Health Risk Associated with Handling of Contaminated Paper Currencies in Circulation

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Abstract

Paper currencies could be one of the most potential vehicles to transmit diseases among the people. The daily transactions have made the paper currency to pass through many hands and pathogens become imposed on them before they are finally deposited in banks. Modern scientific studies have confirmed the presence of various pathogenic bacteria on paper currencies. Amongst others, Staphylococcus aureus, Salmonella spp, Citrobacter spp, Mycobacterium leprae, Shigella spp, Streptococcus spp, Pseudomonas aeruginosa, Klebsiella spp and Escherichia coli were the dominant contaminants of paper currency samples. Furthermore, researches have also shown that paper currencies could be contaminated by several fungal pathogens like Aspergillus niger, Aspergillus flavus, Rhizopus spp, Penicillium spp, Candida spp, Trichoderma spp, Trichoderma viride, Alternaria tenuis A. paraticus, Sporotrichum spp and Fusarium spp. Besides, several studies revealed that, paper moneys were also contaminated by parasitic species of different helminthes that include parasitic nematodes and tapeworm like Ascaris lumbricoides, Trichuris trichiura, Enterobius vermicularis, hookworm, Strongyloides stercoralis, and Dipylidium caninum. Therefore, paper currency is generally contaminated with pathogenic microorganisms and this contamination may play a significant role in the transmission of potentially harmful microorganisms that are resistant to commonly used antibiotics and therefore represents risks and public health hazards to the community and individuals handling paper currencies. So, there needs frequent awareness development efforts to improve the poor hygienic practices being exercised while handling paper currencies.

Introduction

Money is an invention of the human mind. Before money was introduced in this world, economic exchange was practiced by barter. The barter economy, which involved the direct exchange of one good for certain amount of a different good, is a simple economy where people produce goods either for self-consumption or for exchange with other goods which they want. However, the barter system is inconvenient as it involves much effort on the part of people in trying to exchange goods for services[1]. Paper currency refers to notes of different denominations made of paper and issued by the central bank or the government of a country. Globally, paper currency is widely exchanged for goods and services[2-4]. However, the combination of its widespread use and its constant exchange make paper currency a likely agent for disease transmission.

The raw materials from which paper currencies are made do play a significant role in harboring high microbial load. As studies have shown, those paper currencies that are made of mixture of cotton and linen usually offer surface area for microorganisms to reside on both sides[5]. Nevertheless, according to Vriesekoop, F. et al.[6], polymer-based paper currencies presented lower bacterial counts than cotton-based paper currencies. This may be due to various physicochemical parameters of polymers[7]. It is likely that the fibrous surfaces of cotton-based paper currencies provide a good surface for microbial attachment[8]. They further showed that, the longer the paper currencies remain in circulation, the more chance there is for them to become contaminated, and lower-denomination notes receive the most handling because they are exchanged more frequently[5,6]. Furthermore, in poorer societies, low value denomination currency notes and especially coins are regularly exchanged unlike in richer communities that use high value denomination.

Contamination of different objects by potential pathogenic microorganisms is the serious concern of public health because items that passed from one to another hand could generate a chance of contamination with wide range of pathogenic microorganisms[8,12].

Most of the things we use in our everyday life work as a potential carrier of pathogenic microorganisms. Though we ignore, unknowingly we used to bear many pathogenic microorganisms through some of the media which we use in our everyday life. One such media is our currency, which is used by people of all categories[13]. It is generally documented that physical transfer of material from hands, surfaces, and the environment can contaminate paper currencies since almost every socio-economic setting regularly hold and transfer paper currencies[14].

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Investigations on the contamination of paper curren-
cies with microorganisms are deficient in most of the developing
countries. Consequently, the shortage of information may con-
tribute to the absence of public health policies regarding cur-
rency usage, handling and circulation[13]. The situation is more
compounded by the incapability of the some of the governments
to consistently withdraw old, worn-out and mutilated paper cur-
rencies from the circulation as these could elevate their contrib-
utory role in transmission of some pathogens, thereby constitut-
ing potential public health hazard.

