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Dirty hands: bacteria of faecal origin on commuters' hands

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SUMMARY

Although many studies have investigated bacteria on the hands of health-care workers and caregivers, few have looked at microbiological contamination on the hands of the general adult public. This study investigated faecal bacteria on the hands of commuters in five UK cities. Of the 404 people sampled 28% were found to have bacteria of faecal origin on their hands. A breakdown by city showed that the proportion of people with contaminated hands increased the further north the city of investigation ($P<0{\cdot}001$), an effect which was due in large part to a significant trend in men but not in women. Bus users were more contaminated than train users. The results of this exploratory study indicate that hand hygiene practices in the UK may be inadequate and that faecal indicator bacteria on hands may be used to monitor the effect of hand-washing promotion campaigns.

Key words: Enteric bacteria, *Enterococcus*, hand hygiene, prevention, public health.

INTRODUCTION

Infectious intestinal diseases are amongst the leading causes of mortality in children worldwide, latest estimates put deaths from diarrhoea at about 1·9 million per annum [1]. It has been suggested that hygiene and hand-washing promotion may be one of the most cost-effective interventions for preventing infectious diseases in developing countries [2] and that hand washing in particular, if globally practised, could save over a million lives [3]. In developed countries like the UK it has been estimated that 1 in 5 people have an episode of diarrhoea every year, causing work and school absence, and a high burden on health services [4]. A study in the north of England found that only 43% of mothers washed hands after changing a dirty nappy [5] and studies have found low rates of hand washing in public washrooms. Lack of adequate hand washing in the community may also be partially responsible for current problems associated with hospital-acquired infections [6].

Whilst a number of studies have isolated bacteria on hands of health-care workers in hospitals [7], of caregivers after changing a nappy [8], of homemakers [9], and bacteria on surfaces in public places [10], few have looked at faecal contamination on the hands of the general adult public. Our objective in this exploratory study was to provide a survey of contamination on

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the hands of commuters to gauge the importance of hands as routes of transmission of bacteria of potential faecal origin in the broad UK population.

METHODS

We took swabs from the hands of commuters waiting at bus stops near London Euston, Birmingham New Street, Liverpool Lime Street, Cardiff Central and Newcastle Central railway stations on weekday mornings between 27 August and 17 September 2008. Trained master's students approached people at the sites, explained the study and asked whether they would like to participate.

Hand swabs were taken and participants were also asked questions regarding age, sex, occupation, mode of transport used, health-care use, antibiotic treatment and hand-washing practices.

The samples were collected by wiping charcoal transport swabs containing 500 μl of nutrient broth across the fingers of the volunteers. These were then sealed and returned to the laboratory within 8 h. Upon arrival at the laboratory the swabs were placed into a glass Universal containing Purple MacConkey broth with a small glass inverted tube (to collect any gas produced). The Universals were then incubated at 44 °C for 24 h and those which turned from purple to yellow and exhibited gas were deemed to be *E. coli*. All Universals were then subcultured onto two types of agar plate: (1) MacConkey agar No. 3 which contains Crystal Violet to inhibit Gram-positive cocci such as staphylococci and micrococci (normal skin flora) and lactose to determine if the organisms could ferment this to produce acid (pink colonies are produced by a change in pH). (2) Bile Aesculin agar upon which enterococci appear as black colonies. Pink colonies of the former were then tested with a spot indole reagent, a change to turquoise colour indicating *E. coli*. The identity of all the other colony types was resolved using an API 20 E biochemical strip predictor. Any black colonies on the Bile Aesculin were then tested with streptococcal group D antisera where a positive result for enterococci was confirmed by the appearance of agglutinating particles. All of the media and antisera used in the study were from Oxoid (UK).

Univariate analysis of the different categories, and the continuous exposure variables (latitude of location) and multivariate analysis were done using Poisson regression with robust standard errors, a method suitable for common binary outcomes [11].

Table 1. *Organisms detected on hands*

Organism	*n*	Percent of samples positive
Enterococcus	87	21·5
E. coli	38	9·4
Klebsiella	10	2·5
Pantoea	4	1·0
Enterobacter	1	0·3
Citrobacter	1	0·3
Multiple isolations	27	6·7
Total positive	111/404	27·5

Ethical clearance was obtained from the Ethics Committee of the London School of Hygiene and Tropical Medicine.

RESULTS

Overall 409 commuters agreed to take part in the study. Five samples had to be discarded due to a technical error. Out of the 404 remaining samples 111 (27·5%) had faecal bacteria present.

