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Microbial profiles of Hands, Foods, Easy contact surfaces and Food contact surfaces: A case study of a University Campus

***Oranusi S., Dahunsi S. O., Owoso O. O. and Olatile T.**

Biological Sciences Department, Covenant University, Ota, Ogun State, Nigeria

ABSTRACT

Human hands usually harbour microbes both as part of body normal flora as well as transient microbes acquired from the environment. One common way by which transient organisms of hand are picked up is by contact with food and surfaces. A total of 130 samples consisting of 40 hand swabs, 20 each of food samples and food contact surfaces and 10 each of swabs from banisters, table top, door handles, taps handles and toilet flushers were collected from different locations of the University campus. Samples were analyzed for total aerobic plate count, fungal count, coliform count and for specific organisms. About 98% of hand swabs, food contact and the easy contact surfaces were contaminated with diverse organisms. Hand swabs from the halls of residence and Library had higher levels of contaminations $2.1x10^5$ and $1.9x10^5$ cfu respectively. Toilet flushers and Banisters had TAPC of $8.3x10^6$ and $4.8x10^6$. Moin-moin, Fried rice and Coleslaw had counts of $3.2x10^7$, $1.6x10^6$ and $1.1x10^6$ cfu/g. The predominant microorganisms isolated were Bacillus spp., Staphylococcus spp., Streptococcus spp., Aspergillus spp., Fusarium spp., Penicillium spp. and Actinomycetes. Also present in the food samples and contact surfaces are Klebsiella spp., Escherichia coli and Salmonella spp. Different types of organisms can be picked up from the environment specifically the easy contact surfaces and the hand can be the most important means by which enteric pathogens are transmitted. Likewise, the rate of food borne illness can be greatly reduced by effective HACCP, GMP and hand washing.

KEYWORDS: Contamination, Easy contact surface, Food contact surface, Normal flora, Transient microbes.

*Corresponding author**:** Oranusi S.
Biological Sciences Department, Covenant University,
Ota, Ogun State, Nigeria
E-mail: orasoluche@gmail.com

INTRODUCTION

The hands are the chief organs for physical manipulation of the environment. As a paired organ, the hand is controlled by the opposing brain hemisphere [1] and enables one to do all manner of things. The hand serves as a medium for the propagation of microorganisms from place to place and from person to person. Although it is nearly impossible for the hand to be free of microorganisms, the presence of pathogenic bacteria may lead to chronic or acute illness. Human's hands usually harbour microorganisms both as part of body normal flora as well as transient microbes contacted from the environment [2, 34, 35]. The natural habitat of microorganisms like Staphylococcus is the human skin and can therefore be passed from one person to another. Many food borne diseases and pathogenic microorganisms are spread by contaminated hands. One common way by which organisms that are not resident in the hand are picked up is by contact with surfaces such as table tops, door knob or handles, banisters,

toilet handles and taps in restrooms. Microbes carried on the human skin are of two types i.e. resident and transient [3, 4, 34, 35]. In addition to these are the infectious with species such as *Staphylococcus aureus* or beta-hemolytic Streptococci, which are frequently isolated from abscesses, whitlows, paronychia or infected eczema [5]. The dominant resident microbes are *Staphylococcus epiderdimis* which is found on almost every hand [6]. It's been estimated that the population of *Staphylococcus epiderdimis* far outnumbers *Staphylococcus aureus* on healthy hands [7]. Others are members of *Corynebacteria and Micrococci spp.* [8, 9] and certain members of the *Enterobacteriaceae* family [10]. Pathogens that may be present on the hand as transient types includes *Escherichia coli, Salmonella spp., Shigella spp., Clostridium perfringens, Giardia lamblia,* Norwalk virus and Hepatitis A virus [7]. Since human hands usually harbour microorganisms both as residents and transients [2, 11], it is conceivable that transfer of pathogens could occur between people who access the same area or surfaces. The chance that other persons will acquire these organisms is dependent on how long the organism can survive in the environment. For example, *Listeria species* can survive for a while on the hand and in the environment [12]. Appropriate hand washing can minimize microbes acquired on the hand by contact with contaminated surfaces. Hand washing is the simplest and most cost effective way of preventing the transmission of infection and thus reducing the incidence of health care associated infections.

