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Comparative study of visual inspections and microbiological sampling in premises manufacturing and selling high-risk foods

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SUMMARY

The possible relationship between the results of a microbiological sampling programme and visual inspections carried out in local food-manufacturing premises was examined. Using five main parameters – overall appearance, personal hygiene, risk of contamination, temperature control, and training and education – a visual inspection rating score was established for each of the premises. A variety of high-risk processed foods, and specimens from hands, wiping cloths and environmental swabs were examined. The results from two study periods indicated that there was an overall poor agreement between microbiological results and inspection ratings. On its own, neither sampling nor visual assessment reliably monitored the performance of the premises. A combined approach, using selective microbiological examination to support a system of standardized inspections, is suggested for monitoring food hygiene standards in premises selling high-risk foods.

INTRODUCTION

It is generally accepted that inspections of food premises should concentrate on specific aspects of hygiene and good temperature control as well as on the structure of the premises. Priority should be given to manufacturers or retailers of high-risk foods, and as far as possible inspections should be standardized. Roberts introduced a points system for quantifying risks in food premises (1). Each was visited by prior arrangement with the proprietor, and assessed according to its overall suitability, working practices, cleaning procedures and staff training. Based on information from several visits a risk factor was established, which was intended to identify the appropriate level of surveillance needed for that establishment.

Although random food sampling in food premises does little to safeguard public health, the value of microbiology as part of a hygiene assessment programme has not been fully investigated. Total viable counts have been frequently chosen to indicate microbial quality, but specific marker organisms, in particular *Escherichia coli*, have also been recommended (2). Whatever indicator bacteria are chosen, an

intensive sampling programme is required to provide sufficient data for a reliable assessment to be made.

Attempts to correlate the results of microbiological sampling with those obtained from visual inspections have not been successful. Bassett, Kurtz & Moore found no clear relationship between bacterial counts at 37 °C and overall hygienic assessments in ten shops selling sliced cooked meats (3). Wyatt & Guy studied raw meats obtained from selected supermarkets, and found no significant correlation between microbiological results and hygiene profiles (4).

In this paper we have combined microbiological monitoring with visual inspection reports, and used this system to assess the performance of local food manufacturers during two sampling periods. The relationship between microbiological results and visual inspections has been studied and the potential role of these methods to predict hygiene practices has been examined.

MATERIALS AND METHODS

Premises and inspection programme

All major producers who were in the catchment area of one local authority, and who sold either cooked meats or real-cream and artificial dairy cakes were studied. Baked pies, which were produced in many of the premises, were also examined. The survey was divided into two sections. The first part was carried out between April and October 1986, and the second part between June and September 1987. During the study each of the premises was inspected four times. The inspections were carried out by three environmental health officers, with each officer being allocated eight premises. For this study a standardized inspection rating report was developed, which assessed facilities and practices under five main headings.

(i) *Overall appearance*. The suitability and cleanliness of the premises were noted. Particular attention was given to the build-up of grease and food debris on surfaces and equipment. Poor design features and any damage which might hinder cleaning were recorded.

(ii) *Personal hygiene*. The appearance of hands and nails, and the presence of jewellery were noted. The officer checked whether or not any cut or abrasion was covered by an appropriate dressing. The facilities for hand washing, in particular the appearance and accessibility of wash-hand basins, the presence of suitable soap and a nail brush, a satisfactory water supply, the hand-drying method, and the frequency of hand washing were assessed. The suitability and cleanliness of protective clothing, and the frequency with which it was changed were noted.

(iii) *Risk of contamination*. The separation of raw and cooked foods was checked in storage, preparation and retail areas. Where equipment or a surface was used for both raw and cooked foods, the officer estimated the increased risk of cross-contamination. Food-handling practices were checked, and those likely to increase the risk of contamination were noted. Particular attention was given to staff working with both raw and cooked foods.

(iv) *Temperature control*. The suitability and capacity of refrigerators and chilled display units were assessed. Using a digital thermometer the surface temperature of refrigerated food was measured. After each use of the thermometer was disinfected with an alcohol-impregnated wipe. The officer tried to determine

whether foods which should have been refrigerated were left for excessive periods at room temperature, for example meat left on food-slicing machines.

