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The effectiveness of hygiene procedures for prevention of cross-contamination from chicken carcases in the domestic kitchen

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T.A. COGAN, S.F. BLOOMFIELD AND T.J. HUMPHREY. 1999. Thirteen sites in each of 60 domestic kitchens were examined for *Salmonella* and *Campylobacter* spp. following the preparation of a chicken for cooking and the application of different hygiene regimes. During food preparation bacteria became widely disseminated to hand and food contact surfaces. Where cleaning was carried out with detergent and hot water using a prescribed routine there was no significant decrease in the frequency of contaminated surfaces. Where hypochlorite was used in addition, a significant reduction in the number of contaminated sites was observed. The study suggests that there is a need to better understand and promote effective hygiene procedures for the domestic kitchen.

INTRODUCTION

Foodborne infection remains a significant worldwide problem. Notified infections in England and Wales exceeded 100 000 per annum in 1997 and 1998, although the actual number of infections may be as high as 9 million (Wheeler *et al*. 1999). A large proportion of such infections arise in the home (Sheard 1986). *Salmonella* spp. is found in up to 30%, and *Campylobacter* in around 90% of chickens on retail sale in England (Anonymous 1997). Fresh chicken carcasses can contain around 10^5 *Campylobacter* and lower numbers of *Salmonella* (Cason *et al*. 1997). Both bacteria are easily transferred from raw chicken to surfaces (de Boer and Hahné 1990). Studies have shown that many sites in the kitchen become contaminated when food harbouring indicator bacteria or *Salmonella* spp. is prepared (de Wit *et al*. 1979; Zhao *et al*. 1998). This may be an important source of *Salmonella* and *Campylobacter* infections in the home.

A number of studies have shown that cleaning using soap and water may not result in decontamination of environmental sites (Scott *et al*. 1984; Scott and Bloomfield 1993). Disinfectants are effective in reducing the population of micro-organisms in domestic kitchens (Josephson *et al*. 1997; Rusin *et al*. 1998), but their efficiency in preventing cross-contamination during food preparation has not been investigated. The concept of HACCP is increasingly employed to achieve cost-effective hygiene in food manufacturing and other environments. A similar approach could have benefits in home hygiene (Griffith *et al*. 1998). This investigation examined the effectiveness of domestic hygiene procedures in preventing the dissemination of *Campylobacter* and *Salmonella* spp. via contact surfaces during food preparation in the kitchen.

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MATERIALS AND METHODS

Chickens

Whole fresh chickens were obtained from retail outlets and given to participants, university students and staff, for the preparation of a meal. Chickens were not preselected on the basis of the presence of the target pathogens. A $\approx$25-g piece of neck skin was removed from each chicken and subsequently analysed for the presence of *Campylobacter* and *Salmonella* spp. (see below).

Food preparation and cleaning regimes

Sixty participants were allotted to one of three groups and were given a chicken, a dishcloth and a hand towel. Group I was asked to prepare a casserole using a specified procedure, the validity of which as typical food preparation behaviour was established from a preliminary questionaire and behavioural studies with university students. Participants were

instructed to unwrap the chicken, rinse it, place it on a chopping board and portion it. The pieces were placed in a dish and water, condiments and spices added. After meal preparation, the kitchens were sampled and the participants allowed to clean in their usual manner. Sites were resampled 3 h later, and the dishcloth and towel removed for examination.

Groups II and III participants were instructed to unwrap the chicken, rinse it and place it on the work surface. They were then asked to transfer it to the chopping board and followed the above procedure. Following this the kitchens were cleaned using a prescribed regime. This involved preparing a bowl of hand-hot water (approx. 45 °C) containing detergent (0·04% solution). The board, knife and utensils were cleaned in the bowl using the dishcloth. The cloth was rinsed in the soapy water, wrung out and used to clean the work surface, taps, sink, condiments and fridge, cupboard, oven and kitchen door handles. Participants washed their hands. Sampling of target sites then took place.