Disinfection of surfaces is also necessary to prevent infections from transient microbes especially surfaces that the hand comes in contact with mostly and frequently. Studies have shown that although these surfaces cannot be totally free from microorganisms, they can be minimized and with precautions, several cases of infection can be prevented. Bacterial pathogens that could be isolated from the hand include *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus mirabilis*, *Citrobacter freundii*, *Enterobacter spp., Streptococcus spp., Klebsiella spp., Micrococcus spp.* and *Salmonella typhi* [13, 14].

Food is one of the most essential needs of man, a source of nourishment for growth and other metabolic activities such as development, immunity building and repairs of damaged tissues in the body. Food handlers (hand) are the major source of food contamination. Hand washing prevents the direct transfer of infectious pathogens on the hand from reaching point of entry and the indirect transfer through food preparation and fomite transmission pathways [15]. Cross-contaminations in the home and in food service establishments are a major contributing factor for sporadic and epidemic food-borne illness [16]. A number of studies have characterized the prevalence of indicator microorganisms and pathogens in household kitchens, commercial food preparation and processing environments [17]. Food workers can spread food-borne illness in the food service environment through hand contact with pathogen from their gastrointestinal tracts or objects or food contaminated with pathogens and subsequent passage of pathogens to food [18]. Therefore, proper hand washing can significantly reduce the transmission of pathogens from hands to food and other objects [19, 20, 21].

MATERIALS AND METHODS

Source of samples:

The study was carried out in South Western Nigeria in a University campus equipped with standard facilities. A total of 130 samples consisting of 40 hand swabs, 20 samples each foods and food contact surfaces (Samples of foods were collected at random and at intervals of two weeks and at peak service times) and 10 swabs each of banisters, table top, door handles, taps handles and flushers were collected from different locations within the University. The evaluation was carried out between February and June, 2012. The campus was divided into five sections: College of Engineering complex (UC_1), College of Human

Development/Management complex (UC_2), College of Science complex (UC_3), the Halls of residence (UC_4) and the Library (UC_5).

Sample collection:

With the aid of sterile moistened swabs, hand swabs (hands and fingers nails) were obtained from students in the five sections (UC_1, UC_2, UC_3,UC_4 and UC_5) and also swabs per square surface of the table top, banisters, door handle, taps handles, toilet flushers, laboratory doors and tables were collected. The swab were collected in triplicate for each sample and labeled appropriately. Food contact surface materials collected includes hand swabs from staff at the food service points, the caterers in the different sections in the kitchen, swabs per square surface of the cutting boards, kitchen utensils, food trays etc. Food samples were also collected for microbial analysis.

Microbial assessment of samples:

The swabs were rinsed out in 5ml of sterile nutrient broth while 10g food samples were serially diluted to 10^{-2} through 10^{-4}. Aliquot 0.1ml sample homogenates was spread inoculated onto Potato dextrose agar (PDA) for fungal count, Nutrient agar for total aerobic plate count, Lactose broth for coliform test, Eosin Methylene Blue (EMB) agar for coliform count, Mannitol Salt agar (MSA) for Staphylococci and following pre-enrichment, onto Salmonella-Shigella agar for Salmonellae. Plates were incubated for 24 to 48 h at 37°C except however, PDA that was incubated at 28± 2°C for 3 to 5 days. After incubation, numbers of colony forming units (Cfu) were counted and characteristic distinct colonies were isolated and purified by repeated sub-culturing on Nutrient agar. Identification of bacterial isolates was by morphological and biochemical characteristics [22]. Fungal isolates were identified by both microscopic and macroscopic characteristics of the hyphae mass, morphology of cells and spores, nature of the fruiting bodies, media presentations and with reference to standard atlas [23].

