Public Health 186 (2020) 116–118

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

Contamination of coins and banknotes as sources of transmission of parasitic pathogens: a pilot study from Iran

N. Hajipour [a, *], M.H. Moosavy [b, **], B. Rostamzadeh [b], A. Hajibemani [c]

[a] Department of Pathobiology, Faculty of Veterinary Medicine, University of Tabriz, Tabriz, Iran
[b] Department of Food Hygiene and Aquatic, Faculty of Veterinary Medicine, University of Tabriz, Tabriz, Iran
[c] Department of Clinical Sciences, Faculty of Veterinary Medicine, University of Tabriz, Tabriz, Iran

ARTICLE INFO

Article history:
Received 23 May 2020
Received in revised form
24 June 2020
Accepted 3 July 2020

Keywords:
Coin
Banknote
Iranian currency
Parasite
Contamination

ABSTRACT

Objective: This study was conducted to determine the presence, type, and rate of parasitic contamination in Iranian currencies.
Study design: This was a cross-sectional study.
Methods: Coins and banknotes of different denominations were randomly collected from sellers and markets in Tabriz, Northwest of Iran, for examining parasitic contamination.
Results: *Entamoeba coli* and *Giardia intestinalis* were the most identified species of parasites in this study. Other parasites detected were *Cryptosporidium parvum*, *Ascaris lumbricoides*, *Entamoeba histolytica*, *Fasciola hepatica*, and *Toxocara cati*. A high rate of parasitic contamination was found in banknotes compared with coins, and a statistically significant association was found between parasitic contamination and the apparent condition of the currencies. The notes of lower denominations showed the highest contamination rates. The highest parasitic contamination was found in coins and banknotes obtained from public toilet services, butchers, and beggars.
Conclusions: The findings emphasize the role of circulating coins and banknotes in the risk of pathogenic parasite transmission.

Introduction

Parasites can be transmitted either directly through hand-to-hand contact or indirectly via contaminated food, water, or an inanimate object known as a fomite. Various diseases such as diphtheria, trachoma, gastroenteritis and whooping cough, and pathogenic agents causing diarrhea are known to be transmitted through fomites.[1] In fact, currency coins and banknotes, objects of great turnover, could be considered as common fomites for the spread of contagious diseases.[2] In the early 1970s, investigators suggested dirty money as a possible subject for the transmission of pathogenic microorganisms.[3] Handling money can introduce the risk of cross contamination in food provided in food supply and distribution centers.[4] In addition, wetting of fingers with saliva or water while counting banknotes and eating food with unwashed hands after handling money are some of the unhealthy behaviors contributing to the ease of transmission of pathogens via these subjects.[5] Some of the influencing factors on the contamination rate and type of microorganisms on the currency are as follows: season, environmental conditions, type of money (banknote, coins), the material from which the money is made, local community flora, and the public hygiene level of the population.[6] Banknotes are categorized based on physical appearance as mint (new or recently obtained directly from the bank), clean (clean appearance without obvious damage), and dirty or mutilated (damaged, soiled, held together with sellotape). Irrespective of the material, more bacteria or parasites are likely to be obtained from a dirty banknote than from a clean or mint note. Several studies have been conducted on contamination of banknotes and coins with parasites in different countries.[4,6,7] However, there is no study conducted with regard to parasitic contamination of currencies in Iran. There was only one study on the bacterial contamination of Iranian currency conducted by Moosavy et al.[8] Thus, this study was conducted to detect the rate and types of parasitic contamination in banknotes and coins

* Corresponding author. Tel.: +98 4136378743, 09141019511, Post Code: 5166616471.
** Corresponding author. Tel.: +98 4136378743, 09122774713, Post Code: 5166616471.
E-mail addresses: n.hajipour@tabrizu.ac.ir (N. Hajipour), mhmoosavy@gmail.com, moosavy@tabrizu.ac.ir (M.H. Moosavy).

https://doi.org/10.1016/j.puhe.2020.07.009
0033-3506/

obtained from different occupational groups, especially food-related workers in Iran.

Methods

Sampling procedure

A total of 519 samples of the Iranian currency in circulation consisting of banknotes including 1000, 2000, 5000, 10,000, 20,000, 50,000, and 100,000 rials and coins including 1000, 2000, and 5000 rials were randomly collected from different profession categories related to food or hygiene, including butchers, bakeries, supermarkets, vegetable sellers, confectionaries, ice-cream sellers, food vendors, bus conductors, toilet conductors, and beggars between June 2018 and January 2019 in Tabriz, Iran. Collected currencies were categorized into four groups including mint fresh, clean, dirty, and very dirty based on physical appearance.

