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Accumulation of Microbial Contamination on Keyboards and Mobile Phone Devices in the University Community

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THIS study was conducted to determine the level of contamination of, and whether there were any bacteria or yeasts on, the mobile phones of staff members and students, as well as on computers with touch displays and keyboards. Amount of 100 samples, being the total number of devices screened, both mobile phones and computer keyboards. All samples obtained from either mobile phones or keyboards showed various species of haemolysis microbes: beta haemolysis (β), alpha haemolysis (α), and gamma haemolysis (γ). A sample of 50 mobile phones and 50 computer keyboards were tested for the presence of coliform bacteria, *Salmonella* and *Shigella* strains, *Staphylococcus* sp., and yeasts. In regard to the percentages of microorganisms found in mobile phone samples, 55% of the total bacteria counted on contaminated devices came from multi-bacterial species, while no considerable contamination was detected by yeasts. The contamination levels of mobile phone samples differed depending on the microbial load found on the samples. Similarly, various microorganisms were detected on the tested computer keyboards, with 50% of bacterial identified, with 25% being coliform bacteria, 16% *Staphylococcus* sp., 5% *Salmonella* and *Shigella* strains, and 4% yeasts. The infection level of computer keyboard samples again differed depending on the microbial load of the samples. The findings reveal that the infection rate for isolated organisms was relatively low. Lack of certain hygiene conditions, such as a protective cover, and use of public touchscreen laptops, keyboards and mobile phones without considering hygiene, are risk factors for microorganism contamination on these devices.

Keywords: Mobile contamination, Keyboard contamination, Microorganisms transmission, public health, Devices hygiene, Community healthcare.

Introduction

Since the beginning of the global technical revolution, the daily use of electronic devices has become widespread, both at work and on the personal level. Consequently, devices have become high-touch surfaces for people, who directly interact with and are close to them throughout the entire day. There is nothing to prevent these devices from being a source of bacteria gathering and transmission of infection from one person to another, especially if they are used by multiple people. Some accumulations of bacterial species on devices may be harmless or may not reach the point of being pathogenic. On the other hand, the devices may be host to harmful microbes that could be pathogenic or highly virulent. It is commonly known that there are three major factors in the outbreak of infectious diseases: 'pathogen', 'host', and 'environment' Infectious disease occurs when these factors are imbalanced. Apparent infection is associated with clinical symptoms (e.g., fever, redness, pus, etc.). A latent infection is a silent infection that persists for an extended period. An infection source is a place or organism in which pathogens can be transmitted to the host directly or indirectly; the places where pathogens live and accumulate, and where

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infectious agents acquire pathogens, are known as ‘reservoirs’. The colonized of an infection can be a person who does not show symptoms and acts as a potential source of infection to others; they can be either a temporary carrier (during an incubation period or convalescence period) or a chronic carrier (over a long-term or lifelong period). The infection transmission route is through contact with pathogens containing microorganisms or inanimate vectors contaminated with infectious substances in the surrounding environment. This can be by direct contact, such as hands, or indirect contact, such as contaminated animate or inanimate vectors. In general, people frequently have a false sense of security in certain areas because they believe that pathogenic bacteria are exclusively found in research labs, hospitals, and clinics. Health issues may result from ignorance about the locations where germs might be found, and contact between hands and objects or other hands accounts for a high proportion of infection transmission (Pittet et al., 2009). Bacteria can be found practically anywhere, including in humans as well as in the soil, water, air, and food. It is well known that inanimate environments can harbour microbes. Generally, bacterial flora is spread within the human body and plays an important role in influencing the health of the host. It is found in various organs, including the skin, digestive system, genitourinary system, and the respiratory system. Some of these organisms are aerobic and others are anaerobic. This natural flora is transmitted with other pathogenic bacterial strains from one person to another, especially if their numbers increase, either through direct contact or through surfaces. Examples of the major gram-positive human pathogen bacteria: *Staphylococcus aureus* sp., *Streptococcus pneumoniae*, *Clostridium difficile*, *Enterococcus* facials, and spore-forming rods (*Bacillus* sp.). Among the gram negatives, the major pathogen bacteria are: *Klebsiella pneumoniae*,*Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Neisseria gonorrhoeae*, *Campylobacter jejune*, *Escherichia coli*, *Salmonella enterica* , *Shigella flexneri* and undetectable gram stain such as *Mycobacterium tuberculosis* (Carvalho et al., 2022). The risk in this type of transmission is exacerbated by the spread of bacterial strains, such as methicillin-sensible (MSSA) and methicillin resistant *S. aureus* (MRSA), from contaminated surfaces (Cave et al., 2021). In public communities, bacteria-contaminated surfaces are the primary source of indirect transmission of infection. Inanimate surfaces, such as devices, can also be important and might be touched at high frequencies, allowing transmission to others. For example, bacteria can spread through use of equipment such as keyboards for computers or mobile phones (Koscova et al., 2018; Verran, 2012). These microbes might be ingested by humans or transferred to food, where bacteria could continue to proliferate. Additionally, the survival of different pathogens on the same surface can be impacted by the creation of biofilm by one bacterial agent (Tagoe et al., 2011). Many pathogens can live for a long time after being deposited on surfaces if they are not removed by sterilisation or disinfection processes, and may remain infectious on surfaces for weeks after being exposed, depending on the environmental conditions (Kramer et al., 2006). The importance of a decontaminated surface environment is shown by the low rate of infection seen when efficient disinfection is implemented (Hayden et al., 2006; Dancer et al., 2009). In the modern world, mobile phones have been in personal use for a long time and have come to be associated with infection gateways, such as the external respiratory system, ears, eyes and hands, which are the most common entry points for infections. Transferred microbes have the potential to lead to opportunistic infections and mild to chronic disease, particularly in persons with immunodeficiency. Even so, mobile devices are among the most important accessories for both social and professional life. They are regularly handled and held very close to the person using it, and can be used by multiple people, and are typically kept in bags or pockets (Smith & Sheridan, 2006). Mobile phone devices have been shown to be reservoirs for germs and can transmit infectious diseases through frequent hand contact (Kilic et al., 2009;