RESULTS

Samples were analyzed for total aerobic plate count, fungi and coliforms in order to determine the number and types of microorganisms associated with hands, foods, food contact surfaces and easy contact surfaces and to establish possible relationships. About 98% of hands and surfaces swabbed were contaminated with diverse organisms. Table 1 presents the different organisms associated with the different easy contact surfaces and from hands of subjects in different locations on the campus. It shows that predominant organisms isolated include *Bacillus spp.*, *Staphylococcus spp.*, *Streptococcus spp. a*nd *Enterococcus spp.*, *Aspergillus* and *Penicillium spp.* Toilet flushers and banisters had higher microbial count compared to other surfaces as shown in Table 2. The mean microbial count of food samples is presented in Table 3; it reveals that fried rice, moin-moin and coleslaw were more contaminated with counts 10^6 and above. The microbial isolates from foods and food contact surfaces are shown in Table 4; it reveals that organisms of same genera are present in most foods and food contact surfaces.

DISCUSSION

The presence of species of *Staphylococcus* and *Streptococcus* in all hand swabs and easy contact surfaces could be attributed to the fact that they are resident flora of the human skin and thus easily contaminate surfaces on contact [6, 24, 25]. Staphylococci and Streptococci are known to be potential/ opportunistic human pathogens [26, 27]. Enterotoxin producing strains of Staphylococci have been implicated in food poisoning [28, 29] and Streptococcus feacalis are indicator organism for feacal contamination [30]. The presence of Staphylococci and Streptococci species on hands and easy contact surfaces could serve an easy route for

human infections. Effective hand washing and sanitization of surfaces will help prevent possible deleterious effects from these organisms [34, 35].

Table 1: Microorganisms isolated from hand swabs and easy contact surfaces from different locations on campus

Sample source	Organisms isolated
UC_1	*Staphylococcus spp, Streptococcus spp, Bacillus spp, Actinomycetes, Listeria, Neiseria spp.*
UC_2	*Staphylococcus spp, Streptococcus spp, Bacillus spp, Fusarium, Neiseria spp, Klebsiella spp, Enterococcus spp, Aspergillus spp.*
UC_3	*Bacillus cereus, Staphylococcus spp, Micrococcus spp, Aspergillus spp, Enterococcus spp, Streptococcus spp.*
UC_4	Bacillus subtilis, *Listeria, Klebsiella spp, Staphylococcus spp, Neiseria spp, Micrococcus spp, Fusarium, Enterococcus spp, Streptococcus spp. Actinomycetes.*
UC_5	*Bacillus cereus, Staphylococcus spp, Klebsiella spp, Micrococcus spp, Neiseria spp, Enterococcus spp, Streptococcus spp, Fusarium spp, Actinomycetes.*
Doors handle	*Bacillus spp, Fusarium spp, Listeria, Actinomycetes, Klebsiella spp, mucur spp, Staphylococcus spp, Aspergillus spp.*
Banisters	*Bacillus spp, Staphylococcus spp, Streptococcus spp, Aspergillus fumigatus, Neiseria spp, Fusarium, Penicillum, Listeria, Aspergillus spp.*
Table top	*Bacillus spp, Streptococcus spp, Aspergillus spp, Penicillum spp, Fusarium spp.*
Tap handles	*Bacillus spp, Aspergillus spp, Staphylococcus spp. Mucur spp, Actinomycetes.*
Toilet flushers	*Bacillus spp, Staphylococcus spp, Enterococcus spp, E. coli Streptococcus spp, Penicillum spp, Micrococcus spp, Klebsiella spp*

Table 2: Mean microbial count of hand swabs and easy contact surfaces

Swab	TAPC	Coliform count	Fungal count
Door handle	$5.7x\ 10^4$	$1.0x\ 10^2$	$3.0x\ 10^2$
Banister	$4.8x\ 10^6$	$1.0x\ 10^3$	$3.0x\ 10^2$
Table top	$7.5x\ 10^5$	<10	$3.3x\ 10^3$
Tap handle	$4.4x\ 10^5$	<10	$6.0x\ 10^1$
Toilet flusher	$8.3x\ 10^6$	$3.3x10^3$	$1.0x\ 10^2$
UC_1	$1.6x\ 10^3$	$1.0x\ 10^1$	$1.0x\ 10^1$
UC_2	$9.8x10^3$	$3.0x\ 10^2$	$2.1x\ 10^1$
UC_3	$1.8x\ 10^4$	$2.0x\ 10^2$	< 10
UC_4	$2.1x10^5$	$3.2x\ 10^2$	$2.0x\ 10^2$
UC_5	$1.9x10^5$	$3.0x\ 10^2$	$2.0x\ 10^2$