Parasitological study

Concentration of parasites isolated from the currency notes and coins was analyzed via standard techniques described by the World Health Oraganization.[9] In brief, coins were placed in a tube containing 10 ml of 0.85% sterile normal saline and were shaken vigorously. The tube was then centrifuged at 2000 g for 5 min. The supernatant was decanted, and a drop of the sediment was placed on a glass slide, covered with a glass cover slip, and examined microscopically for parasite ova and cysts as per standard guidelines.[10] Banknotes were swabbed on both surfaces using a sterile cotton-tipped swab soaked in normal saline.[2] The swab was then placed in a tube containing 0.85% sterile normal saline, and the tube was shaken vigorously. The swab was then pressed against the inner wall of the tube with forceps, and the tube was centrifuged at 2000 g for 5 min. The sediment was examined for parasite ova and cysts under a microscope.[4] Kinyoun's acid-fast stain was used to detect coccidial contamination.[11]

Statistical analysis

Associations between the categorized groups and parasitic contamination were analyzed using the chi-squared test with SPSS software version 16.2. P <0.05 was considered statistically significant.

Results and discussion

A total of 519 Iranian currencies including coins (n = 180) and banknotes (n = 339) from different professions in Iran were examined; of which, 116 (22.35%) were contaminated with intestinal parasites. This value was higher than that previously reported in Manila (11.67%)[12] and Ibadan city in South West Nigeria (14%),[6] while the value was lower than that reported in Lagos, Nigeria (59%),[13] and Alexandria, Egypt (58.4%).[2] The possible explanation for substantial variation in percentage might be due to the individual's health, number of samples, and type of currency.

Table 1
Parasitic contamination rate of currency coins and banknotes among different professions.

Parasite/professional	Contamination rate, no. (%)								
	Entamoeba coli	*Entamoeba histolytica*	*Giardia intestinalis*	*Fasciola hepatica*	*Toxocara cati*	*Ascaris lumbricoides*	*Cryptosporidium parvum*	Mixed contamination	Total
Coin (rial)									
1000 (n = 60)	3 (5.0)	1 (1.7)	2 (3.3)	1 (1.7)	0	2 (3.3)	3 (5.0)	1 (1.7)	11 (18.3)
2000 (n = 60)	9 (15.0)	1 (1.7)	1 (1.7)	1 (1.7)	0	2 (3.3)	2 (3.3)	1 (1.7)	15 (25.0)
5000 (n = 60)	1 (1.7)	2 (3.3)	1 (1.7)	0	2 (3.3)	1 (1.7)	2 (3.3)	0	9 (15.0)
Total (n = 180)	**13 (7.2)**	**4 (2.2)**	**4 (2.2)**	**2 (1.1)**	**2 (1.1)**	**5 (2.8)**	**7 (3.9)**	**2 (1.1)**	**35 (19.4)**
P-value*	0.01	0.7	0.7	0.6	0.1	0.8	0.8		
Banknote (rial)									
1000 (n = 58)	5 (8.6)	2 (3.4)	5 (8.6)	1 (1.7)	1 (1.7)	6 (10.3)	4 (6.9)	0	24 (41.4)
2000 (n = 60)	13 (21.7)	5 (8.3)	5 (8.3)	3 (5.0)	2 (3.3)	3 (5.0)	6 (10.0)	15 (25.0)	22 (36.7)
5000 (n = 60)	2 (3.3)	2 (3.3)	5 (8.3)	2 (3.3)	2 (3.3)	3 (5.0)	3 (5.0)	0	19 (31.7)
10,000 (n = 60)	2 (3.3)	0	2 (3.3)	3 (5.0)	0	1 (1.7)	0	0	8 (13.3)
20,000 (n = 41)	4 (9.8)	0	0	1 (2.4)	1 (2.4)	0	0	2 (4.8)	4 (9.8)
50,000 (n = 30)	1 (3.3)	0	1 (3.3)	0	0	0	0	0	2 (6.7)
100,000 (n = 30)	0	0	1 (3.3)	0	0	0	0	0	1 (3.3)
Total (n = 339)	**27 (8.0)**	**9 (2.7)**	**19 (5.6)**	**10 (2.9)**	**6 (1.8)**	**13 (3.8)**	**13 (3.8)**	**17 (5.01)**	**80 (23.6)**
P-value	0.001	0.05	0.3	0.6	0.6	0.06	0.02		
Professions									
Butchery (n = 52)	12 (23.1)	1 (1.9)	3 (5.8)	0	0	0	0	0	16 (30.8)
Bakery (n = 52)	3 (5.8)	1 (1.9)	1 (1.9)	0	0	0	0	0	5 (9.6)
Supermarket (n = 52)	4 (7.7)	3 (5.8)	1 (1.9)	0	1 (1.9)	2 (3.9)	0	2 (3.9)	9 (17.3)
Vegetable seller (n = 52)	5 (9.6)	0	2 (3.8)	9 (17.3)	0	0	5 (9.2)	6 (11.5)	15 (28.8)
Confectionary (n = 52)	2 (3.8)	2 (3.8)	1 (1.9)	1 (1.9)	0	2 (3.8)	0	1 (1.9)	7 (13.5)
Ice-cream seller (n = 52)	3 (5.8)	2 (3.8)	1 (1.9)	0	1 (1.9)	2 (3.8)	1 (1.9)	3 (5.7)	7 (13.5)
Food vendor (n = 52)	3 (5.8)	0	1 (2.0)	0	2 (3.9)	2 (3.9)	7 (13.7)	0	15 (29.4)
Bus conductor (n = 52)	2 (3.8)	1 (1.9)	3 (5.8)	1 (1.9)	0	1 (1.9)	0	0	8 (15.4)
Toilet conductor (n = 52)	2 (3.8)	2 (3.8)	9 (17.3)	1 (1.9)	2 (3.8)	4 (7.7)	2 (3.8)	5 (9.6)	17 (32.7)
Beggar (n = 52)	4 (7.7)	1 (1.9)	1 (1.9)	0	2 (3.8)	5 (9.6)	5 (9.6)	2 (3.8)	16 (30.8)
Total (n = 519)	**40 (7.7)**	**13 (2.5)**	**23 (4.4)**	**12 (2.3)**	**8 (1.5)**	**18 (3.5)**	**20 (3.9)**	**19 (3.6)**	**115 (22.2%)**
P-value	0.01	0.7	0.003	0.000	0.3	0.09	0.000		