Brady et al., 2006). Additionally, mobile phones may serve as a mobile reservoir for microbiological pathogens (Koroglu et al., 2015). Patients, visitors, and healthcare professionals frequently use mobile phones in hospitals, making it one of the most common sources of nosocomial (hospital-associated) infections (Akinyemi et al., 2009). One study found that the harmful impacts of microorganisms are present on almost 40% of the mobile phones used by hospital patients and 20% of the mobile phones used by hospital staff (Tagoe et al., 2011). Another of the most popular user interfaces is the computer keyboard. The numerous separate keys on the keyboards make cleaning them challenging and time consuming, especially when used by more than one person (multiuser devices) in public places. The majority of owners frequently fail to disinfect and clean the keyboard, for a variety of reasons. Computer keyboards have also been mentioned as a possible reservoir for pathogens, along with mobile phones (Weber et al., 2005; Nepomuceno et al., 2018;

Cave et al., 2021). Computers are not constantly disinfected, thus there is a chance that infecting germs could spread through computer use. The keyboard and mouse on a computer represent a particularly dynamic environment, and the bacteria on hands, skin, fingernails, and other body parts are likely to spread new bacteria to the keyboard (Ide et al., 2019). Particularly in places where many people come and go, like hospitals, schools, or offices, there are likely to be people carrying germs and infections; through them, new bacteria are spread, and these bacteria will eventually land on the keyboard, either through the air or by physical touch. Computer keys may be contaminated by microbes for two reasons: improperly executed hand hygiene and unclean surfaces. As a result of either kind of contamination, potential diseases may be indirectly transmitted. Bacterial infection can also result from eating close to computer keyboards, as food residue from spills can get between the keys and lead to the growth of millions of bacteria. In addition, dust can also contains and encourage the growth of various microbes already present on the keyboard (Wu et al., 2022)

