

## Microbial Contamination of Mobile Phones (Literature Review)

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### ABSTRACT

In today's world, mobile phones are ubiquitous in all regions and different contaminated settings. People view them as essential tools for social interaction and communication. Nevertheless, because they are not cleaned well and people do not always wash their hands after using them, they might harbor bacteria, viruses, and parasites that may lead to various infections.

**Keywords:** Cross-contamination, healthcare workers, mobile phones, parasites, pathogens, viruses.

### التلوث الميكروبي للهواتف المحمولة

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### الخلاصة

في عالم اليوم، أصبحت الهواتف المحمولة منتشرة في كل بقاع العالم وفي بيئات مختلفة التلوث، وتعد أدوات أساسية للتفاعل والتواصل الاجتماعي بين الأفراد. ومع ذلك، ونظرًا لعدم تنظيفها جيدًا وعدم قيام الأشخاص بغسل أيديهم بعد استخدامها بصورة دائمة، فقد تصبح تلك الهواتف بمثابة مستودع للبكتيريا والفيروسات والطفيليات يمكن أن تؤدي إلى مجموعة متنوعة من الأمراض.

**الكلمات المفتاحية :** التلوث المتبادل، العاملين في مجال الرعاية الصحية، الهاتف المحمول، الطفيليات، مسببات الأمراض، الفيروسات.

### INTRODUCTION

These days, cell phones are practically necessary accessories for people. Globally, there were more cell phones in 2020 than people on the planet (7.5 billion). These gadgets are employed in restrooms, markets, kitchens, and work because of their various uses<sup>1</sup>.

Mobile phones have become an essential personal property in daily life due to the rapid advancement of technology, particularly in the industrial sector. They are now widely available and used by people of all ages. Moreover, since it has replaced televisions, cameras, and game consoles and is more frequently used in different situations, regardless of hygiene assurance, these gadgets have become a haven for various pathogens. It contains a quantity of bacteria almost ten times higher than a toilet seat, the inside of a user's shoe, or a toilet doorknob. So mobile phones are among the dirtiest items we use daily, as illustrated in Fig. 1<sup>1-3</sup>.

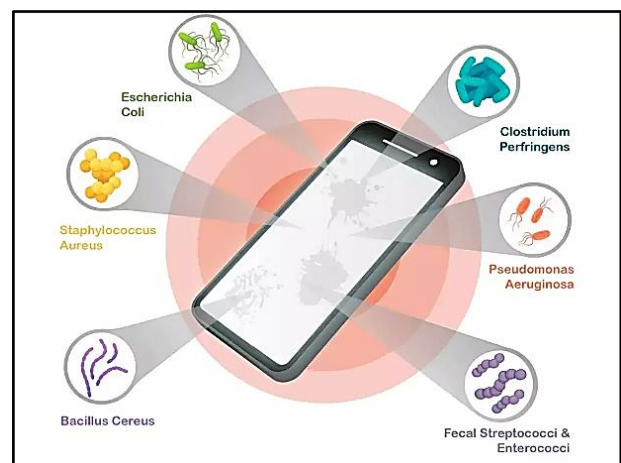


Fig. 1: Bacteria on the mobile phone screens<sup>4</sup>.

People handle their cell phones in multiple locations, exposing them to and contaminating them with a range of germs, some of which may be harmful and others not. The surface of a cell phone has pathogens that can spread to the user's skin, other surfaces, or food, and anywhere there is a chance for life and growth. Surfaces on mobile phones can act as reservoirs for microbiological infections. They can, therefore, serve as active media for transmitting viruses from the environment to people. According to several epidemiological studies, pathogens can survive on fomites for weeks to months, highlighting the critical role that contaminated surfaces play in transmitting a wide range of infectious diseases <sup>5,6</sup>.

Living among trillions of germs at each moment of life and the expanded daily use of mobile phones by students, especially undergraduates, expose them to these tiny creatures from these devices <sup>2</sup>.