Table 1 shows the organisms that were detected. Most common were *Enterococcus* in 22% of samples, followed by *E. coli* in 9%. Seven percent of samples were positive for several organisms.

Table 2 shows the prevalence of detection of any faecal organism by city (overall and stratified by gender). Overall, a significant trend towards a higher contamination prevalence with increasing latitude of the city was detected (Poisson regression, P for linear trend $<0{\cdot}001$). This effect was found to be entirely due to men: whilst the overall prevalence of contamination was similar in men and women, male hands tended to be more contaminated the further north the city of investigation (Fig. 1, P for linear trend $<0{\cdot}001$). For women, no such trend was observed ($P=0{\cdot}285$).

The risk of hand contamination by different population characteristics is summarized in Table 3. The risk of contamination did not vary strongly by age, by use of antibiotics, by whether they had visited a hospital or whether they reported having washed their hands with soap that morning. People who used the bus were more likely to show contamination than people who used the Underground. There is also an indication that people who used the bus were more contaminated than those who used overground trains; however, the confidence interval was wide and

Table 2. *Prevalence of faecal organisms by city and gender*

	Latitude	Number positive/total	Percent with contaminated hands		
			Males and females	Males	Females
London	51·51	13/100	13	6	20
Cardiff	51·49	11/49	22	15	29
Birmingham	52·48	21/86	24	23	26
Liverpool	53·40	26/77	34	36	31
Newcastle	54·97	40/92	43	57	31
Overall		111/404	27	28	27

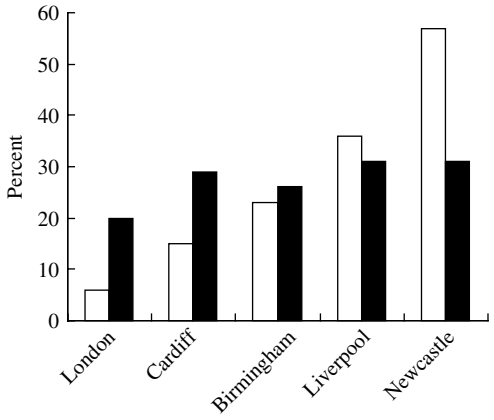

Fig. 1. Prevalence of contamination of hands of men and women in sampled cities. □, Percentage of men with contaminated hands; ■, percentage of women with contaminated hands.

included 1. There was a trend for those in manual occupations to have less contamination than those in administrative jobs, or students, retired, or unemployed people, and especially those in professional occupations. However, again, the confidence intervals were wide and include 1.

The results of the multivariate analysis are shown in Table 4. The analysis broadly confirmed the results of the univariate analysis: there was a strong trend of increasing contamination from south to north in men but not in women. In men the risk of contamination increased with every degree of latitude by around 70%, independent of transport use and occupation. In both men and women there was a trend towards higher risk of contamination in bus users than in train/tube users, although the confidence intervals were wide and included 1. There was also some indication that women in professional occupations had a higher risk of contamination, but again the confidence intervals were wide and included 1.

DISCUSSION

This study did not attempt to quantify the number of bacteria that were found on hands, hence hands could be reported as positive with only one or very few bacteria. Nevertheless, we were surprised by the high prevalence of bacteria of faecal origin on hands. Although the presence of bacteria like *Enterococcus faecalis* is probably not a health hazard in itself, it may be indicative of a failure of good hygiene practice, and more specifically a failure to wash hands after contact with faecal material. Alternatively, these bacteria may have been picked up by touching a surface which someone with poor post-defecation hygiene had previously touched. This contamination can then spread via surfaces through successive individuals. Those with poor hygiene and those who have picked up bacteria from others with poor hygiene cannot be distinguished in our study as we do not know the number of bacteria found in each of the contaminated samples. However, any pathogens present in excreta are likely to spread between individuals via this route of transmission. A study by Pinfold & Horan [12] found that the occurrence of *Enterococcus* from a finger impression technique was positively related to the incidence of diarrhoea. Enterococci were the most frequently isolated organism in our study, which may be due to their high stability on hands compared for example to *E. coli* [13]. We did not check for the presence of pediococci or *Aerococcus viridians*, which may have been a source of false-positives for enterococci. This could be easily addressed in further planned studies, by plating onto blood agar, where colonies of pediococci or *A. viridians* would be much smaller than those of *Enterococcus*. Further biochemical tests could also be carried out. In addition, these organisms tend to form tetrads upon Gram staining, and could therefore be distinguished from enterococci in this way.