(v) *Training and food hygiene knowledge*. The officer determined whether or not staff had received any instruction in food hygiene, and if so, how long ago this training occurred. Staff who had attended an approved course of instruction were regarded as formally trained, and those who had received some instruction in food hygiene during the course of their work were considered to be informally trained. A basic set of questions on food hygiene was devised to help assess the working knowledge of catering staff.

After each series of inspections a formal meeting was arranged to analyse the reports. A points scoring system was developed and eventually each establishment was given an inspection rating score on a scale of 1 (very good) through to 5 (very poor) for each of the five main inspection headings.

Collection of specimens

Sliced cooked meats (beef, ham, pork, pressed tongue and turkey), processed meats (black pudding, brawn, corned beef, faggot, ham sausage, meat loaf, meat paste, polony and saveloy), baked pies (fresh-egg custard, meat pies, pasties, pork pie and sausage roll), real-cream products and artificial-dairy foods (mostly vanilla slices) were studied. Six food products were chosen from each retail outlet, and these were studied throughout the study period.

Environmental sampling was carried out in premises before production was started for that day. With one exception the premises had been cleaned at the end of the previous working day. In one bakery routine cleaning was carried out after the first production batch for that day had been completed. Finger-rinse specimens, cloths and swabs samples from surfaces and items of equipment were collected as previously described (5). A solution containing 0·4% sodium thiosulphate was added to cloths, which were stored in hypochlorite solution between use. Sometimes swab samples from different areas and equipment were combined before microbiological examination.

After collection samples were kept in cool-boxes, and transported to the laboratory as soon as possible.

Microbiological examination of specimens

At least 10 g of food sample was weighed, sufficient diluent (Minimal Recovery Diluent, Oxoid) added to form a 1/10 dilution, and the sample homogenized using a Colworth Stomacher 400. For total viable counts decimal dilutions were prepared, and 25 μl of each dilution were spread on to CLED agar. Cultures were incubated for 48 h at 30 °C. One millilitre of the food suspension was inoculated on to MacConkey agar (MA), Kranep agar (KA) and, during part of the study, on to kanamycin–blood agar (KBA). MA was incubated at 37 °C overnight, KA for 72 h at 37 °C, and KBA was incubated anaerobically at 37 °C for 48 h. Ten millilitres of the food suspension was also added to an equal volume of double-strength MacConkey broth. This was incubated overnight at 37 °C, and if acid and gas had been produced, a loopful of the culture was spread on to MA. Suspect colonies of *Escherichia coli*, *Streptococcus faecalis*, *Staphylococcus aureus* and *Clostridium perfringens* were identified as previously described (5).

A few sterile glass beads were added to each swab sample. The samples were agitated on a vortex mixer, and left for about 10 min before examination. Unless added at the time of collection, 20 ml of Ringer solution were added to the plastic bag containing the cloth and the contents mixed thoroughly. The fluids from the swab and cloth samples were collected, and total viable counts and examination for *E. coli*, *S. faecalis*, *Staph. aureus* and *Cl. perfringens* were performed as previously described.

About 25 ml of Ringer solution were added to each finger-rinse specimen, and the sample filtered through a 0·22 μm pore-size membrane. Each membrane was cut in half, and one half was placed face up on MA, the other half face down on to KA. After 30 min the membrane on the KA plate was discarded. Cultures were incubated and examined for *E. coli* and *Staph. aureus*.

Microbial contamination was scored as follows. For *E. coli*, *Staph. aureus* and *S. faecalis*, less than 10 colony forming units (cfu) per g of food or per environmental sample was scored as 1, between 10 and 100 cfu as 2, more than 100 but less than 1000 cfu as 3, and greater than 1000 cfu as 4. For *Staph. aureus* the minimum number of organisms that could be detected by the method was 10. For total viable counts, between 10^4 and 10^5 cfu/g was scored as 1, up to 10^6 cfu/g as 2, up to 10^7 cfu/g as 3, and more than 10^7 cfu/g as 4. For each food the total score for each indicator organism or for the total count was divided by the number of samples examined to obtain a value (index score) which took into account the level of microbial contamination.

