18th to August 18th, 2015 in a laboratory of a semi-public Hospital at Cotonou, (Benin). A checklist was used to assess the hygiene level and biosafety compliance of each section of the laboratory (Table 1). The biological material consisted of various samples collected in this semi-public laboratory. These samples were made of swabs from the hands and mobile phones of laboratory staffs, door knobs and work spaces of various sections. For culture and identification of bacteria, usual bacteriological culture media were used (Méité et al., 2007).

The reagents used were rabbit plasma for research of staphylocoagulase in *Staphylococcus aureus*, OX discs for research of oxidase in bacteria, reagents for the Gram stain, hydrogen peroxide for the detection of catalase in bacteria, the rapid Leminor gallery for identification of enterobacteria and antibiotic disks (Table 2) to perform the susceptibility testing.

Equipment such as refrigerators, microscopes, autoclaves, graduated cruets, precision balances, ovens at 37°C and some containers were used to carry out the study.

Consumables such as gas cylinders, markers, slides and chips, Petri dishes, sterile disposable loops, sterile haemolysis tubes of 10 and 05 milliliters, pipettes, Bunsen burners, physiological and distilled water have also been used.

Table 1. Laboratory audit checklist

DESIGNATIONS	ANSWERS		
	YES	NO	ID
PERSONAL HYGIENE			
Do sick technician come to laboratory?			
Do technicians with open wound protect them?			
Do technician relate their illnesses or injuries to their head?			
Are hand often washed ?			
Are there constantly soap for hand washing in the laboratory?			
Are there hand sanitizer in the laboratory?			
Are there hot water for hand washing?			
Is hand washing potable and common?			
Is it sink for hand washing?			
Are there toilet paper or hand dryer after washing?			
Are the technicians nails cut?			
Do the technicians wear clean overalls?			
Do they use changeable gloves?			
Do the technicians wear closed shoes?			
Do the technicians drink in the laboratory?			
Do the technicians eat in the laboratory?			
Is it forbidden to eat chewing gum in the laboratory?			
Do the technicians smoke in the laboratory?			

Do technicians wear jewelry (watches, rings etc.) during handling?			
Do technicians use their mobiles phones during handling?			
Do they touch their eyes, ear, nose, hair during handling?			
Are hair covered ?			
Are technicians beards shaved?			
Are there protective masks in the laboratory?			
Are technicians bring their personal property in the laboratory?			
Are blouses washed as frequently as possible?			
WORK PLACE CONDITIONS	YES	NO	NTR
Are Technicians work under a hood in the lab?			
Is the hood away from doors and walkways?			
Is the laboratory locked?			
Is the laboratory equipped with self-closing door?			
Are the surfaces, walls and ceilings of the laboratory intact and washable?			
Are the laboratory's windows lockable?			
Are there a functional autoclave in the laboratory?			
Are the refrigerators clean and functional?			
Is the laboratory kept clean?			
Does flies and other insects present in the laboratory?			
Is rodents present in the laboratory?			
Are there restrictions on access to the laboratory?			
Are there enough furniture in the laboratory?			
Is the laboratory comfortable enough for its purpose?			
Are the surfaces decontaminated before and after work?			
Does the internal arrangement of the laboratory facilitates the passage and cleaning every corner?			
Are there any biological danger warning signs and instructions?			
Is laboratory ventilation appropriate for safety?			
Are the materials carefully labeled?			
Is there a command platform for laboratory hygiene trainees and students?			
Do they use disinfectants in the laboratory?			
Are the exterior and surroundings of the laboratory clean?			
WASTE MANAGEMENT	YES	NO	NTR
Are infectious waste sterilized before disposal?			
Are chemical wastes discharged closed?			
Do they use an incinerator?			
Are the garbage kept closed?			
Are the garbage removed every night?			
Do their sort waste according to their condition?			
Are the garbage away from the bench?			
Technicians do they really use the garbage?			
TECHNICAL PROVISIONS	YES	NO	NTR
Have Laboratory technicians a hygiene training?			
Are the working protocols developed and known to all before the manipulations?			
Are biosafety instructions in the laboratory?			
Was They adopting a Biosafety Manual in the laboratory?			
Is there a separation of work areas (reception, preparation and sample handling)?			

Table 2. List of antibiotics

	Antibiotics	Symbols	Content
	Amoxicillin +Clavulanic acid	AMC	30 mcg
	Cephoxitin	CX	30 mcg
	Cephotaxim	CTX	30 mcg
	Chloramphenicol	C	30 mcg
	Doxycyclin	DO	30 mcg
Bacilli	Netilmicin	NET	30 mcg
	Cephalothin	CEP	30 mcg
	Gentamicyn	GEN	30 mcg
	Ceftazidime	CAZ	30 mcg
	Aztreonam	AT	30 mcg
	Fosfomycin	FO	200 mcg
	Colistin	CL	10 mcg
	Gentamicyn	GEN	10 mcg
	Doxycycline	DO	30 mcg
Cocci	Netilmicin	NET	30 mcg
	Amoxicillin + Clavulanic acid	AMC	30 mcg
	Cephoxitin	CX	30 mcg
	Cephotaxime	CTX	30 mcg
	Cephalothin	CEP	30mcg
	Ceftazidime	CAZ	30 mcg
	Vancomycine	VA	30 mcg
	Pristinamycin	RP	15 mcg
	Oxacillin	OX	1 mcg
	Erytromycin	E	15 mcg

2.2 Methods

Collection and analysis of data related to good laboratory practices

To carry out this study, a checklist was designed for the evaluation of good laboratory practices based on the WHO laboratory inspection checklist established for the accreditation of biomedical research laboratories in the Africa (WHO, 2013).