Table 3. *Risk of hand contamination compared across different factors*

	n	Contaminated	%	Risk ratio	95% CI
Overall	404	111	27		
Age (yr)					
<30	183	54	30	1·0 (ref.)	
>30	211	53	25	0·85	0·62–1·18
Occupation					
Manual	34	6	17	1·0 (ref.)	
Administrative	159	40	25	1·43	0·66–3·10
Professional	78	27	35	1·96	0·89–4·31
Student	61	15	25	1·39	0·60–3·23
Retired	30	8	27	1·51	0·59–3·86
Unemployed	15	4	27	1·51	0·50–4·58
Mode of transport*					
Bus	247	73	30	1·0 (ref.)	
Overground	39	9	23	0·78	0·43–1·43
Underground	41	4	12	0·41	0·18–0·96
Hospital visits this week?				0·70	0·70
No	355	95	27	1·0 (ref.)	
Yes	44	13	30	1·10	0·68–1·80
Taking antibiotics					
No	380	103	27	1·0 (ref.)	
Yes	19	5	26	0·97	0·45–2·10
Washed hands with soap this morning?					
No	40	12	30	1·0 (ref.)	
Yes	356	94	26	0·88	0·53–1·46

CI, Confidence interval.
* Excludes those who used more than one.

Table 4. *Multivariate analysis regarding the effect of transport and occupation on the trend for contamination to increase with latitude*

	Prevalence ratio	95% CI
Men		
Latitude	1·68	1·40–2·00
Occupation: professional	0·94	0·50–1·76
Transport: bus	0·55	0·28–1·11
Women		
Latitude	0·99	0·79–1·24
Occupation: professional	0·69	0·31–1·39
Transport: bus	0·66	0·36–1·30

CI, Confidence interval.

We have no exact data on refusal to participate, but the field staff indicated that approximately half the people approached agreed to take part in the study. This may have caused some selection bias; however, those people who were willing to take part in the study were probably those who thought that their hygiene was good, and so any bias was unlikely to have ruled in people with more contaminated hands. Interestingly, we found that there was no difference in contamination between those reporting having or not having washed their hands with soap in the morning. This could either indicate that self-report of hand washing with soap is unreliable, as has been found in other studies [14, 15] or that many people who showed contamination had picked up bacteria from surfaces during their journey, regardless of whether they had washed with soap beforehand.

It should be noted that although the bacteria we isolated are likely to be of faecal origin, *Enterobacter*, *Pantoea*, *Citrobacter* and *Klebsiella* are also found in many other niches of the environment, and could therefore have been picked up from non-faecal sources, e.g. from working with food or animals. However, these bacteria were not isolated in many samples, so this fact should not affect the interpretation of our results. As outlined above, all the bacteria isolated from individuals may also have been found due to transmission from other individuals

who picked up the bacteria from faecal or other sources.

We were also surprised to note the geographic trend with lower isolation risk in southern cities gradually rising to higher risk the further north the samples were taken. This trend was due to a significant increase in detection of faecal bacteria on the hands of males, but not females, with increasing latitude. We can see no obvious reason for the result of this *post-hoc* analysis. People who travelled by bus rather than by train, and those in a professional occupation were more likely to show contamination; however, neither of those factors explained the trend observed for people in the northern cities to be more contaminated than those in the south. However, there are several confounding factors. Commuters in some cities may have had longer journeys from home, and hence longer for bacteria to die off. Superficial contamination picked up from objects would also be physically removed by contact with other surfaces. Therefore, the more contacts of this nature there are, the more opportunity there is for bacteria to be removed. (However, this also makes the bacteria available to be picked up by other people.) Sampling was carried out by different individuals in each city, so there may have been subtle differences in sampling technique, and train and bus cleaning regimens may have varied from city to city. Hand-washing customs may have varied across different locations. Different cities were sampled on different days, so climatic conditions may also have varied. Despite these variables, there is no reason to expect that any of these factors would have varied in a systematic way in males in order to produce the pattern observed. We plan to investigate the hypothesis that hands are washed more often or more thoroughly in the south of the UK relative to the north, and that male and female hand-washing prevalence differs geographically, taking into account the confounding variables which were not measured in this study. Future studies, perhaps with an experimental component, should also look at whether better hand-washing practices reduce the risk of contamination with bacteria of faecal origin. In this case, indicator bacteria like *Enterococcus* could be used as a marker for hand-washing practices, at least to detect trends over time.

In conclusion, this exploratory study on hand contamination with bacteria of faecal origin produced a number of unexpected results in terms of overall prevalence and risk of contamination according to geographic and socio-economic factors that need to be confirmed in larger surveys.

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DECLARATION OF INTEREST

None.

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