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A microbiological study of various food premises with an assessment of cleaning and disinfection practices

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SUMMARY

A study of cleaning and disinfection methods in a variety of types of catering premises has been carried out. The level of bacterial contamination of the hands and of equipment was related to cleaning methods and to the type of catering establishment. Wiping cloths were frequently contaminated with *Escherichia coli*, and these may be important reservoirs of bacteria for contamination of the hands of catering staff. Regular and efficient cleaning of food surfaces and equipment was found to be more important than the use of a disinfectant as part of the cleaning process. Methods for reducing the risks of cross-contamination in catering premises are discussed.

INTRODUCTION

Although in many outbreaks of food poisoning the contributing factors are unknown, transfer of bacteria to cooked food on the hands, or from raw foods, or from contaminated surfaces and equipment are among those commonly reported (Roberts, 1982). Because of practical and technical problems of tracing bacteria spread in this way, the importance of cross-contamination may be underestimated (Hobbs & Gilbert, 1978).

Pether & Gilbert (1971) demonstrated that salmonellas and *Escherichia coli* were easily transferred from a raw to a cooked food by the hands. Except in special circumstances, however, handwashing with antibacterial soaps is unnecessary, because micro-organisms which are transferred to foods in this way are readily removed by a good wash with soap and water. Problems occur if the staff forget to wash their hands when they transfer from one work area to another, or if their hands are contaminated by touching dirty surfaces or equipment. Nail brushes, which must be provided, are frequently contaminated with Gram-negative bacilli and are difficult to disinfect (Ayliffe *et al.* 1969).

Disinfectants are probably not required for cleaning food preparation surfaces (Lowbury *et al.* 1981), but, used properly, they may provide an extra margin of

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safety, and can reduce the danger of cross-contamination in high-risk areas, e.g. meat-slicing machines (Gilbert, 1970). Gilbert found that a two-step cleaning procedure using an anionic detergent and a disinfectant was more satisfactory than a single-step method using a combined detergent and disinfectant solution. As expected, cleaning with disinfectant alone was unsatisfactory. Cloths used for wiping surfaces are frequently heavily contaminated with bacteria (Davis, Blake & Woodall, 1968). Such cloths readily transfer bacteria from one surface to another (Gilbert, 1969; Babb *et al.* 1981). The risk of cross-contamination is considerably reduced by the use of paper towels (Gilbert, 1969).

Studies on hand-washing and cleaning practices have usually been performed under controlled laboratory conditions or have been restricted to a limited number of highly selected premises. In practice, catering staff, particularly in small premises, are given little or no training in personal and kitchen hygiene. The aim of this study was to investigate the bacterial contamination of the hands of catering staff and of equipment and work surfaces, and to evaluate the performance and effectiveness of cleaning in a variety of commercial kitchens.

MATERIALS AND METHODS

Sampling programme

Where possible, one environmental health officer from each of the four authorities taking part was designated as sampling officer. He was asked to sample soaps, towels, nail brushes and wiping cloths, to collect finger-rinse samples from two catering staff, and to complete a questionnaire about cleansing and disinfectant practices for each kitchen visited. For part of the survey, samples from tea towels and from cutting boards were also requested. Where possible, the brands of disinfectants and combined detergent and disinfectant preparations were recorded.

The environmental health officer from one authority (Stockton Borough Concil) was asked to determine whether staff had received some form of instruction in food hygiene. Staff who had attended an approved course of instruction were regarded as formally trained, and staff who had received some instruction in hygiene during the course of their work, but had not attended an approved course, were regarded as informally trained. In each kitchen, the officer also looked for a written cleaning plan, and for evidence that this plan was used.

Diluents

All diluents contained quarter-strength Ringer solution with 0·1 % peptone. For finger-rinse specimens Tween 80 was added to give a final concentration of 0·1 % (designated FRD). For soaps and towel swabs Tween 80 was added to give a final concentration of 1 % (designated STD). For nail brushes, cloths and cutting boards the diluent (designated BCSD) contained Tween 80 (1 %) and sodium thiosulphate (0·4 %).