Additionally, because of the nature of their jobs, the health sector specialists handle smartphones and other electronics more and more at their workplaces. These portable devices are often contaminated and may act as reservoirs for cross-contamination between staff and patients, endangering the health of tens of thousands of people <sup>7,8</sup>. Through skin-to-skin contact, microbes can transfer from one individual to another. It has been believed recently that the surfaces of mobile phones may contain bacterial diseases, making them potentially harmful media <sup>9</sup> ever since the first study revealed the existence of bacteria on cell phones in 2007. It has been shown that consistent usage, in temperatures ranging from 25 °C to 43 °C, and the moisture generated by these gadgets significantly encourage the reproducibility of bacteria. Bacterial cells could easily stick to the surfaces of mobile phones and create well-organized colonies. These bacteria only reflect the bacteria that live on our bodies, be they indigenous or indicative of specific infections <sup>2</sup>.

Mobile phones can readily become contaminated with bacteria through contact or face-oral transmission. According to numerous studies, up to 7,000 distinct species of bacteria are present on mobile phones. They include the germs *Staphylococcus aureus* and the gut bacteria *Escherichia coli* that are commonly seen in warmer, humid climates away from sunlight, on the skin, and in the noses of up to (25%) of healthy humans and animals <sup>10</sup>.

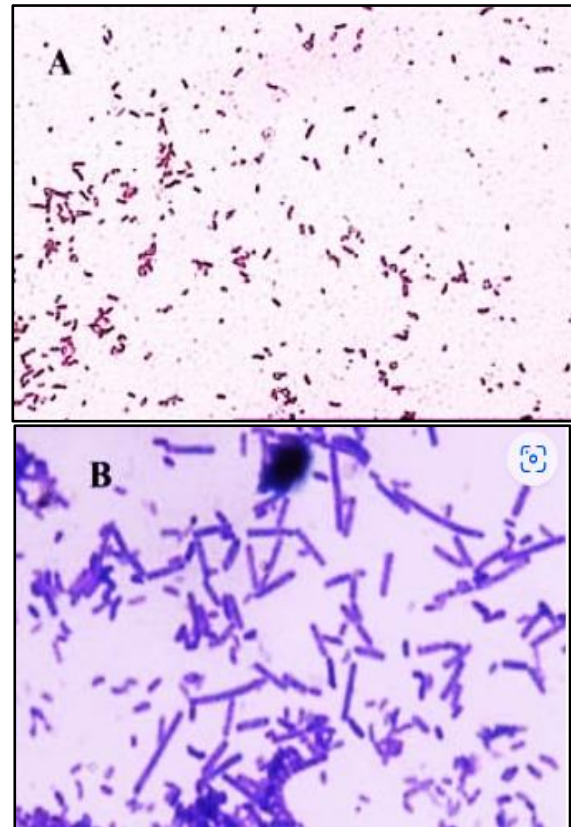


Fig 2: Bacteria on mobile phones, shown under the microscope (A, gram-negative bacteria) and B, gram-positive bacteria\* <sup>4</sup>.

\*When a Gram staining techniques performed, Gram-positive bacteria are those that appear purple-blue under microscope, whereas Gram-negative bacteria are those appear pinkish-red under microscope. This procedure is used for rapid screening and classification bacteria at the location of a suspected infection.

Researchers have found that human skin, which is naturally contaminated with microbes that typically do not threaten health, can be a source of contamination for cell phones. Additionally, natural bacteria can be found on everyone's hands, mouth, nose, and intestines, with the hands being the top source. Millions of good bacteria, fungi, and viruses help us digest food, fight sickness, and influence how the body reacts to drugs. Nevertheless, we also deal with pathogenic bacteria and viruses, some even resistant to medications (like methicillin-resistant *Staphylococcus aureus*) <sup>10-12</sup>. Packs, food particles, ecosystems, phone bags, and bags are sources that link with microorganisms and infect cells, leading to mild chronic diseases <sup>6,11</sup>. Mobile phones are commonly used in healthcare facilities for rapid communication within hospitals.

Concerns increase about the widespread usage of these devices in hospitals, as they can be used everywhere, even in toilets. As a result, they may serve as a means of contaminating patients<sup>13</sup>. Hospitals are open breeding grounds for the spread of germs and illnesses linked to medical care because of the frequent handling of mobile phones by staff members, patients, and visitors<sup>11</sup>.

People working outside of hospitals may have very different microorganisms on their phones than health workers. This could be because community preventative security, cleaning, and disinfection practices are less stringent, and antimicrobial use practices differ in livestock and poultry farming<sup>1</sup>.

