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Assessment of bacterial contamination of paper currency notes in Bangladesh

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ABSTRACT

Handling of paper currency notes might be a regular means of exposure to microbiological contamination. To assess the extent of bacterial contamination of Bangladeshi paper currency notes (known as Taka) in circulation, a total of 540 notes of three denominations (2, 10 and 100) were collected from different occupational groups and were subjected to bacteriological analysis. Among the notes examined, 506 (93.70%) were found to be contaminated with 5 different bacterial isolates. The load of *Salmonella* spp., *Shigella* spp., *Vibrio* spp., *Pseudomonas* spp. and *Staphylococcus* spp. ranged between 0 to 2.49×10^8 cfu/cm^2, 0 to 1.50×10^8 cfu/cm^2, 7.7×10^7 to 1.59×10^9 cfu/cm^2, 4.5×10^7 to 8.24×10^8 cfu/cm^2 and 3.6×10^7 to 1.32×10^7 cfu/cm^2, respectively. Furthermore, 200 bacterial isolates were tested for their resistance against 10 commonly used antibiotics and 20-86% *Salmonella*, 8-96% *Vibrio*, 16-82% *Pseudomonas* and 18-82% *Staphylococcus* isolates were found to be resistant against at least one of the antibiotics tested. Thus, the present study revealed that most of the currency notes were contaminated with a huge range of bacteria including the antibiotic-resistant ones which might pose a severe public health risk.

KEYWORDS

Public health risk;
Paper currency;
Pathogenic bacteria;
Antibiotic resistance.

INTRODUCTION

Currency is widely exchanged for goods and services worldwide[18] and handled by large numbers of people under a variety of personal and environmental conditions. Currency notes may carry potentially pathogenic organisms and serve as potential source in the transmission of infection[10]. Paper currency notes are susceptible to bacterial contamination during continuous handling to person to person, storing them at contaminated polythene/ cotton, leather bags at moist, sweaty and dark conditions which are most favorable for the growth of coliforms as well as other pathogenic bacteria[7,14,18] The relatively older paper notes offer

more space for microorganisms (both pathogenic and nonpathogenic) to accumulate[4,7]. Consequently, this increases the amount of bacteria circulated among its handlers.

Contamination of matter by pathogenic microorganisms is of much public health concern because the contaminated materials can further transmit the pathogens among a population. Paper money, therefore presents a particular threat to public health, since contagious diseases can broaden through the contact of these paper currencies[13,16,18]. The high rates of microbial contamination of currency and harmful pathogens associated with gastroenteritis, pneumonia, throat infection, tonsillitis, peptic ulcers, urino-genital tract infection, and lung abscess have been reported from different parts of the world[7,9,13,14,15,1618,].

Currency can be contaminated by droplets of various people during coughing, sneezing, touching with hands and placement on dirty surface during the handling or transaction and capable of absorbing, harboring and transmitting infectious microorganisms. In some fish, poultry and vegetables markets, the salesmen handle money and their respective sales product simultaneously neglecting hand washing between these two tasks. This practice introduces the risk of cross-contamination, possibly resulting in random cases of infectious intestinal disease among sellers and customers. Since, money is not screened for microbes so, paper currency become a potential route and vehicle for transmission of various pathogenic bacteria to the users[15].

Paper currencies are handled by all classes of people including children and therefore the contaminated notes may play an vital role in spreading of diseases by taking foods without washing hands after handling of money or due to contact of paper money by using saliva usually by the illiterate people both in cities and the rural area of Bangladesh[9]. In Bangladesh, most people are not habituated to wash their hands after handling Taka (Bangladesh currency) and even they are not aware about the reality that they may be affected by many dodgy diseases caused by pathogenic bacteria transmitted to them by handling of Taka.