This first part of the research was conducted through direct observations made on the basis of the questions on the checklist. The questions were structured into 4 sections namely personal hygiene, work place conditions, waste management and technical provisions.

Each question was then marked according to the method of analysis of the WHO laboratory audits (WHO, 2013) where the right answers got 1 point against 0 for the bad ones. The overall score per section was then calculated by arithmetic addition and then converted into percentage for the construction of tables and graphs using Microsoft Excel 2013 calculation sheets. The scale followed as per the methodology used is: below 50% = poor and needs improvement; 50% to 60%= fair or acceptable or satisfactory; 61% to 70% good; 71% to 80% very good; above 80% is excellent. However, every score above 50% is regarded as being in accordance with minimum biosafety rules.

The laboratory was divided into two subsections. Multidisciplinary room grouping services of biochemistry, immunology and haematology was named Lab A1. Microbiology room where bacteriology and parasitology exams are held was named Lab A2.

Using the EPI- INFO Version 7 software, the Chi² test or Fisher exact test was used depending on the sample size to assess differences between positive and negative scores by categories of questions within each laboratory. Furthermore, the proportions of positive scores were also compared between laboratories to evaluate their relative levels of acceptability. A significance level of 5% was defined and used.

2.2.1 Evaluation of Bacteriological Risks in the Laboratory

The choice of the number of samples to be taken differed according to the laboratories. Based on the total number N of permanent technicians in sections, a random sampling was conducted in accordance with a step of a ladder, which amounts to $n = N / 2$.

In each section, the most frequently used sites were divided into three groups. Work surfaces were listed as high risk of contamination sites. Unused sites for the manipulation of organic products but most often used by staff such as door knobs and mobile phones were identified as sites of frequent use by staff.

Alongside these compartments, both hands of the personnel were included in the study. Using sterile wet swabs, the left and right hands of the staff were swabbed at three separated times during the day: in the early morning, during the manipulations and in the evening at the end of works. The same operation was conducted for door knobs (internal and external), the telephones and work surfaces in the evening at the end of works. However, let's note that these operations were performed in a single day, during the training period.

All collected samples were sent to the bacteriology laboratory of the Polytechnic School of Abomey-Calavi where analyses were carried out within four hours of sampling. It is a biosafety level II laboratory where most of Researchers and Postgraduate Students carry out their studies. The lab serves for both academic practical's and Research. Table II shows the distribution of the number of samples collected from each section (Table II).

Isolation of bacteria was performed using conventional bacteriological media such as MacConkey Agar, Mannitol Salt Agar and Mueller Hinton Agar. Fresh blood agar allowed to read the character of hemolytic bacteria. DNase agar was used to search for DNase in *S. aureus*. The identification of bacteria was done according to conventional biochemical techniques (Méité et al., 2007).

Rapid gallery Leminor was used to identify Gram- bacilli. Catalase, oxidase and free staphylocoagulase were sought for the identification of Gram+ cocci.

The bacterial resistance profile was searched through the implementation of the antibiogram. The disc diffusion method was used. The interpretation of the diameters of inhibition was done according to the recommendations of the Antibiogram Committee of the French Society for Microbiology (Société Française de Microbiologie, 2014). Alongside the strains studied, a reference strain of *Escherichia coli* ATCC 25922 was used to validate the results.

Table II. Summary table of the sampling procedures

Laboratory	Sections	Sites	Number of samples
A	A1	Work surfaces	11
		Door knobs	04
		Telephones	07
		Hands (Left + Right)	42
	A2	Work surfaces	04
		Door knobs	02
		Telephones	03
		Hands (Left + Right)	18
		Total	

3. Results and Discussion

3.1 Results

Data collection on Good Laboratory Practices

With respect to the methodology used, the maximum possible score is 100% and 50% is the cut-off point of a satisfactory and non-acceptable safety level of the tested laboratories.

The overall biosafety level at Lab A1 is relatively poor (48.39%). This result is due to poor waste management practices (37.5%) and bad technical provisions (40%) together with a fair observation of personal hygiene (51.85%) and a slightly acceptable conditions of the work place (50%). (Figure 1).

Nevertheless, Lab A2 has a good biosafety level with a total score of 69.35%. The level of personal hygiene, waste management and the technical provisions are in agreement with the biosecurity rules (70.37%, 62.5% and 60%, respectively). The conditions of work places significantly meet the standards (72.73%, $p = 0.006$) as shown in Figure 1.

