PERGAMON

Social Science & Medicine 57 (2003) 657–672

SOCIAL SCIENCE & MEDICINE

www.elsevier.com/locate/socscimed

Hygiene in the home: relating bugs and behaviour

Val Curtis[a,*], Adam Biran[a], Katie Deverell[b], Clarissa Hughes[b], Kate Bellamy[c], Bo Drasar[a]

[a] *Department of Infectious and Tropical Diseases, DCVBU/ITD London School of Hygiene and Tropical Medicine, Kepple Street, London WCIE 7HT, UK*

[b] *Unilever Research, Port Sunlight Laboratory, Quarry Road East, Bebington, Wirral, UK*

[c] *Unilever Research, Colworth Laboratory, Sharnbrook, Bedford, UK*

Abstract

Much infectious intestinal disease (IID) arises in the home environment. If programmes to prevent infection are to be effective it is essential to both identify the particular practices that risk disease transmission, and to understand the reasons for these practices. An in-depth, multidisciplinary study of carer and child hygiene in the domestic environment in the Wirral, UK, employed structured observation, surface swabbing for polio vaccine virus and enteric marker organisms, semi-structured interviews, projective interviews and focus group discussions. Observations revealed that child carers washed hands with soap after changing a dirty nappy on 42% of occasions, and that one in five toilet users did not wash hands with soap afterwards. Microbiological samples were taken from household surfaces at sites thought likely to be involved in the transfer of faecal material. 15% of bathroom samples showed contamination with polio vaccine virus. Nappy changing took place mainly in living rooms. Contact with living room surfaces and objects during nappy changing was frequent and evidence of faecal contamination was found in 12% of living room samples. Evidence of faecal contamination was also found in kitchens, again on surfaces thought likely to be involved in the transmission of faeces (taps and soap dispensers). Key factors motivating hygiene were the desire to give a good impression to others, protection of the child and aesthetics. In this setting, the particular risk practices to be addressed included washing hands with soap after stool and nappy contact and preventing the transfer of pathogenic organisms to the kitchen. The occasion of the birth of a child may be a privileged moment for the promotion of safer home hygiene practices. Using polio vaccine virus as an indicator of faecal contamination produces results that could be used in large-scale studies of household disease transmission. A better understanding of the household transmission of the agents of IID using multidisciplinary methods is needed if effective hygiene promotion programmes are to be designed.

Keywords: Hygiene; Faecal–oral transmission; Infectious intestinal disease; Polio vaccine virus; UK

Introduction

In the UK there are estimated to be over nine million cases of infectious intestinal disease (IID) every year (Wheeler et al., 1999). The transmission of pathogenic agents of IID via foods and in kitchens has been documented (Dawkins, Bolton, & Hutchinson, 1984; Dewitt, Broekhuizer, & Kamplemacher, 1979; Humphrey, Martin, & Whitehead, 1994; Mendes & Lynch, 1978; Scott & Bloomfield, 1993). However, there remains a strong suspicion that much infection originates in the home, where human excreta are the primary source of infection (Curtis, Cairncross, & Yonli, 2000; Feachem, 1984). Sockett looked at 2766 *Salmonella* outbreaks occurring over a 2 year period and classed 86% of these as family outbreaks (Sockett et al., 1993). Data from the Netherlands, Germany and Spain indicate that more than 50% of reported outbreaks of

*Corresponding author. Tel.: +44-20-7927-2628; fax: +44-20-7636-7843.

E-mail address: val.curtis@lshtm.ac.uk (V. Curtis).

0277-9536/03/$ - see front matter © 2002 Published by Elsevier Science Ltd.
PII: S0277-9536(02)00409-4

gastro-intestinal infection arose in the home (Scott & Bloomfield, 1993). In the USA, Daniels et al. (2000) describe an outbreak of viral gastroenteritis that resulted from the household transmission of Norwalk-like virus to a food handler from her child. Despite the obvious health implications, few studies have investigated the transmission of disease via the faecal–oral route within the home.

The principle habitat and place of reproduction of the common endemic IID pathogens is the human gut (Curtis et al., 2000). Fig. 1 shows how these pathogens enter the domestic environment in human faeces and transit to new hosts. In order to design effective interventions against IID it is necessary to pick out those particular practices which permit the transmission of IID agents. It is also necessary to understand why these practices occur and what might motivate a change in hygiene behaviour. Designing interventions thus requires skill not just in microbiology and epidemiology, but also in disciplines such as anthropology and consumer research.

Although several studies have reported the effects of various forms of hygiene promotion on behaviour (e.g. Alam, Wojtyniak, Henry, & Rahaman, 1989; Aziz et al., 1990; Ahmed, Zeitlin, Beiser, Super, & Gershoff, 1993; Shahid, Greenough, Samadi, Huq, & Rahman, 1996) fewer have focussed on trying to understand existing hygiene behaviours. Work in Burkina Faso suggests that water availability has an important influence on faeces disposal practices, but also points to the importance of the social environment and the desire for social approval in motivating hygiene behaviour (Curtis et al., 1995). In developed country settings, work on domestic hygiene behaviour has largely been confined to experimental studies of the potential for food handling practices to spread pathogens in the kitchen environment (e.g. Cogan, Bloomfield, & Humphrey, 1999).

A multidisciplinary study of the hygiene practices of mothers and children was carried out in North-West England. This small-scale, intensive study aimed to pinpoint particular risk practices and to understand what motivated domestic hygiene behaviour. A secondary objective was to develop the methodology for research into home hygiene (Curtis et al., 1997). Beyond being one of the first multidisciplinary studies of home hygiene in the UK, the study was innovative in a number of respects. Firstly, polio vaccine virus was used as an indicator of viral contamination from faeces. Viruses are a prime cause of infant diarrhoea, especially in the winter in Europe (Ryan et al., 1996). However, studies of pathogenic viruses in the domestic environment have proved impractical because of the low rate of viral isolation (Bellamy et al., 1998). By recruiting families with a recently vaccinated infant it was possible to identify the spread of viruses of faecal origin in the domestic environment. Secondly, because questionnaires are notoriously poor at eliciting what people actually do, structured observation was employed to document hygiene practices in the home. Thirdly, the study sought to combine the skills and techniques of industrial and academic microbiological and behavioural scientists.