Fomite-dependent transmission occurs when microorganisms from an infected individual are deposited on an inanimate object and transmitted to a new host. This transmission is critical for causing infectious diseases in community and healthcare settings. Keeping the mobile phone out of the bathroom will help reduce infection transmission, but if it is cleaned, some different methods must be used; the most commonly used is wiping the mobile phone with a soft microfiber cloth (Fig. 3), which will remove a lot of germs, and for a deeper cleaning it is recommended to use a mixture of (60 %) water and (40%) rubbing alcohol, then mix the ingredients and dip the cloth in the solution before gently wiping it on the phone<sup>14</sup>.

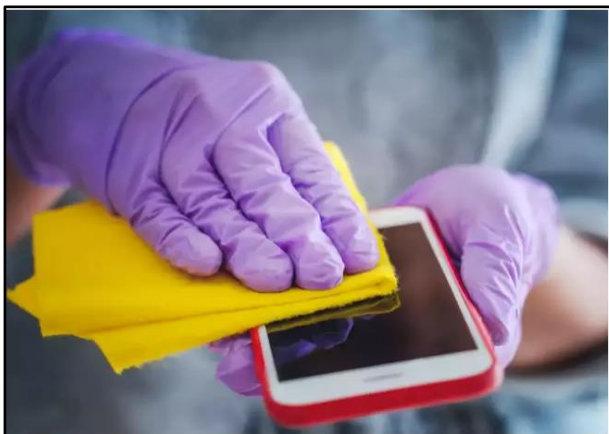


Fig. 3: Wiping the mobile phone with a soft microfiber cloth to remove the germs<sup>4</sup>.

When a mobile phone comes into regular contact with hands, it can transmit infectious diseases. There is a potential health risk with tens of thousands of germs living on each square inch of a mobile phone<sup>15</sup>. Over hours or days, bacteria from the flu, colds, and other infectious disorders can travel from a mobile phone to the user's mouth or nose. Using mobile devices that are contaminated with germs is dangerous for one's health because one's hands, mouth, ears, and face come into constant contact with them<sup>10,11</sup>.

Coagulase-negative staphylococci (CoNS) are the most common bacterial contamination on mobile phones, especially among healthcare workers. Studies have shown that these bacteria account for a significant portion of the microbial load on mobile phones, followed by *Staphylococcus aureus*. In a systematic review, CoNS accounted for about 44% of bacterial contamination on mobile phones used by healthcare workers, while *Staphylococcus aureus* accounted for about 31.3%. In addition, other bacteria, such as *Escherichia coli* and *Klebsiella* species, are also commonly found, although they are less common than *Staphylococcus* species. These findings highlight the importance of regular cleaning and proper hygiene practices for mobile phone users, especially in healthcare settings, to reduce the risk of bacterial transmission and potential infections. On a related note, viruses cause diseases such as influenza, colds, and COVID-19, and these viruses can be transmitted by touching hands to contaminated surfaces and then touching the face. Therefore, mobile phones act as tools for infection and transmission of viruses such as influenza, coronaviruses (SARS-CoV-2), and other respiratory viruses. As these viruses spread through mobile phones, there will be a risk when people touch their phones and their faces because these viruses can live on surfaces for different periods. Moreover, parasites like pinworms and giardia can infect mobile phones because of inadequate cleaning procedures. By touching phones with contaminated hands, these parasites can spread to the mouth and other surfaces, causing infection mainly through the fecal-oral route<sup>16-18</sup>.

## DISCUSSION

Mobile phones have become necessary for daily life, as everyone, from children to adults and older people, can communicate via mobile phones. Between 2000 and 2012, the number of mobile phones used worldwide surged from less than one billion to approximately six billion. For instance, in 2015, almost 78 million individuals in Mexico utilized mobile phones; (66%) of users own a smartphone, while the rest have a device that allows making/receiving calls or messages without access to the Internet. The use of this mobile communications technology in health care and higher education has increased, and this has raised the need for attention in evaluating the role of mobile phones as a reservoir of bacteria, becoming a source of pollution in general and thus causing the occurrence of many diseases<sup>19</sup>.