Although the overall biosafety scores of lab A1 are below the required level, no significant difference was observed when they are compared with the one of the second laboratory ($p > 0.05$) (Figure 1).

3.1.1 Bacteriological Risk for Laboratory Workers

As shown in Figure 2, samples were taken from four primary sites including hands of personnel (66 %, $n = 60$), mobile phones from laboratories staff (11 %, $n = 10$), the door knobs (7 %, $n = 6$) and work surfaces (16 %, $n = 15$).

After bacteriological analysis, at least one bacteria species was detected in all samples of door knobs and work surfaces. Regarding personnel hands and mobile phones, respectively 48.33 % and 40 % of the analysed samples were contaminated with bacteria (Figure 3).

It is revealed that door knobs and work surfaces are the most contaminated sites compared to staff hands and mobile phones ($p < 0.05$). Furthermore, the detailed results of each section showed that the lab A1 is more contaminated than lab A2 with respect to staff's hands (59.5 % and 27.8% respectively with a significant difference, $p = 0.04$). Similar situation was observed for mobile phones (42.9 % and 33.3% respectively) (Figure 4).

Moreover, the rate of contamination of the hands of staff gradually increases during a work day. Thus, the rate of bacteria on the hands ranged from 24.14 % in the morning before the manipulations to 31.03% during handling and to 44.83 % in the evening at the end of the day (Figure 5). However, no significant difference was recorded when the proportion of the morning (the lowest) was compared to the one of the evening (the highest) ($p > 0.05$).

Several bacteria were identified. These included *Pseudomonas aeruginosa* (19.7%), *Escherichia coli* (34.4%), coagulase-negative *Staphylococcus* (36.1%), *Enterobacter cloacae* (4.9%), *Acinetobacter spp* (1.6 %) and *Klebsiella pneumoniae* (3.3%). Coagulase-negative *Staphylococcus* and *Escherichia coli* were the most isolated ones followed by *Pseudomonas aeruginosa* ($p < 0.05$).

As shown in Figure 6, a wide distribution of the bacteria based on samples was noted. Thus, in samples from the staff hands, coagulase-negative *Staphylococcus* (57.58 %, $n = 19$) and *Pseudomonas aeruginosa* (33.33 %, $n = 11$) were the most isolated bacteria with significant superiority ($p < 0.05$) on the other germs. Mobile phones were substantially contaminated with *Pseudomonas aeruginosa*, *Enterobacter cloacae*, *Klebsiella pneumoniae* and *Acinetobacter spp*. From the work surfaces, *Escherichia coli* (83.33%) were the most isolated and significantly exceed the amount of coagulase-negative *Staphylococcus* (16.67%) ($p = 0.0001$). Door knobs were essentially contaminated by *Escherichia coli* (100%). It was noted that the dominant bacteria in laboratory A1 were coagulase-negative *Staphylococcus* followed by *E. coli* whereas Laboratory A2 was mostly contaminated by *E. coli*.

Most strains were multidrug resistant (86.88%). The greatest rate of multiresistant bacteria was found in Enterobacteriaceae (92.3%), followed by non- fermentative bacilli (84.61%) and coagulase-negative staphylococci (81.81%) (Figure 7).

Workstations and door knobs were mostly contaminated by multidrug resistant Enterobacteriaceae strains. Furthermore, non- fermentative bacilli were the mostly isolated on the hands of staff. As for multi-drug resistant strains of coagulase-negative *Staphylococcus*, they most contaminated hands of staff and workstations (Figure 8).

Tables III, IV, V, VI, VII and VIII present the identified bacteria resistance patterns.

Table III. Resistance profile of *Escherichia coli*

Profiles	Phenotypes	Number
Profile 1	AT ^R , GEN ^R , DO ^R , C ^R , CL ^R , FO ^R	1
Profile 2	AT ^R , GEN ^R , DO ^R , C ^S , CL ^R , FO ^S	17
Profile 3	AT ^R , GEN ^R , DO ^R , C ^R , CL ^S , FO ^S	2
Profile 4	AT ^R , GEN ^R , DO ^R , C ^S , CL ^S , FO ^S	1

All the twenty-one *Escherichia coli* strains are multidrug resistant.

Table IV. Resistance profile of *Klebsiella pneumoniae*

Profile	Phenotypes	Number
Profile 1	AT ^R , GEN ^S , DO ^R , C ^S , CL ^R , FO ^R	2

Both strains of *Klebsiella pneumoniae* are multi-drug resistant

Table V. Resistance profile of *Enterobacter cloacae*

Profiles	Phenotypes	Number
Profile 1	AT ^R , GEN ^S , DO ^R , C ^S , CL ^R , FO ^R	1
Profile 2	AT ^S , GEN ^S , DO ^S , C ^S , CL ^R , FO ^R	1
Profile 3	AT ^S , GEN ^S , DO ^S , C ^S , CL ^R , FO ^S	1

A strain out of three of *Enterobacter cloacae* was multi-drug resistant

Table VI. Resistance profile of *Pseudomonas aeruginosa*

Profiles	Phenotypes	Number
Profile 1	AT ^R , GEN ^R , DO ^R , C ^R , CL ^R , FO ^R	6
Profile 2	AT ^R , GEN ^R , DO ^S , C ^R , CL ^R , FO ^S	1
Profile 3	AT ^S , GEN ^R , DO ^S , C ^R , CL ^R , FO ^R	1
Profile 4	AT ^R , GEN ^S , DO ^R , C ^S , CL ^R , FO ^R	1
Profile 5	AT ^R , GEN ^S , DO ^S , C ^S , CL ^R , FO ^R	2
Profile 6	AT ^R , GEN ^S , DO ^S , C ^S , CL ^R , FO ^S	1

Pseudomonas aeruginosa strains were almost multi-drug resistant.

