Original Article

Indian currency uncovered with microbes retrieved from expected and unexpected transaction points

Abstract

The aim of the study is to determine the presence, type and nature of bacterial contamination on paper currency and coins in circulation. Total 96 paper currency and 48 coins of different denominations were randomly collected from butcher shop, vegetables seller, auto rickshaw and rickshaw man, chemist store, tuberculosis chest outpatient department (OPD) and general OPD from the different areas of Lucknow city in a sterile paper bags. A total of 249/92 bacteria, 49/24 fungal isolates and 1/0 parasite were obtained from the paper currency and coins respectively. Different bacterial species were isolated with the most common isolates being *Bacillus* species (60.41%, 47.91%) and followed by *Escherichia coli* (41.66%, 35.41%), *Proteus* species (39.58%, 42.0%), *Klebsiella pneumoniae* (35.41%, 12.5%), Coagulase-negative *Staphylococcus* (28.12%, 31.25%), *Staphylococcus aureus* (20.83%, 23.1%), *Diphtheroids* (17.70%, 0%), *Enterococcus* species (11.45%, 0%), *Streptococcus pyogenes* (11.45%, 0%), *Salmonella* species (2.08%, 0%), *Shigella* species (1.04%, 0%) and acid fast *Bacilli* (2.08%, 0%). Different fungus that is, *Aspergillus* species (27.08%, 37.5%), *Candida albicans* (13.54%, 12.5%), *Cladosporium cladosporioides* (9.37%, 0%) and *Ascaris* egg (1.04%, 0%) were found in paper currency and coins respectively. These results suggest that the currency is commonly contaminated with microbes, and this contamination may play a role in the transmission of antibiotic resistant or potentially harmful organism. This work seeks to confirm microbial contamination of currency and also introduces the nature and levels of contamination of the Indian currency. The distribution of contamination was unexpectedly higher in unexpected locations, indicative of our wide ignorance and indifference toward contamination through this route.

Key words: Contamination, currency, Indian

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INTRODUCTION

A currency refers to diverse denominations made of paper issued by the Reserve Bank of India or the nationalized banks and coins made of metal. Paper currency and coins are broadly used, and every currency is swap a lot of times during the time of circulation. Money can get contaminated and may thus play a role in the transmission of microorganisms to other people during its circulation.[1] For example; a currency note may get contaminated with microorganisms from the respiratory and gastro-intestinal tract during counting. In addition, contamination from the skin, anal region, wounds, nasal secretions and aerosols generated by sneezing and coughing are also potential sources of transfer of microorganisms to paper currency during handling.[2]

The currency note is not usually suitable for the continued existence of microorganisms, except for some that are resistant to external conditions and nonresistant forms of spores.[3] On the other hand, the general hygiene levels of a society possibly contribute to the amount of microbes found on paper currency and thus the more chance of transmission during handling of money.[4] At the same time as the type of isolated bacteria between studies can vary due to the environmental conditions, methods used, sort of money (paper currency or coin) or local community flora. As paper currency serves commonly as a mode of transaction; it is handled by various sets of population at various levels and conditions. This handling introduces same or other contamination that could infect the susceptible population.

It is considered that in a healthcare set up such as a chemist store, clinics especially infectious disease clinics like leprosy, tuberculosis (TB), skin etc., is more disposed to the contamination and considered as expected transaction points. Some nonsensible transmission also occurs in unexpected areas such as a market or transport.

STUDY OBJECTIVES

The primary study objective was to explore the presence of microorganisms in sample wash of currency denomination in expected and unexpected location samples. The secondary objectives were to study the effect of aging and condition of paper currency with contamination status, value denomination of note and coin with contamination status. Based on this; hypothesis of the trial was set for noninferiority as "in sample wash of currency denominations, culture characteristics of unexpected areas is at least the same as expected areas" and margin for noninferiority was set at 3%.

