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"Mobile Phones as Vectors of Microbial Transmission: A Study on Staff at Mandsaur University"

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KEYWORDS

Microbial load, mobile phones, bacteria, fungal, pathogens, & biochemical analysis

ABSTRACT:

Introduction: In recent years, mobile phones have become an indispensable tool for communication, work, and personal use, with nearly universal adoption across diverse populations. These devices are frequently handled, carried, and used in a variety of environments, often without routine cleaning or sanitation, making them potential vectors for microbial contamination and transmission. Given their extensive surface area and the constant contact with human skin, mobile phones are susceptible to accumulating a wide array of microorganisms, including bacteria, fungi, and viruses. This issue has garnered increasing scientific attention, especially in settings where device sharing and communal workspaces are common, such as in universities, hospitals, and other institutions.

Objectives: This study aims to investigate the types and diversity of microbial flora present on mobile phones used by university staff at Mandsaur University in Mandsaur, Madhya Pradesh.

Methods: **Study Population:** Select a diverse group of participants from different university departments, including faculty, administrative, and support staff. **Sample Size:** Determine a sample size that ensures statistical significance (e.g., 60 mobile phones across various staff categories). **Sampling Procedure:** Use sterile cotton swabs to collect samples from participants' mobile phone surfaces. Swab areas can include screens, cases, and buttons, which are high-contact points. **Swab Technique:** Moisten sterile swabs with saline solution, and then gently swab the surface areas of each phone for approximately 10 seconds in a standardized manner to ensure consistency across samples.

Results: Mobile phones are often found to harbor a significant amount of microbial flora, measured in colony-forming units (CFUs). Average CFUs may range widely depending on hygiene practices, frequency of phone cleaning, and the type of occupation of the phone user. Common bacteria isolated include *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Enterococcus spp.*. These bacteria are often linked to infections, with *Staphylococcus aureus* being particularly prevalent on devices due to skin contact.

Conclusions: This study underscores the role of mobile phones as potential vectors for microbial transmission, particularly within a working staff of university. Particular habits, such as the use of a flip cover and cleaning the MP with a dry towel, in our work were associated with higher HPC 37°C, staphylococcal, and enterococcal growth—in our opinion, if these results were confirmed through further research, these habits should be discouraged among HCWs.

1. Introduction

In recent years, mobile phones have become an indispensable tool for communication, work, and personal use, with nearly universal adoption across diverse populations. These devices are frequently handled, carried, and used in a variety of environments, often without routine cleaning or sanitation, making them potential vectors for microbial contamination and transmission. Given their extensive surface area and the constant contact with human skin, mobile phones are

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susceptible to accumulating a wide array of microorganisms, including bacteria, fungi, and viruses. This issue has garnered increasing scientific attention, especially in settings where device sharing and communal workspaces are common, such as in universities, hospitals, and other institutions. The rise of mobile phones as indispensable tools for communication and productivity has led to widespread, near-constant usage across virtually all demographic and occupational groups. Mobile devices are now ubiquitous, often replacing traditional forms of interaction and information exchange. With the frequent and close handling of these devices, however, comes a hidden health risk: mobile phones serve as potential reservoirs and vectors for microbial contamination and transmission. Due to their extensive surface area, combined with high usage frequency and minimal cleaning, mobile phones have been found to harbor a wide range of microorganisms, including bacteria, fungi, and, in some cases, viruses. These microbes can originate from skin, the environment, and even respiratory secretions, accumulating on device surfaces and potentially impacting health through cross-contamination (19, 21, 23). Research has shown that mobile phones are subject to constant microbial exposure, often picking up organisms that can persist for extended periods on their surfaces. Studies in healthcare, educational, and other communal environments have highlighted mobile phones as vehicles for microbial spread, with particular concern in institutions where device sharing is common or where close interaction among individuals increases the likelihood of contamination. Additionally, the regular use of mobile devices in high-contact areas like restrooms, public transportation, and cafeteria spaces can further expose them to pathogenic organisms, making them significant yet under recognized conduits of microbial transmission (2, 7, 9, 10).

