

**Faecal contamination on children's hands and environmental surfaces in primary schools in Leeds**E. C. KALTENTHALER<sup>1</sup>\*, A. M. ELSWORTH<sup>1</sup>, M. S. SCHWEIGER<sup>2</sup>,  
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## SUMMARY

Gastro-intestinal diseases continue to be a major health problem in primary schools in the UK. This study, which took place in 20 primary schools in the Leeds area, investigated the presence of faecal indicator bacteria on children's hands and environmental surfaces. Faecal streptococci were used as an indicator of faecal contamination.

A handwashing knowledge score was developed for each child. Those children with good hygiene knowledge had less faecal contamination on their hands (relative risk: 1.4, 95% CI = 1.09-1.81,  $P = 0.005$ ). Those schools with higher hand counts were more likely to have had a reported outbreak of gastroenteritis in the past. Values of the Townsend Deprivation Index, an indicator of deprivation, were compared with the hand results and those schools in high deprivation areas had higher hand counts. Of the swabs taken from surfaces in the toilet areas and classrooms, the carpets in the classrooms were the most frequently contaminated surfaces.

## INTRODUCTION

Diarrhoeal diseases and hepatitis A continue to be public health problems in England. Primary schools and day care centres are often involved in outbreaks of these diseases. In 1988, nearly a tenth of reported hepatitis A cases were part of school outbreaks [1]. This has important health and economic implications for both schools and families. Until recently, most research into the epidemiology of hepatitis A and diarrhoeal diseases has concentrated on day-care centres. Black and colleagues [2] found handwashing to be an important part of controlling diarrhoeal diseases in day-care centres. A recent study of secondary schools in the UK has highlighted the potential for inadequate handwashing and sanitation facilities to contribute to the spread of gastro-intestinal infections [1]. Koopman [3] in a study from Cali, Columbia related 44% of diarrhoea cases to unhygienic toilet conditions in schools. In an 18-year study in England, dysentery epidemics

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were found in primary schools where hygienic toilet facilities were lacking [4]. The authors recommended improvements in school toilet hygiene. Twenty years later many school toilets still need improvement.

In order to explore spread of faecal contamination in the environment and on the hands, most workers have used a bacterial indicator of faecal contamination rather than the detection of pathogens *per se* [5]. In the past, most studies in day-care centres have used faecal coliforms for this purpose [6-8]. Faecal coliforms have also been used to investigate the epidemiology of hospital infections [9, 10]. However, studies have shown that faecal streptococci survive longer on the hands [11] and in the environment [12] than faecal coliforms. For these reasons, faecal streptococci were used as an indicator of faecal contamination in this study.

The main objectives of the study were as follows: (1) to determine the relationship between children's hygiene knowledge and presence of faecal contamination on the hands; (2) to explore the association between faecal contamination on children's hands and specific school level variables; and (3) to determine which areas within the toilet facilities and classroom were faecally contaminated.

#### METHODS

Twenty primary schools in the Leeds area were selected to take part in the study. Ten of these schools were chosen because they had reported problems with either outbreaks of diarrhoeal diseases or hepatitis A in the past, whereas the other ten had no known problems with gastro-intestinal diseases. The study took place from July 1993 to March 1994 and involved reception class children aged 4-5 years. At each school, 30 children took part in the study. If the class had more than 30 children, 30 were randomly chosen by pulling numbers from a hat. A story and questionnaire were administered to each child taking part in the study. The story presented two situations where children were asked what should happen next, with the correct answer being to wash hands. The story questions and the rest of the questionnaire are presented in Table 1.

