TÜV Produkt und Umwelt GmbH

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concerning
a study conducted with regard to the
different methods used for drying hands

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REPORT

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different methods used for drying hands

Customer:	Verband Deutscher Papierfabriken e.V. Mr. Gert-Heinz Rentrop Adenauerallee 55 D-53113 Bonn
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Subject:	Practical test Study conducted with regard to the different methods used for drying hands
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Summary

On 21 January 2004, TÜV Produkt und Umwelt GmbH was requested by Mr. Rentrop on behalf of the German Pulp and Paper Association (Verband Deutscher Papierfabriken e.V. – VdP) to conduct a study with regard to the different methods used for drying hands.

Three different paper towels and two different paper rolls, a roll of cloth towelling and a hot-air drier were studied in seven series.

Our findings are as follows:

Our investigation confirms the findings of the "Westminster Study" according to which the number of bacteria decreases after washing the hands and subsequently drying them with paper or cloth towels and that the number of bacteria increases when using a hot-air drier.

The following changes in the bacterial count after drying the hands were observed as a result of our investigation:

Paper towels and roll	Decrease of 24%
Cloth roller	Decrease of 4%
Hot-air drier	Increase of 117%

Our investigation shows that the number of bacteria present on the hands increases after washing the hands. This clearly highlights the importance of drying the hands after washing them. The number of bacteria on the hands is only reduced by drying them with absorbent materials.

Since hot-air driers increase the number of bacteria present on the hands, attention should focus first and foremost on the hygienic advantages of paper towels when selecting a drying system.

1 Task

On 21 January 2004, TÜV Produkt und Umwelt GmbH was requested by Mr. Rentrop on behalf of the German Pulp and Paper to conduct a study with regard to the different methods used for drying hands.

In conjunction with this investigation, the functionality and cost-efficiency of the products were also assessed in addition to the hygiene properties of the various methods used for drying hands. The following different types of paper towel were compared with cloth towels and hot-air driers in a practical test:

- Folded paper towels (ZigZag, Interfold, C-Fold)
- Roll of paper
- Cloth roller towel (not new)
- Hot-air drier (already in use)

Seven products were compared altogether in a practical test.

Our investigation was based on the study "Hand drying: A study of bacterial types associated with different hand drying methods and with hot air dryers" by the University of Westminster (1994) which was placed at our disposal.

In our practical test, we compared the various hand drying methods on the basis of total microbial counts obtained and with regard to representative bacterial types of hygienic importance when washing hands.

The customer provided TPU with all the products and equipment to be investigated within the framework of this study. The customer also supplied the necessary product data / specifications together with the products.

2 Introduction

Hygiene

Hygiene is the theory of preserving the health of people and their environment. Infectious diseases still kill millions of people, even in the 21st century. New pathogens and germs which were long thought to be under control present the medical community with immense challenges. The problems are aggravated by resistance to antibiotics, widespread travel and the growing number of people with immune deficiency and elderly people. Personal hygiene, for instance by washing hands, contributes immensely and above all inexpensively to preventing the spread of infection.

Transmission of infections

Whether or not an infection actually becomes manifest, i.e. whether it displays symptoms, depends on the specific properties of the pathogen concerned, the sensitivity of the person affected and sometimes also on the means by which the infection is transmitted.

Infections can be transmitted directly or indirectly. Direct transmission requires direct contact with the organism to be infected. In this way, we can directly infect other people – and ourselves – for example by coughing up germ-laden droplets which are then inhaled. This may be the case with whooping cough and measles, for instance. Indirect transmission proceeds via detours, meaning that pathogens reach the so-called portals of entry of their next "victim" through foodstuffs, objects or people's hands. Depending on their specific resistance, microbes can survive for a long time in dust, water, the soil, the cold, the heat or the blood.

The hands are one of the most important transmitters of infectious pathogens. Above all, they play a very important part in the transmission of gastro-enteric and respiratory infections. We make contact with one another directly through our hands and many microbes feel comfortable in the warm physiological environment of the dermal microflora, at least temporarily, before they are passed on. Our hands touch our nose and mouth innumerable times every day, for instance when eating, brushing teeth, blowing the nose, coughing or sneezing; every single time, microbes are transferred from these areas to our hands and from our hands to the mouth and mucosa.

We should feel a moral obligation to the people around us to prevent the spread of pathogenic microbes.

