

## Dirty Croatian Money: How Big is the Threat?

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### Abstract

**Aim:** The objective of this study was to determine the extent of bacterial contamination, expressed as colony forming units (CFU), on individual banknotes and coins of Croatian Kuna (HRK). The purpose of the study was to define if the fear of money-transmitted diseases is founded.

**Methods:** One-hundred twenty pieces of banknotes and coins were collected for the experiment, 10 bills of 10, 20, 50, 100, 200 and 500 HRK and 10 coins of 10, 20 and 50 Croatian Lipa and 1, 2 and 5 HRK. At the Department of Microbiology and Parasitology, Faculty of Medicine, University of Osijek, swabs were taken from money, moistened in saline, planted on blood agar and incubated for 24 hours under ambient conditions at 37 °C. After growing the bacteria, CFU were counted and replanted for further identification, which was performed in accordance with the microbiological professional standards.

**Results:** In total, 739 bacterial CFU were grown and six bacterial species have been identified: *Staphylococcus epidermidis*, *Staphylococcus saprophyticus*, *Streptococcus viridans*, *Bacillus sp.*, *Klebsiella sp.*, *Neisseria sp.* Almost 30% of the money was bacteriologically clean. There were no statistical differences between the prevalence of bacterial contamination of banknotes and coins. The most common bacteria isolated was *S. epidermidis* (86.33%) with statistical significance both on banknotes and coins ( $p < 0.0001$ ).

**Conclusion:** The identified bacterial species are mostly part of the normal human flora. Pathogenic, and potentially pathogenic bacterial species were not found on Croatian banknotes and coins in a respect for one colony of *Klebsiella sp.*

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## Introduction

The conventional wisdom is that the money is dirty and contaminated with microorganisms that cause diseases. Generally, money keeps circulating from person to person, from device to device and probably is the most frequently exchanged article between human beings. The microorganisms present on money are part of the normal human flora or pathogens such as bacteria, viruses and fungi. Microbial contaminants may be transmitted directly, through hand-to-hand contact, or indirectly, via food or other inanimate objects. Cause for special concern is the possibility of transmission of nosocomial pathogens that represent one of the most important global threats of our time, such as the spread of multi-resistant bacteria. For example, methicillin-resistant *Staphylococcus aureus* (MRSA) is one of the most resistant nosocomial pathogens. This pathogen can survive on banknotes and coins (1). Medical staff and patients who do not observe prescribed protection measures (hand washing and disinfection) before and after a direct contact with an infected person are the most common carriers of MRSA. There is no person that did not suffer from diarrhea at least once in their life. Diarrhea is mainly caused by enteric pathogens such as enterotoxigenic *E. coli*, *Vibrio Cholerae*, *Salmonella*. It has been proven in well-designed experimental research that bacteria mentioned above can survive on money surface (1, 2). Although this is an important issue, currently there is limited literature available. In this research, we are trying to answer some important questions regarding the hygienic safety of Croatian money and its role in transmission of infectious diseases and to clarify some urban legends and fears regarding the impurity of money. Indeed, what kind of money is dirty?

## Methods

We collected 120 pieces of banknotes and coins for the experiment, 10 pieces (paper money) of 10, 20, 50, 100, 200 and 500 Croatian Kuna (HRK) and 10 coins of 10, 20 and 50 Croatian Lipa and 1, 2 and 5 HRK. These different denominations of

HRK were circulating between people and were collected during everyday activities: in various shops and a bank. In the laboratory of the Department of Microbiology and Parasitology, Faculty of Medicine, University of Osijek, plain sterile swabs (Copan Italia S.p.A, Brescia, Italy) were taken for complete notes and coins (on both sides). Swabs were moistened in saline, plated on blood agar plate (BD, Sparks, USA) and incubated for 24 hours under ambient conditions at 37 °C. After growing the bacteria, colony forming units (CFU) were counted and replanted to a new solid growth medium for further identification. Identification of genera and species of bacteria was performed in accordance with the microbiological professional standards. Moreover, chromogenic UriSelect agar (BioRad, Redmond, USA), Gram staining and additional enzymatic and biochemical tests have been performed, such as coagulase, catalase, bacitracin test, optochin test, novobiocin test for identifications of Gram-positive bacteria and oxidase, sugar fermentation with acid and gas production (triple sugar iron), test for indole production, H<sub>2</sub>S production, citrate utilization and urease test for identification of Gram-negative bacteria.