Although there are several reports on the microbial contamination of paper currency in some countries all over the world, only a few reports are available on the Bangladesh currency notes[1,9]. However, those studies were limited to the reporting the percentage of notes contaminated with bacteria rather than actual bacterial load on the paper currency notes. Here, we report the actual load of bacteria across on the paper currency notes of three different denominations and for the first time, we determined the antibiotic resistance patterns of the bacterial isolates from Bangladeshi currency notes.

MATERIALS AND METHODS

Sample collection

The currency samples [two taka (TK2), ten taka (TK10) and hundred taka (TK100) notes] were collected aseptically in separate sterile polythene bags from different areas of Dhaka, Bangladesh. Samples were collected from different chosen occupational groups such as poultry and poultry products seller (PS), fish seller (FS), vegetables seller (VS), food vender (FV), shopkeeper (SK) and rickshaw puller (RP). After collection, samples were transferred immediately to the laboratory. Three replications of each sampling were made in case of every collection site for all the sample types.

Bacteriological analyses

Each currency note of all sample types *i.e*., two taka, ten taka and one hundred taka collected from various occupational groups were soaked in 12 ml, 15 ml and 20 ml of sterile distilled water respectively and vigorously agitated for 5-10 minutes. After soaking, serial dilutions of each aqueous sample were made up to 10^{-8}. The isolation of bacteria from the collected samples was done by viable culture method using spread plating, pour plating and membrane filter technique. 0.1 ml of sample from each currency note and category was spread on the solid surface of *Salmonella-Shigella* (SS) agar (Hi-media, India), McConkey agar (Hi-media, India), Tergitol-7 agar (Hi-media, India), and Thiosulphate Citrate Bile Salts Sucrose (TCBS) agar (Hi-media, India) medium, and 1.0 ml sample from each currency note and category was placed onto sterile plates which was then mixed with sterile media of Salmonella-Shigella (SS) agar, McConkey agar, Tergitol-7 agar and TCBS agar poured into the plates after being cooled to about 42 ^{o}C- 45 ^{o}C and diluted 10 ml

sample from each category was filtrated through the membrane filter (Millipore, Bedford, MA, USA) and the filters were then placed on selective media plates. All the plates were incubated at 37 °C for 24 hours. Replications of all samples were tested for successful isolation. The cultures from the plates were purified by subculture into single identical colonies. Standard morphological and biochemical tests were followed for confirmed identification of the characteristic colonies (Buchanan & Gibbons 1974). In addition, using several polyvalent antisera (DENKA SEIKEN Co. Ltd, Tokyo, Japan), *Vibrio, Salmonella, Shigella, Staphylococcus* and *Pseudomonas* were finally identified after being subjected to latex agglutination test.

Antibiotic susceptibility test

The antibiotic susceptibility of each of the test organisms [*Salmonella* (n=50), *Vibrio* (n=50), *Pseudomonas* (n=50) and *Staphylococcus* (n=50)] was determined using the standard disc-diffusion method[3] and the guidelines recommended by Clinical and Laboratory Standards Institute[6]. The antibiotic discs (Becton Dickinson, USA) used in this study were: Ampicillin (10 µg), Chloramphenicol (30 µg), Erythromycin (15 µg), Gentamicin (10 µg), Riphampicin (5 µg), Penicillin (10 units), Tetracycline (30 µg) and Streptomycin (10 µg), Cephalexin (30 µg), and Ciprofloxacin (5 µg). For inoculation, the top of a single and well-isolated colony was touched with a sterile inoculating loop and the culture was then inoculated into 2 ml Mueller-Hinton broth. The broth was then incubated at 37 °C for 4 hours to obtain the young culture. The turbidity of the culture was then adjusted to a 0.5 McFarland standard. A sterile cotton swab was then dipped into suspension and rotated the swab firmly against the inside of the tube above the fluid level to remove excess fluid. The swab was used to spread the bacterial suspension evenly over the surface of Mueller-Hinton agar plates to obtain uniform inoculums. The plates were then allowed to dry for several minutes. Antibiotic discs were then placed aseptically on the surface of inoculated plate by means of sterile forceps. Each disc was gently pressed down to ensure complete contact with the solid medium. Usually, five discs (Four discs containing different antibiotic and one empty disc as a control) were placed in one Petri plate. The plates were incubated at 37 °C for about 24 h. After incubation, plates were examined and the diameters of the zone of inhibition were measured in nearest whole millimeter. The tested stain was grouped as resistant on the basis of the interpretation chart provided by the supplier (Becton Dickinson, USA).

