

Microbiological analysis of banknotes circulating in the Venda region of Limpopo province, South Africa

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WE EXAMINED USED AND NEW BANKNOTES in various denominations, circulating in the Limpopo province of South Africa, for the presence of microorganisms using the rinse method. Used banknotes were collected from open-air markets, banks, filling-stations, supermarkets, residential homes and hostels. Bacteria and/or fungi were isolated from 96% of the used banknotes, and none from the new (control) notes. Twelve bacterial and one fungal species were isolated, with *Staphylococcus epidermidis* (13%), *Candida albicans* (13%), *Klebsiella* species (11%) and *Staphylococcus aureus* (11%) being the most prevalent. The low-denomination notes (R10 and R20) were the most contaminated. Infected currency is identified as a potential public health hazard, as pathogens can be spread by circulating banknotes. Immunocompromised persons stand the risk of acquiring opportunistic infections, such as *C. albicans*, through handling of contaminated currency.

Introduction

Money in the form of notes or coins is handled by everyone, and 'dirty' money (money contaminated with pathogenic microorganisms) is always in circulation.^{1,2} Contamination may occur during production, during storage after production, and during use.³ Microorganisms on the skin can be transferred from cashiers, salespeople and the general public to the

currency notes that they handle. Contamination from the anal region, wounds, nasal secretions and aerosols generated by sneezing and coughing are potential sources of transfer of microorganisms to currency notes during handling. *Staphylococcus epidermidis*, *Pseudomonas aeruginosa* and *Klebsiella aerogenes* have been reported to survive well on the skin, and are known to be transferred from fabrics to hand as well as from hand to fabrics.⁴

Currency contamination is of importance to public health as it can provide a vehicle for easy transmission of pathogens between handlers. Bosch and Steyn⁵ showed that 90% of South African banknotes in circulation in 1997 were contaminated with either bacteria or fungi. Potential pathogens constituted 30% of the organisms isolated and these included *Escherichia coli*, *Proteus* species, *Staphylococcus aureus*, *Streptococcus* spp. and *Klebsiella* species. The corresponding figure reported for Nigerian banknotes is 83%,⁶ and in Zimbabwe¹ all used circulating currency notes examined were contaminated by various species of microorganisms.

The objective of this study was to identify microbial contaminants of South African banknotes in circulation in the Venda region of Limpopo province, and to highlight the implications for public health in this locality.

Materials and methods

See appendix.

Results

Two hundred and forty (96%) of the sample banknotes analysed were contaminated by bacteria or fungi. Eighty-four to one hundred per cent of all the banknotes obtained from the various sources were contaminated with bacteria. Twelve different bacterial species were isolated, with the most common isolates being *Staphylococcus epidermidis* (13%), *Klebsiella* species (11%), *Staphylococcus aureus* (11%) and *Escherichia coli* (9.2%). Only one fungus, *Candida albicans* (13%), was isolated. Enteropathogens comprised *E. coli* (9.2%), *Enterobacter* (5.8%), *Salmonella* species (2.5%) and *Shigella* (1.7%) (Table 1). Most of the banknotes had more than one microbial contaminant (data not shown).

Discussion and conclusion

Ninety-six per cent of the sample banknotes were found to be contaminated. Since no microorganisms were isolated from new banknotes used as controls, the source of contamination of the circulating notes must be from usage and handling. Although microbial contamination of new banknotes has been reported,¹ this was not observed in the present study, and moreover fewer number of microorganisms was observed in the present study than was earlier recorded.^{1,2,5,6} The reason for this may possibly be due to differences in hygienic practices and handling of banknotes in the different study areas. Currency notes of lower denominations (R10, R20) were the most contaminated and this is consistent with a previous report.¹ This is expected, as lower denomination notes pass through more hands than the higher denominations. The isolation of *Shigella* and *Salmonella* in the present study indicates faecal

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Table 1. Relative occurrence of microorganisms on banknotes in circulation in Limpopo province, South Africa.

