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Bacteriological Examination of Computer Keyboards and Mouse Devices and Their Susceptibility Patterns to Disinfectants

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ABSTRACT

Computers are ubiquitous and have been shown to be contaminated with potentially pathogenic bacteria in some communities. There is no economical way to test all the keyboards and mouse out there, but there are common-sense ways to prevent bacterial contamination or eliminate it if it exists. In this study, swabs specimens were collected from surfaces of 250 computer keyboards and mouse and plated on different bacteriological media. Organisms growing on the media were purified and identified using microbiological standards. It was found that all the tested computer keyboards and mouse devices, were positive for microbial contamination. The percentages of isolated bacteria (*Staphylococcus* spp., *Escherichia* spp., *Pseudomonas* spp. and *Bacillus* spp.) were 43.3, 40.9, 30.7, 34.1, 18.3, 18.2, 7.7 and 6.8% for computer keyboards and mouse respectively. The isolated bacteria were tested against the 6 different disinfectants (Dettol, Isol, Izal, JIK, Purit and Septol®). Antibacterial effects of the disinfectants were also concentration dependent. The agar well diffusion technique for determining Minimum Inhibitory Concentration (MIC) was employed. The Killing rate (K) and Decimal Reduction Time (DRT) of the disinfectants on the organism were also determined. The overall result of this study showed that Dettol®, followed by JIK® was highly effective against all the bacterial isolates tested while Septol and Izal® were least effective. Isol and Purit® showed moderate antibacterial effects. Keyboards and mouse should be disinfected daily. However, it is recommended that heightened surveillance of the microbial examination of computer keyboards should be undertaken at predetermined intervals.

Keywords: Bacteria, Computer, Disinfectants, Antibacterial Activity, MIC, DRT, Killing Rate

1. INTRODUCTION

Computer is an electronic data processing machine which accepts data from the out-side world inform of an input and manipulates, calculates, computes on the basis of set of instructions supplied and stored in the memory and give the required or desired results in the form of an output to the user (Ravichandran, 2001). Because of frequent-dermal contact by numerous users, microbial reservoirs of interest includes the computer keyboard and mouse (Neely *et al*., 2005a; Wilson *et al*., 2006). Anderson and Palambo (2009) documented that the average number of microorganisms present on multiple-user computer keyboards was significantly greater than on single-user keyboards.

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Computer hardware has been implicated as a potential reservoir for infectious agents (Neely *et al*., 2005b). Of increasing concern, however, is the role of keyboards in the non-hospital environment as pathogen reservoirs (Eguia and Chamber, 2003). It follows that the ubiquitous sharing of public computers by a broad user base might facilitate increased transmission and prevalence of pathogenic microorganisms throughout the community (Eltablawy and Elhifnawi, 2009). Inadequately performed hand hygiene and non-disinfected surfaces are two reasons why the keys and mouse-buttons of laptops could be sources of microbial contamination resulting consequently in indirect transmission of potential pathogens and nosocomial infections (Siegmund *et al*., 2010).

Surprisingly, little effort has been dedicated to identify the role of inanimate surfaces as pathogen reservoirs in the non-hospital settings (Pancholi *et al*., 2005; Stepanovic *et al*., 2008). Therefore, successive steps to edge the spread of antimicrobial resistant pathogens throughout the community should include efforts to not only increase awareness of appropriate hygiene and decontamination strategies, but also to reveal the ecology of bacteria contaminating community surfaces.

This study was undertaken to evaluate the bacteriological examination of computer keyboards and mouse devices and their susceptibility patterns to commonly used disinfectants.

2. MATERIALS AND METHODS

2.1. Study Area

This study was conducted within three campuses (Presco, CAS and Ishieke) of the Ebonyi State University, Abakaliki.

2.2. Ethical Clearance

The consent and permission of the cyber cafes owners were inquired in order to carry out this research work. Subsequently, the confidentiality of the information obtained from cyber cafes was kept.

2.3. Sample Collection and Preparation

The surfaces of 250 computer keyboards and mouse of 15 cyber cafes in three campuses (Presco, CAS and Ishieke) were randomly selected for this study. This was performed during operating hours featuring normal students and staff traffic at the cyber cafes. The single sterile swab stick moistened with sterile saline solution were moved over the surfaces being tested (keyboard and mouse). The swab sticks were immediately transported to the laboratory.

