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An investigation of microbial contamination in the home

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SUMMARY

An investigation of the bacterial flora in over 200 homes is reported. The occurrence of potential pathogens and the levels of contamination at individual sites, particularly in the kitchen, toilet and bathroom is described and the implications for hygiene practices in the home discussed.

INTRODUCTION

Relatively little published information is available on the bacterial content of the domestic environment, but there are indications of marked differences compared with hospitals and other public premises.

A survey of the total environment in 21 homes is reported by Finch, Prince & Hawksworth (1978), but the majority of domestic studies deal with specific situations such as toilets (Gerba, Wallis & Melnick, 1975), dishcloths and tea-towels (Davis, Blake & Woodall, 1968), the handling of frozen chickens in the kitchen (De Wit, Broekhuizen & Kampelmacher, 1979) and the bottle-feeding of babies (Anderson & Gatherer, 1970).

Although it is accepted that the infection risk in the general community is less than that associated with patients in hospital, nevertheless, yearly increases in food poisoning cases in which household outbreaks are a major contributory factor (Sheard, 1980), combined with increasing tendency to home nursing of people with abnormally high susceptibility to infection, indicate that a comprehensive survey would be valuable as a basis for improving standards of hygiene in the home. Further, a recent prevalence survey indicated that approximately 50 % of so-called hospital infections are actually acquired in the community, prior to patient hospitalization (Meers *et al.* 1981).

Reviewing the use of domestic disinfectants, Bloomfield (1978) indicated four major categories of contamination that include dry areas (floors, walls, furnishings, clothing, linens, etc.), wet areas (baths, basins, toilets, drains, etc.), food and people. This paper describes a study of environmental sites representing the various areas and activities in the home.

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METHODS

Media

Except where specified otherwise, all media were prepared and supplied by Tissue Culture Services Ltd. (Slough, Bucks.) using media bases obtained from Oxoid Ltd.

Distribution of homes

Samples were taken from 251 domestic houses, the majority being situated in towns and villages in Surrey (south east sample). Thirty homes in the Manchester and Sheffield area were also visited.

Initial contact was made through talks given to ladies' social clubs or by mailing, and volunteers were invited to participate in the survey. Appointments were made to visit each housewife, who was requested to maintain her normal cleaning routine prior to the visit.

Although the majority (75%) were owner-occupied, the homes visited were considered to be representative in terms of age, location (main road, suburban, estate, etc.) and surroundings (industrial, residential, rural, etc.)

Sampling sites and methods of sampling

Environmental sites selected for study and sampling techniques for each site are described by Scott, Bloomfield & Barlow (1981). Samples were taken from 60 sites in the bathroom, toilet and kitchen. Nine sites in the living rooms and bedrooms of the first 75 houses were also examined. Not all sites (e.g. nappy buckets) were available for sampling in all houses and results are therefore expressed as a percentage of sites available for sampling.

Flat surfaces such as the kitchen sink and work surface were sampled by placing blood agar rodac plates in contact for 10 s. Awkward surfaces such as taps and door handles were sampled by means of MacConkey/cysteine–lactose electrolyte-deficient (CLED) contact slides (Tillomed Ltd, Henlow). serum-coated cotton wool swabs pre-moistened in $\frac{1}{4}$ strength Ringer's solution were used to sample areas of approximately 50 cm^2 adjacent to the contact sampling area and returned immediately to plastic containers. Liquid samples (10 ml) from toilet bowls and sink U-tubes were collected by pipette and transferred to contact slides in their containers. Air was sampled by exposing blood agar settle plates for a period of 1 h.

Samples were returned to the laboratory in an insulated cool box within 2 h of collection. Swabs and a loopful of each liquid sample were streaked onto blood, MacConkey, desoxycholate citrate and milk agar and incubated aerobically together with contact plates, slides and settle plates at 37 °C for 24 h.