For example, in a tertiary care hospital setting, the microbial contamination of mobile phones and the hygiene practices of medical students and doctors were examined. Samples were collected from 259 mobile phones belonging to medical students and doctors across different clinical departments. The majority of the mobile phones owned by these individuals were found to be contaminated with bacterial pathogens (Ahmad et al., 2021). The characteristics of mobile phones used by employees, students, and healthcare professionals have been studied (Koslowski et al., 2021). The correlation between the number and types of microorganisms present on the phones was also investigated. The study considered the sociodemographic information data on mobile phone usage in addition to microbiological load determination. The bacterial growth in mobile phones was estimated at 68%, with the most abundant isolated bacterium being negative coagulase *Staphylococcus* sp. (47%). Specifically, more than 100,000 CFU/mL of bacteria were found on the mobile phones of residents (26.5%) and undergraduates (23.5%). Thus, frequent mobile phone usage during work could be linked to the prevalence of contaminated devices. In addition, another study showed the presence of microorganisms on mobile phones owned by final-year medical students at the Makerere University College of Health Sciences (Lubwama et al., 2021). The authors also evaluated the students' infection prevention and control (IPC) practices related to mobile phone hygiene in a hospital setting. The study identified microorganisms on the mobile phones of 79 medical students and conducted antimicrobial susceptibility tests. The results indicated that 88.6% of the mobile phones were contaminated with at least one organism. In another study, randomly selected mobile phones from teachers, students, and staff collected and screened (Basnet et al., 2022). The results showed that 100% of the phones were contaminated with microorganisms. The identified bacterial strains included *S. aureus*, coagulase-negative *Staphylococci* (CoNS), *Bacillus* sp., *K. pneumoniae*, *E. coli*, and *P. aeruginosa*. The study highlighted mobile phones as potential sources of modern-day contamination, posing potential health risks. In different departments of two referral hospitals in Uganda, investigated the incidence of pathogenic bacterial contamination on healthcare workers' mobile phones and their role as potential vehicles for the transmission of antimicrobial-resistant bacteria (Tusabe et al., 2022). Swab samples were collected from the mobile phones of participants in different hospital departments, followed by bacterial culture and antimicrobial susceptibility testing. The study revealed a 93% prevalence of bacterial contamination on healthcare workers' mobile phones. Various organisms were isolated, including *E. coli*, *Micrococcus* sp., *Staphylococci* (CoNS), and *Bacillus* sp., with 45% showing multidrug resistance. The study emphasised the need for disinfection protocols for mobile phones and underscored the importance of hand hygiene during patient encounters, especially when healthcare workers handle phones. In another study, the efficiency of disinfection of mobiles phone was estimated, with swab samples collected from mobile phones before and after disinfection (Sadeeq et al., 2021). The results showed an 81% microbial contamination rate in swab samples. The bacterial strains isolated were: *Staphylococci* (CoNS), estimated at 69%, of the total samples, while the fungal strain *Aspergillus niger* was found by 13%. It was shown overall that bacterial strains were the most common microorganisms identified. It was also found that the usage of alcohol-based disinfection methods for mobile phones played an effective role in decreasing the level of microbial load on phone surfaces. Similar results were reported with an overall prevalence of 94.2% for mobile phone contamination with one or more bacterial strains; of these, 58.8% of the total samples were *Staphylococci* (CoNS), 14.4% were *S. aureus,* and 6.9% were *Klebsiella* sp. The study concluded that mobile phones are frequently contaminated with nosocomial pathogens (Bodena et al., 2019). The diversity of microbial genetic signatures found on mobile phones belonging to hospital medical staff has also been studied (Olsen et al., 2022). In this study, 26 mobile phones were swabbed and DNA extraction was performed for microbial profiling. The results showed contamination with various microbes, including bacteria, fungi, protists, viruses, and bacteriophages. Additionally, the study revealed that 46% of participants used their mobile phones in the bathroom, suggesting that the devices could serve as vectors for microbial dissemination and nosocomial diseases. It is known that infectious disease control can be achieved by following healthcare restructures, such as infectious disease surveillance including monitoring factors related to the source of infection, infection route, and susceptible host. This should involve systematic and continuous collection and analysis of data related to the occurrence of infectious diseases, data on vectors and carriers, and distributing the results promptly to relevant individuals to prevent and prevent infectious diseases, as part of management processes. In addition, infectious agent measures should include isolation and identification of disease-causing pathogens at an early stage and taking appropriate measures to isolate from the source of infection; removal of pathogens from the hospital through appropriate disinfection and sterilisation methods; eradicating vectors such as mosquitoes and flies; and treatment with microbial agents to eliminate infectivity. Countermeasures against infection routes should also be taken, such as distancing between people, wearing gloves, masks, goggles, etc., removal of contaminated items, and frequent sterilisation. To counter air transmission, wearing of N95 masks, ventilation, and use of negative pressure rooms are effective. Finally, susceptible host countermeasures include reducing the number of susceptible hosts at high risk of infection and increasing the level of population immunity through vaccination.Top of Form

Materials and Methods

Samples population and preparation

For this study, the samples were prepared by using disposable sterile cotton swabs wet with sterile saline (Nazeri et al., 2019). Swabs were taken from the surfaces of 50 mobile phones and 50 computer keyboards used as public devices. The samples were voluntarily collected from the devices of employees and student from the university community of King Abdulaziz University in Saudi Arabia. Samples were taken by thoroughly spinning a cotton swab over a 1-cm^2 area on the touch screen of the mobile phone. The same procedure was used to fully wipe out both the space between the keys and individual keys on the computer device keyboards, focusing on high-touch keys such as the space key, and enter key. After sampling, swabs were inserted into the normal saline, and immediately transferred to the laboratory to complete the experiment. It was assumed that the hands play a critical role in microbial transfer dynamics (Edmonds-Wilson et al., 2015). In addition, the assumption of dealing with devices as fomites for bacterial infections was adopted, as the main purpose of the current study.