2.4. Collection of Disinfectants

The following disinfectants: Dettol® (Reckitt Benkiser Ltd, Nigeria), Isol® (Medreich Ltd, Nigeria), Izal® (Medreich Ltd, Nigeria), JIK® (Reckitt Benkiser Ltd, Nigeria), Purit® (Saro Lifecare Ltd, Nigeria) and Septol® (Gongoni Company Ltd, Nigeria) commonly used in Abakaliki Metropolis were obtained from Ceno Pharmacy, Abakaliki, Ebonyi State.

2.5. Identification of the Isolates

Identification of the test isolates was done based on morphological and biochemical test: Sugar fermentation test (glucose, fructose and lactose), Voges Proskauer test, catalase test, coagulase test, oxidase test and indole test, including Gram staining reaction and motility test was carried out for proper characterization of bacterial isolates according to Cheesbrough (2006).

2.6. Dilution of Disinfectant

Serial dilution method was used to dilute the disinfectants into 50, 25 and 12.5% concentration according to Awodele *et al.* (2007).

2.7. Standardization of Test Organisms

The isolates used for sensitivity were standardized using the 0.5 McFarland equivalent standard as described by Cheesbrough (2006).

2.8. Susceptibility Testing

The susceptibility testing of the commonly used disinfectants were ascertained using agar well diffusion method (Awodele *et al*., 2007; Iroha *et al*., 2011).

3. RESULTS

The organisms were then characterized as shown in **Table 1**. Four bacteria were isolated in this study and suspected to contaminate computer keyboards and mouse.

Out of 250 samples analyzed, a total of 148 bacteria isolates were isolated from computer keyboards and mouse. Out of which 63 *Staphylococcus* spp. were present; 45 of the isolates were from keyboards and 18 from mouse. 11 were *Bacillus* spp.; 8 of the isolates from keyboards and 3 from mouse. 47 were *Escherichia* spp.; 32 of the isolates from keyboards and 15 from mouse. 27 were *Pseudomonas* spp.; 19 of the isolates from keyboards and 8 from mouse. A total of 104 bacterial isolates were obtained from keyboards and 44 bacterial isolates from mouse (**Table 2**).

Table 1. Morphological and biochemical test result of bacterial isolated from computer keyboards and mouse

Morphological characterization		Sugar fermentation test									
Colour	Consistency/ texture	Gram staining	Catalase test	Oxidase test	Indole test	Voges proskauer	Motility test	Glucose	Lactose	Fructose	Suspected organisms
Creamy	Raised/smooth edge	+ve	+	-	-	-	-	+	-	-	*Staphylococcus* spp.
Grayish	Small round colony	+ve	-	+	-	-	-	+	-	-	*Bacillus* spp.
Greenish	Rough surface	-ve	+	-	+	-	-	+	+	-	*Escherichia* spp.
Light yellow	Slightly raised	-ve	+	+	-	-	-	+	-	-	*Pseudomonas* spp.

Table 2. Frequency of bacterial occurrence in computer keyboards and mouse

Isolates	Keyboards (%)	Mouse (%)	Total No. (%)
Staphylococcus spp.	45 (43.3)	18 (40.9)	63 (42.6)
Bacillus spp.	8 (7.7)	3 (6.8)	11 (7.4)
Escherichia spp.	32 (30.7)	15 (34.1)	47 (31.8)
Pseudomonas spp.	19 (18.3)	8 (18.2)	27 (18.2)
Total	104	44	148

Table 3. Antimicrobial activities of disinfectants against organisms at 100, 50, 25 and 12.5% concentration and inhibition zone diameter (mm)

	Staphylococcus spp.				*Bacillus* spp.				*Escherichia* spp.				*Pseudomonas* spp.			
Disinfectants	100	50	25	12.5	100	50	25	12.5	100	50	25	12.5	100	50	25	12.5
Dettol®	15	12	10	10	14	10	14	8	15	13	10	12	14	10	12	8
Isol®	12	10	7	4	10	11	5	-	11	8	-	-	10	8	5	-
Izal®	8	-	-	-	12	4	-	-	10	5	-	-	5	-	-	-
JIK®	13	12	10	8	13	12	11	5	12	5	8	5	10	11	9	7
Purit®	10	8	5	-	9	-	5	-	5	-	4	-	7	4	-	-
Septol®	5	-	-	-	9	6	-	-	-	-	-	-	10	5	-	-