Identification of bacterial isolates

Colonial morphology and Gram staining reactions of isolates from streak plates, contact plates and slides were noted. Gram negative rods were identified by the API 20 system for Enterobacteriacae and other Gram negative rods (API

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Table 1. *Bacterial species and their percentage frequency occurrence in* 201 *homes*

Enterobacteria	
Esch. coli	64·5%
Kleb. pneumoniae	29·5%
Klebsiella spp.	6·0%
Proteus mirabilis	4·0%
Presumptive *salmonella*	1·5%
Citrobacter freundii	42·0%
Citrobacter spp.	29·0%
Ent. cloacae	26·0%
Ent. agglomerans	7·5%
Pseudomonads	
Ps. aeruginosa	4·0%
Ps. maltophilia	37·0%
Ps. cepacia	5·0%
Ps. putrifaciens	8·5%
Ps. fluorescens	9·5%
Pseudomonas spp. (non-typable)	55·0%
Others	
Staph. aureus	31·5%
Bac. cereus	20·5%
Streptococci	16·0%
Micrococci	100·0%
Bacillus spp.	97·0%
Aeromonas hydrophila	47·5%

Laboratory Products Ltd, Farnborough, Hants), while presumptive *Staphylococcus aureus*, and *Bacillus cereus* were identified using DNase agar and egg yolk agar respectively. Isolates of *Escherichia coli* were serotyped by slide agglutination tests using a range of polyvalent sera for strains most commonly associated with diarrhoeal disease. Serological evidence for presumptive *Salmonella* species was limited to slide agglutination tests with poly O, poly H and Vi sera (serum supplied by Wellcome Reagents Ltd, Beckenham).

Determination of contamination levels

As described previously (Scott, Bloomfield & Barlow, 1981), levels of contamination were estimated by comparing contact plates and slides with standard charts and placing them in the following categories: 0 colonies, 1–19 colonies, 20–99 colonies, 100 – approximately 450 colonies and greater than 450 colonies. Colonies on settle plates were all counted.

RESULTS

Bacterial species

Initially, 201 homes were examined in the south east of England. The range of organisms and their occurrence as a percentage of homes examined are listed in Table 1. The following organisms were also identified but are not listed due to their infrequent occurrence: *Flavobacterium* spp., *Acinetobacter calcoaceticus* and *Xanthomonas*.

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Although the most frequently occurring organisms were those generally considered as non-pathogenic, the majority of homes were contaminated with species of enterobacteria and pseudomonads, many of which are potentially pathogenic. Other potential pathogens included *Staph. aureus*, *Streptococcus* species and *B. cereus*.

The occurrence of these organisms at individual sites is shown in Tables 2 and 3. Several sites such as vegetable racks, bread bins, tin openers, door handles, walls and air samples have in most cases been omitted due to infrequent occurrence of organisms other than micrococci and Gram-positive bacilli at these sites.

More than 80% of the 201 homes examined contained one or more species of enterobacteria. As shown in Table 2, highest isolation rates for enterobacteria within those homes were from 'wet sites' such as the toilet water, nappy bucket, all U-tubes, kitchen sink and draining board, dishcloth, cleaning cloth and mop. The most frequently occurring species were *Esch. coli*, *Citrobacter freundii*, *Klebsiella pneumoniae* and *Enterobacter cloacae*.

Isolates of *Esch. coli* were serotyped in a group of 41 homes. From these houses a total of 194 *Esch. coli* isolates was obtained, of which 29 (from 20 out of 41 homes) were potentially enteropathogenic serotypes. Sixteen of the isolates were from sites in and around the kitchen sink, whilst the remainder were isolated mainly from toilet areas but also from bathroom areas.

Salmonella species were isolated from four houses (providing five isolates in total) from the following sites: sink surface, sink U-tube, fridge, cutlery and toilet door handle. The organism isolated from the sink surface was identified using the API system as *Salm. arizonae*. The presence of salmonella isolates was confirmed serologically but no attempt was made to identify isolates to species level.