Isolates of pathogenic bacteria possess a variety of virulence and adhesion factors and the capacity to create biofilms that aid in their survival on both non-living surfaces and in the host environment. People spend a lot of time on their mobile phones when holding them close to their faces. As we mentioned, hands are essential in transmitting bacteria by touching contaminated objects, including mobile phones, or shaking hands with others. This problem is significantly exacerbated for healthcare workers in their daily practice in hospitals and education, where their mobile phones are contaminated with different microorganisms.<sup>5-8,20</sup>

Despite their frequent use, most people, even healthcare workers, are unaware of the dangers of phone sharing. They often ignore the possibility that these devices contain a variety of microbes during and after examining patients. Many studies have shown that the percentage of bacterial contamination of mobile phones may reach approximately (95%). It has also been found that mobile phones are a natural accumulation of germs on the face, ears, lips, and hands of various users with different health conditions, carrying many types of bacteria present and harmful to patients who suffer from weak immunity. Microbiologists say that the constant handling of mobile phones and the temperature of mobile phones resulting from the long period of use may serve as an incubation temperature for many pathogens that are naturally resident on the skin, which may lead to the spread of microorganisms<sup>11,19,21</sup>. People spend much time on their phones when they press them, bringing them closer to their faces. In addition, the hand is essential in transmitting bacteria through contact with other contaminated objects or when shaking hands with others. Microbes from one user can be transferred to other users through dermal contact. Mobile phone surfaces are now regarded as potentially harmful media through which bacterial pathogens can be transmitted, and mobile phones are increasingly used in hospitals. They may act as a mobile reservoir for microbial pathogens<sup>22</sup>.

Several laboratory tests conducted in hospitals have revealed the existence of male and female infections that may live and grow on a person's skin, other surfaces, or food. Some pathogens include Staphylococcus epidermidis, Streptococcus species, Staphylococcus aureus, and Pseudomonas aeruginosa. Table 1 below displays the frequency of various infections in a sample of male and female patients. According to the table, Staphylococcus epidermidis causes the most infections (48%), followed by Streptococcus species (29%), Staphylococcus aureus (16%), and Pseudomonas aeruginosa (8%).

To live in the host environment and on inanimate surfaces, these pathogenic bacterial isolates possess many virulence and adhesion factors and the capacity to create biofilms. The microbial communities are seen in various places of body parts, and according to a study conducted in the USA, more than 80% of these microbial communities end up on mobile phone displays. The species most often discovered on phone surfaces is Staphylococcus epidermidis<sup>6,12,19,22</sup>.

Table 1: Bacterial isolated from mobile phones.

Separated Infections	Mobile phones involved		Percentage		Total percentage
	Male	Female	Male	Female	
Staphylococcus epidermidis	20	10	32%	16%	48%
Streptococcus species	11	7	17%	11%	29%
Staphylococcus aureus	5	5	8%	8%	16%
Pseudomonas aeruginosa	3	2	5%	3%	8%
Total	39	24	62%	38%	100%

Staphylococcus aureus, coagulase-negative staphylococci, Micrococcus species, Pseudomonas species, and Escherichia coli are the most often isolated germs from mobile phone surfaces. Several studies that isolated pathogenic bacteria from mobile phones revealed that the most common isolate, Staphylococcus epidermidis, followed by Escherichia coli, Pseudomonas, Salmonella, and Pantoea species. Table 2 shows the total percentage of positive cultures was found to be (75%), with Staphylococcus epidermidis being the most common isolate at (32.8%). In comparison, the percentage of negative culture was (25%), with Pseudomonas species being the most common at (8.9%)<sup>5,14,23</sup>.



Table 2: Total percentage of cultures obtained from hospitals and society using the gram stain test to identify microorganisms.

Microorganisms	Gram stain test	Number of mentions in:		Total percentage
		Hospital	Community	
Staphylococcus epidermidis	g+	44	19	32.8%
Bacillus Species	g+	26	7	17.2%
Micrococcus species	g+	12	5	8.9%
Enterococcus species	g+	9	4	6.8%
Streptococcus Species	g+	9	2	5.7%
Corynebacterium Species	g+	5	2	3.6%
Pseudomonas species	g-	12	5	8.9%
Escherichia coli	g-	7	8	7.8%
Klebsiella species	g-	7	4	5.7%
Acinetobacter Species	g-	5	0	2.6%
Total		136	56	100%