Table 4. Minimum inhibitory concentration of disinfectants against test bacteria

	MIC (mL/mL)					
Strain Name	Dettol®	Isol®	Izal®	JIK®	Purit®	Septol®
Staphylococcus spp.	4.5731	3.5375	4.9556	3.4498	1.0273	3.5156
Bacillus spp.	1.5093	2.1468	1.9063	3.7273	1.9629	2.5182
Escherichia spp.	8.4431	7.7875	4.6249	4.2433	2.0659	3.5116
Pseudomonas spp.	1.7824	2.1468	6.3081	5.5326	6.6711	6.1816

At 100% concentration, Dettol® and JIK® were the most effective in inhibiting the four organism tested, followed by Isol®, while Septol®, showed the lowest inhibitory activity on all the organisms at 100% concentration (**Table 3**).

However, at 50% concentration Dettol and JIK® were also the most effective in inhibitory activities, followed by Isol® on the four organism tested. Izal® showed no inhibitory activity on *Staphylococcus* and *Pseudomonas* spp., but showed inhibitory activities on *Bacillus* and *Escherichia* spp.. In the same vein, Purit® showed inhibitory activities on *Staphylococcus* and *Pseudomonas* spp., but had no inhibitory effect on *Bacillus* and *Escherichia* spp. At this 50% concentration, Septol® showed inhibitory activities on *Bacillus* spp. and *Pseudomonas* spp., but disclosed no inhibitory effect on *Staphylococcus* and *Escherichia* spp **Table 4**.

Furthermore, at 25% concentration it was revealed that Dettol and JIK® showed reasonable inhibitory activities on *Staphylococcus*, *Bacillus*, *Escherichia* and *Pseudomonas* spp. followed by Isol® on *Staphylococcus*, *Bacillus* and *Pseudomonas* spp. respectively and showed no inhibitory activity on *Escherichia* species. Purit® showed inhibitory activities on *Staphylococcus*, *Bacillus* and *Escherichia* spp., but had no inhibitory activity on *Pseudomonas* spp. Izal

and Septol® did not show any inhibitory activity at this 25% concentration to the entire organisms tested.

Finally, at 12.5% concentration, Dettol and JIK® demonstrated inhibitory activities on *Staphylococcus*, *Bacillus*, *Escherichia* and *Pseudomonas* spp. Isol® showed inhibitory activity on only *Staphylococcus* spp. and had no inhibitory effect on the other organisms. At same 25% concentration, Purit, Izal and Septol® revealed no inhibitory effects on the other organisms tested.

The killing rates (K) of the organisms obtained from the graphs are given in **Table 5**. The higher the value of k, the faster the efficiency of the killing process. The killing rates of *Staphylococcus* spp. by Dettol® were higher than for other disinfectants. Thus, the killing rates (K) of *Staphylococcus* spp. were -0.044, -0.048, -0.052, -0.058, -0.086 and -0.058 for Dettol, JIK, Isol, Purit, Izal and Septol® respectively. The killing rates (K) of *Bacillus* spp. were -0.046, -0.050, -0.055, -0.050, -0.061 and 0.055 in Dettol, JIK, Isol, Purit, Izal and Septol® respectively. The killing rates of the other 2 organisms (*Escherichia* spp. and *Pseudomonas* spp.) followed a similar pattern.

Table 6 and 7 showed the slopes and the Decimal Reduction Times (DRT) respectively. The DRT is known to be the time required for 90% reduction in the number of viable cells (Meynell and Meynell, 1970). The DRT for *Staphylococcus* spp. were 30.30, 33.33, 35.71, 40.00, 58.82 and 40.00 min in Dettol, JIK, Isol, Purit, Izal and Septol® respectively, while for *Bacillus* spp. were 32.29, 34.48, 38.46, 34.48, 41.67 and 25.64 min in Dettol, JIK, Isol, Purit, Izal and Septol® respectively. A similar pattern was recorded for the other 2 organisms (*Escherichia* spp. and *Pseudomonas* spp.).

The higher the value of killing rate (K), the lower the value of Decimal Reduction Time (DRT).

Colony counting technique was used to determine the number of colony that survived the effects of various dilutions of each disinfectants and the data plotted as $Log_{10}{}^{N}{}_{t}/{}^{N}{}_{o}$ versus time as in **Fig. 1** (*Staphylococcus* spp.), **Fig. 2** (*Bacillus* species), **Fig. 3** (*Escherichia* spp.) and **Fig. 4** (*Pseudomonas* spp.). For all the organisms there was an overall similarity in the shapes of the curves. The curves initially showed a lag, the duration of which depended on the concentration of the disinfectant and the type of organism.