Our hands are our main tool and, as such, frequently come into contact with such harmful substances as oil, petrol, paint, lacquer or glue. By washing the hands, we can not only prevent these substances being absorbed through the skin, but also prevent them being ingested orally through hand – mouth contact. In the United States, a higher safety factor has already been introduced for children when assessing the risks attributable to pesticides and other substances.

There are still no statutory regulations governing hand hygiene in non-medical communal institutions, but the new law concerning the prevention of infectious diseases reinforces the concept of preventing infection by educating and informing the general public, as well as through controls by public health authorities.

Theoretical principles of hand hygiene

Microflora of the skin

Healthy human skin is naturally populated by microorganisms forming what is known as the resident microflora. These bacteria are permanent "residents" inhabiting the skin, but as a rule, these bacteria do not cause illness. At the same time, however, our skin is permanently covered with microscopic cracks through which bacteria can enter the body and multiply.

The types and numbers of microorganisms per unit skin area can vary, depending on the different conditions prevailing in different regions of the body, as well as on age, sex, personal hygiene and way of life. Resident microflora are located in deeper layers of the skin and can therefore only be reduced but not removed entirely by washing the hands. These microorganisms include micrococci, staphylococci and corynebacteria which do not cause infections in healthy people, only in immunosuppressed people.

Non-resident or transient microorganisms make up another category of microflora. Their name comes from the Latin "transire", meaning to pass by. In other words, these are unwanted guests; they are commonly and very easily passed on from hand to hand.

Transient microflora may accommodate all manner of pathogens, including those which cause infections, but they normally only remain for a short time. As a rule, they do not feel at home among the resident microorganisms and in conditions hostile to them (acid pH value, low moisture content of the horny layer, fatty acids liberated by the resident microflora). Transient microorganisms normally die of their own accord after a certain time, although it is hard to say exactly how long this time is. Transient microflora also include such potential pathogens as Staphylococcus aureus, pseudomonas and other gram-negative rod bacilli. Unlike the case with resident microflora, transient microorganisms can essentially be removed by adequate hand washing.

Mention should finally also be made of the so-called infection flora. These microorganisms are only to be found in conjunction with, and in, existing skin infections, such as abscesses or infected skin diseases. Unlike the resident and transient microflora, they are therefore indirectly "visible" as a result of the infection. Staphylococci and haemolytic Group A streptococci are among the commonest.

We carry innumerable unnoticed microorganisms on our skin. The type and number of microbial flora change, depending on how we interact with the world around us – environment, other people, animals. The risk of receiving or passing on potentially infectious pathogens consequently changes accordingly without our being aware of them.

3 Method

3.1 Practical test

The study was conducted in the period from May 2004 to February 2005.

In order to obtain comparable results with regard to functionality and hygiene properties, each of the seven products to be compared were used in conformity with their intended use by 45 volunteers in a practical test. To optimize costs, the volunteers were recruited from the TÜV workforce; to ensure adequate comparability, each volunteer was only allowed to participate once in a single test series.

Since the volunteers' availability was limited, 25 tests were carried out per day.

3.2 Questionnaire

Before beginning the test, a suitable questionnaire for interviewing the volunteers was drawn up in consultation with the customer. All volunteers were instructed and prepared for the questionnaire before the test began. To ensure optimum comparability, the questionnaires were completed by the project manager during a short interview. The entire practical test was closely monitored by the project management, thus ensuring a high level of comparability.

3.3 Sampling process for microbiological laboratory tests

The paper / towel dispensers and electric hot-air drier were installed in one of the sanitary areas in the headquarters building of TÜV Rheinland Berlin Brandenburg (TRBB). This is where the hands were washed and the relevant microbiological samples were taken for assessing the hygiene properties.

Samples were first taken from the volunteers' hands before they were washed. For this purpose, the surface of the fingers was exposed to culture medium for 10 seconds. The hands were washed with cold water and a gentle, skin-compatible liquid soap. The next sample was taken after washing (wet hands); the volunteers then dried their hands and a third sample was taken. For the purpose of demonstrating specific bacterial types, samples were additionally taken from ten volunteers per series using selective culture

media. These samples were assayed for the presence or absence of such bacteria as E.coli, coliform or staphylococcus.

