MintWorld Compendium

The finest source of comprehensive information focused on all topics connected with coin production

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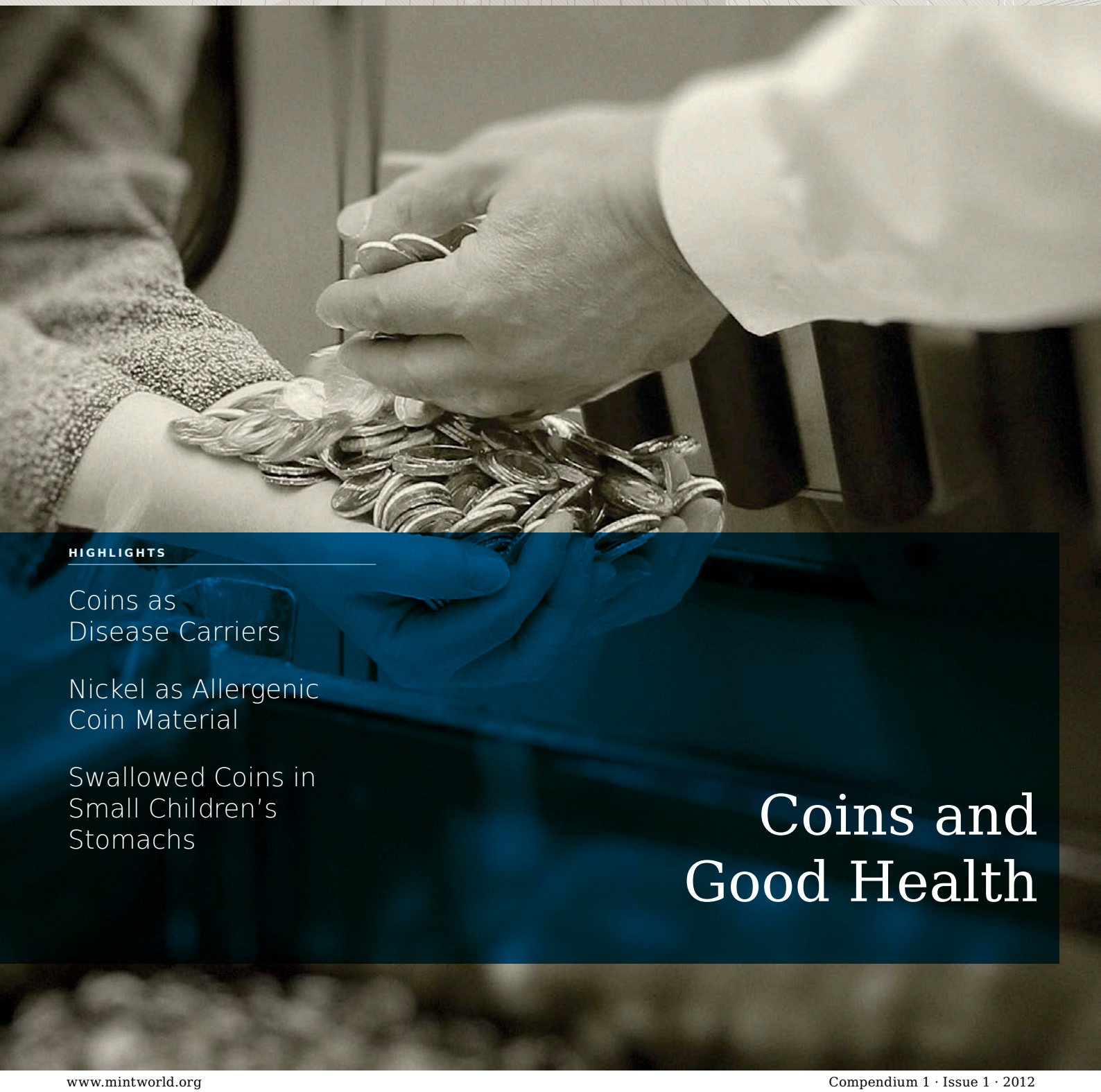

HIGHLIGHTS

Coins as Disease Carriers

Nickel as Allergenic Coin Material

Swallowed Coins in Small Children's Stomachs

Coins and Good Health

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Welcome to the World of Mints

Few markets are as international as the coin manufacturing industry and its suppliers. And in few markets is there such a variety of fellow players: politicians in central banks, technicians in supplier firms, artists in mints and marketing experts in selling commemorative coins – to name just a few of the most extreme contrasts.

We at Amera are campaigning for the cooperation of all those involved to be closer and therefore more fruitful. We regard as fundamental an impartial, professionally led platform giving room for updates and information. We therefore initiated MintWorld and MintWorld Compendium. This publication combines the advantages of the internet – through a monthly newsletter and a homepage with archive – with those of the printed publication which people still use as a reference years later to consult professional articles.

We have managed to acquire Dr. Ursula Kampmann as editor. With her good name she represents the editorial autonomy of MintWorld and MintWorld Compendium which we have guaranteed her by contract. She ensures impartial, objective and also entertaining information and the greatest variety in choice of topic possible.

MintWorld is at the moment financed by the firm German Expertise. However, we hope that other members from the world of mints, central banks and suppliers recognise the advantage that this form of publication offers, and play their part as sponsors and help to report more frequently and more extensively in MintWorld and MintWorld Compendium.

We have broken ground. It's up to us all to bring the idea of MintWorld to life.

Daniel Sheffer
Chairman Amera International AG

The first MintWorld Compendium in your hands

"Coins and Good Health" – we have chosen this topic for the first edition of the MintWorld Compendium. Why? It's quite simple: because there is hardly any other topic that is seen to be so controversial and discussed so much in the various countries. Whilst in the German newspapers there seemed to be concern for the life and health of the population due to the nickel content of the euro coins, the same euro was used in other countries completely unquestioningly. Whilst in the USA hundreds of children had to be operated on because they had swallowed a coin which triggered dangerous reactions in the stomach, this problem hardly plays a role in discussions about new materials.

Health may only be a side issue compared with the discussion about exploding costs of raw material, but a compilation of the current state of knowledge seemed to be sensible to us. For this reason we have chosen three areas:

- *coins as disease carriers*
- *nickel as allergenic coin material*
- *swallowed coins in small children's stomachs*

The leading scientists have sent us short summaries for each area explaining the current state of research. Supplementary articles put this research report in its context. And of course there will also be articles, which ensure entertaining reading.

We hope that this MintWorld Compendium is of use to you – maybe not straightaway, but at least if you have to make a decision about an issue of circulation coins again.

Ursula Kampmann
Editor of MintWorld and MintWorld Compendium

Bacteria and Viruses – Necessary basics

Bacteria and viruses are the pathogens for a multitude of diseases. Both can arrive on or in the human body by contact or smear infection, caused, for example, by touching a coin or a banknote. From such sources bacteria can cause diseases such as cholera or tuberculosis, while viruses can cause influenza, hepatitis B and AIDS. The two pathogens are quite distinct from each other.

Bacteria are single-celled organisms with no cell nucleus. They can operate their own metabolism and reproduce themselves by cell-division, in other words, by cloning themselves. The largest bacterium has a diameter of about 0.7 mm and can therefore be distinguished with the naked eye. Indeed, its volume

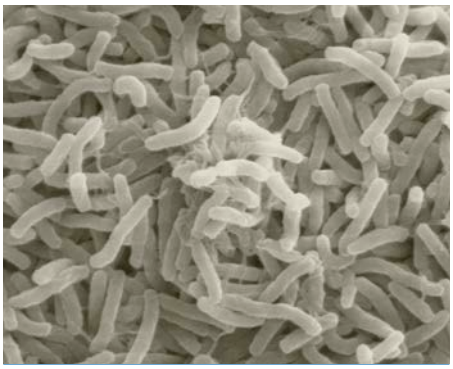

Figure 1 Cholera bacterium: Cholera bacteria (Vibrio cholerae) (secondary electron microscopy). Typical dimensions are 2-3 micro metres long, 0.5 micrometres thick. Source: Wikipedia

exceeds that of the smallest bacterium by tens of thousands of millions of times. Because they are relatively large, the researcher, Antoni van Leeuwenhoek has been able to examine 1676 bacteria under a light optical microscope.

Bacteria have considerable importance in the environment. For instance, the metabolic action of bacteria in the soil makes mineral nutrients accessible to plants. They perform important functions even in the human body. The human being is made up of some 10 billion cells, but carries on and in it ten times as many bacteria. One billion of the single-celled creatures live on the skin alone. The majority, however, colonise the digestive tract and make up what is known as the intestinal flora and it is they which allow the intestine to perform the functions which are essential for our survival.

Nevertheless, the metabolic secretions of certain types of bacteria cause the human being to become ill. Thus, certain microbial strains of the intestinal bacterium Escherichia coli (EHEC) are extremely useful in the intestine. If, however, there should be any contact with this bacterium outside the intestine, the result can be outbreaks of serious diseases. Anti-biotics can prevent these bacteria from forming a new cell wall after the cloning process. Individual pathogens have over time, however, become resistant to anti-biotics.

Viruses were discovered only some hundred years ago, since they are about one hundred times smaller than bacteria. Researchers are still debating

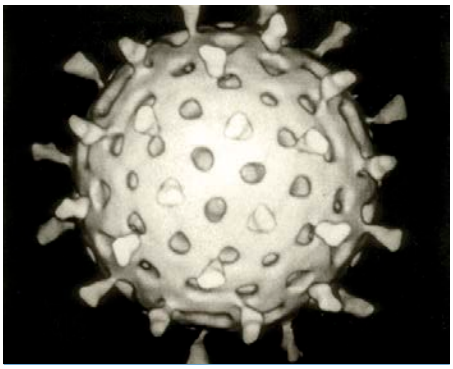

Figure 2 Computer assisted reconstruction of a rotavirus particle. Source: Graham Colm / Wikipedia

whether viruses are living organisms, since many of them carry unusually voluminous genetic material. Viruses are also single-celled organisms, but are unable to perform any independent metabolic processes and therefore cannot reproduce autonomously. In order to reproduce they need a host cell, in which the virus takes up residence. These host cells can be cells of the human body, but they can also be bacteria. The virus carries only its DNA, or genetic material and a programme for its reproduction, which controls the host cell.