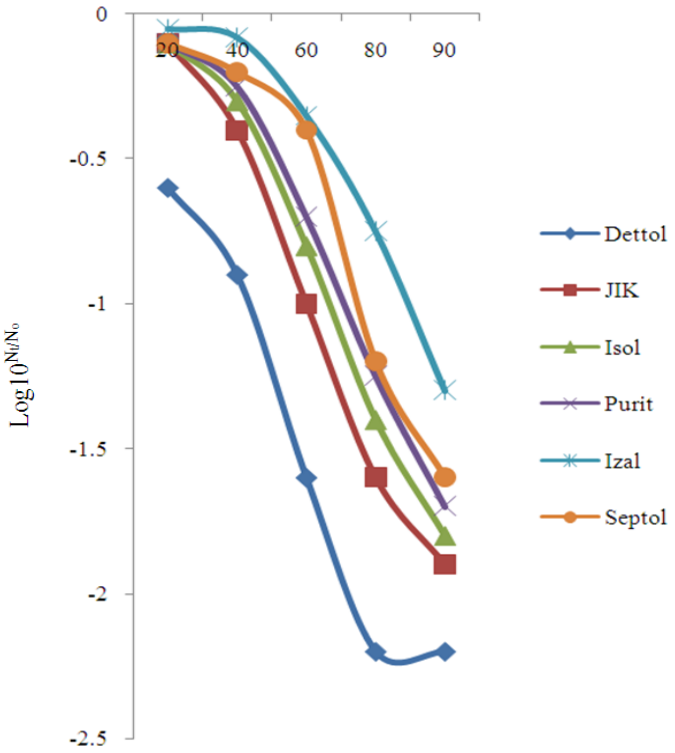

Fig. 1. Survivor curve of the effect of the various disinfectants on *Staphylococcus* spp.

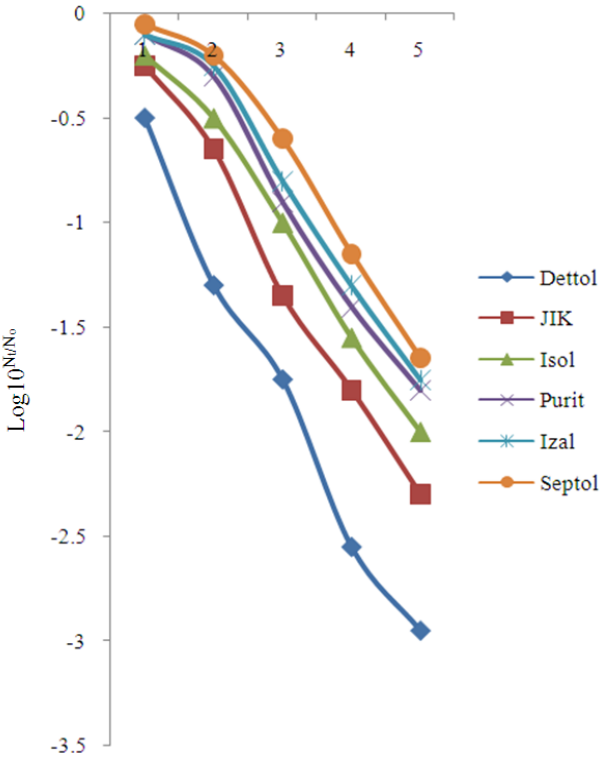

Fig. 2. Survivor curve of the effect of the various disinfectants on *Bacillus* spp.

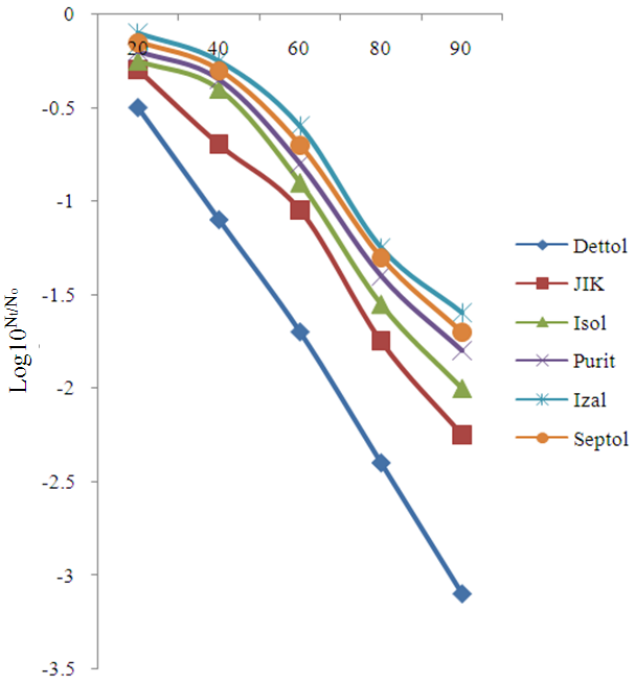

Fig. 3. Survivor curve of the effect of the various disinfectants on *Escherichia* spp.