Pseudomonads were found in 91% of homes at one or more sites as indicated in Table 3; the presence of potential pathogens (either *Pseudomonas aeruginosa*, *Ps. maltophilia*, *Ps. cepacia*, *Ps. putida* or *Ps. putrifaciens*) was confirmed in 59% of homes whilst further non-typable strains were found in the remaining 32%. Of these *Ps. maltophilia* was isolated most frequently (35% of homes) whilst, as shown by other workers (Whitby & Rampling, 1972; Finch, Prince & Hawksworth, 1978) *Ps. aeruginosa* was only occasionally isolated (4% of homes).

Although pseudomonads, like enterobacteria, do not survive well in the absence of moisture we found these organisms more frequently in dry than wet sites in the home. It is possible that this reflects their opportunistic nature, which allows colonization of sites unsuitable for growth of other Gram negative organisms, rather than a preference for dry conditions. Pseudomonads were isolated most often from floors, with isolation rates of 33%, 36% and 46% for bathroom, toilet and kitchen respectively.

Of the other potentially pathogenic organisms, as shown in Table 3, *Staph. aureus* (found in 31% of 201 homes) tended to predominate at sites of contact with human skin such as toilet and tap handles, facecloths and towels, etc. *B. cereus* (found in 20·5% of homes) was located mainly on kitchen work surfaces and vegetable racks but overall, like the pseudomonads, both organisms were most often isolated from floors. *Streptococcus* spp. (found in 16% of 201 homes) were isolated most often

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from wet sites such as sink surface, toilet bowl, potty, nappy bucket, wash basin and bath and from floors.

All homes were contaminated with micrococci and/or *Bacillus* species; for most sites micrococci were found in more than 70% of samples whilst *Bacillus* species were found mainly on floors, food shelves and vegetable racks (isolation rates 35–74% of samples). The other commonly occurring organism was *Aeromonas hydrophila* found mainly at wet sites in the kitchen and all types of cloths.

Overall, the pattern of bacterial contamination was similar to that reported by Finch, Prince & Hawksworth (1978), although these workers reported higher isolation rates for *Esch. coli* at sites in and around the kitchen sink (65–85% compared with 13–39% in this survey) and a higher incidence of *Staph. aureus* on tea towels and hand towels.

Contamination levels

All sites were examined for contamination levels. Tables 4*a* and 4*b* show the cumulative percentage frequency of occurrence of uncountable plates (or slides) and colony counts greater than 100, 20 or 1 or more at individual sites as a percentage of samples taken.

Relatively high levels of contamination (a count of 100 colonies or more per 25 cm^2 contact plate or 20 colonies or more per 5 cm^2 contact slide) were at some time found at almost all sites. However, many sites yielded only occasional high counts (less than 2·1%) and these have not been included in the tables. High counts were found mostly in wet areas associated with baths, basins and sinks, washing machines and nappy buckets, but were also frequently obtained from cleaning cloths, dishcloths and facecloths. In addition, high levels of contamination were quite often present in dry areas such as floors, bathmats and vegetable racks.

Livingrooms and bedrooms

Livingroom and bedroom sites were sampled for the first 75 houses only. In view of the relatively low contamination levels and relatively infrequent occurrence of potentially pathogenic organisms (Table 5) further sampling was considered to be of little value.

Repeat sampling

Twenty randomly selected houses were resampled on a surprise-call basis, 20–40 weeks after the initial survey.

Comparison of the results (Scott, 1981) with the original sampling provided reassurance that householders had not influenced the results by cleaning in anticipation of visits and that the pattern of bacterial contamination in a home does not change simply as a function of time.

