



Original Research Article

<https://doi.org/10.20546/ijcmas.2020.904.284>

Currency as a Large Scale Fomite for Transmitting Pathogenic Bacteria in Community and Utility of UV Light to Disinfect Currency

C. S. VinodKumar^{1*}, Prajwal Shanker², K. G. Basavarajappa¹ and Suneeta Kalasuramath³

¹Department of Microbiology, S. S. Institute of Medical Sciences & Research Centre,
NH-4, Bypass Road, Davangere, Karnataka, India

² Intern, S. S. Institute of Medical Sciences & Research Centre,
NH-4, Bypass Road, Davangere, Karnataka, India

³Department of Physiology, S. S. Institute of Medical Sciences & Research Centre,
NH-4, Bypass Road, Davangere, Karnataka, India

*Corresponding author

A B S T R A C T

Keywords

Currency notes,
Antibiotic
resistance, MRSA,
UV light,
Disinfection, fomite

Article Info

Accepted:
18 March 2020
Available Online:
10 April 2020

The role of currency as reservoirs of pathogenic bacteria and UV light to disinfect the contaminated notes was evaluated. Two hundred currencies of different denomination were collected from different places from central part of Karnataka. The sterile swab was rolled over the currency and dipped in a falcon tube containing 10 ml of brain heart infusion broth. After 24 hours, subculture was done on Blood agar, Mac Conkey agar plates and SDA tube. After incubation for 24-48 hours, plates were examined for the growth and microorganisms were identified by standard microbiological techniques. Anti-microbial susceptibility test was done as per CSLI guidelines. To disinfect currency, the notes were exposed to UV light inside the laminar air flow for different time intervals and the currencies were subjected for culture to evaluate the efficacy of disinfectant. Three hundred and seventeen organisms were isolated from the currencies. Mixed contamination was observed in a higher percentage 60% (120/200) of tested notes. *Bacillus* species was the predominant bacteria grown followed by diphtheroids, CoNS, *Staphylococcus aureus*. Among the fungus yeast, *Rhizopus* spp and *Aspergillus* spp was isolated. Bacteria isolated were resistant for more than 2 class of antibiotics and hence all the isolates were multidrug resistant. Ten out of 26 *Staphylococcus aureus* were methicillin resistant and all the MRSA strains were sensitive to Clindamycin, Linezolid and Vancomycin. UV light was very effective in disinfecting all the currency notes at 30 mins of exposure. The transmission of pathogenic drug resistant bacteria through currency notes is well documented. Our study highlights the need for the public awareness regarding hygiene to be followed after any form of transaction and also banks to explore the various possibilities to disinfect the currencies.

Introduction

Microorganisms are ubiquitous in nature and could be source of infection if proper disinfection policies are not followed properly. The increasing number of

infections^{1,2} may be a result of the two way transmission of microorganism from the community to the hospital setting and vice versa^{3,4}. This may be due to the increasing asymptomatic carriage of pathogenic organisms in humans^{1,2} along with the

occurrence of community-associated infection. The money in the form of currency and coins is extensively traded for goods and services in countries all over the world⁵. Perhaps it is the most widely handled commodity throughout the world being exchanged by several hands each day^{5,6}. Money goes through clean and dirty hands and can get contaminated with microorganism which may be non-pathogen or pathogens thus the likelihood of currency being a fomite in transmitting the diseases⁵⁻⁷. Paper currency offers a large surface area as a propagation medium for microorganism.

The soiled currency could be transferred from the cashiers to the public^{9,10}. The habit of wetting of fingers with saliva or the use of water to lubricate fingers during money counting can lead to the transfer of bacteria, viruses, ova / cyst of parasite to currency and then in to the community through vendor is very well documented⁵⁻¹¹. There is no literature to illustrate how to disinfect the contaminated currency. Hence the study is designed to study the level of contamination of paper currency notes and explore the possibility of using UV light to disinfect the soiled currency.

Materials and Methods

Ethics statement

The study and the consent procedure were approved by the Institutional Ethics Review Board of S. S. Institute of Medical Sciences and Research Centre, Davangere, Karnataka.

Bacterial isolation

200 currencies of different denomination were collected from different places from central part of Karnataka. The sterile swab was rolled over the currency and dipped in a falcon tube containing 10 ml of brain heart infusion broth.

