



# Vulnerability of Infants to Infections Due to Contamination of Mobile Phones of Nursing Mothers in Maiduguri Metropolis, Nigeria

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**Abstract:** Mobile phones have rapidly increased globally, and it is believed that there are as many mobile phones as there are humans on Earth. Mobile phones can harbor pathogenic microorganisms, especially as a majority of mobile phones are hand-held. The present study investigated the contamination of mobile phones belonging to nursing mothers and the potential health risk to their infants. A total of 180 mothers with infants not more than 24 months old were randomly selected from different parts of the Maiduguri metropolis. A questionnaire was used to generate information on risk factors that may lead to infants' vulnerability. Swabs samples were collected from mobile phone surfaces and cultured using aseptic techniques. Positive bacterial cultures were observed in 75.56% ( $n = 136$ ) of the samples collected. The bacterial isolates were identified to be *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Proteus* sp. *Klebsiella pneumoniae*, and *Micrococcus* sp. with occurrence rate ranging between 26.47%, and 2.94%. Demographic data showed that infants of 31% mothers were vulnerable to infection and that the ages of infants, ages of mothers, phone usage rate, lack of regular cleaning of phones, and absence of phone cover may play a significant role in infants' vulnerability. However, the educational status of the mothers and area of residence had no significant effect on vulnerability. Therefore, there is a need to increase awareness among nursing mothers to avoid infants' contact with mobile phones; and the need for regular cleansing of mobile phones using disinfectants.

**Keywords:** Mobile phone, nursing mothers, infants, vulnerability, contamination, bacteria

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## I. INTRODUCTION

A mobile phone is an electronic device that allows individuals to make and receive telephone calls over a radio link. It is achieved by connecting to a cellular network provided by mobile phone operators, allowing access to public telephone networks [1]. In addition to the standard voice function of a mobile phone, it also allows other services such as text messaging, email, access to the in-

ternet, and sending and receiving photos and videos [2]. With the advent of sophisticated smartphones, individuals can exchange huge information among themselves, collect large volume of data, self-tracking and monitoring of personal and environmental health [3]. Since the last decade, it is believed that there are almost as many mobile phones as there are humans on the planet and their usage is indispensable [4].

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Mobile phones, like other inanimate objects, can harbor microorganisms associated with human infections especially as the majority of mobile phones are hand-held. In most cases, human hands are constantly associated with microorganisms either as part of person's autochthonous normal flora or allochthonous, coming from the environment. Undoubtedly, there is a continuous exchange of microorganisms between hands, environment and mobile phone surfaces [5]. Combination of prolonged handling and warmth may provide microbes with suitable conditions for growth and rapid colonization of phone surfaces. This makes it a potential route through which infection can be transmitted from person to person. The number of persons using the same mobile phones and the personal hygiene of individuals may also play key roles in the transmission of microbes from person to person [6].

Mobile phones have been identified to be potential vectors of infections including nosocomials - acquired from the hospital environment. Although some studies on mobile phone contamination reported the presence of individuals' normal flora, the mobile phones may likely remain reservoirs of pathogenic organisms capable of causing infections with varying degree of severity [6]. Apart from handler's normal flora, other sources of mobile phones contamination may include bags, phone pouches, pockets, environment and food particles [7]. Food particles from unclean hands and sweat from hands and other body parts (especially in the tropics) provide the required nutrients for microbial survival and growth [8].

A number of studies were conducted to examine the occurrence of bacteria on mobile phone surfaces of different categories of individuals. The outcomes were of health interest considering the percentage of bacterial contamination. For instance, a study by [9] was among the few instances where a relatively less (62%) bacterial occurrence was recorded among sampled population. In some other studies, rate of contamination reaching up to 94.5% [10], [11], 98% [12] and 100% [13] were reported. Some studies suggested that a mobile phone can harbor more microorganisms than a lavatory seat; sole of a shoe or a door handle [14].

Despite the number of researches undertaken in this respect, information on possible transmission of potential pathogens between mothers and their infants through mobile phone contamination is sketchy. Recently, the United Nations Children's Fund (UNICEF) reported that most deaths of under-five children are caused by diseases that are readily preventable or treatable with proven and cost-effective interventions [15]. Many nursing mothers often allow their infants' access to phones especially when over-

whelmed by chores or just to please them in case they are crying. In some instances, nursing mothers allow their toddlers to use mobile phones as teething rings. It is against this backdrop, the present study investigated the nature of bacterial contaminants colonizing the surface of mobile phones used exclusively by nursing mothers; with a view to assessing children vulnerability to infections as a result of phone contamination. The study provided a platform for the isolation and identification of bacteria associated with mobile phones of the persons under study and also the role played by demography and personal hygiene in bacterial contamination. Previous researches on the subject matter were largely centered on clinicians and also under clinical settings; neglecting other important populations. Bearing in mind the fact that there are no proper guidelines for care, cleaning and usage of mobile phones and difficulty or impossibility of keeping the devices aseptic, it became a paramount task to venture into such investigations especially in developing tropical countries where preventable infectious diseases are the major cause of infant mortality. The study provides baseline information on mobile phone contamination among nursing mothers in an urban population in North-Eastern Nigeria and will enable us to create awareness among the subjects involved and emphasize the need for proper hygiene for improved childcare and public health.

