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Comparative Study of Infectious Risks in Diagnostic Laboratories between Public and Private Hospitals in Benin

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Abstract

Introduction: Laboratory associated infections are serious occupational hazards for laboratory workers who are exposed through various routes. The present study aimed to compare the bacteriological risks encountered at diagnostic laboratories in public and private hospitals in Southern Benin.

Methodology: A scorecard of laboratory practices was developed based on WHO laboratory inspection checklist. The private laboratory was split into two sections B1 and B2 and the public in C1 to C5. A total of 125 swabs from hand, cell phones, work surfaces and door knobs were collected from all laboratories and submitted to bacteriological analyses.

Results: Apart from some sections of the public laboratories where poor sanitation was noticed, the overall hygiene level are satisfactory in both hospitals even though the private laboratories were significantly safer ($p<0.05$) than the public ones (68.55% and 55.81% respectively). Bacteriological investigations showed that mobile phones were the most contaminated items in the private labs while work surfaces harboured more germs in the public laboratories.

Although private laboratories were contaminated by over 11 bacteria species against 5 from the public labs, coagulase negative *Staphylococcus* were the most prevalent isolated organisms from both hospitals. All the isolated bacteria form public and private laboratories were multidrug resistant.

Conclusions: Though the hygiene level in the private labs was better than in public labs, the risk of lobaratory associated infections is rampant in both areas with respect to isolated organisms. Serious safety instructions and monitoring must be set to avoid worse situations.

Keywords: Laboratory associated infections; Private/public hospitals; Diagnostic; Benin

Introduction

In this era of increased emergence of infectious agents and diseases, working with infectious materials in health, clinical and diagnostic laboratories has known expansion [1]. This is not without adverse effect on the health of laboratory workers because work in a diagnostic laboratory entails safety considerations [2]. People working in clinical diagnostic laboratories are exposed to a number of health risks including laboratory associated infections. Reports demonstrated that whether the patients are humans or animals and whether workers intervene in microbiology or elsewhere in the laboratory, it remains a challenging environment [1,3]. Laboratory associated infections are occupational hazards for laboratory workers. They are reported since the 20th century. Recent reports have shown that bacteria were responsible for more than 40% of infections, with more than 37 species reported as etiologic agents in laboratory acquired infections [3,4] have demonstrated that most of bacterial contaminants of laboratory surfaces are not easily susceptible to surface decontamination with disinfectants and can thereby get into contact with the personnel and cause adverse health effects. Moreover, laboratory technicians are exposed to laboratory associated infections through various routes. Contaminants from workers' hands, mobile phones, jewelleries and other personal objects that are brought into the laboratory are mechanical vectors of laboratory associated infections [5-7]. To alleviate these risk factors, working at such laboratories require biosafety measures designed to protect the staff, the population and the environment [8]. Besides, laboratory associated infections constitute serious health threat since infected laboratory professionals can cross-contaminate their relatives and spread infections in the general population [4]. In addition, contamination of the laboratory staff can induce samples' contamination leading to false positive culture reports from bacteriology laboratories. These false results are responsible for unnecessary and inappropriate administration of antimicrobials to people. Such situation ultimately gives rise to unwanted drug-resistant mutant strains [9]. With respect to the aforementioned issues, it is of paramount public health importance to monitor the adherence and respect of biosafety measures among laboratory staffs at a regular basis so as to arise awareness on current infectious risks.

On the other hand, it is claimed and even reported that health care services delivered at private hospitals are of better quality than the one in public hospitals whereby personnel of the latter do not always comply with biosafety rules even though the same studies emphasized that private hospitals are not more efficient than the public ones in

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terms of performance [10,11]. Therefore, it is essential to conduct a comparative study in these two different settings in order to point out the role of the hospitals' status in the actual laboratory infectious risks.

The present study aimed to evaluate and compare the bacteriological risks encountered at diagnostic laboratories in public and private hospitals. This was achieved by assessing the suitability of two diagnostic laboratories in terms of biosafety measures, the bacteriological risks to the personnel working in a laboratories and the association between public/private status of the hospital harbouring the labs and their biosafety level.

