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Pathogen bacteria associated with multi-user computer keyboards and mouse in the administrative offices

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Abstract

Computer peripherals, particularly keyboards and mice, were among the most frequently touched surfaces in academic and shared environments and were rarely subjected to routine disinfection. This study aimed to investigate the microbiological contamination of these multi-user devices in the administrative offices of the Faculty of Science at Omar Al-Mukhtar University, to identify the bacterial isolates present, and to evaluate their antibiotic resistance profiles. A total of 160 swab samples were collected from keyboards and mice and cultured on selective and differential media, including Blood Agar, Mannitol Salt Agar, MacConkey Agar, and CzapekDox Agar. Microbial growth was observed on 56 plates, yielding 78 bacterial isolates. Gram staining revealed that 84.6% were Gram-positive and 15.4% were Gram-negative. No fungal growth was detected on CzapekDox Agar. The identified bacterial species included *Staphylococcus hominis*, *Staphylococcus lugdunensis*, *Staphylococcus capitis*, *Pseudomonas stutzeri*, *Pantoea* spp., *Klebsiellaoxytoca*, *Escherichia coli*, *Citrobacter* spp., and *Pseudomonas aeruginosa*. Antimicrobial susceptibility testing revealed varying patterns of resistance, with amoxicillin-clavulanic acid (50%) and cefoxitin (62.5%) showing the highest resistance

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rates. Notably, all isolates remained completely susceptible to imipenem, ceftazidime, levofloxacin, gentamicin, and ciprofloxacin. The results highlighted the critical need for improved hygiene practices by demonstrating that computer peripherals could serve as potential reservoirs for pathogenic bacteria.
Keywords: keyboard, mouse, pathogen bacteria, administrative offices, multi-user.

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الملخص

تُعدّ ملحقات الحاسوب، ولا سيما لوحات المفاتيح والفأرة، من أكثر الأسطح التي يتم لمسها في البيئات الأكاديمية والمشتركة، ونادرًا ما تخضع للتعقيم الروتيني. هدفت هذه الدراسة إلى تقيم التلوث الميكروبيولوجي لهذه الأجهزة متعددة المستخدمين في المكاتب الإدارية بكلية العلوم بجامعة عمر المختار، وتحديد العزلات البكتيرية الموجودة، وتقييم أنماط مقاومتها للمضادات الحيوية. جُمع ما مجموعه 160 عينة مسحة من لوحات المفاتيح والفأرات وزُرعت على أوساط انتقائية وتفاضلية، بما في ذلك أجار الدم، وأجار ملح المانيتول، وأجار ماكونكي، وأجار تشابك دوكس. لوحظ نمو ميكروبي على 56 طبقًا، أسفر عن 78 عزلة بكتيرية. كشف صبغ جرام أن 84.6% منها كانت موجبة جرام، و15.4% كانت سالبة جرام. لم يُرصد أي نمو فطري على أجار تشابك دوكس. شملت أنواع البكتيريا التي تم تحديدها: *Staphylococcus hominis*, *Staphylococcus lugdunensis*, *Staphylococcus capitis*, *Pseudomonas stutzeri*,

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Pantoea spp., *Klebsiellaoxytoca*, *Escherichia coli*, *Citrobacter* spp., and *Pseudomonas aeruginosa* وكشف اختبار حساسية المضادات الحيوية عن أنماط مقاومة متفاوتة، حيث أظهر الأموكسيسيلين–حمض الكلافولانيك (50%) والسيفوكسيتين (62.5%) أعلى معدلات المقاومة. والجدير بالذكر أن جميع العزلات ظلت حساسة تمامًا للإيميبينيم، والسيفتازيديم، والليفوفلوكساسين، والجنتاميسين، والسيبروفلوكساسين. وأبرزت النتائج الحاجة الماسة إلى تحسين ممارسات النظافة، إذ أظهرت أن ملحقات الحاسوب قد تكون بمثابة خزانات محتملة للبكتيريا الممرضة.