In summary, people living in unhygienic conditions
with unhygienic practices will contaminate the paper curren-
cies with microorganisms in the course of improper hand washing
after using the toilet, counting paper currencies using saliva,
coughing and sneezing on hands subsequently exchanging cur-
rencies, and placement or storage of paper currencys on dirty
surfaces leads to the contamination and these currencies will act
as a vehicle delivering microorganisms to contaminate the hands
of the next user. Consequently, paper currencies have significant
role in the transmission of pathogenic microorganisms and pres-
ent sensible risk to public health.

Microbial Contamination of Paper Money and Sources of
Contamination

Some epidemiological studies have shown that contam-
ination of different objects by potential pathogenic microorgan-
isms is of public health importance as contaminated materials
can be possible sources of transmission of such pathogens[12,16].
Accordingly, several studies revealed that paper currency have
been identified as one of the Vehicle through which pathogens
could be transmitted and could be a particular risk to public
health[11]. Many people do not care how dirty their fingers are
when handling money: the butcher with the bloody fingers, the
street-food vendor with the wetly-oily fingers and others receive
or pick the paper currency with contaminated hands and there-
fore, leading to the contamination of the notes with microorgan-
isms[17].

Microbial contamination of paper currency could be
from several sources, it could be from the counting machine,
atmosphere, during storage, usage, handling or production[18,7].
Daily transactions have made the paper currency to pass through
many hands and pathogens become imposed on them before they
are finally deposited in banks[12]. Ogo, et al.[19] also reported that
the source of contamination could be as a result of poor money
handling practices like spraying during ceremonies where such
notes may be trampled upon when they fall on the ground. Indi-
viduals handling the notes shed some of their body flora on the
notes; leading to the spread of the microorganisms among the
handlers. Moreover, the contamination of the notes can be traced
to dust, soil, water, microflora of the body of handlers (hand,
skin, etc.), the saliva often used when counting the notes and
wounds[20].

A great majority of the people does not carry money in
wallets and squeezing of paper currency is common, especially
among market women, motorcyclists, bus drivers and their con-
ductors, butchers and meat sellers, restaurant operators, etc. For
instance, women often place money underneath their brassier
with sweat; under the carpet or rugs, men in their socks. Mar-
et men and women squeeze paper moneys and put them into
their dirty pockets. Such money handling habits can introduce
microbes to the notes. Similarly, storage of paper currency in
polythene, cotton, leather bags in humid and dark conditions
also favor the growth of microorganisms.

Meat sellers in slaughter houses and in market places
collect money from buyers with hands contaminated with blood
and animal wastes. The case in restaurants is not different. In
most parts of the world, it is believed that the simultaneous han-
dling of food and money contributes to the incidence of food-re-
lated public health incidents[21]. Brady and Kelly[22] also analyzed
money handled by people who were also food handlers and es-
established the presence of coagulate-positive staphylococci on
the money surface. Also, swabbing and culturing from various
paper currencys collected at random from doctors, laboratory
staff and other employees at a New York hospital in the U.S is
said to have resulted in the recovering of many pathogenic mi-
crobes[21].

Microbial contaminants may be transmitted either
directly through hand-to-hand contact, otherwise indirectly,
through food, water or other inanimate objects[23]. Paper Curren-
cy, can be contaminated by droplets during coughing, sneezing,
touching with previously contaminated hands or other materials
and placement on dirty surface. According to several studies[24-26]
many bacteria are found associated with paper currency such as
Citrobacter sp., Mycobacterium latiae, Salmonella sps, Shigella
sps, Escherichia coli, Staphylococcus aureus and Pseudomonas
aeroginosa have been isolated from notes. Most of them are
normal flora of the human skin; however, some for example, S.
aureus and P. aeroginosa can be opportunistic pathogens. These
organisms may probably have found their entry to the paper cur-
rency through the skin and hand to hand mechanism. This sug-
gests that the notes could serve as fomites for some infectious
agents[27].

