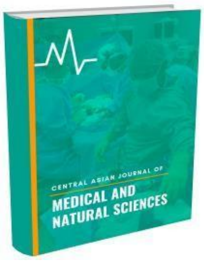

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Article

Microbial Load Comparison Between Clinical and Non-Clinical Student Environments in Al-Kindy College of Medicine

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Abstract: The environmental surfaces hygiene of college premises like classrooms play role in spreading different pathogenic bacteria, furthermore a Medical students are often potential vectors for resistant bacteria to their entourage. This study aimed to assess bacterial contamination and their susceptibility to various antimicrobial agents in the educational classroom of Al-Kindy College of medicine in two classrooms: one occupied by clinical visitor and non-clinical visitor students to evaluate and determine its health risk. In this cross-sectional study, different sites of the educational classroom of Al-Kindy College of medicine were studied. Ninety-sex Different swab samples were collected from 8 different sites of college across both classrooms were included in this study for one month, all surface samples were preceded under standard guidelines of isolation and identification of bacteria**.** A total of 180 bacterial isolates were identified, comprising 82 from the non-clinical visitor classroom and 98 from the clinical visitor classroom. *Escherichia coli* were the predominant isolate in both classrooms, accounting for (21.11%) of the total isolates, followed by *Staphylococcus spp.* at (16.67%). Notably, the clinical visitor students' classroom exhibited additional bacterial species, including *Clostridium* .difficile and *Citrobacter spp*., which were not detected in the non-clinical visitor students' classroom. The VITEK system also conducted an antimicrobial susceptibility test to the most common bacterial isolates in order to demonstrate the presence of antibiotic-resistant bacteria in college classrooms. *Escherichia .coli* isolates tested highly sensitive to imipenem and amikacin, but more resistant to carbapenem (CRO) and trimothoprim/sulfamethoxazole (SXT), according to antibiotic susceptibility testing. The increased diversity and bacterial load in the clinical visitor students' classroom could be a result of different hygiene habits or exposure to healthcare settings. According to the findings, the most common bacterial pathogen found in college classrooms is *Escherichia.coli* isolates. Improved infection control procedures are therefore desperately needed, particularly in settings where clinical training is conducted. To lower the risk of bacterial transmission and the spread of antibiotic-resistant strains, classrooms must be regularly decontaminated.

Keywords: College, *Escherichia Coli.* Antibiotics, Resistant, CLSI, Iraq

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1. Introduction

Classroom environment is a significant part of medical students' education in the areas of hygiene and infection control. Classroom settings in universities, particularly those frequented by clinical students, can serve as reservoirs for pathogenic microbes due to high human traffic, frequent surface contact, and exposure to healthcare-associated pathogens. Students, teachers, and staff are at risk for health problems due to the increased risk of cross-contamination and infection transmission caused by bacterial contamination in these settings [1]. Antibiotic-resistant strains of the various microorganisms that medical students encounter during clinical training may unintentionally enter classroom environments. Because these pathogens can linger on surfaces and equipment, it's critical to comprehend microbial load and follow good hygiene procedures [2][3]. Although there are many helpful microorganisms in the human body, infections happen when bacteria multiply too much or spread to unexpected places, which can harm important organs [4][5]. When the number of bacterial infections increases too much, they can affect the lungs, heart, or other organs [6]. Hand hygiene is a key factor in infection prevention. Contaminated hands harbor pathogenic microorganisms, facilitating the spread of fecal-oral diseases [7]. Proper hand washing with soap effectively reduces infections such as diarrhea and respiratory illnesses, yet it is not universally practiced [8][9][10]. Moreover, feaces is considered the fundamental refuge for the human pathogens that might cause serious infections such as shigellosis.[11] Poor toilet hygiene and inadequate hand washing after using the restroom can lead to bacterial transfer to frequently touched surfaces like door handles, desks, and taps, increasing transmission risks [8]. *Escherichia. Coli*, *Streptococci spp.*, *staphylococcus spp.* considered as opportunistic pathogens, some of which are aerobic or aerobic, cause disease in healthy but highly virulent people in patients with mild bacteremia or eye injury Ear infection, skin infection, wound injury, central nervous system infection, heart attack, and joint infections [12]. *E. coli*, a prevalent gram-negative bacterium in the human gut, has both benign and pathogenic strains, with some causing diarrhea and urinary tract infections [13]. *Staphylococcus aureus*, a gram-positive bacterium, is typically harmless on the skin but can cause infections under certain conditions, particularly through direct contact or contaminated surfaces [14][15]. Both *Staphylococcus* and *Streptococcus* contribute to respiratory, intestinal, and skin infections, sometimes with severe consequences [16]. Disinfectants are essential for infection control, with their effectiveness influenced by concentration, pH, temperature, and contact duration. While *Staphylococcus aureus* and *Enterococci* are generally sensitive to disinfectants, their misuse can lead to resistance [17]. The objective of this research is to compare the rates and degrees of bacterial contamination of two classroom surfaces environments in a medical college: one by clinical visitor students, who are directly exposed to healthcare environments, and the other by non-clinical visitor students. Furthermore, the study aims to investigate the sensitivity of the isolated bacterial strains to antibiotics. The findings of this research will yield valuable data on the potential risks of bacterial spread and antibiotic resistance among schools, which will then guide the implementation of specific infection control policies to make the school environment safer for all students