الكلمات المفتاحية: لوحة المفاتيح، الفأرة، بكتيريا ممرضة، متعددة المستخدمين، المكاتب الإدارية.

Introduction:

Computers are indispensable across educational, administrative, and healthcare settings, yet their role as pathogen reservoirs remains underappreciated. Frequent hand contact during operation, combined with structural complexities that impede thorough cleaning, creates ideal conditions for microbial persistence. Research indicates that approximately 80% of infections are transmitted via direct contact with contaminated surfaces, positioning shared computing devices as significant vectors for pathogen dissemination (Hamida*et al*., 2017). Keyboards present particular hygiene challenges due to their intricate design, which typically features over 101 keys with numerous interstices that harbor microorganisms and resist conventional disinfection (Koscova*et al*., 2018). These densely packed keys, recessed surfaces, and porous materials establish microenvironments that trap organic debris and moisture, thereby hindering routine cleaning and facilitating microbial retention (Bures*et al*., 2000). Consequently, multi-user keyboards in university settings exhibit significantly higher microbial loads than single-user devices, confirming that cumulative exposure intensifies contamination (Anderson and Palombo, 2009).

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Surveillance studies consistently report near-universal microbial colonization of keyboards and mice, with contamination rates reaching 100% across universities, hospitals, and offices (Rutala *et al*., 2006; Eltablawy and Elhifnawi, 2009; Hamida*et al*., 2017). Coagulase-negative staphylococci are the predominant isolates, detected in all sampled keyboards, followed by diphtheroids (80%), *Micrococcus* spp. (72%), *Bacillus* spp. (64%) Rutala*et al* . (2006). Additional clinically relevant pathogens, including *Salmonella* spp., *Klebsiella* spp., *Enterobacter* spp., *Pseudomonas* spp., and *Streptococcus* spp., are frequently isolated across diverse settings (Hamida*et al*., 2017). Fungal contaminants constitute approximately 17.6% of total isolates, with *Aspergillus* and *Penicillium* species predominating due to their environmental ubiquity and rapid surface colonization capacity (Edidiong*et al*., 2024; Nepomuceno*et al*., 2018; Nazeri*et al*., 2019). Transmission experiments further demonstrate that pathogens deposited on keyboards are transferred to users' hands in 92–96.7% of contact events, confirming these devices as dynamic reservoirs that actively circulate infectious agents (Ide *et al*., 2019; Ledwoch*et al*., 2021; Chukwudi*et al*., 2013; Anastasiades*et al*., 2009).

The persistence of pathogens on computer peripherals is exacerbated by their remarkable environmental resilience and adaptive microbial mechanisms. Clinically significant organisms, including methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci, remain viable on keyboard and mouse surfaces for 24–72 hours under typical academic conditions, providing ample opportunity for hand-mediated transmission (Neely and Maley, 2000). This extended survival is augmented by microbial adaptations such as extracellular polymeric substance (EPS) secretion, surface adhesion proteins, and quorum-sensing-mediated biofilm development, which collectively enable rapid colonization and confer resistance to standard cleaning protocols (Almuhanna*et al*., 2020; Kumar *et al*., 2019). Alarmingly, computer surfaces serve as reservoirs for multidrug-resistant pathogens. Oxacillin-resistant *S. aureus* (4%), vancomycin-resistant *Enterococcus* (12%), and non-fermentative Gram-negative rods (36%) have been documented, with MDR bacteria detected on

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43.3% of keyboards (Rutala*et al*., 2006; Olu-Taiwo*et al*., 2021). Isolates exhibit extremely high resistance to ampicillin (96.7%) and tetracycline (75.8%), alongside significant resistance to chloramphenicol, ciprofloxacin, and gentamicin (Olu-Taiwo*et al*., 2021; Neely *et al*., 2000).

Therefore, this study aimed to: assess bacterial contamination rates on multi-user keyboards and mice in the administrative offices of the Faculty of Science at Omar Al-Mukhtar University and identify isolated pathogens using conventional morphological-biochemical assays and the RENDER MA120 automated system, and to evaluate the sensitivity of isolated bacterial pathogens to antibiotics.