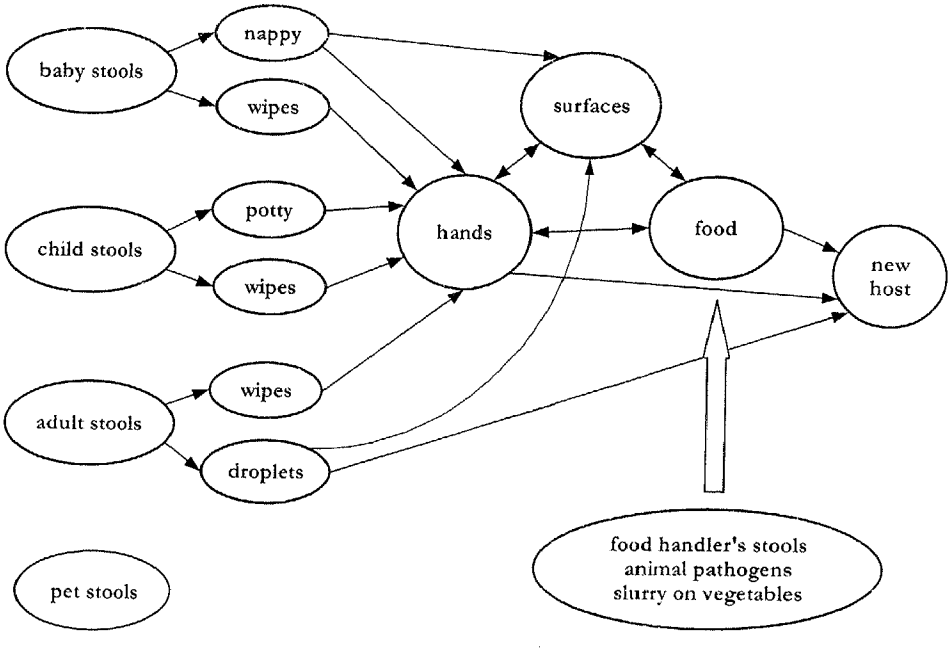

Fig. 1. Routes of transmission of IID agents.

Table 1
Types of data collected

Method of data collection	Size of sample
Structured observation	10 Households (33 nappy changes, 21 toilet uses)
Semi-structured interviews	10 Adults responsible for child care in study households
Projective interviews	5 Adults responsible for child care in study households
Focus group discussion	5 Adults responsible for child care in study households
Virology	10 Households, 250 samples
Bacteriology	10 Households, 75 samples

Methods

A combination of study methods including structured observation, surface virology and microbiology, semi-structured interviews, projective interviews and a focus group discussion were employed to study the hygiene practices of carer–child couples in 10 households. The methods used are summarised in Table 1.

Recruitment of participants

The study was carried out in the Wirral in North-West England. Ten households were recruited by word of mouth from amongst those attending two local GP clinics or via personal contact. A condition of recruitment was that households contained an infant aged below 3 months who had received a polio vaccine within the past 2 weeks, and a toddler under the age of 3 years. Recruits were given a description of the study and signed a consent form. Each household was visited three times and the child-carer then attended the research centre for an in-depth interview or focus group discussion. Timings of visits with respect to the polio vaccination dates are shown in Table 2. At the end of the study volunteers were paid a small sum in compensation for their time.

Table 2
Timing of visits with respect to polio vaccination dates (days since most recent polio vaccine)[a]

Household ID number	Visit 1	Visit 2	Visit 3
101	79	85	100
102	26	33	6
103	25	30	38
104	27	33	34
105	13	15	21
106	2	12	16
107	23	27	30
108	4	8	18
109	2	6	18
110	3	5	6
Median (range)	18 (2–79)	21 (5–85)	19.5 (6–100)

[a] In all cases but one the most recent polio vaccination was also the first vaccination. The exception was ID 102, visit 3. In this case, the second vaccination was the most recent (6 days). Forty-one days had passed since the first vaccination.

Structured observation

Structured observation was used to collect data on hygiene practices in the home. The technique, drawn from studies of animal behaviour and anthropology, is used to record specific, predetermined aspects of behaviour (Altman, 1973; Borgerhoff-Mulder & Caro, 1985; Martin & Bateson, 1986; Curtis et al., 1993).

Each household was visited by one of two observers on three separate days. An interval of 1–15 days was allowed between visits. The observer explained to the child-carer that the purpose of the study was to investigate how the health of children could best be promoted. On each visit the observer sat for 3 hours in the lounge or kitchen whilst child carers were asked to carry on with their daily activities as normal. The start time for the observation periods was varied across the three visits. The earliest start time was 08:30 and the latest 17:00. In order to reduce the extent to which the presence of the observer would influence the behaviour of the subjects, the same observer carried out all observations of a single household. In one household, however, observations were carried out by both observers. During the observation periods nappy changing, potty use and toilet use was recorded whenever it occurred.

At each occurrence of nappy changing the following information was recorded:

- identity of the individuals,
- time and location of changing,
- the surface on which the child was placed,
- the condition of the nappy (dry, wet or containing faeces),
- where the dirty nappy was placed and how it was disposed of,
- when, how and how often hands were washed during and after nappy changing.

On occasions when the nappy contained faeces, a list was made of items or surfaces touched by the

person changing the nappy during and after nappy changing.

At each occurrence of toilet or potty use the following information was recorded:

- identity of the individual using the toilet/potty,
- whether hands were washed afterwards,
- if hand-washing occurred, where it took place, whether soap was used and whether and how the hands were dried.

When it was not possible to observe hand-washing directly, the sound of a running tap or the presence of wet taps or a damp towel was used to infer that hand-washing had taken place. Soap use was inferred by inspecting whether soap or dispensers were wet shortly after hand-washing.

Microbiology

At the end of each of the three observation visits surface swab samples were taken. Samples were taken from sites that were thought likely to be involved in the transfer of faecal material. These included nappy changing areas, potty use locations and toilets. In this exploratory study, sampling was non-random, purposive and opportunistic.

Samples for virology were collected on every visit, some sites being sampled on more than one occasion. Samples for bacteriology were collected on the final visit only. When possible, a small sample of faecal material from the child's nappy was also collected to check for the presence of oral polio vaccine virus.

Sampling and viral and bacterial isolation followed the protocol for microbiology described in Appendix A. Briefly, at the end of each observation visit sterile moistened swabs were used to sample 10–12 sites of potential faecal contamination. Swab tips were broken off and returned to the lab in transport medium on ice. From here they were spun down and separated. After centrifugation, Poliovirus in the supernatant was identified using standard cell culture techniques and the remaining pellet was re-suspended, frozen and transferred for bacteriology. Quantitative cultures were carried out and bacteria isolated on the basis of Gram's stain and cultural characteristics.

Semi-structured interviews

During the third visit to each household, a semi-structured interview was carried out with the adult responsible for the majority of nappy changing. These interviews followed a predetermined schedule and covered the topics of domestic hygiene, attitudes to faeces, nappy changing behaviour, hand-washing practices, domestic cleaning practices and perceptions of pathogens. Interviews were tape-recorded and transcribed.

Projective interview

Five participants were later interviewed individually using projective techniques developed for use in consumer research. Participants were asked to collect pictures cut from magazines of images that represented hygiene. An experienced interviewer then discussed with the interviewee the reasons why those images had been chosen, the images that the participants would have liked to add, the story told by the images, feelings about the images and the issues raised. The discussions were recorded and transcribed.

Focus group discussion

The other five respondents were invited to attend a focus group discussion during which they were asked to make collages of images that were felt to be dirty, unhygienic or unhealthy. An experienced facilitator discussed the collages with the group. The tape recording of the discussion was transcribed.

Transcripts of all of the interviews and the focus group were first reviewed manually for insight into hygiene motivation. They were then pooled and entered into QSR*NUDIST. Statements were classified, coded and tabulated according to subject. This was carried out by a social scientist (AB) who had not been involved in the data collection.

Results

Table 3 shows the demographic characteristics of the 10 households involved in the study. In a total of 30 observation/sampling visits 33 nappy changes, 3 uses of a potty and 21 uses of the toilet were noted.