Methodology

Experimental section

Materials: The study was conducted between May and August, 2015 in the diagnostic laboratories of a private and religious hospital and a Regional Public Hospital in Southern Benin. Apart from the checklist used to assess the hygiene level and biosafety compliance of each section of the laboratories, some laboratory materials were used. The biological material consisted of various samples collected in the diagnostic laboratories of the two Hospitals. These samples were made of swabs from the hands and mobile phones of laboratory staff, door knobs and work surfaces of various sections. Samples were collected from two sections of the private hospital's laboratory (B1 and B2) and from five sections of the regional hospital's laboratory (C1, C2, C3, C4 and C5). For culture and identification of bacteria, bacteriology usual culture media were used [12]. The reagents used were rabbit plasma for research of staphylocoagulase in *Staphylococcus aureus*, OX discs for research of oxidase in bacteria, Gram staining reagents, hydrogen peroxide for the detection of catalase in bacteria, the Api 20E gallery for identification of enteric bacteria and antibiotic disks 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. Materials such as markers, slides and chips, Petri dishes, sterile disposable loops, sterile haemolysis tubes of 10 and 05 millilitres, pipettes, Bunsen burners, physiological and distilled water have also been used.

Methods

Collection and analysis of data related to laboratory hygiene 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 Africa [13].

This first part of the study was conducted through direct observations made on the basis of questions on the checklist. The questions were structured into 4 categories 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 [13] where the right answers got 1 point against 0 for the wrong 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.

Using the EPI- INFO Version 7 software, the Chi^2 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.

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 [12]. Using sterile wet swabs, the left and right hands of the staff were swabbed at three separate 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. Samples were thereafter sent to laboratory for bacteriological tests. 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 [12]. Api 20E 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 [14]. Alongside the strains studied, a reference strain of *Escherichia coli* ATCC 25922 was used as control to validate the results.

Results

Laboratory practices

At the private hospital, the laboratory B1 presents a suitable hygiene level (74.19%) thanks to good personal hygiene (59.26%), safe working environment (72.73%, p=0.006) and satisfactory waste management practices (62.5%) even though the technical provisions do not guarantee biosafety in the lab (40%) (Figure 1).

By analogy, the laboratory B2 shows a satisfactory level of biosecurity (62.90%) where the score of personal hygiene was 66.67% (p=0.028) and 77.73% (p=0.0007) for the working environment. Waste management practices scored up to 87.50% (p=0.01) and technical provisions of the laboratory scored 80% (p=0.206).

Although lab B2 seems to score better than lab B1, no statistical difference was recorded on the biosafety level of the two laboratories (p>0.05) (Figure 1).

At the public hospital, the lab C1 revealed an acceptable level of respect of biosecurity rules with a global score of 50%. In this lab, the quality of personal hygiene and technical provisions are relatively poor (40.74% and 40% respectively) while the working environment in that lab seemed to be adequate (68.18%, p=0.03) (Figure 2).

The laboratory C2 presents a global biosafety score of 56.45% with satisfactory adequacy of the working environment 72.73% (p=0.006) and an acceptable level of waste management (50.00%). However, personal hygiene practices and technical provisions in the laboratory are quite poor (48.15% and 40%, respectively) (Figure 2).

The overall biosafety score of the laboratory C3 is of 46.77% where personal hygiene, waste management practices and technical provisions scored 33.33%; 25% and 40% respectively. Nevertheless, the working environment was satisfactory biosafety wise (72.73%, p=0.006) (Figure 2). The laboratory C4 scored 59.68% for general biosafety with 51.85% and 62.50% for personal hygiene and waste management practices respectively. The working environment was (72.73%, p=0.006), whereas the technical provisions remained poor (40.00%). The laboratory C5 shows a satisfactory level of biosafety (66.13%). Personal hygiene practices and the working environment scored 51.85% and 81.82%, respectively. Waste management practices were safe 87.50% but the technical provisions do not satisfy hygiene requirements (40%) (Figure 2).

