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ABSTRACT

Objectives: **To determine the quantity and quality of bacterial and fungi on money coins and to identify those that could pose a public health risk.**
Design: **Random sampling of coins from subjects within predetermined categories.**
Setting: **Westlands division of Nairobi Metropolitan province.**
Subjects: **Twenty-shilling coin samples were collected from *matatu* (a common commuter vehicle in Kenya) taxi conductors, greengrocers, shoe shiners, butchers, food kiosk/restaurant attendants, grocery shops attendants, roast maize vendors and school children. Forty coin samples were analysed for both the total viable content and the types of bacterial and fungal organisms.**
Results: **Average bacterial content on the coins ranged from 2.3xl0^3 to 25.5x10^3 and fungi content from 11 to 377 colony forming units. The following potentially pathogenic bacteria were among those isolated: *Escherichia coli, Klebsiella, Serratia, Enterobacter, Salmonella, Acinetobacter, Enterococci, Staphylococcus* and *Bacillus cereus.* In addition, this is the first report of potentially pathogenic fungal isolation from money coins. *Penicillium spp, Aspergillus niger, Fusarium, Rhizopus, Altenaria spp, Candida spp* and *Cryptococcus* were isolated.**
Conclusion: **Money coins harbour potentially pathogenic bacteria and fungi that may pose a public health risk. Hand hygiene is therefore strongly recommended, especially for those who simultaneously handle food and money.**

INTRODUCTION

Money is handled by persons of varying health and hygienic standards and also stored under varying environmental and personal hygienic conditions. Consequently, chances of pathogens being present on money and persisting through multiple handling cannot be underestimated (1). It has been established that *E.coli 0157:H7* and *Salmonella enteritidis* can survive for up to eleven days and up to nine days respectively on the surfaces of money coins, thus making it possible for coins to transfer bacteria to human hands (2).

Although there are numerous reports on bacteriological examination of paper currency (3-8), there are few reports on examination of monetary coinage. There are no reports on fungal isolation from coins. The objectives of the current study were to determine the bacterial and fungal quantity on money coins sampled from Westlands Division, Nairobi, Kenya, and to detect any potentially pathogenic bacteria or fungi, that may pose a public health risk.

MATERIALS AND METHODS

Coins: Money coins were collected from *matatu* taxi conductors, greengrocers, shoe shiners, butchers, food kiosk/restaurant attendants, grocery shop attendants, roast maize vendors, and school children. The twenty shilling coin (diameter 25mm) was selected for sampling due to its wide circulation. A total of five coins were randomly collected from persons in each category of sampling, and from different units. To collect the coin, the individual was requested to drop a coin into a 30 millilitres volume sterile plastic container. The container was promptly capped and the individual given a replacement coin. The containers were immediately transported to the laboratory.

Quantitative bacterial analysis: In the laboratory, 3 mls of sterile tryptone soy broth (TSB) were added into each container. The containers were then agitated on a mechanical shaker for 30 minutes after which the coins were aseptically removed. Five doubling dilutions of TSB from each container

(200 uls), were then prepared and 100 uls of each of the dilutions plated, in duplicates, in plate count agar plates, using the pour plate method. The plates were then incubated at *37°C* for 48 hours after which colonies were enumerated and the total bacterial (colony forming units) yield from each coin calculated.

Quantitative fungal analysis: Three hundred mls of TSB from each container were cultured onto Saboraud's dextrose agar (SDA) and onto Mycophil® agar plates using the spread plate method. The plates were then incubated first at 37°C for two days and thereafter for a further five days at room temperature. At two to five days, yeast colonies in both media were confirmed by microscopy of smears stained with methylene blue. The colonies were then enumerated. Mould colonies were enumerated at seven days of incubation.

