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Short Communication

Bacterial Contamination of Iranian Paper Currency

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Abstract

Background: Transmission of human pathogens can be occurred via inert objects. Paper currency is a further common contact surface whereby pathogens can be transferred within a population although the significance remains unknown. Hence, the aim of the present study was to investigate microbial populations associated with Iranian paper currency.

Methods: This study was carried out by getting 108 samples of the Iranian currency notes (1000, 2000, 5000, 10000, 20000 and 50000 RIALS) from food-related shops that included food service outlets, greengrocery, supermarket, bakery, confectionary and poultry meat retail outlets. All currency notes were examined for total bacterial count and identification of pathogenic bacteria.

Results: The average total bacterial count that was recovered from currency notes was found to be 3.27±0.31 colony forming unites. 2000R had the highest total bacterial count, followed by 5000R, 10000R and the lowest in 50000R. In this study, the isolated bacteria recovered were *Bacillus cereus* (8.33%), *E. coli* (48.14%), *Staphylococcus aureus* (28.7%), *Salmonella* (0.92%), *Listeria monocytogenes* (0.92%), *Yersinia entrocolitica* (6.48%). It was revealed that all the pathogens screened for where encountered on currency notes were recovered from one sample. There were no significant ($P>0.05$) correlations between the carriage of pathogens/fecal indicator bacteria and currency note condition.

Conclusion: Our findings demonstrate that Iranian currency notes represent a significant vehicle for human pathogens.

Keywords: Paper currency, Bacterial contamination, Iran

Introduction

Human pathogens can be transferred between hosts via zoonotic, food and environmental routes (1). Person-to-person contact and transfer through common contact surfaces are further routes that can lead to widespread infectious outbreaks of pathogens such as norovirus and methicillin resistant *Staphylococcus aureus* (1-3). When considering inert surfaces it is generally acknowledged that door handles and forcets are key points where potential virulent pathogens can be transferred (1).

Currency (paper notes and coins) is a further common contact surface whereby pathogens can be transferred within a population although the significance remains unknown (4, 5). Given that currency is frequently handled and transferred over large geographical areas there is the potential to readily disseminate contamination across the globe (4-6). With respect to risk factors, it can be considered that contamination carried on currency would be most significant in food retail outlets

whereby pathogens can be transferred to high risk products such as meat that can support growth of introduced microbes to hazardous levels (7-10). *E. coli* O157:H7 and *Salmonella enteritidis* can survive for up to eleven days and up to nine days respectively on the surface of money coins (11), thus making it possible for coins to transfer bacteria to human hands (12, 13). Paper currency can be contaminated by droplets during coughing, sneezing, touching with previously contaminated hands or other materials and placement on dirty surface (13). Surveys performed on the pathogens carried via currency have illustrated that *E. coli*, *Salmonella* and *S. aureus*, amongst others, are highly prevalent on notes and coins handled at food retail (1, 4, 5, 9). Several studies from United States reported contamination of coin and paper bills and identification revealed presence of pathogenic or fecal indicator microbes that included *S. aureus*, *E. coli*, *Klebsiella* and *Enterobacter* (13, 14). To date, the carriage of pathogens on currency has been studied in Europe and North America with little data on other countries (6, 9, 14).

The aim of this study was to investigate the microbial populations associated with Iranian paper currency notes.

Materials and Methods

A total of 108 samples of the Iranian currency in circulation consisting of six Iranian denominations (including 1000, 2000, 5000, 10000, 20000 and 50000 RIALS) were collected using random sampling approach. These currencies were collected from seven areas representing Tabriz city and 108 food-related shops that included food service outlets, greengrocery, supermarket, bakery, confectionary and poultry meat retail outlets. In the laboratory, the currency was categorized according to three criteria; denomination of currency, source of currency and the physical condition based on the appearance of banknotes. With regards to the latter, currency notes were classed as clean (notes that had a clean appearance without any obvious damage), soiled notes (notes that were not new, torn or frayed and had not sticky tape), very soiled notes (notes that were frayed, dirty and had sticky tape) (1, 12, 13).