Potential risk practices

Structured observation

A total of 21 toilet visits were observed in 7 households. Hand-washing following use of the toilet usually took place in the bathroom or toilet and could not be directly observed. However, it proved easy to infer hand-washing by listening for the sound of running water and by inspecting the taps, soap and towel immediately afterward. Hand-washing after toilet use was almost universal and the only individuals not to wash hands were children. However, hands were washed with soap after only 81% of toilet uses. These results are shown in Table 4. Hands were usually washed then dried on a towel. Potty use was observed on 3 occasions in 2

households. This took place once in the living room and twice in the kitchen. On one occasion the mother wiped the child and then washed both hands with soap in the kitchen sink. On the other two occasions the child was not cleaned.

Thirty-three nappy changes were observed. Almost all changes took place on a plastic mat or towel in the living room (see Table 5). Nappy changes took place amongst a variety of everyday household objects and contact with these objects during changes was common (see Table 6). Hands were not washed on 13 occasions following nappy changing. On only 43% of occasions did carers wash hands with soap after finishing the process of nappy changing, usually in the kitchen. The presence of faeces in the nappy did not increase the likelihood of hand-washing. These results are shown in Table 7.

Table 3
Demographic characteristics of study households

Demographic characteristic	Frequency in sample
Housing type	
Semi-detached	7
Detached	2
Apartment	1
Number of household residents[a]	
3	2
4	6
5	2
Household income £[a]	
11–15K	2
16–20K	4
21–25K	2
> 31K	1
No data	1
Mother's employment[b]	
Part-time	3
Full-time	3
Not employed	3
No data	1
Father's employment[c]	
Part-time	2
Full-time	6
No data	2
Mother's age[b]	Mean 30 (Range 18–38)
Father's age[c]	Mean 31 (Range 24–36)

[a] In every household this includes both parents and one or two or three children.

[b] 'Mother' refers to the mother of the infant in the participating households.

[c] 'Father' refers to the father of the infant in the participating

Virology

Fifteen samples of faecal material were collected from nappies. All faecal samples were positive for poliovirus.

Two hundred and thirty-four domestic surface samples were collected and tested for poliovirus. Some of the sites for virology sampling were visited on more than one occasion and the results for virology are therefore presented as percentage of *samples* rather than percentage of *sites* sampled. A total of 13% of environmental samples were positive. 15% of bathroom samples were positive, 12% of living room samples and 10% of kitchen samples (see Table 8). Most frequently contaminated were bathroom taps, door handles, toilet flushes, liquid soap dispensers, nappy changing equipment and potties.

Bacteriology

The 73 samples from the third household visits were tested. Evidence of faecal contamination (*E. coli* or enterococci) was found at 19% of sites. 30% of living room sites, 20% of bathroom and 6% of kitchen sites were positive for faecal indicator bacteria. The number of sites sampled was small, but toilet flushes and potties were most frequently contaminated. Nappy changing equipment such as mats and wipes boxes also showed evidence of faecal contamination. These results are shown in Table 8.

Table 4
Hand-washing after toilet use

	Number of observations	Number of households	Not washed	Rinsed	Washed with soap (%)
Parent	11	6	0	1	10 (91)
Child	8	4	2	1	5 (63)
Other	2	2	0	0	2 (100)
Total	21	10	2	2	17 (81)

Table 5
Where nappies were changed

Nappy change location (%)		Nappy change surface (%)	
Living room	28 (85)	Changing mat	25 (76)
Bathroom	2 (6)	Changer's knee	4 (12)
Bedroom	1 (3)	Towel	2 (6)
Dining room	1 (3)	Carpet	1 (3)
Other	1 (3)	Child standing	1 (3)
Total	33 (100)	Total	33 (100)

Table 6
Items touched during 11 nappy changes in which the nappy contained faeces

Item touched	Number of nappy changes
Changing mat	10
Wipes	7
Nappy bag	4
Changer's clothes	4
Cotton wool	3
Carpet	3
Outside bin	3
Cotton wool bag/box	2
Toys	2
Other (baby lotion, sponge, spray can, water bowl, food for toddler, phone, baby gym, spectacles, kitchen bin, mail, furniture, door handle)	1 each

Table 7
Hand-washing during and after nappy changing

	All changes (%)	Changes with faeces in nappy (%)
Hands washed after changing	17 (52)	8 (50)
Hands washed with soap after changing	14 (42)	6 (38)
Hands washed during changing	2 (6)	1 (3)
Hands not washed during or after changing	13 (39)	7 (44)
Missing data	1 (3)	0 (0)
Total	33 (100)	16 (100)

Hygiene motivation

The aim of the qualitative research was to generate insights into the motivations underlying hygiene and of the potential risk practices that were observed. The questions that we wished to answer were 'What is understood by hygiene?', 'What influences home hygiene practices?', and 'What influences hand-washing and nappy changing behaviour?' Because it has a bearing on the methodology of future such studies, we also wished to determine how carers had felt about being observed and whether they thought that this had influenced their behaviour. Table 9 gives an illustrative selection of responses.

What is understood by 'hygiene'?

Hygiene was primarily described as cleanliness; keeping house, clothes and people clean. A typical response was: "I'd say it was cleanliness—everything was as clean as you could possibly make it." A hygienic house was described as looking tidy, bright and ordered.

Table 8
Microbiological results

Site	Virology			Bacteriology		
	No. samples	No. positive	% Positive	No. samples	No. positive	% Positive
Toilet/bathroom						
Door handle	4	2	50	7	1	14
Nappy bucket	3	1	33	1	1	100
Liquid soap dispenser	5	1	20	2	0	0
Toilet/bathroom taps	32	6	19	11	1	9
Toilet flush	29	5	17	11	4	36
Toilet rim	6	1	17	1	0	0
Toilet roll holder	5	0	0	2	1	50
Radiator (by toilet)	1	0	0	1	1	100
Other sites (bath, trainer seat, wall by toilet, door lock, baby bath, bin, radiator, toilet seat, toilet brush, etc.)	24	0	0	8	0	0
Total	109	16	15	44	9	20
Living room						
Potty	10	3	33	6	2	30
Water bowl	3	1	33	—	—	—
Wipes box	14	2	14	5	1	20
Door handle	12	1	8	1	1	100
Changing mat	16	1	6	5	1	20
Other sites (Basin, baby bag, toy, plate, cotton wool bag)	14	0	0	3	0	0
Total	69	8	12	15	5	30
Kitchen						
Liquid soap (kitchen)	2	1	50	2	0	0
Kitchen taps	17	2	12	9	1	11
Other sites (sink, worktop, washing up liquid, bin, cupboard door, etc.)	10	0	0	5	0	0
Total	29	3	10	16	1	6
Other sites						
Newel post	2	1	50	1	0	0
Carers hands	23	2	9	7	1	14
Baby/child	2	0	0	3	0	0
Total	27	3	11	11	1	9
Overall total	234	30	13	86	16	19

Unhygienic things looked untidy and dirty, contained faeces, bacteria, or food remains, smelled bad or could spread disease or inflame allergies. The function of hygiene was described as protecting babies and to fight bacteria in kitchen and toilet. Hygiene was also thought to involve some personal effort. Viruses, lice and cigarette-ends were described as *not* unhygienic.

What influences home hygiene practices?