Collection of specimens

Finger-rinse specimens. Whenever possible, the finger-tips of two members of staff, who had not handled raw foods, were sampled in each kitchen. The method

was a modification of that described by Pether & Gilbert (1971). The tip of each finger, including the thumb, of one hand was rubbed against the bottom of a 50 ml plastic container (Sterilin Ltd, Teddington, Middlesex) to which 5 ml of FRD had been added. Each finger was wiped on the rim to leave as much diluent in the container as possible.

Hand cleanser. Swab samples from bar soaps were collected into 10 ml of STD. For liquid soaps, about 1 ml of soap was dispensed into 10 ml of diluent.

Towels. A surface area measuring approximately 100 cm^2 was sampled with a swab previously moistened in STD. The swab-stick was broken off into 10 ml of diluent.

Nail brushes. Swab samples were collected from areas between the bristles, particularly where these emerged from the holder, and the swab sticks broken off into 10 ml of BCSD.

Cloths. Whenever possible, cloths were submitted in plastic bags. If not, an area measuring about 100 cm^2 was sampled with a swab moistened in BCSD, and the swab-stick was broken off into 10 ml of the diluent.

Cutting board. An area of approximately 100 cm^2 was sampled with a swab moistened in BCSD, and the swab-stick was broken off into 10 ml of the diluent.

After collection, samples were stored in cool boxes and transported to the Laboratory as soon as possible.

Microbiological examination

Finger-rinse specimens. One hundred microlitres of the sample were placed on to Kranep Agar (KA), Oxoid CM441, and the cultures incubated for 72 h at 37 °C. Colonies which were surrounded by an opalescent zone, and which gave a positive tube coagulase test with human plasma, were regarded as *Staphylococcus aureus*. After adding about 25 ml of quarter-strength Ringer solution, the remainder of the finger-rinse fluid was filtered through a 0·22 μm pore-size membrane. The membrane was cut in half, and one half was placed on MacConkey Agar No. 2 (MA), Oxoid CM109, and the other half was added to selenite broth. After overnight incubation at 37 °C, colonies on MA which resembled coliform bacilli, which produced indole from tryptophan at 44 °C, and which formed acid and gas in brilliant green bile broth (Oxoid CM31) at 44 °C were identified as *E. coli* type I. The colonial appearance on MA and the ability to hydrolyse aesculin were used to demonstrate colonies of *Streptococcus faecalis*. The selenite broth was incubated overnight at 37 °C, and a 2 μl loopful of the culture was spread onto Desoxycholate Citrate Agar (DCA), Oxoid CM35. After overnight incubation at 37 °C the plate was examined for potential salmonella colonies.

Swab and liquid-soap samples. An equal volume of double-strength nutrient broth No 2 (Oxoid CM67) containing 10% (v/v) horse serum (Wellcome number 3) was added to each sample. The samples were incubated overnight at 37 °C, and then a 2 μl loopful of the broth was inoculated on to KA, MA and DCA. KA was incubated for 72 h at 37 °C, MA at 44 °C overnight, and DCA was incubated at 37 °C overnight. Suspect colonies of *S. aureus*, *E. coli*, *Str. faecalis* and salmonellas were recognized as previously described.

Cloths. Twenty millilitres of quarter-strength Ringer solution were added to the plastic bag containing the cloth, and the contents were mixed thoroughly. Ten

millilitres of the fluid were poured off into a sterile universal bottle and an equal volume of double-strength nutrient broth containing 10% horse serum was added. Methods for the isolation and identification of *S. aureus*, *E. coli* type I, *Str. faecalis* and salmonellas were as described previously.

RESULTS

Although 239 kitchens were visited, occasional samples from some items of equipment were not received, and the results from some specimens could not be analysed because the relevant part of the questionnaire had not been completed. For the purposes of this study the premises were divided into four groups: group A contained 72 premises and consisted of 49 kitchens in schools and 23 in hospital and social services premises, group B consisted of 41 staff canteens, group C consisted of 54 kitchens in cafés, and group D contained 72 premises and consisted of 57 kitchens in restaurants and 15 in hotels.

Str. faecalis and salmonellas were not isolated from the finger-tip samples. The detection of *E. coli* and *S. aureus* on finger-tips is shown in Fig. 1. The numbers of *E. coli* ranged from 6 to 1000 cfu per finger-rinse sample (mean count 230 cfu per sample), and for *S. aureus* the counts ranged from 50 (the minimum number detectable by the method) to 1500 (mean count 226 cfu per sample).