Comparison of results in the south-east of England with the north of England

To investigate possible differences related to geographical location and surroundings, 30 houses in the Manchester and Sheffield areas, most of which were situated in industrial or heavy residential areas, were sampled and compared with

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Table 2(a). *Frequency of isolation of enterobacteria from kitchen sites as a percentage of sites examined (figures in brackets indicate numbers of homes sampled)*

	Sink (198)	Washing-up bowl (95)	U-tube (171)	Sink taps (395)	Dishcloth (186)	Draining board (198)	Teatowel and handtowel (317)	Cooker surface (198)	Foodshelf (191)	Refrigerator* (392)	Worktop and chopping board (358)	Cutlery and crockery (396)	Cleaning utensils† (489)	Floor (207)	Waste bin (168)	Washing machine (124)	Cleaning cloth (38)	Washing-up brush (93)
Esch. coli	18·7	8·4	38·8	6·8	13·5	12·8	1·9	3·0	3·1	2·3	4·7	2·0	3·5	5·0	5·4	5·7	10·5	8·8
Kleb. pneumoniae	6·6	5·3	11·2	4·6	7·6	4·1	1·6	3·5	1·0	1·5	4·2	1·5	1·4	2·5	6·6	1·6	5·3	4·4
Pr. mirabilis	0·5	0	0	0·5	0	0	0	0	0	0	0·8	0	0	0	0	0	0	0
Salmonella spp.	1·0	0	1·2	0	0	0	0	0	0	0·3	0	0·2	0	0	0	0	0	0
C. freundii	11·1	11·6	15·3	5·8	11·9	8·7	4·1	3·0	2·1	3·3	8·5	1·8	3·7	3·5	4·8	2·4	13·2	11·0
Citrobacter spp.	6·1	8·4	10·6	4·0	5·4	4·6	0·3	1·0	0·5	0·7	2·1	1·5	3·0	2·0	0·6	4·9	0	5·5
Klebsiella spp.	0·5	2·1	3·5	0·3	2·2	2·0	0	0·5	0·5	0·2	0·4	0·2	0·4	0	0·6	0	2·6	4·4
Ent. cloacae	11·0	11·5	3·3	1·0	7·6	5·9	0·6	1·0	0	1·7	7·6	2·3	3·2	0	2·4	1·5	5·2	2·9
Ent. agglomerans	1·0	2·1	0·6	1·8	2·2	1·5	0	0·5	0	1·8	2·9	0·5	1·4	1·0	0·6	0	0	1·1

* Refrigerator, interior and inner door.
† Cleaning utensils = mop and bucket, broom and duster.

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Table 2(*b*). *Frequency of isolation of enterobacteria from toilet and bathroom sites as a percentage of sites examined (figures in brackets indicate numbers of homes sampled).*

	Toilet									Bathroom								
	Water (195)	Bowl (199)	Handle (197)	Seat* (396)	Brush (146)	Floor (104)	Door handles† (251)	Potty (48)	Nappy Bucket (32)	Washbasin (198)	Basin and bath U-tubes (215)	Basin taps (395)	Soap dish (195)	Facecloth (171)	Bath (198)	Bath taps (388)	Towel (196)	Floor and bathmat (165)	Cleaning cloth (130)
Esch. coli	16·3	6·1	2·0	3·7	9·3	2·9	0·5	12·5	21·9	4·0	10·7	3·8	4·1	6·4	1·0	0·7	2·6	1·8	2·3
Kleb. pneumoniae	3·6	1·0	0·5	0·5	1·3	1·0	0·5	0	6·2	1·0	0·9	0·2	2·1	3·5	1·0	0	0·5	0	3·1
Pr. mirabilis	0·5	0·5	0	0·5	0·7	0	0·5	2·1	6·2	0·5	0·5	0	0	1·2	0	0·3	0	0	1·5
Salmonella spp.	0	0	0	0	0	0	0·8	0	0	0	0	0	0	0	0	0	0	0	0
C. freundii	7·1	6·1	0·5	1·5	6·6	1·9	2·0	6·2	6·2	2·0	12·6	1·0	2·6	6·4	2·0	1·2	1·0	2·4	6·9
Citrobacter spp.	6·1	2·5	0·5	0·5	2·0	1·0	0	0	6·2	0·5	3·7	2·0	1·5	1·7	0·5	0·5	0	1·2	0·8
Kleb. spp.	1·5	0	0	0	0·7	0	0	0	3·1	0·5	1·4	0·5	0·5	1·2	0	0	0·5	0	0·8
Ent. cloacae	1·0	0	2·0	0·5	0	1·4	0	0	6·2	0	1·8	0	2·0	1·0	1·0	0	1·0	0	5·3
Ent. agglomerans	0	0	0	0	0	0	0	0	0	0	1·9	0	0	0·6	0	0	0·5	0	0·8