After 24 hours, subculture was done on Blood agar and Mac Conkey agar plates^{5,6}. After incubation for 24-48 hours, plates were examined for the growth and microorganisms were identified by standard microbiological techniques⁹⁻¹¹. The yeast was isolated and identified by sub culturing on Sabroaud dextrose media after 24-48 hours and moulds were identified after incubating for 5 days^{10,11}.

Anti-microbial susceptibility testing

Antimicrobial susceptibility test was performed by disc diffusion method¹² as per Clinical Laboratory Standards Institute (CLSI)¹³. Antimicrobial susceptibility testing was done only for bacteria, specifically for CoNS, *Staphylococcus aureus*, *Pneumococci*, *Eoli*, and *Pseudomonas aeruginosa*.

Detection of methicillin resistance *Staphylococcus aureus* was performed according to the Kirby-Bauer method¹², as described in the guidelines of the CLSI with a 1µg oxacillin and Mueller-Hinton agar (Hi-Media, India)¹¹. The CLSI recommends the direct colony suspension method for testing *Staphylococci* for potential methicillin or oxacillin resistance.

The plates were incubated in ambient air at 35°C, and inhibition zones around the disk were measured after 24h. In addition, all isolates were screened by the disk diffusion method for resistance to 30µg cefoxitin according to CLSI guidelines to ensure that they were methicillin resistant^{13,14}.

Furthermore, to evaluate the susceptibility pattern of methicillin resistant *Staphylococci*, we tested different antimicrobial agents; gentamicin (10µg), carbenicillin (100µg), ciprofloxacin (5µg), clindamycin, linezolid, vancomycin (30µg) and amikacin (30µ). *Enterococcus faecalis* ATCC 29212 and *S. aureus* ATCC 25923 were used as controls.

Disinfection of currency

To disinfect currency, the currencies were exposed to UV light (180-280 nm)¹⁵ for different time interval inside the laminar air flow. The currencies were exposed for 10 minutes, 20 minutes and 30 mins respectively. After exposure the currencies were subjected for microbiological culture to evaluate the effect of disinfectant at different time intervals.

Results and Discussion

Total of two hundred currencies were collected from different part of central Karnataka and examined for microbial contamination and all samples were found to be contaminated with different species of bacteria, yeast and moulds. Out of 200 collected notes, 96 (48%) were dirty, 62 (31%) were clean, and 42 (21%) were very dirty based on physical observation.

But there was a no significant relationship between the number of isolates and the physical appearance of banknotes. Two or more than two microorganisms was observed with high percentages in dirty, clean, very dirty, banknotes by 68%, 24%, and 8% respectively.

Three hundred and seventeen organisms were recovered from the samples. Mixed contamination was observed in a higher percentage 60% (120/200) of tested notes.

Bacillus species (30.9%) was the predominant bacteria grown followed by diphtheroids (27.4%), CoNS (21.5%), *Staphylococcus aureus* (8.2%), *Pseudomonas aeruginosa* (3.8%), and *E. coli* (1.9%) Pneumococci (0.6%) and among mould *Rhizopus* spp was isolated in (1.6%) and *Aspergillus* spp was isolated in (0.9%) yeast was isolated in 3.2% (Table 1).

Antimicrobial susceptibility testing

Among Gram positive cocci, all the Coagulase negative staphylococci were sensitive to Clindamycin, Linezolid, Vancomycin, Amikacin, Netilmycin and none of them were resistant to methicillin. Pneumococcus was sensitive to all the antibiotics tested.

Out of 26 *Staphylococcus aureus* isolated 22 isolates were resistant to more than two classes of antibiotics, hence multidrug resistant *Staphylococcus aureus*. Out of 22 MDR isolates, 10 were resistant to oxacillin and cefoxitin.

All the MRSA strains were resistant to penicillin, chloramphenicol, carbenicillin and gentamicin. 70% were resistant to amixacin, 80% were resistant to netilmycin and none of the isolates were resistant to Clindamycin, Linezolid and Vancomycin.

Among Gram negative bacilli, all the *Pseudomonas aeruginosa* isolates were resistant to more than 2 antibiotics, hence multidrug resistant isolates. 66.7% *Pseudomonas aeruginosa* were sensitive to Imipenem, Meropenem and Ertapenem.