Samples from hands and environmental surfaces were taken over a period of 3 days, Monday to Wednesday. Impression plates were used to isolate faecal streptococci from the hands in order to achieve the necessarily large sample size [13]. KF (Kenner Faecal) Agar (Oxoid) was used to isolate faecal streptococci. Both hands were tested, by placing each fingertip on to the agar plate for about 5 s. Children then wiped their hands with a wet wipe and washed them with soap and water. Each child was sampled five times over 3 days because preliminary studies had shown wide variation per child and per day. On the first day, sampling was either in the morning or afternoon. On the following days, each child was tested in both the morning and afternoon. The exact timing of the sampling was determined by the class timetable so as to cause minimum disruption. Swabs of surfaces were made with a sterile swab dipped in quarter strength Ringer's solution. A template, with an area of 5 x 5 cm, was used wherever possible. The swabs were directly plated onto KF agar. The surfaces sampled were: toilet seat, flush handle, cubicle floor, toilet floor, and classroom carpet. Each surface was sampled for 3 consecutive days at approximately 10.00 h each day in order to coincide with the first break. Five swabs were taken on each day from the toilet

Table 1. Story and questionnaire with responses

		No.	(%)
(1) What should Mr Smiley do now (after working in the garden, before eating)?	Wash his hands	392	(72)
	Other	30	(6)
	Do not know	122	(22)
(2) What should Mr Smiley do now (after using the toilet, before eating)?	Wash his hands	354	(65)
	Other	18	(3)
	Do not know	172	(32)
(3) When do you wash your hands at school?	After toilet	265	(49)
	Before meals	280	(52)
	Do not know	88	(16)
	After toilet	195	(36)
(4) When do you wash your hands at home?	Before meals	164	(30)
	Do not know	107	(20)
	After toilet	195	(36)
(5) Do you think it is important to wash your hands?	Yes	482	(89)
(6) Why or why not?	Remove germs	175	(33)
	Remove dirt	56	(10)
	Do not know why	291	(54)
	Mother said so	15	(3)

seat, carpet and flush handle and 20 swabs each day from the cubicle floor and toilet floor. Initially, the tap handles, cubicle door locks and toilet rim were included but gave consistently negative results and were therefore omitted from the study.

Plates from the hands and swabs were stored in a cold box, then transported back to the laboratory. They were incubated at 37 °C for 4 h then 44 h at 44 °C as described by Oragui and Mara [14]. This helped to inhibit the growth of staphylococci and non-faecal streptococci. Plates were incubated in sealed plastic boxes to maintain adequate humidity. All colonies of presumptive faecal streptococci were confirmed by showing growth on Bile Aesculin Agar (Oxoid), after incubation at 37 °C for 24 h. Each plate was considered positive if there were any confirmed faecal streptococcal colonies present and negative if there were no confirmed faecal streptococcal colonies present. Relative humidity and temperature were measured when hands were sampled or swabs collected.

## RESULTS

### Questionnaire

From the 20 primary schools, 559 children took part in the study and of these 544 began the questionnaire. The results of the questionnaire are presented in Table 1. The answers to the child questionnaire varied substantially both individually and by school in the number of correct answers given. Out of 13 possible correct answers, children scored from 0 (14 children) to 12 (1 child). The school means varied from 4.7 to 8.1. Girls tended to have better hygiene knowledge than boys ( $P = 0.04$ ).

### Hand contamination

A total of 2285 hand impression plates were made. A sample of this size was needed due to the large number of negative samples which were expected. Of the

Table 2. Children's hand culture results and answer score

Child hand result	Answer score			
	0-2	3-5	6-8	9-12
All negative	31	99	209	94
At least one positive	11 (26%)	31 (24%)	57 (21%)	11 (11%)

$\chi^2 = 0.039$ .

*P* value (trend) = 0.01.

Cronbach's alpha was 0.69 indicating good internal reliability among the questions used to create the answer score.