Qualitative bacterial analysis: The remaining TSB in the containers was incubated at 37°C for 12 hours. Thereafter the broth cultures were plated on selective and/or differential media, namely sodium azide crystal violet blood agar, xylose lysine desoxycholate agar, blood agar, mannitol salt agar, and MacConkey agar. The plates were incubated at 37°C overnight. Bacterial colonies in each medium were then characterised on the basis of colonial, cellular morphology and staining characteristics. On this basis, the colonies were categorised as Gram positive spore-forming bacilli; Gram positive nonspore-forming bacilli; Gram positive, catalase positive cocci; Gram positive, catalase negative cocci; Gram negative bacilli and Gram negative cocci. Organisms in each category were then identified, when possible, on the basis of cultural, and biochemical characteristics. Gram positive spore-forming rods were sub-cultured on *Bacillus cereus* selective media (CM617, Oxoid, UK) and suspected *B. cereus* colonies identified by a rapid staining test (9). Gram negative rods were characterised using the UPI® system and Gram positive, catalase negative cocci were classified serologically using a streptex® kit.

Qualitative fungal analysis: Mould fungi were identified, when possible, on the basis of cultural and microscopic morphological characteristics. Yeast fungi were identified on the basis of colour, cellular morphology and where applicable, by biochemical tests. Suspected *Candida spp* colonies were sub-cultured on cornmeal agar and then subjected to the germ-tube test.

RESULTS

Quantitative bacterial and fungul content: Table I shows the mean total viable counts of bacteria, moulds and yeasts from the coins. Total viable bacterial counts ranged from $2.3xl0^3$ to $25.5xl0^3$, mould counts from seven to 62 and yeasts from zero to 347 colony forming units (CFU). The mean total fungal content ranged from 11 to 377 CFU.

Table 1
The mean total viable bacterial and fungal counts on money coins

Coin source	Mean total viable counts		
	Bacteria (000)	Moulds	Yeasts
Butchers	25.5	16	16
Matatu conductors	18.9	31	0
Greengrocers	13.4	26	0
School children	13.1	11	1
Maize roasters	11.2	30	347
Shoe shiners	6.3	62	27
Food kiosks attendants	3.1	7	27
Grocery shop attendants	2.3	11	0

Qualitative bacterial content: Table 2 shows the total number and types of bacteria isolated from coins from each category of sampling, and the proportion (%) of coins found contaminated. A total of 29 Gram positive bacilli were isolated, 26 Gram positive catalase positive cocci, 13 Gram positive catalase positive cocci, 21 Gram negative rods and two Gram negative diplococci.

Table 2
The type and number of bacterial organisms isolated from money coins

Coin source	Type of organism, total number of isolates and proportion (%) of coins contaminated				
	G +ve Bacilli	G+ve, catalase +ve cocci	G+ve, catalase -ve cocci	G-ve rods	G-ve cocci
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Butchers	2 40*	2 40	2 40	7 40	0
Matatu conductors	5 100	1 20	20	0	0
Greengrocers	2 40	2 40	2 40	5 40	0
School children	5 100	7 100	4 80	2 40	1 20
Maize Roasters	5 100	1 20	1 20	0	0
Shoe shiners	3 40	7 100	1 20	1 20	0
Food kiosks attendants	5 100	3 60	2 40	3 40	0
Grocery shop attendants	2 40	3 60	0	3 60	1 20
Total number of isolates and isolate type proportions	29 31.8	26 23.7	13 14.3	21 23	2 2.2

*Percentage of the five coins found contaminated with the particular type of microorganism

Gram positive bacilli: Twenty nine isolates (31.8%), of all isolates recovered were Gram positive *bacilli*. These were recovered from 28 of the 40 coins. Twenty one of the isolates were spore formers while the rest were none spore-formers. Eight of the spore-formers, were identified as *Bacillus cereus*. Of these, three were recovered from coins from *matatu* conductors; three from maize roasters and one from a coin each from a butcher and a food kiosk attendant. The rest of the spore formers were mostly *Bacillus subtilis.* The none-spore formers were identified as *Lactobacillus spp* .