Among 6 *E. coli*, 2 isolates were resistant to more than 2 groups of antibiotics. Other 4 *E. coli* were sensitive to Norfloxacin, Amikacin, Levofloxacin, Nitrofurantion, Ceftriaxone, Imipenem and Meropenem

Effect of UV on culture positivity of contaminated currency notes at different intervals

Of 200 currencies cultured, all the samples showed growth. After 10 mins of exposure to UV light, 142 currency notes did not show growth for bacteria or fungi, 58 currencies showed growth for mixed bacteria and

fungus. *Bacillus* and *Diphtheroids* were the predominant organisms isolated (Table 2). After 20 mins of exposure to UV light, 6 currency notes showed growth. No mixed aetiology was observed in this 6 currency notes. 4 *bacillus* species, one *Rhizopus* and one *Aspergillus* were grown (Table 2). After 30 mins of exposure to UV light, none of the currency notes showed growth of bacteria or fungus.

Money has mass circulation among the general public and has potentiality to transmit disease causing microorganisms so that paper currency is commonly contaminated with bacteria and this may play a role in the transmission of potentially harmful microorganisms. These currency notes may serve as a carrier of microbes, thus leading to the transmission of infectious diseases and the outbreak of serious infection^{5,10}. There is an indication that money contamination is associated to unhygienic practice of people and is suggestive of significant fecal contamination of currency, and is a reflection of poor local environmental sanitation⁶⁻⁸.

In our study we found all the currency collected revealed growth for microbes and 60% of the notes showed growth for multiple microbes. In our study we observed *Bacillus* species as the commonest contaminant of the circulating currency and *Bacillus* species is commonly found in the soil. So it is common practice to keep notes in contact with surfaces such as the ground, soil, table surfaces may have contaminated the notes. The next most common bacteria isolated were *Diphtheroids* and *CoNS* which are normally found as the colonizer of the skin. Currency coming in contact with the skin and the sweat and also the saliva used while counting the money might have contributed for colonization of *Diphtheroids* and *CoNS* on the currency. Presence of *Pseudomonas* which is also seen in the soil or seen in the hospital might have colonized during hospital visit or coming in

contact with the soil. Presence of *E. coli* suggests unhygienic practices since *E. coli* is the fecal flora. This is in corroboration with other similar studies⁷⁻¹⁰.

Presence of *Staphylococcus aureus* which is a versatile and precarious human pathogen armed with various virulence factors and is the foremost cause of important infections in hospital settings and community^{2,3} is alarming. *S. aureus* is responsible for infections ranging from folliculitis, food poisoning, osteomyelitis, endocarditis, septic arthritis, pneumonia, and skin and deep tissue infections to life-threatening invasive diseases².

Twenty six *Staphylococcus aureus* were isolated from currency and 22 of them were multidrug resistant isolates and 10 of them were resistant to methicillin suggesting these isolates are methicillin resistant *Staphylococcus aureus*.

MRSA is a major cause of morbidity and mortality both in healthcare settings and in healthy individuals in the last two decades^{2,3}. The global emergence and spread of MRSA harbouring multi-resistance genes limits the effectiveness of therapeutic options for staphylococcal infections and worsens their clinical outcomes¹. The difference between hospital-associated MRSA (HA-MRSA) and community-associated MRSA (CA-MRSA) is becoming hazy as transmission of *S. aureus* from the community to hospitals and vice versa easily occurs¹⁶.

All the MRSA strains were resistant to penicillin, chloramphenicol, carbenicillin and gentamicin. 70% were resistant to amixacin, 80% were resistant to netilmycin and none of the isolates were resistant to Clindamycin, Linezolid and Vancomycin. Studies have identified MRSA contamination in public facilities, probably because of the higher prevalence of CA-MRSA in the developed

countries^{17,18}. Kaseem *et al.*, identified MRSA on two (8%) of 24 keyboards in open access student computer rooms¹⁸. These studies suggest widespread contamination with CA-MRSA. Furthermore, contaminated fomites have been implicated in community outbreaks of CA-MRSA, and a recent review proposes CA-MRSA infection pathogenesis relies much more on acquisition from environmental sources and less on nasal colonization^{17,18}.