## II. MATERIALS AND METHOD

### A. Study Area and Design

This study was carried out in Maiduguri (comprising parts of Maiduguri Metropolitan Council and Jere Local Government Area Council; Lat. 11.4°N; Long. 13°E) of Borno State, Northeastern Nigeria. Samples were randomly collected from volunteer nursing mothers residing in ten different parts namely: Bulunkutu, Yerwa, ATC community, Hausari, Unimaid community, London ciki, Ngomari, Wulari and Dala. Samples were randomly collected between January and May 2016. In addition, a questionnaire was used to generate some data for this study. The key areas addressed in the questionnaire were type of mobile phone, mode of usage, its cleanness, its contact with infants and the mothers' demographics.

### B. Inclusion and Exclusion Criteria

In this study, only mothers with children of 0 to 24 months of age who possessed mobile phones were involved. The mothers with child of more than 24 months old and or without a child and or without a phone were excluded.

### C. Sampling

A total of 180 samples were collected from the areas mentioned above and during the specified period of time. Surface samples were collected aseptically using sterile cotton swabs moistened with normal saline; swabbing over the screens, keypads and back of mobile phones. Each surface was swabbed for approximately 20 seconds. The swabs were immediately placed into their original sterile containers, sealed and transported to Microbiology Laboratory, Faculty of Science, University of Maiduguri in iced containers for analysis.

### D. Isolation

Cotton swabs containing samples were soaked in 5 ml nutrient broth and incubated aerobically over-night at 37°C. Aliquots (0.1ml) of each of the overnight culture was spread on sterile Nutrient Agar (NA) and MacConkey Agar (MA) and incubated at 37°C for 24hr. Distinct colonies were subcultured into NA and MA also in order to obtain pure cultures.

### E. Identification

Bacterial characteristics including colonial, morphological and biochemical were investigated as described elsewhere [16]. Based on the observed characteristics, the isolates were identified using the schemes of [17].

### F. Statistical Analysis

Data obtained from this study were analyzed using InStat 3 Graphad Prism 7 package. Descriptive statistics like mean, frequency, and percentage were performed on different data sets. Chi-square tests were evaluated at 95% confidence limit.

## III. RESULTS AND DISCUSSION

In this study, a total number of 180 nursing mothers residing in nine different locations in Maiduguri were involved. An equal number (20) of mobile phone samples of breastfeeding mothers were collected each from the sampling areas. Of the total number of samples collected, 136 were shown to have a positive bacterial culture upon cultivation; giving a 75.56% overall phone contamination. Results in Table 1 shows that mothers in Yerwa (10.55%,  $n = 19$ ), London ciki (10.55%,  $n = 19$ ) and Bulunkutu (10.0%,  $n = 18$ ) had more contaminated mobile phones than mothers in other parts of the study area with prevalence greater or equal to 10%. Conversely, swab samples from Ngomari had lesser (5.0%) rate of contamination than those from other areas. Statistical analysis revealed a significant association between phone contamination and sampling area at 95% confidence limit. The rate

of contamination observed in this study is an apparent reflection on the extent of contamination the mothers' mobile phones are exposed to. It is a common knowledge that mobile phones are in contact with aerosols generated from the mouth while talking and coughing, washrooms, cluttered bags and other unclean surfaces. As a result, mobile phones are seldom without contamination since tens of thousands of microbes live on each square inch of the phone surface [18]. High temperature, moisture, the presence of food particles and lack of regular disinfection enhance microbial colonization and survival on phone surfaces [19]. A surveillance study by [20] reported 100% contamination of mobile phones belonging to parents with neonates admitted to an intensive care unit. Presently, reports on mobile phone contamination are on the increase. The variation observed in the distribution of phone contamination is phenomenal as it does not reflect our expectation regarding participants' awareness. However, a study by [21] showed that awareness regarding mobile phone contamination in both urban and rural communities is generally low.