The culture media were incubated in the microbiological laboratory at TPU. The bacterial colonies grown on the culture media were quantified and reported as bacterial colony forming units (CFU).

Unused towels (paper / cotton) were randomly sampled before the test; the storage containers and equipment were randomly sampled during the test phase.

3.4 Culture media used

a) Total bacterial counts

Nutrient agar (Oxoid)

This is a non-selective culture medium and was used to determine the total bacterial counts. All non-exacting aerobic bacteria can grow on this medium.

b) Specific bacteria

The following selective culture media were used to identify individual types of bacteria and obtain information on the bacteria present.

MacConkey agar
This selective culture medium is used to isolate such facultative pathogenic bacteria as enterococci, staphylococci and salmonellas, shigella and coliform bacteria.

Mannitol salt agar
Mannitol salt agar is a selective culture medium used to isolate presumptive pathogenic staphylococci. The high salt concentration inhibits growth of most other bacteria except for a few halophile, marine microorganisms. Coagulase-positive staphylococci form colonies with a light yellow halo, while other staphylococci strains form colonies with a reddish halo.

4 Results

4.1 Microbiological investigation

a) Total bacterial count

The results obtained for the individual series are summarized in tabular (Table 1) and graphic (Fig. 1) form below. Nutrient culture agar was used to assay the total bacterial count (CFU). Average bacterial counts were determined before washing (VW) and after washing and drying (NT) the hands by the various methods, i.e. single-use paper towels and paper rolls, cloth roller towel and hot-air drying. The values before washing have been standardized at 100%.

Table 1

Series	Before washing (VW) (CFU)	After drying (NT) (CFU)
Roller towel, 2-ply tissue	100	66
Roller towel, TAD	100	76
Folded towel, 3-ply Interfold Tissue	100	77
Folded towel, Crepe 1-ply ZigZag	100	80
Folded towel, Tissue 2-ply C-fold	100	88
Cloth roller towel	100	96
Hot-air drier	100	217

Fig. 1

Bacterial count before washing (VW) and after drying (NT) (%age values)

Bacterial count

Roller towel, 2-ply tissue

Roller towel, TAD

Folded towel, 3-ply Interfold Tissue

Folded towel, Crepe 1-ply ZigZag

Folded towel, Tissue 2-ply C-fold

Cloth roller towel

Hot-air drier

Figure 1 compares the mean values for the change in total bacteria on the hands before and after washing and drying for the seven individual series. The values before washing have been standardized at 100%.

No distinction is made here between the bacterial types concerned.

Fig. 2

Mean bacterial populations before washing (VW) and after drying (NT)

Bacterial count

Paper roll

Paper towels

Cloth roller

Hot-air drier

Figure 2 compares the mean values for the change in total bacteria on the hands before and after washing and drying according to the different groups of material. This graph shows that the greatest decrease is observed with the paper rolls, followed by the paper towels. Only a slight decrease is observed in conjunction with the cloth roller and a major increase after drying with hot air.

No distinction is made here between the bacterial types concerned.

Fig. 3

Percentage change in bacterial populations after the individual test series

Percentage change

Paper roll

Paper towels

Cloth roller

Hot-air drier

Overall, we found that the number of bacteria present on the hands increases after washing the hands, with counts of between 250 and 400 CFU being achieved on average in the individual series. The microbial population on the hands was only reduced after drying with absorbent material. This reduction is observed in all test series with paper and cloth, but not with the hot-air drier.

The bacterial population decreased by 29% after drying with the paper roll, by 18% after drying with paper towels, but by only 4% after drying with a cloth towel. After drying with hot air, there were 117% more microbes present on the hands after washing than before washing.

Fig. 4

Mean bacterial populations before washing (VW) and after drying (NT)

Bacterial count

Paper

Cloth

Air

Figure 4 compares the mean values for the change in total bacteria on the hands before and after washing and drying according to the three groups of material. This graph shows that the greatest decrease is observed with paper. The cloth roller yields only a slight decrease, while drying with hot air leads to a major increase.

No distinction is made here between the bacterial types concerned.

Fig. 5

Percentage change in bacterial populations after the individual test series

Percentage change

Paper

Cloth

Air

Figure 6 shows the percentage change in mean values for total bacteria (Fig. 5) on the hands before and after washing and drying according to the three groups of material. This graph shows that the greatest decrease is observed with paper. The cloth roller yields only a slight decrease, while drying with hot air leads to a major increase.