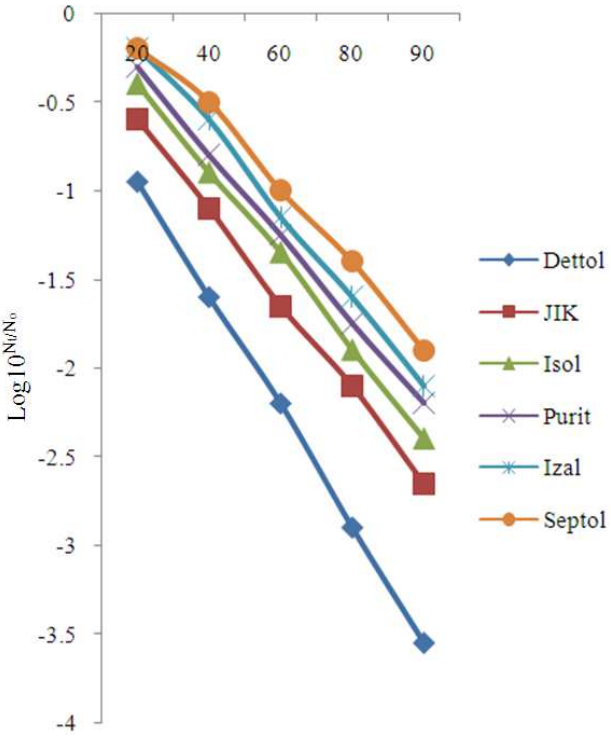

Fig. 4. Survivor curve of the effect of the various disinfectants on *Pseudomonas* spp.

Table 5. Killing rate (K) of the organisms treated with the various disinfectants

Strain Name	Dettol®	JIK®	Isol®	Purit®	Izal®	Septol®
Staphylococcus spp.	-0.044	-0.048	-0.052	-0.058	-0.086	-0.058
Bacillus spp.	-0.046	-0.050	-0.055	-0.050	-0.061	-0.055
Escherichia spp.	-0.044	-0.055	-0.055	-0.055	-0.058	-0.058
Pseudomonas spp.	-0.044	-0.058	-0.050	-0.061	-0.055	-0.058

Table 6. Slope (S) of the survivor curves of the organisms treated with the various disinfectants

Strain Name	Dettol®	Isol®	Izal®	JIK®	Purit®	Septol®
Staphylococcus spp.	-0.033	-0.030	-0.028	-0.025	-0.017	-0.025
Bacillus spp.	-0.031	-0.029	-0.026	-0.029	-0.024	-0.039
Escherichia spp.	-0.033	-0.026	-0.039	-0.026	-0.025	-0.025
Pseudomonas spp.	-0.033	-0.025	-0.026	-0.024	-0.026	-0.025

Table 7. Decimal reduction time (min) of the organisms treated with the various disinfectants

Strain Name	Dettol®	Isol®	Izal®	JIK®	Purit®	Septol®
Staphylococcus spp.	30.30	33.33	35.71	40.00	58.82	40.00
Bacillus spp.	32.29	34.48	38.46	34.48	41.67	25.64
Escherichia spp.	30.30	38.46	25.64	38.46	40.00	40.00
Pseudomonas spp.	30.30	40.00	38.46	41.67	38.46	40.00

4. DISCUSSION

Numerous studies have indicated that computer keyboards (and mouse) can become contaminated with pathogenic bacteria (Schultz *et al*., 2003; Hartmann *et al*., 2004; Rutala *et al*., 2006; Eltablawy and Elhifnawi, 2009; Anastasiades *et al*., 2009; Shen, 2010; Tagoe and Kumi-Ansah, 2011). In health care settings, it is perhaps

not unexpected that such microorganisms would contaminate these common work surfaces. However, this present work showed that microbial contamination also occurs on computer keyboards and mouse located in a large university environment.