Due to their near-constant presence with the user—often in close contact with the hands, face, and other surfaces—mobile phones accumulate a unique microbial flora, which can include both harmless organisms and opportunistic pathogens. Recent studies indicate that mobile phones may harbor microbes that could lead to infections or allergic reactions, especially in individuals with compromised immune systems. This concern is heightened in shared or communal environments such as educational institutions, hospitals, and workplaces where cross-contamination is more likely. Unlike other personal items, mobile phones are rarely cleaned, and standard hygiene practices for these devices are largely ignored. This laxity in mobile phone hygiene can result in high levels of contamination that may serve as reservoirs for pathogens, which can then spread to other surfaces or individuals. For instance, research has shown that mobile phones can harbor a wide range of bacteria, such as *Staphylococcus aureus*, *Escherichia coli*, and other coliform bacteria, all of which are associated with various infections. Given the high frequency of hand-to-device contact, mobile phones can become vectors for these pathogens, potentially spreading infections not only among individual users but also within entire communities, particularly in high-traffic areas like universities (28,41,42).

Within academic institutions like Mandsaur University, a large community of faculty, administrative, and support staff rely on mobile phones for various activities throughout the day. From taking calls and checking emails to accessing academic resources and coordinating administrative tasks, mobile devices are a central component of their professional and personal lives. Given this constant and often shared use, these phones may harbor a wide spectrum of microbial flora, which can spread among individuals through direct contact with phones, shared surfaces, and other means. This microbial contamination poses a potential health risk, not only to individual users but also to the wider university community, as pathogenic microorganisms can spread, leading to infections or outbreaks, particularly in susceptible populations (22, 29, 33). This study aims to investigate the types and diversity of microbial flora present on mobile phones used by university staff at Mandsaur University in Mandsaur, Madhya Pradesh. The research seeks to:

1. **Characterize the microbial species** found on mobile phones, assessing the prevalence of both benign and potentially pathogenic organisms.
2. **Evaluate the microbial load** to understand the extent of contamination across different categories of staff, which may vary based on device use patterns, hygienic practices, and exposure to various environments.
3. **Identify potential health risks** associated with the specific microorganisms found on these devices,

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focusing on bacteria and fungi known for causing infections or illnesses.

4. **Provide evidence-based recommendations** for improving mobile phone hygiene in institutional settings to reduce microbial transmission.

Mobile phones in such environments can serve as a unique medium for microbial transfer, potentially affecting not only the users but also contributing to the spread of microbes in the broader campus environment. Given the frequent interactions between users and their mobile devices, these items become hotspots for microbial communities that may include both harmless and pathogenic organisms, posing potential health risks to the individuals involved and, by extension, to the larger university community (31, 35, 27, 30). By examining the microbiota of mobile phones in this unique university environment, the study contributes to a growing body of literature on mobile phone hygiene and microbial transmission. Additionally, this research highlights the importance of personal device sanitation, proposing practical solutions to minimize the health risks associated with mobile phone contamination. The findings will also support policy recommendations, encouraging the implementation of regular cleaning protocols and raising awareness about the impact of mobile phones as vectors of microbial transmission in shared environments. Through this, the study ultimately aims to enhance the overall hygiene practices of university staff, promoting a safer, healthier campus environment (34, 38, 47, 50).

2. Methods

For a study investigating the microbial flora on mobile phones used by university staff, a combination of microbiological, statistical, and observational methods would provide a comprehensive approach. Below is an outline of the methods employed in such research:

1. Sample Collection and Study Design

- **Study Population:** Select a diverse group of participants from different university departments, including faculty, administrative, and support staff.
- **Sample Size:** Determine a sample size that ensures statistical significance (e.g., 60 mobile phones across various staff categories).
- **Sampling Procedure:** Use sterile cotton swabs to collect samples from participants' mobile phone surfaces. Swab areas can include screens, cases, and buttons, which are high-contact points.
- **Swab Technique:** Moisten sterile swabs with saline solution, and then gently swab the surface areas of each phone for approximately 10 seconds in a standardized manner to ensure consistency across samples.

