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Research Article

Multi-drug Resistance of Microbial Contaminants of Paper Currencies in Bangladesh: An Overlooked Public Health Concern

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Abstract

Bangladeshi banknotes, like other world currencies, are passed through the hands of many people and are involved in the transmission of microorganisms, some of which are potentially harmful to health. This study aims to identify the bacterial pathogen on circulating Bangladeshi banknotes in Dhaka city and their antibiotic resistance. A total of 160 bacteria belonging to five genera such as *Pseudomonas* spp., *Klebsiella* spp., *Enterococcus* spp., *Staphylococcus aureus*, Coagulase-negative *Staphylococcus* were isolated from 110 banknote samples collected from different commercial areas in Dhaka city. The highest bacteria was found in 20 taka notes on the fish vendor's site. Most of the isolates were found to be highly resistant to commonly used antibiotics. Among the coagulase-negative *Staphylococcus* strains, the highest resistance was found against gentamycin (60%), followed by azithromycin (40%) and clindamycin (40%), among the *Klebsiella* spp. Isolated in this investigation, the highest resistance was found against clindamycin (60%), followed by ampicillin (50%). Such multi-antibiotic-resistant bacteria in the Bangladeshi banknote is a potential public health threat, and this long-overlooked concern should be dealt with a coordinated approach.

Keywords: Currency; Antibiotic Resistance; Bacteria; Pathogens; Public Health

Abbreviations

AMR: Antimicrobial Resistance; EMB: Eosin Methylene Blue Agar; MSA: Mannitol Salt Agar; MR: Methyl Red; VP: Voges-Proskauer; TSI: Triple Sugar Iron; MIU: Motility Indole Urease

Introduction

One of the greatest threats to the population is antimicrobial resistance (AMR), which could end centuries of medical advances, making it difficult or sometimes impossible to treat diseases such as pneumonia, tuberculosis, urinary tract infections, and pharyngotonsillitis, among others. As a result, the management of disorders becomes more complex every day: the patient either does not respond to a treatment scheme that his doctor has established, more doses are required, or, sometimes, the patient has to be hospitalized and may die because there are no alternatives available to treat infections caused by resistant microorganisms, to which are added the costs in care and for the health system in general [1,2]. Contamination of commonly handled materials with pathogenic microorganisms is a public health concern because the contaminated material can be a source of transmission of pathogenic microorganisms and the origination of multi-antibiotic resistant organisms [3,4].

In many nations worldwide, currency is frequently exchanged for products and services [5]. Money is essential to human existence since it helps us with our financial and commercial needs. Banknotes and coins were reported as carriers of potentially pathogenic microorganisms in the early 1970s [6]. The risk of pathogenic microorganisms and diseases being transmitted by currency has been reported worldwide. Still, most of these studies have been conducted in tropical or subtropical regions [7]. Banknotes obtained from hospitals can be contaminated with *Staphylococcus aureus. Salmonella* and *Escherichia coli* are isolated from grocery store banknotes [8]. These findings suggest that currency notes could be a universal vehicle for transmitting potentially pathogenic microorganisms between people, either directly through hand-to-hand contact or indirectly through water and food [9]. Microbial transmission from banknotes to humans depends on the number of microbes, their ability to survive in the environment, and the mode of contact with the currency [10]. The research aimed to investigate the prevalence of pathogenic bacteria from circulating banknote currencies in Dhaka city and assess their antibiotic resistance.

Materials and Methods

Study area

Dhaka city is located in the central part of Bangladesh. Dhaka is Bangladesh's capital and largest city, with a population of around 20 million and an area of 306.4 square kilometers. It is one of the most densely populated areas in Bangladesh.

Figure 1: Sampling locations.

Sample collection and transport

A total of 110 Bangladeshi banknotes were collected from its five locations and from people from different social classes and activities (Bus drivers, fishvendor's, slaughterhouse, fast food restaurants, Ward boys, etc.). We selected Notes of distinct values (BDT 5, BDT 20, BDT 50, and BDT 100) were selected for this research to ascertain a complete picture. Each note was collected from different areas chosen with sterile polybags and transferred to the microbiological laboratory of Primeasia University. All samples were dipped into 1% peptone water using a clean cotton swab stick.