Soap samples were not received from eight premises. Bar soap was provided for hand washing in 78% (181/231) of the kitchens. No salmonellas were isolated, but four samples grew *E. coli*, one grew *S. aureus*, and one grew *Str. faecalis*. Liquid and bactericidal soaps were used in 32 (14%) and 18 (8%) of the premises respectively. None of these samples grew *E. coli*, *S. aureus*, *Str. faecalis* or salmonellas.

Disposable paper was provided for drying hands in all the school and hospital kitchens. Communal towels were used for hand drying in 64% of cafés (33/52) and in 58% of restaurants (33/57). Hot-air driers were provided in 7 of the premises, and 19 premises, 10 of them in staff canteens, used a continuous roller-towel system. Information about hand-drying procedures was not obtained from four kitchens. Five swab samples from communal towels grew *E. coli* (5/85, 6%) and one sample grew *Str. faecalis*.

Nineteen (9%) of the premises did not provide nail brushes for staff during hand washing. Twenty-seven premises were excluded because either the cleansing method for nail brushes was not stated or no swab was received. Of the 193 nail brushes sampled, 108 (56%) had wooden handles and 85 brushes (44%) were of nylon. Wooden brushes were provided in most school kitchens (42/49), and most cafés and restaurants provided nylon brushes (30/45 and 32/46 of these premises respectively). No salmonellas were isolated from nail brushes. Fig. 1 shows the percentage isolations of *E. coli*, *S. aureus* and *Str. faecalis* from nail brushes. Nine per cent of wood brushes (10/108) and 15% of nylon brushes (13/85) were contaminated with one or more of these microorganisms.

Table 1 compares the isolation of *E. coli*, *S. aureus* and *Str. faecalis* with the cleaning method for nail brushes. None of the brushes was stored in disinfectant solutions. Although it was claimed in some premises that nail brushes were cleaned daily, most brushes were obviously cleaned less often. Generally, untreated brushes