Microorganisms	Currency denominations and frequency of isolation of microorganisms								Total (%)
	R10		R20		R50		R100		
	Used	New	Used	New	Used	New	Used	New	
<i>Bacillus</i> spp.	4	–	3	–	2	–	–	–	9 (3.8)
<i>Candida albicans</i>	8	–	9	–	6	–	6	–	29 (13)
<i>Citrobacter</i> spp.	7	–	5	–	5	–	3	–	20 (8.3)
<i>Enterobacter</i> spp.	4	–	7	–	3	–	–	–	14 (5.8)
<i>Escherichia coli</i>	14	–	6	–	2	–	–	–	22 (9.2)
<i>Klebsiella</i> spp.	8	–	7	–	9	–	3	–	27 (11.3)
<i>Proteus</i> spp.	8	–	7	–	4	–	–	–	19 (7.9)
<i>Pseudomonas aeruginosa</i>	4	–	7	–	6	–	–	–	17 (7.1)
<i>Salmonella</i> spp.	2	–	4	–	–	–	–	–	6 (2.5)
<i>Shigella</i> spp.	3	–	1	–	–	–	–	–	4 (1.7)
<i>Staphylococcus aureus</i>	11	–	13	–	2	–	–	–	26 (11)
<i>Staphylococcus epidermidis</i>	12	–	9	–	6	–	5	–	32 (13)
<i>Streptococcus pyogenes</i>	8	–	5	–	3	–	–	–	16 (6.7)
Total	92 (36%)	–	83 (35%)	–	48 (20%)	–	17 (6.7%)	–	240 (96%)

contamination. Common unhygienic practices in the open-air markets in rural areas, where traders and buyers eat market products after handling contaminated currency notes, may place the individuals at risk of ingesting enteropathogens. The frequency of occurrence of *Candida albicans* was the second highest in the present study (13%). *Candida albicans*, though a normal flora in humans, is a common opportunistic infection in HIV/AIDS, causing extensive oral candidiasis.^{11–13} The presence of this organism on banknotes in a region with a relatively high HIV prevalence (approximately 16%)¹⁴ may pose a challenge to the prevention of candidiasis in HIV-positive individuals. Contamination of banknotes by *Pseudomonas aeruginosa* has been consistently reported,^{1,2,4} and in the present study it was detected with a frequency of 7.9%. *Pseudomonas aeruginosa* is a successful survivor on hands⁴ and this may account for its ubiquitous presence on circulating currency notes, and by extension, its implication as a cause of opportunistic infections.¹⁵

This study has shown that South African banknotes in circulation in the Vhembe region of Limpopo province are contaminated with potential pathogens and that users and handlers of banknotes are the sources of contamination. We therefore advocate a greater sensitivity in the handling of money, either as banknotes or coins. Hygienic measures such as a thorough hand-washing with soap after shopping should be observed. The practice of keeping money in brassieres, handkerchiefs and in shoes should be discouraged. Public education on proper handling and care of currency is advocated, in order to reduce currency contamination.

