Automatic teller machines (ATMs) as potential sources of food-borne pathogens – a case from Ghana

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Abstract: The metallic keypads of automatic teller machines (ATMs) were examined to investigate their potential as sources of food borne pathogen. The procedure involved culturing and identifying swabs of the keypads of five ATMs, swabs of disinfected fingers and swabs of disinfected fingers used in a cash-redraw simulation. The results indicated the possibility of cross-contamination of the fingers during usage of the machines with foodborne pathogens such as species of *Aeromonas, Bacillus, Enterobacter, Escherichia, Klebsiella* and *Salmonella*. Proper cleaning regimen to sanitize these facilities regularly and public education on their hygienic usage are recommended to reduce the associated risks.

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1. Introduction

Automatic teller machines (ATMs) are the longest standing and most widely used form of computer drive public technology (Hone et al., 1998), with an estimated over 2.4 million units in use (Anonymous, 2011a) since their invention and use in the late 1960's. Working as a data terminal communicating through a host processor which links all other such machines operated by a bank across a wide area network, it makes cash withdrawal and other services available to the account-holder more convenient. A typical usage of the machine involves slotting a card into a recipient hole and following onscreen instructions, by punching the keys of the metallic keypads to enter secret codes and commands; thus instructing the machine as to the kind of service one requires (Anonymous, 2011b). There is no restriction as to who has access to the facility, and no guidelines to ensure hygienic usage. But like all surfaces, microbial colonization of these metallic keypads are eminent, particularly so when there are no proper cleaning regimen in place for most of these facilities. Such colonisations and their subsequent biofilm formation have been the theme of research by several investigators (Hood and Zottola, 1997; Sharma and Anand, 2002).

Many factors have been shown to influence the bacteria transfers between surfaces, including the source and destination surfaces features, bacterial species involved, moisture levels, pressure and friction between the contact surfaces and inoculum size on surfaces (Chen et al., 2001; Rusin et al., 2002; Montville and Schaffner, 2003; Whitehead and Verran 2006). *Salmonella spp.* and *E. coli* strains have also been shown to be transferred from the hands to raw, processed and cooked foods, even at low levels on the fingers (Humphrey et al., 1994; Rusin et al., 2002). Kissiedu (2002) also showed that snacks eaten with the fingers can easily be cross contaminated by bacteria from the hands after handling dirty currency notes. It has also been have shown that, microbes, once attached to hands and to some surfaces may survive for a while and may be difficult to remove (Filho et al., 1985; Hood and Zottola 1997).

The aims of this study were to detect the presence of food-borne bacteria, especially those of pathogenic significance, on the frequently touched metallic keypads of ATMs; to identify the species and then investigate the possibility of cross-contaminating fingers during use of the facility with these microorganisms. The purpose was to investigate the possible role of ATMs in the transmission of food-borne diseases, especially in parts where eating with the fingers is common.

2. Materials and Methods

2.1 Materials and Surfaces

Five automatic teller machines of three different banks, situated on the University of Ghana main campus were used for the study. Permission was sought from the management of all the banks to use the facilities. Cotton swabs made on applicator sticks were slightly

moistened with distilled water and autoclaved in a transparent glass bottle with screw cap. Double strength nutrient broth (Oxoid Basingstoke, England) in screw cap test tubes and nutrient agar (Merck, Darmstadt, Germany) plates were also prepared.

2.2 Determining Contaminants on Command-keys

The command keys of each ATM were double swabbed on each of three visits for five days; between the hours of 08:00 to 09:00, 13:00 to 14:00 and 17:00 to 18:00 GMT. The five days included a week-end day and a public holiday, to reflect the low and peak periods of usage of the facilities. The swabs were immediately dipped into labelled tubes of nutrient broth. Control preparations were made by dipping unused swabs in labelled broth tubes.

2.3 Cross Contamination Simulations

For cross contamination trials, all the fingers were thoroughly washed with a disinfectant soap and further disinfected with 70% alcohol and allowed to dry briefly. A finger of choice was then used to punch the command keys of an ATM, simulating the act of withdrawing cash. Five to eight keys were touched in each simulation. After the operation, the contaminated finger was used to touch the surface of a nutrient agar plate, at several spots, to transfer contaminants from the keys. Another disinfected finger of choice was then used to touch the surface of another labelled nutrient agar plate as control for evaluating the effectiveness of disinfection. These operations were carried out on different but similar days from the previous swabbing operations at similar frequency. The choice finger used each time was changed randomly to minimize any bias that may be associated with a particular finger.