If this is the case, we can expect to see more environmental contamination with CA-MRSA as prevalence increases, particularly in community settings prone to outbreaks such as gymnasium, facilities used by sports teams and public transport. In the present study we could not classify the MRSA isolates as community-associated MRSA clones (SCCmec type IV) or health care-associated MRSA clones (SCCmec type II). One more study from central Karnataka on public transport as a fomite found 45% of *Staphylococcus aureus* were methicillin resistant¹⁸. In a systematic review, Kramer *et al.*, (2006) reported that many bacterial,

fungal, and viral pathogens could survive on the inanimate objects for several months²⁰, and such pathogens could cause epidemic infections as a result of direct or indirect transmission in “hand-object susceptible patient” cycle. Specifically, high rates of microbial accumulation were found on the mobile phones and computers’ keypads which had similar features with ATMs according to their physical and operational aspects. Tekerekoglu *et al.*, (2011) reported that cell phones of patients, visitors and health care workers carried multidrug-resistant hospital pathogens including *Acinetobacter spp.*, *S. aureus*, and extended-spectrum β-lactamase ESBL-positive Enterobacteriaceae²¹. Similarly, Dogan *et al.*, (2008) found many types of pathogens on the computers’ mouse and key-pads which were used in hospitals and in education institutes¹⁶. These studies suggested frequent disinfection of mobile phones, keypads and mouse to reduce bacterial reservoir on these devices. But there are no clear directions how to disinfect the currencies. It is not possible to disinfect the currency by using liquid disinfectant since the currencies we use are made up of paper.

Table.1 Bacteria isolated from swab collected from different sites of the bus

Organisms	Numbers	Percentage
<i>Bacillus species</i>	98	30.9
<i>Diphtheroids</i>	87	27.4
<i>Coagulase negative staphylococcus</i>	68	21.5
<i>Staphylococcus aureus</i>	26	8.2
<i>Pseudomonas species</i>	12	3.8
<i>E. coli</i>	6	1.9
<i>Yeast</i>	10	3.2
<i>Rhizopus</i>	5	1.6
<i>Aspergillus</i>	3	0.9
<i>Pneumococci</i>	2	0.6
Total	317	

Table.2 Efficacy of UV light in disinfecting contaminated currency notes

Organisms	0 mins	Exposure to UV light for different intervals		
		10 mins	20 mins	30 mins
Bacillus species	98 (30.9)	62	4	0
Diphtheroids	87 (27.4)	24	0	0
Coagulase negative	68 (21.5)	12	0	0
Staphylococcus				
<i>Staphylococcus aureus</i>	26 (8.2)	8	0	0
Pseudomonas species	12 (3.8)	4	0	0
<i>E. coli</i>	6 (1.9)	1	0	0
Yeast	10 (3.2)	8	0	0
<i>Rhizopus</i>	5 (1.6)	4	1	0
<i>Aspergillus</i>	3 (0.9)	3	1	0
Pneumococci	2 (0.6)	0	0	0
Total	317	126	6	0

Hence an attempt was made to disinfect the currency by using UV light in our laboratory. We exposed the notes for the UV light of wave length 180-280 nm for different intervals. When the notes were exposed for 10 mins 60.3% of reduction of microbial load was observed and on exposure to 20 mins 98.1% of reduction was observed and when the currency notes were exposed to 30 mins, no microbes were isolated on culture suggesting the circulating currency notes were completely disinfected.

It is not possible for the public's to disinfect the currency at their home, at least they can wash their hands regularly with soap and water or sanitize their hand with the alcohol based sanitizers. But in bank every day the currency notes and or coins could be disinfected by exposing them to UV light before lending money to the bank customers.

The transmission of pathogenic drug resistant bacteria through currency notes is well documented by various studies. Our study highlights the need for the public awareness regarding hygiene to be followed after each transaction and also banks to explore the

various possibilities to disinfect the currencies.

Acknowledgments

Authors are grateful to the public in participating in the study, S. S. Institute of Medical Sciences and Research Centre for the facilities.