RESULTS

Prevalence of pathogenic bacteria among the paper currency notes

In general 97.23% TK2 notes, 95% TK10 notes and 88.88% TK100 notes were contaminated with bacteria (Figure 1). *Salmonella* contamination was detected on 66.66 to 80% paper currencies procured from Fish sellers followed by Poultry-product sellers (63.33 to 73.33%), Vegetables sellers (36.66 to 46.66%), Food vendors (20 to 36.66%), Rickshaw pullers (0 to 30%) and Shop keepers (13.33 to 16.66%). No *Salmonella* was detected on the TK100 notes procured from Rickshaw-pullers (TABLE 1). *Shigella* was detected on the 46.66 to 73.33% paper currencies collected from Fish sellers followed by those collected from Poultry-product sellers (23.33 to 43.33%). Only 10 to 13.33% notes obtained from Vegetables sellers were found positive for *Shigella*. But the currency notes procured from Food vendors and Shop keepers were found free from *Shigella* contamination (TABLE 1). *Vibrio* was detected on all the TK2 notes received from Fish sellers. Currency notes of other two denominations (TK10 and TK100) collected from the same occupational group also registered high level

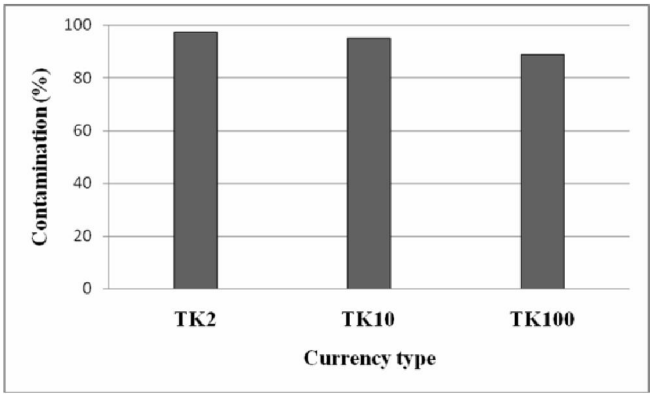

Figure 1 : Contamination rate (%) of paper currency notes of three denominations (TK2, TK 10 and TK100).

TABLE 1 : Percentage of currency notes contaminated with various pathogenic and potentially pathogenic bacteria in different occupational groups