Anti-viral agents often cause side effects in patients, because they must either prevent the virus from penetrating into the body, or - if the pathogen has already taken up residence - they must act on the cell metabolism; as a third possibility the agents can also prevent the new viruses from escaping from the somatic cell. All these types of intervention however can only with difficulty be reconciled with cell metabolism.

Viruses and bacteria have one thing in common; they cause diseases, which depending on their pervasiveness can spread and cause an epidemic (one cumulative occurrence within a defined region) or even a pandemic (one cumulative occurrence over different locations at some distance from each other). For instance, the infamous Plague in the Middle Ages was caused by bacteria and the dreaded „Spanish Flu“ (1918-1920), which is estimated to have resulted in 25 to 50 million deaths, was caused by viruses. These different types of pathogens each have the capacity to survive for varying lengths of time, depending on the environmental conditions to which they are exposed. Many survive in frost and die in heat, whereas others actually need warmth for their survival. In addition the course and possibilities for disease control are individually and quite specifically limited. However, all these pathogens have the potential to survive and to be transported on money. And this is how money may play a role in the spread of disease pathogens, to which hitherto very little attention has been paid.

Pathogens and Money – the Current State of Research

Whereas the function of banknotes as carriers of pathogens has been studied in detail, research into the similar role of coins is still in its infancy, principally because coins seem to play a considerably lesser role in the transmission chain than bank notes.

Bank notes versus coins
A team of Australian and New Zealand scientists led by Frank Vriesekoop compared coins and notes from the two countries north and south of the Tasmanian Sea. The bank notes analysed were composed not of cotton-based, but of polymer materials. The team found on average 10 bacterium cells per square centimetre on them. This is clearly more than on coins. Only one or two bacterium cells survived on these, which the researchers attributed to the copper and nickel content of the coins. It is conceivable that these two metals kill bacteria. This has yet to be proved.

The scientists were astonished, when as well as Escherichia coli and Staphylococcus aureus they also found Salmonella bacteria - all of them bacteria, which are usually transmitted by poor standards of hygiene and which can cause diarrhoeal diseases. Especially in groups at risk (pregnant women, elderly people, those debilitated by pre-existing conditions or children) the consequences can be fatal. Pathogens resistant to anti-biotics could also be identified. Although the bulk of the finds were surprisingly negative, the quantity of pathogens lay, nonetheless, in a small area.

How long do the pathogens survive?
And how long do these pathogens survive on banknotes? Specialists in Geneva subjected the cultures, which they had found on Swiss banknotes, to an investigation. Influenza A viruses survived in high concentration for up to three days. This time span lengthened considerably, if the cell cultures were coated in mucus from the respiratory passages. Then they did not die until after 17 days. The result for Influenza B viruses was entirely similar. In the normal case, the viruses are dangerous only in the first two hours. When they were embedded in mucus, they remained infectious for more than 24 hours. The authors of the study concluded that the capacity for flu viruses to survive for longer on banknotes under certain circumstances should be considered, where there was a need to prepare for pandemic scenarios.

Money in circulation as a mapping device for the spread of a pandemic.
Banknotes are not just carriers of bacteria and viruses. They have in the meantime become an aid to our understanding of how a pandemic spreads in our globalised society. The pathogens are usually - like banknotes - passed directly from human being to human being. However there is still no common model for the pattern of human movement. It is unclear how rapidly and how far pathogens can spread.

The "Where's George?" project in the United States is seeking such a common model. The aim of the project is to predict the routes people may take and on which they may spread individual pathogens. For this purpose the project is tracking via the Internet the routes taken by banknotes by means of the numerical codes printed on them. Volunteers regularly inform the project about the numbers of the banknotes in their wallets. In this way the speed with which any given banknote has travelled a given distance can be tracked. In the meantime similar projects have been set up for Canadian banknotes and Euro banknotes.

Photo: 1100 / photocase.com

Always good for a headline: Drugs and money

Anyone who works with banknotes in the United States discovers that it is not only the usual microbes which turn up there. Banknotes are a reflection of everything which comes in contact with them. In the United States traces of cocaine are so widespread on banknotes, that the police have given up suspecting that the owners of such banknotes are themselves drug users. Money counting machines can distribute cocaine particles from a contaminated note over countless other banknotes.

Cocaine hydrochloride, Photo: dye / photocase.com

Cocaine particles seem not to adhere to coins, whose surfaces are too smooth.

Hygiene factors in banknotes

Not all banknotes are the same. A study at the University of Wageningen in 2010 (Frank Vriesekoop was also leader of this project) concentrated on the nature and structure of paper money and the differences which there are in various countries across the world - with the consequences of this on potential pathogens. 1280 banknotes from ten different countries were put to the test.

Two aspects emerged as central for the concentration of pathogens on notes: the nature and structure of the notes and how long they had been in circulation. On polymer based banknotes (like those used in Australia, New Zealand or to some extent in Mexico) bacteria were present in a quantity only some 25 % of the quantity found on cotton-based banknotes. This must have something to do with the clearly smoother surface structure. Equally significantly, the quantity of bacteria decreased the higher the country, from which the notes originated, was rated on the Index of Economic Freedom. This in turn is explained by the higher standards of hygiene in the wealthier countries, but also by the shorter time the banknotes are in circulation. The longer a banknote is in circulation and in use, the more creased and crumpled it becomes. Contaminants take up residence on these uneven surfaces more easily than on the smooth polymer banknotes. A shorter time in circulation and a smooth material such as polymer reduce the quantity of potential pathogens on banknotes.

Since clearly lower concentrations of bacteria and viruses were discovered on coins in general, the need for action seems less urgent. Investigations conducted hitherto suggest that the nature of the material may have the capacity to kill off pathogens.

Credit must be given to the studies, that they are not painting any exaggerated horror scenarios during their investigations. However, the issues should not be dismissed as a purely academic problem.

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The "Where's George?" Project is presented on its own website: www.wheresgeorge.com

Looking For Germs? reports on banknotes covered in cocaine and other insights into US currency. Check Your Money. Jack Dini, Hawaii Reporter, May 15, 2008, presented online on: http://myblogscience.blogspot.com/2008/05/looking-for-germs-check-your-money.html

Only one article reports on the Australian-New Zealand study, led by Frank Vriesekoops: Anna Evangeli, Myth of dirty money exposed, ABC Science Online, 12.7.2006 (http://www.abc.net.au/science/news/health/HealthRepublish_1684553.htm, released on 8.11.2011).

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Dirty Coins?

Frank Vriesekoop examines the importance of coins as carriers of diseases. He comes to the conclusion that infected coins are not really a problem, because the surface of the metal is devitalizing most bacteria and viruses within only a few hours. Most of the problems can be avoided, as soon as those handling coins wash their hands before they handle food.

Text Frank Vriesekoop

While high-tech electronic payment systems are becoming more and more available and prominent when we purchase our goods and services; hard currency (notes and coins) are still commonly used in the exchange of low value goods and services. However, banks, and debit and credit cards providers are unrelenting in their push for consumers to use their facilities to pay during the acquisition of even very low value goods; all in the name of speed, convenience, and progress.

The question to be asked has to be: Is this increased convenience benefiting the banks or the consumer? The banks have a significantly reduced workload with regards to the handling of notes and coins, which must conveniently benefit their bottom line; while consumers do not have to carry hard cash on them.

Selling food in Seattle. Photo: Joe Mabel / Wikipedia

Despite the rapid invasion of electronic payment systems into our lives; bank notes and coins are still in practical use. Apart from convenient benefits, both banknotes and coins have often been accused or implicated of being unhygienic. Arguments about the possible and perceived unhygienic status of currency is nothing new. In the late 1800s, Schaarschmidt reported that microorganisms could easily be isolated from notes and coins because they existed in the "thin incrustations of organic detritus deposited upon their surfaces in the course of long circulation". In the early 1900s a number of articles appeared in the "New York Times" and "The Popular Science Monthly" magazine in which the hygienic status of banknotes and coins were heavily debated. The people involved in the debate in the early 1900s did not dispute that potentially harmful bacteria could be found on coins and/ or notes; their dispute centred on whether the risk of humans contracting contagious diseases from handling currencies was within acceptable limits or not.

Over the decades various scientists from a range of countries and backgrounds have investigated the bacterial loading on both coins and banknotes. All reports that looked into this phenomenon have always been able to find numerous bacteria. Some of the bacteria identified in these studies have the potential to cause disease, while other are typically considered to be harmless. While the presence of potentially disease causing bacteria may sound alarming; none of the studies have ever reported levels of those bacteria beyond what is considered an "infective dose". The infective dose is the minimum number of disease causing bacteria necessary to cause an infection in a healthy person. The range of bacteria found on currencies can be considered to be typical of items that are frequently touched by a wide range of people; e.g. railings on staircases, door handles, buttons in lifts and ATMs. The main argument for why currency might be an efficient vehicle for the transfer of potentially harmful bacteria would be the fact that currency is used as the preferred bartering exchange material for goods and services, which implies that it will change hands frequently in a well-functioning economy.

One of the current concerns about the potential of bacteria to be transferred via currency is during the co-current handling of food and money. People often purchase their fresh ready-to-eat food items in cafes and the person preparing the food could well be the same person facilitating the exchange of the ready-to-eat food for money. If that person would handle the money with the

Selling food in Thailand, Washington. Photo: Dinkum / Wikipedia

same hands (s)he handles the food, it could be argued that the food handler could have "dirty" hands during that transfer. A recent study of banknotes obtained from food outlets in a range of countries (Australia; Burkino Faso; China; USA; UK; Ireland; Netherlands; Mexico; Nigeria; and New Zealand) found that the overall carriage of bacteria on banknotes was relatively low. The study did find that countries that ranked lower on the index of "economic freedom" had a higher bacterial loading on their banknotes compared to those countries that ranked markedly higher on the same index. The study also found that the material the banknotes were made of played a significant role in the amount of bacteria found on the notes. Banknotes made predominantly from cotton carried greater numbers of bacteria compared to the banknotes made from a polymer material. The main argument for this disproportion was that cotton notes are more fibrous and can absorb moisture better than the inert polymer notes.

