Are there Public Health Risks Associated with Physical Handling of Paper Money and Coins in Zambia? A Case Study of Chirundu Border Post at the Zambia/Zimbabwe International Boundary

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Abstract

This study was carried out at Chirundu border post located on the Zambia - Zimbabwe international boundary which is one of the busiest entry/exit points. Data collection took place between November 2015 and June 2016. The aim of the study was to investigate public health risks associated with physical handling of money and suggest plausible measures to control certain personal habits as a way of addressing such public health concerns. The main objectives of the study were to; i) identify species of microbes found on paper and coin money, ii) compare microbial levels between large and small currency denominations, and iii) investigate money handling practices used by traders and their clients as sources of contamination and transmission of microbes of public health concern. The study methods involved use of questionnaires, interviews and collection of samples of paper and coin money for laboratory examinations to isolate common pathogens associated with currency. Results showed that there were total coliforms, feacal coliforms, and *Escherichia coli*. Lower denominations, K2 in particular had the heaviest load of microbes and lower in larger denominations. Public money handling practices showed ignorance of public health concerns as most men and women kept money in under garments where it was in direct contact with the skin while others used saliva when counting money. It was concluded that physical handling of money is a matter of public health concern. Further research is required to determine the levels of microbes at Automated Teller Machines as these could also act as points of pathogen transmission.

*Keywords***:** Transmission, Microbes, denomination, coin, paper money, money exchange

1. Introduction

Currency, in economics is as term designating all the circulating media of exchange of a country. In this sense, a currency includes coins and paper money. The term sometimes includes credit instruments but coins are generally designated as metallic currency, and paper money and credit instruments as paper currency. Further distinctions are made in the latter classification: Government notes are called government currency; bank notes are designated as bank currency; and cheques drawn on bank deposits are called deposit currency (Encyclopædia Britannica, 2010). In this study currency it is restricted to paper money and coins.

This use of the term *currency* is of comparatively recent origin; dating from the period following World War I. Earlier uses of the term were more restricted. In countries in which governments did not issue paper money, the term *paper currency* was applied exclusively to bank notes. In the United States and a number of other countries, on the contrary, the application of the term *currency* was limited to government-issued, legal-tender paper money. The change from the earlier, restricted meanings of the term to its modern significance resulted in part from the great increase, following World War I, in the use of credit instruments (Encyclopaedia Britannica, 2010). The use of the term currency in this study will be restricted and only applied to paper money and coins which are in public use at markets, shops and other trading points.

At a border crossing like Chirundu, money enables trade to take place without the double coincidence of the barter system. In principle, credit could have performed this function, but, before extending credit, the seller would want to know about the prospects of repayment. It requires that there be more information about the buyer which imposes costs of information and verification that the use of money avoids. Since some of the buyers or sellers are passengers in transit or originate from the other side of the border, use of money is the most appropriate medium of exchange.

At Chirundu like many other border areas, if a person has something to sell and wants something else in return may be from across the border in Zimbabwe, the use of money avoids the need to search for someone able and willing to make the desired exchange of items (barter system).

The importance of this function of money is dramatically illustrated by the experience of Germany just after World War II, when paper money was rendered largely useless because of price controls that were enforced effectively by the American, French, and British armies of occupation. Money rapidly lost its value. People were unwilling to exchange real goods for Germany's depreciating currency. They resorted to barter or to other inefficient money substitutes (such as cigarettes). Price controls reduced incentives to produce. The country's economic output fell by half. Later the German "economic miracle" that took root just after 1948 reflected, in part, a currency reform instituted by the occupation authorities that replaced depreciating money with money of stable value. At the same time, the reform eliminated all price controls, thereby permitting a money economy to replace a barter economy.

These examples show the "medium of exchange" function of money. Separation of the act of sale from the act of purchase requires the existence of something that will be generally accepted in payment. But there must also be something that can serve as a temporary store of purchasing power, in which the seller holds the proceeds in the interim between the sale and the subsequent purchase or from which the buyer can extract the general purchasing power with which to pay for what is bought. This is called the "asset" function of money (Encyclopaedia Britannica, 2010). As such, money passes through many hands daily accumulating and transmitting microbial cells in each handling.

With regard to varieties of money, anything can serve as money that habit or social convention and successful experience endow with the quality of general acceptability, and a variety of items have so served from the *wampum* (beads made from shells) of American Indians, to cowries (brightly coloured shells) in India, to whales' teeth among the Fijians, to tobacco among early colonists in North America, to large stone disks on the Pacific island of Yap, to cigarettes in post-World War II Germany and in prisons the world over (Figure 1).

Figure 1 Early Forms of Money

Notes: Before paper and coins were introduced as permanent forms of money, people used a variety of other objects to serve as money for trading goods. Examples of early forms of money, as shown here, include rice (China), dogs' teeth (Papua New Guinea), small tools (China), quartz pebbles (Ghana), gambling counters (Hong Kong), cowrie shells (India), metal disks (Tibet), and limestone disks (Yap Island). (Source: Encarta, 2009)

In fact, the wide use of cattle as money in primitive times survives in the word pecuniary, which comes from the Latin *pecus*, meaning cattle. The development of money has been marked by repeated innovations in the objects used as money. However, the common practice today is the use paper and coin money.

The use of metal for money can be traced back to Babylon more than 2000 years BC, but standardization and certification in the form of coinage did not occur except perhaps in isolated instances until the 7th century BC. Historians generally ascribe the first use of coined money to Croesus, king of Lydia, a state in Anatolia. The earliest coins were made of electrum, a natural mixture of gold and silver, and were crude, bean-shaped ingots bearing a primitive punch mark certifying to either weight or fineness or both. Irrespective of the type of metal it was made from, coins have been used as money throughout history. As Aristotle observed, the various necessities of life are not easily carried about; hence people agreed to employ in their dealings with each other something that was intrinsically useful and easily applicable to the purposes of life, for example, iron, silver, and others. The value of the metal was at first measured by weight, but in time governments or sovereigns put a stamp upon it to avoid the trouble of weighing it and to make the value known on sight (Encyclopaedia Britannica, 2010).

The use of coins enabled payment to be by "tale," or count, rather than weight, greatly facilitating commerce. But this in turn encouraged "clipping" (shaving off tiny slivers from the sides or edges of coins) and "sweating"

(shaking a bunch of coins together in a leather bag and collecting the dust that was thereby knocked off) in the hope of passing on the lighter coin at its face value. The resulting economic situation was described by Gresham's law (that "bad money drives out good" when there is a fixed rate of exchange between them); heavy, good coins were held for their metallic value, while light coins were passed on to others. In time the coins became lighter and lighter and prices higher and higher. As a means of correcting this problem, payment by weight would be resumed for large transactions, and there would be pressure for re-coinage. These particular defects were largely ended by the "milling" of coins (making serrations around the circumference of a coin), which began in the late 17th century.

A more serious problem occurred when the sovereign would attempt to benefit from the monopoly of coinage. In this respect, Greek and Roman experience offers an interesting contrast. Solon, on taking office in Athens in 594 BC, did institute a partial debasement of the currency. For the next four centuries until the absorption of Greece into the Roman Empire, the Athenian drachma had an almost constant silver content (67 grains of fine silver until Alexander, 65 grains thereafter) and became the standard coin of trade in Greece and in much of Asia and Europe as well. Even after the Roman conquest of the Mediterranean peninsula in roughly the 2nd century BC, the drachma continued to be minted and widely used (Encarta, 2009; Encyclopaedia Britannica, 2010).