Occupational Group (Sample type)	No. of notes contaminated with (%)				
	Salmonella	*Shigella*	*Vibrio*	*Pseudomonas*	*Staphylococcus*
Fish seller					
(TK2)	24 (80.00)	22 (73.33)	30 (100.00)	29 (96.66)	27 (90.00)
(TK10)	22 (73.33)	17 (56.66)	28 (93.33)	27 (90.00)	27 (90.00)
(TK100)	20(66.66)	14 (46.66)	28 (93.33)	28 (93.33)	26 (86.66)
Poultry-product seller					
(TK2)	22 (73.33)	13 (43.33)	25 (83.33)	27 (90.00)	26 (86.66)
(TK10)	19 (63.33)	13 (43.33)	20 (66.66)	22 (73.33)	24 (80.00)
(TK100)	20 (66.66)	7 (23.33)	26 (86.66)	22 (73.33)	24 (80.00)
Vegetables seller					
(TK2)	14 (46.66)	4 (13.33)	20 (66.66)	23 (76.66)	20 (66.66)
(TK10)	13 (43.33)	3 (10.00)	20 (66.66)	20 (66.66)	16 (53.33)
(TK100)	11 (36.66)	4 (13.33)	16 (53.33)	20 (66.66)	22 (73.33)
Food vendor					
(TK2)	11 (36.66)	0 (00.00)	19 (66.33)	20 (66.66)	16 (53.33)
(TK10)	10 (33.33)	0 (00.00)	16 (53.33)	16 (53.33)	15 (50.00)
(TK100)	6 (20.00)	0 (00.00)	14 (46.66)	15 (50.00)	14 (46.66)
Shop keeper					
(TK2)	5 (16.66)	0 (00.00)	17 (56.66)	19 (63.33)	15 (50.00)
(TK10)	4 (13.33)	0 (00.00)	15 (50.00)	16 (53.33)	13 (43.33)
(TK100)	4 (13.33)	0 (00.00)	16 (53.33)	13 (43.33)	11 (36.66)
Rickshaw puller					
(TK2)	9 (30.00)	3 (10.00)	17 (56.66)	15 (50.00)	17 (56.66)
(TK10)	7 (23.33)	0 (00.00)	14 (46.66)	11 (36.66)	15 (50.00)
(TK100)	0 (00.00)	0 (00.00)	19 (63.33)	9 (30.00)	9 (30.00)

of *Vibrio* contamination (93.33%). Currency notes collected from Poultry-product sellers also registered high level of *Vibrio* contamination (66. 66 to 83.33%). More than half of the currency notes procured from Vegetables sellers, Food vendors, Shop keepers and Rickshaw pullers were found contaminated with *Vibrio* (TABLE 1). The Pseudomonads and *Staphylococcus* were detected on the notes procured from each occupational group. As like the prevalence of enteric bacteria the prevalence of *Pseudomonas* and *Staphylococcus* were high (96.66 and 90%, respectively) on the TK2 notes obtained from Fish sellers (TABLE 1).

As depicted from TABLE 2, bacterial prevalence was found among each of the three denominations (TK2, TK10 and TK100). Maximum load (1.59×10^9 cfu/cm^2) of *Vibrio* was in the TK10 received from Fish sellers. However, highest load of *Salmonella* (2.40×10^8 cfu/cm^2), *Shigella* (1.50×10^8 cfu/cm^2), *Pseudomonas* (8.24×10^8 cfu/cm^2) and *Staphylococcus* (1.32×10^9 cfu/cm^2) were recorded on TK2 procured from Fish sellers. On the contrary, minimum counts of *Vibrio* (7.7×10^9 cfu/cm^2), *Pseudomonas* (4.5×10^9 cfu/cm^2) and *Staphylococcus* (3.6×10^8 cfu/cm^2) were recorded on the TK100 notes procured from Rickshaw pullers.

Antibiogram

Antibiotic susceptibility pattern of *Salmonella*, *Vibrio*, *Pseudomonas* and *Staphylococcus* isolated from paper currency notes are presented in Figure 2. Resistance spectrum of *Salmonella*, for 10 antibiotics tested in descending order was Penicillin> Tetracycline> Ampicillin> Cephalexin> Erythromycin> Riphampicin> Chloramphenicol> Streptomycin> Ciprofloxacin> Gen-

TABLE 2 : Load of pathogenic and potentially bacteria on currency notes tested from different occupational groups