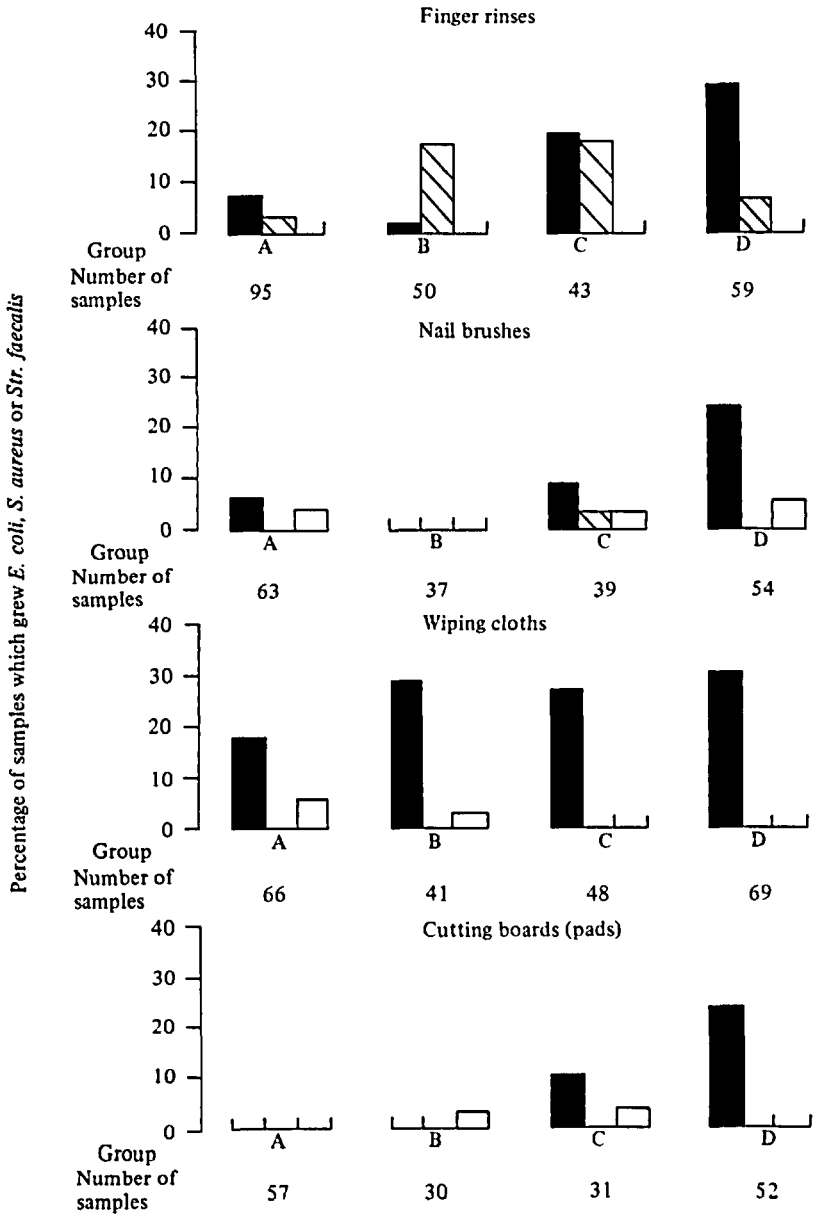

Fig. 1. Isolation of *E. coli* (■), *S. aureus* (▨) and *Str. faecalis* (□) from finger rinses, nail brushes, wiping cloths and cutting boards or pads from kitchens in schools, hospitals or social services premises (group A), in staff canteens (group B), in cafés (group C) and in restaurants and hotels (group D).

and those rinsed in water after use were more often contaminated than brushes cleaned by other methods. Disinfection by boiling or by rinsing in detergent and soaking in disinfectant solution overnight were the most effective methods of cleaning. Hypochlorites were almost always chosen for chemical disinfection of nail brushes (Table 2). A pine fluid was used for this purpose in one of the staff canteens.

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Table 1. *Comparison of cleaning methods for nail brushes with the isolation of* E. coli, S. aureus, *and* Str. faecalis

Method	No. positive*/ no. in group† using method				No. positive (% of total using method)
	A	B	C	D	
None	0/12	0/9	1/11	7/15	8 (17)
Rinse in hot water	0/5	0/6	1/2	3/5	4 (22)
Wash in detergent	3/25	0/16	2/12	4/21	9 (12)
Boiling	1/13	0/1	0/10	0/5	1 (3)
Soak in disinfectant	0/3	0/3	1/1	0/5	1 (8)
Wash in detergent then soak in disinfectant	0/4	0/2	0/3	0/4	0

* Indicates that *E. coli*, *S. aureus*, or *Str. faecalis* was present.

† Group A consisted of school, hospital and social services kitchens, group B consisted of staff canteens, group C consisted of kitchens in cafes, and group D consisted of kitchens in restaurants and hotels.

Table 2. *Types of chemical disinfectants used for cleaning nail brushes, wiping cloths, cutting boards (pads) and work surfaces*

Type	Group*	Area of use			
		Nail brush	Cloth	Cutting board	Work surface
Hypochlorites	A	7	27	11	22
	B	4	17	5	10
	C	4	14	11	10
	D	9	20	8	17
Pine fluids	A	0	0	0	0
	B	1	1	0	1
	C	0	3	0	1
	D	0	4	0	1
QAC's†	A	0	0	1	1
	B	0	0	0	0
	C	0	1	0	0
	D	0	2	3	2
Not stated	A	0	0	0	0
	B	0	2	0	0
	C	0	1	0	0
	D	0	0	0	0

* A–D are groups of premises (see Table 1).

† QAC's = Quaternary ammonium compounds.

Information about drying crockery and utensils was obtained from 160 premises. Tea towels were not provided in 24 % of the kitchens (38/160). In these, 24 of which were school or hospital kitchens, crockery was air-dried in racks or dried by hand using paper towels. Of the 122 tea towels sampled, three grew *E. coli*, two grew *S. aureus* and three grew *Str. faecalis*.