The Roman experience was very different. Not long after the silver denarius, patterned after the Greek drachma, was introduced about 212 BC, the prior copper coinage (*aes*, or *libra*) began to be debased until, by the onset of the empire, its weight had been reduced from 1 pound (about 450 grams) to half an ounce (about 15 grams). By contrast the silver *denarius* and the gold *aureus* (introduced about 87 BC) suffered only minor debasement until the time of Nero (AD 54), when almost continuous tampering with the coinage began. The metal content of the gold and silver coins was reduced, while the proportion of alloy was increased to three-fourths or more of its weight. Debasement in Rome (as ever since) used the state's profit from money creation to cover its inability or unwillingness to finance its expenditures through explicit taxes. But the debasement in turn raised prices, worsened Rome's economic situation, and contributed to the collapse of the empire. Coin money despite the long and tortuous history, continues to be an acceptable medium of exchange to date. Coins work very well as payment for goods and services of less value, public transport fare and others and may change hands very frequently and freely because there is no fear of damage.

Use of paper money on the other hand eliminated the problem of weight especially in instances where the goods being purchased were of high value. Experience had shown that carrying large quantities of gold, silver, or other metals proved inconvenient and risked loss or theft. The first use of paper money occurred in China more than 1,000 years ago (Encyclopaedia Britannica, 2010). By the late 18th and early 19th centuries paper money and banknotes had spread to other parts of the world. The bulk of the money in use came to consist not of actual gold or silver but of fiduciary money promises to pay specified amounts of gold and silver. These promises were initially issued by individuals or companies as banknotes or as the transferable book entries that came to be called deposits. Although deposits and banknotes began as claims to gold or silver on deposit at a bank or with a merchant, this later changed. Knowing that everyone would not claim his or her balance at once, the banker (or merchant) could issue more claims to the gold and silver than the amount held in safekeeping. Bankers could then invest the difference or lend it at interest. In periods of distress, however, when borrowers did not repay their loans or in case of over issue, the banks could fail (Encarta, 2009).

Gradually, governments assumed a supervisory role. They specified legal tender, defining the type of payment that legally discharged a debt when offered to the creditor and that could be used to pay taxes. Governments also set the weight and metallic composition of coins. Later they replaced fiduciary paper money promises to pay in gold or silver with fiat paper money that is, notes that are issued on the "fiat" of the sovereign government, are specified to be so many dollars, pounds, kwacha, shilling, or yen, etc., and are legal tender but are not promises to pay something else (Encarta, 2009; Encyclopaedia Britannica, 2010).

The first large-scale issue of paper money in a western country occurred in France in the early 18th century. Subsequently, the French Revolutionary government issued assignats from 1789 to 1796. Similarly, the American colonies and later the Continental Congress issued bills of credit that could be used in making payments. Yet these and other early experiments gave fiat money a deservedly bad name. The money was over issued, and prices rose drastically until the money became worthless or was redeemed in metallic money (or promises to pay metallic money) at a small fraction of its initial value.

Subsequent issues of fiat money in the major countries during the 19th century were temporary departures from a metallic standard. In Great Britain, for example, the government suspended payment of gold for all outstanding banknotes during the Napoleonic Wars (1797–1815). To finance the war, the government issued fiat paper money. Prices in Great Britain doubled as a result, and gold coin and bullion became more expensive in terms of paper. To restore the gold standard at the former gold price, the government deflated the price level by reducing the quantity of money. In 1821 Great Britain restored the gold standard. Similarly, during the American Civil War the U.S. government suspended convertibility of Union currency (greenbacks) into specie (gold or silver coin), and resumption did not occur until 1879. At its peak in 1864, the greenback price of gold, nominally equivalent to $100, reached more than $250 (Encyclopaedia Britannica, 2010).

Episodes of this kind, which were repeated in many countries, convinced the public that war brings inflation and that the aftermath of war brings deflation and depression. This sequence is not inevitable. It reflected 19th-

century experience under metallic money standards. Typically, wars required increased government spending and budget deficits. Governments suspended the metallic (gold) standard and financed their deficits by borrowing and printing paper money (Encarta, 2009; Encyclopaedia Britannica, 2010).

Throughout history, the price of gold would be far above its prewar value when wartime spending and inflation ended. To restore the metallic standard to the prewar price of gold in paper money, prices quoted in paper money had to fall. The alternative was to accept the increased price of gold in paper money by devaluing the currency (that is, reducing money's purchasing power). After World War I, the British and the United States governments forced prices to fall, but many other countries devalued their currencies against gold. After World War II, all major countries accepted the higher wartime price level, and most devalued their currencies to avoid deflation and depression (Encyclopaedia Britannica, 2010).

The widespread use of paper money brought other problems. Since the cost of producing paper money is far lower than its exchange value, forgery is common (it cost about 4 cents to produce one piece of U.S. paper currency in 1999). Later the development of copying machines necessitated changes in paper and the use of metallic strips and other devices to make forgery more difficult. In addition, the use of machines to identify, count, or change currency increased the need for tests to identify genuine currency.

Since then, coin and paper money have been and will for many years to come remain a medium of exchange particularly in transactions that do not require electronic transfers. The volume of currency needed to transact the business of a country is determined, basically, by the volume of commodities and services in circulation. Ordinarily, the larger the volume of commodities and services, the greater the volume of currency needed to circulate them. During periods of increasing production, the volume of currency tends to rise; during recessions it may fall.

At Chirundu, all payments for goods and services are done in coin and paper money, and therefore there is a daily exchange of money between different individuals which acts an agent of transmission of microbes form one person to another.

2. Materials and Methods
2.1 Location and Description of Study Area
Chirundu border town is located at about 136 km south east of Lusaka the capital city of Zambia at coordinates 16° 3' S and 28° 50' E which also coincides with the border between Zambia and Zimbabwe (Figure 2), and has about 3,000 residents. It is one of the busiest border crossings in Zambia with more than 800 people crossing it on a daily basis and has an active daily money transactions involving open air currency exchange and ordinary buy - and - sell business transactions, suggesting a high currency turnover on a daily basis.

Figure 2: Location of Chirundu Border Post (Source: Nations Online Project)

2.2 Field Methods
The target population comprised mainly street vendors, marketers, and known regular travellers, owners of small shops locally called *Tuntemba* because these are the ones that usually exchange money at a higher frequency than ordinary travellers or formal merchants and their money has a potential to carry microbes of public health concern.

2.2.1 Collection of Money Samples, Paper Money and Coins

Paper and coin money of the denominations K100, K50, K20, K10, K5, K2, and coins K1, (USD 1 equivalent to K10) (Figure 3) were collected through buying goods from traders and getting change in return, in some instances interviewees agreed to release money on exchange basis while others willingly gave to the survey team free of charge particularly smaller denominations. Ten samples of each denomination were collected and immediately secured in sterile plastic pockets to prevent contamination through handling, and later taken to the laboratory for culture and species identification. Each sample was given an identification number which enabled us to trace the source of the money. The currency was divided into two categories; i) small denominations which included K1 to K20, and large denominations of K50 and K100, because it was thought that smaller denominations were exchanged more frequently than large denominations, and ii) paper money and coins.

Figure 3 Kwacha Denominations Collected in the Sample.

Testing of the money samples collected was carried out by weighing and putting the sample in 300 ml of sterile water so as to free bacteria into water for at least 2 hours a method well explained by Gijzen and Magingo (1991) and Dubey and Maheswari (2006). A sterile membrane filter was then placed on the filter support using forceps sterilized by flaming which prevents contamination if it were to be handled with hands. It was then placed in matched metal funnel secured into place with metal clamp. About 100 ml of each bacteria sample was poured and the vacuum pump switched on for suction and eventual filtration. After the sample had passed through the filter, the pump was then switched off and the funnel rinsed with about 20 ml of sterile water. The membrane was picked from the funnel and placed into a solidified medium ensuring that no air bubbles were trapped under the filter. A petri dish (see Figure 4a and b) was then placed in an incubator for no less than 24 hours, to allow colonies to

develop. In this method, total coliforms appear dark sheen, feacal coliforms appear blue and *Eschericia coli* appears red and where; Coliforms/ g = No. of coliforms counted/ weighed samples (money). If the medium was free of contamination then there would be no colonies formed.