Group III participants were asked to follow the cleaning procedure prescribed for group II. After rinsing, the cloth was immersed in hypochlorite disinfectant containing 5000 p.p.m. available chlorine (Lever Brothers, Port Sunlight, UK) and wrung out. Using a trigger spray, the hypochlorite disinfectant was applied to all of the cleaned surfaces and sites which were then wiped with the disinfected cloth. A disinfectant contact time of 5 min was allowed before sampling of target sites.

Collection of samples

Sampling sites in the kitchen comprised the chopping board, work surfaces, hands, knife and the sites cleaned during directed cleaning (above). For kitchens in groups II and III, swabs were also taken from the surface on which the chicken was placed before preparation. Sites were swabbed using a cotton swab of $\approx 5 cm^2$ moistened with buffered peptone water (BPW, Oxoid, Basingstoke, UK) containing 0·05% sodium thiosulphate. The swabs were placed in a 60-ml container of this medium. Dishcloths and hand towels were collected. Hand towels from group II and III kitchens were not collected as their use was not included in the directed cleaning regime. Samples were stored at 4 °C until analysis.

Microbiological techniques used

On arrival at the laboratory 100 ml BPW was added to the chicken skin, dishcloths and hand towels and the samples macerated for 2 min in a stomacher.

For isolation of *Campylobacter*, 25 ml of the BPW used to recover organisms from swabs, cloths and chicken samples was added to 25 ml of double-strength modified Exeter *Campylobacter* broth (Humphrey *et al*. 1995) containing 0·05% sodium thiosulphate. The broth was incubated at 37 ± 0·5 °C for 4 h before addition of rifampicin and polymixin B, then incubated for a further 44 h (Mason *et al*. 1996). The broth was sub-cultured onto modified cefoperazone charcoal deoxycholate agar (CCDA-Preston, Oxoid) and plates incubated in a micro-aerobic atmosphere at 37 ± 0·5 °C for 48 h. Presumptive *Campylobacter* spp. were identified by a hippurate hydrolysis test and typical motility on microscopy and morphology in Gram-stained smears.

For isolation of *Salmonella* the remaining BPW was incubated at 37 ± 0·5 °C for 18–24 h; 100 μl of this culture was added to 10 ml Rappaport–Vassiliadis soya peptone enrichment broth (RVS, Oxoid) and incubated at 41 ± 0·5 °C for 24 h. The broth was subcultured on to xylose lysine deoxycholate agar (XLD, Oxoid) and modified brilliant green agar (mBGA, Oxoid) and the plates incubated at 37 ± 0·5 °C for 24 h. Presumptive salmonellae were confirmed by standard biochemical tests and serotyping.

Laboratory studies of the bactericidal effect of the hypochlorite disinfectant

Whole chickens were screened for *Salmonella* and *Campylobacter* spp. as above and kept at 4 °C pending results. Those positive for both organisms were unwrapped and 12 sterile 20-mm diameter stainless steel disks pressed onto the surface of each and left for 1 min. Two disks were cultured immediately to confirm transfer of *Salmonella* and *Campylobacter* spp. to the disks by contact. The remaining 10 disks were sprayed on both sides with hypochlorite spray, left for 30 s and then cultured for the above bacteria. This was repeated with hypochlorite contact times of 1, 2 and 5 min.

Statistical analysis of results

In order to examine the effect of the cleaning regimes used, the number of sites in each kitchen positive for either or both of the target organisms after cleaning was recorded and compared with the number of positive sites found before cleaning in group I kitchens. Data were statistically examined using the Wilcoxon test for correlated samples and the Mann–Whitney *U*-test for independent samples.