2. Materials and Methods

Sample acquisition and processing

This study was carried out between January and March. 2025. A total of 96 swab samples were obtained from eight distinct locations within two classrooms at al-Kindy College of Medicine in: one utilized by clinical visitor students and the other by non-clinical visitor students. The sampling locations comprised high-touch surfaces, including desks, door handles, window handles, chairs, floors, smartboards, tablets, and switches. Six swabs were collected from each site, resulting in a total of 96 samples from the college classrooms. Each swab was moistened with sterile saline and moved back and forth across a designated area of approximately 10 cm². The swabs were promptly placed into sterile transport containers, labeled with the relevant site and classroom details, and then transported to the laboratory. In the laboratory, each swab was directly cultured by streaking onto media that are both selective and non-selective, including blood agar and MacConkey agar, and mannitol salt agar, to promote the growth of a diverse array of bacteria. For 24 to 48 hours, the inoculated plates were incubated aerobically at 37°C. Gram staining, morphological traits, and biochemical tests such as the catalase, oxidase, and indole tests were used to identify the bacterial colonies after incubation [18][19]. The VITEK system was then used to confirm the results of the test for antibiotic susceptibility using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar. The antibiotics evaluated included Imipenem (IMI), Amikacin (AK), Tirapazamine (TPZ), Ceftazidime (CAZ), Carbapenem (CRO), Trimethoprim/Sulfamethoxazole (SXT), Ciprofloxacin (CIP), and Levofloxacin (LEV). To determine the isolates' sensitivity and resistance patterns, the results were examined using the Clinical and Laboratory Standards Institute's (CLSI) guidelines.

3. Results

96 swab samples were taken from eight locations within each classroom to represent areas that the students in the two groups—clinical visitor students and non-clinical visitor students—most frequently touch or come into contact with. This study was carried out to determine the frequency of bacterial contamination in Al-Kindy College of Medicine classrooms. The sites sampled included (desks, door handles, window handles, switches, chairs, floor, smart boards and tablets). The total number of different bacterial isolates is 180 isolates in both groups, clinical and non-clinical visitor students respectively. The results revealed that the highest percentage of bacterial contamination in both groups was associated with chairs (28.89%), followed by tablets (22.22%) while the, least sites were the window handles (4.44%) and smartboards (5.56%). As shown in Table 1.

Table 1. No. of isolate of bacterial contamination from different sites of classrooms by swab method.

Sites.	Non clinical classroom			Clinical classroom.			Total average
	No. Samples.	No. Of Bacterial Isolate	Percentage (%).	No. Sample.	No. Of Bacterial Isolate	Percentage (%).	Percentage (%).
Desks	6	8	9.76%	6	9	9.18%	9.44%
Door handles	6	14	17.07%	6	11	11.22%	13.89%
Window handles	6	3	3.66%	6	5	5.10%	4.44%
Chair	6	23	28.05%	6	29	29.59%	28.89%
Floor	6	5	6.10%	6	9	9.18%	7.78%
Smartboards	6	4	4.88%	6	6	6.12%	5.56%
Tablets	6	18	21.95%	6	22	22.45%	22.22%
Switches	6	7	8.54%	6	7	7.14%	7.78%
Total	48	82	100.00 %	48	98	100.00%	100.00 %

The distribution of bacterial strains isolated from two classroom groups averaged 21.11% for *E.coli*, followed by 16.67% for *staphylococcus* species and then 14.44%, 11.11%, 10.00% and 7.78% for *bacillus spp. Micrococcus spp. Streptococcus spp.* and *pseudomonas aeruginosa* respectively. Other strains ranged between 5.00%- 1.11% as shown in table (2).The prevalence of bacterial strains in the classrooms of clinical visitor students was recorded at 20.41% for *E. coli,* followed by 16.33% for *Staphylococcus spp* and 14.29% for *Bacillus spp*. Other strains exhibited percentages ranging from 10.20% to 2.04%. Additionally, the presence of both *Clostridium difficile* and *Citrobacter spp* was observed, see Table 2.