Respondents explained that most household cleaning was prompted by the sight of dirt. Cleaning sometimes followed a routine, but often had to be done opportunistically, when the baby was asleep or when children were out. Toilets, bathrooms and kitchens required the most cleaning. Bleach was often used for toilets and

Table 9
Hygiene motivation, illustrative responses

Question	Key findings	Examples from interviews and discussions
What is understood by hygiene?	1. Cleaning, tidying, ordering	"Hygiene's just being clean." B09 "If you walked into my house and the first thing you saw that there was no dust on the side everything was neat and tidy, there was nothing lying around the floor—you look in the kitchen, all the surfaces are clean, all the dishes are washed in the cupboard, there's no things round—you look in the lounge and it's been hoovered and everything's in its place, ... I think that would say hygiene." **Proj 01** "Keeping myself clean and my clothes clean and... my personal space clean." Proj 02
	2. Protecting babies from bacteria and allergens	"It's like protecting against something that could cause harm—so being hygienic would be to protect in as many ways as you can if it's something that would damage a baby, because I'm not worried about me." **Proj 01.** [Hygiene is] getting rid of...asthma, eczema, hay fever, rhinitis, it's trying to combat those kind of things... **Proj 01**
What influences home hygiene?	1. Removing visible dirt	If there was sort of soap scum on the sink I'd clean it ... the toilet, I put toilet cleaner down it a couple of times a week and then if it looks dirty I clean it as well— B04 [Reason for cleaning the toilet] "Well if I'm being honest with myself it has to be the look of it..." B06
	2. Removing smells and bacteria	"... eliminating some of the bacteria that are going to be around,... including E. Coli, Salmonella...the big ones that everyone knows about that are so hyped up that you can't help but try and counteract those risks can you–I can't," **Proj 01** "I know sometimes you can smell it when you walk in—you can smell the clean, you know..." B09
	3. What other people think	"... well it's a small house isn't it, you can smell everything as soon as you walk in–I don't like it and I think if I can smell it, then other people will be able to." B02 "I clean up every room because.... my mum'll ... might go in and have a look you know—see how tidy they are!... she'd say oh that room's not very tidy...she'd check yes, she'd say oh that wasn't very clean..." B08 "I think you just want people you know to think that you're tidy and your house is tidy... I get very embarrassed if I notice at my house there's something grotty...." B06
	4. Routine and/or opportunity	"The bathroom I clean about once a week or so, just have a general clean." B04 "I usually hoover round and everything again on a Saturday [because] my husband takes the two children to his mum's" B08 "If [my toddler] isn't here I do tend to do a clean up then... rather than when he's here, it's easier because he wants to help all the time." B02
	5. Having a new baby	"My kitchen I would do daily because to me that's a food preparation—that's where I do the key things for the baby." **Proj 01** "I'm antibacterial mad at the moment, since I've had him, everything... like the dishcloths I'd buy anything, but I buy Microban antibacterial do you know—everything is antibacterial—just to try and eliminate anything that I can do really. I never used antibacterial anything until I had the baby." B09 "You wouldn't forgive yourself if it had asthma because you haven't kept hoovering up" B09 "Feel like I'm doing the best for the baby if I buy those kind of [anti-bacterial] things." B09
What influences nappy changing behaviour?	1. Convenience	"He only ever gets done on the floor because he's too wriggly" **Proj 02** "More convenience really, when we had just Sam we always changed nappies upstairs, just because it didn't seem very nice really, the living room having a pooey smell and things like that, but now, I mean, three of them, it isn't convenient to go upstairs every time..." B04 [change upstairs] "If it's in the night and I don't want to come downstairs." B05
	2. State of the nappy	"It's just not nice when it's pooey all over their backs and it takes ages to clean off and then you've got to give them a bath, but it's not particularly—it's not disgusting it's just you know—it's just a fact of life." B05 "Sometimes when it's all up his back and over his clothes and... he needs a whole change, but his doesn't smell too bad with him being breast fed as well so it's not the smell—just sheer quantity." B10
	3. Nappy changing is	"I wouldn't say it was favourite thing—but actually with him yes, because it's a real bonding time and laughing and talking and that." B05

Table 9 (*continued*)

Question	Key findings	Examples from interviews and discussions
	bonding time	"Because she feels freer without a nappy on so she smiles a lot more and it's time just like to talk to her—as if you're getting to know her–so it's nice." B07 "When the baby's got her nappy off she likes to lie there and kick her legs about and she's quite happy, have a little smile and little giggle." B09
	4. Nappy contents not always seen as risky	"I wouldn't have thought [that what's in the nappy] is dangerous or harmful." B05 "Well [what's in the nappy] would be harmful if like they ate it... it's full of bacteria... yes it's full of waste and...yes it's not the sort of thing you want hanging around." B06
What factors influence hand-washing behaviour?	1. Feel a need to wash after certain activities	"They feel alright [after nappy changing] but I feel as if I need to go and wash them" B07 "You just have to wash your hands after you've been to the loo." B04 whenever I've had a cigarette outside, I'll come in and ... I wash my hands, **Proj 01** if you've been into the garden touching anything out there, always wash your hands. B09
	2. Discomfort	"During I'm preparing food—just because I don't particularly like the feel on my hands you know if you're sticky or whatever." B06
	3. Smell	"When you've done...like the baby's nappies or whatever if it gets on your hands and you're walking down the road later you can still smell it—even though you've washed your hands it's just...seems to have got this incredible ability to keep the smell there." B03
	4. Having a baby	"...to get rid of the smell and the odours and anything that might be kind of lingering—because it's not good for him." B05 "You seem to wash your hands more with having the baby." B08 "Since having him I wash my hands all the time." B05 "Just a bit frightened of more germs going about than anything because they've got no immune system really, have they, when they're under two." B08 "I found I wash my hands a lot more than I would have....before I had the babies." **Group** "Because, like germs and bacteria left on your hands and then you put like your fingers in your mouth you could transmit all different germs." B07
	5. To prevent spread of bacteria	"If you go to the loo if you have diarrhoea for example and you go to the loo and don't wash your hands and then start eating an apple or something and you would have thought you'd be more likely to get worse or something." **Proj 03** "No I don't.(always wash hands after nappy change) don't have time do you." B01
	6. Conveniance	"With food yes. Not always after toilet.... if something's distracted me." B10 "I've probably gone straight from seeing to one of the children—maybe wiped A's nose or whatever on to doing something else without thinking." B02 " I try very sure to make sure I wash his hands before his meals, but you know being honest with you I don't always, quite often I'll sit him down and...you know."..... B06
How acceptable was the study?	1. Acceptable	"Erm... yes it was fine yes, once I got used to it, it was a bit strange to begin with, but once I got used to someone sitting in the house, then it was OK yes." B01 "It doesn't bother me—it would have bothered if you were going to come back and say, well really you should clean your house more—then it would bother me, but no it doesn't bother me to think that you've taken swabs." B01 "My thought was when I knew she was coming, I thought to myself well, what I've got to think is she's not...she's not judging me—she's just merely doing her job. And that was it." B09 "At first I was a bit, like—nervous because I didn't know you, but you're fine to get on with, so it was alright really." B07 "Quite normal... quite fun—good conversation point over coffee or whatever with friends—quite amusing. It's a bit of a.... when you're stuck in the kitchen with three kids, it's quite fun having to entertain them—and a bit of a change different people to talk to and the money's good (laughter)...the money's handy." B03
	2. One participant found it stressful	" I felt very... quite nervous, which surprised me...I felt very nervous and when you were around although you weren't, you know, intrusive at all. I felt the whole time gosh, I'm being watched, something's being written and I did, I found it quite stressful." B06 "I think cleaned the bathroom and the kitchen and hoovered the carpets—I didn't know what she was going to be doing or why she was doing it at the time..." B01
	3. Some people cleaned more, Some did not	"No I didn't [clean up], I spoke to G. who was also doing this study and she said I don't think they'd appreciate it if you cleaned everywhere before they came." B02 "Tried my best—I did most things the same I think." B03