A total of 136 bacteria were isolated from the cultures of mobile phone swabs. *Staphylococcus epidermidis* and *Staphylococcus aureus* were most prevalent with 26.47% and 25.00% rate of occurrence respectively. These were followed by *Escherichia coli* and *Pseudomonas aeruginosa* with 17.65% and 12.50% respectively, whereas *Micrococcus* sp. was the least prevalent with 2.94% as shown in Table 2. Even though the most prevalent isolates in this study could be part of the participants' normal flora, their presence on phone surfaces is alarming considering the fact that they are potentially pathogenic. In the last few decades, *Staphylococcus epidermidis* have evolved as important opportunistic pathogens, primarily responsible for nosocomial infections and early-onset neonatal sepsis [22]. Its ability to form biofilm and resistance to multiple drugs has remained a major challenge to clinicians [23]. Hands, being the main reservoirs of *S. aureus* may be the major source of the organism in this study. Its high rate of occurrence is a reflection of continues contact of the phone with hands. Ability to invade tissues and production of toxins has made *Staphylococcus* highly pathogenic. Apart from targeting organs like skin, blood, and bones, it also causes toxic shock syndrome - an illness caused by one of its toxins [24]. Of particular interest, is the widespread occurrence of its multidrug resistant phenotypes including Methicillin-Resistant *S. aureus* (MRSA) and its occurrence on phone surfaces have been reported [21], [24]. [7] reported that *S. aureus*, *S. epidermidis* and *Bacillus* sp. were the frequent bacteria present on mobile phone surfaces of different categories

of staff in a University in Saudi Arabia.

TABLE 1  
DISTRIBUTION OF MOBILE PHONE CONTAMINATION  
OF NURSING MOTHERS

Sampling community	Number of sample (%)	
	Positive	Negative
Unimaid	14 (7.77)	6 (3.33)
Hausari	17 (9.44)	3 (1.67)
ATC	11 (6.11)	9 (5.0)
Yerwa	19 (10.55)	1 (0.56)
Bulunkutu	18 (10.0)	2 (1.11)
London ciki	19 (10.55)	1 (0.56)
Ngomari	09 (5.0)	11 (6.11)
Wulari	13 (7.22)	7 (3.89)
Dala	16 (8.89)	4 (2.22)
Total	136 (75.56)	44 (24.44)

$\chi^2 = 27.85$   $p = 0.05$  Significant

TABLE 2  
FREQUENCY DISTRIBUTION OF BACTERIAL  
CONTAMINANTS

Isolates	Frequency (%)
<i>Escherichia coli</i>	24 (17.65)
<i>Proteus</i> sp.	11 (8.09)
<i>Klebsiella pneumoniae</i>	10 (7.35)
<i>Staphylococcus aureus</i>	34 (25.00)
<i>Pseudomonas aeruginosa</i>	17 (12.50)
<i>Staphylococcus epidermidis</i>	36 (26.47)
<i>Micrococcus</i> sp.	04 (2.94)
Total	136 (100)

*E. coli* - a potentially pathogenic bacteria and fecal in origin, was isolated in this study and had a 17.65% occurrence rate. This is an indication of poor hygiene and the inability of individuals to clean hands after defecation. As a result, people spread fecal bacteria not just to their phones, but to everything else they touch in the surrounding. *E. coli* can survive on hands and other surfaces for hours, especially in warm conditions as in the tropics, and consequently transferred to food, other objects like phones, door handles, computer keyboards, and other people. In addition to *E. coli*, other enterobacteria like *Proteus* sp. and *Klebsiella pneumoniae* have been identified in this study. Being members of the coliform group, fecal contamination of the mobile phones involved

in this study is undisputable. These organisms are associated with a number of infections including sepsis which is most commonly caused by *E. coli* and *Klebsiella* sp. Studies by [25] reported that *E. coli* had 23.53% occurrence rate among some University staff in Ethiopia, whereas [26] reported the occurrence of *Klebsiella pneumoniae* on mobile phone surfaces, thus supporting our findings.

To correlate possible transmission of pathogens from contaminated phones to infants, we investigated if they were allowed to have access to the phones as playing objects, teething rings or grab them knowingly or unknowingly. Results (Fig. 1) showed that 31% ( $n = 56$ ) of the participants agreed that their infants access their phones for one or all of the mentioned purposes. Out of the 56 (100%) mothers, the phones of 42 (75%) mothers had positive bacterial cultures and thus their infants were vulnerable. Vulnerable in this context is defined as children who are more exposed to a risk of acquiring infection more than their peers in the study due to the infant's contact of the mothers' phone and also phone contamination.