## Statistical Analysis

Statistical analysis was performed using the SPSS software (IBM SPSS Statistics ver. 16, IBM Corporation, Chicago, IL) and Microsoft Excel. Proportions were compared by chi-square test and Fisher's exact test. P values <0.05 were considered to be statistically significant.

## Results

In total, 739 bacterial CFU were grown with the mean value of 6.16 colonies in six species of bacteria: *Staphylococcus epidermidis*, *Staphylococcus saprophyticus*, *Streptococcus viridans*, *Bacillus sp.*, *Klebsiella sp.*, *Neisseria sp.* Altogether, 36 samples (30%), 14 coins and 22 banknotes, were without the growth of bacteria, as shown in Figure 1.

On the coins of 1 and 2 HRK, bacteria were detected in 90% of cases (9/10), as opposed to 5

HRK coins, where bacteria were detected in 60% of cases (6/10).

With regard to banknotes, on 500 HRK notes bacteria were detected in 80% of cases (8/10), as opposed to 20 HRK notes, where bacteria were detected in 40% of cases (4/10) (Figure 2).

All the banknotes and coins were taken from everyday life: there were nine banknotes which appeared almost "brand new" with the assumption that a minimum number of people touched them, as well as two coins and three banknotes that appeared extremely dirty. In total, there were 571 colonies on 38 coins, and 168 colonies on 46 banknotes isolated, which shows that some coins or banknotes had multiple colonies isolated. On the 10 Lipa, 2 HRK and 5 HRK coins, *S. epidermidis* and *Bacillus sp.* were isolated. Along with the above listed bacteria, on the coin of 50 Lipa, *Neisseria sp.* was also isolated. *S. epidermidis* and *S. viridans* were found on the 20 Lipa coin. It should be noted that on a single 20 Lipa coin there were 201 colonies isolated, which was the maximum number of colonies found on a single coin. Money with the most bacteria grown was 1 HRK, *S. epidermidis*, *S. viridans*, *Bacillus sp.*, *Neisseria sp.* Among banknotes, the most common bacterial species was *S. epidermidis*, found on notes of 10, 20, 50, 100, 200 and 500 HRK. *Bacillus sp.* was also found on all of the listed notes, except 10 and 20 HRK. On the banknotes of 10 HRK, beside *S. epidermidis*, *Klebsiella sp.*, *S. saprophyticus* were also isolated. There is no statistical significance between the prevalence of bacterial contamination of banknotes and coins. The identified bacterial species are mostly part of the normal human flora. Clinically relevant pathogenic, and potentially pathogenic bacterial species were not found on Croatian banknotes and coins except for one colony of *Klebsiella sp.*