Table 2. The distribution of bacterial contamination strains across two groups.

Bacterial Isolation	Non-Clinical Student		Clinical Students		Total Percentage (%).
	No. isolate	Percentage (%).	No. isolate	Percentage (%).	
E. Coli	18	21.95%	20	20.41%	21.11%
Staphylococcus	14	17.07%	16	16.33%	16.67%
Bacillus	12	14.63%	14	14.29%	14.44%
Micrococcus	10	12.20%	10	10.20%	11.11%
Streptococcus	8	9.76%	10	10.20%	10.00%
Pseudomonas Aeruginosa	6	7.32%	8	8.16%	7.78%
Enterobacter	4	4.88%	5	5.10%	5.00%
Acinitobacter	4	4.88%	4	4.08%	4.44%
Salmonilla	4	4.88%	4	4.08%	4.44%
Klebsiella	2	2.44%	2	2.04%	2.22%
Clostridium Difficile	0	0.00%	3	3.06%	1.67%
Citrobacter	0	0.00%	2	2.04%	1.11%
Total	82	100.00%	98	100.00%	100.00%

The findings presented in Table 3 illustrate the distribution of all 82 isolates based on their respective sources of isolation. The chair in non-clinical visitor student classrooms exhibited the highest number of isolates, totaling 23, followed by the student's tablets, which contained 18 isolates. In contrast, the window handle demonstrated the lowest level of bacterial contamination, with only 3 isolates identified.

Table 3. Frequency of different bacterial species isolated from different sites of non-clinical student classrooms.

Bacterial species	Non-clinical classroom sites								
	disk	door handle	window handle	chair	floor	smartboard	tablet	switch	totally
Staphylococcus	1	3	0	5	0	1	3	1	14
streptococcus	1	1	1	2	0	0	2	1	8
psedumonas	0	1	0	2	0	0	2	1	6
Enterobacter	1	1	0	1	0	0	1		4
Bacillus	1	1	1	3	2	1	2	1	12

micrococcus	1	2	0	3	1	1	1	1	10
E. coli	2	3	1	4	1	1	4	2	18
Klebsiella	0	0	0	1	0	0	1	0	2
Acinetobacter	1	1	0	1	1	0	0	0	4
Salmonella	0	1	0	1	0	0	2	0	4
Total	8	14	3	23	5	4	18	7	82

The data presented in Table 4 indicates a notable increase in the number of isolates obtained from clinical visitor classrooms, rising by 98 isolates. Specifically, 29 isolates were detected on the surfaces of students' chairs, while tablets accounted for 22 isolates. Additionally, new strains contaminating classroom surfaces suggests a transfer of contamination from hospital environments to educational settings such as *clostridium difficile* and *citrobacter.*

Table 4. Frequency of different bacterial species isolated from different sites of clinical student classrooms.

Bacterial species	clinical classroom sites								
	Desk	Door handle	Window handle	Chair	floor	smartboard	tablet	Switch	Totally
staphylococcus	2	2	1	5	0	1	4	1	16
streptococcus	1	1	1	3	0	0	3	1	10
pseudomonas aeruginosa	1	0	0	3	1	0	2	1	8
enterobacter	0	1	0	2	1	0	1	0	5
Bacillus	2	1	1	3	3	1	2	1	14
micrococcus	1	1	1	2	2	1	1	1	10
E. Coli	2	4	1	6	0	2	4	1	20
acinitobacter	0	0	0	1	1	1	1	0	4
clostridium difficile	0	0	0	1	1	0	1	0	3
Citrobacter	0	0	0	1	0	0	1	0	2
Klebsiella	0	0	0	1	0	0	1	0	2
Salmonilla	0	1	0	1	0	0	1	1	4
Total	9	11	5	29	9	6	22	7	98

Biochemical tests for bacterial for identification.
The biochemical tests for gram positive bacteria and gram negative.