2.2.1 Investigating Money Handling Practices between Males and Females

A total of 100 questionnaires for each category were randomly distributed to get people's views on money handling practices; where currency $\geq$ or $\leq$ ZK 1000 (USD 100) was kept by men or women and handling of money after using the toilet by both males and females. Interviews were also done with 100 males and females to investigate whether they used saliva to wet fingers when counting paper money and also whether they handled money while eating without washing hands. Questionnaires were used in instances where it was thought that interviewees would feel shy to give answers if they were interviewed in person. In order to ensure privacy where necessary, respondents were only asked to put gender and occupation and not their name.

The merits of the questionnaire method were that; i) it was free from bias of the interviewer which provided interviewees with an opportunity to answer in their own words, ii) respondents had enough time to read through and give good answers. In handing out questionnaires to each interviewee it was assumed that they all understood English as a precondition.

Before applying this method, a pilot study for testing the questionnaire was conducted to detect weaknesses in the questionnaire, during which time an undergraduate student was used as part of her project. The questionnaires and interview guides were then refined to improve effectiveness in collecting the relevant information. Sensitive questions that were seen to arouse emotional responses were removed at this stage.

The questionnaires and interview guides were designed in such away that they captured data on gender of respondents, ii) nationality and or whether visitor or resident, iii) major activities for which money was used, iv) how often money was exchanged, and v) denominations commonly used, v) as well as inquiring if respondents knew any health risks associated with money and how that would be avoided.

The nature of questions was diverse to capture a wide array of data sets. For example, i) closed format questions; in this category, respondents selected from sets of predetermined answers which were - dichotomous, multiple choice, multiple responses, rank/match or likert scale formats, ii) in dichotomous questions; respondents answered yes or no and a provision for don't know was also given, iii) in multiple choice questions there were no restrictions on the number of options given, respondents were also able to answer 'don't know', ''all'' or none. The respondents were allowed to answer 'don't know' in instances where they did not have an answer such as, do you know any health risks associated with physical handling of money?, iv) in ranking format questions; choices were ranked in order of importance, with the least important coming last, and v) in likert questions; visitors had the choice to respond and indicate the level of agreement such as; strongly agree, disagree, strongly disagree or neither. In rating questions visitors were able to rate based on some attribute from poor to excellent as earlier described by Gosh (2013).

3. Results

All the questionnaires provided for each category were dully completed and therefore collected, hence a 100 percent questionnaire return success.

3.1 Levels of Microbes on Money

The bacteriological examination of money collected and tested showed that all paper money samples had bacterial colonies (Figure 4 a, b). There were total coliforms, feacal coliforms and *Escherichia coli*.

(a)

(b)

Figure 4a and b, Total coliforms on petri dishes with dark sheen appearance, feacal coliform appeared blue and *Eschericia coli* appeared red

3.1.1 Microbial Levels and Currency Denominations

Of all currency denominations sampled, K2, K20 and K5 had the highest load, (χ^2 = 18.31, DF = 10, α = 0.05, P < 0.05), while K100 which is also the largest denomination had the least. K10 and K50 did not have any microbes (Figure 4). A comparison between paper money and coins showed that coins did not carry any microbes (Figure 5).
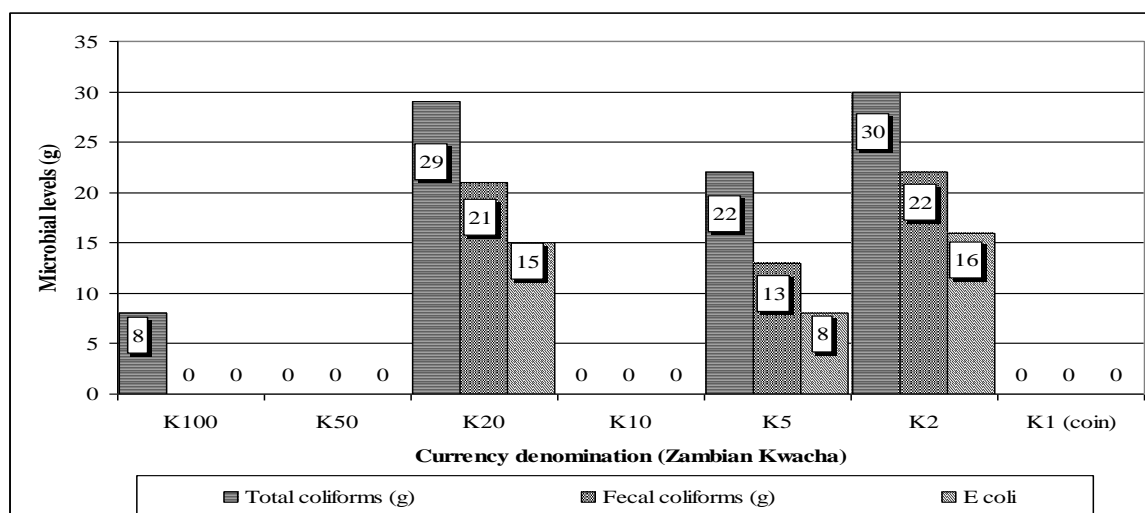
Figure 5 Comparison of microbial levels between currency denominations and between paper money and coins.

3.2 Money Handling Practices
3.2.1 Where Money is Kept by Males when it is Greater and Less than ZMK 1,000 (USD 100)

Handling of money varied between males and females. When currency exceeded ZK 1,000 the most popular method of keeping it was in an undergarment locally named *Bombasa* (60%) ($\chi^2 = 9.49$, DF = 4, $\alpha = 0.05$, P < 0.05), in socks (20%) and the least was in the pocket of a shirt (3%) (Figure 6a). The pattern however changed when the amount was less than ZMK 1000, when the popular place was the rear pocket of the trousers 55 % ($\chi^2 = 9.49$, DF = 4, $\alpha = 0.05$, P < 0.05), and the least was front pocket of trousers or short 5% each, while none was kept in the socks or *Bombasa* (Figure 6b).