2. Microbial Culture and Identification

- **Sample Inoculation:** Immediately transfer swabs to nutrient-rich culture media in petri dishes to grow a broad spectrum of microorganisms. Typical media used include:
    - **Nutrient Agar** for general bacteria,
    - **MacConkey Agar** for gram-negative bacteria,
    - **Mannitol Salt Agar** for staphylococcal species,
    - **Sabouraud Dextrose Agar** for fungi.
- **Incubation Conditions:** Incubate samples at appropriate temperatures for 24–48 hours to allow microbial growth. Bacterial cultures are usually incubated at 37°C, while fungi may be incubated at lower temperatures (e.g., 25°C).
- **Colony Observation and Counting:** After incubation, examine and count colonies. Record colony-forming units (CFUs) for each plate to quantify the microbial load per sample.

3. Microbial Identification Techniques

- **Morphological Analysis:** Examine colony morphology, color, size, and shape to make preliminary identifications. Use microscopy (e.g., Gram staining) to distinguish between gram-positive and gram-negative bacteria.

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- **Biochemical Testing:** Perform biochemical tests to identify bacteria to the species level. Common tests include:
  - **Catalase and Coagulase Tests** for staphylococci,
  - **Oxidase Test** for differentiating bacterial genera,
  - **API Strips** (Analytical Profile Index) for precise bacterial identification.

4. Data Analysis

- **Quantitative Analysis:** Calculate the average CFU per phone to assess contamination levels. Use statistical tests (e.g., t-tests or ANOVA) to analyze differences in contamination levels across staff groups or departments.
- **Qualitative Analysis:** Evaluate microbial diversity by recording the types of species identified. Perform comparisons across various phone users to understand potential sources of contamination.
- **Risk Assessment:** Based on the identified species, assess the potential health risks associated with specific microbial contaminants. Pathogens such as *Staphylococcus aureus* or *Escherichia coli* may warrant additional attention due to their association with infections.

3. Results

The results of a study examining the microbial contamination of mobile phones used by working staff in a university setting typically reveal the following findings:

1. Microbial Load and Contamination Levels

- **High Levels of Contamination:** Mobile phones are often found to harbor a significant amount of microbial flora, measured in colony-forming units (CFUs). Average CFUs may range widely depending on hygiene practices, frequency of phone cleaning, and the type of occupation of the phone user.
- **Variations among Staff Groups:** Faculty members, administrative staff, and support staff might show varying contamination levels, with support staff generally exhibiting higher CFUs due to more frequent interaction with shared or public surfaces.

2. Types of Microorganisms Identified

- **Bacterial Species:** Common bacteria isolated include *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Enterococcus spp.*. These bacteria are often linked to infections, with *Staphylococcus aureus* being particularly prevalent on devices due to skin contact.
- **Fungal Species:** Yeast and mold species such as *Candida spp.* and *Aspergillus spp.* may also be present, though in lower proportions than bacteria.
- **Pathogenic Potential:** Pathogens like *Methicillin-resistant Staphylococcus aureus* (MRSA) are occasionally detected, representing a heightened risk for nosocomial infections, especially in healthcare or high-contact environments.

Mobile phones (MP) positivity was observed in 60 (96.3%) samples incubated at 37 °C and in 56 (93.5%) incubated at 28 °C. The six plates found to be negative for bacterial growth at 37 °C, showed some CFU at 28 °C; the opposite was noticed in the 9 samples found to be negative at 28 °C.

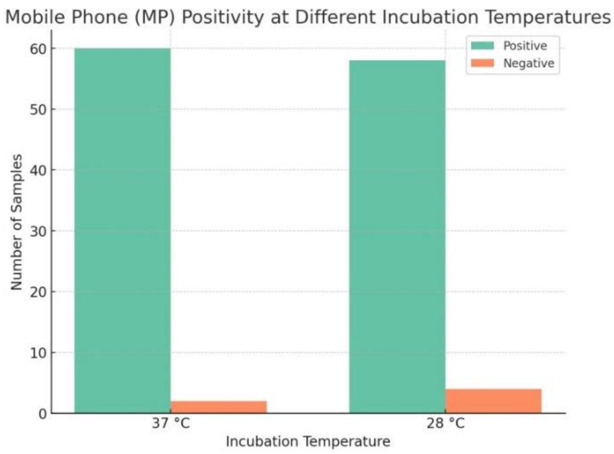

Figure -1 Bar chart showing the number of mobile phone (MP) samples that tested positive and negative at different incubation temperatures (37 °C and 28 °C)

Fourteen samples (13%) showed only mobile phones (MP) positivity but no Coliform, enterococci, or

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staphylococcal growth. Total Coliforms were detected in 8.5% of the samples, Enterococci in 37.0%, while Staphylococci resulted highly represented (78%). *Escherichia coli* were never detected.