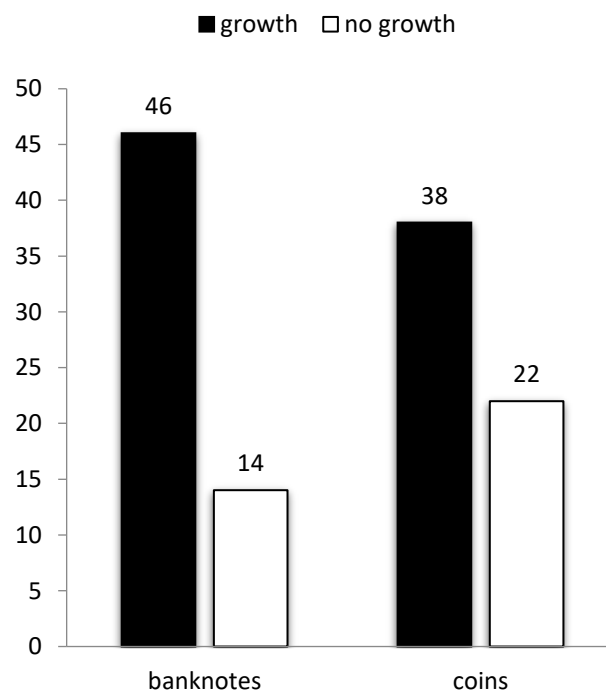
## Discussion

Six species of bacteria were grown in 739 bacterial CFU. Almost 30% of the money was bacteriologically clean. There were no statistical differences between the prevalence of bacterial contamination of banknotes and coins. The most common bacteria isolated was *S. epidermidis*

(86.33%) with statistical significance both on banknotes and coins.

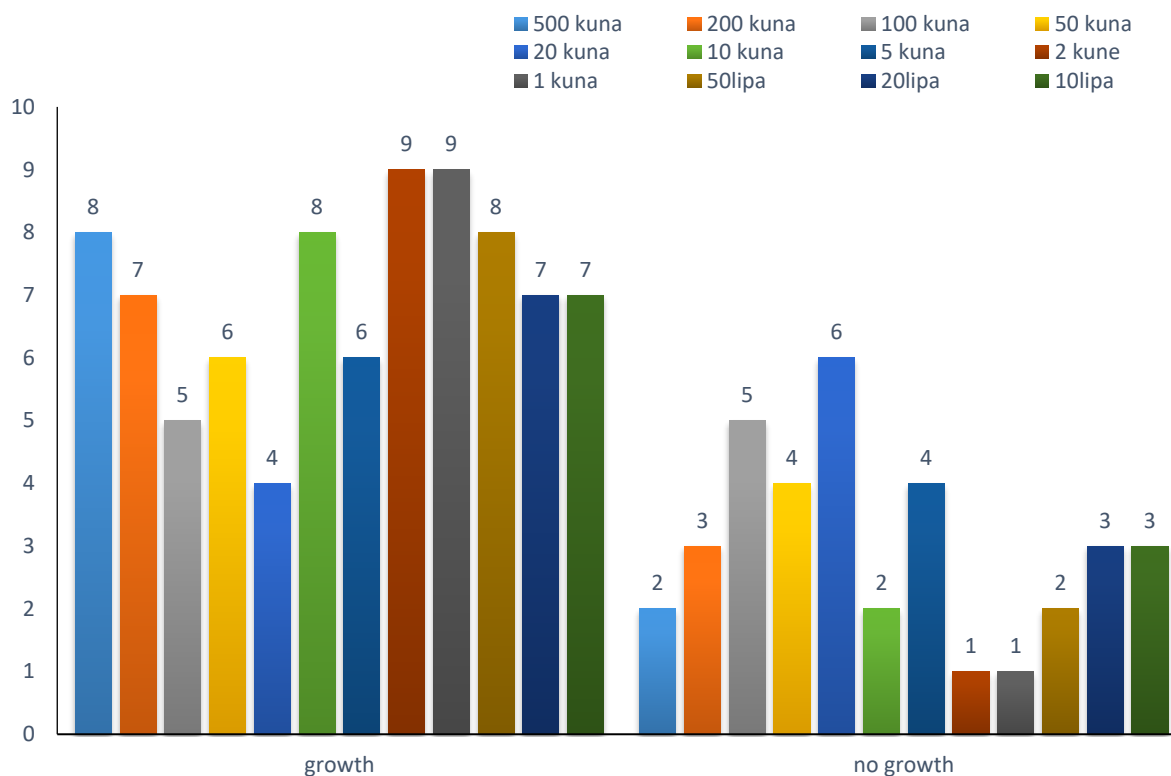
Despite the expectation that money is highly contaminated with bacteria and fungi (3), in this experiment we have shown that 30% of Croatian money was bacteriologically clean, which is in accordance with observations from an experimental bacterial survival study conducted in the Netherlands (4). It was also expected that the banknotes or coins with lower denomination will have more contaminants compared to those with higher denomination, but that was not proven in our study. There is no statistical significance between the prevalence of bacterial contamination of banknotes and coins. Identified bacterial species are mostly part of normal human flora. Some studies have shown that copper seems to be a limiting factor for bacterial survival on coins (1, 5, 6, 7), but in our study no statistical significance was found between banknotes and coins. Also, it was expected that lower denomination banknotes are used more frequently in daily life and would be more contaminated, as shown in a Bangladesh study (8), but in our study no statistical significance was found between