All the inoculated plates and broths were immediately transported to the laboratory and incubated for 18-24 h at 37^{o}C.

2.4 Isolation and Identification of Bacterial Isolates

One millilitre aliquots of each nutrient broth culture from swabs were pour- plated in Levine's eosine methylene blue (EMB) agar, violet red bile glucose agar (VRBGA) and MaConkey agar (Merck, Darmstadt, Germany), all at 37^{o}C, to test for the presence of coliforms. Colonies from the nutrient agar plates were also tested for faecal coliforms in MaConkey broth (Oxoid, Basingstoke, England) with Durham tubes and on EMB agar (Thatcher and Clark, 1978). Representative colonies were repeatedly and sequentially streaked on to fresh media until pure microscopically. The isolates were then characterized for identification, using their colonial and cellular morphology, Gram reactions and their aerobic growth characteristics. Biochemical reactions including motility were also carried out on isolates using standard basic media and reagents (Atlas, 1997; Thatcher and Clark, 1978) (Table 1). Presumptive identifications were done based on descriptions in the Bergey's Manual of Determinative Bacteriology (Holt et al, 1994) and Bergey's Manual of Systematic Bacteriology (Breed *et al*, 1975).

3. Results and Discussion

A total of 25 swab cultures of command keys, 22 agar plates of fingers used in withdrawal simulations and 22 control agar plates were prepared and examined. All identified isolates along with the results from the various tests used in the characterizations are shown (Table 1). Though the counts of these organisms were not determined on the surfaces, the health significance of the results is nonetheless clear, especially as it has been documented that even low levels of *Salmonella spp.* and some *Escherichia coli* strains can easily be transferred from the fingers to food surfaces (Rusin et al., 2002), which lead to acute ailments (Anonymous, 2010).

Species of *Staphylococcus* were the most commonly isolated on all three surfaces. Their presence on the fingers, even after washing might be expected if washing was not thoroughly done especially as it is a known resident microflora of the skin (Holt et al., 1994). Occasional presence of *Lactobacillus spp.* may represent improper disinfection of the fingers selected (Table 2). It is important to note however that, disinfection of the fingers was effective most of the time (77%), thus hand washing is an important tool for control of cross contamination from fingers (Bloomfield et al., 2007).

Seven species of microorganisms: *Aeromonas, Bacillus, Enterobacter, Escherichia, Klebsiella, Pseudomonas* and *Salmonella*, were found to cross contaminate the fingers during cash-redraw simulation, having been isolated also from keypad swabs (Table 2). Two organisms- *Alcaligenes spp.* and *Streptococcus spp.* were only isolated from the used fingers, and thus may be assumed present on the keypads, as the two sampling stages were done on different days.

The pathogenicity of most of the isolated species is well documented. Almost all serovars and species of *Salmonella* are known to be pathogenic. However, out of the more than 2300 serovars, which are considered pathogens, 200 are associated with human illness including salmonellosis and typhoid fever (Anonymous, 2010; Braden, 2006; FDA, 2002). *Salmonella spp.* have been found to survive on dry surfaces for long periods, making its presence significant (Humphrey et al., 1994). *E. coli* serovars, especially the enteropathogenic *E. coli* O157: H7, has been implicated in major food borne

disease outbreaks and infections, mainly from eating contaminated meat (Anonymous 2010). *Listeria monocytogenes, Bacillus cereus, Staphylococcus aureus, Klebsiella pneumoniae, Enterobacter spp.* and *Pseudomonas aeruginosa* are all well documented for their high pathogenicity, causing even death in some major outbreaks and infections (Anonymous, 2010; FDA, 2002; Mead et al., 1999). Other microbes isolated such *Micrococcus, Alcaligenes, Aeromonas* and *Streptococcus* spp. are known opportunistic pathogens in infections and food spoilers (FDA, 2002; Holt et al., 1994; Kaluski et al., 2006).