Coins are significantly different to banknotes. They are most definitely not fibrous and their metallic nature is likely to give them an enormous advantage because bacteria are unlikely to easily adhere to them. Most studies that involved both banknotes and coins have typically found that coins contain significantly lower levels of bacteria. While in the late 1990s an American study showed that some of the most pathogenic food-borne bacteria could survive for a long time on various US coins; the levels used to inoculate the coins were roughly 1,000,000 times higher than what would ever be encountered in a real-life situation. This does not mean that these bacteria do not have the ability to survive on coins – they most definitely do! However, the real-time survival times are likely to be much shorter than what was reported. Figure 1 shows the survival of bacteria on Australian coins. In this study bacteria were applied through touch – a group of twelve people were asked to touch a large amount of coins as if they were counting them one-by-one. This application of bacteria provides a more realistic introduction of bacteria on to money to assess their survival on coins compared to the use of laboratory-grown cultures. Figure 1 show that bacteria very rapidly die off following their introduction on to coins; while very few surviving bacteria could be found within days of their application. In order to assess whether the decrease in viable numbers of bacteria on these coins was due to a toxic effect associated with the coins or whether they were just starved for nutrients; the coins were assessed for their levels of sterility.

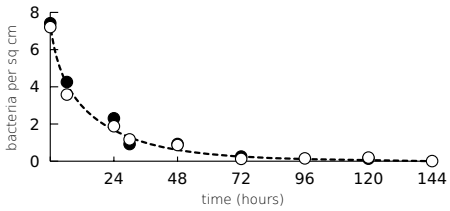

Figure 1 Bacterial loading on coins and their survival over time. The coins were touched by a group of people after which the average number of bacteria per square cm was determined over a period of time.

● Australian twenty cent coins
○ Australian one dollar coins.

Figure 2 shows the percentage of coins that we found not to harbor any viable bacteria (sterile coins). The data in Figure 2 reveals that all coins harboured living bacteria for at least the first ten hours after being handled. However, following the first ten hours the fraction of coins that were sterile (did not contain any measurable living bacteria) rapidly increased and after approximate five days almost all coins were found to be sterile.

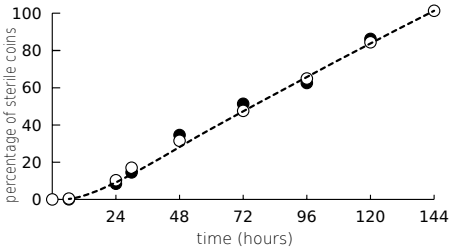

Figure 2 Portion of sterile coins following touch by people. The coins were touched by a group of people after which the average number of bacteria per square cm was determined over a period of time and the percentage of sterile coins was ascertained.

● Australian twenty cent coins
○ Australian one dollar coins.

It is very likely this is due to the fact that most metallic products slowly oxidize when exposed to moisture at low pH (skin contact). Oxidized metallic compounds (rust) and their colloidal forms are typically considered to be toxic to a range of microorganisms. When the growth media for bacteria has been exposed to coins, there is a distinct region surrounding the coin where bacteria will not grow (*see Figures 3 and 4*). The degree by which metallic coins impart their inhibitory effect differs from coin to coin. Figure 5 gives an indication of the inhibitory effect that coins can have on the growth of the bacterium Staphylococcus aureus.

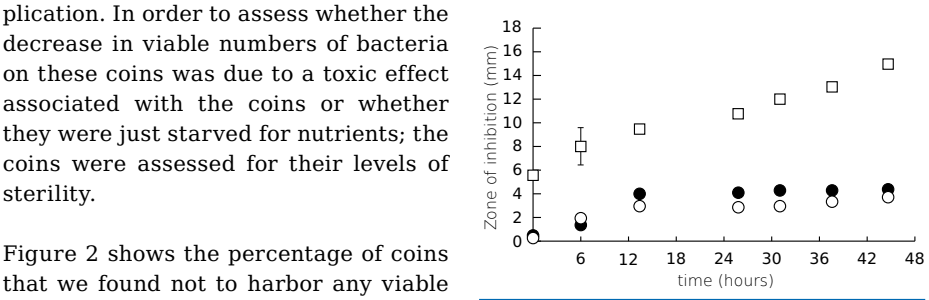

Figure 4 Zones of inhibition of bacteria (Staphylococcus aureus) due to the presence of coins. The coins were placed on the bacterial growth media at various times before the bacteria were applied.

□ copper coins
● Australian twenty cent coins
○ Australian one dollar coins.

While coins that are in common circulation will contain bacteria due to the fact that they are frequently touched by humans and might even be exposed to

Figure 3 Inhibition of bacteria due to the presence of copper coins. The coins were placed on the bacterial growth media (Nutrient Agar) at various times (0, 6, and 14 hours) before the bacteria were applied.

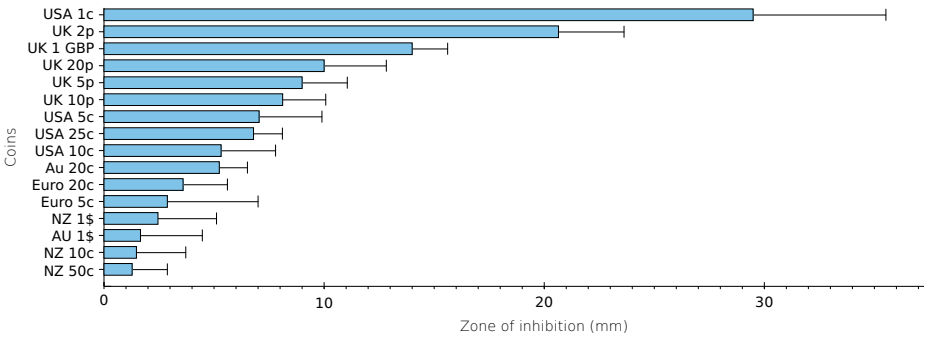

Figure 5 Inhibiting of bacterial growth (Staphylococcus aureus) by various coins.

extremely dirty environments; the coins themselves do NOT represent an optimal location for bacteria. It is likely that the facts that coins do not contain or harbour any moisture to sustain life per se; and metallic (colloidal) ions from the coins are the likely cause of the inhibitory effect that coins have on the ability of bacteria to grow in the presence of coins. This is not to say that handling coins is completely without any hygienic risks. People who very frequently handle coins are very likely to be exposed to a number of hygienic risks, such as an accumulation of bacterial detritus on their skin. This is probably easily removed when standard hand washing procedures are adhered to, which will be a "standard operating procedure" for people who frequently handle money and foods or other people as part of their vocation. This would mean that in some instances the handling of food and money have to be physically separated by employing separate individuals to carry out one task each; while in other instances it could be advantageous to handle food only with a gloved hand and coins or banknotes with the other hand. If neither of these precautions can be effectively implemented, it could be suggested that food service personnel implement proper hand washing procedures after the handling of money and before handling food. Note, this latter suggestion is merely a reiteration of a statement made by Boyer in 1921: "... people run a risk of infection ... by handling dirty money and their bread or fruit without first washing the hands".

Frank Vriesekoop

Dr. Vriesekoop currently holds a position as Senior Lecturer in Food Safety at Harper Adams University College in Shropshire, England; while he was previously employed as a Food Biotechnologist the University of Ballarat in Australia. Dr Vriesekoop has a great interest in contemporary microbiology and as such undertook a worldwide study on the hygienic status of coins and banknotes. In many instances he tries to differentiate between the various truths and myths that exist with regards to hygiene in our everyday life.

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Typical "restaurant" in Burkina Faso. Source:
Wikipedia / http://www.fas.usda.gov/excredits/FoodAid/PhotoGallery/Burkina.htm

Cash and Street Vendors – the Burkina Faso Example

What role is played by coins as carriers of disease pathogens during the trade of street vendors of foodstuffs in developing countries? A 2003 study in Burkina Faso, which investigated the hygiene of open food processing stalls for the sale of foodstuffs, touched upon the role of coins.

In 2003 a group of researchers investigated hygiene in sales of foodstuffs by street vendors. As in many poor countries, the sale of prepared and raw dishes on the street is widespread in Burkina Faso. Some three quarters of the vendors are women, more than half of whom are illiterate. They therefore have little knowledge of modern perceptions of hygiene.

Someone from Central Europe, at least, will be shocked by the description of the normal situation. Since there is a lack of running water, crockery and hands are washed in buckets. The water used for washing seldom contains soap or washing-up liquid and is hardly ever changed. The foodstuffs are seldom stored in air-conditioned conditions, but are carried along in tropical temperatures. In addition the vendors regularly handle coins - although at the same time they are handling rice, pork or salad with their bare hands and serving the food on to plates.

The study on hygiene on food processing stalls was conducted in three districts of Ouagadougou, the capital of Burkina Faso. As well as carrying out interviews with individuals, the authors collected the following materials: washing water, cutlery, coins; they also tested the hands of the vendors. *Food-borne pathogens* in varying quantities were found on all the specimens: Salmonella, Shigella, coli forms and Staphylococcus aureus. The *Food Hygiene Office* recommends three different washing containers for various tasks; however, only 38.5 % of the vendors complied with this requirement, while the others limited themselves to only two types of water. The seldom-used third type of water was the type with the smallest density of pathogens. Generally the water was seldom changed, which is another explanation for the high proportion of pathogens. *Coli forms* and *Staphylococcus aureus* were identified on 100 % of the quantity of knives tested. The knives are often never washed and come into contact with flies. The quota of the same pathogens was equally high on the coins tested. This is particularly worrying, because these pathogens can very easily be transferred back on to the food by direct contact. *Escheria coli* can survive on coins for approximately eleven days; the danger exists over a relatively long period that such pathogens will be passed on along the chain to those who handle money and at the same time touch the food. In particular measurable quantities of pathogenic bacteria were found on the hands of the vendors themselves (60 %); however, more than a third of the customers (37 %) also carried these pathogens on their skin. Escheria coli and Salmonella can also survive on hands for more than three hours and even longer in food, which is not at the appropriate temperature.