Isolation and identification of bacterial isolates

The enriched peptone water samples were then inoculated on a non-selective medium (Nutrient agar) and a selective medium such as Cetrimide agar, MSA agar, Staphylococcus agar 110, Blood agar, EMB agar, and MacConkey agar. All culture media purchases from Hi Media, India. Previously protocols were followed in this study [11]. All inoculated plates were incubated at 37 °C for 24 h. The plates were then examined for bacterial growth. Colonies were repeatedly picked based on differences in appearance and subcultures to obtain pure settlements. Territories were phenotypically determined by colony characteristics, Gram staining, and biochemically examined using standard procedures. A group of biochemical tests, such as Catalase, MR-VP, TSI, and MIU, were performed by conventional methods [12].

Antibiotic sensitivity test

The antibiotic disc diffusion method Antibiotics determined the antibiotic susceptibility of the isolates (Fondisk, Lagos, Nigeria), namely Gentamycin (10 µg), Chloramphenicol (30 µg), Gatifloxacin (5 µg), Linezolid (30 µg), Azithromycin (15 µg), Ciprofloxacin (10 µg), Amikacin (30 µg), Clindamycin (5 µg), Vancomycin (2 µg), Ampicillin (10 µg) were used. The diameter of the zone of inhibition was measured and interpreted according to the Institute of Clinical Laboratory Standards (2011) guidelines [13].

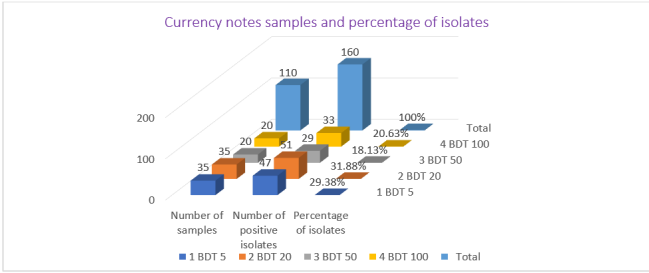

Figure 2: Currency notes samples and percentage of isolates.

Results and Discussion

A total of 160 bacterial strains were isolated from the 110 banknote samples. Among 160 isolates, 47 (29.38%) were isolated from five taka currency, whereas 51 (31.88%) from twenty taka currency, 29 (18.13%) from fifty taka currency, and 33 (20.63%) were from hundred taka currency. Figure 2 shows the contamination rate and culture positivity according to the physical state of banknotes. This data indicates that smaller-value coins contain more bacterial load than higher-value notes, possibly due to more frequent hand-to-hand exchanges. A similar phenomenon was observed in previous reports from Bangladesh [14-16].

In our study, among the 160 isolates, 57.5% were Gram-negative bacteria, while 42.5% were Gram-positive bacteria, similar to the results of [17]. Based on culture-based identification, the 160 strains isolated belong to five genera, namely *Pseudomonas* spp. (17.5%), *Klebsiella* spp. (23.12%), *Enterococcus* spp. (16.87%), *Staphylococcus aureus* (18.12%), and coagulase-negative *Staphylococcus* spp. (24.37%) (Table 1). Out of 28 *Pseudomonas spp.*, 8 (17.02%) were identified from five taka currency, 7 (13.72%) from twenty taka notes, 6 (20.68%) from fifty taka notes, 7 (21.21%) from hundred taka notes, respectively. Out of 37 *Klebsiella* spp., 11 (23.40%) were identified from five taka notes, 12 (23.52%) from twenty taka notes, 6 (20.68%) from fifty taka notes, and 8 (24.24%) from hundred taka notes, respectively. Out of 27 *Enterococcus* spp., 6 (12.76%) were identified from five taka currency, 8 (15.68%) from twenty taka notes, 5 (17.24%) from fifty taka notes, and 8 ((24.24%) from hundred taka notes, respectively. Out of 29 *Staphylococcus aureus*, 10 (21.27%) were identified from five taka currency, 9 (17.64%) from twenty taka notes, 6 (20.68%) from fifty taka notes, and 4 (12.12%) from hundred taka notes, respectively. Out of 39 Coagulase-negative *Staphylococcus* spp., 12 (25.53%) were identified from five taka currency, 15 (29.41%) from twenty taka notes, 6 (20.68%) from fifty taka notes, and 6 (18.18%) from hundred taka notes, respectively. Table 1 summarizes the prevalence of bacterial isolates from different sources with different currencies.

