



Review Article

Health Risk Associated with Handling of Contaminated Paper Currencies in Circulation

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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 also play significant role in harboring high microbial load. As studies have shown, those paper currencies that are made of mixture of cotton and linen usually offers 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

Abstract

Paper currencies could be one of the most potential vehicles to transmit diseases amongst 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* sps, *Citrobacter* sps, *Mycobacterium leprae*, *Shigella* sps, *Streptococcus* sps, *Pseudomonas aeruginosa*, *Klebsiella* sps 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* sps, *Penicillium* sps, *Candida* sps, *Trichoderma* sps, *Trichoderma viride*, *Alternaria tenuis* A. *paraticus*, *Sporotrichum* sps and *Fusarium* sps. 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.

polymers^[7]. It is likely that the fibrous surfaces of cotton-based paper currencies provide a good surface for microbial attachment^[6]. 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].

Investigations on the contamination of paper currencies with microorganisms are deficient in most of the developing countries. Consequently, the shortage of information may contribute to the absence of public health policies regarding currency usage, handling and circulation^[15]. The situation is more compounded by the incapability of some of the governments to consistently withdraw old, worn-out and mutilated paper currencies from the circulation as these could elevate their contributory role in transmission of some pathogens, thereby constituting potential public health hazard.

In summary, people living in unhygienic conditions with unhygienic practices will contaminate the paper currencies 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 currencies, and placement or storage of paper currencies 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 present sensible risk to public health.

Microbial Contamination of Paper Money and Sources of Contamination

Some epidemiological studies have shown that contamination of different objects by potential pathogenic microorganisms 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 therefore, leading to the contamination of the notes with microorganisms^[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. Individuals 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 conductors, 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. Market 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 polythenes, 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 handling of food and money contributes to the incidence of food-related public health incidents^[21]. Brady and Kelly^[22] also analyzed money handled by people who were also food handlers and established the presence of coagulate-positive staphylococci on the money surface. Also, swabbing and culturing from various paper currencies 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 microbes^[21].

Microbial contaminants may be transmitted either directly through hand-to-hand contact, otherwise indirectly, through food, water or other inanimate objects^[23]. Paper Currency, 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 lapiae*, *Salmonella* sps, *Shigella* sps, *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* have been isolated from notes. Most of them are normal flora of the human skin; however, some for example, *S. aureus* and *P. aeruginosa* can be opportunistic pathogens. These organisms may probably have found their entry to the paper currency through the skin and hand to hand mechanism. This suggests 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, respiratory track diseases, gastro- intestinal diseases etc Table 1.

Table 1: Mean counts (CFU/note) of microbial pathogens isolated from paper currency^[53]

Microorganisms	CFU/ note	Pathogenesis
<i>E. coli</i>	2x10 ⁸	Virulen <i>E.coli</i> strains cause either non-inflammatory diarrhea or Inflammatory diarrhea (dysentery with stools usually containing blood, mucus, and leukocytes).
<i>Pseudomonas</i> spp.	6x10 ⁸	Skin disease.
<i>Klebsiella</i> spp.	3x10 ⁸	Mouth skin, intestinal diseases
<i>Streptococcus</i> spp.	2x10 ⁸	Strep throat, maningitis, bacterial pneumonia.
<i>Staphylococcus</i> spp.	8x10 ⁸	<i>Staphylococcus aureus</i> is an uncommon 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, *Penicillium* 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-*

derma viride, *A. paraziticus* and *Sporotrichum* spp^[28] Table 2.

Table 2: Relative occurrence and frequency of different isolates of fungi isolated from banknotes^[54].

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

According to report by Girma et al^[29] in Ethiopia, paper currency samples were dominated by *Staphylococcus* spp, *Bacillus* spp, *Enterobacteraceae*, *Micrococcus* spp, *Streptococcus* spp, *Acinetobacter* spp and *Pseudomonas* spp 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* spp Table 3.

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

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

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^[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.

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

Parasite species	Physical conditions of currency		
	Clean Number contaminated (%) (N=31)	Dirty Number contaminated (%) (N=57)	Total number Number contaminated (%) (N=88)
<i>Ascaris lumbricoides</i> ,	0(0.0)	15(26.3)	15(17.1)
<i>Strongyloides stercoralis</i>	1(3.2)	4(7.0)	5(5.7)
<i>Enterobius vermicularis</i>	0(0.0)	3(5.3)	3(3.4)
<i>Trichuris trichiura</i>	0(0.0)	2(3.5)	2(2.3)
Hook worm	0(0.0)	1(1.8)	1(1.1)
<i>Dipylidium caninum</i>	0(0.0)	1(1.8)	1(1.1)
Total	1(3.2)	26(45.6)	27(30.7)

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^[33] 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^[35]. Among the others, coagulase negative Staphylococci, Diphtherians, *Staphylococcus aureus*, *Streptococci* spp., *Bacillus* spp, *Mallassezia furfur* and *Candida* spp and other rare *Mycobacterium* spp, *Pseudomonas* and *Eterobacteriaceae* 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^[30,36,12,37], 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 rooms in banks revealed that the presences of both various bacteria and fungi isolates like *S. typhi*, *Staphylococcus aureus*, *E. coli*, *Streptococcus* sps, *Enterococcus* sps, *S. 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 fomites in general and paper currency in particular, plays a key role in the spread of bacterial infections with antimicrobial resis-

tance. Antimicrobial resistance is a global phenomenon that has resulted in high morbidity and mortality as a result of treatment failures and increased health care costs^[41].