Materials and Methods

Study Site and Sample Collection

This study was conducted at the administrative offices of the Faculty of Science, Omar Al-Mukhtar University. A total of 160 swab samples were collected from shared computer keyboards and mice using a simple random sampling technique. Swabs were thoroughly rubbed over key surfaces and peripheral buttons, then transported to the laboratory under aseptic conditions for immediate processing.

Microbial Isolation and Purification

Collected swabs were directly inoculated onto MacConkey agar, Mannitol Salt agar, and Blood agar for bacterial isolation, and incubated at 37 °C for 24 h. Pure colonies were obtained using the standard streak-plate method (Sharma and Singh, 2015). For fungal isolation, CzapekDox agar supplemented with antibacterial agents was employed to inhibit bacterial overgrowth, followed by incubation at 25 °C for up to 10 days (Awe *et al*., 2013). Colony morphology, pigmentation, and hemolytic patterns were recorded for preliminary screening.

Biochemical Characterization and Automated Identification

Preliminary enzymatic profiling was performed using catalase and oxidase tests to guide downstream identification workflows (Forbes *et al*., 2007). Confirmed bacterial isolates were processed using the RENDER MA 120 automated system (Render Biotech, China), which integrates species identification and antimicrobial

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susceptibility testing (AST) in a single 120-well microtiter panel (24 wells for identification, 96 wells for AST). The system utilized colorimetric metabolic profiling and broth microdilution principles in accordance with manufacturer protocols and CLSI guidelines (CLSI, 2024).

Antimicrobial Susceptibility Testing and Interpretation

Minimum inhibitory concentrations (MICs) were determined for a standardized antibiotic panel using the broth microdilution method per CLSI M07 guidelines. Zone diameters/MIC values were interpreted as susceptible (S), intermediate (I), or resistant (R) based on the clinical breakpoint tables outlined in CLSI M100 (CLSI, 2024). All assays were performed under strict aseptic conditions, and quality control strains were included to validate media performance and automated system accuracy.

Results and Discussion:

A study was conducted at Omar Al-Mukhtar University to evaluate microbial contamination on computer mice and keyboards. Out of 160 culture plates inoculated with samples from these surfaces, 56 plates (35%) showed microbial growth after incubation, 78 microbial isolates were obtained. Gram staining revealed that the majority of isolates were Gram-positive 66 isolates (84.6%), while 12 isolates (15.4%) were Gram-negative. Morphologically, 44 isolates were cocci and 34 were bacilli.
In terms of the distribution of growth in cultural media, Blood Agar supported the highest growth (54 plates), followed by Mannitol Salt Agar (16 plates) and MacConkey Agar (8 plates). No growth was observed on CzapekDox Agar, indicating the absence of fungi in the sampled environments under the study conditions. These findings were consistent with a substantial body of research conducted in clinical, educational, and public settings, which repeatedly demonstrated that high-touch electronic devices carried significant microbial burdens (Al-Ghamdi*et al*., 2011; Anderson and Palombo, 2009; Ide *et al*., 2019).

The analysis of the samples using the Render MA 120 system identified several bacterial species, including *Klebsiellaoxytoca*, *Escherichia coli*, *Citrobacter*spp, and *Pseudomonas aeruginosa*.

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Their presence on keyboards and mice served as a clear indicator of inadequate hand hygiene following restroom use, a known source of cross contamination (Podschun and Ullmann, 1998; Kaper*et al*., 2004). The following table (1) summarized the morphological characteristics and properties of the bacterial isolates.