Determination of total microbial count

The growth medium of total bacterial count was supported by the non-fastidious nutrient agar HiMedia M001 (28g/L) using direct plating technique. The number of estimated colony forming units (CFU/ml) for each sample subjected to pour plate (PP) method was then counted using the colony counter and recorded as (CFU/ml). Isolated colonies on agar plates using the surface spread (SS) method were counted using the YUCHENGTECH Microbial Bacterial Colony Counter Bacterial Quantity Counting Machine Instrument Microbiology Tester, and recorded in order to counted the total number of bacteria in 1 ml of sample (Devika et al., 2021; Selim & Abaza, 2015).

Microbial pathogens screening and quantification

To isolate microbial pathogens, various selective media were used. A 51.50g/L amount of MacConkey Agar w/o CV w/ 0.15% bile salts (HiMedia M008) was used for isolating coliform organisms. In order to isolate and enumerate the *Staphylococci* sp., the Baird Parker Agar

Base (HiMedia M043S) used. A 65g amount was suspended into 950ml of distilled water and heated to boiling to dissolve the medium completely. After autoclaving, 50ml of EggYolk Tellurite emulsion FD046 was added and the medium mixed properly and then plated into sterile petri plates. The isolation of *Salmonella* sp. and some *Shigella* sp. species was carried out by using SS agar (salmonella shigella agar) M108 by dissolving 63.02g/L in distilled water, heating to boiling to dissolve the medium completely, and sterilising by autoclaving at 15 lbs pressure (121^{o}C) for 15 minutes. The blood agar medium used in the experiments was prepared using Tryptone Soya Agar (HiMedia M1968) mixed with 5% of defibrinated sheep erythrocytes to detect the haemolytic activity bacteria. Rose Bengal Agar Base (HiMedia M842) was used for isolating and enumeration for yeasts. This was prepared by suspending 31.55g/L distilled water and heating to boiling to dissolve the medium completely, and then sterilised by autoclaving at 15 lbs pressure (121^{o}C) for 15 minutes. Bacteria plates were incubated aerobically at 37 $^{\circ}$C for 24 to 48 hours, while yeasts were incubated in aerobic conditions at 25–30 $^{\circ}$C for 48 to 72 hours.

Identification of isolates

Various biochemical reactions were used to identify the bacteria that were isolated. The ability of the bacteria to produce the enzymes catalase and oxidase, as well as the capacity of the members of the Enterobacteriaceae family to ferment the sugar series, were assessed using biochemical tests. Tests were also conducted for the detection of urease activity and H_2S generation. Furthermore, the cultivation process makes it possible to recognise colonies by their distinctive growth patterns, while acquired pure bacterial cultures are diagnosed using microscopic examination and culture examinations. Gram staining was used to determine the shape and particular arrangement of observed pure isolated colonies and to distinguish between gram-positive and gram-negative bacteria (Koscova et al., 2018).

Statistical analysis

Data were analysed such that counts and percentages could be used for describing and summarising qualitative data.

Results

The present work was conducted on 100 samples, being the total number of devices screened, consisting of 50 mobile phone samples as 50% of the total device samples and 50 computer keyboard samples as the remaining 50% of the total device samples. It is commonly known that both mobile phones and computers are used heavily in different communities, especially in the educational community, though they are cleaned periodically and have covers. The current work revealed that some of the isolated bacterial contaminants contained a mix of more than one organism. As shown in Figure 1, the preliminary morphological results using blood agar showed that the most of mobile phone samples contained multiple haemolysis bacterial species. Figures 1-A, B, and C show beta haemolysis (β), alpha hemolysis (α) and gamma haemolysis (γ), respectively. Some of the isolated species were initially identified *Streptococcus* sp. and *Staphylococcus* sp.. Accordingly, there is a high possibility of the presence of pathogens on the screened mobile phone devices.

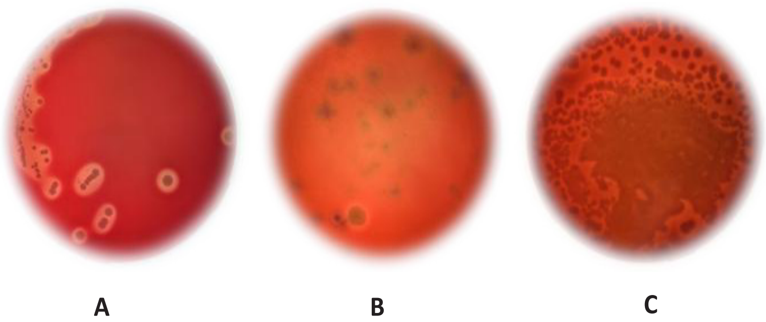

Fig.1. Different types of blood haemolysis bacterial strains isolated from tested mobile phones: (A) beta haemolysis (β), (B) alpha haemolysis (α), and (C) gamma haemolysis (γ).