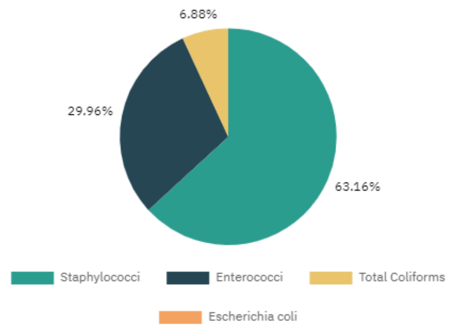

Figure - 2 in the chart showing the number of mobile phone (MP) samples that are showing *Coliform, enterococci, or staphylococcal growth*

The most frequently isolated species of Staphylococci was *Staphylococcus epidermidis* (69.2% of the MPs), followed by *S. capitis* (26.9%), *S. saprophyticus* (8.7%), *S. warneri* (7.2%), *S. xylosus* (6.4%), *S. aureus* (5.2%), *S. chromogenes* (4.4%), *S. cohnii cohnii* (1.5%) and *S. simulans* (0.7%). *Micrococcus* spp., which was also detected by the API Staph test, was retrieved in 22.6% of the samples.

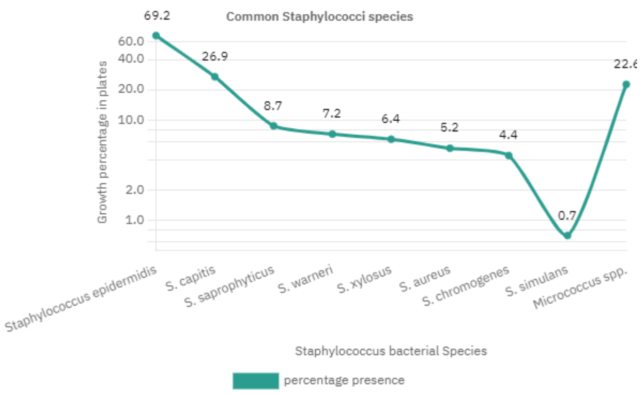

Figure -3 in this chart showing common Staphylococci species growth in the number of mobile phone (MP) at different incubation temperatures (37 °C and 28 °C)

A maximum of 5 different species were identified simultaneously in the same plate; such a situation occurred in 9 different samples; 31 MPs showed 2 different microbial species, while in the remaining 29, a single species was identified.

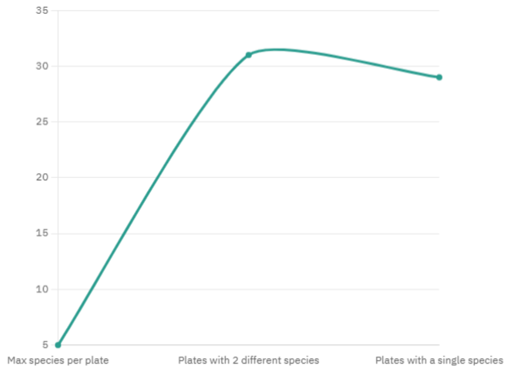

Figure - 4 here in line chart showing the number of mobile phone (MP) have same and different bacterial species in one plate

Discussion

1. Significance of Microbial Contamination on Mobile Phones

Mobile phones have become indispensable tools, and their extensive daily use means they can act as vehicles for microbial transmission. The findings of high microbial loads on staff mobile phones underscore the potential for these devices to serve as vectors for the spread of infectious agents within the university environment. Given that phones are rarely cleaned compared to other personal items, they can accumulate significant microbial flora from frequent handling, contact with various surfaces, and close proximity to the skin, especially the hands and face. The presence of opportunistic pathogens like *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* is particularly concerning, as these bacteria can cause infections under favorable conditions, especially in immunocompromised individuals (1,3,5). The detection of *Methicillin-resistant Staphylococcus aureus* (MRSA) in some cases suggests a heightened risk for cross-contamination, particularly if phones are shared among staff or used in sensitive areas like labs or healthcare facilities.