METHODOLOGY AND STRATEGIES

Designing statistics

Null hypothesis from the above hypothesis sets to be "the paper currency in market location is not contaminated (sterile)" this was ruled out in population estimation by setting to a Type I error (α) on each set as 0.05 leading to a confidence interval of 95%. Proposed hypothesis at alternate hypothesis was "the currency in unexpected areas has contamination at least equal to expected location." To accept the alternate hypothesis a Type II error (β) of 0.10 was preset, leading to power 90%. Considering that culture positive for paper currency in expected locations is 100%, and in banks will be 0%, the design effect is taken as 30% by statistical calculations.

Determination of locations

Common population in India visits most commonly in market places such as vegetable shops and a butcher shop in daily routine. Auto rickshaw and rickshaw is a common mode of transportation of common public in this area and transact their currencies directly or indirectly. The control is taken as negative control as new issued currency from bank that was never issued to public, testimonial is taken as the places where highest environmental contamination is predisposed such as a butcher shop, vegetable shop and positive from chemist shop, general and tubercular outpatient departments (OPDs).

Sample collection

The geographical locations were selected based on density of the population attending the fifteen markets in Lucknow. The first available note from denomination of INR 5-500 and coin from denomination of INR 1-5 were collected either against a purchase or in form of change of a higher denomination from target centers without any information and currency collected from bank for control. The individuals who collected the samples used sterilizers immediately before handling paper currency or coins and the collection place is kept confidential. The paper currency and coins collected were preserved in a sterile location in a closed pouch immediately after collection. Total 144 various denominations were randomly collected from each location comprising of two numbers of each paper currency of Rs. 5, 10, 20, 50, 100, 500 and coins of Rs. 1, 2, 5 for testimonial, positive and negative control [Table 1].

Examination of currency status

The paper currencies were examined for appearance and condition based aging by several criteria. The condition was determined on the criteria of accumulating the score of cleanliness, integrity and stiffness of paper currency using the scoring system from 1 to 5 on the basis of physical condition. The aging was defined as high when score was 3-6, moderate when score was 7-14 and was defined as new when score was 15 [Table 2].

Culture of currency

Currency of all the available denominations were processed for microbial isolation. Nutrient broth enrichment of coins was done in a sterile container, and broth-wetted swabs rubbed on both sides of the paper currency were enriched for 4 h. After enrichment of swab; blood agar, MacConkey agar, and Lowenstein Jensen media was inoculated and incubated for 24 h at 37°C and 48 h at 25°C on Sabouraud's dextrose agar for fungus.[5,6] Growth was examined and identified after defined duration.

Table 1: Location-wise currency distribution

Type	Location code	Location identity	Sample	
			Notes	Coin
Testimonial	G1	Butcher shop	12	6
	G2	Vegetable shop	12	6
	G3	Auto	12	6
	G4	Rickshaw	12	6
Positive control	H1	General OPD	12	6
	H2	Chemist store	12	6
	H3	Tuberculosis OPD	12	6
Negative control	B1	Banks	12	6

OPD = Outpatient department

Table 2: Physical evaluation of paper currency

Criterion	Score 1	Score 2	Score 3	Score 4	Score 5
Cleanliness	Blackish dirty appearance	Faded note with dirty folds, corners/edges	Faded denomination appearance	Dirty edges and folds	Looks fresh
Integrity	Joint part	Torn on all folds	Torn on any fold	Torn corners	No tears
Stiffness	Crushed look	Does not stand still	Stands still without support	Sounds on tapping on stiff end	Cutting edge feel

Identification of bacterial isolates

Pure isolated colonies were identified using their morphology, gram reaction as well as standard biochemical techniques.[7]

Identification of parasites and acid fast *Bacilli*

After inoculating the agar plates, the remaining test sample was transferred into sterile centrifuge tubes and centrifuged at 3000 rpm for 5 min. The supernatant was decanted. Two smears were made on microscope slides from the deposit. To one smear, a drop of Dobell's iodine was added, covered with a cover slip and examined under the microscope for parasites. The another film was air-dried, heat fixed and stained with Ziehl–Neelsen method and then examined under the microscope for acid-fast *Bacilli*.[8]