RESULTS AND DISCUSSION

Results are given only for kitchens in which a chicken positive for at least one of the target pathogens was prepared. A chicken positive for *Campylobacter* or *Salmonella* spp. was prepared in 20 kitchens of each group. The number of chickens that were contaminated with either or both bacteria is shown in Table 1. Sites from which either one or both were isolated were counted as 'positive'. No kitchens in which a negative chicken was prepared were positive for either

	Percentage of chickens or sites contaminated with *Salmonella* only	*Campylobacter* only	Both
Group I			
Chickens	35	35	30
Sample sites after meal preparation	10·5	14	1
Sample sites 3 h after cleaning	7·1	4	1
Group II			
Chickens	2	7	11
Sample sites	27	8	5
Group III			
Chickens	4	11	5
Sample sites	5	1	0

Table 1 Comparison of incidence of contamination of chickens and sample sites with *Salmonella* and/or *Campylobacter*. Group I kitchens sampled before and after undirected cleaning. Group II kitchens sampled after directed cleaning with soap and water, group III used additional hypochlorite spray disinfectant

bacterium. *Campylobacter* was more prevalent in the chickens but not this was not significant. *Salmonella* spp. were isolated from surfaces more frequently than *Campylobacter* spp. (Table 1), which correlates with the fact that *Salmonella* is believed to survive better on dry surfaces than *Campylobacter* (de Boer & Hahné 1990).

Transfer of *Campylobacter* and *Salmonella* to surfaces in the kitchen during the preparation of the meal occurred frequently (Fig. 1). The undirected cleaning in group I was ineffective in removing the pathogens. *Campylobacter* and/or *Salmonella* were isolated from 38/220 sites sampled (17·3%). Contamination of sites such as the door handle shows how widely bacteria from food may become disseminated. *Campylobacter* and/or *Salmonella* spp. were found in 16/20 kitchens in group I. In a small majority of kitchens (11/20) only one or two sites were found to be contaminated. In two kitchens, however, more than six sites were *Campylobacter*- or *Salmonella*-positive.

Analysis of results for group I indicated that the difference between the total number of sites contaminated before and 3 h after cleaning was not significant, despite the fact that the overall isolation rate was reduced to 9·1%. Four kitchens

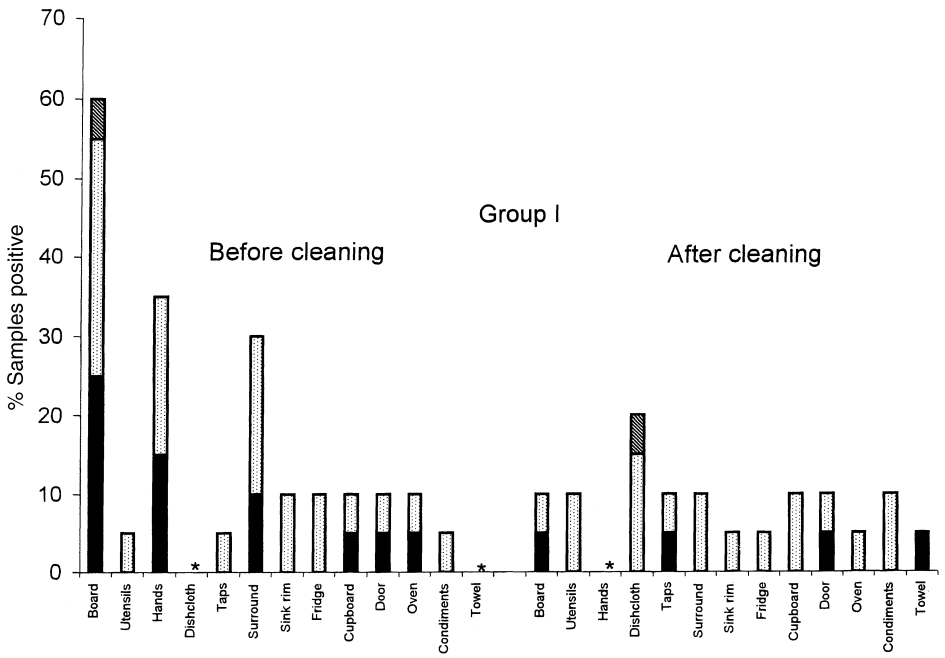

Fig. 1 Comparison of percentage of sites contaminated in group I kitchens. * Site not tested. Sites positive for ■ *Campylobacter*, ⬚ *Salmonella*, ▨ both organisms

showed an increase in the number of sites contaminated after cleaning. Fewer preparation surfaces were contaminated after cleaning but more positive samples were recovered from the taps, utensils and condiments, indicating that bacteria may have been transferred to these sites during the 'cleaning' process. However, only 25% of dishcloths were positive, possibly due to high levels of other species of bacteria on the cloth interfering with the isolation of the target pathogens.

