

Original Paper

A study on the effect of hand washing to remove bacterial contamination on fingers

Tomoyo OHNO *Aino Gakuin College*

Abstract

Bacterial contamination on fingers before and after washing hands, defecation activities and other conditions were examined by counting bacterial colonies on four kinds of agar plates exposed to finger tip bulbs or swabs dipped in physiological saline.

Marked contamination was found on the fingers before washing with running water. After defecation the contamination observed was not necessarily only by *E. coli*. Contamination from coins or bills was as much as that from the toilet door knobs in a hospital or at home. Washing hands with soap, then running water and drying were effective for removing bacterial contamination on fingers. Hand washing is strongly recommended to avoid food poisoning and other infections.

Key words: bacterial contamination, hand washing, defecation, coins and bills, toilet doorknob

Introduction

People in modern industrialized countries are usually concerned about hygiene. Drainage systems and flush toilets are commonly used. Nevertheless, in crowded urban environments, it is not certain whether the sanitation measures are enough to keep people's hands and fingers clean. There are only few studies which have examined how hands and fingers are contaminated under different conditions (Takahashi et al., 1991). Some studies have examined the sanitary conditions of nurses' fingers (Haraguchi et al., 1991). Most of studies have examined microbial flora on nails and the area around the nail beds but very few have studied bacterial contamination on finger bulbs. We therefore studied the sanitary condition of finger bulbs under different conditions by counting the number of bacterial colonies.

Materials and Methods

Five adult subjects, one male and four females, were subjected to examination of finger contamination in daily living conditions by counting the number of bacterial colonies on agar plates with different culture media. One finger was exposed to the agar before washing with running water and then again after wiping with cloth or air drying. Cotton swabs which had been dipped in physiological saline were used to touch the door knobs of toilets and then inoculated on to the culture medium to examine the bacterial colonies.

The following four culture media were used: (1) ordinary nutrient agar culture, (2) dextrose agar medium for *Staphylococcus*, (3) blood agar, and (4) selective culture medium for *Escherichia coli* (*E. coli*). The composition of each culture medium (per liter) was as follows:

- (1) Mannitol salt agar: 1.0g broth, 10.0g peptone, 75.0g NaCl, 10.0g mannitol, 0.025g phenol red, and 15.0g agar, pH 7.4.

- (2) *Staphylococcus* medium No. 110: 10.0g peptone, 2.5g yeast extract, 30.0g gelatin, 10.0g mannitol, 75.0g NaCl, 2.0g lactose, 5.0g KH₂PO₄, 15.0g agar, pH 7.0.
- (3) Blood agar base No. 2: 15.0g proteose-peptone, 2.5g liver digests, 5.0g yeast extract, 5.0g NaCl, 12.0g agar, pH 7.4.
- (4) Desoxycholate lactose agar for *E. coli*: 5.0g pancreatic digests of casein, 5.0g pepsin digests of animal tissue, 10g lactose, 5.0g NaCl, 2.0g citrate, 0.5g Na-desoxycholate, 15.0g agar, 0.033g neutral red, pH 7.1.

After inoculation, the petri dish was incubated for 24–48 hours and the number of colonies was counted. Bacterial growth was determined as the number of colonies as follows: (1) 0, not detected -, (2) 1–4, +, (3) 5–9, ++, (4) 10–20, +++, (5) 21 or more colonies, #, (6) numerous colonies, countable, ##, (7) numerous colonies with some space among them, ###, (8) numerous colonies with no space among them, ####.

Results

At the start of the experiments, one finger of both hands of each subject was examined to observe the

contamination level without any treatment (Table 1). There was essentially no difference between the fingers of the right and left hands, both being heavily contaminated with nonspecific bacteria and *E. coli*. There was no difference between male (A) and female (B–D) subjects.

The effects on hand contamination after wiping with a handkerchief or a cloth towel or warm-air drying after washing with running water and wiping with a handkerchief or cloth towel or drying after washing with soap and running water, were examined (Table 2 and 3). In both culture media, as compared with the start of the experiment, washing was quite effective, and the number of bacterial colonies was remarkably reduced. Washing with running water and soap were particularly effective.

In our next experiment, we tried to see how bacterial contamination on fingers increased on wiping after defecation and then decreased by washing (Table 4). Interestingly, we found no conspicuous increase in the bacterial population on the finger after defecation and wiping the anus with toilet paper. Also, comparing the cultures before and after wiping, following defecation showed that the population of *E. coli* was not conspicuously increased, and sometimes not at all. There was no conspicuous difference between male and

Table 1 Cultivation of bacteria on finger bulbs under daily life conditions

Item Subject	Culture plate	Right finger	Left finger
A	Blood agar	(#)	(#)
B	Blood agar	(#)	(#)
C	Blood agar	(+++)	(#)
D	Selective medium for <i>E. coli</i>	(++)	(++)

Notes: (++) : 5 to 9 colonies (+++): 10 to 20 colonies (#) : 21 or more colonies
E. coli : *Escherichia coli*

Table 2 Bacterial contamination on finger after different hand-washing procedures

Item Subject	Culture plate	Before hand-washing	Running water→ Handkerchief	Running water→ Cloth towel	Soap→Running water→ Handkerchief	Soap→Running water→ Cloth towel
A	Dextrose agar	(##)	(#)		(-)	
	Blood agar	(##)	(#)		(#)	
B	Nutrient agar	(+++)		(+++)		(+++)
C	Nutrient agar	(#)	(++)		(++)	
D	Nutrient agar	(+++)		(+++)		(+++)
E	Dextrose agar	(#)		(#)		(+)
	Blood agar	(##)		(#)		(#)