Identification of fungi

The growth of fungi on Sabouraud's dextrose agar was examined critically after 1-week using prepared microscope slides. The prepared specimens were mounted on lacto phenol cotton blue and identification of the fungal species was performed with the aid of binocular compound microscope (×40) adopting the techniques.[9]

Bacterial load

Serial doubling dilutions were prepared from the test sample as shown thus-1:10^1, 1:10^2, 1:10^3…1:10^{10}. This was done by transferring dispensed 1 ml of test sample into 9 ml of sterile buffered peptone, vortexes, and then 1 ml aliquot transferred into the next tube using a micropipette. Starting with the highest dilution 0.1 ml of the test dilution was dispensed onto agar plates in duplicate. The inoculum was spread evenly over the entire surface of the plate using a sterile bent spreader. All plates were incubated at 37°C, aerobically in an incubator overnight. After overnight incubation, all colonies on the plates containing 30-300 colonies were counted from the duplicate plates and the mean counts determined.[8]

RESULTS

The Indian paper currency and coins of different denomination (paper currency: 5, 10, 20, 50, 100, 500 and coins: 1, 2 and 5) analyzed were contaminated by bacteria, fungi and parasites. In this study, we have used two types of controls with testimonial. Negative controls from Reserve Bank of India, positive controls from the places having high probability of contamination as in medical OPDs and chemist store along with a testimonial from rickshaw, auto, vegetable and butcher shops were taken. Age of the currency note was determined upon its condition [Figure 1]. Contamination was also related to the physical condition of the currency; the high aging paper currency had the highest, moderate aging paper currency had lesser and new paper currency having least prevalence of contamination.

Results reveal that, almost 100% of all the currency obtained from the various sources was contaminated with bacteria, fungus and parasite. Most of the currency had more than one microbial contaminant. Different types of microbial contaminant were found on currency

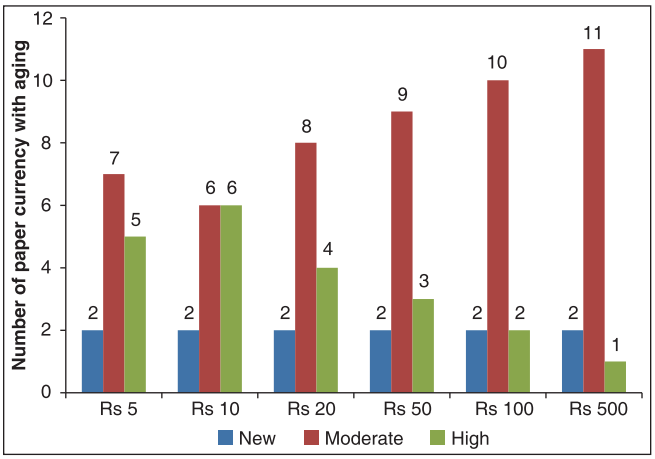

Figure 1: Aging of paper currency

collected from various sources [Figure 2]. There are different bacterial species were isolated, with the most common isolates being *Bacillus* species (60.41%, 47.91%), *Escherichia coli* (41.66%, 35.41%), *Proteus* species (39.58%, 42.0%), *Klebsiella pneumoniae* (35.41%, 12.5%), Coagulase-negative *Staphylococcus* (28.12%, 31.25%), *Staphylococcus aureus* (20.83%, 23.1%) *Diphtheroids* (17.70%, 0%), *Enterococcus* species (11.45%, 0%), *Streptococcus pyogenes* (11.45%, 0%), *Salmonella* species (2.08%, 0%), *Shigella* species (1.04%, 0%) and acid fast *Bacilli* (2.08%, 0%). Different fungus *Aspergillus* species (27.08%, 37.5%), *Candida albicans* (13.54%, 12.5%), *Cladosporium cladosporioides* (9.37%, 0%) and *Ascaris* egg (1.04%, 0%) were found in paper currency [Figure 3] and coins [Figure 4] respectively.