The study therefore concluded that education is essential. Traders must be made aware of the need to break the chain of potential transmission: in other words, washing hands, handling food with cutlery instead of with the bare hands etc. It is also essential to inform the vendors why it is important to clean the dishes with clean water. It is almost impossible to assess the situation for coins under such circumstances. Other studies have shown that the density of pathogens decreases, once the hygiene standards of the relevant country have improved. But while coins in Burkina Faso continue to be as dangerous as cutlery, it is absolutely essential to become even more vigilant on the other points.

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Some Questions about – Coins as Carriers of Deseases to Mr. Paterson L. Encabo, Officer in Charge of the Mint & Refinery Operations Department Philippines

How relevant are coins as carriers of bacteria and viruses in your eyes compared to banknotes and other everyday objects?

Since the material composition of coins as compared to banknotes is more resistant to pathogenic bacterial growth, we are not really that concerned. Since the direct transfer agent of bacteria is through the hands, it is good hand hygiene that should be encouraged.

What do you do in order to reduce the importance of coins as possible source of infection?

It is the Philippines' Department of Health that promotes the use of proper hand washing techniques to minimize the spread of germs and viruses since the mode of bacterial transfer from coins to humans is usually by hand.

What kind of aspects are you trying to improve?

At present, the BSP Mint focuses on (1) exploring cost-effective and suitable coinage material for the New Generation Coins and (2) improving design and security features.

Health Concerns arose regarding US Coin Design

This is a funny story about a US gold coin featuring an incuse design, which was suspected to be predestined to become dirty.

Text Richard Giedroyc

5 US-dollar of 1911 featuring the sunken design (enlarged). Photo: Gorny & Mosch

The highest point of the design on a coin is the first to wear. Ask any coin collector. This high point of a design is what is used to determine the grade in which a coin has survived. Almost all coins are struck in relief, resulting in some design element becoming destined to be that first point of wear. I said "almost"... there have been some notable exceptions. A 20th century exception raised some unanticipated concerns of another nature.

US President Theodore Roosevelt was well known for many things, among them being his interest in bolder new designs for his nation's coins. Roosevelt carried an ancient Athenian silver tetradrachm with him, an illustration of his appreciation for the arts.

It was during Roosevelt's presidency that the famed Augustus Saint Gaudens' design for the $20 Double Eagle coin was introduced. It was also during Roosevelt's presidency that the Bela Lyon Pratt design of an Indian on the obverse and a perched eagle on the reverse was introduced during November 1908 on the US $2.50 Quarter Eagle and on the $5 Half Eagle coins. While the wear on the Saint Gaudens Double Eagle coin was a concern due to the high points of the design relief the Pratt design went in the opposite direction – being incused.

While the president was enthusiastic about the new and innovative Pratt design not everyone agreed with him. US Mint Engraver Charles E. Barber was one dissenter, insisting on reworking the design, likely due to jealousy rather than technical problems.

Once the coin design became a reality it didn't take long for Philadelphia coin dealer Samuel H. Chapman to lead the charge for what became an unexpected urban legend regarding the incuse designs.

Chapman wrote an open letter to the president that reads: "It was the hope of every one that when our new coinage appeared we would have one of great beauty and artistic merit. But the new $5 and $2.50 gold pieces just issued totally lack these qualities, and not only those of beauty, but actually miss the practicability to which every effect of beauty in relief has been sacrificed.... The head of the Indian is without artistic merit, and portrays an Indian who is emaciated, totally unlike the big, strong Indian chiefs as seen in real life.....The sunken design, especially the sunken portion of the neck of the Indian, will be a great receptacle for dirt and conveyor of disease, and the coin will be the most unhygienic ever issue.... These coins will be a disgrace to our country as a monument of our present ideas of art as applied to coinage."

Dr. William Sturgis Bigelow was a friend of Roosevelt's who had urged him to adopt the Pratt design. Roosevelt forwarded Chapman's letter to Bigelow, who quickly defended the health concerns regarding the coin design in a letter to the president in which Bigelow wrote, "The question of hygiene has more relation to silver coins than gold, as they find their way into dirtier pockets. A dirty gold coin would be an anomaly. I have never happened to see one."

Both Chapman's letter and the Bigelow response appeared in the February 1909 issue of The Numismatist.

This concern was quickly forgotten as the coins continued to circulate successfully. Protected both by the president and by a law that required the coin type to remain in use for at least 25 years, the incuse design would continue to be used through 1929. As for Pratt, he died young. His incuse coin design outlived him, however Pratt died of heart disease, not due to some infection that might be contracted from coins.

Allergies – Necessary Basics

These days, allergies are among the most frequent chronic diseases in industrialised countries. In Germany for example it is estimated that one in three or one in four is said to suffer from an allergy. Pollen and grasses, foodstuffs and likewise materials such as the nickel used in coins are responsible. And the list goes on and on. All possible substances can erroneously be classified as dangerous by the human body; we call these substances allergens. Our immune system deems these to be pathogens and forms antibodies (immunoglobulins) as a defence.

The Viennese paediatrician Freiherr Clemens von Pirquet described such hypersensitivity reactions as early as 1906. He termed this reaction as an allergy (from the Ancient Greek allos = other and ergon = activity).

The triggering factors can be divided according to different criteria, for instance according to the allergen source (pollen allergens, animal hair allergens) or according to the type of contact (inhalation allergens or food allergens).

The reactions of the body are as individual in any individual case as the pathogens of an allergy are varied. Some people react immediately to allergens, others only much later; the dosage and length of time those affected are exposed to the allergens play a role in this. The pathological immune reaction of the body (anaphylaxis) sometimes only limits itself to mild skin irritations, coughing or sneezing. However, anyone who has an allergic reaction to pollen knows how exhausting constant sneezing is. In extreme cases, an allergic reaction can end in a so-called anaphylactic shock, a fatal circulatory collapse.

Allergic skin rash on a man's back. Photo: Frank C. Müller / Wikipedia

In the meantime, there are various tests to find out to what allergen a person overreacts. In some cases, for example in certain pollen allergens, a so-called hyposensitivity can help, a kind of "allergy vaccination". However, most of the time doctors can only reduce the symptoms. For although so many people are affected, we don't know much about the causes – this is why there are hardly any treatments.

These days, the "traditional allergies" seem to occur in western industrialised countries significantly more frequently than in the past. We assume the reason to be that our high standard of hygiene leads to underloading of the immune system. Environmental influences could also be part of its development. An "allergy gene" has so far not been found. However, the proven increased risk of children of allergy sufferers also suffering from allergies themselves points to a genetic predisposition.

Nickel allergy and coins

Carola Lidén stresses the fact that the nickel content of some coins is harming seriously a group of people who are sensitive to nickel and who have to handle change on a permanent basis. She suggests that coins without nickel release shall substitute the currently widely used high nickel-releasing coins.

Text Carola Lidén

Nickel is an important cause of skin allergy globally. It is well known that consumer items such as jewellery, buttons, and watches have been major causes of nickel allergy, and that nickel-allergic individuals often develop hand eczema. Some occupational groups are more often than others affected by nickel allergy. The significance of coins as a cause of nickel allergy has been considered controversial. Recent research on nickel release and skin exposure shows clearly that nickel in coins is a risk factor for nickel allergy and hand eczema.

Figure 1 Hand eczema is frequently occurring in persons with nickel allergy due to skin exposure to nickel.

Nickel allergy

Approximately 17% of women and 3% of men in the general population in Europe is allergic to nickel. Nickel allergy is estimated to be similarly common in other industrialised countries. Indications have been noted in some European countries, that allergy to nickel has started to decline in young females. This is interpreted as a result of the EU nickel regulation (see below). Nickel is however still the most frequent cause of allergy by skin contact with chemicals (contact allergy).

Nickel allergy is caused by skin exposure to nickel ions. The symptoms are redness, swelling, blisters, itching and scaling, often seen under jewellery, watches, buttons etc. 30-40% of nickel allergic persons develop hand eczema (fig. 1) that may become chronic, affect the work ability and quality of life. Patch testing is the diagnostic method to detect contact allergy. Contact allergy is lifelong, but the eczema can heal if further skin contact with the allergen is avoided. Prevention of nickel allergy and dermatitis requires that skin exposure to nickel is minimised. It is often obvious if items such as jewellery are responsible for eczema, and the exposure may be discontinued. But it may not be obvious to nickel allergic individuals with hand eczema that nickel is the cause, or how exposure of the hands occurs. Contact may also be very difficult to avoid.

It has sometimes been claimed that the duration of skin contact with coins is too short to cause release of nickel ions and dermatitis. It is however well known by dermatologists specialised in occupational skin disease, and by their nickel-allergic patients, that hand eczema in cashiers and other professionals who handle coins may be caused by nickel release from coins.

The EU nickel regulation

Due to large costs and suffering related to nickel allergy, nickel has been regulated in the EU for prevention of nickel allergy and eczema. The EU Nickel Directive was adopted in 1994; it entered into force in 2000, and was included in Reach (the EU chemicals regulation) in 2009. The regulation limits release of nickel ions from items in direct and prolonged contact with the skin, such as jewellery, watches, buttons, zippers etc., and from items intended for pierced parts of the body. Mobile phones were added in 2009. “Prolonged contact” has not yet been defined in the regulation. This is currently discussed in the Commission and may in the future cover repeated contact for some hours.

Items for direct and prolonged contact with the skin shall not release more than 0.5 µg nickel/cm2/week, and items for pierced holes not more than 0.2 µg/cm2/week. The reference test method for showing compliance with the regulation (EN 1811) describes that items shall be immersed in artificial sweat for one week; then the nickel concentration in the solution is analysed, and nickel release is calculated.