Information about the use of wiping cloths was obtained from 234 premises. In

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Table 3. *Comparison of cleaning methods for wiping cloths with the isolation of* E. coli, S. aureus *and* Str. faecalis

Method	No. positive*/ no. in group† using method				No. positive (% of total using method)
	A	B	C	D	
None	0/0	1/1	0/0	1/1	2 (100)
Wash in detergent	3/10	5/12	3/18	9/32	20 (28)
Boiling	6/29	2/7	5/11	3/8	16 (29)
Soak in disinfectant	1/6	2/9	3/11	3/12	9 (24)
Wash in detergent then soak in disinfectant	4/21	0/8	2/7	3/12	9 (19)
Soak in combined agent	0/0	1/3	0/1	0/2	1 (17)
Laundered	0/0	0/1	0/0	1/2	1 (33)

* Indicates that *E. coli*, *S. aureus* or *Str. faecalis* was isolated.
† A–D are groups of premises (see Table 1).

96 % of these, cleaning agents for food surfaces were applied with reusable cloths. Only 24 % of premises provided separate cloths for cleaning surfaces used for raw or cooked foods. Although no salmonellas nor *S. aureus* were detected on cloths, and *Str. faecalis* was isolated infrequently, a significant number of samples grew *E. coli* for each of the four groups of premises (see Fig. 1). All cloths were cleaned daily, but none of the methods appeared to be satisfactory (Table 3), because the cloths were recontaminated during use each day. Hypochlorites were generally used for chemical disinfection of cloths, but pine fluids were provided for this purpose in eight of the kitchens (Table 2).

Swab samples and information about cleaning methods for cutting boards were obtained from 170 premises. Wooden cutting boards were used in 87 premises (51 %), synthetic cutting pads (made of either hard rubber or polypropylene) were used in 53 premises (31 %), and formica-covered boards were used for cutting up foods in 30 premises (18 %). Separate boards or pads were provided for cutting up raw and cooked foods in 90 % of the kitchens. In 16 premises separate cutting surfaces were not provided, and foods were cut up on formica or stainless-steel work surfaces. Swab samples from some cutting boards or pads in cafés (Group C) and in restaurants and hotels (Group D) grew *E. coli* or *Str. faecalis* (see Fig. 1). Of 15 isolates, eight were from wooden boards, five were from synthetic pads, and two were from formica boards.

Table 4 compares the isolation of *E. coli*, and *Str. faecalis* with the methods of cleaning cutting boards or pads. The types of chemical disinfectant used for cleaning boards are shown in Table 2. Boards which were cleaned 'as required' were more often contaminated with *E. coli* or *Str. faecalis* (11/45, 24 %) than those cleaned after each use (2/72, 3 %).

Except for cafés, separate surfaces were almost always used for the preparation of raw and cooked foods. Work surfaces in 33 % of cafés, however, were used for more than one purpose. Although in most premises cloths were provided for cleaning work surfaces, in 13 % of staff canteens disposable paper was used. Information about the methods which were used for cleaning work surfaces was

Table 4. *Comparison of cleaning methods for cutting boards or pads with the isolation of* E. coli *and* Str. faecalis

Method	No. positive*/ no. in group† using method				No. positive (% of total using method)
	A	B	C	D	
Scrub with detergent‡	0/45	1/26	4/29	9/41	14 (10)
Scrub with disinfectant	0/7	0/1	0/2	0/5	0
Scrub with detergent then disinfectant	0/4	0/2	0/0	0/4	0
Scrub with combined agent	0/1	0/1	0/0	1/2	1 (25)

* Indicates that *E. coli* or *Str. faecalis* was isolated.
† A–D are groups of premises (see Table 1).
‡ One polypropylene pad was put into a dishwasher.

Table 5. *Cleaning agents used for food preparation surfaces in the four groups of premises*

Method	Group* of establishment				Total using method (%)
	A	B	C	D	
Water	1	0	0	2	3 (1)
Detergent	47	30	43	50	170 (72)
Disinfectant	2	0	4	7	13 (5)
Detergent then disinfectant	19	8	5	10	42 (18)
Combined agent	2	3	2	3	10 (4)

* A–D are groups of premises (see Table 1).

Table 6. *Availability of staff training and written cleaning plans in* 116 *retail food premises*

Establishment		Staff training			Cleaning plan	
Group*	Number	Formal	Informal	None	Available	Not available
A	43	29 (68)†	12 (28)	2 (3)	24 (56)	19 (44)
B	22	4 (18)	7 (32)	11 (50)	4 (18)	18 (82)
C	23	5 (22)	6 (26)	12 (52)	2 (9)	21 (91)
D	28	3 (10)	13 (46)	12 (43)	4 (14)	24 (86)
Totals	116	41 (35)	38 (33)	37 (32)	34 (29)	82 (71)

* A–D are groups of premises (see Table 1).
† Figures in parentheses are percentages.

obtained from 238 premises and is shown in Table 5. Hypochlorites were usually provided for the chemical disinfection of surfaces, but in three premises pine fluids were reported to be used for this purpose.