The presence of various pathogenic microorganisms
such as E. coli, Pseudomonas sps, Klebsiella sps, Streptococcus
sps and Staphylococcus sps, which are known to be responsible
for watery diarrhea, mouth skin diseases, pneumonia, respirato-
ry track diseases, gastro- intestinal diseases etc Table 1.

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>CFU/ note</th>
<th>Pathogenesis</th>
</tr>
</thead>
</table>
| E. coli                 | 2x10^8    | Virulen E.coli strains cause either non-inflammatory diarrhea or Inflam-
                        |            | matory diarrhea (dysentery with stools usually containing blood, mucus, and
                        |            | leukocytes).                                                                |
| Pseudomonas spp.        | 6x10^8    | Skin disease.                                                              |
| Klebsiella spp.         | 3x10^8    | Mouth skin, intestinal diseases.                                            |
| Streptococcus spp.      | 2x10^8    | Strep throat, meningitis, bacterial pneu-
                        |            | monia.                                                                     |
| Staphylococcus spp.     | 8x10^8    | Staphylococcus aureus is an uncom-
                        |            | mon cause of pneumonia in animals.                                           |

Study by Alwakeel and Nasser in Saudi Arabia in 2011,
reported that currency notes were also contaminated with fungi
which include Aspergillus niger, A. flavus, Candida sps, Peni-
cillium sps and Rhizopus sps. Moreover, survey of the currency
bills in Egypt for fungal contaminations revealed the ability of
the paper currency to be infected by different genera and species
of fungi such as Aspergillus flavus, A. niger and Penicillium
sps, Alternaria tenuis, Trichoderma sps, Fusarium sps and Tricho-
positive for Staphylococcus aureus 25% were positive for study showed that from a total of 100 paper currency samples, Acinetobacter lus...ted with parasites like Ascaris lumbricoides, Trichuris trichiura, and Enterobius vermicularis, Strongyloides stercoralis, and Dipylidium caninum on their human hosts[19]. Study on Nigerian currency, by Elom et al.[31] revealed that paper moneys were contaminated by parasitic species of various helminthes. Furthermore, study by Ogbu and Uneke[10] has shown that paper currencies were contaminated by individuals of various socio-economic classes, there is a tendency to spread from one individual to another[30]. Recovery of parasitic helminthes from surfaces of paper currency signifies a looming damage to the public health, considering the nutritional, immunological and physiological effects of the helminthes on their human hosts[19]. Study on Nigerian currency, by Elom et al.[31] revealed that paper moneys were contaminated by parasitic species of various helminthes. Furthermore, study by Ogbu and Uneke[10] has shown that paper currencies were contaminated with parasites like Ascaris lumbricoides, Trichuris trichiura, Enterobius vermicularis, Strongyloides stercoralis, hookworm, and Dipylidium caninum Table 4.

According to report by Girma et al.[29] in Ethiopia, paper currency samples were dominated by Staphylococcus sps, Bacillus sps, Enterobacteraceae, Micrococcus sps, Streptococcus sps, Acinetobacter sps and Pseudomonas sps Table 3. Moreover, this study showed that from a total of 100 paper currency samples, 25% were positive for Staphylococcus aureus and 10% were positive for Salmonella sps Table 3.

Since paper currency is one object being handled daily by individuals of various socio-economic classes, there is a chance that paper currency is contaminated with parasites and tendency to spread from one individual to another[10]. Recovery of parasitic helminthes from surfaces of paper currency signifies a looming damage to the public health, considering the nutritional, immunological and physiological effects of the helminthes on their human hosts[19]. Study on Nigerian currency, by Elom et al.[31] revealed that paper moneys were contaminated by parasitic species of various helminthes. Furthermore, study by Ogbu and Uneke[10] has shown that paper currencies were contaminated with parasites like Ascaris lumbricoides, Trichuris trichiura, Enterobius vermicularis, Strongyloides stercoralis, hookworm, and Dipylidium caninum Table 4.