Table 3: Mean microbial count (Cfu/g) of food samples

Food sample	TAPC	Coliform count	Fungal count
Fried rice	$1.6x\ 10^6$	$5.6x\ 10^1$	$7.5x\ 10^3$
Spaghetti	$1.3x\ 10^4$	$5.0x\ 10^1$	$1.2x\ 10^2$
Beans	$1.2x\ 10^3$	$2.3x\ 10^2$	$1.7x\ 10^2$
Moin-moin	$3.2x\ 10^7$	$7.2x\ 10^3$	$5.1x\ 10^3$
Cole slaw	$1.1x\ 10^6$	$1.5x\ 10^2$	$1.4x\ 10^4$
Chinese rice	$1.4x\ 10^5$	$9.3x\ 10^1$	$1.3x\ 10^1$

Table 4: Microorganisms isolated from foods and food contact surfaces

Sample types	Organisms isolated
Fried rice	*Bacillus spp, Staphylococcus spp, Mucor spp, Lactobacillus sp., Staphylococcus aureus.*
Spaghetti	*Bacillus subtilis, Staphylococcus aureus, Bacillus spp,Rhizopus spp*
Beans	*Klebsiella spp, Escherichia coli, Staphylococcus aureus, Bacillus spp, Penicillium spp.*
Moin-moin	*Bacillus spp, Klebsiella spp, Aspergillus spp, Staphylococcus aureus, Streptococcus spp.*
Cole slaw	*Enterobacter spp, Rhizopus spp, Bacillus spp, Klebsiella spp, Staphylococcus aureus, Lactobacillus spp.*
Hand swab	*Staphylococcus spp, Klebsiella spp, Salmonella spp, Neiseria spp, Staphylococcus aureus, Escherichia coli, Aspergillus niger.*
Finger nail swab	*Enterococci, Klebsiella spp., Escherichia coli, Staphylococcus aureus, Salmonella spp., Candida spp, Aspergillus niger.*
Cutting board for fish	*Fusarium spp, Klebsiella spp, Escherichia coli, Staphylococcus aureus, Salmonella spp, Bacillus spp, Aspergillus spp.*
Hot dog tray	*Bacillus spp, Saccharomyces spp, Penicillium spp, Staphylococcus spp, Staphylococcus aureus.*
Stick meat tray	*Pseudomonas aeruginosa, Staphylococcus spp, Bacillus spp, Rhizopus spp, Aspergillus spp.*
Chopping board	*Bacillus spp, Aspergillus spp, Pseudomonas aeruginosa, Klebsiella spp, Salmonella spp, Escherichia coli, Proteus spp.*
Rolling pin	*Bacillus spp, Saccharomyces spp, Rhizopus spp, Staphylococcus spp, Neiseria spp*
Serving spoon handle	*Staphylococcus aureus, Lactobacillus spp, Fusarium spp, Bacillus spp, Aspergillus niger.*
Food table	*Saccharomyces spp, Aspergillus niger, Bacillus spp, Staphylococcus spp, Cladosporium spp.*

