Money and transmission of bacteria

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Abstract

Money is one of the most frequently passed items in the world. The aim of this study was to ascertain the survival status of bacteria including Staphylococcus aureus, Escherichia coli, and Vancomycin-Resistant Enterococci (VRE) on banknotes from different countries and the transmission of bacteria to people who come in contact with the banknotes. The survival rate was highest for the Romanian Leu yielding all three microorganisms used after both three and six hours of drying. Furthermore, the Leu was the only banknote to yield VRE after one day of drying. Other currencies either enabled the survival of Extended-Spectrum Beta-Lactamases (ESBL) and VRE (e.g. Euro), but not of MRSA, or the other way round (e.g. US Dollar). While a variety of factors such as community hygiene levels, people’s behaviour, and antimicrobial resistance rates at community level obviously have influence on the transmission of resistant microorganisms, the type of banknote-paper may be an additional variable to consider.

Introduction

Globally, money is one of the items most frequently passed from hand to hand. During its passing, money can get contaminated and may thus play a role in the transmission of microorganisms to other people. For example, money may get contaminated with microorganisms from the respiratory- and gastro-intestinal tract during counting. Money is not usually suitable for the survival of microorganisms, except for some that are resistant to external conditions and non-resistant forms of spores [1,2]. In addition, the general hygiene levels of a community or society may contribute to the amount of microbes found on coins and notes, and thus the chance of transmission during handling of money. While antimicrobial resistance has steadily been increasing, e.g. with Extended-Spectrum Beta Lactamases (ESBL) producing Escherichia coli and Klebsiella spp [3], contaminated banknotes and coins contribute to the transmission of these multi-drug resistant microorganisms in the community.

While the kind of isolated bacteria between studies can vary, due to the methods used, season, environmental conditions, sort of money (coin or banknote) or local community flora, in general, Gram positive bacteria were the most predominant [4-9].

The aim of this study was to ascertain the survival status of bacteria including Staphylococcus aureus, E. coli, and Vancomycin-Resistant Enterococci (VRE) on banknotes from different countries and the transmission of bacteria to volunteers getting in contact with contaminated banknotes under experimental conditions.

Material and method

This study was conducted in the medical microbiology laboratory of Canisius Wilhelmina Ziekenhuis in 2012. The first step of study was to inoculate a few colonies of methicillin-resistant S.aureus (MRSA) ATCC 43300, Vancomycin-resistant Enterococcus faecium (VRE) ATCC 51559 and an extended spectrum of beta lactamases (ESBL) producing E. coli ATCC 25922 strains into 5 ml Tryptic Soy broth medium in tubes, which then were incubated at 35°C for 24-h. All banknotes were inoculated with 8 dilutions of a serial dilution of the original inoculum, by spreading 100 μl from each tube onto different described areas of the banknotes which were previously sterilized under ultraviolet light radiation. As a control, 100 μl of all dilutions were inoculated onto Columbia agar.

After a 24-h incubation at 35°C, all colony-forming units were counted, and the number of bacteria given onto the banknotes calculated. All experiments were done in duplicate. All banknotes were dried in ambient conditions. Cultures from the banknotes were taken by a moistened swab (0.9% saline) after 3-h, 6-h and 24-h. Swabs were directly inoculated onto Columbia agar and into tubes...
with 1 ml 0.9% saline. 100 μl from each tube were spread onto Columbia agar.

For the second part of the study, methicillin sensitive *S. aureus* (MSSA) ATCC 25923 and non-extended spectrum beta lactamases producing *E. coli* ATCC 35218 strains were inoculated into 5 ml (Tryptic Soy broth), incubated at 35°C for 24-h. A 100 μl inoculum of MSSA was spread onto one side of a US Dollar and Romanian Leu (RON) banknote, that has previously been sterilized by ultraviolet light radiation. In the same way, *E. coli* was spread onto one side of a Euro and a Romanian Leu (RON) banknote. After the banknotes were dried for 30 minutes, three people whose hands were disinfected by alcohol-based hand rub, and washed with sterile 0.9% saline, rubbed the banknotes for 30 seconds, respectively. After rubbing, the fingers were sampled by placing the fingertips directly on the 5% sheep-blood agar plate. Semi-quantitative colony counts were established after a 24-h incubation period for each person.

After the study was completed, all of the banknotes were sterilized by ultraviolet light radiation. The banknotes were not damaged during the study and brought into re-circulation.