A comparison of the biosafety levels of these five laboratories in relation to hygiene practices shows that only waste management practices varied significantly between the bacteriology (C5) laboratory of and the Emergencies (C3) lab, whereby the latter was lower than the former (p<0.05). Furthermore, among the five studied laboratories, bacteriology laboratory (C5) got the highest biosafety score (66.13%) followed by Serology laboratory (C4) and haematology lab (C2) then comes biochemistry lab (C1) (59.68%, 56.45% and 50.00% respectively). The laboratory of the emergencies is the one that has the lowest overall score (46.77%) which is significantly lower than the one of Bacteriology lab (p< 0.05).

Comparison of the Hygiene Level betwen the Private and Public Lanboratories

The overall hygiene score of the private laboratories is 68.55% and significantly higher than the one of the public laboratories 55.81% (p=0.019).

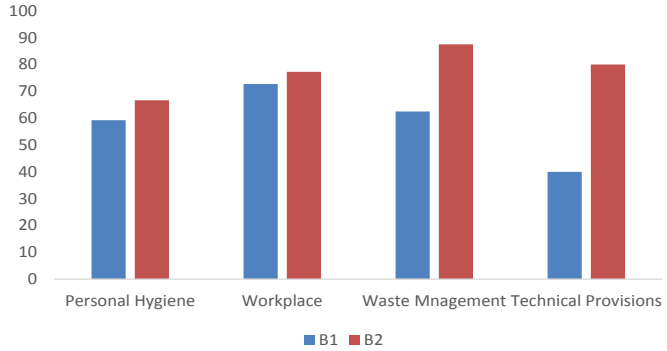

Figure 1: Comparison of Biosafety levels in the private labs (B1 and B2).

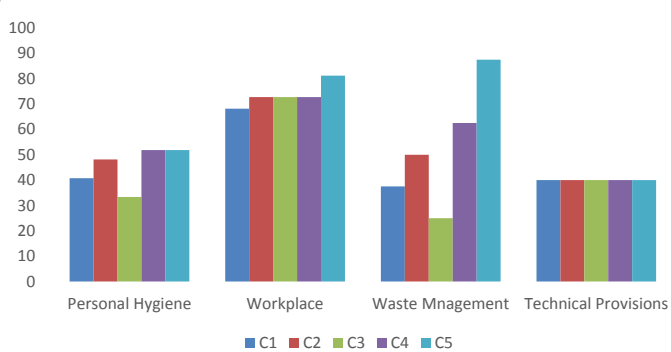

Figure 2: Comparison of Biosafety levels in the public labs (C1 to C5).

Bacteriological Risk for Laboratory Workers

After bacteriological analysis, most of hand samples from the private and public laboratories showed growth (50% and 56.66%, respectively). All mobile phone samples from the private hospital were contaminated by at least one bacteria species (100%) against 80% from the public hospital. Door knobs were more contaminated in the private hospital than the public one (83.33% and 41.66%, respectively). Although none of the above results showed a significant difference between private and public laboratories, the work surfaces were less contaminated in the private sector than in the public with significant difference (50% and 100%, respectively with p=0.023) (Figure 3). Moreover, within the private laboratory, mobile phones were the most contaminated among all the analysed items (100%, p<0.05), while work surface samples were more contaminated than all other analysed samples from the public laboratories (100%, p<0.05) (Figure 3).

Elven bacteria species were identified in specimens from the private laboratory as shown in (Figure 4). However, *coagulase-negative Staphylococcus* spp. were the most isolated ones (21.66%, n=60) (p <0.05) followed by *Pasteurella pneumotropica* (16.66%, n=60).