Fig. 6

Percentage change in bacterial population VW – NT

Change in population

Paper

Cloth

Air

b) Specific bacteria

The following table summarizes the results obtained for the three different culture media with indication of the bacterial numbers and types before and after washing and drying the hands by means of the various methods (paper, cloth and air).

Table 2

Medium	Type of colony	Hand drying method	Mean CFU value before washing	Mean CFU value after drying	Change
NA	All	Paper	125	95	-30
NA	All	Cloth	125	120	-5
NA	All	Air	115	249	134
MAC	All	Paper	25	4	-21
MAC	All	Cloth	10	1	-9
MAC	All	Air	16	13	-3
MSA	All	Paper	82	84	2
MSA	All	Cloth	60	63	3
MSA	All	Air	91	95	4

Legend:
CFU = Colony forming unit
NA = Nutrient agar
MSA = Mannitol salt agar
MAC = MacConkey agar
All = Total number of CFUs (all bacterial types)

Number of volunteers (N) for NA = 5 x 47 Paper
1 x 44 Cloth
1 x 41 Air
for MAC + MSA 5 x 10 Paper
1 x 10 Cloth
1 x 10 Air

Fig. 7

Average change in CFU in absolute numbers before and after washing and drying

Change

Paper

Cloth

Air

5 Assessment of the results

Resident microorganisms comprise bacteria which are normally not pathogenic on healthy skin, while the transient microflora comprise bacteria which were recently acquired from contaminated materials or the surroundings. The purpose of hand washing is to reduce the number of transient bacteria and thus prevent pathogenic microbes entering the body via the hands.

A study by the University of Westminster "Hand drying: A study of bacterial types associated with different hand drying methods and with hot air dryers" (1994) showed that the number of bacteria present on the hands decreased by 42% on average when using paper, but by only 10% when using textiles and that it increased by 50% when using hot-air driers.

Our investigations confirm the study's findings that the number of bacteria decrease after washing the hands and then drying them with paper or cloth towels. We were able to demonstrate an average reduction of 24% in the number of most bacterial types present on the hands when using paper, as compared with a decrease of 4% for textiles and an increase of 117% when the hands were dried with hot air.

Selective media were used in our investigation to assess the change in specific bacteria. Transient microflora include gram-negative bacteria of the Enterobacteriaceae family (Escherichia coli, coliform bacteria, salmonellas). These were isolated with the aid of MacConkey agar, a selective culture medium. However, gram-positive cocci belonging to the resident microflora and infectious bacteria also grow on this medium.

For all three hand drying methods, we observed a decrease in specific microbes after washing. The greatest decrease in transient microbes (21 CFUs) was found with paper, followed by cloth with 9 CFUs and air with 3 CFUs. Closer identification of the microbes revealed that a mixture of resident and transient microorganisms, as well as facultative pathogenic bacteria were present on the hands of all volunteers before washing. After washing, however, only microbes belonging to the resident microflora were still present after drying the hands with cloth or paper towels.

When using hot-air driers, on the other hand, there was still a mixture of bacteria to be found on the hands after drying. The facultative pathogenic microbes remained on the hands after washing. This is due to the fact that transient microorganisms are removed from the surface of the skin when washing with soap and are then absorbed by the material when drying the hands. When using a hot-air drier, however, the bacteria cannot be absorbed by material. Moreover, additional bacteria may be deposited on the hands by the contaminated air stream when using a hot-air drier.

Mannitol salt agar is another selective medium which was used to isolate staphylococci. A slight increase in specific microbes was observed here after washing and drying the hands by all three of the methods investigated. Staphylococci belong to both the transient and the resident microflora, with a distinction being made between coagulase-positive and coagulase-negative staphylococci, due to their different pathogenicity. We have only referred to the total number of staphylococci in our study, without making this distinction.

The need for drying hands is also revealed in the transfer of bacteria from the hands to the towels used. While only very small bacterial populations were detectable on the towels before use, their number increased strongly after use. This finding corresponds with that of previous studies.

Clean and absorbent towels are needed, as the skin must be thoroughly dried after washing to remove any remaining dirt. As physical tests have demonstrated, paper towels can absorb up to nine times their own weight in moisture. A material's absorptive capacity or moisture absorption correlates with the acquisition of bacteria when drying hands. The greater its moisture absorption, the more bacteria can be acquired by the material; its consumption and the volume of waste decrease correspondingly.