**Figure 1.** The frequency of banknotes and coins with cultured bacteria (60 banknotes and 60 coins).



**Table 1.** Number of colony forming units (CFU) on banknotes and coins. There were 120 pieces of banknotes and coins in total.

Bacterial species	Total CFU	Coins with growth	Banknotes with growth	Total positive (percentage)
<i>S. epidermidis</i>	638	41	38	79 (66%)
<i>Bacillus sp.</i>	33	9	7	16 (13%)
<i>S. saprophyticus</i>	6	0	1	1 (1%)
<i>S. viridans</i>	41	2	0	2 (2%)
<i>Neisseria sp.</i>	20	2	0	2 (2%)
<i>Klebsiella sp.</i>	1	0	1	1 (1%)
<b>total</b>	<b>739</b>	<b>54</b>	<b>47</b>	<b>101 (84%)</b>

**Figure 2.** Distribution of bacteriologically positive and negative findings per denominations in HRK (10 per each banknote/coin, total 120)

higher and lower denominations of banknotes. In recent, well designed experimental research, whose objective was to ascertain the survival rates of some of the most important bacterial species, including nosocomial pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA), extended spectrum beta-lactamase (ESBL) producing *Escherichia coli*, and *Vancomycin-Resistant Enterococci* (VRE), it has been shown that Croatian Kuna was the cleanest

currency among those examined (4). Furthermore, the Croatian Kuna was found to inhibit the growth of all of the multi-drug resistant bacteria tested, which was completely unexpected (4). Other currencies had a tendency to grow colonies of different pathogens: cultures of the Romanian Leu yielded MRSA, VRE and ESBL producing *E. coli*, the Canadian and US Dollar only yielded MRSA; the Euro only ESBL-producing *E. coli*, the Indian Rupee only VRE, and

the Croatian Kuna did not yield any of the 3 microorganisms (4). This can be the result of the material of which banknotes are made, as polymer-based banknotes presented lower bacterial counts than cotton-based bank-notes (1,3). Other studies have shown that 100% of currency notes from India (9, 10, 11), Bangladesh (8,9), Iraq (9,11), and Ghana (9,11,12) were found to carry pathogenic or potentially pathogenic bacteria. In 1972, a study was conducted by Abrams and Waterman and it was found that 42% of paper money and 13% of coins collected from laboratory workers was contaminated by potential pathogens, such as *S. aureus*, *E. coli*, *Klebsiella sp.*, *P. aeruginosa*, and *Proteus mirabilis* (6).

Studies which showed significant contamination of banknotes and coins of different currencies with pathogenic and potentially pathogenic bacteria have been conducted previously (3, 13). It was also shown that money can be a vector for the spreading of the most significant clinical bacterial isolates and also have an impact on the emergence of hospital infections (1).

## Conclusion

The identified bacterial species are mostly part of the normal human flora. Pathogenic, and potentially pathogenic bacterial species were not found on Croatian banknotes and coins, except for one colony of *Klebsiella sp.* Despite the resulting information from our research, hand hygiene should be implemented after each contact with money.

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## Transparency declaration

Competing interests: None to declare.

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