

## Microbial contamination of hands with or without the use of bidet toilets (electric toilet seats with water spray) after defecation

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### ABSTRACT

Bidet toilets (electric toilet seats with water spray) are increasing in popularity worldwide. However, the extent of reduction of microbial contamination of the hands with the use of bidet toilets after defecation is unclear. Microbe contamination of the hands with and without the use of bidet toilets after defecation was examined in 32 nursing students. Double gloves were worn on the dominant hand and four layers of toilet paper were used to wipe the buttocks after defecation, and microbe contamination of the second glove (outer glove) of the double gloves was examined. The volunteers were free to select the flow volume, wash time of the bidet, and the type of bidet. Without the use of a bidet toilet, the average value  $\pm$  standard deviation of the number of microbes attached to the gloves was  $39,499.3 \pm 77,768.3$  colony forming units (cfu)/glove; however, it was  $4,146.9 \pm 11,427.7$  cfu/glove when the bidet toilet was used. The number of microbes adhering to gloves was significantly reduced when a bidet toilet was used ( $p < 0.00001$ , Wilcoxon signed-rank test).

**Key words:** bidet toilet, hand, microbial contamination

### HIGHLIGHT

- Using the bidet function of toilet is efficacious in maintaining hand hygiene.
- Use of bidet decreases transmission of fecal microbe to the hand.

### INTRODUCTION

The bidet toilet was developed in Japan and its use is spreading worldwide (Iyo *et al.* 2018). Although the health-related advantages (beneficial for bowel movements, no clinical health risk for preterm birth or bacterial vaginosis, and low incidence rates of bacterial vaginitis) of using bidet toilets have been reported (Uchikawa *et al.* 2007; Kiuchi *et al.* 2017; Asakura *et al.* 2018), there are also health-related disadvantages (aggravation of vaginal microflora and correlation with itch of the anus) (Ogino *et al.* 2010; Tsunoda *et al.* 2016). The transmission of infectious diseases among individuals is also of concern as warm-water nozzles of bidet toilets may be infected with bacteria such as *Staphylococcus aureus* (Kanayama Katsuse *et al.* 2017). However, it is unclear whether the use of a bidet toilet affects the hygiene of the hands. Studies on the effectiveness of bidet toilets in the prevention of microbial contamination of the hands after defecation have only involved *in vitro* experiments (Oie *et al.* 2018). Therefore, this study examined microbial contamination of the hands of 32 volunteers after defecation with and without the use of a bidet toilet.

### METHODS

This study was conducted with the participation of volunteer nursing students from the Ube Frontier University (Ube City, Yamaguchi Prefecture). Therefore, approval was received from the Ube Frontier University Ethics Review Committee (Title: Hands and finger contamination after defecation – comparison of use with and without warm-water washing toilet seats (bidets), Approval date: November 8, 2017, Examination certificate management number: 17007).

### Microbiological analysis

The number of microbes adhering to gloves after defecation of 32 nursing students (17 males and 15 females, 18–26 years old) with and without the use of bidets was examined. However, the subjects were instructed to note the strength (strong, medium,

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or weak) of the stream pressure and the length of bidet use, which they timed using a standardized stopwatch. Double gloves (Plastic Glove No. 2500 Kyowa Ltd, Osaka, Japan) were worn, and the number of microbes adhering to the gloves after wiping with four sheets of toilet paper was examined. Four sheets of toilet paper were used because a survey conducted by the Japan Sanitary Equipment Industry Association on the number of sheets and the length of toilet paper for wiping involving 1,748 subjects revealed that four sheets of toilet paper are the most frequently used amount (Japan Sanitary Equipment Industry Association 2016). The outer gloves of the double gloved hand that held the toilet paper were peeled and placed into bottles containing 200 mL of normal saline and subjected to sonication at 36 kHz (Since Sonic 100, Ikemoto Scientific Technology Co., Ltd, Japan) for 5 min (Oie *et al.* 1996). Each sample was diluted 10-fold, 100-fold, and 1,000-fold in sterile saline; four aliquots (0.25 mL each) of each dilution and of an undiluted sample were plated on four trypticase soy agar (TSA; Eiken Chemical, Tokyo, Japan) plates. In addition, the remaining saline sample (approximately 200 mL) in the bottle was filtered through a 0.22- $\mu$ m membrane filter (diameter of 5 cm; Nippon Thermo Scientific, Wilmington, NC, USA) and placed on a TSA plate (Wu *et al.* 2005). These TSA plates were cultured aerobically at 35 °C for 48 h. Microorganisms were identified by Gram staining, morphological examination, oxidation fermentation test, cytochrome-oxidase test, and the API system (bio-Mérieux SA, L'Etoile, France).

## RESULTS

In the pre-experiment (five subjects), when the colony forming units (cfu) of microorganisms attached to gloves after defecation cultured aerobically with TSA and anaerobically with GAM (modified Gifu Anaerobic Medium) agar were compared, the samples recovered had more cfu with TSA. Therefore, in this experiment, anaerobic culture with GAM agar was not performed and only aerobic culture with TSA was performed.