Evaluation of the questionnaire

Every volunteer taking part in our study was briefly interviewed and their responses entered in the questionnaire by the project manager after washing and drying their hands. The volunteers were asked to award marks for simplicity, speed, cleanliness, appearance, functionality, dryness, softness and satisfactory nature of the appliance and drying agent used. The rating good corresponded to the marks very good and good; the rating satisfactory to the marks adequate and satisfactory; and the rating poor to the marks inadequate and poor.

The graphs show the percentage distribution of marks for the individual criteria.

After drying their hands with paper from the roll, 40 to 50% of the volunteers awarded a mark of very good for all criteria to be assessed. No volunteer considered them to be poor or inadequate. Poorer marks were only awarded by the volunteers for satisfaction and dryness. This was the case with coarser paper grades. Softness was also considered good by the majority of volunteers in this series.

After drying their hands with paper towels, 50 to 60% of the volunteers awarded a mark of very good for simplicity, cleanliness and functionality; 40 to 50% awarded the same mark for speed and appearance. The mark inadequate was not awarded by any volunteer. Only the satisfaction, softness and dryness were considered satisfactory by the volunteers. This was the case with coarser paper grades. Some volunteers also considered the functionality to be adequate in this series.

After drying their hands with hot air, around 40% of the volunteers awarded a good mark for simplicity, cleanliness and functionality. The volunteers approved of the design of the hot-air drier and 50 to 60% considered its appearance to be very good. The mark inadequate was not awarded by any volunteer. Satisfaction, dryness and functionality were considered satisfactory by the volunteers. It is striking that more than 50% considered the softness to be good. The marks awarded for speed are very widely spread, from a middle range to poor.

In allen Grafiken

Percent

Paper roll – Paper towels – Cloth roller – Hot-air drier

Good – Satisfactory – Poor

Assessment of simplicity

Assessment of speed

Assessment of dryness

Assessment of cleanliness

Assessment of appearance

Assessment of functionality

Assessment of softness

Assessment of satisfaction

6 Opinions on hygienic means of drying hands

When asked which form of drying is preferred, 72% of our volunteers preferred paper, 19% preferred cloth and only 9% wanted hot air.

Numerous studies by independent institutes have confirmed the physiologically safe nature of paper. While the quality of paper always remains the same, the quality of cloth towels deteriorates steadily every time they are washed. They become shorter, thinner and harder after washing, thus reducing their ability to absorb moisture.

Most dispensers allow the towels to be removed without touch, so that the user only comes into contact with the paper once. This ensures that used and unused towels are hygienically separated. Since paper towel dispensers are designed to dispense only single sheets, it is impossible to remove a whole pack of towels at once.

The cloth towel is firmly integrated into its dispenser. There is no strict separation between used and unused towel here. The damp, used part of the cloth roller towel offers ideal conditions in which bacteria and mould can multiply.

From a hygienic point of view, towels are preferable to hot air for drying hands. Bacteria and other microbes in the bathroom and toilet area are blown onto the user's hands by the stream of air from the hot-air drier. If such driers are used regularly, the skin can become dry, flaky and chapped. Alkaline soap residues on the skin can cause irritation.

In order to assess the time required, we stopped the time and found that 20 seconds are spent washing the hands on average and 15 seconds for drying them with paper and cloth, but that considerably more time – namely 30 seconds on average – is needed to dry them with hot air. This correlates with the findings of other studies.

Since there are still no statutory regulations on hand hygiene in non-medical communal institutions, this raises the question as to which aspects should be given priority, economics or health.

The new law concerning the prevention of infectious diseases reinforces the concept of prevention through education and control by the public health service.

As our study and others have shown that hot-air driers increase the number of bacteria on the skin, attention should focus above all on the hygienic advantages of paper towels when deciding on a particular drying system.

Contrary to widespread opinion, paper towels are a particularly eco-friendly way of drying hands, for more than half the towels used are now made from recovered paper. Ecologically aware firms in the controlled forestry sector cover the remaining requirement with sawmill scrap and broken wood without industrial value. Even recovered paper is reused up to six times and used in the production of paper towels.

Due to the extensive soiling, cloth towels have to be sent to a laundry where they are cleaned and disinfected with chemical agents.

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