### Table 2: Relative occurrence and frequency of different isolates of fungi isolated from banknotes[28].

<table>
<thead>
<tr>
<th>Isolated fungi</th>
<th>Total isolates</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternaria tenuis</td>
<td>11</td>
<td>10.68</td>
</tr>
<tr>
<td>Aspergillus flavus</td>
<td>28</td>
<td>27.18</td>
</tr>
<tr>
<td>Aspergillus niger</td>
<td>18</td>
<td>17.48</td>
</tr>
<tr>
<td>Aspergillus paraziticus</td>
<td>3</td>
<td>2.91</td>
</tr>
<tr>
<td>Fusarium spp.</td>
<td>6</td>
<td>5.83</td>
</tr>
<tr>
<td>Penicillium spp.</td>
<td>19</td>
<td>18.45</td>
</tr>
<tr>
<td>Sporotrichum spp.</td>
<td>1</td>
<td>0.97</td>
</tr>
<tr>
<td>Trichoderma viride</td>
<td>6</td>
<td>5.83</td>
</tr>
<tr>
<td>Trichoderma spp.</td>
<td>11</td>
<td>10.68</td>
</tr>
</tbody>
</table>

### Table 3: Frequency distribution (%) of dominant bacteria isolated from paper currencies collected from food vendors, Jimma town, Southwest Ethiopia[29].

<table>
<thead>
<tr>
<th>Bacterial isolates</th>
<th>Total isolates</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus spp.</td>
<td>328</td>
<td>34.06</td>
</tr>
<tr>
<td>Bacillus sps.</td>
<td>307</td>
<td>31.88</td>
</tr>
<tr>
<td>Enterobacteraceae</td>
<td>129</td>
<td>13.39</td>
</tr>
<tr>
<td>Micrococcus spp.</td>
<td>92</td>
<td>9.55</td>
</tr>
<tr>
<td>Streptococcus spp.</td>
<td>87</td>
<td>9.03</td>
</tr>
<tr>
<td>Acinetobacter spp.</td>
<td>14</td>
<td>1.45</td>
</tr>
<tr>
<td>Pseudomonas spp.</td>
<td>6</td>
<td>0.62</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Salmonella spp.</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 4: Frequency of isolation of parasite species from contamination of currency notes in relation to physical conditions[31].

<table>
<thead>
<tr>
<th>Parasite species</th>
<th>Physical conditions of currency</th>
<th>Clean Number contaminated (%) (N=31)</th>
<th>Dirty Number contaminated (%) (N=57)</th>
<th>Total number contaminated (%) (N=88)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascaris lumbricoides</td>
<td></td>
<td>0(0.0)</td>
<td>15(26.3)</td>
<td>15(17.1)</td>
</tr>
<tr>
<td>Strongyloides stercoralis</td>
<td></td>
<td>(1(3.2)</td>
<td>47(0.0)</td>
<td>5(5.7)</td>
</tr>
<tr>
<td>Enterobius vermicularis</td>
<td></td>
<td>0(0.0)</td>
<td>3(5.3)</td>
<td>3(3.4)</td>
</tr>
<tr>
<td>Trichuris trichiura</td>
<td></td>
<td>0(0.0)</td>
<td>2(3.5)</td>
<td>2(2.3)</td>
</tr>
<tr>
<td>Hook worm</td>
<td></td>
<td>0(0.0)</td>
<td>1(1.8)</td>
<td>1(1.1)</td>
</tr>
<tr>
<td>Dipylidium caninum</td>
<td></td>
<td>0(0.0)</td>
<td>1(1.8)</td>
<td>1(1.1)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>(13.2)</td>
<td>26(45.6)</td>
<td>27(30.7)</td>
</tr>
</tbody>
</table>

### Skin Contamination

Paper currency is perhaps the most widely handled article by people every day throughout the world. Money moves among several clean and dirty hands[32]. The lower-denomination notes receiving the most handling because they are exchanged many times[10]. Furthermore, the cross contamination from the anal section, injuries, nasal discharges and aerosols produced by sneezing and coughing are potential sources of transfer of microorganisms to currency notes during handling[16].