Antibiotic testing analysis clearly indicated that bacterial isolates were resistance to the commonly used antibiotics. All bacteria isolates were resistance (100%) to Ampicillin, Cloxacillin, Penicillin and Cefuroxime which are commonly used antibiotics that have been observed in studies presenting a public health problem^[42]. Cefixime, Tetracycline and Erythromycin had 80% to 88% resistivity.

Similarly, previous report on Ghanaian currency notes in 2011 had shown that bacterial isolates showed varied resistance to commonly use antibiotics with *Coagulase negative staphylococci* (CNS), *E. faecalis* and *Salmonella* sps having high resistivity of 87.5% whilst *B. cereus* and *P. aureginosa* showed 50% sensitivity. Isolates were 100% resistant to Ampicillin, Penicillin and Cefuroxime whilst Gentamicin and both Amikacin and Cotrimoxazole were 85.7% and 77.8% activity effective respectively.

Moreover, Study conducted elsewhere^[43] indicated that all *Staphylococcus aureus* isolates showed multidrug resistance to Penicillin (100%), Methicillin (80%) and Vancomycin(76%) whereas all isolates were sensitive to Lenzoid antibiotic (81%). The high antibiotic resistances could be attributed to the abuse of antibiotics as observed in a study showed that majority of the populace sampled purchases antibiotics in the open market without any medical prescription and use them for the wrong diseases and infections^[42].

The currency notes in circulation are usually contaminated with various microbial agents of which most are resistant to commonly used antibiotics and therefore represents risks and public health hazards to the community and individuals handling currency notes^[42].

Thus individuals should improve upon their personal health consciousness by washing their hands regularly after handling of currency notes, prevent babies from handling currency notes and avoid the use of saliva during counting of currency notes as well as desist from placing money in the mouth and sticking currency notes in brassieres.

Potential Health Risk of Handling Contaminated Paper Currency Notes

Paper currency is commonly handled by various categories of people during transaction^[20]. Paper money, therefore presents a particular risk to public health, since communicable diseases can spread through contact with fomites and harbor various deadly pathogenic microorganisms^[30,24,44,25,45,7].

Pathogenic microorganisms that may survive on paper currency may serve as a potential source of enteropathogens causing food poisoning because food vendors may serve food with the hands and at the same time handle paper currency as they sell^[24,46,26]. Such practices transfer bacteria from paper currency to humans through food^[47].

As significance reports confirmed with concern over communicable diseases is giving a new meaning to the term "Dirty Money". Researchers at the Regional Sophisticated Instrumentation Center (RSIC) at the North Eastern University in Shilong, India, who examined Indian paper currencies, identified several pathogenic microorganisms related with meningitis, pneumonia, tuberculosis, peptic ulcers, tonsillitis, gastroenteri-

tis, genital tract infections, lung abscesses and throat infections^[48,49].

Studies in different parts of the world have reported high rates of microbial contamination of currency notes in circulation^[25,45,7]. The microorganisms implicated included members of the family *Enterobacteriaceae* *Mycobacterium tuberculosis*, *Vibrio cholerae*, *Bacillus* sps, *Staphylococcus* sps, *Micrococcus* sps and *Corynebacterium* sps. Evidently, a study in Egypt reported that 65% of the paper currencies contaminated by bacteria members of the family *Enterobacteriaceae*, *Mycobacterium tuberculosis*, *Vibrio cholerae*, *Bacillus* sps, *Staphylococcus* sps, *Micrococcus* sps, *Klebsiella pneumonia* and *Corynebacterium* sps^[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 *Diphtheroids*^[13,51,30,5].

Study on the Nigerian paper currency which were collected from motorcyclists, market women, restaurant operators 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^[22]. *Aspergillosis* usually associated with allergic bronchopulmonary aspergillosis and its appearance range from asthma to fatal destruction of the lungs, haemoptysis, which the disruption of blood vessels results to internal bleeding. Zygomycosis includes mucocutaneous, rhinocerebral; genitourinary, gastrointestinal, pulmonary and disseminated infections^[52].

Conclusion

Paper currencies are one of the important fomite for infectious diseases in various countries due to their wide circulation. The common infectious microorganisms include *Citrobacter* sps, *Mycobacterium leprae*, *Salmonella* sps, *Shigella* sps, *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella* sps, *Streptococcus* sps, *Micrococcus* sps, *Acinetobacter* sps, *Aspergillus niger*, *A. flavus*, *Candida* sps, *Penicillium* sps, *Rhizopus* spp. *Alternaria tenuis*, *Trichoderma* sps, *Fusarium* sps, *Trichoderma viride*, *A. parvaticus* and *Sporotrichum* sps and parasite species such as *Ascaris lumbricoides*, *Strongyloides stercoralis*, *Enterobius vermicularis*, *Trichuris trichiura*, hookworm and *Dipylidium caninum*. Most of the bacteria isolated are resistant to commonly used antibiotics, thus it represents risks factor for health hazards to the community.

It can be inferred that periodic 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 microbicidal 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.

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