In addition, the microbial load on paper currency is much higher than coins. Most prevalent contamination was found among the Rs. 5 and 10 paper currency and coin Rs. 1 and 2 least prevalent among the Rs. 500 and 100 paper currency, and coins Rs. 2. Bacterial load reported more on paper currency than coins, and it was more on lower value denominations then the higher [Figure 5].

DISCUSSION

There is a possibility that paper currency might act as environmental vehicles for the transmission of potential pathogenic microorganisms.[10] The results of this study confirmed that paper currency could serve as a vector for disease transmission of pathogenic microorganisms and fungal elements. Results of this study had shown that most of paper currency and coins were contaminated with a variety of microorganisms some of which are pathogenic. This finding supports reports from other parts of the world that paper currency are usually contaminated by microorganisms that can cause a wide range of diseases.[11-13] Contamination frequency was found related to the denomination of currency.

The most common prevalence was observed in the market places, the highest among all being a butcher shop. This can infer that a common man generally are in contact with infective environment, which circulate from common points of contact such as butchers, vegetables seller, auto man, rickshaw man and so on. Usually, we

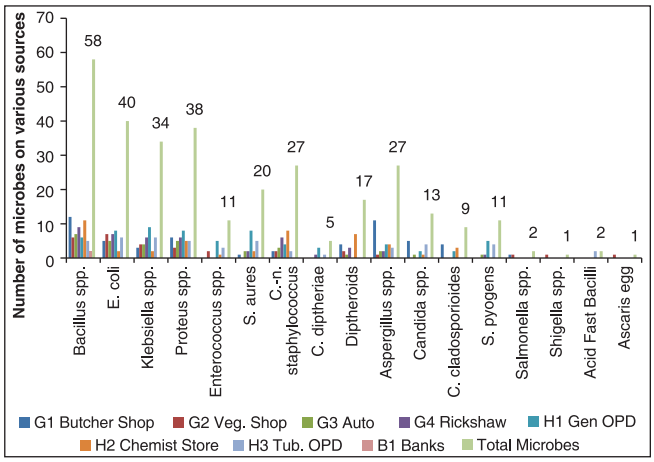

Figure 2: Differential microbes on various sources

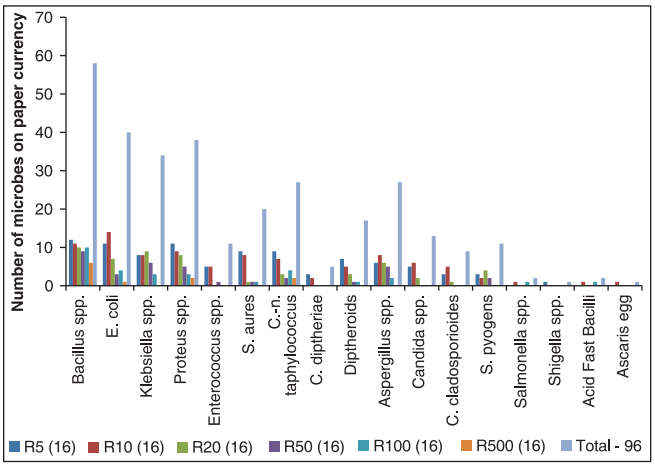

Figure 3: Different bacterial species on various paper currencies

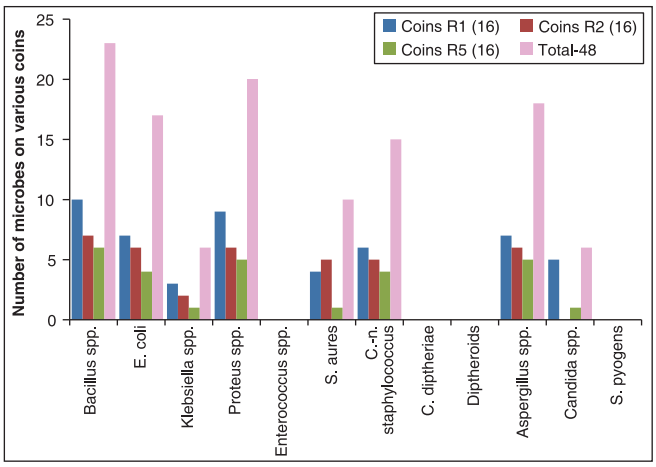

Figure 4: Different bacterial species on coin currency

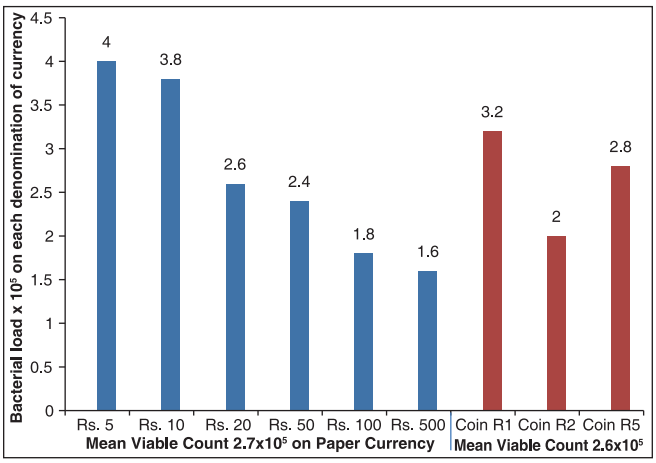

Figure 5: Total bacterial load on currency

do not give much attention to hygienic practices during currency transactions. Chemist store, which can be considered a commercial front of healthcare industry has more to contribute to the trend. General OPD and TB hospital OPD also contribute in initiation of the positive trends. This showed that patient, attendants, and chemist generally are in contact of infective environment which is major concern in respect of health.