Bosch and Steyn[31] showed that 90% of South-African bank notes in circulation in 1997 were contaminated with either bacteria or fungi[16]. According to report by Prescott, et al.[34], the human surface tissue (skin) usually is constantly in contact with environmental microorganisms and become readily colonized by certain microbial species. Microorganisms on the skin can be transferred from cashiers, sales people and the general public to the currency notes that they handle. Skin is one of the habitats for microorganisms in the body. The adult human body is covered approximately 2m2 of skin, with the surface area supporting about 1012 bacteria[30]. Among the others, coagulase negative Staphylococci, Diphtherians, Staphylococcus aureus, Streptococci sps., Bacillus sps, Mallassaeus furfur and Candida sps and other rare Mycobacterium sps, Pseudomonads and Enterobacteraceae that can be transmitted from an individual to others by animate and inanimate objects. Currency notes are therefore possible vehicles through which infectious agents can be transmitted to humans through frequent contact[26,12].

An evaluation of the public health risk associated with the simultaneous handling of food and money in the food industry in Australia[22] showed the presence of Staphylococci on the money surface. As a result, constant handling with combination of these all, make them a prime multiplication for various microorganisms and could constitute a major health hazard[14]. Thus, it calls for awareness development on the potential risks associated with poor handling of paper currencies at all level of the food establishments.

According to several studies[36,12,37], indicated that pathogenic bacteria isolates like S. aureus and S. dysenteriae which are diseases causing microbes, can cross to contaminate food items. Likewise, depending on the Mycobacterium species, a wide range of diseases including acid fast bacilli which can cause either tuberculosis, leprosy or buruli ulcer and so constitute a major health hazard[32].

*Staphylococcus aureus* can cause illnesses from skin complaint and boils to pneumonia and meningitis and is a close...
relative of methicillin resistant *Staphylococcus aureus* (MRSA). *S. aureus*, is mainly reserved in the hand from where it is introduced in to food during preparation

An investigation that was reported in 1997 and that involved swab culture from both coins and paper currency samples collected health workers at a New York hospital resulted in the recovery of many pathogenic microorganisms[38,21].

**Fecal Contamination**

Enteric pathogens such as enterotoxigenic *E. coli*, *Vibrio* and *Salmonella* have been isolated from paper currency samples obtained from butchers and fishmongers in Rangoon, Myanmar[39]. Hence, the presence of gram-negative rod, Enterobacter aerogenes, and a member of coliform indicates the possibility of the presence of faecal contamination on the paper moneys. Gram-negative sepsis is most commonly caused by *E. coli*, *Klebsiella* sps, and *Pseudomonas aeruginosa*. The frequency of occurrence of *E. coli* indicates the presence of fecal contamination via cross-contamination with raw products or poor personal hygiene. Common unhygienic practices in day to day transactions especially in rural areas, where trader and buyers eat market products after handling germ-infested currency notes, possibly will leave the users at risk of ingesting enteropathogens[16]. A study by Jiang and Doyle[40] in 1999 on fate of *E. coli* O157:H7 and salmonella enteritidis on currency suggested that paper currency could serve as a potential vehicle for transmitting both *E. coli* O157:H7 and *Salmonella enteritidis*.

Parasites that have been observed to be contaminants of paper moneys are mainly of faecal origin[18]. When hands used in cleaning up the anus after passing out faeces are not properly washed and are used to touch paper moneys in anyway, the tendency is contamination with the trophozoite of the developed parasite, eggs, cysts or even the oocyst.

**Currency Counting Machines and Counting Room Environment**

The occurrence of the heavy load of microorganisms on paper currency can constitute a potential health hazard to users. It has been suggested that humans keep strict adherence to hygienic practices before handling food and water after contact with paper currency and counting machines[12,7]. Microbes are ubiquitous, hence their ability to contaminate currency counting machines.