Table (1): identification of isolated bacteria by using the RENDER MA 120 system

Bacteria and characteristics	*K. oxytoca*	*E. coli*	*K. oxytoca*	*Citrobacter sp*	*P.aeruginosa*
Colony morphology	Circular	Circular	Circular	Circular	Irregular
Colony elevation	Convex	Convex	Convex	Convex	Flat
Colony margin	Entire	Entire	Entire	Entire	Spreading edge
Colony surface	Smooth	Smooth	Smooth	Smooth	Smooth
Colony size	Medium	Large	Medium	Small	Large
Growth amount	Weak	Moderate	Weak	Weak	Weak
Odor	Present	Present	Present	Present	Present
Motility	Motile	Motile	Motile	Motile	Motile
Gram stain	(-)	(-)	(-)	(-)	(-)
Media	Macconkey agar	Macconkey agar	Macconkey agar	Blood agar	Blood agar
Pigment production	No pigment	No pigment	No pigment	No pigment	Green
Catalase test	(+)	(+)	(+)	(+)	(+)
Oxidase test	(-)	(-)	(-)	(-)	(+)
Pathogenicity	Opportunistic pathogen (Podschun and Ullmann, 1998)	Pathogenic and non-pathogenic strains (Kaper*et al*., 2004)	Opportunistic pathogen (Podschun and Ullmann, 1998)	Opportunistic pathogen (Adeolu*et al*., 2016)	Opportunistic pathogen (Gellatly and Hancock, 2013)

Most colonies were circular and convex, with smooth surfaces and entire margins, except for *P. aeruginosa*, which exhibited irregular, flat colonies with undulate edges. Colony sizes ranged from small to large, and growth intensity varied from weak to moderate. All isolates produced a noticeable odor and were Gram-

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negative, Motility was observed in all isolated. All five bacterial isolates were Gram-negative, as determined by Gram staining. The catalase test yielded positive results for all isolates, indicating their ability to break down hydrogen peroxide. The oxidase test was negative for all isolates except *P. aeruginosa*, which tested positive. These findings supported the preliminary identification of isolates and aligned with their biochemical profiles (Ryan and Ray., 2018).

The results of the antibiotic susceptibility testing revealed varying levels of bacterial resistance. The highest resistance rate (60%) was observed against the following antibiotics: Gentamicin, Tobramycin, Tetracycline, Cefepime, Ceftriaxone, and Cefotaxime. This was followed by a moderate resistance rate (20%) to Aztreonam and Minocycline. No resistance was detected against the remaining antibiotics tested, which included: Ceftazidime, Chloramphenicol, Piperacillin, Ticarcillin/Clavulanic Acid, Trimethoprim/Sulfamethoxazole, Piperacillin/Tazobactam, Meropenem, Levofloxacin, Imipenem, Ampicillin/Sulbactam, Amikacin, Ciprofloxacin, Cefoperazone, Colistin, and Polymyxin B. These findings indicated selective resistance patterns among the tested isolates. And the results indicated that the highest level of antibiotic resistance was observed in *Citrobacter* spp., with a resistance rate of 34.7%, followed by two strains of *K. oxytoca*, which exhibited a resistance rate of 26%. This aligned with the growing prevalence of Enterobacteriaceae producing extended-spectrum beta-lactamases (ESBLs) (Pitout and Laupland, 2008). In contrast, both *E. coli* and *P. aeruginosa* showed no resistance to the tested antibiotics, suggesting their susceptibility to the current antimicrobial agents. These findings were summarized in Table (2).
The discovery of potentially harmful and multidrug
resistant bacteria on computer accessories brought attention to the part fomites play inthe spread of illnesses linked to healthcare and acquired in the community. (Wilson *et al*., 2006). In clinical and academic settings where computers were utilized for extended periods without routine cleaning, these devices could act as silent vectors for microbial dissemination. This was particularly relevant at institutions such as Omar Al-Mukhtar University (Ide *et al*., 2019). The findings of this investigation were consistent with global

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reports on the microbial burden of electronic equipment. For instance, Al-Ghamdi *et al*., (2011) reported comparable levels of contamination in public and hospital environments, while Belihun *et al*. (2015) emphasized the importance of regular disinfection protocols in university hospitals.