Table VII. Resistance profile of *Acinetobacter spp*

Profiles	Phenotypes	Number
Profile 1	AT ^S , GEN ^S , DO ^S , C ^S , CL ^S , FO ^S	1

The strain of *Acinetobacter spp.* was sensitive to antibiotics tested.

Table VIIIa. Resistance profile of negative coagulase *Staphylococcus*

Profiles	Phenotypes	Number
Profile 1	OX ^R , CX ^S , GEN ^S , DO ^R , FO ^R , VA ^R	1
Profile 2	OX ^R , CX ^R , GEN ^S , DO ^R , FO ^R , VA ^S	3
Profile 3	OX ^R , CX ^R , GEN ^S , DO ^R , FO ^R , VA ^R	2
Profile 4	OX ^R , CX ^R , GEN ^S , DO ^S , FO ^R , VA ^R	3
Profile 5	OX ^R , CX ^R , GEN ^S , DO ^S , FO ^R , VA ^R	1
Profile 6	OX ^R , CX ^R , GEN ^S , DO ^R , FO ^S , VA ^R	1

Table VIIIb. Resistance profile of negative coagulase *Staphylococcus*

Profiles	Phenotypes	Number
Profile 7	OX ^R , CX ^S , GEN ^S , DO ^S , FO ^R , VA ^R	2
Profile 8	OX ^R , CX ^R , GEN ^S , DO ^S , FO ^R , VA ^S	1
Profile 9	OX ^R , CX ^S , GEN ^S , DO ^R , FO ^S , VA ^R	2
Profile 10	OX ^R , CX ^R , GEN ^S , DO ^S , FO ^S , VA ^R	1
Profile 11	OX ^R , CX ^S , GEN ^S , DO ^S , FO ^R , VA ^S	1
Profile 12	OX ^R , CX ^R , GEN ^S , DO ^S , FO ^S , VA ^S	2
Profile 13	OX ^R , CX ^S , GEN ^S , DO ^S , FO ^S , VA ^S	2

All strains of coagulase-negative *Staphylococcus* isolated were almost multiresistant.

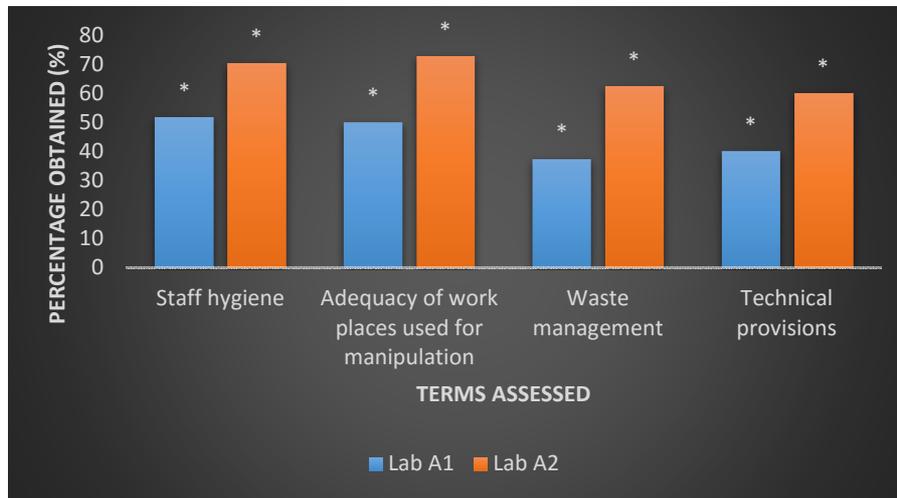


Figure 1. Comparison of assessed parameters between laboratories A1 and A2

For each parameter evaluated, mean followed by different asterisks are statistically different at the significance level of 5%