Additionally, a wide distribution of the bacteria based on sample type was noted. Thus, as shown on (Figure 4), the staff's hands from the private laboratory were contaminated by 8 different bacteria species with the most isolated ones being *Pasteurella pneumotropica* (24%, n=25), *Burkholderia cepacia* (20%, n=25), *coagulase-negative Staphylococcus* (20%, n=25) and *Enterococuss spp.* (12%, 25). Among all the 8 bacteria species isolated from mobile phone samples in the private laboratory (Figure 4), the most common ones were *coagulase-negative Staphylococcus* (21.43%, n=14), *Pasteurella pneumotropica* (21.43%, n=14), *Proteus mirabilis* (14.29%, n-14) *and Bordetella spp.* (14.29%, n=14). Moreover, door knobs were contaminated by various bacteria species. However, the most predominant ones were *coagulase-negative Staphylococcus* (25%, n=16), *Pasteurella pneumotropica* (18.75%, n=16), *Aeromonas salmonicida* (18.75%, n=16) and *Pseudomonas aeruginosa* (12.5%, n=16). Nevertheless, the work surfaces of the private laboratory were contaminated by only four bacteria species with *non-fermenter spp* (40%, n=5) as the most predominant ones followed by *Burkholderia cepacia*, *coagulase-negative Staphylococcus* and *Enterococcus spp.* with equal proportions of 20% each (Figure 4). No significant difference was recorded proportions of isolation from specimens in the private laboratory were compared to each other (p>0.05).

The public laboratory was contaminated by fewer bacterial species than the private one. These were *Alcaligenes faecalis* (11.36%, n=44), *Flavobacterium odoratum* (11.36%, n=44), *Klebsiella pneumonia*

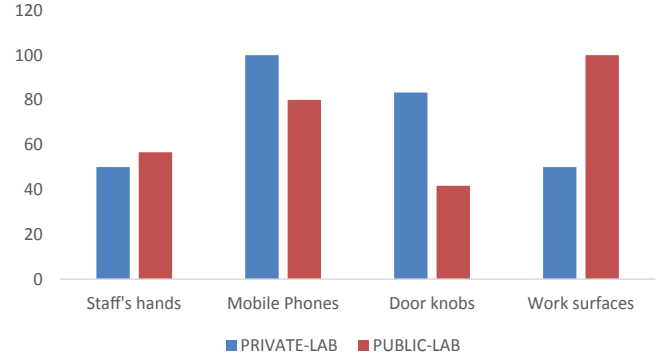

Figure 3: Proportion of bacterial growth in assessed items per lab.

(4.55%, n=44), *coagulase-negative Staphylococcus* (47.72, n=44) and *Pseudomonas aeruginosa* (11.36%, n=44) (Figure 5). However, *coagulase-negative Staphylococcus* were the most prevalent ones with a significant superiority over the others ($p<0.05$). Furthermore, a variation was observed in bacteria species isolated in the public laboratory according to specimens. As per (Figure 5) hands of the personnel of the public laboratory were contaminated by all the aforementioned bacteria with *coagulase-negative Staphylococcus* being the most prevalent (53.85%, n=26, $p<0.05$). Mobile phone samples were contaminated by *coagulase-negative Staphylococcus* (50%, n=8), *Staphylococcus aureus* (25%, n=8), *Alcaligenes faecalis* (12.5%, n=8) and *Flavobacterium odoratum* (12.5, n=8) without significance difference between the proportions ($p>0.05$) (Figure 5). However, door knobs were only contaminated by *coagulase-negative Staphylococcus* (100%, n=2). On the other hand, the work surfaces of the public laboratory were contaminated by all the bacteria species found in this laboratory except *Klebsiella pneumoniae* (Figure 5).

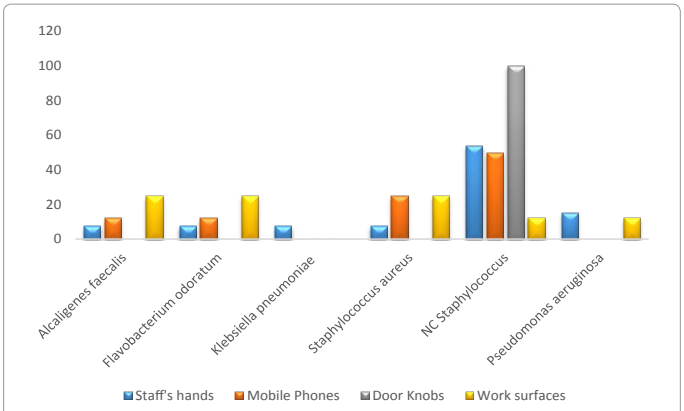

Figure 5: Distribution of bacteria isolated in the public laboratory depending on specimens.