* Toilet seat, upper and lower surfaces.

† Door handles, toilet and bathroom.

Table 3(*a*). *Frequency of isolation of pseudomonads and other bacteria from kitchen sites as a percentage of sites examined (figures in brackets indicate number of homes sampled)*

	Sink (198)	Washing-up bowl (95)	U-tube (171)	Sink taps (395)	Dishcloth (186)	Draining board (198)	Teatowel and handtowel (317)	Cooker surface (198)	Foodshelf (191)	Refrigerator‡ (392)	Worktop and chopping board (358)	Cutlery and crockery (396)	Vegetable rack (97)	Floor (201)	Cleaning utensils§ (489)	Wastebin (168)	Washing machine (124)	Cleaning cloth (38)
Ps. aeruginosa	0·5	0	0·6	0	0·5	1·0	0·3	0	0·5	0·2	0·3	0	0	0	0	0	0	0
Ps. mallophilia	7·6	5·3	0	1·0	2·7	6·6	4·4	7·5	11·5	8·2	8·8	0·7	3·1	10·5	6·1	4·2	3·3	2·6
Other pseudomonads*	3·5	0	4·1	1·3	4·9	2·6	2·2	1·5	2·1	1·0	2·2	0	2·0	1·0	2·1	1·8	2·4	5·2
Pseudomonas spp.†	2·2	16·8	11·1	10·9	21·1	19·8	16·7	29·6	36·6	27·0	21·1	5·1	31·6	37·1	23·7	23·4	16·2	15·7
Bac. cereus	2·0	4·2	0	0·7	0	0·5	2·2	2·5	3·7	2·8	3·1	0·2	6·1	6·5	4·5	1·8	0·8	0
Staph. aureus	3·0	2·1	2·4	2·5	3·2	2·0	3·8	1·0	2·1	1·5	7·4	0	0	5·0	1·2	2·4	0·8	2·6
Streptococci	2·0	0	0	0·7	1·1	1·0	1·6	0·5	1·6	0·5	0·8	0·5	3·1	2·0	0·4	1·2	0·5	0

* Other pseudomonads = *Ps. cepacia*, *Ps. putrifaciens*, *Ps. putida* and *Ps. fluorescens*.
† *Pseudomonas* spp. = mixed group of pseudomonads not identified to species level.
‡ Refrigerator, interior and inner door
§ Cleaning utensils = mop and bucket, broom and duster.

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Table 3(*b*). *Frequency of isolation of pseudomonads and other bacteria from toilet and bathroom sites as a percentage of sites examined (figures in brackets indicate number of homes sampled)*