In all isolates, *Bacillus* was the highest one. In fact, no other bacterial contamination was observed on paper currency sampled from the banks than *Bacillus* species. This indicates the penetration of the organism in the environment. *Bacillus* species, a vast group of hardy spore forming species that live in soil and are found in the environment could also be transferred on money due to in placement on dirty surfaces or handling with dirty hands. As per previous researches, *Bacillus* so contaminated, produces an emetic exotoxin capable of inducing disease in man.[14]

The isolates viz., *E. coli*, *Proteus* species, *K. pneumoniae*, *Salmonella* species, *Shigella* species and *Enterococcus* species are Enteropathogens. Presence of these isolates on Indian currency is an indication of fecal contamination. This reveals the poor sanitary condition of the environment as well as poor personal hygiene practices observed.[15] *K. pneumoniae* is a virulent organism that may cause both community and hospital acquired infections.[16] The *S. aureus* is a potential pathogen present on hands, normal skin, nasal cavities and suppurative lesions of man.[17] This organism can survive outside a living host for prolonged periods. 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.[17] A number of studies show that fungal contamination of money is also common. Present study showed fungal elements including *Aspergillus* species. Though it is less likely to cause human disease, when many spores are inhaled, it can cause aspergillosis.[18] Candida can cause serious endocarditis[19] and *C. cladosporioides*. We also found *Corynebacterium species*, *S. pyogenes* and *Diphtheroids*.[20-22] Our study also reported acid fast *Bacilli* and *Ascaris* egg that is reported in other studies.[23,24]

LIMITATION AND CONCLUSION

This study had several limitations due to its sample size and geographical boundaries. It was inadequately powered to quantify the cell numbers of the bacterial agents. It did not record the presence

of another category of potential pathogens such as viruses that might contaminate currency. This study has determined the nature, type and presence of microbial contamination but not sensitivity pattern on currency. Public awareness of handling paper currency in the right way became essential for the safety of human health. Currency sterilization needs at every level to prevent transmission of infection by ultraviolet radiation and hygienic handling of currency.

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