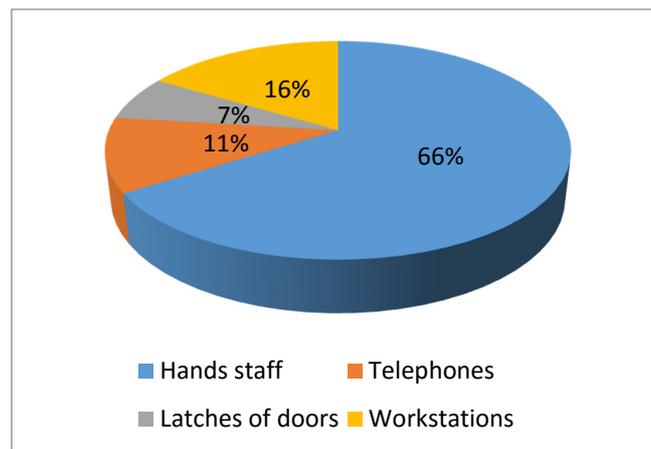


Figure 2. Repartition of samples according to their source

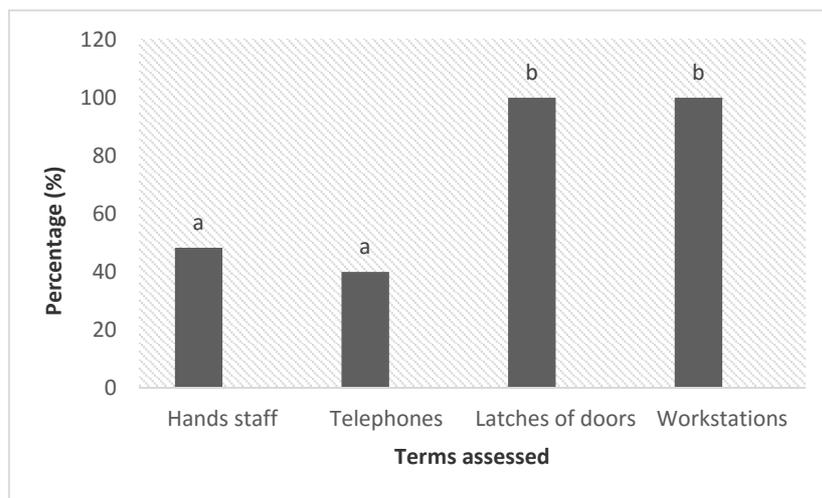


Figure 3. Repartition of samples according to their positivity (the most infected one)

For each parameter evaluated, mean followed by different letters are statistically different at the significance level of 5%.

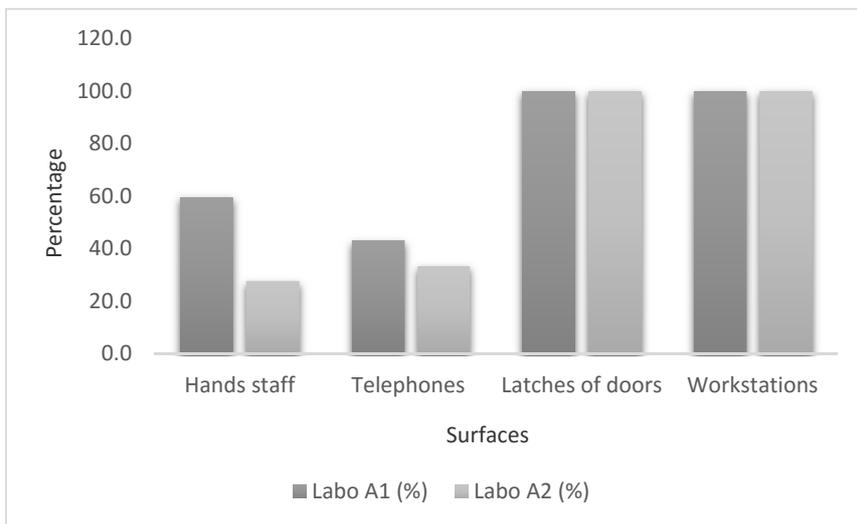


Figure 4. Distribution of samples according to their origin and positivity

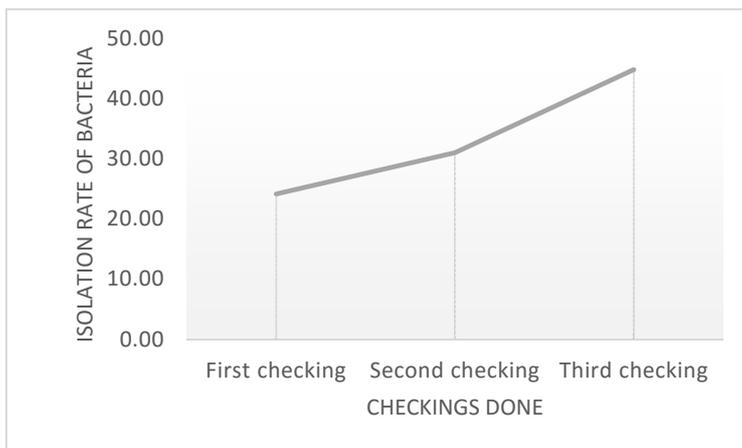


Figure 5. Evolution of the isolation rate of bacteria on the hands of the staff from the morning to the evening