Table 1. Characteristics of isolates from all the source surfaces in the study

Observations/ Tests																						
					Acid from																	Presumptive Identification (spp.)
Isolates	Shape	Gram stain	Motility	Endospore	Glucose	Lactose	Sucrose	Gas	O/F	M.R.	V.P.	Indole	Oxidase	Catalase	Citrate	Lysine	Ornithine	H_2S	Nitrate	Urea	
1	Rod	+	+	+	+	-	-	+/-	F	ND	ND	-	+	+	+	ND	ND	-	+	-	*Bacillus*
2	Cocci	+	-	-	+/-	-	-	-	O	ND	ND	-	-	+	+	ND	ND	-	+	-	*Micrococcus*
3	Cocci	+	-	-	+	+	+	+	O/F	ND	ND	+	-	+	+	ND	ND	-	+	-	*Staphylococcus*
4	Rod	-	+	-	+	+	-	+	O/F	+	-	-	-	+	+	+	+	+	+	-	*Salmonella*
5	Rod	-	+	-	+	+	-	+	O/F	-	+	+	+	+	-	-	-	-	+	-	*Aeromonas*
6	Rod	-	+	-	+	-	-	-	O	-	-	-	+	+	+	ND	ND	-	+	-	*Pseudomonas*
7	Rod	-	+	-	+	+	+	+	O/F	+/-	+	-	-	+	+	-	+	-	+	-	*Enterobacter*
8	Rod	-	+	-	+	+	+	+	O/F	+	-	+	-	+	-	+	+/-	-	+	-	*Escherichia*
9	Rod	-	-	-	+	+	+	-	O/F	-	+	-	-	+	+	+	-	-	+	+	*Klebsiella*
10	Rod	+	-	-	+	+	-	-	F	ND	ND	-	-	-	+	+	+	-	-	-	*Lactobacillus*
11	Cocci	+	-	-	+	+	+	-	F	ND	ND	+	-	-	+	ND	ND	-	-	+	*Streptococcus*
12	Coccal rod	-	+	-	-	-	-	-	O	ND	ND	-	+	+	+	ND	ND	-	-	+	*Alcaligenes*

Gas – gas from carbohydrate (glucose), O/F – oxidation- fermentation test, M.R. – methyl red reaction, V.P. – Voges Proskauer reaction, Lysine – Lysine decarboxylation test, Ornithine – ornithine decarboxylation test, H_2S – hydrogen sulphide production, Nitrate – nitrate reduction test, Urea – urease activity, + - positive reaction, - – negative reaction, +/- – variable in repeats or weak reaction, ND – not determined.

4. Conclusion

The findings of the study identify the ability of food-borne disease organisms to be cross contaminated onto the fingers from the metallic keypads of the ATM. This is likely true for other surfaces like public telephones and doors handles in public facilities. Consumer awareness is of paramount importance in the handling of foods, especially ready-to-eat foods, as some studies have provided insight into the inadequacies in the general public's knowledge with regards to food handling principles (de Jong et al., 2008; van Asselt et al., 2009). Handwashing is well documented as a means of reducing, if not eliminating these organisms to avoid cross contamination. It removes soil and transient microorganisms from the hands and markedly reduces population of microbes. (Bloomfield et al., 2007). Cleaning regimen aimed at reducing the population and presence of these organisms on such surfaces should be developed using appropriate sanitizers and strictly adhered to by operators of such facilities.

Table 2. Simulation results under designed operation condition

Isolate	Swabs of ATM command key surfaces	Swabs of disinfected fingers	Swabs of disinfected fingers used in cash withdrawal simulation
Bacillus spp.	3 (11.1%)		2 (9.1%)
Micrococcus spp.	2 (7.4%)		
Staphylococcus spp.	5 (18.5%)	4 (18.2%)	4 (18.2%)
Salmonella spp.	3 (11.1%)		3 (13.6%)
Aeromonas spp.	1 (3.7%)		1 (4.5%)
Pseudomonas spp.	2 (7.4%)		3 (13.6%)
Enterobacter spp.	1 (3.7%)		3 (13.6%)
Escherichia spp.	3 (11.1%)		1 (4.5%)
Klebsiella spp.	1 (3.7%)		2 (9.1%)
Lactobacillus spp.	4 (14.8%)	1 (4.5%)	
Streptoococcus spp.			2 (9.1%)
Alcaligenes spp.			1 (4.5%)

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