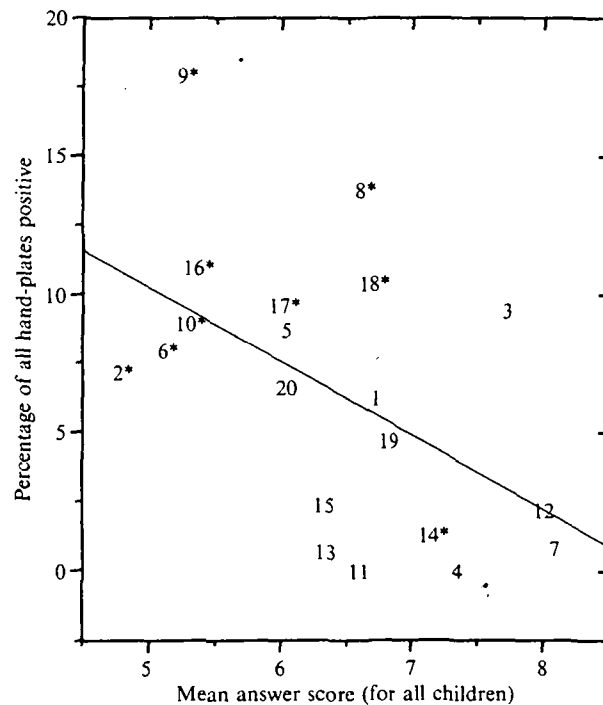


Fig. 1. Percentage of hand-plates positive, by mean answer score. By school. Calculated using all hand-plates, and all children respectively. The numbers plotted are the school reference numbers. An asterisk denotes an outbreak of gastro-intestinal disease reported within the last 10 years. The linear regression line fitted is:  $Y = 23.7 - 2.7 * X$  (S.E. of coefficient of  $X$  is 1.0). The correlation coefficient is  $-0.52$  ( $P = 0.019$ ).

2285 plates, 150 (7%) were positive for faecal streptococci. The relationship between hand contamination and answer scores is presented in Table 2 and graphically in Figure 1.

The answer scores were split into three groups per school indicating high, medium and low hygiene knowledge. Those children from the highest hygiene knowledge groups had less faecal contamination on their hands (RR: 1.4, 95% CI = 1.09-1.81,  $P = 0.005$ ). The number of children with positive faecal contamination on the hands also varied with day, increasing progressively from

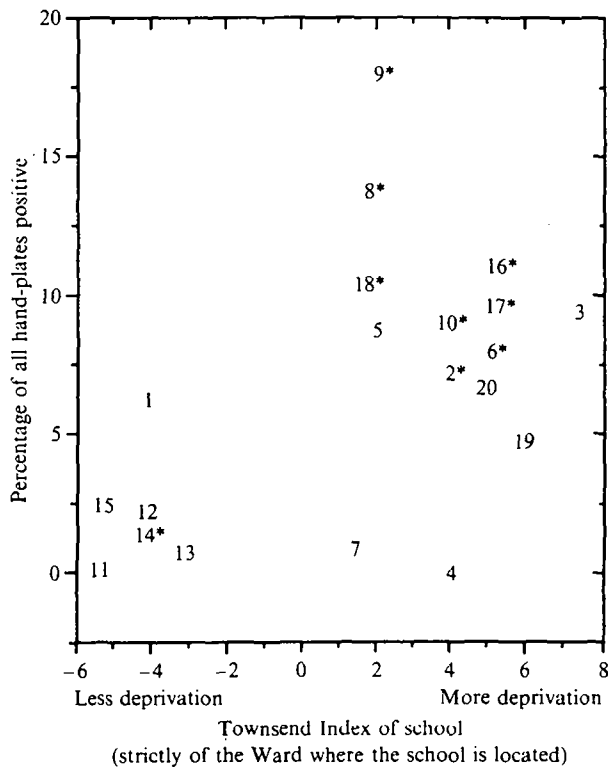


Fig. 2. Percentage of hand-plates positive, by Townsend Index. By school. Calculated using all hand-plates, and for the Ward where located respectively. The numbers plotted are the school reference numbers. An asterisk denotes an outbreak of gastro-intestinal disease reported within the last 10 years.

Monday to Wednesday (estimated standardized risks were: Monday 0.046, Tuesday 0.063, Wednesday 0.084).