Isolates	BDT 5	BDT 20	BDT 50	BDT 100	Total
Pseudomonas spp.	8(17.02%)	7(13.72%)	6(20.68%)	7(21.21%)	28(17.5%)
Klebsiella spp.	11(23.40%)	12(23.52%)	6(20.68%)	8(24.24%)	37(23.12%)
Enterococcus spp.	6(12.76%)	8(15.68%)	5(17.24%)	8((24.24%)	27(16.87%)
Staphylococcus aureus	10(21.27%)	9(17.64%)	6(20.68%)	4(12.12%)	29(18.12%)
Coagulase-negative Staphylococcus	12(25.53%)	15(29.41%)	6(20.68%)	6(18.18%)	39(24.37%)
Total	47(29.37%)	51(31.87%)	29(18.13%)	33(20.62%)	160 (100%)

Table 1: Prevalence of bacterial species on currency notes.

Previous reports from Bangladesh also reported the presence of the same bacterial genera in Bangladeshi bank notes. Ahmed., *et al*. said microbial contamination of circulating banknotes in Dhaka, Bangladesh. They have isolated bacteria belonging to *E. coli*, *Klebsiella* spp., *Staphylococcus aureus*, *Salmonella* spp., *Bacillus* spp., *Pseudomonas* spp., and *Vibrio cholera*. [14]. Body., *et al*. reported microbial contamination in high amounts in Bangladeshi banknotes with bacteria belonging to *E. coli*, *Klebsiella* spp., *Proteus* spp., *Staphylococcus aureus*, *Salmonella* spp., *Shigella* spp., *Pseudomonas* spp. and *Enterobacter* spp. [15]. Barua., *et al.* reported microbial contamination in paper currency notes in Mymensingh city, Bangladesh, and found bacteria belonging to *Staphylococcus* spp., *Salmonella* spp., and *E. coli*. Hence, our study is on the same page as the previous reports [16].

Among the 160 bacterial strains isolated, 46(28.75%) were isolated from currencies collected from fish vendors, 44(27.5%) from currencies collected from fast food outlets, 26(16.25%) from currencies collected from ward boys, 23(14.37%) from currencies collected from slaughterhouses, and 21(13.1%) were from currencies collected from bus conductors (Figure 3). Due to in general poor hygienic conditions in the fish market, banknotes collected from fish markets are heavily contaminated with microbes. Previous reports from Bangladesh also reported high levels of microbial contamination in banknotes sampled from local market dwellers such as fish sellers, vegetable sellers, fruit sellers, etc. [14-16].

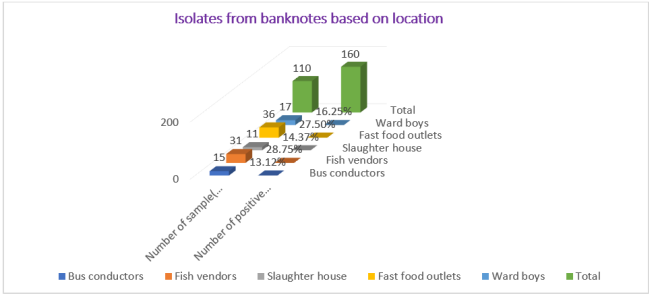

Figure 3: Isolates from banknotes based on location.

Source of currency notes	*Pseudomonas* spp.	*Klebsiella* spp.	*Enterococcus* spp.	*Staphylococcus aureus*	Coagulase-negative *Staphylococcus*
Bus conductors	-	-	-	+	+
Fish vendors	++	-	+	++	+
Slaughterhouse	-	+	-	+	-
Fast food outlets	+	++	-	+	++
Ward boys	+	-	+	+	-

Table 2: Distribution of banknotes according to the handler.

++= Highest Positive, += Lowest Positive, -= Absence

In the case of notes collected from fish vendors, *Klebsiella* spp. was absent, but *Pseudomonas* spp., *Enterococcus* spp., *Staphylococcus aureus,* and coagulase-negative *Staphylococcus* spp. were present. *Pseudomonas* spp., *Enterococcus* spp., and Coagulase negative *Staphylococcus* spp. were absent in slaughterhouse samples, whereas only *Klebsiella* spp. and *Staphylococcus* spp. were present. In the case of fast food outlet currency notes, bacteria belonging to all the above-mentioned genera (*Pseudomonas* spp., *Klebsiella* spp., *Enterococcus* spp., *Staphylococcus aureus,* and coagulase-negative *Staphylococcus* spp.) was present. In the case of word boys samples, *Klebsiella* spp. and coagulase-negative *Staphylococcus* spp. were absent, but *Pseudomonas* spp., *Enterococcus* spp., and *Staphylococcus aureus* were present (Table 2).