Table 9 (*continued*)

Question	Key findings	Examples from interviews and discussions
		"Well before she came I thought, I've just got to think I mustn't run round and start cleaning madly because this lady's coming because she just I thought wants to see normal everyday muck." B09 "I couldn't help but, you know, clean a bit probably more than I would normally or, you know, I was thinking if she was going to... I was more aware of say hygiene or what I was doing, I was very aware of myself and my routine..." B06

antibacterial sprays for surfaces. An increased use of antibacterial products was reported as a result of having a new baby. Some mothers also reported cleaning more often because of the new baby; for example, one mother reported cleaning the kitchen several times a day because that was where things were prepared for her baby. Another reported cleaning floors with a vacuum cleaner on most days now that her child spent much time on the carpet. The most frequently given reasons for cleaning were to improve the appearance of the house, especially to save embarrassment if a visitor was expected, and to remove smells and bacteria, especially from kitchens and toilets.

What influences nappy changing practices?

The choice of room for nappy changing was determined largely by convenience. Thus, changes during the day were usually done in the sitting room, while at night or early in the morning nappies were changed upstairs in the bedroom. The kitchen was often seen as an unsuitable place for changing nappies, although the reasons given were as often connected with convenience and the comfort of the baby as with the possibility of contaminating a food preparation area. "It doesn't smell nice and it's not nice" said one mother. "I don't think it's necessarily a cleanliness thing, I think it is more of a comfort", said another. Although dirty nappies, dirty babies and the smell of faeces were considered unpleasant, nappy changing was often seen as a positive, bonding experience, which could be enjoyed by the mother and baby. "I don't particularly like, you know, his poos, they're horrible, but it's nice when they're all clean." "...it's a real bonding time and laughing and talking and that." The observations confirmed that carers spent much of an, often prolonged, nappy changing time in communication and play with the baby.

What influences hand-washing behaviour?

The times when it was recognised as important to wash hands were; after changing nappies, or using the toilet, and before preparing food, making up bottles or feeding a baby. Other occasions mentioned were after handling raw meat, smoking, using cleaning agents, gardening, cleaning a pet cage and putting something in the bin. Only one interviewee reported washing hands before eating. Although washing hands after toilet use or nappy changing and before food preparation was regarded as ideal, it was recognised that hand-washing does not always occur. Two mothers said they always washed their hands after changing a nappy, after having been observed not to do so. The main reasons given for not washing hands were distraction with other tasks, especially children. The reasons given for washing hands were to remove smells, to remove faeces, to prevent the spread or ingestion of germs or bacteria and also to protect the baby from tobacco smells and dangerous chemicals. "...again just to get rid of the smell and the odours and anything that might be kind of lingering—because it's not good for him." Interviewees generally reported an increase in hand-washing associated with having a new baby. "...since having him I wash my hands all the time." "We should have shares in soap now (laughter)." Reasons given for the changes were the perceived weakness of the baby's immune system and the desire to do what is best for the child. "Feel like I'm doing the best for the baby if I buy those kind of (antibacterial) things."

How did carers feel about being observed and did they think their behaviour had changed as a result?

The majority of participants were happy with the methods used. Although the presence of an observer was often felt to be strange initially, once this wore off several participants reported enjoying the company and attention. "Fine, it's been informal, pleasant—someone to talk to, unobtrusive—it's been fine yes. I've enjoyed it." Two participants reported feeling nervous initially and one described the experience as stressful. "I felt very nervous and when you were around although you weren't, you know, intrusive at all, I felt the whole time, gosh, I'm being watched, something's being written and I did, I found it quite stressful." Most participants felt that they should clean or tidy before the first visit. This urge was resisted to varying degrees and no extra effort was reported for subsequent visits. "I tried not to, sort of like, do anything that I wouldn't normally. I couldn't help but, you know, clean a bit, probably more than I would

normally." Participants were interested in the microbiological sampling and some reported that this process highlighted surfaces to which they would pay more attention when cleaning in future.

Discussion

Despite its importance for public health, IID transmission in the home has been relatively little studied. One reason for this neglect is that hygiene is a difficult subject to study because it is private and morally bound. Questionnaires are notoriously poor at eliciting what people actually do. Observation can produce more valid results, but is intrusive and expensive (Curtis et al., 1993). Multiple agents of IID and their rarity and transience make studies of pathogen transmission in situ impractical. The alternative, to employ viral and bacterial indicators of faecal contamination, is less than ideal, since pathogens and indicators do not behave identically in the environment. This study suggests that using multiple methods in concert to study home hygiene can provide new insights and also information for the design of hygiene promotion interventions.

Limitations of the study

This study has four main limitations. First, due to its small size, and non-random, sampling methods, statistically meaningful conclusions cannot be drawn about patterns of contamination, and generalisations from the qualitative data must also be treated with caution. Second, we assumed that all virus detected was excreted by the vaccinated infants in faeces, though nasopharangeal excretion is technically possible, as is infection and excretion by other household members. Third, the pattern of spread of poliovirus may not accurately model the behaviour of pathogenic intestinal viruses such as rotavirus in the domestic environment. Nevertheless, the study does highlight the potential for faecal pathogens from any source to contaminate and survive on household surfaces. Fourth, there is no perfect method for recording what people actually do about hygiene in their own homes, or of determining their motivation. Behaviour is subject to reactive biases due to the presence of an observer (Curtis et al., 1993) and motivation can only be recorded as reported. This favours rational explanation if respondents feel they need to offer coherent explanation. Subconscious or irrational motivation may determine behaviour, but not be reported.

Multidisciplinary, cross-sectoral collaborations of the sort exemplified by this study are complex to organise, co-ordinate and analyse, and expensive in human resources. Complexity and cost should not, however, be expected to grow in proportion to the sample size.

Potential risk practices

The study was based around the proposition that there would be frequent opportunities for contamination of the domestic environment with faecal pathogens. Audit studies of bacterial and viral pathogens in households have generally proven negative (Bellamy et al., 1998; Finch, Prince, & Hawksworth, 1978; Scott, Bloomfield, & Barlow, 1982), probably because the excretion of infective materials is a rare event. However, experimental studies with *Salmonella* and *E. coli* show the potential for spread from toilets to bathroom surfaces and hands (Barker & Bloomfield, 2000; Gerba, Wallis, & Melnick, 1975) and from hands to other surfaces (Rheinbaben et al., 2000). We hypothesised that we would find evidence of contamination by 'in vivo' tracing of everyday contact with faeces, during defecation or childcare, and subsequent hand-washing, or lack of it. Microbiological samples showed that faecal contamination of the domestic environment does occur. Faecal coliforms were found at a number of sites, not only in toilets and bathrooms but also in kitchens and on a variety of objects connected with nappy changing. All households in the study contained an infant who had recently received oral polio vaccine. These infants were shedding poliovirus in faeces. This allowed poliovirus to be used as an indicator of viral contamination originating from faeces. Such viral contamination was found in toilets, bathrooms, kitchens and other household sites. This is the first study, to our knowledge, to successfully investigate the spread of viruses of faecal origin and to specifically examine the microbial contamination associated with nappy changing.