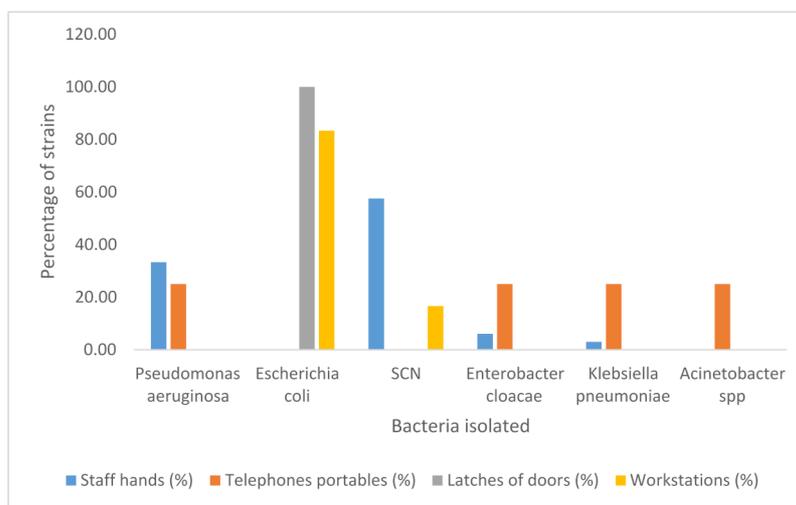


Figure 6. Distribution of bacteria isolated in the laboratory depending on the source

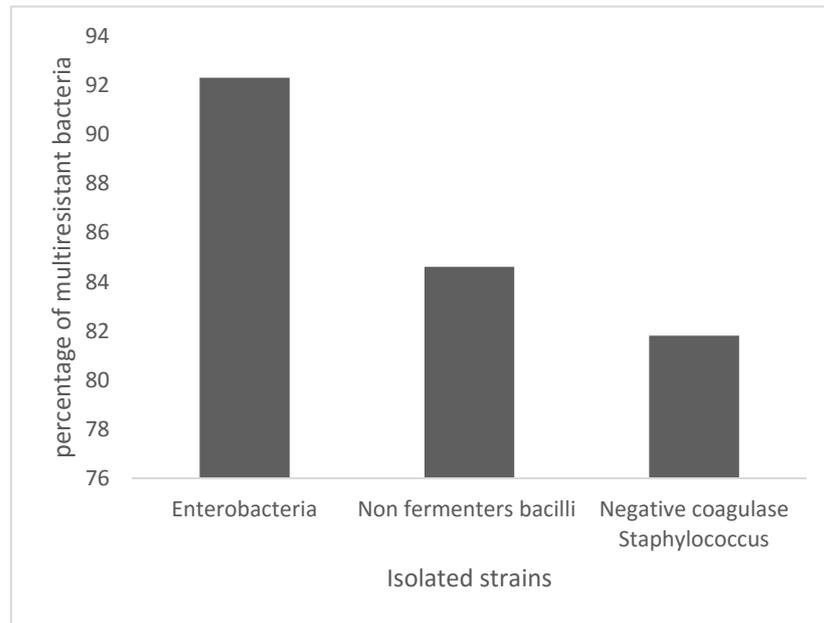


Figure 7. Frequency of multiresistant strains

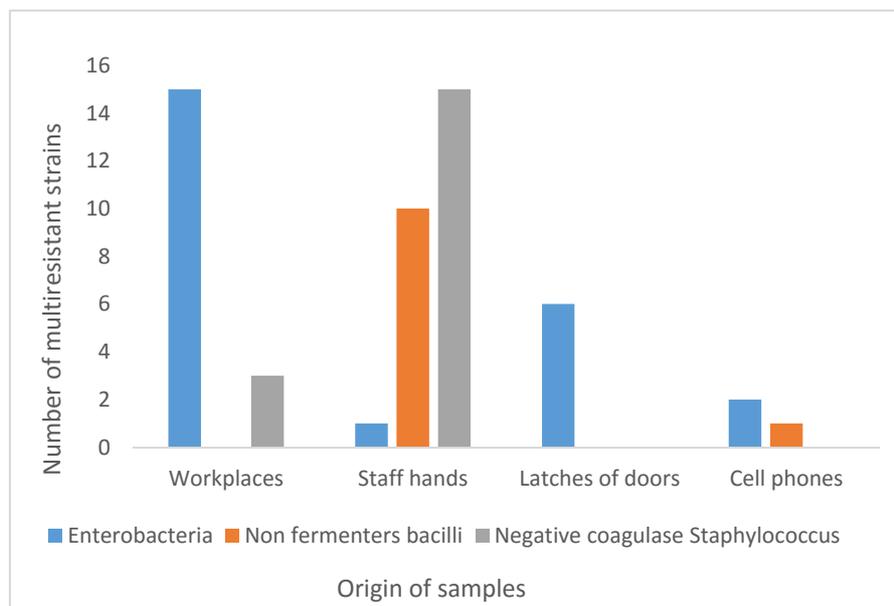


Figure 8. Distribution of multiresistant bacteria depending on specimen type

4. Discussion

Laboratory A1 revealed a relatively poor biosafety level. This low score, reflecting high biosecurity risks was mainly due to poor waste management practices and technical provisions which do not comply with biosecurity rules. Additionally, personal hygiene and the sanitary conditions of the work places are not safe. Indeed, in a biomedical laboratory, waste is very delicate contamination factors especially because they are likely to harbour infectious agents both dangerous for the handler as well as the samples. Generally, wastes are causes of environmental pollution and diseases. During the investigations, it was noted that some technicians especially from lab A1 do not use glove for some activities that are regarded as quick or riskless to them. This was one of the reasons why lab A1 got a low biosafety score especially in the category personal hygiene.