The antibiotic resistance pattern of the isolates has been investigated to ascertain the public health risk associated with these isolates. In the *Pseudomonas* spp. group organisms were most resistant to chloramphenicol (50%), azithromycin (40%), and vancomycin (40%). *Klebsiella* spp. were most resistant to azithromycin (60%), clindamycin (60%), and ampicillin (50%),

Whereas *Enterococcus* spp. were most resistant to azithromycin (50%). *Staphylococcus aureus* was most resistant to linezolid (50%) and ampicillin (50%). Coagulase-negative *Staphylococcus* spp. were most resistant to gentamicin (60%) (Figure 4). Barua., *et al*. reported that the microorganisms tested were resistant to Amoxicillin, Ampicillin, and Ciprofloxacin but were susceptible to Azithromycin and Norfloxacin [16].

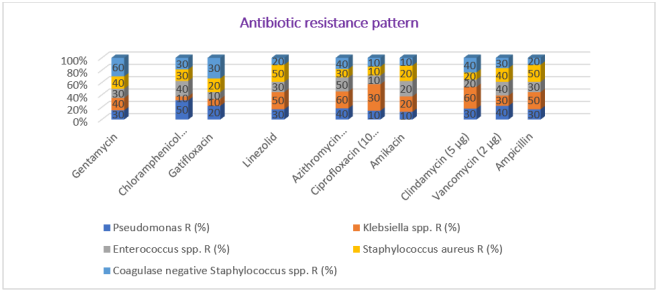

Figure 4: Antibiotic resistance pattern of banknotes isolates.

Currency or banknotes can represent a potential factor for the transmission of microorganisms, many resistant to antibiotics, which would increase the risk of disease [18,19]. A study by Hosen., *et al*. in Bangladesh found 80% coliform contamination on 30 old two-taka banknotes. This study demonstrated that the Bangladeshi banknotes (taka) in circulation are contaminated with Gram-positive and Gram-negative bacteria. In our study, out of 110 banknotes with four types of banknotes (5 takas, 20 takas, 50 takas, and 100 takas), all banknotes were contaminated [20]. The most common bacteria associated with all banknotes in this study were coagulase-negative *Staphylococcus* spp. The highest contamination levels were found in currencies from local fish markets and fast food outlets. Many bacterial isolates from currency notes showed resistance to commonly used antibiotics. In the present research, it is clear that there is an inverse correlation between the decrease in the value of banknotes and the increase in the microorganisms found, regardless of the species found.

It is indisputable that banknotes in Bangladesh harbor a higher proportion of the microbial load. Currency notes may act as a possible fomite of pathogenic and non-pathogenic microorganisms; it can increase the rate of infections and morbidity, constituting a potential risk from the epidemiological point of view, given the possibility that this fact continues rising. The results of this study will raise awareness about the role of banknotes and coins as contamination factors, which will mean a new contribution to improving personal hygiene habits, significantly reducing the public health risk associated with this long-overlooked transmission source of pathogens.

Conclusion

The Bangladeshi banknotes sample was contaminated with many medically significant bacteria and thus could be a potential source of disease-causing organisms. Educating the public through appropriate education about the health risks of contaminated currency notes and proper handling is strongly encouraged. The public should know that paper money can be a source of infection and a health hazard.

Conflict of Interests

The author has no conflict of interest.

Acknowledgments

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Authors Contribution

Md. Abdul Khalek carried out the experimental work. Md. Aoulad Hosen and Mohammad Shariful Islam checked the plagiarism and grammatical errors. Ms. Jinia Afroz supervised the granted research. Md. Fakruddin and Raisa Rafia helps with writing manuscripts. Md. Hasibul Hasan and Md. Shiblee Shadik Sabuj prepared the graph and other figures. Cotton chakma prepared the tables. Md. Iqbal Hossain and Harunur Rashid finally revised and prepared the manuscript. All auhors read the entire manuscript thoroughly before final publication.

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