3.2.2 Where Money is Kept by Females When it is Greater and Less than ZMK 1,000 (USD 100)

Females kept money in different places from males except for *Bombasa* in which most of the money was kept by both males and females 75% ($\chi^2 = 9.49$, DF = 4, $\alpha = 0.05$, P < 0.05), the second most popular was hand bag or purse 18%, and the least was bra 2% (Figure 7a). When the money was less than ZMK 1000, most of the money was kept in the hand bag/purse. When the amount exceeded ZMK 1,000 most ladies (75%) like male counterparts kept money in *Bombasa.*
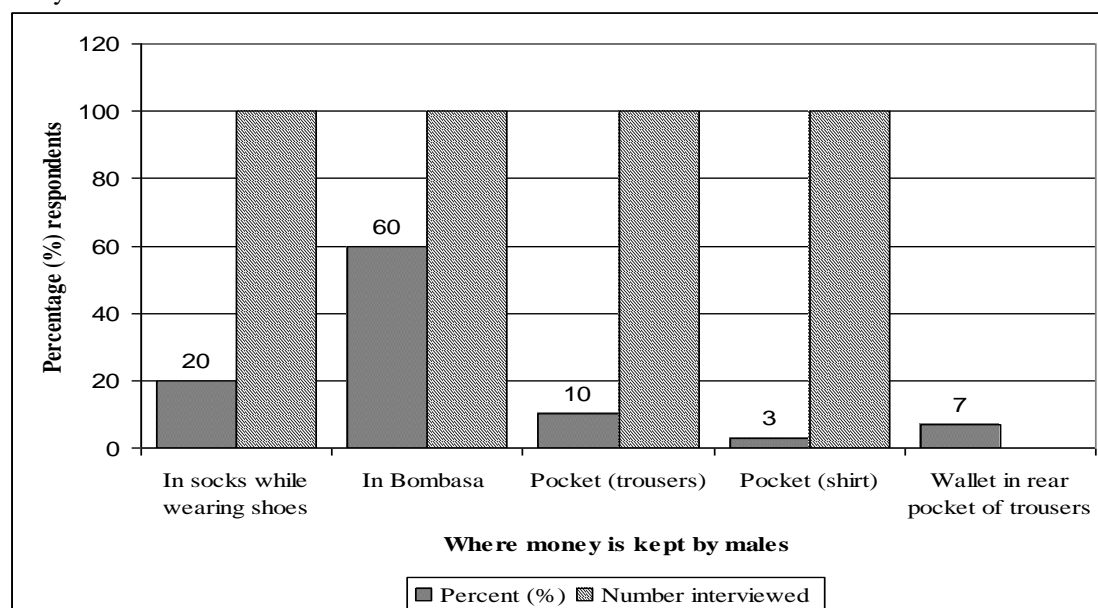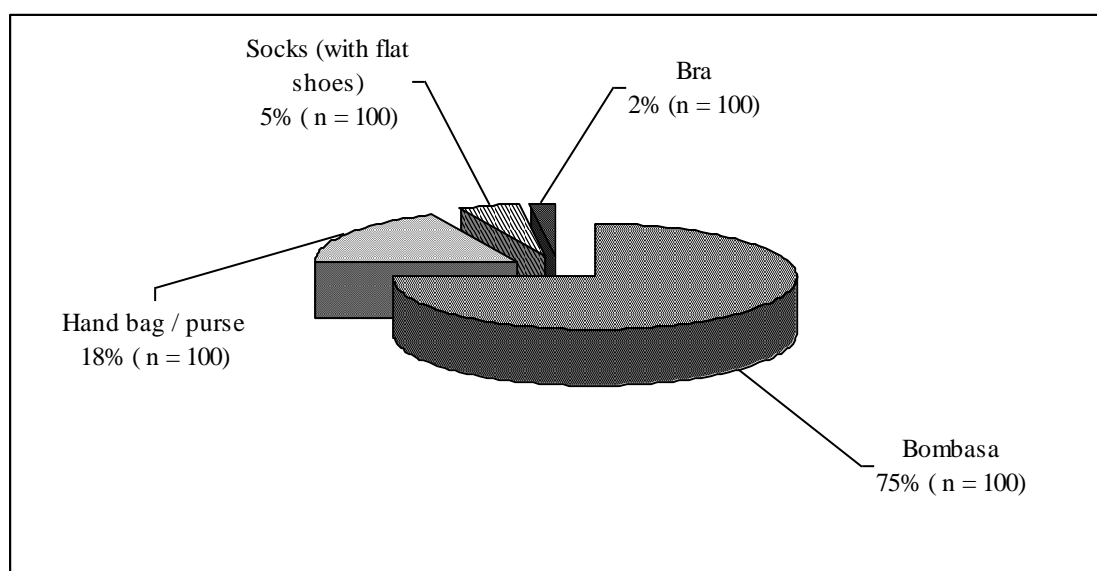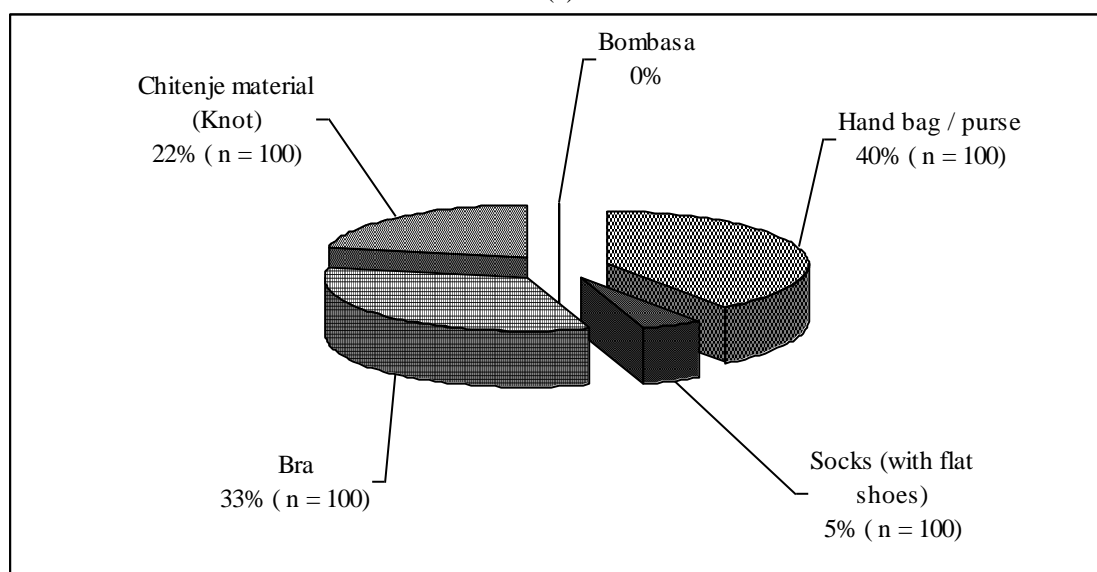

(a)
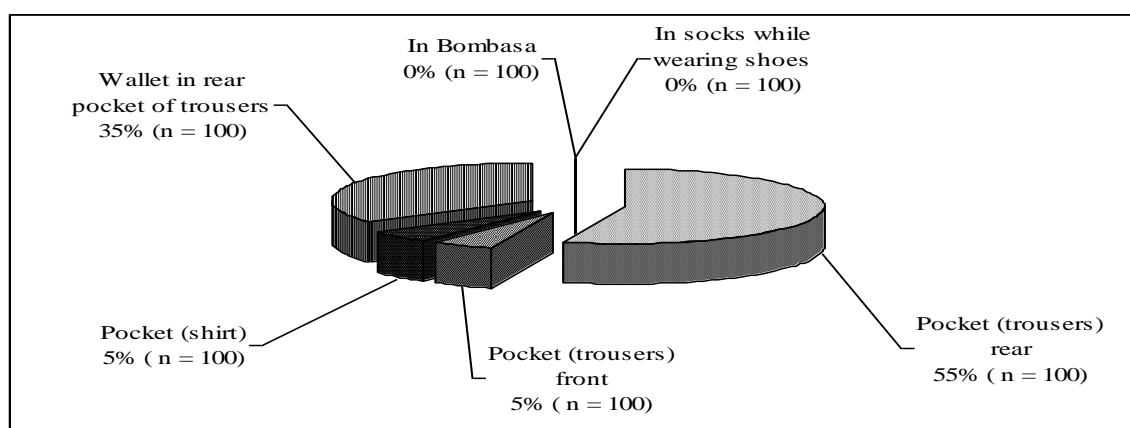
(b)

Figure 6 a) Where money is kept by males when the amount exceeds ZMK 1000, and b) when it was less than ZMK 1,000.