	Toilet									Bathroom								
	Water (195)	Bowl (199)	Handle (197)	Seat‡ (396)	Brush (146)	Floor (104)	Door handles§ (251)	Potty (48)	Nappy bucket (32)	Washbasin (198)	Basin and bath U-tubes (215)	Basin taps (395)	Soapdish (195)	Facecloth (171)	Bath (198)	Bathtaps (388)	Towel (196)	Floor and bathmat (165)	Cleaning cloth (130)
Ps. aeruginosa	0	0	0	0	0·7	0·7	0	0	0	0	0·5	0	0	0·6	0	0	0·5	0·6	0
Ps. maltophilia	0·5	0·5	0·5	3·7	0·7	12·2	0	0	0	2·0	0·9	1·0	0·5	2·9	3·6	1·0	1·0	7·4	2·3
Other pseudomonads*	2·6	1·0	1·0	0·9	2·0	1·0	1·6	2·1	0	1·5	5·5	1·0	3·1	0·6	1·5	1·0	1·0	3·1	2·3
Pseudomonas spp.†	8·1	10·8	4·0	19·6	10·5	35·9	4·8	14·1	9·4	14·1	21·0	8·8	9·7	17·4	22·9	9·5	16·3	26·4	20·7
Bac. cereus	0	0	1·0	2·0	0	7·6	0·4	0	0	0·5	0·9	0·5	0·5	0	1·0	0·7	0·5	4·3	0·8
Staph. aureus	0	3·0	2·6	3·0	0	2·9	3·6	2·1	0	3·0	0·5	3·0	2·6	4·7	3·1	1·5	3·6	6·1	2·3
Streptococci	0	3·0	1·5	1·7	2·6	0	0·8	4·2	6·2	4·5	0·9	2·0	2·1	1·7	3·6	0·5	1·5	1·8	1·5

* Other Pseudomonads = *Ps. cepacia*, *Ps. putrifaciens*, *Ps. putida* and *Ps. fluorescens*.

† *Pseudomonas* spp. = mixed group of pseudomonads not identified to species level.

‡ Toilet seat, upper and lower surfaces.

§ Door handles, toilet and bathroom.

Table 4(a). Contamination levels, expressed as cumulative frequency of percentage occurrence at individual sites in kitchens (figures in brackets indicate numbers of homes sampled)

No. of colonies	Sink (198)	Washing-up bowl (95)	U-tube (171)	Sink taps (395)	Dishcloth (186)	Draining board (198)	Teatowel and handtowel (317)	Cooker surface (198)	Food shelf (191)	Refrigerator‡ (392)	Cutlery and crockery (396)	Worktop and chopping board (358)	Vegetable rack (97)	Bread bin (125)	Cleaning utensils* (489)	Floor (201)	Waste bin (168)	Washing machine (124)	Cleaning cloth (38)	Washing-up brush (93)	Door handles† (103)
450 or more	7·1	8·4	27·5	0·5	13·4	5·1	0	0·5	1·0	1·4	3·6	0·3	14·4	1·6	9·0	2·0	4·2	9·7	26·3	7·5	0
100 or more	31·1	35·8	56·2	5·8	47·3	33·0	13·6	15·1	11·5	11·2	17·6	2·1	41·2	7·2	29·0	38·7	23·8	35·5	55·2	24·7	3·0
20 or more	74·7	73·7	80·2	40·2	77·9	80·2	68·5	82·3	73·8	43·9	62·6	15·1	86·6	42·4	68·0	95·5	57·1	58·1	73·6	44·1	14·2
1 or more	97·0	91·6	93·0	94·2	97·8	99·5	98·8	99·0	100·0	90·7	98·0	68·9	98·0	92·8	97·0	99·5	95·8	89·5	100·0	82·8	81·0

* Cleaning utensils = mop, bucket, broom and duster.
† Door handles, kitchen door, handles both sides.
‡ Refrigerator, interior and inner door.

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Table 4(*b*).*Contamination levels, expressed as cumulative frequency of percentage occurrence, at individual sites in toilet and bathrooms (figures in brackets indicate number of homes sampled)*