The sample size in the present study is too small for patterns of contamination to be linked to behavioural patterns at the level of the individual household, although the results suggest that this would be feasible in a larger study. Nevertheless, the observational data highlight some possible risk and protective practices.

The hands of adults were washed with soap after using the toilet on the majority of occasions observed. However, one in five uses of the toilet were not followed by hand-washing with soap. We suspect that hand-washing with soap may be overestimated for several reasons. The current study took place during the daytime when many family members were not present. Those present were the infant's main caretaker (usually the mother), and sometimes older siblings, not yet of school age. These groups may be more concerned about hand-washing or more compliant than older siblings or spouses who were not present. Those who were present in the home were aware that they were being observed by a researcher with an interest in hygiene and might have been more likely to live up to the ideal of washing hands after using the toilet. The fact that a number of bathroom and toilet sites including door handles, were

found to show signs of faecal contamination suggests that hand-washing after using the toilet is not always regularly practised.

Hand-washing after nappy changing stands in marked contrast to that after toilet use. Hands were washed following only 52%, and soap was used after only 42% of nappy changings. Hand-washing behaviour was not influenced by the presence of faeces in the dirty nappy. Nappy changing generally took place in the living room. It may be that the absence of convenient washing facilities discouraged hand-washing and also that cues to trigger hand-washing that exist in a bathroom are absent from the sitting room. This situation may have been compounded in some cases by the presence of an older child and the additional demands this placed on the time and attention of the caretaker. Kitchen taps were found to harbour enteric microbes on occasion. Hand-washing in the kitchen after nappy changing may represent a prime route for the transfer of pathogenic organisms to new hosts.

Nappy changing took place in the midst of a variety of everyday objects such as changing equipment, furniture, toys and telephones, and contact was made with these objects during nappy changing. Contact was increased because of the prolongation of the nappy changing process because it was enjoyed by mother and child. These facts may combine with irregular hand-washing to increase the risk of contamination of the household environment with faeces from nappies.

Indicator organisms clustered at points where direct contact with faecal material on hands was most likely; toilet flushes, nappy mats and wipes, taps and potties. Direct observation of behaviour combined with surface sampling offers a powerful means of tracking the transmission routes of infectious agents in the home.

The frequency with which hands were not washed after changing nappies was a striking finding of this study, especially in view of the fact that participants knew they were being observed by a researcher with an interest in hygiene. The scale of the difference between hand-washing after toilet use and after nappy changing suggests that there is a difference in attitude towards these activities. It has been noted in developing countries that mothers often fail to regard child excreta as dangerous (Kanki et al., 1994b). This seems also to be the case in the UK. However, if children are the main victims of infectious intestinal disease, their stools are also the main source of diarrhoeal pathogens.

Motivation for hygiene behaviour

From the perspective of the public health scientist, pathogens cause disease, faeces are a potent source of pathogens and hygiene behaviour is a rational response to this disease threat. Hygiene thus serves to reduce the likelihood of harmful contact with pathogens. The idea that health behaviour is a rational response to a perceived disease threat underlies models of individual health behaviour such as the Health Belief Model (Becker, 1974). However, from the perspective of the person carrying out the practices, hygiene serves very different purposes. The desire to nurture children, to create a tidy and aesthetically pleasing environment, to be rid of substances that occasion disgust and to be respected by others, all influence hygiene behaviour. Carers who described their hygiene behaviour in terms of germ avoidance may have been offering rational medical explanations for behaviours that are, in fact, indulged in for other reasons (to remove a bad smell, to demonstrate affection for a child, to avoid opprobrium from visitors). The present study suggests that, where a health motivation for hygiene behaviour exists, it is likely to be concern about the health of a third party (the baby) rather than the health of the caretaker.

Efforts to promote safer hygiene might be more effective if they built on the universal positive desire for cleanliness, rather than relying on the traditional, rational, but not very attractive, appeal to fear of gut infection.

The increase in hand-washing and use of antibacterial products which was reported to follow the birth of a baby suggests that this may be a time when parents are particularly amenable to behaviour change. The time following the birth of a baby may be especially favourable for interventions aimed at changing hygiene practices.

It has been suggested by an increasing number of authors that too much hygiene may have negative impacts on health through failure to stimulate the correct balance between the Th1 and Th2 components of the immune response (Rook & Stanford, 1998). There is, however, no evidence to suggest that the ingestion of the pathogenic agents of IID has a net benefit to health. If the hygiene hypothesis proves well-founded, it will underline the need to target hygiene promotion much more specifically at risk practices for intestinal infection, such as failure to wash hands after stool contact, and not at 'hygiene' in general. More studies such as this one will therefore be needed.

Methodology: feasibility of a larger study

There is no perfect way to document private and morally loaded behaviours such as those related to hygiene. Interviews are notoriously poor at eliciting behaviour and methods other than direct consensual personal observation are difficult and unethical. Structured observation can give a good overall view of the prevalence of particular behaviours without necessarily painting a true picture of what usually happens in individual households (Curtis et al., 1993, Cousens et al., 1996). This is because people react to being observed,

often by trying to project an image as 'cleaner or more hygienic' (Kanki et al., 1994a). Others are flustered by the presence of an observer and forget to do what they might otherwise routinely practice. The behaviour of individuals also varies by time of day, week or year and by mood and circumstance. These difficulties notwithstanding, structured observation remains the best available tool for documenting hygiene behaviour.

Observation and surface swabbing was well accepted by 9 out of 10 child carers in the study. Four people who were contacted did not wish to participate in the study, giving a number of reasons, including lack of time. A high refusal rate from a particular group could affect the external validity of a larger study, especially if these were the most, or the least, hygienic members of society. External validity was aided by the choice of mothers of infants in their first few months of life as the target group. Mothers who normally work were at home for maternity leave and could thus be represented in the sample. Such mothers often welcomed the distraction of having visitors. However, recent mothers are a particular sample of the population who have particular concerns and habits. They may not be representative of the population as a whole. Hence, the finding of unexpectedly high levels of hand-washing after using the toilet may be a reflection of our hypothesised heightened sense of hygiene when a new baby is present and not a true picture. The study took up a considerable amount of participant's time and the remuneration was important in motivating participants to continue to the end.

Documenting the motivation for hygiene practice is more complex. Using interviews, projective techniques and focus groups gave some insight into why people do what they do. However, such techniques rely on people rationalising their own behaviour. Much behaviour is automatic, habitual or determined by stimuli that are not open to conscious scrutiny. Self-reports of motivation are therefore inherently limited in their scope. So, for example, a mother might report that she washed her hands to avoid germs for the sake of offering a rational explanation, whilst her real motivation might be long habit, the discomfort of sticky hands or their smell. Of the three techniques, projective approaches, which tackle the subject from an indirect angle were best at eliciting underlying motivation. However none are ideal. New developments in the understanding of the relationship between emotion and behaviour may help to shed light on these issues (Curtis & Biran, 2001).