Gram positive, catalase positive cocci: Twenty six isolates forming 23.7%, isolated from 22 of 40 coins, were Gram positive, catalase positive *cocci*. Of these, eight were identified as *Micrococcus spp*, 14 as coagulase-negative *Staphylococcus Spp* (including *staphylococcus albus* and S. *epidermidis* and S. *haemolyticus)* and four as β-haemolytic, coagulase-positive *Staphylococcus aureus*. The latter were isolated from a coin each from a butcher, a grocery shop attendant, a maize roaster and a school child respectively.

Gram positive, catalase negative cocci: Thirteen of the 40 coins yielded none-haemolytic Gram-positive, catalase-negative *cocci*. These constituted 14.3% of the isolates (Table 2). All the isolates possessed Lancifield group D antigen, and grew in 6.5% sodium chloride broth and also grew at 10°C and 45°C. They were identified as *Enterococci spp.*

Gram negative rods: Twenty one isolates (23%) were Gram negative rods obtained from 12 of the 40 coins. Of these, one was identified as *E.coli*, three as *Serratia spp (Serratia marcescens, Serratia liquefaciens* and *Serratia ficcaria),* five as *Klebsiella spp* (including *K. oxytoca* and *K.pneumoniae),* five as *Acinetobacter spp* (including *Acinetobacter baumanii),* four as *Enterobacter spp* (including *Ent. amnigenus),* one as *flavimonas oxyzihabitans* and one as *Salmonella spp.* The rest could not be conclusively identified. The sources from which the isolates were recovered were as shown in Table 3.

Gram negative diplococci: Two Gram negative diplococci organisms (2.2%) were recovered (Table 2). They were however not conclusively identified.

Qualitative fungal content: The results are summarised in Table 4. Mould fungi were isolated from 34 of 40 coins, that is, five coins each from *matatu* conductors, maize roasters and school children; four each from vegetable and fruit sellers, butchers, food kiosks attendants and grocery shops attendants; and three from shoe shiners. The significant isolates included *Penicillium spp* (8), *Aspergillus niger (3), Fusarium spp* (1), *Rhizopus* (3) and *Altenaria spp* (1). Yeast fungi were isolated from 14 of 40 coins. These included five from butchers; three from maize roasters; two each from food kiosks attendants, and school children; and one each from shoe shiners and vegetable and fruit sellers. A total of 15 isolates were recovered and identified as *Candida spp,* other than C. *albicans* (6), *Cryptococcus* (2) and *Rhodotorula spp* (1). The rest were identified as *Saccharomyces spp.*

Table 3
The significant Gram negative bacteria isolated from money coins

Source of coin	Number of isolates	Significant isolates
Matatu conductors	0	None
Greengrocers	5	*Enterobacter amnigenus* *Salmonella spp* *Klebsiella oxytoca* *Acinetobacter spp*
Shoe shiners	1	*Enterobacter amnigenus*
Butchers	7	*E. coli* *Flavimonas oxyzihabitans* *Serratia liquefaciens* *Serratia marcescens* *Klebsiella pneumoniae* *Acinetobacter spp* *Klebsiella spp*
Food kiosks attendants	5	*Serratia ficcaria* *Enterobacter spp* *Klebsiella spp* *Acinetobacter spp*
Grocery shops attendants	1	*Acinetobacter spp*
Maize roasters	0	None
School children	2	*Klebsiella spp*

Table 4
The proportion of money coins contaminated by fungi and the significant fungi recovered from the coins