It was also important to acknowledge that the absence of growth on CDA did not necessarily indicate the complete absence of fungal spores. Spores might have been present in a latent state but failed to germinate due to suboptimal culture conditions, competition from bacterial flora, or the requirement for specialized media or extended incubation periods (up to 14 days) for slow-growing species (Samson *et al*., 2019).

Table (2): Antimicrobial susceptibility profiles of clinical isolates of *K. oxytoca* (two distinct isolates), *E. coli*, *Citrobacter* spp., and *P.aeruginosa*, as determined by minimum inhibitory concentration (MIC) testing. MIC values (in µg/mL) were interpreted according to current clinical breakpoints, with corresponding susceptibility categories: Susceptible (S), Intermediate (I), or Resistant (R).

Table (2): Antibiotics susceptibility for *Klebsiella oxytoca, E. coli, Klebsiella oxytoca, Citrobacter SP, Pseudomonas aeruginosa*

Antibiotics	MIC µg/ml	*K. oxytoca*	MIC µg/ml	*E. coli*	MIC µg/ml	*K. oxytoca*	MIC µg/ml	*Citrobacter sp*	MIC µg/ml	P. aeruginosa	Antibiotic resistance rate
GEN	>16	R	<=2	S	>16	R	>16	R	<=2	S	60%
TOB	=16	R	<=1	S	=16	R	=16	R	<=1	S	60%
CAZ	=8	I	=2	S	=4	S	=8	I	<=1	S	0%
AZM	<=4	S	<=4	S	<=4	S	=32	R	<=4	S	20%
TET	>=16	R	<=4	S	>=16	R	>=16	R	-	-	60%
C	<=8	S	<=8	S	<=8	S	<=8	S	-	-	0%
PIP	<=8	S	<=8	S	<=8	S	<=8	S	<=8	S	0%
MIN	=8	I	<=4	S	=8	I	=16	R			20%
TIM	<=8/2	S	<=8/2	S	<=8/2	S	<=8/2	S	<=8/2	S	0%
FEP	=16	R	<=2	S	=16	R	=16	R	<=2	S	60%
SXT	<=2/38	S	<=2/38	S	<=2/38	S	<=2/38	S	-	-	0%
TZP	<=4/4	S	<=4/4	S	<=4/4	S	<=4/4	S	<=4/4	S	0%
MER	<=1	S	<=1	S	<=1	S	<=1	S	<=1	S	0%
LEV	<=2	S	<=2	S	<=2	S	<=2	S	<=2	S	0%
IMP	=2	I	<=1	S	<=1	S	=2	I	<=1	S	0%
SAM	<=8/4	S	=16/8	I	<=8/4	S	=16/8	I	-	-	0%
AMK	=32	I	<=4=1	S	=32	I	=32	I	<=4	S	0%
CRO	=8	R	<=1	S	=8	R	=32	R	-	-	60%
CIP	=2	I	<=1	S	<=1	S	<=1	S	<=1	S	0%
CTX	=8	R	<=1	S	=8	R	=32	R	-	-	60%
CFP	<=4/2	S	<=4/2	S	<=4/2	S	<=4/2	S	<=4/2	S	0%
COL	-	-	-	-	-	-	-	-	<=2	S	0%
PMP	-	-	-	-	-	-	-	-	<=2	S	0%
The rate of bacterial resistance to antibiotics	26%		0%		26%		34.7%		0%		

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Conclusion:

In summary, this study provided robust evidence that computer peripherals in educational settings served as significant sources of microbial contamination, particularly involving opportunistic and multidrug-resistant pathogens. The findings highlighted the necessity of institutional hygiene programs; accordingly, we recommend that universities enforce routine disinfection protocols, promote hand hygiene awareness, and integrate cleanliness standards into official facility policies, alongside periodic microbial surveillance. Future research should investigate the efficacy of various disinfectants, assess the impact of intervention programs on microbial load reduction, and evaluate whether antimicrobial-coated surfaces could help prevent contamination.

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