Bacillus species are known to bear resistant spores and are common environmental contaminants; it has been shown to be a transient micro flora of the hand and surfaces due to the spore forming ability. *Bacillus cereus* has been implicated in food poisoning [31] and several other *Bacillus species* have been implicated in human pathogenesis and as food spoilage organisms [30]. The spore forming ability of moulds and the wide distribution of actinomycetes are responsible for their spread on surfaces and on hand swabs. Species of Aspergillus, Penicillium, and Fusarium produces deleterious mycotoxins under favourable growth conditions and have also been implicated in superficial, cuteneous, sub-cuteneous and systemic mycoses [32]. Neiseria spp are common flora of the nasal cavity and the mouth, contamination of hands and contact surfaces could be from discharges/aerosols from nose and mouth. *Listeria, Klebsiella, Enterococci* spp can last long on surfaces for days or even months and can last on the hand for a while [12, 27], therefore, as long as it is present on the hands, it will be spread continually by the individuals to other places. This is likely the case with the hand swabs and the easy contact surfaces. *Listeria* and *Staphylococcus* have been linked with food poisoning. The presence of *Enterococcus* could be indicative of poor domestic and personal hygiene as the hands will most likely be contaminated after visits to the rest room and this may also predispose to disease. Such hands can easily be contaminated if the finger nails are long [33, 34, 35]. The high degree of prevalence of microorganisms on the hands of students could mean that there is a high risk of food poisoning/infection by self-contamination among the students. Students are likely to take meals and water/drinks without washing their hands due to rush to meet up with daily schedules, carelessness, ignorant of the fact that the hand could pick up microorganisms from the environment, general student attitude/peer pressure etc increases their risk of coming down with infections [15].

The high microbial counts recorded for hand swabs and easy contact surfaces could be a reflection of the level of exposure and thus cross contamination. The hand is the main organ

used for manipulating the environment and pick microorganism in these diverse environments. Microorganisms are picked by the hands and spread from person to person during exchange of pleasantries or contacted from surfaces and this could be the reason why *S. aureus*, *Bacillus* and *Streptococcus spp.* were isolated from the hands of the individuals in all the locations because these organisms would have been picked up from a place and then spread to another where they were picked up by individuals.

It could be inferred that the presence of fungi and other contaminants on surfaces is an indication that proper cleaning procedures and decontamination of surfaces were absent. Therefore, people could easily pick these organisms from such surfaces and this could also lead to great consequences. The contamination on tap handle could be due to dirty hands used to open the taps prior to washing of the hands from where such organisms can be picked up and transferred. Decontamination of such surface should therefore not be taken for granted [34, 35]. The door handle and table top were observed to have high levels of contamination and this could be due to the fact that these surfaces are always in contact with the hand and since the hands could be contaminated, they could be deposited on this surfaces. The environment is a learning facility and as such, students, staff and faculty will always come in contact with table tops and thereby deposit these organisms.

The Halls of residence (UC_4) and the Library (UC_5) indicated highest levels of contamination and this could be because these areas are most accessed by students including faculty and staff at large and as such, organisms are picked up from various places and transferred to these areas. In such areas, hand washing facilities should be installed and used prior to entry and exit to minimize spread.

The microbial loads of the foods analyzed are within acceptable standard specifications [36], 1998) except however for moin-moin, coleslaw, and fried rice which are above acceptable limit. These could be associated to the several handling processes thus possible contamination in the preparation of these products, coleslaw is a raw product and needed extra care and effective washing in the preparation. The presence of similar genera of microorganisms in the food contact surfaces and foods point to the possibility of cross contamination from the personnel to food contact surfaces and to foods and *vis-à-vis.* Further work is ongoing to draw a relationship in the contaminants of hand swabs, easy contact surfaces, food contact surfaces and food.

CONCLUSION

Different kinds of organisms can be picked up from the environment specifically the easy contact surface and the hand can be the most important means by which enteric pathogens are transmitted. Proper hygiene and public enlightenment on the role of easy contact surface and the hands in disease dissemination is advocated. Regular hand washing is necessary even when hands are not visibly soiled, before eating and after using the rest room and of course when contamination of hands with bacteria spores is suspected. In these situations, the simple hand wash reveals the best result compared with other possible hand treatments. Hygienic hand disinfection when moving from a contaminated body site to a clean one and after contact with possibly contaminated environmental surfaces is very important. Hand hygiene is equally advocated after using the restroom in cases of diarrhea and after blowing the nose in case of an upper respiratory tract infection. Application of Hazard Analysis Critical Control Point (HACCP) and Good Manufacturing Practices (GMP) in food processing is highly recommended.

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