Antibiotic Sensitivity Tests

Antibiogram of isolates from the public laboratory

Most of the bacteria species isolated from the public hospital's laboratories were multidrug resistant.

Antibiogram of isolates from the private hospital's laboratories

Majority of all bacteria isolated from the private hospital were also multidrug resistant.

Discussion

The satisfactory biosafety level of both laboratories B1 and B2 of the private hospital was due to the sanitary personal hygiene practices, good waste management practices and safe working environment of those labs. Such laboratories can guarantee adequate biosecurity to users and consequently protect samples as well as the environment. This good biosafety practices could be explained by the fact that this hospital is a private hospital which are known to be more controlled than public ones [10,11]. However, a strict maintenance and improvement of the hygiene status of these labs are necessary to preserve public health. This requires regular auto-inspection within the laboratories in order to detect weaknesses in the hygiene status of the laboratories and address them adequately the earliest possible.

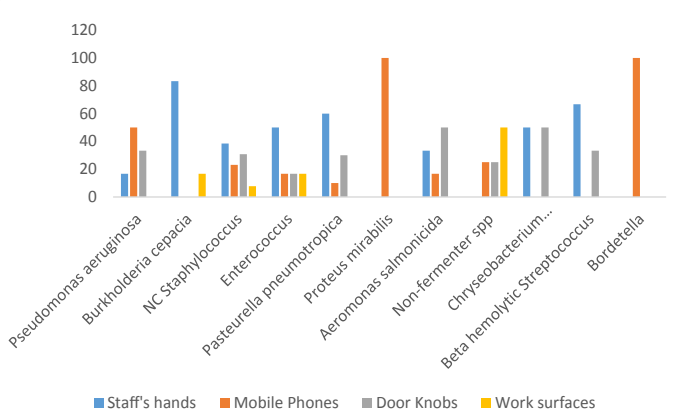

Figure 4: Distribution of bacteria isolated in the private laboratory according to sample type.

From the public hospital, all the five laboratories had a hygienically poor technical provisions. In principle, the organization of the laboratory is supposed to allow a clear distinction between the clean areas that are not supposed to be exposed to external contaminants and the exposed areas where samples and hazardous materials are handled [5]. This is not the case of this laboratories which are therefore hotspots of laboratory associated infections. Moreover, under technical provisions, the Head of laboratory is supposed to provide workers with biosafety and biosecurity instructions which should be documented and followed in all routine activities in the laboratory as safety regulations. Failure to comply with such rules, is a risk factor of contaminants dissemination.

The working places of the five laboratories of the public hospital were safe biosecurity wise. This testifies the comfort of the facilities, including appropriate ventilation and the presence of some important risk mitigation such as autoclaves and safety cabinets. Such conditions are very important to guarantee the safety of laboratory technicians [8].

In the public hospital, good waste management practices were recorded in lab C4 and C5 unlike C1, C2 and C3. These findings corroborate the results of safety investigation conducted in 22 developing countries by WHO, which revealed that the proportion of health care facilities that doesn't practise safe waste disposal methods varied from 18% to 64% [15]. Wastes from biomedical laboratories are partly constituted of hazardous materials. If technicians are exposed to such hazardous wastes, injuries, contaminations and illnesses can occur. Besides, a poor waste management can lead to the presence of pests mainly flies and rodents in the laboratory. This can in turn encourage transmission of serious illnesses to laboratory workers [16].

Good hygiene practices need to be improved in these laboratories since none of them scored more than the minimum satisfactory level.