The number of microbes attached to gloves after defecation with and without the use of a bidet toilet is shown in Table 1. Seven subjects opted to use the strong stream strength, 18 used medium, and 7 used the weak stream pressure for the bidet setting. Six subjects used the bidet between 5 and 15 s, 20 subjects used it between 20 and 30 s, 3 used it between 40 and 50 s, and 3 used it between 60 and 80 s. We found that samples recovered on the gloves in 31 out of 32 volunteers (96.8%) had markedly decreased cfu from recovered samples after using the bidet compared to without using the bidet. Furthermore, 21 out of the 32 (65.6%) samples recovered from bidet users had less than 10% average microorganisms (cfu) attached compared to the control group; 8 out of 32 (25%) had less than 1% cfu of those without using the bidet. The amount of microbes adhering to the glove after defecation was significantly reduced when a bidet toilet was used ( $p < 0.00001$ , Wilcoxon signed-rank test). The major microorganisms attached to gloves were *Bacillus* spp., coagulase (–) staphylococci, *Citrobacter freundii*, *Enterobacter cloacae*, *Serratia marcescens*, *Klebsiella pneumoniae*, *Escherichia coli*, and *Candida* spp. such as *C. parapsilosis*. The average  $\pm$  standard deviation cfu attached to gloves after defecation without using a bidet toilet was  $39,499.3 \pm 77,768.3$  cfu/glove; however, it was  $4,146.9 \pm 11,427.7$  cfu/glove when a bidet toilet was used.

## DISCUSSION

As we previously reported the effectiveness of bidet toilets using *in vitro* experiments, in this study, we examined the effects of bidet toilets *in vivo* using human subjects in real-life settings. In our previous study using the model buttocks smeared with artificial diarrheal feces containing *S. marcescens*, the use of a bidet toilet reduced the cfu of *S. marcescens* significantly ( $p < 0.00001$ ) (Oie *et al.* 2018). Consistent with our previous *in vitro* experiment, a similar trend was noted in this *in vivo* study, confirming the effectiveness of a bidet toilet in reducing the cfu ( $p < 0.00001$ ).

Microbial contamination from feces on the hands after defecation is estimated to have a major impact on the spread of intestinal infections such as norovirus gastroenteritis, hepatitis A, *Salmonella* infections, *Clostridioides difficile*-related infections, and enterohemorrhagic *E. coli* infections (Worsley 1998; Evans *et al.* 2002; Wu *et al.* 2005; Greig *et al.* 2007; Todd *et al.* 2007; Lyman *et al.* 2009; Salama *et al.* 2013). For example, there have been outbreaks resulting from food handlers who are infected or asymptotically infected with norovirus and do not sufficiently wash or disinfect their hands after using the toilet, and then handle food (CDC 2011; Mathijs *et al.* 2012; Tsuchiya *et al.* 2015). In most cases, outbreaks of communal diarrhea are often attributed primarily to the contamination of the hands (Black *et al.* 1981; Ekanem *et al.* 1983). With basic understanding rooted in the understanding of how pathogen spreads from the fecal–oral route, the utmost importance on the method for maintaining hand hygiene after defecation has been considered important (WHO 2009), and it is also important to prevent fecal contamination of the hands after defecation as much as possible. In this study, the use of a

**Table 1** | Contamination of the hands after defecation with or without the use of bidet toilets<sup>a</sup>

Experiment participant number	cfu/glove		Sex	Strength of the bidet	Time spent using bidet (s)
	Bidet not used	Bidet used			
1	$4.1 \times 10^5$	$5.4 \times 10^4$	Male	Strong	30
2	$1.7 \times 10^5$	664	Male	Weak	30
3	$1.0 \times 10^5$	$3.4 \times 10^4$	Male	Weak	80
4	$8.5 \times 10^4$	$2.4 \times 10^4$	Male	Medium	30
5	$7.8 \times 10^4$	131	Male	Strong	20
6	$7.2 \times 10^4$	115	Female	Medium	5
7	$7.1 \times 10^4$	328	Female	Weak	30
8	$5.6 \times 10^4$	38	Female	Medium	15
9	$2.4 \times 10^4$	310	Male	Strong	30
10	$2.4 \times 10^4$	720	Male	Medium	30
11	$2.2 \times 10^4$	5	Male	Medium	10
12	$2.1 \times 10^4$	$7.2 \times 10^3$	Male	Medium	25
13	$1.8 \times 10^4$	352	Female	Medium	10
14	$1.7 \times 10^4$	816	Female	Medium	30
15	$1.7 \times 10^4$	$4.8 \times 10^3$	Male	Medium	15
16	$1.5 \times 10^4$	$1.0 \times 10^3$	Male	Strong	30
17	$1.4 \times 10^4$	420	Male	Medium	30
18	$1.1 \times 10^4$	66	Male	Strong	45
19	$1.0 \times 10^4$	134	Male	Medium	60
20	$7.0 \times 10^3$	$1.5 \times 10^3$	Female	Weak	40
21	$5.0 \times 10^3$	848	Female	Strong	30
22	$4.0 \times 10^3$	172	Female	Weak	30
23	$4.0 \times 10^3$	360	Male	Medium	10
24	$2.0 \times 10^3$	38	Male	Strong	20
25	$2.0 \times 10^3$	15	Female	Medium	20
26	$2.0 \times 10^3$	63	Male	Medium	30
27	$1.0 \times 10^3$	29	Female	Weak	30
28	$1.0 \times 10^3$	265	Female	Medium	50
29	320	97	Female	Medium	24
30	244	18	Female	Weak	60
31	228	124	Female	Medium	30
32	184	75	Female	Medium	20
Mean $\pm$ standard deviation*	39,499.3 $\pm$ 77,768.3	4,146.9 $\pm$ 11,427.7			

<sup>a</sup>Wiped with four layers of toilet paper.\* $p < 0.00001$  (Wilcoxon signed-rank test).

bidet toilet was demonstrated to be effective in reducing microbial contamination of the fingers after defecation. We provide evidence that a bidet toilet is effective at preventing the spread of intestinal infections.

## CONCLUSIONS

Although the number of participants in this experiment was small, with only 32 nursing students, all participants were young and it was conducted under semi-controlled conditions, the use of a bidet toilet was an effective method for reducing the

adherence of feces to the hands at the time of defecation. The reduction of microbe contamination of the hands is possible with the use of a bidet toilet after defecation.

## DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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