(a)

(b)

Figure 7a) Where Females Keep Money when it Exceeded ZMK 1,000, b) When it is Less than ZMK 1,000

3.2.3 Handling Money after Using a Toilet and Counting Money Using Saliva

Females were more cautious in washing hands after using the toilet before handling money than males. Of all

female respondents only 13 % (n = 100) handled money before washing hands while a larger number of males 35 % (n = 100) handled money before washing hands (Figure 8).
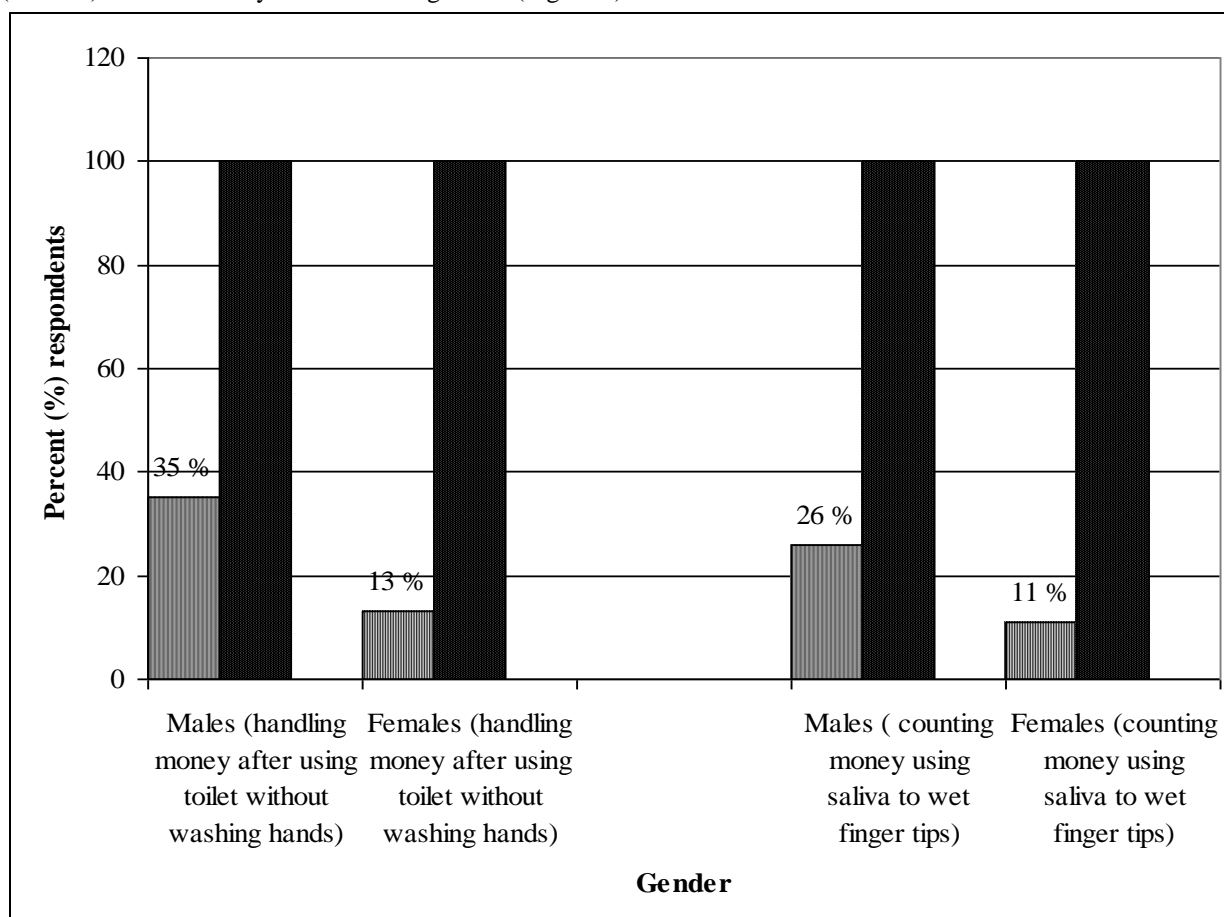

Figure 8 Handling of money before washing hands after using the toilet and counting money using saliva as finger wetting agent.
Notes: Fewer females (13%) handled money before washing hands after using the toilet than males where 35% handled money before washing hands.

With regard to counting money using saliva, more males 26 % (n = 100) used saliva to wet their finger tips when counting money. Fewer females 11% (n = 100) used saliva, suggesting that females were more aware of health risks associated with handling money after using the toilet without washing hands and counting paper money using saliva to wet finger tips (Figure 8).

3.2.4 Handling Money While Eating and Breast Feeding
A large proportion of females 75 % (n = 100) (χ^2 = 7.81, DF = 3, α = 0.05, P < 0.05) handled money while eating without washing hands and another 10% (n = 100) even breast fed their babies after handling money without washing hands. Fewer males handled money while eating and without washing hands 30% (n = 100) (Figure 9).
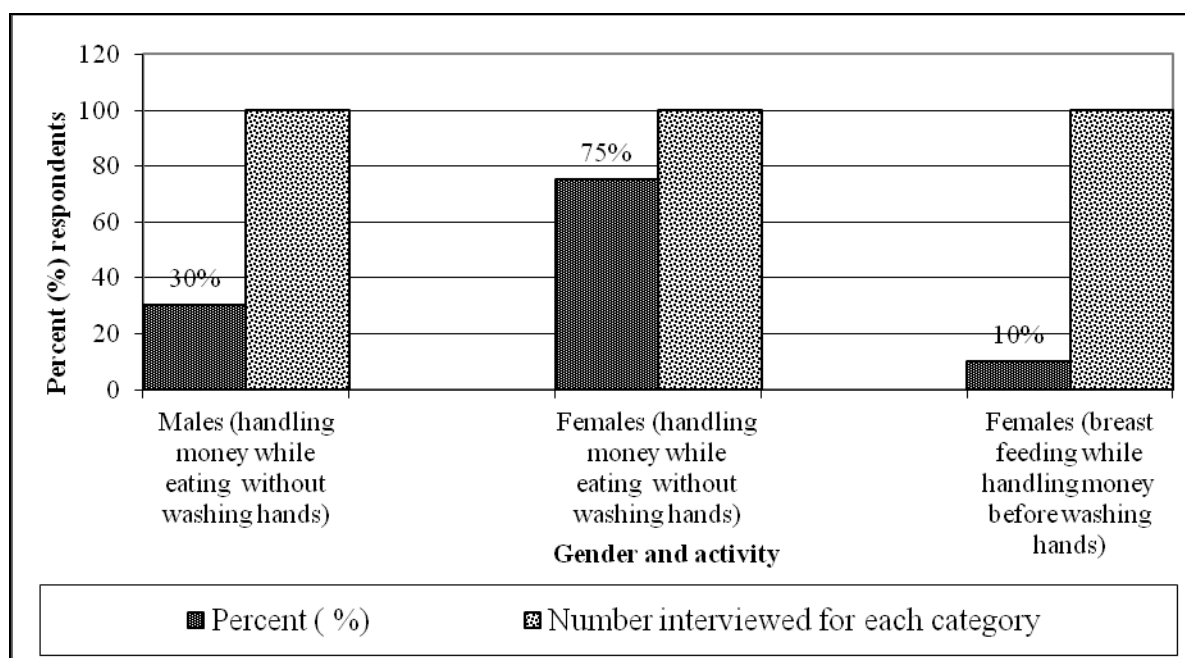
Figure 9 Physical handling of money while eating without washing hands and breast feeding

4. Discussion, Conclusion and Recommendations
4.1 Discussion
4.1.1 Levels of Microbes on Money

Money is a commodity accepted by general consent as a medium of economic exchange. It is the medium in which prices and values are expressed; money as currency therefore, circulates anonymously from person to person and country to country, thus facilitating trade and exchange of goods and services and as principal measure of wealth is the most desired possession in the world. The subject of money has fascinated people from the time of Aristotle to the present day. The piece of paper labeled k2, k5, 10, k20, k50 and k100 (Zambian currency) (see Figure 3) is of no little difference, from other pieces of paper of the same size torn from an exercise book, newspaper or magazine, yet it enables its bearer to command some measure of food, drink, clothing, and other goods and services of life while the other is fit only to be discarded. The contrivance lies in the words written on it. People accept money as such because they know that others will. This common knowledge makes these pieces of paper valuable because everyone thinks they are, and everyone thinks they are because in his or her experience money has always been accepted in exchange for valuable goods, assets, or services.