*P <0.05 was considered statistically significant.

The percentage of parasitic contamination in banknotes (23.6%) was insignificantly higher than that in coins (19.4%). This is mainly attributed to the substantial size of the surface area of banknotes compared with smaller coin size. In addition, the larger pore size in paper currency most likely contributes to accumulation of more microorganisms than the smaller pore size in metallic coins. It seems metallic coins, especially those made of Cu, are a limiting factor for microorganism survival.

In terms of apparent condition, the results showed a statistically significant association between the physical condition of coins as well as banknotes and parasitic contamination. Contamination was most demonstrated among very dirty coins and banknotes (78.3%), followed by 24.4% and 2.4% for dirty and apparently clean coins and banknotes, respectively, whereas no contamination was found in mint fresh money. A statistically significant difference was found with respect to the rate of parasitic contamination between all groups under study, except for the two groups of fresh mint and clean money for which the difference was insignificant. Because dirty and very dirty currencies have been in circulation for a long time, they are more likely to get contaminated.

The highest contamination rate was found in 1000 rial and 2000 rial banknotes, which was 41.4% and 36.7%, respectively, along with the rate of 3.3–31.3% for the rest of denominations. A higher rate of contamination was obtained with the notes of lower denomination, which might be due to more frequent handling by hands. The parasites isolated from coins and banknotes in this study, included *Entamoeba coli* cysts (7.7%), *Giardia intestinalis* cysts (4.4%), *Cryptosporidium parvum* oocysts (3.8%), *Ascaris lumbricoides* eggs (3.4%), *Entamoeba histolytica* cysts (2.5%), *Fasciola hepatica* eggs (2.3%), and *Toxocara cati* eggs (1.5%) (Table 1). Currency contamination with *T. cati* was reported for the first time, which may have resulted from contaminated vegetables in the market. The parasite cysts and eggs isolated from coins and banknotes are of high socio-economic importance, with a high impact on human health. For instance, *G. intestinalis*, *E. histolytica*, and *A. lumbricoides* are easily transmitted because many people wet their fingers while counting money.

There was no significant association between currency denomination and parasite type, except for contamination with *E. coli* in both coins and banknotes and with *C. parvum* in banknotes. *E. coli* and *G. intestinalis* were the most prevalent species, with the prevalence rate of 7.7% and 4.4%, respectively.