g+: gram-positive, g-: gram-negative

Highly polluted mobile phones come into close contact with human body parts during every phone call, whether from hand to hand or other places (mouth, nose, ears, etc.). *Escherichia coli* bacteria have been widely found on mobile phones, likely due to people not washing their hands well after using the facilities, which can lead to food poisoning. Through several studies, researchers found that (95%) of mobile phones contain infectious bacteria, which are antibiotic-resistant pathogens in stool and cause fever, diarrhea, and nausea. The survival period of the microbe ranges from minutes to months. For people with a weak immune system, infection with these bacteria is fatal whenever the concentration of bacteria increases, and bacteria remain alive<sup>24-28</sup>.

Healthcare professionals' mobile phones are infected with harmful microorganisms. If these mobile gadgets are not handled carefully, they could serve as conduits for spreading infection to patients<sup>14</sup>.

The results of a study in which hospital infection agents such as coagulase-negative staphylococci, *Escherichia coli*, and *Bacillus* species were isolated from the personal mobile phones of healthcare workers suggested that the presence of *Escherichia coli* in the personal telephones of men but not women, which indicates fecal contamination of these devices result in infection, outbreaks, and diseases contracted in the community<sup>20</sup>.

Because mobile phone users are everywhere—in the grocery store, at home, in hospitals, and in schools—they can potentially contribute to the spread of infection throughout society. According to one study, high school students' phones contained up to 17,000 genetic copies of bacteria that were only found there. This leads one to conclude that schools rank among the most contaminated locations in society<sup>14,23,29</sup>.

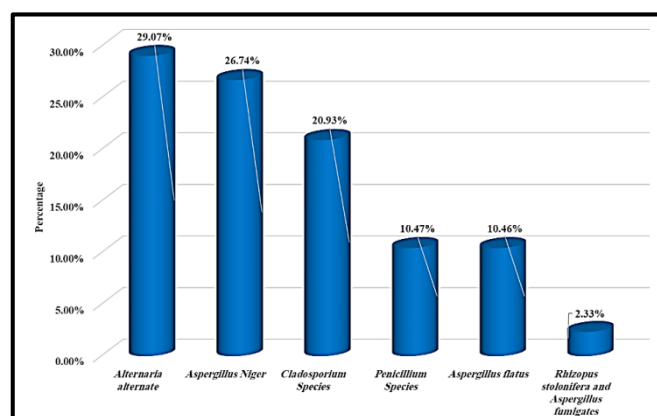


Fig. 4: Fungi isolated from mobile phones in a canteen.

People always carry their cell phones even when they usually wash their hands before doing anything. All the tested mobile phones (100%) were contaminated with single or mixed bacterial agents. The most prevalent bacterial contaminants were methicillin-resistant *S. aureus* and coagulase-negative staphylococci, representing (53%) and (50%), respectively<sup>14,22,30,31</sup>.

Other contaminated areas include "canteens," which are tiny shops or receptacles that provide food and beverages in various establishments like camps, universities, and schools. A wide variety of fungi, including those shown in Figure 4 for one of the studies based on fungi, color, and spores, were isolated from the mobile phones of the employees of these canteens. These isolates include *Alternaria alternative* (29.07%), *Aspergillus Niger* (26.74%), *Cladosporium Species* (20.93%), *Penicillium Species* (10.47%), *Aspergillus flatus* (10.46%), *Rhizopus stolonifera* and *Aspergillus fumigates* (2.33%). These isolates significantly

impact food spoilage and food infection through the production of toxins<sup>12,32</sup>.

To develop effective preventive strategies for the proper handling of mobile phones, which have been mentioned above to be easily contaminated despite some simple preventive measures such as washing hands after using the toilet, it is necessary to clean the mobile phone well with alcohol, which contains an antibiotic that reduces the risk of infection. Moreover, another way is to use standard cleaning agents to reduce mobile phone pollution by educating people about the circulation of small mobile phone colonies, redesigning their environment, and not handling mobile phones in toilets or dirty places<sup>30</sup>. These results have shown that mobile phones are contaminated with several types of microbes, that their diversity and proximity to an essential part of the body, such as the face, ears, lips, and hands, can be real repositories of germs, and that chances of infection are possible<sup>15,33</sup>.

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