At bottom, money is, then, a social convention, but a convention of uncommon strength that people will abide by even under extreme provocation (Encyclopaedia Brittanica, 2010).

As such it is the most exchanged form of possession than any other. In exchange, each person unknowingly or knowingly introduce in an unintended passive inoculation of various species of microbes present on them to another person. In the process several species of microbes may occupy money surfaces for an unspecified period of time for as long as conditions remain optimum for their survival. This explains why smaller denominations which are more often exchanged between individuals contained the highest levels of total coliforms, feacal coliforms and *Escherichia coli.* The absence of microbes on coins in this survey does not imply that they are clean but may only suggest that because the value of coins is very low in Zambia, very few people use them and hence the frequency of exchange may also be low. In countries where coins have high value such as reported by Igumbor, et al. (2007) in Limpoopo South Africa showed no significant difference in the levels of microbes between paper money and coins. Reports from countries in Asia in particular have also shown that coins carry similar high levels of microbes as paper money (Brady and Kelly (2000).

Similar results on bacteriological examination of currency notes in Atbara Town in Sudan carried out by Al-Ghamdi (2011) showed that currency notes and coins were agents of transmission of microorganisms because they passed freely from hand to hand as a medium of exchange. Such hands usually are not washed before and after handling money. In that survey, a total of 60 samples of Sudanese Pounds (1, 2, 5 and 10 for paper notes and one pound only for coin currency) were randomly collected from different sources at Atbara town from bus conductors, butcher, vegetable sellers, and restaurant and grocery owners and analysed for bacterial contamination.

Among the total aerobic bacteria, 98% were contaminated with coliform bacteria, 98 % showed presence of *Staphylococci,* 90 % for *Bacillus spp.* The percentage of predominant bacteria found in paper currency notes were *Staphylococcus aureus* (33. 5%)*, Eschericia coli* (41.8 %)*, Staphylococcus epidermidis* (36.7%)*, Streptococcus* spp. (3 6.8%)*, Bacillus* spp. (27.8%)*, Micrococcus* spp (6.7%), while in coins were*, Staphylococcus aureus* (17.7%),

Eschericia coli (13.3 %), *Staphylococcus epidermidis* (17.8. %), *Streptococcus* spp., (17.8%), *Bacillus* spp., (6.7%) *Shigella* spp., (4.4%) isolated from coins. Paper notes were heavily contaminated when compared with coins as was the case in this study. The presence of high microbial load on currency notes and coins indicated the potential of such currencies being major agents in spreading disease in the community.

A similar study in Bangladesh including results by Jiang and Doyle (1999) dealing with paper currency notes (Taka) in circulation revealed active presence of various species of microbes most of if not all of them being disease causing agents; *Escherichia coli 58%, Klebsiella pneumoniae (50%), Staphylococcus aureus* (25 %), *Salmonella* (15 %), *Bacillus* (9%), *Pseudomonas* spp., (7%) and *'Vibrio cholerae* (5%). A hundred and sixty nine bacterial isolates were recovered belonging to these seven species. Currency notes collected from fish sellers, meat sellers, vegetable sellers, food vendors, office workers, students, bus conductors, beggars and shop keepers had 42.85% - 85.71% *Escherichia coli,* 28.57% - 92.85%, *Klebsiella* spp., 9.09% - 53.84% *Staphylococcus aureus*, 0% - 42.85% *Salmonella* spp., 0% - 28.57% *Vibrio cholerae,* 0% - 25% *Bacillus* spp., and, 0% - 28.57% *Pseudomona* spp., respectively. The study suggested that Bangladesh paper currency was commonly contaminated with pathogenic microorganisms and this contamination played a significant role in the transmission of potentially harmful microorganisms or different diseases such as cholera, diarrhoea, skin infections which in away contributed to the accentuated levels of widespread antibiotic resistance. Great care was needed during handling of money and the preparation and handling of food to avoid cross contamination.

Another study carried out in Nepal (Murray, 2003) using currency polymer notes and coins, involved 63 samples of polymer notes and coins from different professionals of different places at Kathmandu the capital city of Nepal. Results showed that paper/ polymer and coin samples had, 98.4% heterotrophic aerobic bacteria, 87.3% were contaminated with coliform bacteria and 79.4% showed presence of *Staphylococci*. Contamination levels were found in increasing order from coins to polymer notes. Similar results were also obtained from India by Basaravajappa, *et al.,* (2005).

In Poland another similar study was carried out on polymer notes and coins to determine the presence of bacteria and fungi. Fungal isolates were recognized using biochemical and morphological criteria. Coagulase-negative *Staphylococci*, (43.6% of the total bacterial count) including, *Enteroccus* spp., (30.8% comprising *E. faecalis, E. faecium* and *E. durans* of the total bacterial count), were the most numerous bacterial contaminations. *Penicillium* spp., and *Aspergillus* spp., were also present. Among fungi were *Candida* spp., yeast also isolated from currency. Total amount of bacteria and fungi recovered from the coins was approximately 2.7 - fold lower than that isolated from the notes. In summary, the Polish currency notes were found to be heavily contaminated mainly with commensally oriented bacteria and fungi while the opportunistic pathogenic microorganisms *Escherichia coli, Pseudomonas stutzeri* and *Candida albicans* were detected at a low frequency.

In Nigeria even cysts of parasites were isolated (Ogo et al., 2004) and a visible dependence between the bank note denomination, the physical condition of paper currency, and the number of bacteria and fungi was found. Overall count of bacteria isolated from currency was a thousand fold higher than that of fungal isolates. Again from the same populous Nigeria, Okungbowa and Dede (2010) isolated various fungi from Naira notes (Nigerian currency) with varying frequencies. A year later, Ayandele and Adeniyi (2011) isolated 79 different microorganisms from Naira notes and some of the prevalent microbes included *Staphylococcus aureus (3.8), Staphylococcus epidermidis* (11.4%), *Escherichia coli* (3.8%), *Pseudomonas putida, Aeromona shydrophila* (6.3%), *Fusarium solani* (5.1%), *Colletotrichum gloesporoides* (7.6%). Orukotan and Yabaya (2011) also surveyed Naira notes, comprising of all the denominations for microbial contamination in Kaduna city in North central Nigeria and recovered from these notes fungi and bacteria including *Escherichia coli, Bacillus* spp*., Salmonella* spp., *Streptococcus* spp., *Staphylococcus aureus, Proteus* spp., *Klebsiella* spp., *Micrococcus* spp., *Fusarium* spp., *Penicillium* spp., *Aspergillus* spp*.,* and *Rhizopus* spp.,. Among the fungal isolates were *Aspergillus* spp., which is commonly associated with organic debris.

Few other additional studies carried out in Nigeria revealed parasite cysts and eggs on dirty and mutilated Naira currency, whereas the fresh notes had no parasites (Ameh and Balogun, 1997; Ogo *et al*., 2004; Matur *et al*., 2010). It was observed that the presence of dirt on notes was related with the presence of cysts or eggs of the parasites. These cysts and eggs recovered from the mutilated notes were of high socio-economic importance as they posed danger to human health for example *Entamoeba histolytica* and *Ascaris lumbricoides* were easily transmitted orally and the results obtained from Chirundu during this study where both males and females were recorded to handle money while eating without washing hands is a major challenge to public health. An important study conducted by (Matur *et al.,* 2010) reported that out of the 200 Naira notes that were examined, 32% were contaminated with various species of parasites and 58% with bacteria, whereas the fresh notes had no contamination. Parasites encountered included *Ascaris lumbricoides* eggs (4.5%), hookworm ova (8.5%), eggs of lice of genus *Enterobius* (0.5%), and flagellate cysts (1.5%). They also recovered bacteria including *Staphylococcus* spp., (30.5%), *Escherichia coli* (9.0%), *Klebsiella* spp., (6.5%), *Pseudomonas* spp., (6.5%) and *Proteus* spp., (5.5%).