Notes: Dextrose agar : Selective medium for *Staphylococcus*
(-) : no colonies (+) : 1 to 4 colonies (++) : 5 to 9 colonies (+++) : 10 to 20 colonies (#) : 21 or more colonies
(##) : numerous and countable colonies blank : not examined

OHNO: Hand washing to remove bacteria

Table 3 Bacterial contamination on finger after a series of hand-washing procedures

Item Subject	Culture plate	Before hand-washing	Running water→ Natural air drying	Soap→Running water→ Natural air drying	Soap→Running water→ Warm air drier
A	Nutrient agar	(###)	(##)	(#)	
	Dextrose agar	(####)	(##)	(#)	
E	Dextrose agar	(#)			(+++)

Notes : (+++) : 10 to 20 colonies (#) : 21 or more colonies (##) : numerous and countable colonies
 (###) : numerous colonies with some spaces among them (####) : numerous colonies with no spaces among them
 blank : not examined

Table 4 Bacterial contamination related to defecation activities

Item Subject	Culture plate	After entering toilet	After wiping anus with toilet paper	After dressing	After hand-washing
A	Selective medium for <i>E. coli</i>	(-)	(+)	(-)	(-)
	Nutrient agar	(#)	(#)	(#)	(#)
B	Selective medium for <i>E. coli</i>	(++)	(-)	(-)	(-)
	Nutrient agar	(+++)	(+)	(+++)	(++)
C	Selective medium for <i>E. coli</i>	(+)	(+)	(-)	(-)
	Dextrose agar	(-)	(-)	(-)	(-)
D	Selective medium for <i>E. coli</i>	(-)	(-)	(-)	(-)
	Dextrose agar	(-)	(-)	(-)	(-)

Notes : Dextrose agar : See Table 2.
 (-)(+)(++)(+++)(#) : See Table 2.
E. coli : *Escherichia coli*

Table 5 Bacterial adhering to the finger after disinfection or washing with soap

Item Subject	Culture plate	After disinfection or washing with soap	After handling a coin	After handling a bill
A	Nutrient agar	(#) [★]	(++)	(#)
E	Dextrose agar	(+) [◆]	(#)	(#)

Notes : ★ : Finger after disinfection with alcohol ◆ : Finger after hand-washing with soap
 (+)(++)(#) : See Table 2.
 Dextrose agar : See Table 2.

female subjects.

We examined the possibility of contamination when a subject (A, male) touched the doorknobs of the toilet at home and at a public toilet in a hospital with a swab dipped in physiological saline. The contamination was not remarkably different between the doorknob of corridor side and toilet side (data not shown). The contamination of the toilet doorknob in the hospital was similar to that in the home.

Table 5 shows the contamination found on the fingers of two subjects, A and E (male and female) when they touched a coin or a bill and after disinfection or washing of hands. Obvious contamination with bacteria was found after touching a coin and more after touching a bill in subject E.

Discussion

The present study used simple but quantitative experiments to reveal that hand washing is an effective method for maintaining sanitation. Contamination can occur after using a toilet or touching coins or bills, and washing the hands can effectively remove the bacteria. An interesting result (Tables 2 and 3) was that warm air drying rather than wiping with a towel was effective for removing bacterial contamination on fingers. Contamination by defecation was not apparent, contrary to our expectation, but that due to coins and bills was marked.

In considering the sanitary condition of the fingers, usually the area under the nails and the area around the nail beds are considered to harbor a large number of microorganisms. Therefore, people engaged in medical treatment, particularly in surgical opera-

tions, maintain short fingernails and use aseptic techniques. However, it has been experimentally proven that nails and related areas are not very much contaminated by microorganisms (Edel et al., 1988). What has been neglected is work on the bulbs of fingertips (Takahashi et al., 1991). We decided to examine the bacterial contamination on the bulbs of fingertips and found that they also have a major number of microbial colonies.

In Japan, in 1996, food poisoning led to a serious problem when a meal service for children at elementary schools in Osaka caused poisoning due to contamination with *Escherichia coli*, O157 (Yamaguchi et al., 1997). While radish seedlings were one of the suspected materials, the real cause remains unknown. It is possible that hands and fingers of cooks or other people involved in the preparation of meals at schools could have been contaminated with the bacteria.

People are generally concerned about hygiene when they use toilets or grasp straps in trains. However, they seem to pay little attention to the possibility of contamination when they handle coins and bills, which are as contaminated as toilet doorknobs. Contrary to our expectation, fingers are not much contaminated after defecation and wiping with toilet paper, although the doorknob of a public toilet is as contaminated as the home toilet.

The most serious effect of finger contamination with microorganisms is food poisoning. Therefore, it is strongly recommended that one washes hands with soap, then with running water, particularly after

touching coins and bills, before preparing food.

Elderly people and small children are usually more easily infected than adults. In homes or hospitals, those involved in the preparation of food for the elderly and children should pay a special attention to hygiene conditions. Also, further studies may be necessary to examine the bacterial contamination on the fingertips of the elderly and children.

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References

- Edel, E., Houston, S., Kennedy, V., Rocco, M. : Impact of a 5-minute scrub on the microbial flora found on artificial, polished, or natural fingernails of operating room personnel. *Nursing Res.* 47 : 54-59, 1988
- Haraguchi, H., Sugahara, H. : Bacteriological studies on the effect of hand-washing in nursing. *Bed-side Nurs.* 17 : 1554-1560, 1991
- Takahashi, Y., Hayashi, K. : Bacterial flora found on fingers after hand-washing before operation. *Effect of brush washing. Operation Medical Res.* 61 : 247-250, 1991
- Yamaguchi, E., Inagaki, N., Kitagawa, F., Shiba, I. : Nursing for children causing rapid change of symptoms by *Escherichia coli* O157 infection. *Kangogijutsu.* 43 : 66-71, 1997