Study conducted elsewhere[19], on currency counting machines and currency counting banks revealed that the presences of both various bacteria and fungi isolates like *S. typhi*, *Staphylococcus aureus*, *E. coli*, *Streptococcus* sps, *Enterococcus* sps, *Streptococcus pyogenes*, *Proteus* sps and *Aspergillus* sps, *Mucor* sps, *Penicillium* sps and *Rhizopus* sps, respectively. Possibly, these microorganisms could have come in contact with money through soil, clothing, food or hands of users before being taken to the bank.

**Drug Resistance in Microorganisms from Currency Notes**

Pathogenic microorganisms that may survive on the currency notes may serve as potential sources of enteropathogens that cause infections and potential sporadic cases of food borne diseases[24]. Research has shown that contaminated fo- mites in general and paper currency in particular, plays a key role in the spread of bacterial infections with antimicrobial resis-
Microbial contamination of paper currency is not only confined to developing nations. Several studies from the United States reported contamination of paper moneys and the identification revealed the presence of pathogenic microbes like species *Staphylococcus*, *Streptococcus*, *E. coli*, *Klebsiella pneumonia*, *Acinetobacter*, *Pseudomonas*, *Bacillus* and *Diptheroids*.[13,51,30,5] Studies in different parts of the world have reported that 65% of the paper currencies contaminated by bacteria members of the family *Enterobacteriacea*, *Mycobacterium tuberculosis*, *Vibrio cholerae*, *Bacillus* spp, *Staphylococcus* spp, *Micrococcus* spp and *Corynebacterium* spp. Evidently, a study in Egypt reported that 65% of the paper currencies contaminated by bacteria members of the family *Enterobacteriacea*, *Mycobacterium tuberculosis*, *Vibrio cholerae*, *Bacillus* spp, *Staphylococcus* spp, *Micrococcus* spp, *Klebsiella pneumonia* and *Corynebacterium* spp.[50]

Microbial contamination of paper currency is not only confined to developing nations. Several studies from the United States reported contamination of paper moneys and the identification revealed the presence of pathogenic microbes like species *Staphylococcus*, *Streptococcus*, *E. coli*, *Klebsiella pneumonia*, *Acinetobacter*, *Pseudomonas*, *Bacillus* and *Diptheroids*.[13,51,30,5] Studies on the Nigerian paper currency which were collected from motorcyclists, market women, restaurant owners and butchers indicated that they were contaminated by disease-causing fungi, *Aspergillus* and *Rhizopus* species. *Aspergillus* species cause the disease, aspergillosis, while *Rhizopus* species cause zygomycosis, in man.[25] Aspergillosis usually associated with allergic bronchopulmonary aspergillosis and its appearance range from asthma to fatal destruction of the lungs, haemoptysis, whith the disruption of blood vessels results to internal bleeding. Zygomyces includes mucocutaneous, rhinocerebral; genitourinary, gastrointestinal, pulmonary and disseminated infections.[52]

### Conclusion


It can be inferred that periodical evaluation of microbial load and safety of paper currencies are recommended besides frequent awareness development efforts to improve the poor hygienic practices being exercised while handling paper currencies. Ready to eat food vendors and other common people should be aware to avoid possible cross contamination between currency notes and foods. For those who handle food and paper currencies simultaneously; it is recommendable to handle food only with a gloved hand and money with the other hand and the practice of keeping money in brassieres, handkerchiefs and in shoes should be discouraged. The government of countries could also assess the possibility of introducing washable plastic paper currencies like in Australia and New Zealand to make the cleaning possible without compromising the life spans of paper currency in the circulation is also recommended. Likewise, the possibility of microbial chemicals to be incorporated into the paper currencies and disinfection of currencies in banks by ultraviolet light and chemicals means, would decrease the risk of transmission of infection. Replacement of the traditional methods of trading with electronic currency transactions such as ATM machine and encouraging the use of credit cards would of course be another good solution for the problem. Therefore, there needs to be care during preparation and handling of foods through regular washing of hands when every there is access to paper currencies.

### References