1. Tswana S.A., Chihota V.N., Moyo S.R., Chigonde S.C. and Nzara M.J. (2000). Contamination of Zimbabwean banknotes by microorganisms – a pilot study. *S. Afr. J. Epidemiol. Infect.* **15**(1), 14–18.
2. Abrams B.L. and Waterman N.G. (1972). Dirty money. *Am. Med. Assoc.* **219**(9), 1202–1203.
3. Hugo W.B., Denyer S.P., Norman A.H., Gorman S.P. and Russel A.D. (1983). In *Pharmaceutical Microbiology*, pp. 124–146. Blackwell Scientific Publications, Oxford.
4. Mackintosh C.A. and Hoffman P.M. (1984). An extended model for transfer of microorganisms via hands: difference between organisms and the effect of alcohol disinfection. *J. Hyg.* **92**, 315.
5. Bosch A.M.T. and Steyn P.L. (1997). Microorganisms of South African banknotes. *S. Afr. J. Food. Sci. Nutr.* **9**(1), 24–26.
6. Ugobor O.F. (1998). Prevalence of microorganisms in Nigerian currencies. *J. Natl Appl. Sci.* **4**, 18–22.
7. Hambreaus A. (1973). Transfer of *Staphylococcus aureus* via nurse's uniform. *J. Hyg.* **6**(71), 799.
8. Farero S.M., Dade M.C. and Robertson J.J. (1968). Microbiological sampling of surfaces. *J. Appl. Bacteriol.* **31**, 36.
9. Anjellottie R. and Foster M.J. (1958). A comparative evaluation of methods of determining the microbial contamination of surfaces. *Food Res.* **23**, 175.
10. Koneman E.M., Allen S.D., Janda W.M., Schreebenberger P.C. and Winn W.C. (1997). *Colour Atlas and Text book of Diagnostic Microbiology*, 5th edn, pp. 265–268. Lippincott, Philadelphia.
11. Gugnanai H.C., Becker K., Fegeler W., Basu S., Chattopadhyaya D., Baveja L., Satyanarayana S., Kalghatgi T. and Murlidhar A. (2003). Oropharyngeal carriage of *Candida* species in HIV-infected patients in India. *Mycoses* **46**(8), 299–306.
12. Bliognat E., Messer S., Hollis R.J. and Pfaller M.A. (2002). Antifungal susceptibility of South African oral yeast isolates from HIV/AIDS patients and healthy individuals. *Diagn. Microbiol. Infect. Dis.* **44**(2), 169–174.
13. Kamiru H.N. and Naidoo S. (2000). Oral HIV lesions and oral health behaviour of HIV-positive patients attending the Queen Elizabeth II hospital, Maseru, Lesotho. *S. Afr. Dent. J.* **57**, 479–482.
14. Department of Health (2003). *National HIV and syphilis antenatal sero-prevalence survey in South Africa: 2002*, pp. 6–7. Pretoria.
15. Igumbor E.O., Gwanzura L., Chihirara M., Obi C.L. and Muza D. (2000). Antibiotic susceptibility and plasmid profiles of *Pseudomonas aeruginosa*. *Centr. Afr. J. Med.* **46**(11), 296–299.

Appendix

Collection of bank notes

Used banknotes were obtained from banks, supermarkets, traders and buyers in open-air markets, residential homes and hostels, and filling-stations in and around Thohoyandou in Limpopo province. Fifty banknotes each of R10, R20, R50, and R100 denominations were collected using the convenience-sampling method. The notes were obtained by exchanging sample notes for new and fresher ones of the same value. One hundred newly minted notes of the same denominations (20 notes for each denomination) were supplied by a commercial bank, to serve as controls. The R200 denomination was excluded because of its rarity.

Two workers effected the collection and the exchange of the notes using sterile gloves. One worker placed the sample notes into sterile polythene moneybags, while the second worker handed out the replacement notes. The different sample currency denominations were placed in separate labelled sterile polythene bags.

Microbiological analysis

Different techniques have been proposed for investigating microorganisms on surfaces.^{7–9} In this study, the Rinse Method was used as described elsewhere.⁷ Each sample banknote was immersed in 10 ml of nutrient broth in a Bijou bottle and shaken for 5–10 min on a shaker-incubator and subsequently incubated at 37°C for 24 h. For bacterial isolation, a loopful of the incubated nutrient broth was then inoculated onto MacConkey and Blood agar plates and incubated for 24 h at 37°C. For fungal isolation, a loopful of incubated nutrient broth was inoculated onto Sabouraud dextrose agar plates and incubated at 37°C for 48–72 h. Bacterial species were identified using standard laboratory procedures.¹⁰ Isolates were further confirmed using the API 20E test strips following the manufacturer's instructions (Biomérieux, France). Identification of fungal isolates was based on growth characteristics and the lacto-phenol cotton blue reaction.