They are even able to contaminate samples because of cross contamination, and thus bias results (Selin, 2012). This is why it is recommended that such laboratories should decontaminate all their wastes before discharging it in the environment. Poor waste management is a factor of vulnerability for laboratory professionals because of the high likelihood of occurrence of several laboratory acquired infections and diseases such as brucellosis, tuberculosis, gastroenteritis etc (Singh, 2009; Wadell, 2014). In addition, the poor waste management can result in the presence of flies and rodents inside the laboratory. This then promotes a serious disease transmission circuit to lab workers. Critical pest control plan must be implemented in such case.

Unlike lab A1, the laboratory A2 showed a good biosafety level. This is because of the good personal hygiene practices, good waste management and the technical provisions that are in accordance with the biosecurity rules and especially the working place conditions that significantly met the standards.

This type of lab is one in which workers and samples are quite protected and can then be considered satisfactory biosecurity wise. Moreover, the score of the work place at this lab, shows the suitability of local comfort, ventilation, and the presence of a number of risk reduction facilities such as biosafety cabinets and autoclaves in the laboratory. These conditions are very important to ensure safety to the technicians (Coelho & Diez, 2015). Although no significant difference was noted while comparing the two laboratories ($p > 0.05$), there is still more improvement to be applied in the first case than in the second to meet the standards. Furthermore, as microbiological examinations take place in the lab A2, this could be the reason why technicians pay much more attention to hygiene than the other lab where no bacteriological threat does exist. This idea is completely false in everyday practice since bacteriological contamination has no partitions.

The risk of spread of resistant bacteria in the lab exists. Most of the sampled sites were contaminated by at least one bacterium. The positivity of samples of hands and door knobs showed the poor hygiene observance in technicians. The contamination level of mobile phones suggest that they are touched during manipulations or after the work without a good sanitation showing that biosafety protocols are not being followed.

The presence of bacteria on work surfaces is an evidence of poor hygiene in this laboratory. The progressive increase of bacterial contamination rate on the hands from the morning to the evening shows the lack of frequent hand washing in technicians. It also reflects the non-frequent glove changing during manipulations in these facilities and the non-use of gloves at some sections of the laboratories. Among the bacteria isolated, coagulase negative *staphylococcus* and *E. coli* were the most identified ones. Laboratory environmental contamination depend on infection control measures and the geographical layout of this laboratory.

The results of this study confirm those of Kumari et al. (2012) who found that, after the analysis of 60 laboratory surface samples, coagulase negative staphylococci were the most isolated contaminants. Unlike the present study, the authors were able to isolate Gram+ bacilli (*Corynebacterium spp*). These bacteria are part of the normal environmental flora and therefore can be classified as environmental contaminants. In this study, the high prevalence of enterobacteria and Gram+ cocci could be explained by the fact that these are saprophytes bacteria widespread in the environment including the hospital (Métité et al., 2007). The laboratory environment is therefore consistent with this rule. In addition, the high frequency of isolation of *E. coli* could be due to the fact that it is a bacterium frequently isolated in this laboratory.

E. coli represents about 23% of the bacteria responsible for nosocomial infections (Métité et al., 2007). Moreover, the presence of *K. pneumoniae* on cell phones showed that biosafety protocols are not being followed in these facilities. Although the source of contamination of cell phones might be elsewhere but not the laboratory, it is important to emphasize on the cell phone's microbiology in relation to the risks that they pose to the users since the isolates that they harbor are multidrug resistant.

Concerning the sensitivity of Enterobacteriaceae to antibiotics, all are multidrug resistant. Among them, *Enterobacter cloacae* is a bacterium which produces cephalosporinase induced by beta-lactams. These results are in agreement with those of Jarlier (2000). Also, some obligate aerobic Gram-, *Pseudomonas aeruginosa* for instance were isolated. They are generally non-pathogenic bacteria for immunocompetent people. They are naturally resistant to several antibiotics and sometimes pose therapeutic problems. *Pseudomonas aeruginosa* strains are responsible for 11% of nosocomial infections (Métité et al., 2007). In this study, almost all of *Pseudomonas aeruginosa* strains are resistant to Aztreonam and these results are similar to those of Métité et al. (2007). Moreover, Gram + cocci are represented by coagulase-negative *staphylococcus*. They are ubiquitous bacteria widespread in the environment. In humans, these bacteria are usually commensal skin bacteria but may be responsible for infections. They are not real threats to lab personnel but their role in nosocomial infections is not to be neglected. All staphylococcal strains are resistant to oxacillin. There is therefore a likely risk of dissemination of these staphylococci in other hospitals. The number of staph infections, including coagulase negative or methicillin resistant, is steadily increasing for the past 10

years (Aldea-Mansilla et al., 2006). The circulation of multidrug resistant bacteria in the laboratory demonstrates insufficient decontamination. Failure to comply with hygiene rules by the same technicians who are not involved in microbiology exposes all laboratory to increased risks.