	Toilet										Bathroom									
No. of colonies	Water (195)	Bowl (199)	Handle (197)	Seat* (396)	Brush (146)	Floor (104)	Wallis‡ (225)	Door handle† (251)	Potty (48)	Nappy bucket (32)	Wash basin (198)	Basin and bath U-tubes (315)	Basin taps and bath taps (783)	Soap dish (195)	Facecloth (171)	Bath (198)	Towel (196)	Cleaning cloth (130)	Floor and bathmat (165)	Air sample (189)
450 or more	2·1	1·0	0	0·5	6·7	1·9	0·5	0·5	2·1	28·1	0·5	51·6	0·1	2·1	18·1	4·6	1·5	13·1	1·8	0
100 or more	10·8	8·5	3·6	18·9	19·5	41·3	2·5	4·9	10·4	78·1	16·7	70·7	9·8	19·0	73·7	41·7	27·0	53·9	42·4	0
20 or more	24·6	37·1	39·6	69·4	30·9	93·2	28·8	35·3	54·1	67·5	60·1	82·8	51·4	53·4	93·6	87·9	81·6	82·4	90·3	36·0
1 or more	56·9	80·4	90·3	96·5	63·8	100·0	91·9	90·0	93·8	93·8	96·0	86·3	93·8	96·9	100·0	98·0	98·0	97·8	100·0	99·5

* Toilet seat, upper and lower surfaces.
† Door handles, toilet and bathroom.
‡ Toilet and bathroom walls.

Table 5. *The percentage occurrence of bacterial species and high contamination levels (100 or more organisms per 25 cm²) at living room and bedroom sites. (figures in brackets indicate number of homes sampled)*

	Living room				Bedroom			
	Carpet (68)	Upholstery (67)	Tabletop (31)	Curtains (36)	Sheets (71)	Blankets or duvet (72)	Carpet (71)	Dressing table (37)
E. coli	2·9	1·5	3·2	2·7	1·4	1·4	0	2·7
Other enterobacteria	0	1·5	3·2	0	0	0	0	2·7
Pseudomonads	17·6	26·8	45·2	16·6	15·5	9·7	29·6	37·8
Staph. aureus	1·5	0	0	0	1·4	1·4	1·4	0
Streptococci	0	0	0	0	1·4	1·4	1·4	0
100 or more orgs/25 cm²	4·4	1·5	6·4	2·7	19·7	8·3	12·6	18·9

30 houses randomly selected from the south-east sample. The only difference found was in the distribution of contamination levels; the Manchester and Sheffield area had a higher incidence of zero and uncountable contamination levels, whereas contamination level 1–99 colonies occurred more frequently in the south-east area sample.

DISCUSSION

This survey defines the pattern of bacterial contamination in the home on a scale not previously described. Examination of over 250 homes revealed potentially pathogenic organisms at all sites in one home or another. For many of these sites, pathogenic contamination is relatively infrequent and probably therefore of little importance, but the survey allowed us to identify areas of potentially greater hazard and suggest possible routes for transfer of contaminaton.

In assuming the importance of contamination, it is recognized that potential hazard depends not only on types but also number of pathogenic organisms present; there is evidence that large doses of 10^5–10^7 enteropathogenic organisms are required to produce infection in healthy adults but on occasions outbreaks from numbers as low as 10^2–10^3 organisms have been reported (Lipson, 1976). It must be borne in mind that even small numbers of organisms such as *Esch. coli* and *Staph. aureus* may proliferate and become hazardous if transferred to food. In our investigation, enterobacteria were commonly found at wet sites, where they generally occurred in large numbers and were the predominant organism. Large numbers of these organisms were rarely present at dry sites. Pseudomonads occurred at wet and dry sites, but seldom in large numbers. Fairly small numbers of *Staph. aureus*, *B. cereus* and streptococci were isolated from any one site.

To identify potentially hazardous situations, the frequency of occurrence of

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potentially pathogenic species (Tables 2 and 3) was considered together with the occurrence of high contamination levels (100 or more colonies/25 cm^2) (Table 4) for various groups of sites (wet, dry, contact, food preparation, etc.)

For dry areas (e.g. floors, vegetable racks, etc.), even where high contamination levels were present, the predominant organisms were Gram positive bacilli and micrococci. Although pseudomonads were quite frequently isolated, particularly from floors, there is little to indicate that they present any particular infection hazard to healthy members of the community, but their presence at food storage and preparation sites may lead to food spoilage (Toule & Murphy, 1978).

