

Types of bacteria isolated from Yemeni Currencies in Sana'a City and potential risk factors

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Abstract

The main objective of this study was to determine the prevalence of bacterial contaminants on Yemeni paper currency notes and coins and some potential risk factors. This study was carried out on 140 paper currency and coins obtained from bus drivers, supermarket cashers and *Qat* sellers shops in Sana'a city, Yemen.

Swabs were taken from 140 paper currencies and coins and were cultured on Blood and MacConkey agars. Gram stain, biochemical and serological tests were done to identify isolated bacteria.

The percentage of different types of bacteria isolated from the currencies were as follow; *Staphylococci* spp (22.2%), *Alcaligenes* spp (11.2%) , *Pseudomonas aeruginosa* and, Gram positive bacilli (10.0%), *Escherishia coli* (9.3%) , *Serratia marcescans* (6.8 %) , *Streptococci* spp (5.3%) , *Enterobacter aerogene* (3.0%) , *Klebsilla pneumoniae* (3.0%) , *Enterobacter cloacae* (2.3%) , *Yersinia enterocolitica* (2.3%) , *Citrobacter* spp (2.3%) , Gram positive diplococci (1.5%) , *Shigella* spp (1.5%) , and same percentage (0.8%) of Gram negative cocci, *Vibrio cholerae*, *Actinomysis* spp, *Proteus vulgaris*, *Proteus mirabilis*.

The highest percentage of Gram negative and Gram positive bacteria was found on currencies taken from supermarket cashers (31.4%) and (30.4), respectively. Whereas, lowest percentage were found in currencies taken from bus driver and *Qat* seller shops.

Yemeni paper currency and coins are contaminated with pathogenic bacteria. Currency contamination is of importance issue to public health as it can provide a vehicle for easy transmission of pathogens between handlers. Therefore, public education on proper handling and great care should be taken during handling of money to avoid cross contamination.

Keywords: Yemeni Currency; Paper currency; Coins; Bacterial Contamination; Yemen

1. Introduction

Money is the most widely used and sought after service all around the world. Since its introduction in China circa 1000 AD; the transfer of paper currency has been the model of economic exchange [1]. Paper notes of currency and coins which are handled by a large number of people increase the possibility of acting as environmental vehicle for the transmission of many types of pathogenic microorganisms [2-4].

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Several studies have shown that paper currency serves as an ideal breeding ground for microorganisms for several reasons. The paper currencies offer a large surface area for organisms and organic debris to collect. Also, banknotes weave their way through the population for many years before they come to rest [5].

Physical transfer of material from hands, surfaces, and the environment can contaminate currency [6, 7]. Individuals from almost every socio-economic background routinely hold and transfer paper currency. Any object that can spread communicable diseases throughout a diverse population should be considered a risk to public health. Therefore, currency has an important role in the transmission of pathogenic microorganisms and presents a moderate risk to public health [6, 8].

Research during the last 20 years indicates that pathogens on currency notes could represent a potential cause of food borne illness. Many food outlets rely heavily on the exchange of paper currency for their products. If the same person is handling both money and food products (especially ready-to-eat products), the risk of cross-contamination increases [8]. The microorganisms most commonly isolated on money included members of the family *Enterobacteriaceae*, *Bacillus* spp, *Staphylococcus* spp, *Micrococcus* spp, *Corynebacterium* spp *Mycobacterium tuberculosis* and *Vibrio cholerae* [6].

This study aimed at isolating and identifying the bacterial contamination of Yemeni currency and identify the possible risk factors associated with Yemeni currency contamination in Sana'a city-Yemen.

2. Material and methods

2.1. Sample collection

Cotton Swabs were moisten with sterile normal saline one hour before sample collection by pouring 1.5 ml of 0.9% normal saline into swab's container then the sample collected by swab the both sides of currency coins and notes in a circular manner. Then these cotton swabs returned to its container and transported vertically to the laboratory within two hours of collection [9, 10].

2.2. Bacterial isolation and identification

Each cotton swab was inoculated on a blood agar (Oxoid) and MacConky agar (Oxoid) that incubated aerobically for 48 h/ 37°C. On the second day, the colonies were identified by colony characteristics, Gram staining, and according to the result of Gram stain the biochemical test were used. Plates with mixed colonies were further subcultured in order to obtain pure culture. The biochemical tests are catalase, coagulase, motility, indole, urea, Kligler iron agar, citrate utilization and oxidase as per standard microbiological techniques; to guide us to the genus of isolated bacteria [9, 10]. On the third day, the results of biochemical test were checked. A confirmatory serology test *Vibrio cholerae* O1 or O139 was performed for all suspected *Vibrio cholerae* results then finally the report was written for each sample.