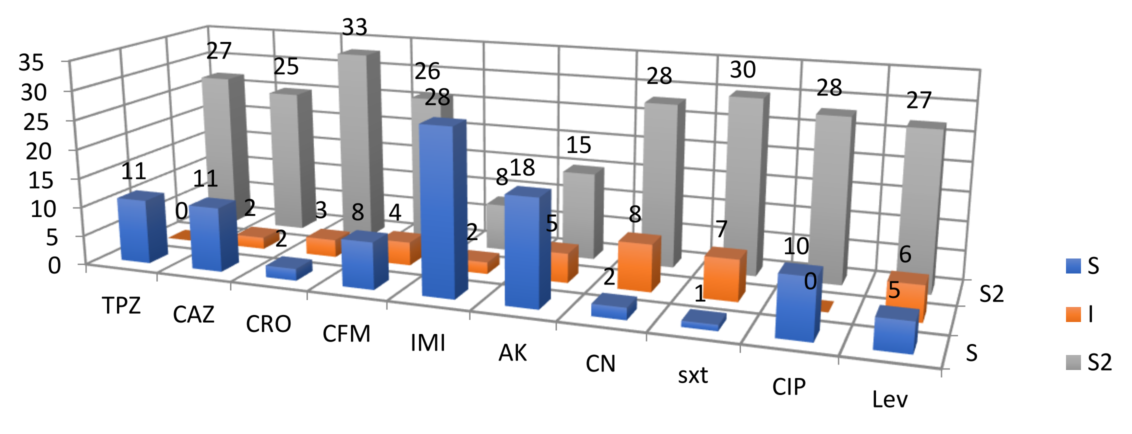
Table 5. biochemical test for bacteria identification.

Bacterial isolate	Catalase test	Oxidase test	O/F test	Coagulase test	DNAse test
Staphylococcus aureus	Positive	Negative	Fermentative	Positive	Positive
Micrococcus species	Positive	Negative	Oxidative		

Bacterial isolate	Catalase test	Oxidase test	O/F test	SIM	MR	VP	Citrate	Urease
E. coli	Positive	Negative	Fermentative	Negative(motile)	positive	negative	Negative	Negative
Citrobacter spp.	Positive	Negative	Fermentative	Negative (motile)	Positive	Negative	Positive	Negative
Enterobacter spp.	Positive	Negative	Fermentative	Negative (motile)	Negative	Positive	Positive	Negative

Antibiotic susceptibility pattern of identified bacteria.

VITEK result of Antibiotics susceptibility show that (imipenem(IMI) and Amikacin(AK) were found to be more sensitive to *E. Coli* Followed by tirapazamine (TPZ) and Ceftazidime (CAZ) While Carbapenem (CRO) and Trimothoprim/Sulfamethoxazole (SXT) were show high resist followed by Ciprofloxacin (CIP) and Levofloxacin (LEV) As show in Figure 1.



	TPZ	CAZ	CRO	CFM	IMI	AK	CN	sxt	CIP	Lev
S	11	11	2	8	28	18	2	1	10	5
I	0	2	3	4	2	5	8	7	0	6
S2	27	25	33	26	8	15	28	30	28	27

Figure 1. Antibiotic Susceptibility Pattern of E. coli

4. Discussion

The investigation of 96 swab samples into bacterial contamination within classrooms at Al-Kindy College of Medicine reveals critical insights regarding the hygiene practices and potential health risks associated with frequently touched surfaces in educational environments. The results indicate a significant presence of various bacterial isolates, with a total of 180 identified during the sampling process in both groups the staggering underscores the prevalence of microbial presence in these settings. The findings revealed that chairs exhibited the highest level of bacterial contamination (28.89%). This may suggest that chairs serve as prominent reservoirs for bacteria, likely due to the repeated contact from students seated for extended periods. Frequent hand contact with clothing and accessories may facilitate bacterial transfer, thereby increasing the risk of microbial cross-contamination among students. This study's findings are consistent with [20][21]. Tablets also demonstrated significant contamination levels, accounting for 22.22% of the isolates. Given the increasing reliance on technology in educational settings, this data highlights the critical need for rigorous disinfection protocols, particularly for shared electronic devices that are often touched by multiple users. In contrast, surfaces such as window handles (4.44%) and smart boards (5.56%) exhibited relatively lower levels of bacterial presence. This disparity may reflect less frequent contact and lower usage rates of these surfaces compared to chairs and tablets which is align with those of the University of Oregon's Institute for Health in the Built Environment [22].However, it's essential to note that even low levels of contamination could pose a risk, particularly in educational institutions where individuals may have varying levels of immunity or underlying health conditions. The bacterial strains distribution of was notably varied, with *Escherichia coli* (21.11%) emerging as the most prevalent Khan, F.M., and Gupta, R. and vishwanath, R. etal [23][24]. study showed that *Escherichia coli* is related with the coliform group and is a more accurate fecal contamination indicator than other coliform bacteria; its existence indicates the potential presence of harmful bacteria causing diseases [20], followed by *Staphylococcus* species (16.67%)[25]. The presence of other significant strains, including Bacillus sp., Micrococcus sp., and Pseudomonas aeruginosa, underscores the diverse microbial load in the environment this result are agreement with the findings of with Oleiwi [26], who also reported the presence of such bacteria on school surfaces. The identification of Clostridium difficile and Citrobacter species further raises concerns about the potential for serious infections.[27], also agree with us by showing both bacterial are mostly hospital-acquired, the presence of these bacteria on surfaces clear that students recently exposed to hospitals may carry and spread them to college classrooms surface.