Eight out of 12 schools having greater than 5% of children with positive faecal contamination on the hands had previously reported gastro-intestinal outbreaks, in contrast to one of those eight schools with a previous outbreak which had less than 5% of children with positive faecal contamination.

Hand counts were compared with the Townsend Deprivation Index [15], an indicator of area deprivation which is based on: proportions of unemployed, car ownership, overcrowding and owner occupation. Schools were allocated the score of the ward in which the school was actually sited. The lower the Townsend Deprivation Index, the less deprived the ward. Figure 2 shows the relationship between hand counts and the Townsend Deprivation Index.

*Environmental swabs*

The swab results are presented in Table 3.

There was no difference between boys' toilets and girls' toilets. Nor was there any significant pattern over the 3-day period when the swabs were collected. There did not appear to be a correlation with either hand or swab counts and relative humidity or temperature.

Table 3. *Swab results by area in school (number of positive swabs/number of swabs)*

Cubicle floor	Toilet floor	Toilet seat	Flush handle	Carpet
87/1061 (8%)	80/1061 (8%)	10/261 (4%)	1/261 (0.04%)	45/296 (15%)

## DISCUSSION

Teachers frequently mentioned their concern that children receive little hygiene education from home. The finding that children with low answer scores were more likely to have faecal contamination on their hands than children with better answer scores indicates that this is an area which needs improvement within the National Curriculum and addressing by schools and teachers.

Schools which had previously reported outbreaks of gastro-intestinal infections had higher levels of faecal contamination on childrens' hands than schools which had not reported outbreaks. Ways to reduce these levels need to be explored including greater emphasis on hygiene education and monitoring of handwashing. It was not possible to relate faecal contamination directly to the incidence of gastrointestinal diseases as reasons for absenteeism are not recorded by schools. This has however been explored in several other studies. In one study both hand contamination and contamination of sites such as taps and sinks were found to be significant predictors of diarrhoeal risk [7]. Another study found that during outbreaks of diarrhoea, faecal coliforms were recovered with significantly greater frequency from hands and classroom objects [6]. The authors concluded that contamination of hands and classroom objects play a role in the transmission of diarrhoea in day care centres.

The Townsend Deprivation Index was found to be associated with faecal contamination on the hands. This result needs to be interpreted with caution. These schools could be targeted to receive additional funding to ensure that their hygiene needs can be met.

Faecal indicator bacteria on the hands are not necessarily good indicators for the presence of pathogenic viruses, which can survive for much longer in the environment. They do however give an indication that hand hygiene is far from ideal. The fact that faecal streptococci were isolated from the hands in this study shows that there is at least potential for the spread of pathogenic viruses.

The failure to detect faecal streptococci from swabs taken from toilet seats and flush handles may be because they are relatively dry areas. A surprising finding was that classroom carpets were the most contaminated area sampled. This is a concern as children touch them frequently. Attention needs to be paid to the frequency of cleaning.

In contrast with other studies [16, 17] no relationship between either relative humidity or temperature and hand or swab counts was found. However, both of these studies were undertaken in tropical climates where relative humidity was much higher.

Although the sample size in this study was too small to draw firm conclusions, some interesting relationships have been suggested. These are: (1) children with

better hygiene knowledge had less faecal contamination on their hands; (2) schools drawing children from deprived areas showed higher levels of faecal contamination on children's hands; (3) schools where children had higher levels of faecal contamination on the hands were more likely to have reported an outbreak of gastro-intestinal infection in the past; and (4) classroom carpets were often faecally contaminated.

The information gained from the study has subsequently been reported back to the Local Education Authority and the schools involved in the study are acting on the recommendations made. The recommendations included the following: (1) carpet cleaning regimes should be improved so that carpets are shampooed once a week; (2) school nurses should be involved in improving hygiene education in the schools; and (3) in the future, renovations to school toilets and the building of new toilets will take into account the importance of adequately maintained and useable facilities for children in order to encourage appropriate hygiene behaviour including handwashing after using the toilet.

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