2.3. Data analysis

Data analysis was done using SPSS program version 20 (SPSS Inc., Chicago, IL, USA). Frequencies and percentages were used to present categorical variables. Chi-square test was used for verifying existence of associations. *P* values ≤ 0.05 were considered statistically significant.

3. Results and discussion

Out of 140 swabs from Yemeni currencies (paper and coins) collected from different areas in Sana'a city; culture results of bacteria isolated from these currencies were (53.4%) of both Gram positive and Gram negative, bacteria that isolated from the same currency's paper or coins while only (3.0%) was with no bacterial growth (Figure 1). The different types of bacteria isolated from Yemeni currencies were as following; (22.2%) of *Staphylococci* species, (11.2%) of *Alcaligenes* species and (10.0%) of *Pseudomonas aeruginosa* while the lowest percentage (0.8%) were *Vibrio cholera*, *Actinomyces* species and *Proteus* species (Table 1). In our study, the most predominant bacteria found on currency were *Staphylococci* species, *Alcaligenes* species, *Pseudomonas aeruginosa* and Gram positive bacilli species. This results were similar to a study was done in Nigeria which mentioned that *Staphylococci aureus* was (22.5%) and *Pseudomonas aeruginosa* was (6.25%) [11]. One such study of US currency isolated 93 types of bacteria belonging to the species *Staphylococcus*, *Streptococcus*, *Enterobacter*, *Acinetobacter*, *Pseudomonas*, *Bacillus*, *Diphtheroids*, *Klebsiella pneumoniae*, and *Escherichia vulneri* [7]. While a study was done in Yemen in Taiz city by Hanash *et al.*, [12] mentioned that *E. coli* (50.28 %) followed by *Staphylococci aureus* (14.04 %) were isolated from currencies. The most characteristics of bacteria that were isolated in this study are aerobic, present mostly in soil and water, also normal flora of skin, nose and

enteric tract, which may found in hands in high percentage and they are able to resistant and survive in the external environmental condition for long time which could enhance an easy transfer these bacteria in inanimate objects like currency notes [13].

Among pathogenic organism *Staphylococci* species (22.2%) were the most frequent organism isolated in our study. The Coagulase-negative *Staphylococcus* is feebly pathogenic or nonpathogenic organism present on the skin, in the hair and in abscesses after suturing of operation wounds as well as in the air, water, and dust. *Staphylococci aureus* is a commensal and opportunistic pathogen that can cause wide spectrum of infections, from superficial skin infections to severe, and potentially fatal, invasive disease [14]. *S. aureus* is an important pathogen due to combination of toxin-mediated virulence, invasiveness, and antibiotic resistance. This organism has emerged as a major pathogen for both nosocomial and community-acquired infections. *S. aureus* is a desiccation tolerant organism with the ability to survive in potentially dry and stressful environments, such as the human nose and on skin and inanimate surfaces such as clothing and surfaces [15]. *S. aureus* can remain viable on hands and environmental surfaces for extended durations after initial contact [16].

Classification of bacteria isolated from Yemeni currencies according to the types of currency as shown in table 2. The highest percentage was Gram negative bacteria (50%) that were found on paper currency while 16 % was Gram positive and 20% were both Gram positive and Gram negative. Whereas 37% of currency's coins were carrying no bacterial growth, however, *P* value was statistically non-significant ($P= 0.6$) (Table 2). In the current study, the percentage of bacteria isolated from paper currency was higher than those isolated from coins. A similar results were mentioned in the Indian study [17]. The explanation was due to that the currency notes made of cotton and nylon fibers that enhance the attachment of bacteria and provide organic matters for bacterial growth whereas the currency coins contain copper atoms that may help in bacterial growth inhibition [18].

Types of bacteria isolated from Yemeni currencies according to the place of currency collection in Sana'a city (Table 3). The larger percentage of Gram negative bacteria was found on currencies taken from supermarket cashers (31.4%) while the smaller percentage (22%) was found on currencies taken from *Qat* sellers shops. Gram positive bacteria were isolated in a large percentage from currencies that were taken from supermarket cashers (30.4%) compared to currencies that were taken from bus driver and *Qat* seller shops. However, there was no big difference in cultures that isolated both Gram positive and Gram negative bacteria from currencies that were taken from each place ($P= 0.9$) (Table 3). The explanation of these results that bus drivers keep the money on dry surface and exposed to potent bactericidal sunlight for many type of bacteria such as *streptococci*, *tubercle bacillus*, *cholerae*, *staphylococcus* [19,20]. Moreover, *Qat* sellers deal with pesticides that used for *Qat* agriculture; these pesticides have a role in bacterial killing [21]. A study in India also reported that bacteria were mostly isolated from market places [17].