### Results

Euro, US Dollar, Canadian Dollar, Croatian Luna, Romanian Leu (RON), Moroccan Dirham, and Indian Rupee banknotes were included into the first part of the study. Cultures of the Romanian Leu yielded all 3 multi-drug resistant pathogens; MRSA, VRE and ESBL-producing *E. coli*. The Canadian and (US) American Dollar only yielded MRSA; the Euro only ESBL-producing *E. coli*, the Indian Rupee only VRE, and the Croatian Luna did not yield any of the 3 microorganisms (Table 1). The Romanian Leu yielded all three microorganisms after both, three and six hours of drying. The Euro yielded ESBL-producing *E. coli* in the 3 and 6-h cultures, VRE in the 3-h culture, but at no time MRSA (Table 2).

The second part of the study, the transmission experiments, was based on the results of the first part. Consequently, the Euro, Romanian Leu and US Dollar was used, after inoculation with *E. coli* (Euro) and MSSA

### Table 1 Survival (semi-quantitative counts) of MRSA, VRE and ESBL-producing *E.coli* on different international banknotes

| Country      | Currency | MRSA     | VRE       | ESBL (+) *E. coli* |
|--------------|----------|----------|-----------|-------------------|
| European     | Euro     | ØØØØØØØØ | ØØØØØØØØ | ØØØØØØØØ         |
| Croatia      | Kuna     | ØØØØØØØØ | ØØØØØØØØ | ØØØØØØØØ         |
| Romania      | Leu (RON)| ØØØØØØØØ | ØØØØØØØØ | ØØØØØØØØ         |
| Morocco      | Dirham   | ØØØØØØØØ | ØØØØØØØØ | ØØØØØØØØ         |
| USA          | Dollar   | ØØØØØØØØ | ØØØØØØØØ | ØØØØØØØØ         |
| Canada       | Canadian | ØØØØØØØØ | ØØØØØØØØ | ØØØØØØØØ         |
| India        | Rupee    | ØØØØØØØØ | ØØØØØØØØ | ØØØØØØØØ         |

+++ = confluent growth, ++ = multiple segments, + = single colonies, Ø = no growth.

### Table 2 Survival (semi-quantitative counts) of MRSA, VRE and ESBL-producing *E.coli* on different international banknotes, over time

| Time (h) | Currency | MRSA | VRE | ESBL (+) *E. coli* |
|----------|----------|------|-----|-------------------|
| 3        | Euro     | Ø    | +   | +                 |
|          | Kuna     | Ø    | Ø   | Ø                 |
|          | Leu (RON)| +++  | +++ | +++               |
|          | Dirham   | Ø    | +   | Ø                 |
|          | Dollar   | +    | Ø   | +                 |
|          | Canadian | +    | Ø   | Ø                 |
|          | Rupee    | Ø    | +   | Ø                 |
| 6        | Euro     | Ø    | Ø   | Ø                 |
|          | Kuna     | Ø    | Ø   | Ø                 |
|          | Leu (RON)| +++  | +++ | +++               |
|          | Dirham   | Ø    | Ø   | Ø                 |
|          | Dollar   | Ø    | +   | Ø                 |
|          | Canadian | +    | +   | Ø                 |
|          | Rupee    | Ø    | Ø   | Ø                 |
| 24       | Euro     | Ø    | Ø   | Ø                 |
|          | Kuna     | Ø    | Ø   | Ø                 |
|          | Leu (RON)| ++   | Ø   | Ø                 |
|          | Dirham   | Ø    | Ø   | Ø                 |
|          | Dollar   | Ø    | Ø   | Ø                 |
|          | Canadian | Ø    | Ø   | Ø                 |
|          | Rupee    | Ø    | Ø   | Ø                 |

+++ = confluent growth, ++ = multiple segments, + = single colonies, Ø = no growth.
Dollar (MSSA) was successful, with the amount of colony 

US Dollar 

S. aureus 

Euro 

Could contribute to the transmission of 

microorganisms within the community. The Croatian 

Croatian studies, that banknotes may play a role in the transmission of multi-drug resistant microorganisms through contact with money, or experiments show that this may be a potential pathway, especially in countries that use polymer-based banknotes.