A total of 250 computer keyboards and mouse were examined for bacterial contamination. The bacteria isolated (*Staphylococcus*, *Bacillus*, *Escherichia and Pseudomonas* spp.) and their percentages of occurrence were represented in **Table 1 and 2** respectively. The contamination rate of keyboards and mouse was 70.3 and 29.7%, respectively. It was revealed by Hartmann *et al*. (2004) that the highest rate of contamination in patients, rooms was found on keyboards. Schultz *et al.* (2003) found that the tested 100 keyboards in 29 clinical areas for bacterial contamination, 95 from them were positive for microbial contamination. Eltablawy and Elhifnawi (2009) also showed that all the tested 24 computer keyboards and mouse at National Center for Radiation Research and Technology (NCRRT), were positive for microbial contamination. However, the degree of microbial contamination of computer keyboards and mouse is high enough to potentially allow transmission via contaminated hands (Rutala *et al*., 2006).

Out of 250 samples analyzed, a total of 148 bacteria isolates were obtained from computer keyboards and mouse. Out of these, 42.6% are *Staphylococcus* spp., 31.8% are *Escherichia* spp., 18.2% are *Pseudomonas* spp.and 7.4% are *Bacillus* spp. This is in line with the study of Rutala *et al*. (2006) who reported that potential pathogens cultured from more than 50% of the computers included coagulase-negative Staphylococci (100% of keyboards), diphtheroids (80%), *Micrococcus* spp. (72%) and *Bacillus* spp. (64%).

Anastasiades *et al.* (2009) reported the presence of coagulase-negative staphylococci (68.5%), *Staphylococcus aureus* (2.1%), Gram-positive bacilli (27.1%), *Micrococcus* (0.6%) and fungi (1.7%) on computer keyboards and mouse, indicating that *Staphylococcus* spp. are prevalent on computer keyboards and mouse compared to other microbial communities. The ecologic niche for *S. aureus* in humans is in the anterior nares (Miller and Diep, 2008). One-quarter to one-third of healthy persons harbour *S. aureus* in the nose at any time (Kluytmans *et al*., 1997) which can easily be transferred to hands by simply rubbing the nose. In this present work the highest bacterial population on computer keyboards and mouse were *S. aureus* (42.6%). This strengthens the possibility of transfer of potentially pathogenic *S. aureus* through human hands which could include antibiotic resistant bacteria such as community associated Methicillin-Resistant *S. Aureus* (MRSA) (Miller and Diep, 2008). Inanimate objects have been known to play a role in the transmission of human pathogens either directly by surface to mouth contact or indirectly by contamination of fingers and subsequent hand to mouth contact (Rusin *et al*., 2002). In addition, one's palm is usually moist to a varying degree due to perspiration, which contains sodium chloride that will sustain the growth of halophilic bacteria such as *S. aureus* (Elliot *et al*., 1997; Mandal *et al*., 2004).

Shen (2010) who investigated the bacterial contamination of computer keyboards and mouse in the office reported the presence of *Staphylococcus aureus*, *Escherichia coli* and *Salmonella* spp. before sterilization at the following frequency 50.0, 41.7 and 8.3%. Many other investigators found the presence of *Escherichia* spp. on computer keyboards and mouse (Man *et al*., 2002; Neely and Sittig, 2002; Neely *et al*., 2005a; Rutala *et al*., 2006; Kumar and Srivastava, 2012). This signifies that *Escherichia* spp. can also be isolated from computer keyboards and mouse at a relatively high proportion, which is in line with the result of this present work, *Escherichia* spp. (31.8%).

Noskin *et al*. (1995) studied both computer keyboards and keyboard covers, reported their ability to harbour Vancomycin-Resistant *Enterococcus faecium* (VRE), Methicillin-Resistant *Staphylococcus Aureus* (MRSA) and *Pseudomonas aeruginosa*. Also Tagoe and Kumi-Ansah (2011) who investigated the bacterial contaminants of keyboards and mice in general offices and internet cafés, reported the presence of *Pseudomonas aeruginosa*. The presence of *Pseudomonas aeruginosa* shown by Noskin *et al*. (1995) and Tagoe and Kumi-Ansah (2011) is consistent with this study, showing that *Pseudomonas* spp. can be isolated from computer keyboards and mouse. Hence Infectious doses of this pathogen may be transferred to the mouth after handling an everyday contaminated object.