Classification of bacteria isolated from Yemeni currencies according to the site of keeping currency as shown in table 4, only 2.8% of Gram positive bacteria were found from currencies were kept in wallet compared to 97.2% of Gram positive that isolated from currencies that has been kept in sites other than wallets such as pockets (Table 4). In our study, we noted that the currencies that were not kept in wallets had more types of bacteria than currencies that kept in the wallets. This finding supports the theory properly dealing with currency lead to decrease level of bacterial contamination. Also Investigator suggest that dirty currency could host harmful microorganisms since communicable diseases can spread through contact with fomites [22, 23].

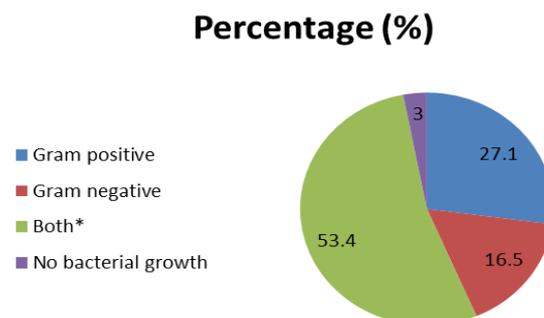


Figure 1 Culture results of bacteria isolated from Yemeni currencies.

Table 1 Percentage of different types of bacteria isolated from Yemeni currencies

Types of bacteria isolated	Percentage (%)
<i>Staphylococci spp</i>	22.2
<i>Alcaligenes spp</i>	11.2
<i>Pseudomonas aeruginosa</i>	10.0
Gram positive bacilli	10.0
<i>Escherichia coli</i>	9.3
<i>Serratia marcescans</i>	6.8
<i>Streptococci spp</i>	5.3
Gram negative bacilli	5.3
<i>Enterobacter aerogene</i>	3.0
<i>Klebsilla pneumoniae</i>	3.0
<i>Enterobacter cloacae</i>	2.3
<i>Yersinia enterocolitica</i>	2.3
<i>Citrobacter spp</i>	2.3
Gram positive diplococci	1.5
<i>Shigella spp</i>	1.5
Gram negative cocci and rod	0.8
<i>Vibrio cholerae</i> O1 / O139	0.8
<i>Actinomysis spp</i>	0.8
<i>Proteus vulgaris</i>	0.8
<i>Proteus mirabilis</i>	0.8
Total	100

Table 2 Classification of bacteria isolated from Yemeni currencies according to the types of currency

Type of currency	Type of bacteria					χ^2	P
	Gram positive	Gram negative	Both*	No bacterial growth	Total		
Paper	16%	50%	20%	14%	100%	1.9	0.6
coins	27.2%	14.9%	20.9%	37%	100%		

*Both= culture yielded both types; Gram positive and Gram negative bacteria; P (probability value) ≤ 0.05 is considered significant
 χ^2 (chi-square) ≥ 3.48 is considered significant

Table 3 Classification of bacteria isolated from Yemeni currencies according to the place of currency collection

Place of currency collection	Type of bacteria					χ^2	P
	Gram positive	Gram negative	Both*	No bacterial growth	Total		
Supermarket cashers	30.4%	31.4%	22.2%	16%	100%	1.8	0.9
Qat sellers	18.9%	22%	24.1%	35%	100%		
Bus drivers	20%	24%	25%	31%	100%		

*Both= culture yielded both types; Gram positive and Gram negative bacteria; P (probability value) ≤ 0.05 is considered significant
 χ^2 (chi-square) ≥ 3.48 is considered significant

Table 4 Classification of bacteria isolated from Yemeni currencies according to the site of keeping currency

Sites for keeping currency	Type of bacteria				Total	χ^2	P
	Gram positive	Gram negative	Both*	No bacterial growth			
Wallets	2.8%	0.0%	0.0%	97.2%	100%	2.7	0.4
**Others	97.2%	0.0%	0.0%	2.8%	100%		

*Both= culture yielded both types; Gram positive and Gram negative bacteria; ** others = Pockets, shoes, socks and under the carpets.
P (probability value) ≤ 0.05 is considered significant; χ^2 (chi-square) ≥ 3.48 is considered significant

4. Conclusion

This study found out that Yemeni currencies in Sana'a city are contaminated with many type of pathogenic bacteria. The currency could serve as a vehicle for transmission of drug resistant pathogenic or potential organisms. Also contamination could be due to improper currency usage and handling. Therefore, hygienic measures such as thorough hand washing with soap after using currency notes should be observed and the practice of keeping money in places other than wallets and using saliva during currency counting should be discouraged. Money cards and electronic money are the best solutions to overcome the problem of bacteria transmission through money. However, there are countries where these services are still not fully available.

Abbreviations

Qat or *Khat*: a shrub (*Catha edulis*) of the staff-tree family that is cultivated in the Middle East and Africa for its leaves and buds which are the source of a habituating stimulant when chewed or used as a tea [24].

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest.

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