Bacteria were isolated from door knobs. This means they are circulating in the laboratory. This circulation may allow the spread of resistant bacteria in clinical services through structure such as the door handling. All these results show the importance and necessity of regular self-inspection in laboratories to detect weak points on time since they can lead to critical biosafety failure of the laboratory.

All isolates bacterial species were multidrug resistant. They were resistant to antibiotics that are in most case, routinely prescribed in various infections in the studied hospital. This poses therefore a serious public health problem that requires to be communicated very earlier to health professionals in order to encourage appropriate measures towards antibiotics prescription to patients in need of anti-biotherapy. Besides, this situation suggests that treatment of infections should be guided by susceptibility test results where possible or empirical evidence of antibiotics that are known to be sensitive in specific outbreak situations. Furthermore, although most of the germs recovered in this study are commensals, it is very important to report their threatening antibiotic sensitivity profile. It has been reported that commensals can serve as reservoirs of multidrug resistance genes for pathogenic ones to whom they may transmit the resistance genes through various mechanisms (Marshall et al., 2009).

5. Conclusions

The working environment of the biomedical analysis laboratory could be a risk not only to staff members but also for patients. This risk has been proven by the presence of specific pathogenic bacteria and most of them were multidrug resistant. Given the results of this study, it is urgent to establish a hygiene plan in the laboratory. More studies must be undertaken in other types of laboratories (private and public) in order to assess the diversity of the infection risk. Clearly written procedures should be posted and accessible in the laboratory in order to reverse the trends and circumvent eventual laboratory acquired infections.

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References

- Aldea-Mansilla, C., de Viedma, D. G., Cercenado, E., Martín-Rabadán, P., Marín, M., & Bouza, E. (2006). Comparison of phenotypic with genotypic procedures for confirmation of coagulase-negative *Staphylococcus* catheter-related bloodstream infections. *Journal of clinical microbiology*, *44*(10), 3529-3532. <http://dx.doi.org/10.1128/JCM.00839-06>
- Coelho, A. C., & Díez, J. G. (2015). Biological risks and laboratory-acquired infections: a reality that cannot be ignored in health biotechnology. *Frontiers in bioengineering and biotechnology*, *3*. <http://dx.doi.org/10.3389/fbioe.2015.00056>
- Jarlier, V. (2000). Mécanismes de résistance aux antibiotiques. In *Précis de bactériologie clinique* (pp. 598-608).
- Kouamé, T. (2009). *Management efficace du risque sanitaire dans un laboratoire de recherches médicales*. Mémoire de Master, Centre de Diagnostics et de Recherche sur le Sida, Côte d'Ivoire, 80p.
- Kumari, V. H. B., Nagarathna, S., Reddemma, K., Lalitha, K., Mary, B., & Sateesh, V. L. (2012). Containment of case-file contamination infection control. *Journal of Evolution of Medical and Dental Sciences*, *1*(6), 1166-1171.
- Méité, S., Boni-Cissé, C., Guéi, M. C., Houédanon, C., & Faye-Ketté, H. (2007). Evaluation du risque infectieux au laboratoire d'analyses médicales: Exemple du laboratoire de bactériologie-virologie du CHU de Yopougon (Abidjan, Côte d'Ivoire) en 2006. *Revue Bioafrica*, *4*, 16-22.
- Misgana, G. M., Abdissa, K., & Abebe, G. (2015). Bacterial contamination of mobile phones of health care workers at Jimma University Specialized Hospital, Jimma, South West Ethiopia. *International Journal of Infection Control*, *11*(1). <http://dx.doi.org/10.3396/IJIC.v11i1.007.15>
- Rhame, F. S. (1998). The inanimate environment. *Hospital infections*. 4th ed. Philadelphia: Lippincott-Raven, 299-324.
- Selin, E. (2013). Solid waste management and health effects: A qualitative study on awareness of risks and environmentally significant behavior in Mutomo, Kenya.

- Singh, K. (2009). Laboratory-acquired Infections. *Clinical Infectious Diseases*, 49, 142–147. <http://dx.doi.org/10.1086/599104>
- Société Française de Microbiologie. (2014). *Recommandations 2014 du Comité de l'Antibiogramme de la Société Française de Microbiologie*. Version 1.0 de mai 2014, 115p.
- Vesley, D. O. N. A. L. D., Lauer, J., & Hawley, R. (2000). Decontamination, sterilization, disinfection, and antisepsis. *Biological Safety Principles and Practices*. 3rd ed. Washington: ASM, 383-402.
- Wadell, D. (2014). *Laboratory waste guide*. Report, 66 p. Retrieved August 5, 2015 from www.labwasteguide.org
- WHO. (2013). *WHO Guide for the stepwise laboratory improvement process towards accreditation in the African region* (with checklist). WHO Regional office for Africa. 68p.
- Wilson D. E., & Chosewood, L. C. (2009). *Biosafety in microbiological and biomedical laboratories* (Edition 5). HHS Publication No. (CDC) 21-1112, 438p.

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