The same results were obtained when using a blood agar medium on computer keyboard samples, as shown in Figures 2A, B, and C (beta haemolysis (β), alpha hemolysis (α), and gamma haemolysis (γ)), respectively. Various strains have emerged that have haemolytic reactions on a blood agar plate. After conducting identification tests for the isolated strains, the presence of the same strains as previously mentioned was identified, which indicates that there is a large presence of pathogens on the computer devices used and, thus, they can be transmitted between users of these devices.

The results of the current study revealed that some of isolated bacterial contaminants were a mix of more than one microorganism. A total of 50 mobile phones were investigated at the same time and divided into two sets, each set containing 25 samples (as shown in Figures 3A and 3B). On the screened mobile devices in both sets, 55% of the total bacteria counted on contaminated devices were microorganisms consisting of multi-bacterial species. Then, coliform bacteria represented 24%, and *Staphylococcus* sp.was also detected and estimated to represent 13%. The results demonstrated that *Salmonella* and *Shigella* strains accounted for ٪٥, while the least detected organisms were yeasts, at 3%.

The results also showed that there was a difference between samples in regard to the effect of exposure, based on the microbial load of the sample. The infection level, depending on the microbial load on mobile device, indicated that 74% of total bacterial count, 62% of coliform bacteria, and 6% of *Staphylococcus* sp. samples were found to be infected at a considerable level of (>100) colonies. In the remaining samples, it was found that 26% of total bacterial count, 38% of coliform bacteria, 94% of *Staphylococcus* sp., 100% of *Salmonella* and *Shigella* strains, and 100% of yeastswere found to be infected at a low level of (<100) colonies.

Similarly, the results revealed that some of the isolated bacterial contaminants from the tested computer keyboards contained a mix of various microorganisms. The investigated keyboards were also separated into two sets, each containing 25 samples. The microorganisms found were classified into: 50% total bacterial count, 25% coliform bacteria, 16% *Staphylococcus* sp., 5% *Salmonella* and *Shigella* strains, and 4% yeasts, as presented in Figures 4A and 4B.

Of these sets, 78% of the total bacterial count, 74% of coliform bacteria, and 4% of *Staphylococcus* sp. samples were found to be at a considerable level of infection (>100). The remaining samples (22% of total bacterial count, 26% of coliform bacteria, 96% of *Staphylococcus* sp., 100% of *Salmonella* and *Shigella* strains, and 100% of yeasts, were found to be infected at a low level (<100). In other words, the majority of the microorganism infections on mobile phones and computer keyboards were at a low level, yet a significant number of total bacterial count, coliform bacteria, and *Staphylococcus* sp. infections were at a considerable level. This suggests that mobile phones and computer keyboards can be a source of infection, but the risk of infection is generally low. However, people who are at a higher risk of infection, such as those with a weakened immune

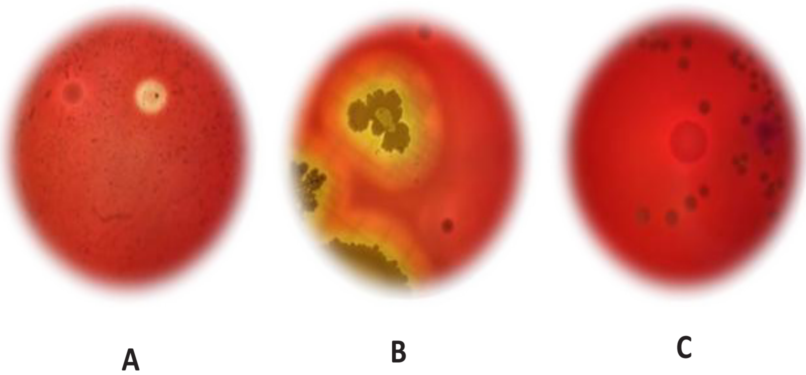

Fig. 2. Different types of blood haemolysis bacterial strains isolated from tested computer keyboards: (A) beta haemolysis (β), (B) alpha haemolysis (α), and (C) gamma haemolysis (γ).