To understand the possible risk factors that could lead to children vulnerability, the impact of mothers' age was investigated. Results showed that a number ( $n = 64$ ; 35.56%) of the nursing mothers involved were 21 to 25 years old. Mothers that were 26 to 30 years ( $n = 54$ ) and 18 to 20 years ( $n = 36$ ) old however had more vulnerable children (11.11%;  $n = 20$  and 8.89%;  $n = 16$  respectively). Older nursing mothers ( $\geq 31$  years  $n = 26$ ) were fewer and also had a little number of vulnerable children (4.4%;  $n = 8$ ). Nursing mothers' age was found to be associated with children risk to infections ( $p < 0.05$ ) using the chi-square test. This association may be linked to the fact that, mothers within the age range of 18 to 30 in this area are predominantly living with children that cannot effectively take care of themselves talk less of laying a helping hands to their younger ones. Consequently, a mother might be over burdened with multi-childcare and can do many things towards maintaining balance between all the children including using phones. At times, a mother might not be aware when an infant will grab her mobile phone for play. The elderly mothers however, are more experienced in childcare, more skilled in organizing chores and may be helped in taking care of infants by older children. As a result, infants' contact with mobile phones could be minimized.



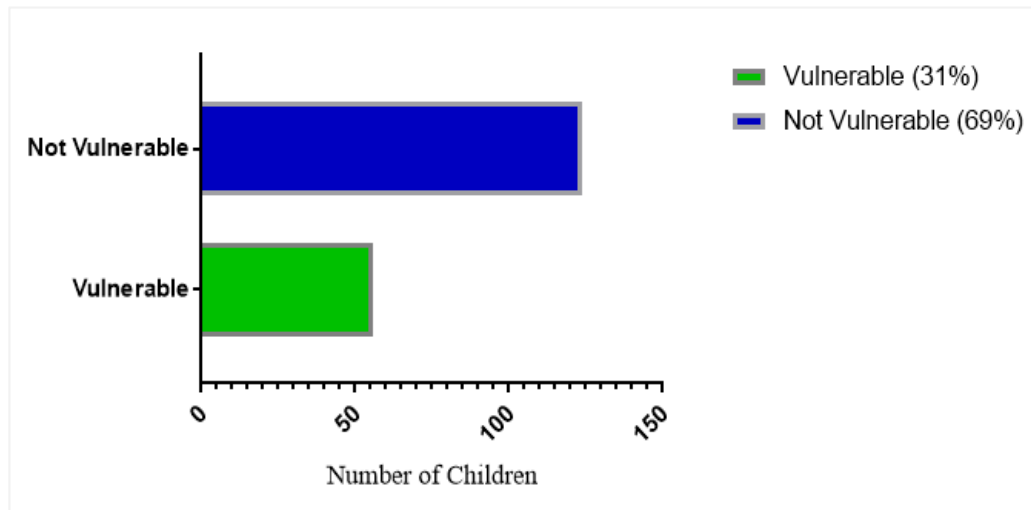


Fig. 1. Vulnerability of children to infections through mobile phone surfaces

Majority of the subjects involved in this study were Secondary school leavers followed by Tertiary and Primary with 56.11%, 36.67% and 7.22% proportions respectively. Despite the fact that no significant association was established between educational status of the individuals and children's vulnerability to infections, it is assumed that mothers that attended at least secondary schools are more aware of phone contamination and also its ability to transmit infection than primary school attenders. On the other hand, significant association ( $p < 0.05$ ) of infant age and vulnerability was observed, with children of 7 to 12 months ( $n = 75$ ) being involved more than any other group; whereas, 19 to 24 months ( $n = 22$ ) old children were less. This might be attributed to the fact that infants at this age are more playful and are able to crawl towards anything they are attracted to including mobile phones (Fig. 2).

Fig. 3 provides the nature and mode of phone usage by the participants. Averagely used phones were 38% ( $n = 68$ ) whereas rarely used and frequently used were 34% (61) and 28% (51) respectively. In addition, covered and uncovered phones were 26% ( $n = 47$ ) and 74% ( $n = 133$ ) respectively and had 13 and 43 vulnerable children. Phone covers are thought to play important role in preventing contamination and studies by [18] reported that by providing a protective plastic cover to mobile phones, growth of microorganism was reduced by up to 90%. Forty eight percent (48%  $n = 86$ ) of mothers involved agreed that they use either water (dampened cloth or cotton wool) or disinfectants to clean their phone whereas, 52% ( $n = 94$ ) do not clean their phones at all with any of the said items. In a particular study [27], it was shown that usage of alcoholic disinfectants eliminated bacterial contamination in 98% of mobile phones of the sampled

population. [24] suggested that the use of alcoholic disinfectants is a simple measure that should be incorporated into daily lifestyle to prevent potential spread of pathogenic bacteria within the hospital and community settings. Statistical analysis using chi square showed that the rate of phone usage, absence of phone cover and lack of cleaning phones is associated with phone contamination and infants' vulnerability to infections.