Discussion

Banknote paper is manufactured from cotton fibre, which gives the paper its strength, durability and distinctive feel [10]. The cotton is sometimes mixed with linen, abaca, or other textile fibres. Unlike most printing and writing paper, banknote paper is infused with polyvinyl alcohol or gelatin to give it extra strength. Polymer (or plastic) banknotes were developed to improve durability and prevent counterfeiting through incorporated security features, such as optically variable devices that are extremely difficult to reproduce [11]. Romania, Israel, Malaysia and some other countries have adopted these polymer-containing banknotes [12]. Probably, the content of banknotes is also a factor that affects the survival of bacteria on the banknotes.

Our experiments showed that the polymer structure of the Romanian Leu banknote allows growth and transmission of multi-drug resistant pathogens. This, in theory, could contribute to the transmission of microorganisms within the Romanian community. Countries using polymer-based banknotes should take this into consideration, especially, if a currency is not exclusively used within one country, such as the Euro and US Dollar. Despite prolonged survival of E. coli on the Euro (up to 6 hours), transmission to the volunteers did not succeed. In contrast, US and Canadian Dollar showed significant and prolonged carriage of MRSA. S. aureus was transmissible from the US Dollar and thus indicates, that banknotes may play a role in the transmission of MRSA within the community. The Croatian Kuna was found to, unexpectedly, not allow growth of any of the multi-drug resistant microorganisms tested. While we could not find further information on the content and make-up of this currency, it could be interesting for other countries who want to eliminate banknotes as a source of bacterial transmission. Gram-

positive and –negative microorganisms, including staphylococci, bacilli, and various enterobacteriaceae, have been found on banknotes in multiple countries, such as in Iran [8] and Turkey [12].

Money is frequently touched during daily life. The observed differences between the various currencies were unexpected and were not based on different climate conditions or hygiene levels, since all experiments were performed at the same conditions, using previously sterilized banknotes. While further studies would be needed to establish transmission of multi-drug resistant microorganisms through contact with money, or experiments show that this may be a potential pathway, especially in countries that use polymer-based banknotes.

Competing interest

The authors declare that they have no competing interests.

Authors’ contribution

HG and AV contributed to the conception and design, HB and TAV to the analysis of the data. All authors (HG, TAV, AV) contributed to drafting the manuscript or revising it and all authors approved the final manuscript all authors.

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Table 3 Transmission of E.coli and/or S. aureus from banknotes to volunteers

| Currency          | Micro-organism | Culture results |
|-------------------|----------------|-----------------|
| Euro              | E. coli        | Ø Ø Ø           |
| US Dollar         | S. aureus      | + + +           |
| Romanian Leu (RON)| E. coli        | ++ ++ ++        |
| S. aureus         | ++ ++ ++       |

+++ multiple segments, + single colonies, Ø no growth.

References

1. Freeman BA: Burrows Textbook of Microbiology. 22nd edition. Philadelphia: WB Saunders Co; 1985.
2. Jawetz E, Melnick JL, Adelberg EA: Review of Microbiology. California: Lange Pub; 1987.
3. Gedik H, Yahiyanlıoğlu M, Yörük G, Fincancı M: Extended-Spectrum Beta-Lactamase production Rates of Klebsiella spp. and Escherichia coli strains isolated from infections and fecal samples of healthy people. Infectious Diseases in Clinical Practice 2010, 18:104–106.
4. Abrams BL, Waterman NG: Dirty money. JAMA 1972, 219(9):1202–1203.
5. Çetin ET, Candan İ: Kullanılan para paralarının bakteriyolojik incelenmesi. İst Tıp Fak Mecm 1975, 38:9–18.
6. Karabiber N: Kullanılan para paralarının bakteriyolojik incelenmesi. Türk Hıd Den Byol Derg 1987, 45(2):269–273.
7. Khin NO, Phyu PW, Aung MH, Aye T: Contamination of currency notes with enteric bacterial pathogens. J Diam Head 1989, 73(3–4):92–94.
8. Rashed T, Ghanaiet J, Ghazvini K, Rashed E: Bacterial contamination of current banknotes and coins. Med J Tab Unb Med Scien 2006, 28(2):67–69.
9. Kuria JKN, Wahome RG, Jobalamin M, Kariuki SM: Profile of bacteria and fungi on money coins. East Afr Med J 2009, 86:151–155.
10. DelaRue: The Banknote Lifecycle – from Design to Destruction. http://www.delarue.com/ProductsSolutions/BanknoteProduction/TheBanknoteLifecycle.
11. Banknote: Wikipedia Free Encyclopedia. http://en.wikipedia.org/wiki/Banknote.
12. Göktaş P, Oktay G: Bacteriological examination of the currency notes. Mikrobiyal Bult 1992, 26344–348.