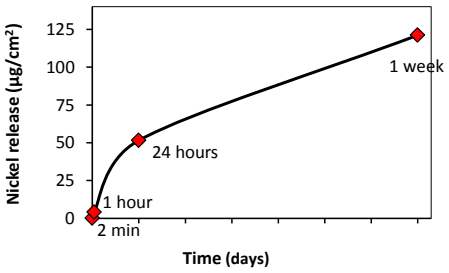

Figure 2 Nickel release from copper-nickel coins (1 krona, SEK) immersed in artificial sweat. The results show that the speed of nickel release is highest during the initial contact (minutes and hours) with artificial sweat. The release was 0.11 µg/cm2/2 minutes, 4.3 µg/cm2/1 hour, 52 µg/cm2/24 hours, and 121 µg/cm2/week, while the limit value of the EU nickel regulation is 0.5 µg/cm2/week.

Assessment of nickel release and deposition on skin

The dimethylglyoxime (DMG) test is a simple spot test indicating, by pink colour, the presence of nickel ions (fig. 2). The item is rubbed with a cotton-wool-tipped stick and a few drops of the test solutions (DMG in ethanol and ammonia). The DMG test is used by dermatologists and nickel-allergic persons to identify items to avoid skin contact with, by industry, authorities, and in research. We have used the DMG test in several studies of nickel release from items on the market, and we have validated the test. The DMG test has also been standardised by CEN as a screening test for nickel release (CR 12471). We have recently shown that the DMG test also may be used to assess nickel on the skin.

Acid wipe sampling is a method developed by us to measure the amounts of nickel and other metals on the skin. We have studied how much nickel that is deposited onto the hands in cashiers and other workers performing their normal work; in an experiment comparing coins; and in patients with nickel allergy and hand eczema. Our studies show that the amounts of nickel deposited onto the skin in cashiers during a working day are large enough to cause nickel allergy and hand eczema. This has been shown also by other researchers.

Short after the euro coins were introduced in 2002, reports in media and some scientific publications speculated that the euro coins presented a larger risk than the former national coins, mainly copper-nickel coins. We compared nickel release from 2 euro coins (Cu 75; Zn 20; Ni 5, and Cu 75; Ni 25) and 1 krona (SEK) coins (Cu 75; Ni 25); and the amounts of nickel deposited onto the skin by one hour coin handling. Similar amounts of nickel were released from 2 euro and 1 krona coins, and similar amounts were deposited onto the skin.

According to EN 1811, test items shall be immersed in artificial sweat for 1 week. This is relevant when assessing items in prolonged contact with the skin, but less relevant for repeated brief contact, such as in coin handling. By measuring nickel release in artificial sweat after 2 minutes, 1 hour, 24 hours and 1 week, we have shown that the speed of nickel release is very high in the beginning, and that it slows down with time (fig. 3). This is why repeated contact with coins

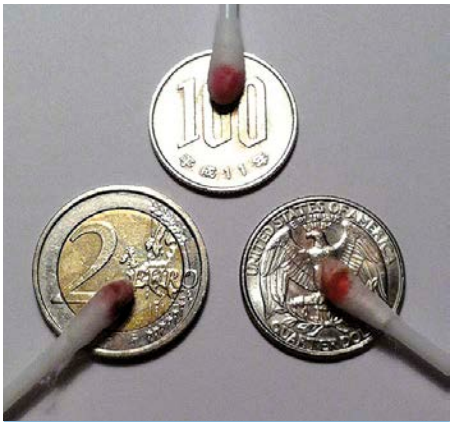

Figure 3 Nickel release from coins, shown by the dimethylglyoxime (DMG) test. Pink colour indicates nickel ions. Coins and their composition: 100 yen: Cu 75; Ni 25 – Quarter: Cu 92.67; Ni 8.33 - 2 euro: white ring Cu 75; Ni 25; yellow centre Cu 75; Zn 20; Ni 5.

can result in accumulated deposition of large amounts of nickel.

It is sometimes claimed that pure nickel metal releases less nickel than copper-nickel. This is true for one week in artificial sweat, but not for brief contact such as immersing coins in artificial sweat for 2 minutes. We have shown that coins made of copper-nickel, nickel brass, pure nickel and nickel-plated steel release similar amounts of nickel during short exposure to sweat (around 0.1-0.3 µg/cm2/2 minutes), and thus possess similar allergy risk at skin contact. It should be added that high-quality stainless steel generally is safe at skin contact, due to low nickel release, also shown by negative DMG-test.

Risk assessment of coins

The composition of the current euro coinage is based on a compromise. All cent coins are nickel free, based on risk assessment considering nickel allergy, while the 1 and 2 euro coins are made of copper-nickel and nickel brass with high nickel release (see above).

New Swedish coins shall be nickel free. The decision in 2011 was based on risk assessment concerning nickel allergy. Copper-nickel shall be replaced. On the evaluation see http://www.riksbank.com/upload/Dokument_riksbank/Kat_sedlar/2011/SedeloMynt_Format,%20materialochfärger_ENG.pdf

Conclusions

Coins that release nickel are a risk factor for ill-health due to nickel allergy. Those who handle coins professionally and consumers with nickel allergy are at particular risk.

Risk assessments of coin materials should consider nickel allergy. For protection of the health of consumers, cashiers and other workers who handle coins, it is suggested that coins without nickel release shall substitute the currently widely used high nickel-releasing coins.

The key risk factor is the ability of materials to release nickel and contaminate skin by repeated contact, as in coin handling. The dimethylglyoxime (DMG) test is an established, simple and specific spot test for nickel. The DMG test is suitable for screening to detect nickel release at levels causing allergy problems.

Carola Lidén

Prof. Lidén is Professor in Occupational and Environmental Dermatology at the Institute of Environmental Medicine, Karolinska Institutet, and Chief Physician at Karolinska University Hospital in Stockholm, Sweden. She has been active in research on occupational and environmental dermatology since more than 30 years. The research covers skin allergy and its prevention; nickel and other metals, pesticides, cosmetics, and hazardous skin exposure. She has published more than 100 papers in peer reviewed scientific journals and served the European Commission, WHO, OECD, and Swedish authorities concerning skin sensitisation. She was member of the former Scientific Committee on Consumer Products (SCCP) and is expert to the current Scientific Committee on Consumer Safety (SCCS). She was convenor and co-ordinator (1991-2005) of the European standardisation (CEN) project which developed the reference test methods (including EN 1811), on which the EU nickel regulation is based. Carola Lidén has also served the Riksbank (Sweden's central bank) as expert on nickel allergy.

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Some Questions about – the Experiences with Nickel-Containing Euro Coins to an expert who played a leading role, when the euro was introduced

When the euro was introduced, the media seized on the dangers threatening sensitive users as a result of the nickel content in the bi-metallic coins. By now 10 years have passed since the euro was introduced. How has this alloy stood the test in the long-term? Are there complaints from victims?

The material composition of the bicoloured euro coins has really proved itself. Despite the high purchasing power of the coins, the quantity of known forgeries is low and the vast majority of these forgeries have apparently never been accepted in a vending machine. Even today, the euro coins can still be easily differentiated from coins from foreign currencies due to their unique material composition. Moreover, they are still really nice to look at even after 10 years in circulation.

I have to date not had any complaints from victims of nickel content in euro coins. Since at the ECB I only have responsibility for the quality assurance of the coin production – the ECB has no other responsibilities for the coin product – this is not surprising. Should any complaints have arisen, then they have probably accrued at the mints or at the European Commission. However, I have never heard anything from these places about any complaints made by those affected or by any victims.

Even when the euro was introduced people knew that nickel is a metal which easily leads to allergies. Why was this combination decided upon in spite of this?

Originally, when the euro monetary system was developed, the middle coins – 10, 20 and 50 cents – were supposed to be made up of CuNi25 (75% copper and 25% nickel). Because of an objection from the representative of one country, an alternative nickel-free material was chosen. As for the bicoloured coins, forgery security and security in automatic identification in automated machines played a substantial role which at the time could only be guaranteed for affordable prices with a certain amount of nickel content in the material. In addition, the nickel content in the alloys makes for very good resistance to corrosion and therefore long life for the coins.

Incidentally, nickel only leads to allergic reactions if it comes into direct contact with the human body for a long period (days and weeks) and only in the case of certain people.

If you compare the monetary systems, which existed before the launch of the euro, only Italy had a monetary system where less nickel was found in the coin surfaces than in the new euro monetary system (see diagram).

In Germany there were many reports in the media about the potential dangers of the new coins. Were you aware of something similar in other countries in the eurozone? And how did the PR department of the ECB react to such reports?

In some countries of the eurozone there were reports about the nickel content, nearly all of which were based on an article in the September 2002 edition of the "NATURE" magazine where the author Frank Nestle believed he established that the bicoloured euro coins radiated considerably more nickel than is permitted in the EU for materials which are in constant contact with the human body.

The ECB did not react to such reports about euro coins since this is not their domain. However, the European Commission made the following statement in 2002:

"The public has recently repeatedly raised the issue of nickel contained in euro coins allegedly causing allergies. Therefore the MDWG [Mint Directors Working Group] would like to recall the following:

Nickel was widely used in national coins in Europe. Only 25% of the national coins in the euro area were nickel-free. It is also used in third-country coins such as the five cent coin in the United States.

Due to its physical properties nickel is a very good material for minting coins. It has been used for the production of coins in large quantities since more than a hundred years throughout the world. Among others the use of nickel improves the security level of coins.