In group II kitchens, in which directed cleaning using detergent and hot water had taken place, 40 of 260 (15·4%) sites were contaminated with either or both pathogens (Fig. 2). Statistical analysis comparing group II with group I kitchens, sampled before cleaning, indicated that the difference between the total number of sites contaminated was not significant. Fewer chopping boards were contaminated compared with group I kitchens, probably due to the fact that a rinse procedure was specified for cleaning. Sites which had been wiped with the cloth during the directed cleaning process were more frequently contaminated than the same sites sampled before cleaning in group I kitchens. The results indicate this method of cleaning was not effective in removing pathogens and that they were spread around the kitchen on the cloth. This has previously been observed where detergent and water alone are used (Scott and Bloomfield 1990; Scott and Bloomfield 1993). Contamination was found in 13/20 kitchens in group II, although in seven only one or two sites in each kitchen were contaminated. In four kitchens, however, six or more sites were positive for *Salmonella* and/or *Campylobacter* spp.

The use of hypochlorite disinfectant in addition to detergent and hot water cleaning resulted in a significant decrease in the number of positive sites compared to those found to be contaminated after the use of detergent and water alone (group II kitchens; Fig. 2). Target bacteria were isolated from one site in each of six group III kitchens (2·3%). It is likely that surfaces still contaminated after disinfection were the result of the disinfectant not reaching the bacteria due to limited application. This was supported by the *in vitro* studies where a hygienic surface (no culturable survivors) could be achieved by contact of the disks with hypochlorite solution for 30 s.

The results of this study show that, during preparation of naturally contaminated food, potential pathogens are frequently spread to hand and food contact surfaces. Food hygiene advice often advocates the use of mechanical removal with soap and water as the most appropriate and effective method for achieving surface hygiene in the domestic kitchen, but the importance of thorough rinsing as an integral part of the process is often not stressed. This study suggests the inadequacy of this procedure. Given the importance of cross-contamination as a contributory factor in outbreaks of food poisoning (Roberts 1986), these observations have important public health implications. This study suggests that the use of a thorough cleaning regime involving, where appropriate,

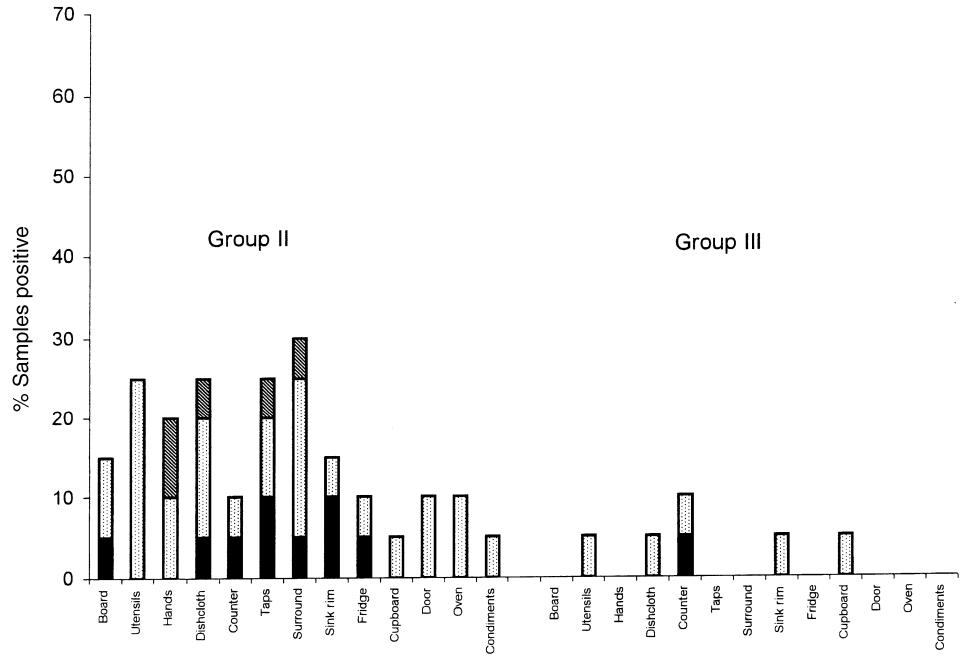

Fig. 2 Comparison of percentage of sites contaminated in group II and III kitchens. Sites positive for ■ *Campylobacter*, ⊡ *Salmonella*, ▨ both organisms