References

1. Hidron AI, Kourbatova EV, Halvosa JS, Terrell BJ, McDougal LK, Tenover FC *et al.*, Risk factors for colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) in patients admitted to an urban hospital: emergence of community-associated MRSA nasal carriage. Clin Infect Dis 2005;41: 159–166.
2. Creech II CB, Kernodle DS, Alsentrer A, Wilson C, Edwards KM. Increasing rates of nasal carriage of methicillin-resistant *Staphylococcus aureus* in healthy children. Pediatr Infect Dis J 2005; 24: 617–621.
3. Eguiua JM, Chambers HF. Community-acquired methicillin-resistant *Staphylococcus aureus*: epidemiology and potential virulence factors. Curr Infect Dis Rep 2003; 5: 459–466

4. Lescure FX, Locher G, Eveillard M, Biendo M, Van Agt S, Le Loup G *et al.*, Community-acquired infection with healthcare-associated methicillin-resistant *Staphylococcus aureus*: the role of home nursing care. *Infect Control HospEpidemiol* 2006;27: 1213–1218
5. Jalgaonkar S V. Currecnry as fomites? Indian journal of Community Medicine 2007; 32: 157-8
6. Barolia SK, Verma S, Verma BK. Coliform contamination on different paper currency in Ajmer, Rajasthan, India. *Univers J Environ Res Technol.* 2011; 1(4): 552-556.
7. Hosen JM, Sarif DI, Rahman MM, Azad MA. Contamination of Coliforms in Different Paper Currency Notes of Bangladesh. *Pak J Bio Sci.* 2006;9:868-70.
8. Adegoke R, Anthony A, Anthony I. The in vitro effect of vancomycin on multidrug resistant *Staphylococcus aureus* from hospital currency notes. *African Journal of Microbiology Research.* 2011; 5(14):1881-7.
9. Badvi JA, Jawed K, Jawed M. Lower Denomination and Dirty Currency Carries More Contaminated than Higher Denomination in Pakistan. *Int J Vaccin.* 2017; 4(3): 1-8.
10. Neel R. Isolation of pathogenic microorganisms from contaminated paper currency notes in circulation from different market places in Korogwe and Mombo towns in Tanzania. *J Microb Biotechnol Res.* 2017; 2(3): 470-474.
11. Sadawarte K, Mahobe H, Saxena G. Microbial contamination of Indian currency notes in Bhopal. *J Evol Med Dent Sci.* 2014; 3(6): 1379-1385. doi: 10.14260/jemds/2014/1995.
12. Bauer A W, Kirby W M M, Sherris JC, Jurek M. 1966. Antibiotic susceptibility testing by a standardized disc method. *American Journal Clinical Pathology* 45: 493-496.
13. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing; CLSI document M100-S25: CLSI, 2019.
14. Chambers HF. Methicillin resistance in staphylococci: molecular and biochemical basis and clinical implications. *Clin. Microbiol. Rev.* 1997; 10: 781–791.
15. Ultraviolet radiation, Gary Zeman, Health physics society, MacLean, VA. August 2011.
16. Dogan M, Feyzioglu B, Ozdemir M, Baysal B. Investigation of microbial colonization of computer keyboards used inside and outside hospital environments. *Mikrobiyol. Bul.* 2008; 42(2): 331-336.
17. Otter, J.A., Havill, N.L., Boyce, J.M. and French, G.L. Comparison of community-associated methicillin-resistant *Staphylococcus aureus* from teaching hospitals in London and the USA, 2004–2006: where is USA300 in the UK? *Eur J ClinMicrobiol Infect Dis* 2009; 28, 835–839.
18. Kassem, I.I. (2009) Concerning public transport as a reservoir of methicillin-resistant staphylococci. *LettApplMicrobiol* 2009;48:268-69
19. VinodKumar CS, Prasad S, Patil S, Reddy AV, Jha A, Raghu Kumar KG, *et al.*, Public transport: a large scale fomite of methicillin-resistant *Staphylococcus aureus*. *Int J Res Med Sci* 2018;6:172-6.
20. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. *BMC Infectious Diseases.* 2006; 6: 130.
21. Tekerekoglu MS, Duman Y, Serindag A, Cuglan SS, Kaysadu H, Tunc E, Yakupogullari Y. Do mobile phones of patients, companions and visitors carry multidrug-resistant hospital pathogens? *Am. J. Infect. Control* 2011; 39(5): 379-381.

How to cite this article:

Vinod Kumar. C. S., Prajwal Shanker, K. G. Basavarajappa and Suneeta Kalasuramath. 2020. Currency as a Large Scale Fomite for Transmitting Pathogenic Bacteria in Community and Utility of UV Light to Disinfect Currency. *Int.J.Curr.Microbiol.App.Sci.* 9(04): 2367-2373.
doi: <https://doi.org/10.20546/ijcmas.2020.904.284>