According to (Awe *et al.,* 2010), microorganisms on the skin can be transferred from cashiers, sales people and the general public to the currency notes that they handle (Badvi *et al.*, 2010) and then passed on to the next person. Paper currency can also be contaminated by droplets during coughing, sneezing, touching with previously

contaminated hands or other materials and by their placement on dirty surfaces (Ahmed *et al.,* 2010). Use of Automated Tailor Machines (ATM), are no exception as different people touch the same buttons on a daily basis to draw money and hence depositing various species of microbes.

4.1.2 Money Handling Practices and Health Risks Associated with Money Handling

Most of the people in the world present and in the past have practiced cleanliness and personal hygiene, often for religious reasons, including, apparently, a wish to be pure in the eyes of their gods. The Old Testament, for example, cites many adjurations and prohibitions about clean and unclean living. Religion, law, and custom were inextricably interwoven. For thousands of years human societies looked upon epidemics as divine judgments on the wickedness of mankind. The idea that pestilence is due to natural causes, such as climate and physical environment, however, gradually developed. This great advance in thought took place first in Greece during the 5th and 4th centuries BC and represented the first attempt at a rational, scientific theory of disease causation (Encarta, 2009). The association between malaria and swamps, for example, was established very early (503–403 BC), even though the reasons for the association were obscure. The first attempt was made by Hippocrates in the 5th or 4th century BC, the first systematic attempt was made to set forth a causal relationship between human diseases and the environment. Until the new sciences of bacteriology and immunology emerged well into the 19th century, Hippocrates' writings provided a theoretical basis for the comprehension of endemic disease and epidemic disease (that affecting a number of people within a relatively short period) (Encyclopaedia Britannica, 2010).

In the middle ages the most outstanding incidences of public health concern were the plague of 542 and ending with the Black Death (bubonic plague) of 1348. Diseases in epidemic proportions included leprosy, bubonic plague, smallpox, tuberculosis, scabies, erysipelas, anthrax, trachoma, sweating sickness, and others. The isolation of persons with communicable diseases first arose in response to the spread of leprosy. This disease became a serious problem in the Middle Ages and particularly in the 13th and 14th centuries.

The Black Death reached the shores of southern Europe from the Middle East in 1348 and in three years swept throughout Europe. The chief method of combating plague was to isolate known or suspected cases as well as persons who had been in contact with them. The period of isolation at first was about 14 days and gradually was increased to 40 days. Stirred by the Black Death, public officials created a system of sanitary control to combat contagious diseases, using observation stations, isolation hospitals, and disinfection procedures. Major efforts to improve sanitation included the development of pure water supplies, garbage and sewage disposal, and food inspection. These efforts were especially important in the cities, where people lived in crowded conditions in a rural manner with many animals around their homes.

During the Middle Ages a number of first steps in public health were made; attempts to cope with the unsanitary conditions of the cities and, by means of quarantine, to limit the spread of disease, the establishment of hospitals; and provision of medical care and social assistance (Encyclopaedia Britannica, 2010). Centuries of technological advance culminated in the 16th and 17th centuries in a number of scientific accomplishments. Educated leaders of the time recognized that the political and economic strength of the state required that the population maintain good health.

No national health policies were developed yet, because governments lacked the knowledge and administrative machinery to carry out such policies. As a result, public health problems continued to be handled on a local community basis, as they had been and still in some isolated areas of the third world.
Scientific advances of the 16th and 17th centuries laid the foundations of anatomy and physiology. Observation and classification made possible the more precise recognition of diseases. The idea that microscopic organisms might cause communicable diseases had begun to take shape.

In the last decades of the 19th century the French chemist Louis Pasteur, the Germans Ferdinand Julius Cohn and Robert Koch, and others developed methods for isolating and characterizing bacteria; and concepts of antiseptic surgery. The English physician Ronald Ross identified the mosquito as the carrier of malaria; a French epidemiologist, Paul-Louis Simond, provided evidence that plague is primarily a disease of rats spread by rat fleas; and two Americans, Walter Reed and James Carroll, demonstrated that yellow fever was caused by a filterable virus carried by mosquitoes. Thus, modern public health and preventive medicine owe much to the early medical entomologists and bacteriologists (Enclopaedia Britannica, 2010; Cotran, Kumar and Collins, 1999). A further debt is owed to bacteriology because of its offshoot, immunology. So, disease transmission is not necessarily restricted to animal carries but even money during the normal day to day practices of buying and selling of goods. This general belief that disease can only be transmitted only through animal agents could be responsible for the poor money handling practices experienced at Chirundu and reported in this study.

In the nineteenth century, movements to improve sanitation occurred simultaneously in several European countries and were built upon foundations laid in the period between 1750 and 1830. From about 1750 the population of Europe increased rapidly, and with this increase came a heightened awareness of the large numbers of infant deaths and of the unsavoury conditions in prisons and in mental institutions.

This period also witnessed the beginning and the rapid growth of hospitals. Hospitals founded in Britain, as the result of voluntary efforts by private citizens, helped to create a pattern that was to become familiar in public health services. First, a social evil was recognized and studies were undertaken through individual initiative. These

efforts molded public opinion and attracted governmental attention. Finally, such agitation led to governmental action. This era was also characterized by efforts to educate people in health matters, a factor found wanting at Chirundu.

In recent years prenatal care has made a substantial contribution to preventive medicine, for it is hoped that through the education of mothers the physical and psychological health of families may be influenced and passed on to succeeding generations, but this seems to have evaded Chirundu residents because some women breast fed without suspecting that money kept in their bra could transmit harmful microbes to the baby. Prenatal care is supposed to include the opportunity to educate the mother in personal hygiene, diet, exercise, the damaging effects of smoking, the careful use of alcohol, and the dangers of drug abuse. Therefore, the money handling practices by mothers that breast feed with money in the bra, as reported in this study are linked to lack of knowledge.

Public health interests also have turned to such disorders as cancer, cardiac disease, thrombosis, lung disease, and arthritis, among others. There is increasing evidence that several of these disorders are caused by factors in the environment; for example, the association of cigarette smoking with certain lung and cardiovascular diseases. Theoretically, they are preventable if the environment can be altered, just like proper handling of money can reduce transmission of microbes of public health concern from one person to another, which means the low knowledge levels recorded in this study is a result of the lack of or inadequate public health awareness programme campaigns.

A comprehensive public health approach should have goals to prevent human disease, injury, and disability; protect people from environmental health hazards; promote behaviours that lead to good physical and mental health; educate the public about health; and assure availability of high quality health services. Public health workers rather than just engaging in the routine activities that include inspecting and licensing restaurants; conducting rodent and insect control programs; and checking the safety of housing, water, and food supplies should expand and include other areas of public health such as the role of physical handling of money as health risk because at the moment it is not perceived as a health risk a factor. Undermining the capacity of physical handling of money was the major factor accounting for high levels of inappropriate money handling practices at Chirundu recorded in this study.

Results obtained in this study showed high quantities of total coliforms which are a group of bacteria found mainly in the large intestine of humans and other warm blooded animals. The counts are used to determine the degree to which water has been polluted by sewage (Dunster and Dunster, 2000), implying therefore that money in circulation at Chirundu was usually contaminated and should have been handled with precaution, which further enforces the suggestion that public health workers at Chirundu only concentrated on routine functions leaving out some other areas of public health concern.