Eltablawy and Elhifnawi (2009) reported the presence of *Bacillus cereus*, *Pseudomonas putida* and *Escherichia tarda*, which are known to be pathogenic in nature. Das *et al*. (2011) reported that computer Keyboards and mouse harbour many pathogenic microorganisms, of which *Bacillus* species were shown to be the most predominant. Contrarily, *Bacillus* spp. was isolated in this study at the lowest proportion (7.4%), but also a clear indication that computer keyboards and mouse are polymicrobial in nature. The isolation of *Bacillus* spp., common soil bacteria, is evidence of environmental contamination (Anderson and Palombo, 2009).

The results obtained in this study showed that the antibacterial activities of the tested disinfectants were concentration dependent. **Table 3** showed that Dettol and JIK® was the most effective in inhibiting the four bacteria at 100% concentration, followed by Isol, Izal and Purit®, while Savlon® showed inhibitory activity on *Staphylococcus*, *Bacillus and Pseudomonas* spp. only, but with lower zones of inhibition than Dettol and JIK® on all the organisms tested, also Septol®showed lower zones of inhibition than Isol, Izal and Purit® on *Staphylococcus* and *Escherichia* spp..

However, at 50% concentration Dettol and JIK® were also the most effective in inhibitory activities: 12, 10, 13, 10, 13, 12, 5 and 14mm on *Staphylococcus*, *Bacillus*, *Escherichia and Pseudomonas* spp. respectively. This was followed by Isol® with inhibition zones of 10, 11, 8 and 8 mm) on the four organism tested. Izal® showed no inhibitory activity on *Staphylococcus* and *Pseudomonas* spp., but showed inhibitory activities on *Bacillus* and *Escherichia* spp. with inhibition zones of 4 and 5 mm respectively. In the same vein, Purit® showed inhibitory activities on *Staphylococcus* and *Pseudomonas* spp. with inhibition zones of 8mm and 4mm respectively, but has no inhibitory effect on *Bacillus* and *Escherichia* spp. At this 50% concentration Septol® inhibitory activities on *Bacillus* and *Pseudomonas* spp. with inhibition zones 6 and 5mm respectively, but disclose no inhibitory effect on *Staphylococcus* and *Escherichia* spp. Olowe *et al.* (2004) reported that Dettol and Savlon® were effective against many pathogenic organisms, especially when the number of cells present were not disinfected in the presence of excess organic matter. Hence this calls for the need for the proper removal of crumbs and spills which wind up on and between the keys that are likely to encourage the growth of microorganisms, before the commencement of disinfection practice.

However, at 12.5% concentration, Dettol and JIK® demonstrated the following zones of inhibition; 10, 8, 12, 8, 8, 5, 5 and 8 mm on *Staphylococcus*, *Bacillus*, *Escherichia* and *Pseudomonas* spp. respectively. Isol® showed inhibitory activity on only *Staphylococcus* spp. with inhibition zone of 4 mm and has no inhibitory effect on the other organisms. At same 25% concentration Purit, Izal and Septol® revealed no inhibitory effects on the other organisms tested. The low inhibitory activities of Septol® on the various organisms isolated might be attributed to active ingredients contained in Septol®. The resistance of microorganisms is known to be limited to only a few antimicrobial agents (Olowe *et al*., 2004). Some disinfectants are reported to share the same mechanism of action with some antibiotics and this can cause resistance to disinfectants used in cleaning our environments (Heath *et al*., 2001). Some other studies have also suggested a potential molecular link between reduced susceptibility to some disinfectants and antibiotic resistance (Kaulfers *et al*., 1987). In the same vein, Iroha *et al*. (2011) reported that resistance of microorganisms to disinfectants within the hospital, industry and other community setting is an emerging public health concern.

The mechanism of action of disinfectant or antiseptic on the micro-organism remains the same irrespective of the type and is exerted through the penetration into the cell and action at the target site(s). The latter can produce a significant effect on the viability as most of the biocides appear to act through intra-cellular mechanism (Russell and Chopra, 1996). The sensitivity or resistance at the level of the bacterial cell membrane, therefore, can be very important factor in determining the final outcome of the treatment with the proposed disinfectant in the hospital practice. Some of these disinfectants also work by production of destructive chemicals against various pathogenic bacteria to attack membrane lipids, DNA and other essential cell components (Rutala *et al*., 2006).