The use of mobile phones has exponentially increased over some years and currently, they are gradually becoming indispensable. With continues emergence of different kind of mobile software and hardware, too much contact to mobile phones is common. It is believed that a person may look on to his phone for about 150 times in a day. With hands been in constant contact with different body parts and environment, there is equally continues transfer of microorganisms to the mobile phone surfaces. Colonization is established by favorable conditions provided by the phone surface, hands and also the environment. Of particular interest is the adaptation of microbes to electromagnetic radiations emitted from mobile phones. [12] showed that bacteria colonizing mobile phones absorb electromagnetic energy from cell phones and also emit the radiations which provide a conducive medium for growth. Thus, there is a close relationship between the emissions of electromagnetic radiation and the microbial load on mobile phones.

#### IV. CONCLUSION

Results from this study have shown that mobile phones of nursing mothers are contaminated with bacteria that are believed to be potentially pathogenic. Over 75% of mothers phone swabs yielded positive cultures with different types of bacteria including *Staphylococ-*

*cus epidermidis*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Proteus sp.* *Klebsiella pneumoniae*, and *Micrococcus sp.* It also revealed that 31% of mothers allowed their infants to, at least grab their phone making the latter vulnerable to infection. The vulnerability might be enhanced by mothers' and infants' ages, the frequency of phone usage, absence of phone covers and lack of disinfection. The contamination and vulnerability observed in this study was quite significant and might have led to serious health problems the origin of which might have been obscure. Presence of certain bacteria, whose pathogenicity is well known among the contami-

nants, is an indication of serious health hazards that the infants are exposed to. Although there are no guidelines for the rate of phone usage and disinfection, there is a need for massive enlightenment with a view to creating awareness among the public about the dangers posed by mobile phones to infants particularly and other categories of individuals in general. This will enable mothers to imbibe good sanitary practices and improved personal hygiene for better childcare. Further studies should be conducted with a large sample size including different possible associated factors and spreading over a wider geographical territory.

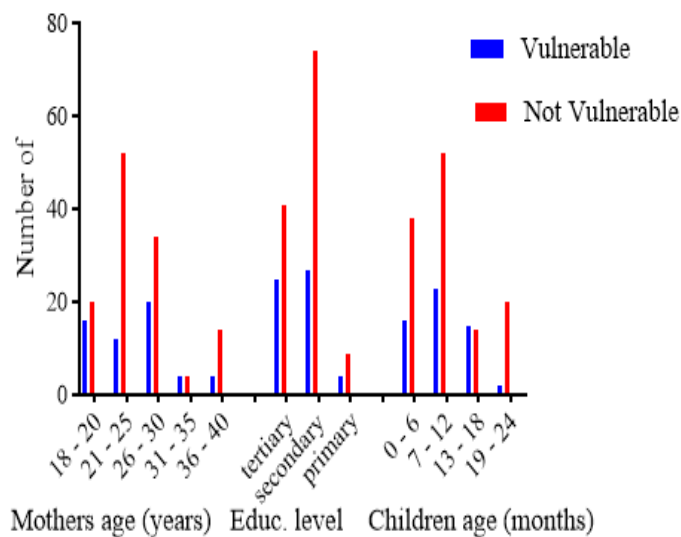


Fig. 2. Demographic factors associated with children vulnerability

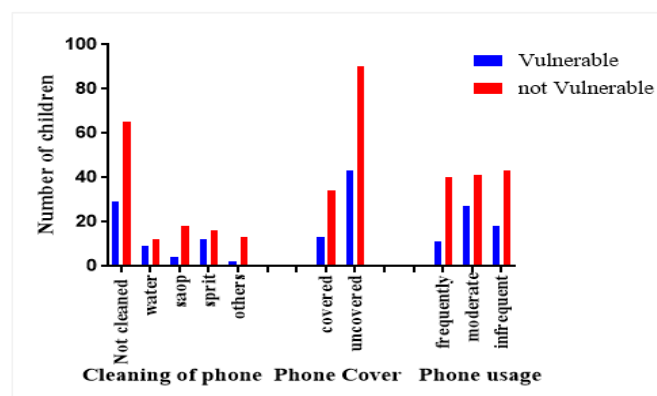


Fig. 3. Mothers attitude towards handling mobile phones

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