Conclusions

The study was small and cannot be used for statistical inference. However, a number of tentative conclusions can be drawn.

1. Faecal–oral spread of pathogenic viruses and bacteria in the home can and probably does occur.
2. Infants may be an important source of intestinal infection. Poor hygiene in association with nappy changing and potty use may be major risk practices for IID.
3. Rigorous hand-washing after contact with faecal material in toilets, nappies and potties, possibly coupled with the decontamination of high-risk surfaces may offer an effective means to break domestic transmission routes of IID.
4. Hygienic behaviour is motivated by a number of factors which include the desire to nurture a baby, to create an attractive environment, to tidy and order, to avoid things that are disgusting and to create a good impression. Interventions to prevent the domestic transmission of pathogens should focus on existing motivation and habit, and on facilitating behaviour change.
5. Studying home hygiene is difficult, but not impossible. This study was unique in using polio vaccine virus as an indicator of viral contamination originating from an identifiable source within the home (infant faeces). It overcomes the major problem of previous studies which have been unable to pinpoint the source of microbial contamination of household surfaces. A larger study using the techniques piloted here is feasible.
6. Combining the skills of industrial and academic microbiological and behavioural scientists using quantitative and qualitative techniques gives good insight into what people do and why. The results can be used to design hygiene promotion interventions.

Acknowledgements

Thanks to collaborators Sue Fisher for field work, Debbie Stevens for lab work, Kwesi Tsiquaye for the idea of using polio vaccine virus. The contributions of Martin Jones, Sally Bloomfield and Sandy Cairncross are acknowledged. Funding was provided by Unilever Research.

Appendix A. microbiology protocols

Preparation of transport medium

Virus Transport Medium (VTM) was prepared from Hanks Basal Salt Solution (HBSS) containing 0.7% Bovine Serum Albumin, the pH of the solution was adjusted by the addition of 1% sterile sodium bicarbonate solution (7.5%). 1.5 ml was added to sterile plastic bijou.

Sampling procedure

An area of 10 cm^2 was sampled using swabs moistened with Hanks BSS (HBSS). Swab tips were returned to the remaining HBSS and the tubes stored in ice until returned to the laboratory. Swabs were vortex mixed in the HBSS for 10 s and allowed to stand for 1 min. The suspension was then transferred to a sterile Eppendorf tube and centrifuged at 13,000 rpm for 20 min. The supernatant was transferred to a second sterile Eppendorf tube containing 10 μl of antibiotic solution for virus isolation. The pellet was re-suspended in 1 ml sterile 10% glycerol and 1% peptone solution. Samples stored at −80°C until sent to LSHTM for bacteriology.

Cell culture and media preparation for virus isolation

Hep-2C cells (Human caucasian larynx carcinoma) were obtained from the European Cell Culture Collection. Growth medium for the cells consisted of Eagles minimal essential medium (with Earle's salts) supplemented with 10% Foetal Calf Serum (FCS), 1% (v/v) 100 × non-essential amino acids, 2.5 μml Amphotericin B, 100 μgml Streptomycin, 50 I.U./ml penicillin, 20 mM L-Glutamine. Cells were maintained on the above medium but with the FCS reduced to 2%. Stocks of cells were in 75 cm^2 cell culture bottles and passaged as required. Plates (48-well) were prepared by sub-culturing at a dilution to give confluent monolayers in 24–48 h.

Monoclonal antibodies against poliovirus

These were obtained from Dr. Philip Minor (NIBSC) by Dr. Kwesi Tsiquaye. They were aliquoted and stored at 20°C until required, (Type 1: 425, Type 2 : 267 and Type 3: 495). The serum was titrated against the three serotypes of poliovirus to determine the level required to neutralise virus.

Preparation of faecal samples for virus isolation

An appropriate volume of Hanks' balanced salt solution (HBSS) (Sigma H8264) was added to give a 10% (w/v) suspension and the sample vortex-mixed for 30 s. The suspension was allowed to settle out for 15 min at 4°C then clarified by centrifugation for 30 min at 1450g/4°C. The supernatant was decanted and antibiotics added to give a final concentration of 1000-I.U./ml penicillin, 1000 μg/ml streptomycin (Sigma P0781) and 2.5 μg/ml amphotericin B (Sigma A2942). The sample was held at room temperature for 1 h then centrifuged for 2 h at 1450g/4°C. The supernatant was decanted and dilutions of 10-1 and 10-2 prepared in HBSS plus antibiotics and mixed with appropriate dilutions of monoclonal antibody, incubated for 1 h at 37°C. The cells were inoculated with 100 μl undiluted and diluted suspension (treated with antiserum) or cell maintenance medium as a control. After 1 h incubation at 37°C, the inoculum was decanted and replaced with 0.5 ml overlay medium. The cells were observed daily, and after 5 days the plates were fixed and stained.

Overlay medium

Carboxymethyl cellulose (CMC) (BDH Low viscosity) was prepared by adding 1.5 g–85 ml deionised water and sterilised by autoclaving at 121°C for 15 min. To the solution of CMC the following were added:

10 ml Eagles MEM 10×,
3 ml sodium bicarbonate (7.5%),
1 ml glutamine 2000 mM),
1 ml penicillin/streptomycin
(10,000 units/10 mg/ml),
1 ml fungizone(250 μg/ml),
2 ml foetal calf serum.

Fixation and staining

Plates were fixed using 20% (v/v) formaldehyde (500 μl/well), the formaldehyde was left in contact with the cells for 1 h. After which it was removed by pipetting and each well was washed five times with deionised water (1 m/wash). Crystal violet stain was added (0.25 ml/well) and left for 30 min. The stain was prepared from 0.2% Crystal Violet, in 20% ethanol made up to 100% with deionised water).

After staining the crystal violet was removed by pipetting and the wells washed with water (4 × 0.25 ml) to remove excess stain. The plates were air dried and the number of plaques counted and recorded.

Control virus

As a control for the neutralisation and plaque assay, a virus control was included in every batch of samples tested. This consisted of Polio type 1 Mahoney strain that had been cultured in Vero cells.

The samples were received frozen and stored at minus 70°C until needed.

Bacteriology: quantitative culture

The samples were thawed and tenfold serial dilutions were prepared in quarter strength Ringers solution. A 0.1 ml sample of the original sample and of each of the dilutions were spread inoculated, using sterile glass spreaders, on Blood agar and MacConkey's agar plates. The plates were incubated overnight at 37°C.

The colonies of bacteria that had developed were counted and identified, on the basis of Gram's stain and cultural characteristics.

References

Ahmed, N. U., Zeitlin, M. F., Beiser, A. S., Super, C. M., & Gershoff, S. N. (1993). A longitudinal study of the impact of behavioural change intervention on cleanliness, diarrhoeal morbidity and growth of children in rural Bangladesh. *Social Science & Medicine, 37*(2), 159–171.

Alam, N., Wojtyniak, B., Henry, F. J., & Rahaman, M. M. (1989). Mothers' personal and domestic hygiene and diarrhoea incidence in young children in rural Bangladesh. *International Journal of Epidemiology, 18*(1), 242–247.