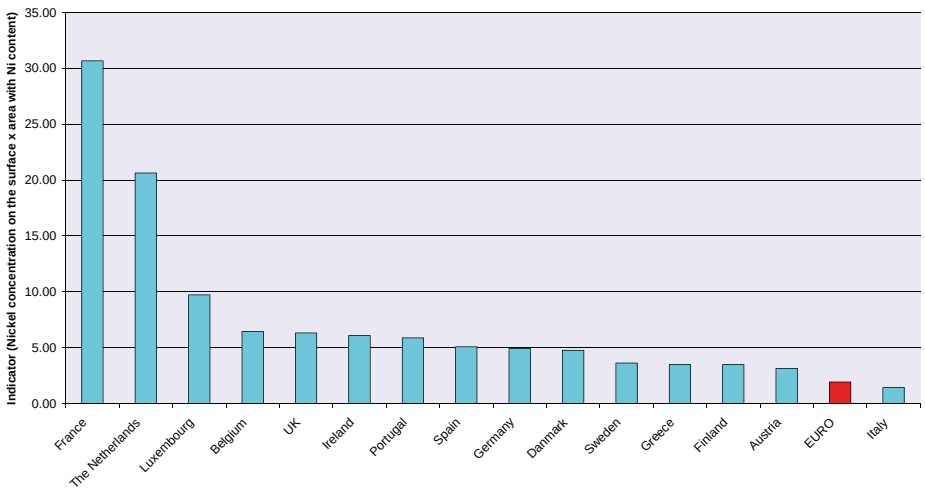

Figure 1 Nickel Indicator of European Coin Systems

The metal composition of euro coins was decided by a Council Regulation in 1998 that followed extensive discussions and scientific research on this issue that had been conducted in collaboration with the Commission. Although no conclusive scientific evidence against the use of nickel was found, it was decided to look for alternatives. While the initial plan was to use nickel in five euro coins (10, 20, and 50 cents and 1 and 2 euro), it was finally decided to use nickel only in the latter two, which demanded a very high level of security. As a result, now 92% of euro coins (in terms of the number of coins in circulation) are nickel-free, as opposed to 25% of the national coins that used to be in circulation. The nickel used in 1-euro and 2-euro coins is essentially contained inside the alloy and not on the surface, thus limiting skin contact. Since nickel was widely used in national coins, it is not plausible that reported of allergies are due to contact with nickel contained in euro coins."

Money laundering as a customer service

At the beginning of the 20th century, the legendary hotel St. Francis was built in San Francisco. Inaugurated in 1904, the tower offered its guests the highest possible comfort. Since the 1930s this also includes regular money laundering. At that time, many ladies would overnight in St. Francis, and from there would visit the local fashion shows. Corresponding to the fashion at the time, they wore delicate, white gloves, which became dirty very quickly. This was due to the silver coins that were used as payment everywhere. Dan London, the Manager at the time, was of the opinion that this condition was unacceptable for a hotel of the standard of the St. Francis: From this point on, all the coins in the St. Francis would be washed before they were placed in the customer's hand again.

Not only women wore gloves at the beginning of the 20th cent. B. Grigoriev, Portrait of the Photographer M. 'A. Sherling, 1916.
Source: Wikipedia

Photograph of the St. Francis dating 1904.
Source: History Room of the Wells Fargo Bank, San Francisco / Wikipedia

Several times a week the responsible money launderer, Rob Holsen, makes his way to the wash room, a small windowless room, secured with four security doors. The room is known as "Arnold's Office" after Holsen's predecessor, Arnold Batliner, who performed the task for over thirty years. First the industrious money launderer sorts the coins according to their denomination. Then the money is cleaned in a special washing solution and polished. When it shines like new, Holsen lays it out under large lamps to dry. Finally, he packs the coins very professionally into paper rolls using a coin roller. And so the change is returned to the customers. The whole process takes roughly seven hours.

But times have changed. Not only are gloves no longer a part of the standard dress of a lady, but also the coins has become rare. These days payments in St. Francis are usually made cashless or using bank notes. The legendary Arnold Batliner was occupied with his money laundering around the clock, his successor dedicates barely ten hours per week to the loose change.

Figure 1 Arrangement of the coins at the start of the experiment.

Swallowed Coins in the Stomach – How Dangerous are Euro Coins?

Oliver Muensterer and Claus-Peter Wallner worked out that the euro change is much less dangerous for children than the US coins, which have to be removed surgically, when swallowed.

Text Oliver J. Muensterer & Claus-Peter Wallner

Up to 80% of foreign bodies swallowed by pediatric patients are coins. The great majority of them pass through the gastrointestinal tract without causing problems, but sometimes they may get lodged in one segment of the digestive tract – in children, coins usually get stuck in the stomach or esophagus. While foreign bodies in the esophagus must be removed as soon as possible, coins in the stomach generally need only to be observed. However, O'Hara and Donnelly showed in an experimental study that American 1-cent coins minted after 1982 can develop sharp edges within a few days due to corrosion in gastric acid and up to 8% of their weight is leached out as toxic zinc chloride[9]. In the authors' opinion, such coins should be removed by endoscopy within one to two days.

After the introduction of the Euro money at the beginning of 2002, the question arises as to whether these coins undergo similar changes on exposure to acid or can safely remain in the stomach.

Materials and Methods

After the "starter kits" were issued in the Federal Republic of Germany, a total of 14 euro coins were exposed for seven days to 0.15 mol hydrochloric acid (HCl) (*Figure 1*), to simulate the effect of postprandial gastric acid.

The coins evaluated were one 1-cent, 2-cent, 5-cent, 1-euro and 2-euro coin each and three 10-cent, 20-cent, and 50-cent coins each (copper-aluminum-

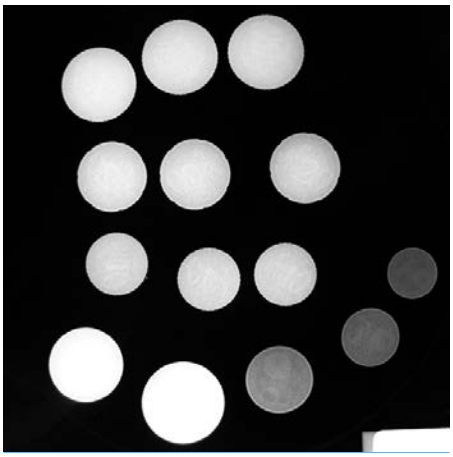

Figure 2 X-ray image of the coins before exposure to HCl (77 kV, 6.3 mAs, non grid, additional filter 1 mm AL/0.1 mm Cu).

tin-zinc alloy). The coins were weighed before the start of the experiment and after seven days of exposure to HCl to quantify the amount of metal dissolved out of them.

A Petri dish containing the coins was filled with 50 ml HCl and closed with a Plexiglas cover. Once a day the coins were x-rayed (*Figure 2*), inspected for visual changes, and the acid was renewed.

Results

Only copper coins with a core of steel showed radiological changes during the period of observation. As soon as the second day of exposure to acid, the x-ray images of the 1-cent coin displayed radiolucency (*Figure 3*).

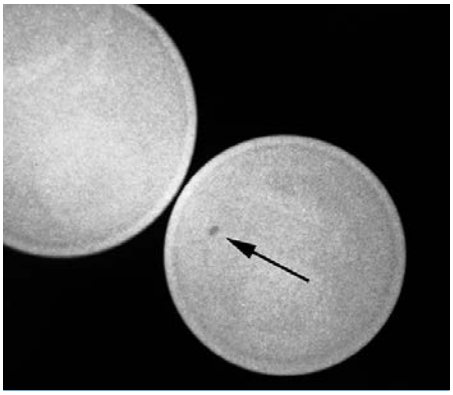

Figure 3 Radiolucent areas on the 1-cent coin after two days.

These erosions were visible on the third day in the 2-cent coin, and after day 5 in the 5-cent coin as well. Neither the coins made of the copper-aluminum-tin-zinc compound (10, 20, and 50 cents) nor the bi-metallic coins made of copper-nickel-brass (1 and 2 euros) displayed any corrosion that could be detected by x-ray.

Even after seven days in HCl, all coins were macroscopically intact; there were no sharp edges and no penetrating erosion. Corrosion discolored all coins to a green-grayish color; only in the area of the deeper erosions in the copper coins was the original color still visible (*Figure 4*).

The weight loss was between 0.1 and 2.3 percent; the greatest change tended to be in the copper-steel coins (*Table 1*). The average weight loss was about one percent of the original weight.

Due to the characteristic milled edges, some of the coins are easy to identify in an x-ray image if the beam is orthograde. The large grooved coins are the 50-cent pieces; smaller grooved coins are the 10-cent pieces. The 20-cent coins have seven notches on the edge. However, the fine interrupted grooves of the 2-euro coin cannot be detected in an x-ray image (*Figure 2*). Differentiating between the double contours of the outer and inner metal of the 1-euro and 2-euro coins is possible only with harder x-rays of more than 80 kV.

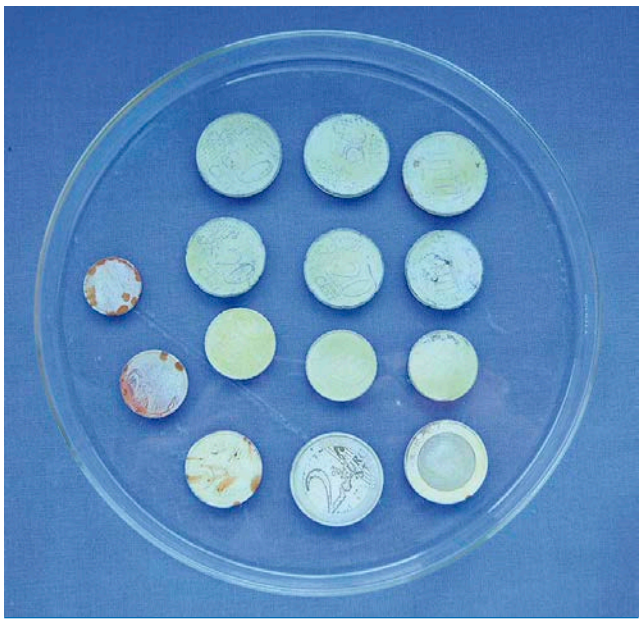

Figure 4 After seven days, clear greenish discoloration of the coins. The copper color of the 1-cent and 2-cent coins is preserved in the area of the radiologically verifiable deeper erosions.

Discussion

Coins are the foreign bodies most frequently swallowed by children and are usually located in the patient's stomach on the first imaging examination[10]. The coin normally passes through the gastrointestinal tract with no difficulty and is excreted in the stool after a few days. However, in some cases, the coin cannot overcome the pylorus and is retained in the stomach.

In the United States of America, 1-cent coins were minted starting in 1982 using a zinc core making up 98% of the weight with a thin copper coating instead of a solid copper alloy (95% copper) in order to save money[4]. When these coins corrode in gastric acid, sharp edges are formed and toxic zinc chloride is leached, which can lead to complications such as erosion of the mucosa or zinc chloride poisoning (1,5). It is therefore recommended that such coins be removed by endoscopy as soon as possible[9].