Table 6 shows the availability of staff training and of written cleansing plans in 116 kitchens. Only those in schools and hospitals provided formal training in food hygiene for the majority of their staff. Overall 29% of kitchens, mostly in schools, used written cleaning plans.

DISCUSSION

The approach used here was probably a valid one in relation to the risks of cross-contamination and transmission of infection in catering premises. *E. coli*, *S. aureus* and *Str. faecalis* were sought because the transfer of these micro-organisms to cooked foods correlates well with poor practices in kitchen hygiene. The finger-rinse method was chosen because it is likely to detect those bacteria which are transferred to foods during handling. Soap, nail brushes, drying towels, cloths and cutting surfaces were sampled because these come into contact either with cooked foods or with the hands and are therefore significant contamination hazards.

The present study suggests that small numbers of potential pathogens are likely to be transferred by hands to foods. By itself, such cross-contamination is not dangerous, but becomes so when it is combined with the multiplication of these micro-organisms during inadequate storage of cooked foods, in which the numbers of competing bacteria have been reduced by the cooking process.

As well as micro-organisms from the bowel and from raw foods, the results described here suggest that the hands of food handlers may sometimes be contaminated with intestinal pathogens from wiping cloths and from nail brushes. Experience in hospitals has shown that nail brushes are frequently contaminated with Gram-negative bacilli, and that their general use in wards should be avoided. We suggest that nail brushes should only be used if the hands are heavily soiled, and that frequent use, which can damage the skin, should be avoided. After use, brushes should be disinfected and stored in the dry state.

There is little doubt that bacterial contamination is frequently transferred by cloths from one surface to another. Daily disinfection of cloths is not sufficient, but more frequent changes of cloth or their disinfection after each use is unlikely to be performed by the staff, unless rigidly supervised. North (1980) recommended wiping cloths which contained disinfectants bonded to the fabric, but preliminary trials with these have been disappointing (Babb *et al.* 1981). There is a good case for prohibiting the use of reusable cloths and providing paper for cleaning food surfaces and equipment.

This study suggests that the frequency and efficiency of cleansing of equipment and work surfaces are more important than the use of a disinfectant as part of the cleaning process. Although disinfectants can provide an extra margin of safety, their uncontrolled use can lead to a false sense of security. In general, it was found that instruction and supervision of staff in the use of disinfectants was inadequate, and many staff did not know whether the cleaning agent that they used contained a disinfectant or not. Hypochlorites were usually chosen, but in some premises pine

fluids, which are unsatisfactory because of their poor disinfectant activity and strong smell, were used. The use of combined detergent and disinfectant preparations was generally restricted to kitchens and hotels which were part of large organizations. Although these agents provide a convenient single-step procedure for cleaning surfaces, their performance, particularly of those containing quaternary ammonium compounds, and their cost-effectiveness, needs careful evaluation.

The risk of cross-contamination appears to be greater in kitchens in cafés, restaurants and hotels than in kitchens in schools, hospitals and staff canteens. One reason for this might be the different work schedules in these types of premises. The frequent handling of raw and cooked foods by staff in cafés and restaurants, particularly in those which employ a small number of staff, could increase the risk of cross-contamination, whereas the large-scale preparation of meals in schools, hospitals or in canteens can be better controlled, such that transfer of bacteria from one product to another may be less likely in these premises. The formal training given to many staff employed in school and hospital kitchens may also be important in reducing the risk of cross-contamination.

As most of the deficiencies described here have been well documented, it is disappointing to have found that they continue to exist in commercial kitchens. It is concluded that the present legislation on food hygiene is inadequate and should be revised. A requirement that all food handlers employed in the catering industry should attend a course in food hygiene, such as those organized by the Institution of Environmental Health Officers, and the introduction of a code of practice for handwashing and for cleaning schedules in kitchens could significantly reduce the number of food-poisoning outbreaks associated with catering premises.

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