Altman, J. (1973). Observational study of behaviour: Sampling methods. *Behaviour, 44*, 227–265.

Aziz, K. M., Hoque, B. A., Hasan, K. Z., Patwary, M. Y., Huttly, S. R., Rahaman, M. M., & Feachem, R. G. (1990). Reduction in diarrhoeal diseases in children in rural Bangladesh by environmental and behavioural modifications. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 84*(3), 433–438.

Barker, J., & Bloomfield, S. F. (2000). Survival of *Salmonella* in bathrooms and toilets following salmonellosis. *Journal of Applied Microbiology, 89*, 137–144.

Becker, M. H. (1974). The health belief model and sick role behaviour. *Health Education Monographs, 2*, 409–419.

Bellamy, K., Laban, K. L., Barrett, K. E., & Talbot, D. C. (1998). Detection of viruses and body fluids which may contain viruses in the domestic environment. *Epidemiology and Infection, 121*, 673–680.

Borgerhoff-Mulder, M., & Caro, T. (1985). The use of quantitative observational techniques in Anthropology. *Current Anthropology, 26*(3), 323–335.

Cogan, T. A, Bloomfield, S. F., & Humphrey, T. J. (1999). The effectiveness of hygiene procedures for prevention of cross-contamination from chicken carcases in the domestic kitchen. *Letters in Applied Microbiology, 29*(5), 354–358.

Cousens, S., Kanki, B., Toure, S., Diallo, I., & Curtis, V. (1996). Reactivity and repeatability of hygiene behaviour: Structured observations from Burkina Faso. *Social Science & Medicine, 43*(9), 1299–1308.

Curtis, V., Cousens, S., Mertens, T., Traore, E., Kanki, B., & Diallo, I. (1993). Structured observations of hygiene in Burkina Faso, validity, variability and utility. *Bulletin of the World Health Organisation, 71*(1), 23–32.

Curtis, V., Kanki, B., Mertens, T., Traoré, E., Diallo, I., Tall, F., & Cousens, S. (1995). Potties, pits and pipes: Explaining hygiene behaviour in Burkina Faso. *Social Science & Medicine, 41*(3), 383–393.

Curtis, V., Kanki, B., Cousens, S., Sanon, A., Diallo, I., & Mertens, T. (1997). Dirt and diarrhoea: Formative research for hygiene promotion programmes. *Health Policy and Planning, 12*(2), 122–131.

Curtis, V. A., & Biran, A. (2001). Dirt, disgust and disease: Is hygiene in our genes? *Perspectives in Biology and Medicine, 44*(1), 17–31.

Curtis, V. A., Cairncross, S., & Yonli, R. (2000). Domestic hygiene and diarrhoea, pinpointing the problem. *Tropical Medicine and International Health, 5*(1), 22–32.

Daniels, N. A., Bergmire-Sweat, D. A., Schwab, K. J., Hendricks, K. A., Reddy, S., Rowe, S. M., Fankhauser, R. L., Monroe, S. S., Atmar, R. L., Glass, R. I., & Mead, P. (2000). A foodborne outbreak of gastroenteritis associated with Norwalk-like viruses: First molecular traceback to deli sandwiches contaminated during preparation. *Journal of Infectious Disease, 181*(4), 1467–1470.

Dawkins, H. C., Bolton, F. J., & Hutchinson, D. N. (1984). A study of the spread of Campylobacter jejeuni in four large kitchens. *Journal of Hygiene, 92*, 357–364.

Dewitt, J. C., Broekhuizer, G., & Kamplemacher, E. H. (1979). Cross-contamination during the preparation of frozen chicken in the kitchen. *Journal of Hygiene, 83*, 27–32.

Feachem, R. G. (1984). Interventions for the control of diarrhoeal diseases among young children: Promotion of personal and domestic hygiene. *Bulletin of WHO, 62*(3), 467–476.

Finch, J. E., Prince, J., & Hawksworth, M. (1978). A bacteriological survey of the domestic environment. *Journal of Applied Bacteriology, 45*, 357–364.

Gerba, C. P., Wallis, C., & Melnick, J. L. (1975). Microbiological hazards of household toilets: Droplet production and the fate of residual organisms. *Applied and Environmental Microbiology, 30*, 357–364.

Humphrey, T. J., Martin, K. W., & Whitehead, A. (1994). Contamination of hands and worksurfaces with *Salmonella* enteriditis PT4 during the preparation of egg dishes. *Epidemiology and Infection, 113*, 403–409.

Kanki, B., Curtis, V., Mertens, T., Cousens, S., & Traoré, E. (1994a). Measuring hygiene behaviours: Experiences of a comprehensive approach in Burkina Faso. In A. Cairncross, & V. Kochar (Eds.), *Studying hygiene behaviour: Issues and experiences*. London: Sage.

Kanki, B., Curtis, V., Mertens, T., Traoré, E., Cousens, S., Tall, F., & Diallo, I. (1994b). Des croyances au comportements: Diarrhée et pratiques d'hygiène au Burkina Faso. *Cahiers Santé, 4*, 335–339.

Martin, P., & Bateson, P. (1986). *Measuring behaviour: An introductory guide*. Cambridge: Cambridge University Press.

Mendes, M. J., & Lynch, D. J. (1978). A bacteriological survey of kitchens. *Environmental Health, 86*, 227–231.

Rheinbaben, F. v., et al. (2000). Transmission of viruses via contact in a household setting: Experiments using bacteriophage $\phi X174$ as a model virus. *Journal of Hospital Infection, 46*, 1–66.

Rook, G. A. W., & Stanford, J. L. (1998). Give us this day our daily germs. *Immunology Today, 19*, 113–116.

Ryan, M. J., Ramsay, M., Brown, D., Gay, N. J., Farrington, C. P., & Wall, P. G. (1996). Hospital admissions attributable to rotavirus infection in England and Wales. *Journal of Infectious Diseases, 174*, S12–S18.

Scott, E. A., & Bloomfield, S. F. (1993). An in-use study of the relationship between bacterial contamination of food preparation surfaces and cleaning cloths. *Letters in Applied Microbiology, 16*, 173–177.

Scott, E. A., Bloomfield, S. F., & Barlow, C. G. (1982). An investigation of microbial contamination in the domestic environment. *Journal of Hygiene (Cambridge), 89*, 279–293.

Sockett, P. N., Cowden, J. M., Le Baigue, S., Ross, D., Adak, G. K., & Evans, H. (1993). Foodborne disease surveillance in England and Wales 1989–1991. *Communicable Diseases Reports, 3*(12), R159–R173.

Shahid, N. S., Greenough, W. B., Samadi, A. R., Huq, M. I., & Rahman, N. (1996). Hand washing with soap reduces

diarrhoea and spread of bacterial pathogens in a Bangladesh village. *Journal of Diarrhoeal Disease Research*, *14*(2), 85–89.

Wheeler, J. G., Sethi, D., Cowden, J. M., Wall, P. G., Rodrigues, L. C., Tompkins, D. S., Hudson, M. J., & Roderick, P. J. (1999). Study of infectious intestinal disease in England: Rates in the community, presenting to general practice, and reported to national surveillance. *British Medical Journal*, *318*, 1046–1050.