The meaningful statistical correlation was found between profession and parasitic contamination from collected currencies from various professions. The highest parasitic contamination was found in currencies obtained from toilet conductors, butchers, and beggars, followed by those obtained from food vendors, vegetable sellers, supermarkets, bus conductors, confectioneries, and ice-cream sellers (Table 1). However, no significant correlation was found between contamination with *E. histolytica*, *T. cati*, and *A. lumbricoides* and professions (Table 1). Poor sanitary conditions at slaughterhouses and meat markets cause cross contamination from simultaneous handling of money and animal products. In addition, parasitic contamination types observed in Iranian currencies were mainly of fecal origin, which results from poor hygiene and inadequate handwashing after anal cleansing and defecation.

Conclusion

The currency plays an important role in the transmission of pathogenic microorganisms including enteric parasites, particularly protozoa. To reduce contamination, some considerations should be applying by Iranian banks: (1) a regular disinfection of circulating currencies; (2) health education on practice of good personal hygiene; (3) periodic withdrawal of dirty currency from circulation; and (4) encouraging people to use digital payments, mobile banking, and bank cards instead of cash.

Author statements

Acknowledgments

The authors thank the staff of the Department of Food Hygiene and Aquatic, Faculty of Veterinary Medicine, University of Tabriz, Tabriz, Iran.

Ethical approval

Not required; the study was performed on the authors' own currency obtained in exchange for larger currency denominations paid to food-related workers.

Funding

This study was supported by the University of Tabriz grant. The authors thank the Vice Chancellor of Research, University of Tabriz, for financial support. The authors disclosed receipt of the financial support for the research, authorship, and/or publication of this manuscript.

Competing interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contributions

N.H., M.H.M., B.R., and A.H. contributed to data collection and study design and oversaw and provided guidance for the statistical analyses. N.H. and M.H.M. took primary responsibility for drafting this manuscript. A.H conducted the statistical analyses. N.H. and M.H.M. provided substantial contributions to the editing of the manuscript and finalized the manuscript to be submitted.

References

1. Smith H, Caccio S, Cook N, Nichols R, Tait A. *Cryptosporidium* and *Giardia* as foodborne zoonoses. *Vet Parasitol* 2007;**149**:29–40.
2. Hassan A, Farouk H, Hassanein F, Abdul-Ghani R. Currency as a potential environmental vehicle for transmitting parasites among food-related workers in Alexandria, Egypt. *Trans R Soc Trop Med Hyg* 2011;**105**:519–24.
3. Vriesekoop F, Russell C, Alvarez-Mayorga B, Aidoo K, Yuan Q, Scannell A, et al. Dirty money: an investigation into the hygiene status of some of the world's currencies as obtained from food outlets. *Foodb Pathog Dis* 2010;**7**:1497–502.
4. Michaels B. Handling money and serving ready-to-eat food. *Food Serv Technol* 2002;**2**:1–3.
5. Pittet D, Allegranzi B, Sax H, Dharan S, Pessoa-Silva CL, Donaldson L, et al. Evidence-based model for hand transmission during patient care and the role of improved practices. *Lancet Infect Dis* 2006;**6**:641–52.
6. Leonard OK, Olajumoke M. Parasite contamination of Nigerian currencies in Ibadan city, South-West Nigeria. *Annu Res Rev Biol* 2016;**10**:1–6.
7. Matur B, Malann YD, Edhomeriegue Y. A survey of parasite cysts, eggs and bacteria on Nigerian currency in FCT, Abuja. *Nucl Sci J* 2010;**3**:10–3.
8. Moosavy MH, Shavisi N, Warriner K, Mostafavi E. Bacterial contamination of Iranian paper currency. *Iran J Public Health* 2013;**42**:1067–70.
9. WHO. *Manual of basic techniques for a health laboratory*. World Health Organization; 2003.
10. Soulsby E. *Helminths. Arthropods and Protozoa of domesticated animals 1982*. 2015.
11. Kehl K, Cicirello H, Havens PL. Comparison of four different methods for detection of *Cryptosporidium* species. *J Clin Microbiol* 1995;**33**:416–8.
12. Glenn Lo Sia S, Coden C, Cruz A, Jose R, Victorino A, Sison MA, et al. Bacteriological and parasitological assessment of currencies obtained in selected markets of Metro Manila. *Asian Pac J Trop Dis* 2015;**5**:468–70.
13. Okwa O, Bello S. Parasitic organisms on nigerian currency notes in ojo local government, lagos, Nigeria. *Int J Pure Appl Zool* 2016;**4**:221–4.