the application of an effective disinfectant to contact surfaces after food preparation could have a significant impact in reducing the potential for *Salmonella* and *Campylobacter* cross-contamination from foods in the kitchen.

The study indicates a need to better understand hygiene procedures which are likely to be effective in the domestic setting, and the educational and motivational processes needed to promote such procedures.

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REFERENCES

Anonymous (1997) PHLS evidence to the House of Commons Agriculture Select Committee Enquiry into Food Safety.

Cason, J.A., Bailey, J.S., Stern, N.J., Whittemore, A.D. and Cox, N.A. (1997) Relationship between aerobic bacteria, salmonellae and Campylobacter on broiler carcases. *Poultry Science* **76,** 1037–1041.

de Boer, E. and Hahné, M. (1990) Cross-contamination with *Campylobacter jejuni* and *Salmonella* spp. from raw chicken products during food preparation. *Journal of Food Protection* **53,** 1067–1068.

de Wit, J.C., Brockhuizen, G. and Kampelmacher, E.H. (1979) Cross-contamination during the preparation of frozen chickens in the kitchen. *Journal of Hygiene, Cambridge* **83,** 27–32.

Griffith, C., Worsfold, D. and Mitchell, R. (1998) Food preparation, risk communication and the consumer. *Food Control* **9,** 225–232.

Humphrey, T.J., Mason, M.J. and Martin, K.W. (1995) The isolation of *Campylobacter jejuni* from contaminated surfaces and its survival in diluents. *International Journal of Food Microbiology* **26,** 295–303.

Josephson, K.L., Rubino, J.R. and Pepper, I.L. (1997) Characterisation and quantification of bacterial pathogens and indicator organisms in household kitchens with and without the use of a disinfectant cleaner. *Journal of Applied Microbiology* **83,** 737–750.

Mason, M.J., Humphrey, T.J. and Martin, K.W. (1996) Isolation of sub-lethally injured campylobacters from water. In *Campylobacters, Helicobacters and Related Organisms* ed. Newell, D.G., Ketley, J.M. and Feldman, R.A. pp. 129–133. New York: Plenum Press.

Roberts, D. (1986) Factors contributing to outbreaks of food poisoning in England and Wales 1970–82. In *Proceedings of the World Congress of Foodborne Infections and Intoxications 1*, pp. 157–159. Berlin: Institute of Veterinary Medicine.

Rusin, P., Orosz-Coughlin, P. and Gerba, C.P. (1998) Reduction of faecal coliform, coliform and heterotrophic plate count bacteria in the household kitchen and bathroom by disinfection with hypochlorite cleaners. *Journal of Applied Microbiology* **85,** 819–828.

Scott, E., Bloomfield, S.F. and Barlow, C.G. (1984) Evaluation of disinfectants in the domestic environment under 'in use' conditions. *Journal of Hygiene (Cambridge)* **92,** 193–203.

Scott, E. and Bloomfield, S.F. (1990) The survival and transfer of microbial contamination via cloths, hands and utensils. *Journal of Applied Bacteriology* **68,** 271–278.

Scott, E. and 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.

Sheard, J.B. (1986) Food poisoning in England and Wales during 1983. A new title but still the same problems. *Environmental Health* **94,** 57–61.

Wheeler, J.G., Sethi, D., Cowden, J.M. *et al.* (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.

Zhao, P., Zhao, T., Doyle, M.P., Rubino, J.R. and Meng, J. (1998) Development of a model for evaluation of microbial cross-contamination in the domestic kitchen. *Journal of Food Protection* **61,** 960–963.