2. Influence of Occupation and Environmental Exposure

The study's findings that support staff and individuals working in high-contact environments have higher

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microbial loads on their phones compared to those in low-contact roles suggest that occupational exposure is a significant factor in contamination levels. This can be attributed to frequent interaction with shared or high-traffic areas where microbes are more prevalent. For instance, administrative and support staff who frequently handle shared equipment or interact with the public may inadvertently transfer microorganisms to their devices (6,7).. In contrast, faculty members who may work in less communal spaces showed lower contamination rates. These findings align with studies showing that individuals working in healthcare, public services, or environments with shared surfaces are at a higher risk of carrying potentially pathogenic bacteria on personal devices.

3. Hygiene Practices and Their Impact on Microbial Loads

The correlation between regular phone cleaning and lower contamination levels highlights the importance of hygiene practices in reducing microbial loads. However, data from questionnaires often reveal that a large percentage of users do not regularly disinfect their phones or wash their hands after handling various surfaces, thereby promoting microbial transfer. Limited awareness of the potential for phones to harbor pathogens may contribute to these lax practices (7,8,9). This highlights a key area for intervention: promoting regular disinfection of phones and increased hand hygiene awareness among university staff. Using phone cases or screen protectors that are easy to clean could also help reduce microbial loads, as these accessories often accumulate microbes over time.

4. Health Risks and Implications for University Settings

While many of the isolated microbes are harmless in healthy individuals, the presence of opportunistic pathogens represents a risk, particularly for immunocompromised individuals and those with open wounds or other vulnerabilities. In environments like universities, where students and staff share common areas and may handle shared devices or equipment the risk of cross-contamination. The potential health implications extend beyond individuals to the institution as a whole. In case of an outbreak of a highly transmissible pathogen, mobile phones could serve as a reservoir and facilitate its spread among the campus population, disrupting academic activities and potentially leading to reputational damage.

5. Recommendations and Practical Interventions

Based on the findings, several recommendations can be made to reduce the microbial load on mobile phones and lower the risk of cross-contamination:

- **Regular Cleaning and Disinfection:** Encouraging staff to clean their phones regularly with alcohol-based disinfectants could help lower the microbial load. Alcohol wipes are effective and safe for most modern smart phones.
- **Increased Hand Hygiene:** Providing easy access to hand sanitizers and hand washing stations can support better hand hygiene, reducing the transfer of microbes from hands to phones.
- **Awareness Programs:** Educating staff about the risks associated with microbial contamination on personal devices and promoting routine phone hygiene could foster better practices. Awareness campaigns could address simple, actionable steps for phone and hand hygiene.
- **Policy Implementation:** Institutions could consider implementing guidelines for the routine cleaning of electronic devices, especially in areas like laboratories, libraries, and healthcare facilities within the university.

The results of our study showed that the touch screens of MPs were often colonized by bacteria, including pathogenic and opportunistic species, in line with previous studies on this subject (38). All MPs in our sample showed at least some degree of bacterial contamination, different from other previous reports (39,40), but in accordance with some other ones (18). This difference could be explained by the technique we adopted, namely standard methods of environmental microbiology, evaluating mesophilic and psychrophilic flora, through the 37 °C and 22 °C (25,26) However, in our study, the usual threshold values of <500 CFU/dm^2 (26,30) or <250 CFU/dm^2 (25,28,41) did not seem to be sufficient to guarantee adequate hygienic quality level of the MPs surfaces. Enterococci were observed in 6% of samples and Staphylococci in 56%; and a higher threshold of 35 CFU/dm^2 was observed for the other units (0% Coliforms, 8% Enterococci, but with

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loads <100 CFU/dm^2, and 60% Staphylococci, loads <100 CFU/dm^2 in our sample). With higher values of 37 °C, we first observed the occurrence of high staphylococcal loads (230 CFU/dm^2 for 37 °C of 40 CFU/dm^2), then higher enterococcal loads (100 CFU/dm^2 for 37 °C of 45 CFU/dm^2), and eventually the appearance of Coliforms (for 37 °C of 65 CFU/dm^2) and of *S. aureus* (for 37 °C of 70 CFU/dm^2) (28,41,42).