4.1.3 Selected Species of Microbes Found on Money and Diseases they Can Potentially Cause

The microbes isolated on money from this research and other similar studies in Africa and elsewhere are associated with various kinds of diseases. To mention just a few of them for instance; i) *Eschericia coli* causes urinary tract infections, wound infections, endotoxemia, endocarditis, abscess and others, ii) *Staphylococcus aureus* for instance which has been isolated on money in many countries is of great concern to humans as it is methicillin-resistant (MRSA), which is characterized by the presence of a single mutation that renders it resistant to methicillin, a semisynthetic penicillin used to treat *Staphylococcus* infections that are resistant to mold-derived penicillin. This strain of *S. aureus* was first isolated in the early 1960s, shortly after methicillin came into wide use as an antibiotic. Today methicillin is no longer used, but the strain of MRSA to which it gave rise is commonly found on the skin, in the nose, or in the blood or urine of humans. Some 50 million people worldwide are believed to carry MRSA, which is readily passed by skin contact but rarely causes infection in healthy individuals. However, very young children and elderly or ill patients in hospitals and nursing homes are particularly susceptible to MRSA infection, which is difficult to treat because of its resistance to most antibiotics. The treatment of MRSA infections with vancomycin, an antibiotic often considered as a last line of defense against MRSA, has led to the emergence of vancomycin-resistant *S. aureus* (VRSA), against which few agents are effective. In 2005 in the United States, deaths from MRSA (approximately 18,000) surpassed deaths from HIV/AIDS (approximately 17,000), underscoring the need for improved surveillance to prevent and control the spread of this potentially lethal organism (Encyclopaedia Britannica, 2010), iii) *Streptococcus pneumonia* causes lobar pneumonia and meningitis, iv)*Vibrio cholera* causes watery diarrhoea, cholera and others, v) *Klebsiella pneumonia* causes pneumonia, endotoxemia, endocarditis and others, vi)*Streptococcus meningitides* causes cerebrospinal meningitis, vii) *Samonella* spp., causes fever pain, diarrhoea, dysentery and others. The high rates of inappropriate physical handling of money in Chirundu suggests general lack of knowledge on money as a potential source of disease transmission.

4.2 Conclusion

No other subject in economics has been studied longer or more intensively than the subject of money. The result is a vast amount of documented experience and a well-developed body of theoretical analysis. The extent to which the students of monetary problems agree in their basic conclusions is concealed by the tendency of laypersons to exaggerate their differences. However, despite the great value attached to money its handling practices as we transact between businesses has been established in this study as a public health risk as also reported by Abrams and Waterman (1972) and is one area that cannot be avoided. The Zambian currency like other

currencies in other parts of the world, as also reported by Xu et.al. (2005) who conducted a comparative study from 17 countries is also contaminated with microbes of public health concern while levels of knowledge regarding the danger linked to physical handling of currency is very low.

4.3 Recommendations

Units of money are readily divisible, easily transported and transferred, and recognized instantly. Legal tender status guarantees final settlement. Currency protects anonymity, avoids record keeping, and permits lower costs of payment. But currency can be lost, stolen, or forged, so it is used most often for relatively small transactions or where anonymity is valued which is common at border posts where most transaction costs are less than USD 100 per transaction.

At national level it would be advisable to attempt to establish, encourage and monitor the use of electronic Commerce or e-commerce, which is the exchange of goods and services by means of the internet or other computer based networks. E-commerce follows the same basic principles as traditional commerce that is, buyers and sellers come together to exchange goods for money. But rather than conducting business in the traditional way in stores and other "brick and mortar" buildings or through mail order catalogs and telephone operators, in e-commerce buyers and sellers transact business over networked computers. This offers buyers convenience. They can visit the World Wide Web sites of multiple vendors 24 hours a day and seven days a week to compare prices and make purchases, without having to leave their homes or offices. In some cases, consumers can immediately obtain a product or service, such as an electronic book, a music file, or computer software, by downloading it over the internet.

For sellers, e-commerce offers a way to cut costs and expand their markets. They do not need to build, staff, or maintain a store or print and distribute mail order catalogs. Automated order tracking and billing systems cut additional labour costs, and if the product or service can be downloaded, e-commerce eliminates distribution costs. Because they sell over the global internet, sellers have the potential to market their products or services globally and are not limited by the physical location of a store. Internet technologies also permit sellers to track the interests and preferences of their customers with the customer's permission and then use this information to build an ongoing relationship with the customer by customizing products and services to meet the customer's needs.

However, e-commerce also has some disadvantages. Consumers are reluctant to buy some products online. Online furniture businesses, for example, have failed for the most part because customers want to test the comfort of an expensive item such as a sofa before they purchase it. Many people also consider shopping a social experience. For instance, they may enjoy going to a store or a shopping mall with friends or family, an experience that they cannot duplicate online. Consumers also need to be reassured that credit card transactions are secure and that their privacy is respected. In attempting this practice government authorities should carry out a thorough survey and be satisfied that it can work. In doing so, the Zambia Revenue Authority (ZRA) should equally develop ways of taxing online transactions because internet is largely a taxi free zone. Security is also necessary and as good as privacy so that customer information is not shared with other businesses.

Explore the possibility of introducing and monitoring public money cleaning and disinfecting facilities. This should be accompanied by public awareness campaigns. People can purchase units to use these facilities in the same manner Zambia Electricity Supply Corporation (ZESCO) units are purchased and used. These facilities can work like money booths in some developed countries such as Japan, where any person that needs coins to buy a train ticket for instance, would push in paper currency and collect coins with change. These facilities would start with busy places such as border places, markets, hospitals and bus stations.

Many diseases are preventable through healthy living, and a primary public health goal is to educate the general public about how to prevent diseases. Public health campaigns teach people about the value of avoiding smoking, getting treatment for high blood pressure, avoiding foods high in cholesterol and fat, and maintaining a healthy body weight. Other campaigns educate the public on ways to prevent birth defects, such as abstaining from alcohol during pregnancy to prevent foetal alcohol syndrome, such programmes should include money handling practices. The modality should be to conduct massive awareness campaigns regarding health risks involved in physical handling of money and advise them to secure their money in appropriate places. This would ensure that all efforts are brought together into one network of integrated services that reaches to the community level.

Encourage the use of Automated Teller Machines (ATMs). ATMs make money more readily available and more convenient to use by accepting transactions even when banks are closed, be it on weekends or holidays or at any time of the day. ATMs also overcome geographic and national boundaries by allowing travelers to conduct transactions in many parts of the world. However, a study would be required to investigate to what extent these machines would contribute to the transmission of microbes because, several people press the same buttons in a day every day throughout the year and many of these people could have not washed their hands (*sensu* Barro et al . 2006; Beumer, R. 2007). Further investigation may be required before up scaling this application.

For public services such bus and train transport for instance, encourage the use of "smart cards" or stored-value cards which contain a computer chip that can make and receive payments while recording each new balance on the card. Users purchase the smart card (usually with currency or deposits) and can use it in place of currency. The issuer of the smart card holds the balance (float e.g. ZANACO) and thus earns interest that may pay for

maintaining the system. Most often the cards have a single purpose or use, such as making telephone calls, paying parking meters, or urban transport systems. They retain some of the anonymity of currency, but they are not "generally accepted" as a means of payment beyond their dedicated purpose. There should be a move towards a "cashless society".

The, public's preference regarding the denominations K 1 - K100 suggest that small denominations were more popular while the common denominations loaded in ATMs are larger denominations usually K50 and K100, which means that most traders rarely use ATM facilities, but would rather keep cash. On a much broader scale, therefore small denominations usually were not loaded in ATMs and were in circulation longer than larger denominations. The recommendation therefore is to compel the handlers of smaller denominations to pass through banking systems and have them cleaned up.

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