Notably, the prevalence of bacterial strains varied between the two groups. Clinical visitor students demonstrated a 20.41% prevalence of *E. coli*, while *Staphylococcus* species accounted for 16.33% which revel of varying hygiene practices or exposure levels resulting from clinical activities. The antibiotic susceptibility testing revealed a concerning level of resistance among common pathogens. While imipenem and amikacin showed high sensitivity against *E. coli*, which the results agree with Khan et al.[28], the resistance to carbapenems and trimethoprim/sulfamethoxazole suggests a growing challenge in treating infections associated with this pathogen, agrement with Recent findings of Frontiers in Medicine [29] which highlight the importance of prudent antibiotic use in clinical settings. Based on these findings, we recommend increased emphasis on cleaning protocols, especially for high-touch surfaces like chairs and tablets. Education on personal hygiene practices among students with combined with Regular disinfection, may help reduce the bacterial load and their risks. While this study provides valuable insights into bacterial contamination in educational settings, it is limited by its sample size and the specific locations chosen for sampling. Future studies should explore additional areas of the campus. In conclusion, the results from this study are alarming and indicate a pressing need for enhanced cleaning protocols within the classrooms of Al-Kindy College of Medicine. Regular disinfection of commonly used surfaces, especially chairs and tablets, should be prioritized to mitigate the potential for bacterial transmission. Educational campaigns aimed at promoting hand hygiene among students could further reduce the risk of infection, particularly in shared spaces.

5. Conclusion

To lower health risks, we did microbial monitoring in our college classrooms. Because some organisms can cause serious diseases, it is important to follow daily cleaning and disinfection rules. The study found a lot of bacteria in classrooms with both clinical and non-clinical students. The classrooms with clinical visitors had more bacteria and a wider range of bacteria. Escherichia coli and Staphylococcus spp. were the most common isolates. Clostridium difficile and Citrobacter spp. were only found in the classroom of clinical students. Escherichia coli isolates were found to be highly sensitive to imipenem and amikacin, but resistant to carbapenem (CRO) and trimethoprim-sulfamethoxazole (SXT), according to antibiotic susceptibility testing.Maintaining a college environment free of harmful microorganisms for both faculty and students depends on the findings of this study. In order to reduce the risk of infections and the spread of resistant bacteria, strict infection control measures are required, which should include improved hygiene practices and regular environmental disinfection. This is further highlighted by the existence of antibiotic-resistant strains.

Recommendation

In this research, *Escherichia coli* were identified as the most prevalent bacterial pathogen isolated from college classrooms. Therefore, the following measures are recommended:

1. Enhanced Hygiene Practices: Enforce rigorous hand hygiene protocols, which include the use of alcohol-based hand sanitizers and frequent handwashing, especially in classrooms utilized by clinical visitor students who may encounter healthcare-associated pathogens.
2. Regular Environmental Disinfection: Develop a systematic cleaning and disinfection schedule for high-touch surfaces (such as desks, door handles, and equipment) in both classroom settings to mitigate bacterial contamination.
3. Infection Control Training: Offer training sessions for students, particularly those in clinical visitor, focusing on infection prevention and control strategies to reduce the risk of cross-contamination.
4. Antibiotic Stewardship: Encourage the judicious use of antibiotics to address the rise of resistant strains, particularly in light of the noted resistance of *E. coli* to Carbapenem (CRO), trimethoprim-sulfamethoxazole (SXT), ciprofloxacin, and levofloxacin.
5. Periodic Surveillance: Implement regular microbiological evaluations of classroom environments to assess bacterial load, diversity, and patterns of antibiotic resistance, facilitating prompt interventions.
6. Awareness Campaigns: Inform students about the dangers of bacterial transmission and the significance of upholding a clean and safe educational environment.
7. Further Research: Explore the origins of bacterial contamination in clinical training settings and assess the effectiveness of the control measures that have been put in place over time.

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