Table 1 Diagram of the Coins and Weight Loss in the Test Period

Coin	Weight before experiment	Weight after experiment	Change (%)
2 euro	8,49 g	8,43 g	–0,06 g (0,7)
1 euro	7,42 g	7,35 g	–0,07 g (0,9)
50 cent A	7,79 g	7,66 g	–0,13 g (1,7)
50 cent B	7,75 g	7,66 g	–0,09 g (1,2)
50 cent C	7,71 g	7,70 g	–0,01 g (0,1)
20 cent A	5,72 g	5,67 g	–0,05 g (0,9)
20 cent B	5,71 g	5,63 g	–0,08 g (1,4)
20 cent C	5,74 g	5,66 g	–0,08 g (1,4)
10 cent A	4,11 g	4,08 g	–0,03 g (0,7)
10 cent B	4,12 g	4,10 g	–0,02 g (0,5)
10 cent C	4,10 g	4,08 g	–0,02 g (0,5)
5 cent	3,95 g	3,86 g	–0,09 g (2,3)
2 cent	3,06 g	3,01 g	–0,05 g (1,6)
1 cent	2,25 g	2,22 g	–0,03 g (1,3)

When the euro was introduced at the beginning of 2002, the new coins became the legal tender for over 300 million people. It is already known that the euro coins are clearly harder in material tests than the deutsche mark, pfennig, or US coins[6]. It is of medical interest whether the new coins display behavior similar to the US pennies coined after 1982 and should be removed from the stomach as soon as possible, or whether it is possible to wait until the coin passes the pylorus.

The specific characteristics, sizes, and composition of the euro coins are available from the Deutsche Bundesbank (*Table 2*). Despite the different impressions on the reverse, the composition is the same all across Europe, so the results of this study are transferrable to the rest of Europe as well.

In contrast to the US 1-cent coins, which consist mainly of zinc, the copper-colored 1-cent, 2-cent, and 5-cent euro coins have a steel core with a copper coating. Only these coins showed changes that could be verified by x-rays. Exposure to acid leads to spot-shaped erosions of the core, primarily in the smaller denomination coins, whereas the more precious copper was protected at these sites by the electro-galvanic action and retained its original color.

In the space of one week, between 0.01 and 0.13 g of metal was leached out of the copper-aluminum-tin-zinc coins. Since zinc is mainly oxidized in the redox series of the metals in question (*Table 3*), it forms the major portion of the leached metal. Although no precise pharmacotoxicological statements can be made due to the unknown percentages of the leached out metals and inconstant absorption, it can be extrapolated from data in literature that many of these coins must remain in the stomach over a week to reach levels of serum concentrations of zinc that could be potentially toxic for humans or animals (2,8).

In the case of the copper coins with a steel core, in this experiment over seven days, maximum 90 mg of iron was leached out (13 mg/d), which for an infant is about the same amount as the recommended daily intake of 2 mg/kg body weight[7]. In any case, no dangerous amounts of iron are leached out.

In summary, the results of this study show that euro coins that have been swallowed can be observed in the stomach for a period of up to a week without any problems, if there are no other complications. In contrast to the US 1-cent coins, the edges of the euro coins remain blunt when they undergo corrosion in gastric acid and the amount of metal leached out is safe from a toxicological standpoint even for children, if as is usually the case, only a few coins are swallowed. There are thus also good medical reasons for the euro.

We would like to thank the x-ray technicians at Dr. von Haunerschen Children's Hospital for x-raying the coins – even during the holidays. We also thank Dr. Alfred Heger of the Department of Pediatric Surgery for preparing the photos.

This article was first published in Deutsches Ärzteblatt, no. 99, issue 31-32 of 5 August 2002.

See the following article on Oliver J. Muensterer;

Dr. Claus-Peter Wallner is employed in the Pediatric Radiology Department at Dr. von Haunerschen Children's Hospital (Director: Prof. Dr. med. Karl Schneider) of the University of Munich.

Table 2 Properties of the Euro Coins

Coin	Diameter	Thickness	Weight	Metal	Edges
1 Cent	16,25 mm	1,67 mm	2,30 g	Copper-steel	Smooth
2 Cent	18,75 mm	1,67 mm	3,06 g	Copper-steel	Smooth
5 Cent	21,25 mm	1,67 mm	3,92 g	Copper-steel	Smooth
10 Cent	19,75 mm	1,94 mm	4,10 g	Gold, copper-aluminum-tin-zinc	Grooved
20 Cent	22,25 mm	2,14 mm	5,74 g	Gold, copper-aluminum-tin-zinc	Smooth with notches
50 Cent	24,25 mm	2,38 mm	7,80 g	Gold, copper-aluminum-tin-zinc	Grooved
1 Euro	23,25 mm	2,33 mm	7,50 g	Nickel-brass Copper-nickel	Fine grooves
2 Euro	25,75 mm	2,20 mm	8,50 g	Copper-nickel Nickel-brass	Interrupted grooves

Deutsche Bundesbank: Summary of the technical characteristics of the euro coins
http://www.bundesbank.de/de/presse/banknoten/euro/merkmale.htm

Table 3 Redox Series of the Metals in Euro Coins

Element	Voltage to 2H-/H2
Zinc (Zn/Zn2+)	–0,76 V
Chromium (Cr/Cr3+)	–0,74 V
Iron (Fe/Fe2+)	–0,44 V
Nickel (Ni/Ni2+)	–0,25 V
Tin (Sn/Sn2+)	–0,136 V
Copper (Cu/Cu2+)	+0,34 V
Gold (Au/Au3+)	+1,33 V

according to: http://www.peterlutz.ch/lernen/chemie/ave/elchem1.htm

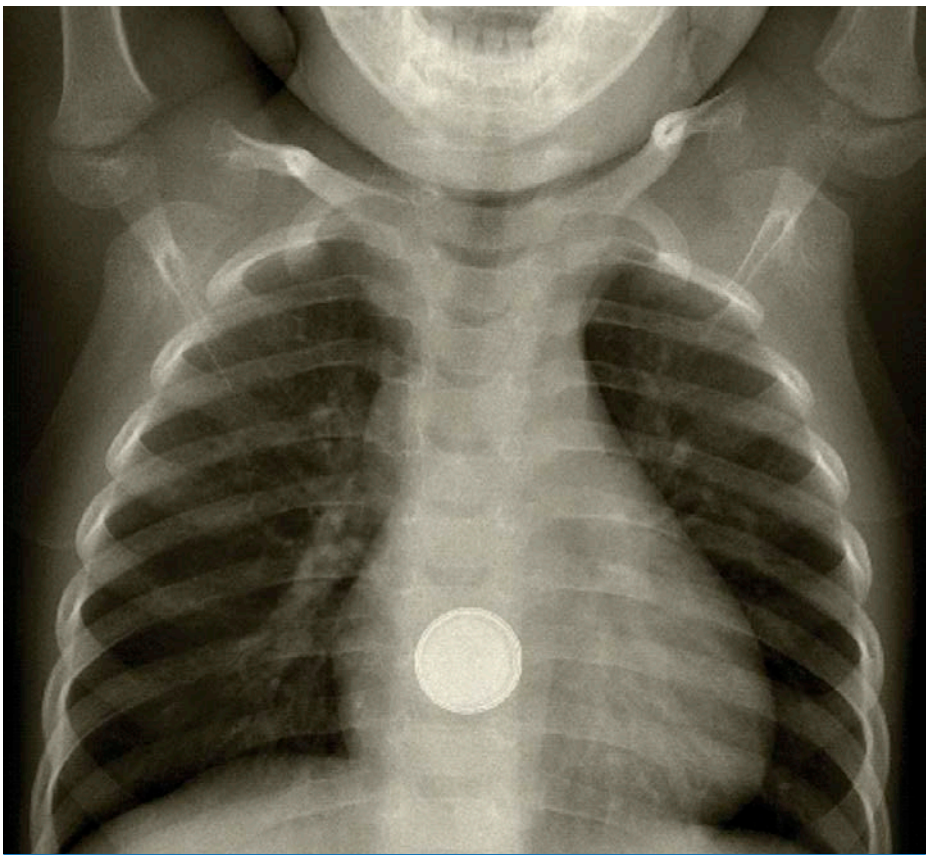

Figure 1 Chest X-ray of a child with a retained button battery in the mid-esophagus. Note the typical double contour of the battery. Coins should not resemble this pattern, and should be unequivocally identifiable on X-rays.

Safe Coins – a pediatric surgeon's perspective

Oliver Muensterer summarizes the features, which would ensure that children are not longer harmed by swallowed coins.

Text Oliver J. Muensterer

Small children have a tendency to put things into their mouth, and because they are so ubiquitous, coins make up a large proportion of such objects. When swallowed, most coins pass the gastrointestinal tract without problems and eventually leave the body upon defecation, but occasionally, they can get stuck in the esophagus (the food pipe), the stomach, or even the small bowel. Rarely, they can even end up being aspirated into the child's airways. In these cases, they need to be removed expeditiously, either by endoscopy or an operation.

As a pediatric surgeon, I have removed many ingested coins from the gastrointestinal tract of my young patients and subsequently attempted to educate the families not to leave loose change lying around to prevent accidental ingestions in the future. I always wondered if money could be designed in a way to make it safer for children. This article explores the published literature on the subject and proposes a few concepts that may be worth considering in the future design of monetary coins.

In general, about 25 to 30 % of coins found in the esophagus of a child will pass spontaneously[5]. Most pediatric surgeons will therefore observe the child for up to 24 hours[7], unless there are symptoms including pain, cough, or difficulty breathing and swallowing. Mostly, chest X-rays are used to make the diagnosis and it is very important to clearly distinguish a retained coin from a similarly-appearing button battery (*figure 1*). While coins cause only minor changes to the lining of the esophagus in the first 24 hours[6], button batteries are much more dangerous and quickly lead to electrical or chemical burns (*figure 2*) that can have life-threatening consequences[12].