Most antimicrobial agents show both inhibitory and lethal effects depending on the concentration used and other factors such as degree of contamination and duration of treatment. The MIC is a helpful parameter used to assess the bacteriostatic activity of a given disinfectant (Olowe *et al*., 2004). The MIC values of dettol, jik, isol, purit, septol and izal obtained in this study showed that concentration of the active ingredients in the recommended dilutions of the disinfectants is lethal to the organisms tested. The relationship between the MIC and the content of the disinfectant is considered to be a useful property of the agents (El-Mahmood and Doughari, 2009). Subsequently, the MIC recorded in this study further indicated that the test organisms screened were most resistant to Septol, followed by Izal and Purit® (**Table 4**). The high rate of decreased susceptibility to these disinfectants (Septol, Izal and Purit®) is worrisome considering the fact that they are among the disinfectants commonly used in our environment.

Counting methods have been used to determine the number of microbial cells that survived the toxic effects of disinfectant at various time intervals for a particular period. The antimicrobial activity of the various disinfectants was assessed by performing viable cell

counts at 20, 40, 60, 80 and 90 min. The number of cells in organisms was observed to decrease gradually after an initial lag, the duration of which is a function of the concentration of the various disinfectants used and the type of organisms. The number of cells decreased faster in Dettol®, followed by JIK® than in Isol, Purit, Izal and Septol® with negative slopes. When a microbial population is subjected to the toxic influence of an agent, the number of cells decreased gradually in such a manner that when the logarithm of the number of cell at any time when plotted against that time falls on a descending straight line with a negative slope (Acheampong *et al*., 1988). This is referred to as the logarithmic order of death (Esselen and Pflug, 1956) as shown in **Table 5**. On the other hand, a non-logarithmic order of death had also been reported (Reed *et al*., 1951; El-Bisi and Ordal, 1956). One characteristic of the logarithmic order of death is that there is a linear relationship between the logarithm of the number of survivors and time. This means that at any time interval a constant proportion of cells loose viability. All the organisms exhibited a uniform response to the various disinfectants as shown by the almost straight graphs (**Fig. 1-4**). This is an indication that there is no sub population of cells resistant to the various disinfectants in the test cultures. Extensive work on the mechanism of death in the presence of microbicidal concentrations of phenols and halogenated phenols (including dichloroxylenol and chlorophenol) had been documented and the mode of action of these compounds had been found to be due to their adverse effect on cellular permeability leading to inhibition of enzymes and leakage of intracellular materials out of the cell (Allwood and Hugo, 1971; Hugo and Bloomfield, 1971). Thus, the cytoplasmic membrane and its component are considered to be the main site of action of the disinfectants used in the presence of lag especially in the higher use-dilutions of this study. The lag is more pronounced when Dettol® was used than other disinfectants in this study. The presence of the lag in microbicidal concentrations of toxic agents have been attributed to non uniform distribution of the cells in the suspension as single cells, but were rather grouped as clumps (Meynell and Meynell, 1970; Cove and Holland, 1983).

However, results of this study revealed low values of the lag where high concentration of Dettol and JIK® used the treatment of the organisms. Variations in use dilutions of the disinfectants affected the kinetics of cell death with respect to the length of the lag, the DRT (**Table 7**) and the slope of the graphs (6). The relationship between the concentration of the various disinfectants used and the above parameters are measures of resistance of cells to the disinfectants. For complete killing of the cells, a sufficiently high concentration of a disinfectant molecule must be in contact with the organisms for a time greater than the lag prior to exponential order of death (Cove and Holland, 1983).

The Decimal Reduction Time (DRT), is the time required for a disinfectant at a certain temperature or concentration to kill 90% of the organisms being studied (Mazzola *et al*., 2003). The DRT was calculated from slopes of the curves (**Table 7**). The DRT depended on the concentration of the disinfectant and also on the type and resistance of the microorganism used. Thus in this study, the test organisms were more resistant to the activity of Septol and Izal® than Dettol, JIK, Isol and Purit®. The order of the decreasing activities of the disinfectants on the test organisms: Dettol> JIK>Isol>Purit>Izal>Septol®.

5. CONCLUSION

In this study, it was found that there was a higher contamination rate of computer keyboards and mouse. The use of Dettol® for the routine disinfection of computer keyboards and mouse is hereby highly suggested.

On the basis of these findings, it is suggested that routine cleaning of keyboards and mouse may aid the fight against pathogens in various communities. Also, hand washing before and after contact with keyboards and mouse should significantly reduce the risk of contamination and cross transmission.

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