Individual currency notes were suspended in 15 ml of Tryptic Soy Broth (TSB; Merck, Darmstadt, Germany) and agitated for 45 min. A serial dilution was prepared in 0.1% peptone and plated onto Plate Count Agar (PCA; Merck) (12). The plates were incubated at 30˚C for 48 hours. Colonies were enumerated and total bacteria (colony forming unites) yield from each note calculate. The currency note rinse TSB was then incubated at 37˚C for 24 hours to enrich for bacteria prior to plating onto selective agar. Specifically, MaConkey Agar (coliforms), Eosin Methylene Blue Agar (EMB) (*Escherichia coli*), Baird-Parker Agar (*S. aureus*), Manitol salt agar (*Enterococcus*), Bacillus cereus selective Agar (*B. cereus*), Palcam Listeria Selective Agar (*Listeria*) (12, 13). For identification *Salmonella* were used ISO Standard 6579 method. In this method was utilized of Manitol Selenite Cystine Broth, Rappaport Vasidialis Broth, Xylose Lysine Deoxycholate Agar (XLD), Bismuth Sulphite Agar, Brilliant green Phenol Red Lactose Agar (BPLS), *Salmonella Shigella* Agar (SS Agar) (15). Data were verified and analyzed using SPSS for WINDOWS statistical software (version 11.0; SPSS Inc, Chicago). Results were presented as frequency (%) for all variables. Chi-square test was used to compare the association between the categorized groups and the bacterial contamination. $P<0.05$ was considered statistically significant.

Results

The average TAC that was recovered from currency notes was found to be 3.27±0.31. 2000R had the highest TAC, followed by 5000R, 10000R and the lowest in 50000R. The majority of notes fell into the soiled or very soiled category reflective of currency that had been in circulation for a period of time. There were no significant ($P>0.05$) correlations between the carriage of pathogens/fecal indicator bacteria and currency note condition. This would suggest that clean notes are as likely to be contaminated compared to very soiled (Table 1).

Table 1: Bacterial contamination of paper currency in relation to their condition

	Banknote condition		
Bacteria	**Clean (%)**	**Soiled (%)**	**Very Soiled (%)**
L. monocytogenes	0	2.32	0
B. cereus	13.66	9.30	4.65
S. aureus	40.90	25.58	25.58
Y. entrocolitica	13.66	4.65	4.65
Salmonella	0	2.32	0
E. coli	54.54	51.16	41.86

In this study the isolated bacteria recovered were *Bacillus cereus*, *E. coli*, *Staphylococcus aureus*, *Salmonella*, *Listeria monocytogenes*, *Yersinia entrocolitica* (Table 2). The fecal indicator, *E. coli*, was the most frequently encountered bacteria recovered from currency notes followed by *S. aureus*. With respect to pathogens, it was noteworthy that all the pathogens screened for where encountered on currency notes were recovered from one sample. This would confirm that bank notes may represent a significant vehicle for disseminating pathogens and also that microbial populations are highly diverse. The source of currency notes was found to impact on the carriage of contamination. Currency notes from confectionary, meat shops, supermarkets or food service outlets had high carriage of *E. coli*. In contrast, notes sampled from bakery tended to have a low prevalence of *E. coli* although carried *S. aureus*. Yet, in general there were no significant correlation between carriage of pathogens/fecal indicators with source of currency notes.

Table 2: Percentage prevalence of different bacterial types per denomination of currency note

Denomination	***L. monocytogenes***	***B. cereus***	***S. aureus***	***Y. entrocolitica***	***Salmonella***	***E. coli***
1000R	0	0	16.66	5.55	0	44.44
2000R	0	5.55	27.77	0	0	44.44
5000R	5.55	11.11	44.44	5.55	5.55	22.22
10000R	0	11.11	27.77	16.66	0	66.66
20000R	0	5.55	38.88	5.55	0	61.11
50000R	0	16.66	16.66	5.55	0	50.00
Total	0.925	8.33	28.70	6.48	0.925	48.14

Discussion

From the results obtained in the study it was evident that currency notes represent a significant vehicle for human pathogens. The results agree with the findings of others who also reported a high prevalence of bacteria such as *E. coli* and *S. aureus* (6, 16). It has been suggested that the prevalence of microbes recovered from notes is related to the period of time in circulation. From the results, the existence of such correlations between pathogen carriage and physical condition of the currency notes. The results are counter to those reported by Hassan et al. (2011) who reported a correlation between carriage and the condition of currency notes (3). In the present study, it is likely that the bacteria encountered on notes reflected recent contamination as opposed to long-term exposure to contamination. This view was supported by the fact that *E. coli* was recovered at high frequency on notes sampled at meat shops compared to those derived from bakery retail outlets. *E. coli* is frequently recovered from meat due to the transfer of faecal material during the slaughter process or via transfer from contact surfaces. Consequently it was not unexpected to en-

counter *E. coli* on currency notes derived from meat outlets where transfer to currency notes was via handling. It was suggested that this route accounted for the high prevalence of enteric bacteria recovered from banknotes sampled from poultry meat shops (1). Yet, the finding that of no correlation between bacterial type encountered and sampling location, suggests that contamination can also be introduced outside the retail environment.

Conclusion

Our findings indicate that paper currencies notes represent a significant vehicle for human pathogenic bacteria. Further investigation should also be focused on how long human pathogens can survive on paper currency.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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The authors declare they have no actual or potential competing financial interests.

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