With the overall comparison, the private laboratory appeared safer than the public laboratory ($p=0.019$). This situation confirms the conclusions of Yousapronpaiboon and Johnson [11] who reported that public hospitals do not always comply with biosafety rules.

Majority of samples collected from all the laboratories revealed positive culture. All samples from work surfaces were positive. One of the reasons is that the work surfaces serve various materials. Besides, they are in permanent contact with the gloves of technicians and various infectious products. Therefore, this rate of bacteria isolation from work surfaces might be quite normal even though periodic surface decontamination is required to minimize the risk of infection to workers.

Bacteria were also isolated from cell phones, hands and door knobs. The presence of bacteria from workers' hands, cell phones and from door knobs testifies the poor personal hygiene and poor handling practices among technicians. Moreover, the analysis of the results shows that the technicians do not really adhere to good hygiene practices throughout mainipulations.

Coagulase negative staphylococci were the most isolated bacteria species from all the samples from both public and private hospitals. This result confirms those of Kumari et al., [17] who reported that out of 60 lab surfaces analysed samples, coagulase negative staphylococci were the predominant microorganisms. *Staphylococcus aureus* are isolated from all laboratories. These results are similar to the results of an investigation conducted in France in 2006 which revealed that the three predominant bacteria species involved in nosocomial infections were *Escherichia coli* (24.7%), *Staphylococcus aureus* (18.9%) and *Pseudomonas aeruginosa* (10%) [18].

In this study, the predominance of Gram+ cocci could be explained by the fact that these are saprophytic bacteria which are widespread in the environment [12]. Majority of isolated Staphylococci strains are resistant to Oxacilline. There is therefore a risk of propagation of drug resistance strains to other hospitals and the community. The number of infections due to staphylococci, notably coagulase negative ones is in constant increase these last decades [19].

The non-fermenter isolated bacilli comprises *A. faecalis*, *F. odoratum* and *P.aeruginosa*. *P.aeruginosa* is environment bacterium and generally non-pathogenic to an immunocompetent individual. Non-fermenter Gram negative bacilli occupies a very important place among germs responsible for nosocomial infections. These bacteria have a high natural drug resistance potential with different resistance mechanisms including enzymes secretion and cell wall efflux. They can acquire resistance either by chromosomal mutation or through plasmid transfer [20]. These species are responsible for 11% of nosocomial infections [12]. *F odoratum.* is widely found in hospital environments [6].

A. faecalis is an opportunistic pathogen mainly implicated in catheters and laboratory materials contamination [21,22]. All the isolated *Klebsiella pneumoniae* strains were multidrug resistant. This demonstrates as well that urgent measure must be taken to improve hygiene practices in this laboratory [23].

The circulation of the bacteria many multidrug resistant bacteria in all investigated laboratories from both public and private centres an insufficient decontamination and disinfection. Furthermore, good hygiene practices must be set in all laboratories not only in Microbiology sections, because a contamination at any level can expose the whole laboratory and hospital centre to high infectious risks. All this shows the importance of the regular auto-inspection within the laboratories in order to detect the deficiencies on time so as to take appropriate measures. The risk of laboratory associated infection seems to be the same from all the laboratories regardless of the status of the hospital where they are sampled from. Both public and private hospitals harboured a number of pathogenic and commensal bacteria which are revealed multidrug resistance.

Conclusion

The working environment of diagnostic laboratories could be a risk not only to staff members but also for patients as well as samples and the environment. This risk has been proven by the presence of specific pathogenic bacteria and most of them were multidrug resistant. Though the hygiene level in the private labs was better than in public labs, the risk of lobaratory associuated infections is rampant in both areas.

Given the results of this study, it is urgent to establish a hygiene plan in the laboratories. More studies must be undertaken in other types of laboratories in order to assess the diversity of the infection risk. Clearly written procedures should be posted and accessible in the laboratory so as to reverse the trends and curb eventual laboratory acquired infections. Public laboratories must improve their hygiene level to ensure safety during manipulations and avoid false positive results.

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