Occupational Group (Sample type)	Bacterial count (cfu/cm^2)				
	Salmonella (×10^8)	*Shigella* (×10^8)	*Vibrio* (×10^8)	*Pseudomonas* (×10^8)	*Staphylococcus* (×10^8)
Fish seller					
(TK2)	2.49	1.50	14.9	8.24	13.20
(TK10)	1.71	0.76	15.94	4.59	7.78
(TK100)	1.01	0.50	9.04	6.39	5.23
Poultry-product seller					
(TK2)	1.93	0.64	6.21	5.13	4.98
(TK10)	1.04	0.55	3.55	1.68	3.06
(TK100)	1.69	0.26	10.26	1.43	6.22
Vegetables seller					
(TK2)	0.73	0.18	3.63	2.46	2.21
(TK10)	0.52	0.09	2.54	1.28	1.28
(TK100)	0.32	0.12	1.21	0.68	1.52
Food vendor					
(TK2)	0.55	0	2.09	1.47	1.35
(TK10)	0.37	0	1.41	0.91	1.01
(TK100)	0.18	0	1.04	0.71	0.65
Shop keeper					
(TK2)	0.27	0	1.81	1.38	1.29
(TK10)	0.18	0	1.41	0.89	0.89
(TK100)	0.12	0	1.13	0.50	0.59
Rickshaw puller					
(TK2)	0.34	0.09	2.00	1.50	1.78
(TK10)	0.21	0	1.10	0.91	1.07
(TK100)	0	0	0.77	0.45	0.36

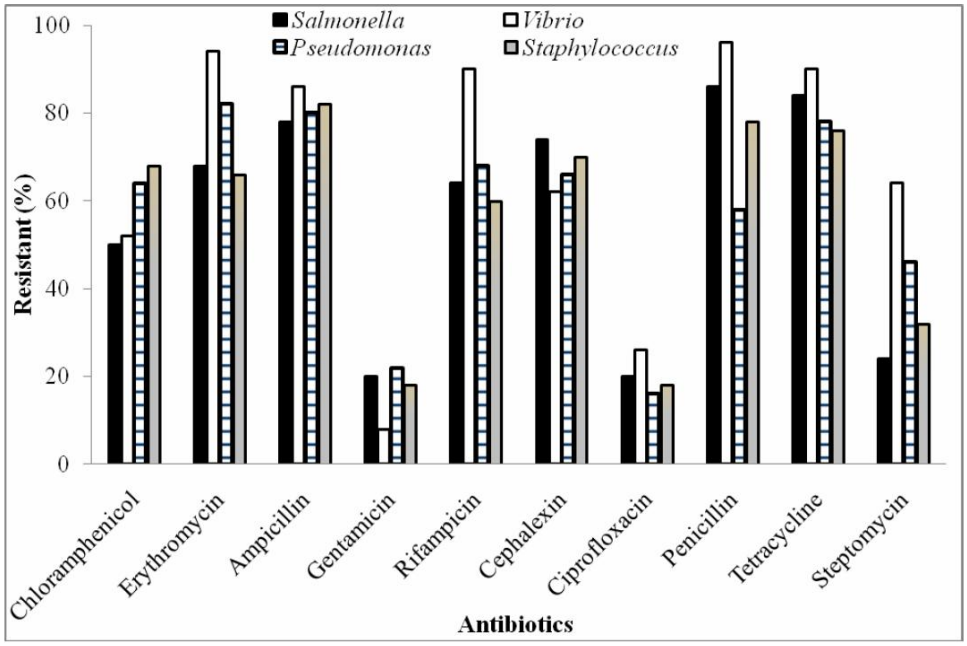

Figure 2 : Antibiotic resistance pattern of the bacterial strains isolated from currency notes of Bangladesh

tamicin. Anitbiotic resistance pattern of *Vibrio* was as follows (in descending order): Penicillin> Erythromycin> Tetracycline> Riphampicin> Ampicillin> Streptomycin Cephalexin> Chloramphenicol> Ciprofloxacin> Gentamicin. However, *Pseudomonas* isolates showed a different pattern of antibiotic resistance (in descending order): Erythromycin> Ampicillin> Tetracycline> Riphampicin> Cephalexin> Chloramphenicol> Penicillin> Streptomycin> Gentamicin> Ciprofloxacin. The Gram positive *Staphylococcus* isolates showed antibiotic resistance pattern as follows (in descending order): Ampicillin> Penicillin> Tetracycline> Cephalexin> Chloramphenicol> Erythromycin> Riphampicin> Streptomycin> Gentamicin> Ciprofloxacin. It is evident from Figure 2 that 20-86% of the *Salmonella* isolates, 8-96% *Vibrio* isolates 16-82% *Pseudomonas* isolates and 18-82% *Staphylococcus* isolates showed resistance against one of the antibiotics tested. Ciprofloxacin or Gentamicin was found effective against most of the isolates.