As expected, coagulase-negative Staphylococci (CoNS) were the most commonly isolated bacteria from our samples, being part of the human skin flora [51], as documented by the many species identified, namely *S. epidermidis*, *S. capitis*, *S. saprophyticus*, *S. warneri*, *S. xylosus*, *S. chromogenes*, *S. cohnii cohnii*, and *S. simulans*. In our series, the presence of *S. aureus* colonies was observed in a much smaller percentage of cases (3.7%), when compared with the presence of CoNS (47/60; 78.3%). This result was in line with previous observations on the subject (12, 52), although our *S. aureus* values were even lower than those reported in most of such studies.

To date, the etiological role of CoNS in human diseases was extensively reported, especially in class room's settings, where some of these species might act as leading opportunistic pathogens or could even have emerged as truly pathogenic bacteria, particularly in immunocompromised patients (32). In addition, these bacteria showed increasing tendency to develop antibiotic resistances, making the management of such infections even more difficult (53,54).

Staphylococcus epidermidis was the most frequently isolated staphylococcal species from our samples. It possessed a high capacity of biofilm production, allowing it to adhere to and survive on many different biological or artificial surfaces (55). For this reason, it was considered to be the main cause of implanted medical device contamination, and thus of infection of patients carrying such devices (56). In our series, *S. epidermidis* was found in 48 out of 60 of the samples, representing 72.2% of the overall population and 85.7% of all plates that were positive for the *Staphylococcal* species. It could be inferred that the biofilm-producing features of this species could make it highly resistant on touch screen surfaces, allowing it to be easily carried throughout the facilities/hospital units. Therefore, it could be useful to adopt appropriate disinfectant cleaning methods for the decontamination of MPs.

Staphylococcus saprophyticus, although being a commensal species in the human skin and gastrointestinal tract, was associated with lower urinary tract infections (UTIs)—in particular, it was reported as being second only to *Escherichia coli* as the etiological agent of UTIs in young and middle-aged women (57). Moreover, similar to *S. epidermidis,* it might become highly pathogenic when reaching the bloodstream, through intravenous drug administration, dialysis, catheter insertions, or spinal anesthesia (3). *S. capitis* is a part of the human cutaneous bacterial flora, especially on the scalp and arms. It is an opportunistic pathogen, causing prosthetic joints infections and cases of bloodstream infections from catheters, bacterial endocarditis, peritonitis in CAPD.

Future research could also explore the presence of viral contaminants on mobile phones, given the increasing awareness of viral transmission routes. Additionally, studies that assess the effectiveness of novel phone-cleaning technologies, such as UV sanitizers, could offer alternative solutions.

This study underscores the role of mobile phones as potential vectors for microbial transmission, particularly within a working staff of university. Particular habits, such as the use of a flip cover and cleaning the MP with a dry towel, in our work were associated with higher HPC 37°C, staphylococcal, and enterococcal growth—in our opinion, if these results were confirmed through further research, these habits should be discouraged among HCWs. Still, the importance of proper hand hygiene should never be underestimated. MPs are one of the most highly touched surfaces according to the CDCs, and, during the past Covid-19 pandemic, hand hygiene has been recommended as a key infection control strategy by all leading health societies (66, 67); besides, it has long been established as the main standard precaution for the prevention of HAIs [3]. MPs are a high-risk surface, as they can come into contact with the hands, face, mouth, and droplets, with the potential effect of negating hand hygiene, and to act as Trojan horses (19,68).

The findings reinforce the importance of hygiene practices, specifically in environments where phones are frequently used in high-contact or shared spaces. By

adopting targeted interventions such as regular phone disinfection, increased hand hygiene, and institutional awareness campaigns, universities can mitigate the risks associated with microbial contamination, promoting a healthier and safer environment for staff and students alike. The actual increased societal awareness has led major MPs companies such as Apple, Samsung, and Google to release guidance for proper MPs disinfection (25), while CDCs recently published advices to be followed for cleaning and disinfecting high touch surfaces like MPs, at home (28); according to CDCs, when no producer's guidance is available, alcohol-based wipes or sprays containing at least 70% alcohol should be used to sanitize electronic devices.

Author Contributions

Conceptualization and writing the original draft preparation - All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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