Source of coins	Number of coins contaminated		Significant isolates and number
	Moulds	Yeasts	
Matatu conductors	5	0	*Penicillium (2)* *Rhyzopus* (1)
Greengrocers	3	1	*Rhodotorula (1)* *Penicillium (1)*
Shoe shiners	4	1	*Penicillium (3)* *Altenaria(1)* *Fusarium (1)*
Butchers	4	5	*Aspergillus niger(1)* *Candida spp (3)* *Cryptococcus* (1)
Food kiosks attendants	4	2	*Aspergillus niger (2)* *Penicillium (2)* *Candida spp* (1)
Grocery shops Attendants	4	0	*None*
Maize roasters	5	3	*Rhyzopus(2)* *Candida spp (2)* *Cryptococcus (1)*
School children	5	2	None

DISCUSSION

Money has mass circulation among the general public and hence has a potential to transmit disease-causing microorganisms. In poorer societies, money and especially low value denomination coins change hands frequently unlike in richer communities using plastic money. Human hands are a major source of disease transmission and money may serve as important vehicles in transmission of disease or disease causing organisms (1, 5).

The investigation revealed that coins in the sampled areas of Westlands Division, Nairobi, carry a good number of potential pathogens. Every coin sampled was found to carry both bacteria and fungi. Common causative agents of food poisoning *Bacillus cereus* and *Staphylococcus aureus* were isolated from 9% and 4% of the coins respectively. The organisms could be transferred from the coins to food by food handlers. Other bacterial isolates were clear indications of faecal contamination of the coins. These were the *Enterobacteria* and the *Enterococci*. The *Enterobacteria* comprised 15% of the total isolates and included *E.coli, Klebsiella, Enterobacter, Salmonella* and *Serratia* species. These organisms are potential pathogens and some are agents of zoonoses. *Enterococcus spp* are important nosocomial infection agents (10,11). Besides the *Enterobacteria*, the other Gram-negative rods isolated were *Acinetobacter spp* (5%) one of which, *Acinetobacter baumanii* causes nosocomial pneumonia, skin and wound infections, bacteraemia and meningitis (12).

Yeast and mould species were also isolated from the coins. The yeasts included *Candida* species (other than C. *albicans), Cryptococcus species* and *Saccharomyces species.* Although these agents are not known to cause any major complications in humans, *Cryptococcus* is reported to cause opportunistic infections in immuno-compromised individuals (13). The mould species isolated namely *Penicillium spp, Fusarium spp, Rhizopus* and *Altenaria spp* cause a variety of opportunistic infections (14). Also isolated was *Aspergillus niger,* an agent that can cause serious lung disease as well as otomycosis (15).

Elsewhere, paper money currency has been found to harbour potential pathogens. Currency bills in Nigeria were found to carry bacteria, fungi and parasites, many of which were potentially pathogenic or indicative of faecal contamination (3). Enteric pathogens such as enterotoxigenic *E. coli, Vibrio* and *Salmonella* have been isolated from paper money samples obtained from butchers and fishmongers in Rangoon, Myanmar (8). Paper money in Egypt was found to be contaminated with bacterial organisms such as *staphylococcus aureus, staphylococcus albus* and *Klebsiella pneumoniae* (4). Similar reports have been made in India (6).

Abrams and Waterman (16) examined both paper and coin currency and found 70% of the coins and notes to be contaminated with bacteria. A similar study (7) reported higher numbers of bacteria in notes than coins in Hungary. Further, potential pathogens such as members of *Enterobacteria* and *Bacillus cereus* were found but on notes only. However, Xu *et al. (17)* cultured bacterial organisms from monetary coinage from 17 countries and identified environmental bacteria including *Bacillus* and *Staphylococcus spp* and concluded that money coinage did not present any particular risk to public health. The results of the study reported here differ from those of Havas (7) and Xu *et al.* (17) leading to a contrary conclusion in that potentially pathogenic Enterobacteria were isolated from coins. Our study further presents the first report on isolation of potentially pathogenic fungi from money coins.

In conclusion, this investigation highlighted the potential of money coins to spread pathogenic bacteria and fungi and also reinforced the need for good hand hygiene after handling money, especially when simultaneously handling food and money.

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