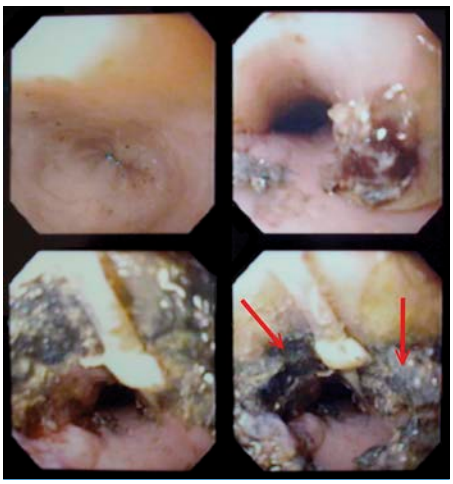

Figure 2 Endoscopic views of the esophagus after removal of button battery that was stuck there for less than 3 hours. The electrical burns are readily visible (red arrows).

Coins can be mistaken for button batteries and vice versa[9], and coins can sometimes obscure second foreign objects on X-rays[8]. Therefore, coins should be designed to have a distinct X-ray appearance. This may include a particular design of the coin's rim, or a radiographic „watermark" built into the composition of the coin that would be apparent on X-rays. For example, a particular emblem made up of a layer of X-ray dense metal could be embedded into a surrounding metal body of lower radiodensity.

Once coins are in the stomach, they are usually watched for several days before considering removal. During that time, the exposure to the stomach's hydrochloric acid causes a variable degree of corrosion and can dissolve some of the metals the coin is composed of. Experimental studies have shown that European and US-American coins exposed to 0.15 molar hydrochloric acid for 7 days lose up to 2.3% of their mass[13] and can release a number of metals including Copper, Nickel, Zinc, Aluminum, and Tin[2]. In particularly, post-1982 US-pennies made of Zink with a copper coating develop severe corrosive changes[4] that can lead to fragmentation and sharp

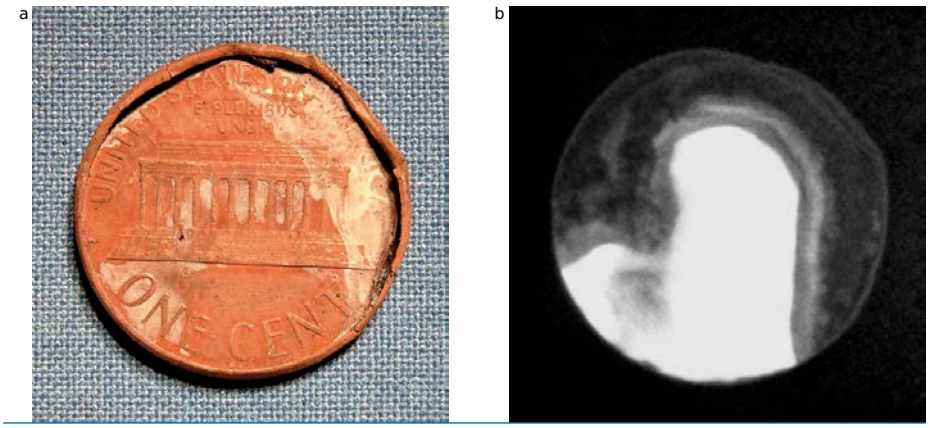

Figure 3 Zinc/Copper United States 1 cent coin exposed to hydrochloric acid for 7 days showing corrosive changes leading to sharp edges (a) and corresponding changes on X-ray (b)

Corrosion in detail

edges (*figure 3*). Although the risk of toxicity is low and has only been described for Zinc and Copper after massive coin ingestions[14,15], coins should not contain toxic heavy metals. Furthermore, corrosion of the coin should not lead to sharp edges.

Coins were more likely to pass through the gastrointestinal tract spontaneously in older children[3]. Larger coins lead to more complications and more difficult extractions[10]. As a general rule, coins should be either too large to be swallowed by small children, or small enough to pass through to the anus. Since the uncomplicated passage mostly depends on the size and age of the child, it is difficult to make any specific recommendations for the ideal dimensions of coins, but coins between 23 and 26 mm had the highest risk of being stuck in the esophagus of children[1]. Therefore, coins probably should be either no more than 23 mm or at least 26 mm in diameter.

Figure 4 Endoscopic removal of a United States one cent piece using a grasper from the duodenum of an infant. Usually, coins will pass through the gastrointestinal tract once they are past the stomach. In small patients, as in this case, they can still get stuck. A raised rim around the coin can facilitate a tight and secure grasp of the instrument.

Although coins made of magnetic material, such as the European 1, 2, and 5 cent pieces, can be extracted with a magnet[11], most pediatric surgeons don't have the equipment readily available to do so, and mostly rely on an endoscopic grasper to retrieve the object (*figure 4*). A raised rim allows for a secure purchase of the grasper on the coin, so that it is not lost when the endoscope is retracted. Magnetic coins have the disadvantage that they can cause holes in the intestines and between intestinal loops when swallowed together with magnets (another popular item for small children to swallow)[16].

Without knowledge of the technical feasibility, one could imagine some innovative approaches to keep children from putting coins in their mouth. Perhaps the coin surface could somehow be flavored with a repugnant taste. An electromagnetically accessible chip embedded in the coin may allow exact characterization and localization of the ingested foreign body without using X-rays, thereby sparing the affected children from being exposed to the associated ionizing radiation.

There surely are many other ways to improve coin safety for small children. In the meantime, pediatric surgeons around the world will continue to take care of children who swallow coins - and will try to educate the parents that lose coins do not belong into a child's hands or mouth - but rather their piggybank!

Characteristics of the „ideal" safe coin

- Easily and unequivocally identifiable on X-ray
- Either too big to swallow or small enough to pass through gastrointestinal tract
- Nonmagnetic so that it cannot cause bowel fistulae when swallowed with magnets
- Corrodes without sharp edges or releasing toxic heavy metals
- Raised rim to facilitate grasping with endoscopic instruments
- Bad taste so that children will spit out rather than swallow
- Embedded electronic chip that can send information about the coin and its location to a scanner

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...“The only ones that work are those where the Mother of God carries the baby on the right hand side.”

Coins as a cure in German folk medicine.

“A Madonna taler held in the hand protects the mother-to-be from a difficult birth. It works even better if scrapings from the taler are swallowed. The only ones that work are those where the Mother of God carries the baby on the right hand side.” can be read in Volume VIII of the pocket dictionary of German superstition.

Figure 1 Bavarian Madonna taler from 1778. The “holy dust” was scratched out here using an awl. Photo: Künker

That everyone understands the connection between disease and germs is also relatively new in the so-called civilised societies. Until well into the 19th century, in Europe disease was thought to be sent by God. Cures were a sign of God. They could be effective - or maybe not, depending on whether they were taken with real belief in their effectiveness. The cure could be anything, herbs and roots, paper with writing on it, talismans, and even coins.

As such, the Bavarian Madonna taler was the most popular (*figure 1*). It protected against a difficult birth if held in the hand. Mary and her child guaranteed help. The scrapings, which can be found on numerous Madonna taler, show how popular it was to take the silver plate.

Figure 2 German Händleinpfennig from Nuremberg, 14th century. To use, swallow it whole. Photo: Künker

The considerably smaller Händleinspfennig with a hand and a cross was swallowed whole (*figure 2*). It was supposed to help against serious wounds, “falling sickness” (epilepsy) and “many other accidents”.

In Silesia, the mother-to-be had a Johannesgroschen bound to the thigh (*figure 3*). St. John was worshipped throughout Europe as the patron saint of women who were pregnant and giving birth, and helper in the case of children’s diseases.

Figure 3 Hungarian Johannesgroschen from the 15th century, minted in Breslau (Wroclaw). Photo: Auction house Rauch

St. Liborius on the other hand was the popular heavenly intercessor for bladder and kidney stones. His reliquary casket was melted down after the conquest of the city of Paderborn by the Protestant duke Christian von Braunschweig-Lüneburg, and coins were minted from the precious metal – the so-called Pfaffenfeindtaler (*figure 4*). They were meant to be used as Protestant propaganda. But the Catholics used them as a “contact relics”. They were after all made from the silver of the shrine of Liborius and therefore, - at least in the imagination of the contemporaries - by direct contact with the Saint, they could absorb his power to help. Thus, those suffering from kidney stones no longer needed to pilgrimage to Paderborn, it was sufficient to hold a Pfaffenfeindtaler in the hand... Incidentally, this is probably also the reason that there are so many restrikes of the Pfaffenfeindtaler in later centuries.

Figure 4 German Pfaffenfeindtaler from 1622 – an important aid against bladder and kidney stones. Photo: Künker

Gold coins offered themselves for jaundice and liver inflammation, due to their yellow colour; copper coins were hung on the body against erysipelas. The Hungarian Rabendukat of Matthias Corvinus - called so because of the raven lower left on the coat of arms - was able to heal many diseases (*figure 5*). Those

Figure 5 Hungarian Rabendukat of Matthias Corvinus, after 1470, particularly effective against jaundice. Photo: Lanz

with liver damage laid the coins in water for four hours and then drank the water; for severe bleeding the dukats were heated in a pan then cooled in a glass of water and the water given as a drink to the sick person.

Obviously, there were also recipes, in which case the type of coin was immaterial, so for example to counteract fever: "He who has fever goes to the field ... to pray, and then he throws a coin over his head, a second sideways and a third under the feet. Then he walks away, without looking back."

The most famous were the English touch pieces, which go back to a ceremony in the Middle Ages. The English king was particularly proud of the fact that he could cure scrofula. To do this the King laid his hands on the afflicted part of the body, made the sign of the cross in the air using a gold coin, the Angel (fig. 6), and then hung the coin with a hole

Figure 6 English Angel, 15th century. For the royal ceremony for the healing of the scrofula, pieces like this were drilled through and hung around the neck of the diseased person. Photo: Künker

drilled in it around the neck of the sick person. The healing power was believed to be in the amulet. Therefore, it was important to wear it right up to death - and there were terrible stories about what would happen if this was not done.

However you look at it, coins and health have been connected since time immemorial.

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