DISCUSSION

Paper currency notes are highly mobile inanimate object in the human society and hence have the potential to transmit disease-causing microorganisms[12]. Present study revealed that on an average, nine out of ten paper currency notes from the tested occupational groups are contaminated with pathogenic and potentially pathogenic microorganisms. Our findings corroborates with the findings that 94% of the US one-dollar bills are contaminated with pathogenic and potentially pathogenic microorganisms[18]. Furthermore, in another study Basavarajappa et al.[2] reported that the 96% of the Indian currency notes are contaminated with bacteria. Contamination rate is higher on the notes of lowest denomination (TK2), probably because the smaller unit notes are most frequently handled in petty in daily monetary transactions[9,19].

We observed a high level of bacterial load on most of the currency notes examined in this study. Presence of such a high number of enteric bacterial load (upto 2.9×10^7 cfu/cm^2) was also reported on the currency notes of Myanmar[11]. In this study, paper currency notes obtained from Fish sellers and Poultry sellers had the high level of bacterial contamination indicating that the members of these two occupational groups give less attention to personal hygiene in addition to the objects they handle. Currency notes received from Rickshaw-puller, Shop keepers had relatively less bacterial load indicating that they are more conscious about personal hygiene than those of other occupational groups included in this study.

It is evident from this study that Penicillin resistance is widespread among *Vibrio* (96%), *Salmonella* (86%) whereas resistance against Ampicillin is high among *Pseudomonas* (80%) and *Staphylococcus* (82%). In this study, currency notes collected from the persons belong to lower level of socioeconomic scale. Presence of such a high level of antibiotic-resistant bacteria on currency notes procured from the people of different occupational groups covered in this study may be explained by the socioeconomic and behavioral factors of those people[17]. Among the antibiotics tested, Gentamicin and Ciprofloxacin appeared to be useful against the bacterial isolates. Emikpe & Oyero[8] also reported the effectiveness of Gentamicin against *Staphylococcus* isolated from Nigerian currency. However, it seems likely that the situation will not prevail for long as because some isolates of present study also showed resistance against Gentamicin and Ciprofloxacin. Microorganisms like *Salmonella, Shigella, Vibrio, Pseudomonas* and *Staphylococcus* can cause various types of diseases. Transmission of antibiotic-resistant bacteria from person to person via contaminated paper currency notes may cause clinically significant infection particularly in immune-compromised persons. Furthermore, contaminated paper currency might have a relation with the spread of antibiotic resistant bacteria in Bangladesh. Thus the presence of high number of antibiotic-resistant bacteria on Bangladeshi currency notes reflects an alarming situation for health policy-makers.

It is quite clear that paper currency notes in circulation in Bangladesh harbor antibiotic resistant pathogenic or potentially pathogenic bacteria which may pose a public health threat. To control the spread of such organisms we recommend: (i) periodic withdrawal of old, soiled, tattered and mutilated currency notes from the circulation, (ii) set up of currency decontaminating facilities by the central bank or other competent authority, (ii) awareness buildup among the people to wash

their hands after counting money and not to wet their hands by saliva before counting paper currency, (iii) introduction of coins replacing the paper currency notes of lower denominations (*viz.*, TK2, TK10 and TK100), and (iv) introduction of plastic currency notes for higher denominations.

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CONFLICT OF INTEREST

Authors have no conflict of interest.

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