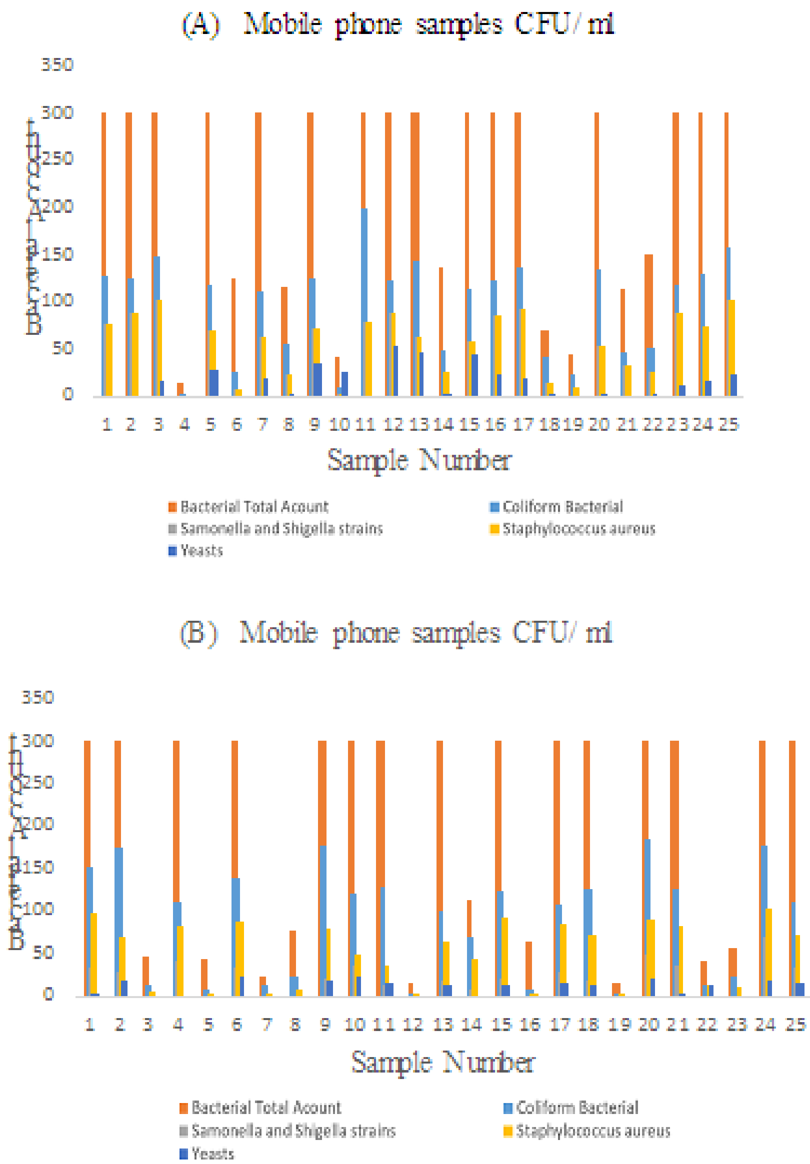

Fig. 3: Total count of isolated bacteria (CFU/ml) included: coliform bacteria, Salmonella and Shigella strains, Staphylococcus sp. and yeasts. Figure A shows the first set of screened mobile phones, which included 25 samples, while Figure B shows the results for the second set of 25 screened mobile phones. Figures A and B indicate that 55% of total samples contained multi-bacterial content, made up of 24% coliform bacteria, 13% Staphylococcus sp., 5% Salmonella and Shigella strains, and 3% yeasts.

system, should take precautions and clean their mobile phones and keyboards regularly.

Discussion

Multidrug-resistant bacteria that cause infections are a growing problem. In particular, mobile phones and keyboards used by students and university employees could act as vectors for the transmission of microorganisms. These devices are used frequently in university settings, where people who are unhealthy or unwell may be more susceptible to infection (Di Mario et al., 2022; Singh et al., 2010). In this study, 50 mobile phones and 50 computers belonging to the university community were tested for bacterial and yeastscontamination. All of the devices were found to be contaminated with varying levels of bacteria and yeasts. In addition, each device contained at least one type of organism. These findings confirm that mobile phones and laptops could be a source of microbial infections in university settings. Thus, it is important for

Fig. 4: Total count of isolated bacteria (CFU/ml) included: coliform bacteria, Salmonella and Shigella, Staphylococcus sp., and yeasts. Figure A shows the first set of screened keyboards, which included 25 samples, while Figure B shows the second set of screened keyboards, with a further 25 samples. Figures A and B indicated that 50% of the total samples contained multi-bacterial content, consisting of 25% coliform bacteria, 16% Staphylococcus sp., 5% Salmonella and Shigella strains and 4% yeasts.