Of greater concern was the finding that, in wet areas most commonly associated with high counts, organisms of enteric origin tended to predominate. Specific sites in this category included U-tubes in the kitchen and bathroom, nappy buckets, sink surfaces, draining boards and all types of wet cloths. From this, it is suggested that, although food is probably the main source by which contamination is continually introduced into the kitchen, the sink, U-tubes and surrounding areas act as reservoirs which harbour and encourage proliferation of enterobacteria. The frequent occurrence of *Esch. coli* in high numbers in sink U-tubes (38·8%) and on sink surfaces (18·7%) indicates that these organisms may be actively growing, although *Esch. coli* has often been considered as transitory outside the gut (Parker, 1971). It was established that potentially enteropathogenic *Esch. coli* strains were present in the kitchen sink areas in 16 out of the 41 homes examined.

Recent work (Palmer *et al.* 1981) suggests that salmonella organisms may be disseminated via the environment during an outbreak of food poisoning. Although published figures indicate that salmonella is the most common cause of household food poisoning incidents, we would not expect to detect many salmonellas in this survey because the sample, 250 homes, was relatively small.

The frequent contamination of dishcloths and other wet cleaning utensils with large numbers of organisms including enterobacteria suggests that these items may act not only as reservoirs but also as disseminators of contamination in the kitchen. Although these organisms are unlikely to survive long in the absence of moisture, their isolation from all parts of the kitchen on one or several occasions indicates that they remain viable for sufficient time to be transferred, for example, to food. The potential for spread of contamination by cleaning utensils and its persistence in the environment has also been recognized by other workers (Davis, Blake & Woodall, 1968; Westwood, Mitchell & Legace, 1971; De Wit, Broekhuizen & Kampelmacher, 1979).

In the bathroom and toilet, the same pattern of contamination was found. Although enteropathogenic organisms probably originate from the toilet and toilet usage, baths, basins and cleaning cloths harbour and may disseminate these organisms. Surprisingly, although enterobacteria were quite often isolated from toilets, the frequency of high counts was less than with other liquid samples (U-tubes) and wet sites. Although the importance of toilet cleaning should not be overlooked, the results suggest that toilet flushing is efficient as a disinfecting procedure.

The survey indicates, as found by Finch, Prince and Hawksworth (1976), that

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contamination with enteric organisms in the domestic toilet and bathroom was substantially less than that reported for public washrooms and toilets (Mendes & Lynch, 1976; Gerba, Wallis & Melnick, 1975) whilst *Strep. faecalis* was entirely absent. Tables 2 and 3 indicate that potentially pathogenic organisms are sometimes isolated from potential contact transfer sites in the bathroom and toilet and the isolation of enterobacteria from areas surrounding the toilet suggests the possibility of some aerosol contamination generated by toilet flushing.

Although nearly all mothers claimed to use nappy disinfecting products, high contamination levels including large numbers of enterobacteria were frequently obtained from nappy buckets. In view of this, it is disturbing that other workers have shown that about one third of mothers stand nappy buckets on kitchen surfaces and pour soak solutions down the kitchen sink (Burn, 1971).

From the results of this study it seems clear that there are sites where current hygiene practices could be improved. In particular, there are the potential reservoir sites (the U-tubes, kitchen sink, draining board, nappy bucket and toilet) and disseminator sites, including all wet cloths and wet cleaning utensils. In addition, although occurrence of pathogens at contact transfer sites such as toilet seats and handles and food contact sites is relatively less frequent, we suggest that regular decontamination is equally important; potentially pathogenic organisms, albeit in small numbers, were isolated from a total of 49% of all the food contact and 28% of all other contact sites examined in this survey. If better hygiene procedures are to be developed for the home these three groups of sites deserve especial attention. Other general sites such as floors, walls and furnishings can be adequately maintained by normal methods and dust and dirt control.

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