students and employees to take steps to clean and disinfect their devices regularly to help prevent the spread of infection. It is reported that high percentage of the specimens that tested positive for microbial culture came from the investigated mobile phones (Olsen et al., 2020); 83% of tested mobile phones in other study revealed bacterial or/and fungal contamination (Bs et al., 2018). In another investigation, scientists discovered that 95% of mobile phones had some sort of bacterial contamination, many of which were antibiotic resistant. Additionally, the researchers were able to demonstrate through testing the participants' hands that a sizeable number of bacteria were transferred from their hands to their phones and vice versa, with roughly 30% of the bacteria on the phones ending up on the owners' hands. Another study investigated the microbial communities on the touch screens of smartphones to identify if there was any overlap with the skin microbiome samples taken directly from the owners of the smartphones (Meadow et al., 2014). They used a technique called 16S rRNA gene sequencing to identify the bacterial species present on the touch screens of smartphones and on the fingertips of the smartphone owners, and found that 22% of the bacterial species on the fingertips were also present on the phones. This suggests that the phones were picking up bacteria from the fingertips of the owners, and that these bacteria were then being transferred to other surfaces. An investigated study showed the bacterial contamination of parents' mobile phones and the effectiveness of an antimicrobial gel in preventing transmission to the hands (Beckstrom et al., 2013). They found that all mobile phones showed evidence of bacterial contamination. They then used a different technique, called culture, to identify the bacterial species present on the hands and phones of parents. They found that all of the phones showed evidence of bacterial contamination, and that the most common bacteria found on the phones were *S. aureus* and *Streptococcus pyogenes*. These bacteria are both known to cause infections, so the findings of this study suggest that mobile phones can be a source of infection. Additionally, 22% of people who had the same bacteria on their hands before applying antimicrobial gel had no growth on their hands afterward, but 90% of those who had the same germs on both their pre-cleansed hands and mobile phones did. These studies suggest that mobile phones can be a source of bacterial contamination, and that effective hand hygiene is essential for preventing the spread of infection. Despite this, the results of the current study indicate that hand hygiene compliance levels are adequate as seen in the total number of microorganisms and the negative/low infection level of hazardous bacteria and yeasts. According to the WHO (2009), the rates of compliance with hand hygiene were between 70% and 72% over the study period. In our study, a greater rate of hand hygiene compliance (72%) was discovered among university workers. Previous studies have found that the mobile phones of healthcare personnel are contaminated with bacteria at a rate of 60% (Kokate et al., 2012; Mark et al., 2014). This study used two different methods to count the bacteria on mobile phones: the pour plates PP method and the surface spread (SS) method. We found that the SS method produced significantly higher numbers of bacteria than the PP method in low and moderate counts (10, or 10 and more). However, the difference between the two methods was not statistically significant in high counts (100 or more). The SS method is also less complicated and time-consuming than the PP method, and numerous researchers have utilised it to count and find bacterial agents (Bs et al., 2018). The median colony count for touch screen phones and keypad devices was 0.09 CFU/ml and 0.77 CFU/ml, respectively, in other studies it is found that mobile phones used by students at the University of Cape Coast were heavily contaminated with bacteria (Pal et al., 2013; Tagoe et al., 2011). The mean viable bacterial count was 9.9 million per phone, which is a very high level of contamination. A UK study found that 25% of 30 tested mobile phones had levels of potentially dangerous germs that were 18 times higher than the permitted range for toilet handles in public restrooms (Selim & Abaza, 2015). A 2013 study by Clean Link found that the average mobile phone contains 25,107 bacteria per square inch. This is a significant number of bacteria, and it is important to note that microorganisms can survive on mobile phones for minutes to months. This means that using a phone after someone who is unwell carries a risk of becoming infected with their germs (Tagoe et al., 2011). In the current study, in the mobile phone samples, total bacterial count detected was 55% of the samples, followed by coliform bacteria (24%), *Staphylococcus* sp. (13%), *Salmonella* and *Shigella* strains (5%), and yeasts (3%). In the computer keyboard samples, total bacterial count was detected in 50% of the total samples, followed by coliform bacteria (25%), *Staphylococcus* sp. (16%), *Salmonella* and *Shigella* strains (5%), and yeasts (4%). It is found that *Staphylococcus* sp. was present on 52% of the mobile phones analysed from healthcare personnel. *Staphylococci* were the most common type of bacteria found on the phones in this study (Al-Safaar, 2017). This pathogen is more dangerous than other bacteria because it is virulent, meaning it can cause serious illness, and it can adapt to various environmental factors. *Staphylococcus* sp. can also produce a wide range of illnesses, some of which can be fatal. In the current investigation, the mean bacterial count isolated from staff and student mobile phones did not differ statistically significantly, and it was discovered that combined infection with microbes had no impact. A study conducted in a hospital setting found that electronic devices can be a source of bacterial contamination. The study identified that 49% of phones only had one type of bacteria, 34% had two types, and 12% had three or more types (Al-Safaar, 2017). Laboratory technicians were more likely to have mixed infections than physicians or nurses. Student laptops and smartphones were also more contaminated than staff laptops and smartphones. Following the study, the community released a practice guideline to address the problems with electronic devices. The guideline recommends that hand hygiene be practised before and after accessing a device, as well as whenever two people come into contact. It is reported that the surfaces exposed to human touch or direct human contact are susceptible to variation in microbial populations depending on surfaces differentiation (Simon et al., 2023).

Conclusion

This study has found that both personal computers and mobile phones can be contaminated with pathogenic bacteria and yeasts. This can lead to the spread of disease, especially in university settings where there is a lot of human interaction. The isolation method is a simple way to identify and count the number of bacterial and yeasts contaminants on these devices. Thus, the present study was undertaken to evaluate the bacteriological and yeasts contamination of mobile phones and computer keyboards, considering total microbial load and some expected pathogens, namely: coliform bacteria, *Salmonella* and *Shigella* strains, *Staphylococcus* sp. and yeasts. The samples were collected from devices of people in the university community, both employees and students.

The purpose of this study was to demonstrate the potential risk of infection that mobile devices pose to the university community. Both mobile phone devices and electronic keyboards have the potential to harbour germs that are dangerous to humans. Many individuals mistakenly believe that pathogen transmission is primarily dangerous in healthcare settings, being unaware that these dangerous bacteria can also spread through normal daily activities and underestimating the importance of disinfecting devices used in other settings. It is possible to reduce the risk of bacterial pathogen contamination and dissemination via mobile phones and keyboards protection such as using disinfection wipes.

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تراكم التلوث الميكروبي على لوحات المفاتيح وأجهزة الهاتف المحمول في مجتمع الجامعة

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في هذه الدراسة تم تقييم التلوث الميكروبي في الهواتف المحمولة واجهزة الكمبيوترات في عينة مأخوذة من مجتمع الجامعة. هنالك العديد من الدراسات التي تطرقت الى هذا النوع من التلوث، ومع ذلك لم يتم توضيح مستوى تعرض المجتمع للبكتيريا والخمائر وانتقالها عبر أجهزة الكمبيوتر والهواتف المحمولة بشكل كاف. أجريت هذه الدراسة لتحديد مستوى التلوث مع تقدير الحمل الميكروبي للبكتيريا أو الخمائر على الهواتف المحمولة للموظفين والطلاب، وكذلك على أجهزة الكمبيوتر المزودة بشاشات تعمل باللمس ولوحات المفاتيح. أجريت التجارب على *100* عينة، وهي إجمالي عدد الأجهزة التي تم فحصها، سواء الهواتف المحمولة أو لوحات مفاتيح الكمبيوتر. أظهرت جميع العينات التي تم الحصول عليها من الهواتف المحمولة أو لوحات المفاتيح أنواع مختلفة من البكتيريا المحللة للدم: بيتا (β)، ألفا (α)، وجاما (γ). تم اختبار عينة مكونة من *50* هاتفا محمول و*50* لوحة مفاتيح كمبيوتر للتأكد من وجود البكتيريا القولونية وسلالات السالمونيلا والشيجلا والمكورات العنقودية والخمائر. وفيما يتعلق بنسب الكائنات الحية الدقيقة الموجودة في عينات الهواتف المحمولة، فإن *55%* من إجمالي البكتيريا المعزولة من الأجهزة الملوثة جاءت من أنواع متعددة من البكتيريا. في حين لم يتم اكتشاف أي تلوث كبير بالخمائر. تختلف مستويات الإصابة في عينات الهواتف المحمولة اعتمادا على الحمل الميكروبي الموجود في العينات. وبالمثل، تم عزل العديد من الكائنات الحية الدقيقة على لوحات مفاتيح الكمبيوتر التي تم اختبارها. حيث كانت بنسبة *50%* تحتوي على حمل ميكروبي، و*25%* منها عبارة عن بكتيريا القولون، و*16%* من المكورات العنقودية، و*5%* من سلالات السالمونيلا والشيجيلا، و*4%* من الخمائر. يختلف مستوى الإصابة لعينات لوحة مفاتيح الكمبيوتر مرة أخرى اعتمادا على الحمل الميكروبي للعينات. تشير النتائج أن معدل الإصابة بالكائنات المعزولة كان منخفض نسبيا استنادا الى الحمل الميكروبي. كما يعد الافتقار إلى بعض شروط النظافة، مثل الغطاء الواقي، واستخدام أجهزة الكمبيوتر المحمولة العامة ذات شاشات اللمس ولوحات المفاتيح والهواتف المحمولة دون مراعاة انها ناقل للميكروبات حتما سيزيد من خطر الاصابة.