Statistical analysis

Pearson's Coefficient of Correlation was used to compare each visual assessment score with that obtained for the total viable count or the presence of *E. coli*, *Staph. aureus* or *Str. faecalis*. This coefficient was chosen because it is an accepted method for determining the relationship between two variables where the sample size is similar to that used here.

RESULTS

Twenty-one local food manufacturers and three market stalls each of which was supplied by one of the producers were studied. Sliced cooked meats and/or processed meats were sold in 14 premises, 9 premises sold real-cream and/or artificial dairy cakes, and 19 produced baked pies. Insufficient results were obtained for analysis from two premises which stopped production of cooked meats early in the survey.

Visual inspections

For the purpose of this study a visual assessment score of 3 was considered to be the minimum standard for any of the inspection parameters. A grading score of 4 or 5 was followed up, with grade 5 scores receiving immediate attention.

(i) *Overall appearance*. Of 88 assessments 9 were scored as grade 4 and 1 as grade 5. During the first part of the survey, three premises consistently had unsatisfactory results. Two of these (one of which scored a grade 5 on the third visit) had clear evidence of a lack of routine cleaning. During the second part of the study, none of the premises scored higher than grade 3.

Table 1. *Relationship between the type of training received and the level of food hygiene knowledge*

	Food hygiene knowledge					
	Number in grade*					
Type of training	1	2	3	4	5	Mean score†
Formal within last 5 years	6	1	0	0	0	1·14
Formal more than 5 years ago	1	0	1	2	0	3·00
Informal during course of work	2	3	8	5	1	3·00
None	3	8	10	7	1	2·82

* The replies to questions on food hygiene were graded 1 (very good) through to 5 (very poor).
† The sum of the scores from the grades divided by the number of people questioned.

(ii) *Personal hygiene*. Facilities for hand washing were considered to be unsatisfactory in nine premises. In these, common faults were dirty wash-hand basins, the use of basins for cleaning equipment, and poor accessibility, particularly in serving areas. In some premises a bucket containing a detergent solution was provided for rinsing hands where wash-hand basins were not readily accessible. One manufacturer provided disposable alcohol-impregnated wipes for hand disinfection in the shop area. After washing, hands were dried on communal towels in 7 premises, and paper or a hot-air drier was provided in 15 premises.

Eighty-eight inspections of personal hygiene practices were made, and of these 20 were assessed as grade 4. We found that staff frequently wiped their hands on aprons or cloths whilst serving foods, and that in some premises staff touched cooked meats with their hands, in particular bulk meats before and after slicing.

(iii) *Risk of contamination*. Seventeen per cent of assessments were grade 4 (15/88). Poor separation of raw and cooked foods, particularly in storage areas, was found in five premises. The risk of bacteria being transferred by hands to cooked foods was increased in four premises. This risk was greater in congested premises, particularly where space for work surfaces was limited, and where staff frequently transferred from one work area to another.

(iv) *Temperature control*. Overall 11 of 88 assessments were scored as grade 4. Inadequate temperature control was more likely to occur in bakeries than in premises selling cooked meats. 'Walk-in' chillers (mean air temperature 2·1 °C) were provided for overnight storage of meats in all premises preparing and selling cooked meats. With one exception, chilled display cabinets were provided for cooked meats offered for sale (mean temperature of meat surface 4·3 °C). One shop had no refrigerated display unit, and meats were kept on a marble surface (mean temperature of meat surface 11·9 °C). Although all nine bakeries had refrigerated display units, it was a common practice to refrigerate cream cakes only during the warmer months of the year. Shop temperatures as high 17 °C were recorded at times when cakes were not refrigerated.

(v) *Training and food hygiene knowledge*. Table 1 compares the type of training received, if any, with basic food hygiene knowledge. Recent formal training was associated with a satisfactory theoretical knowledge of food hygiene. However, staff who had received some training during the course of their work were no

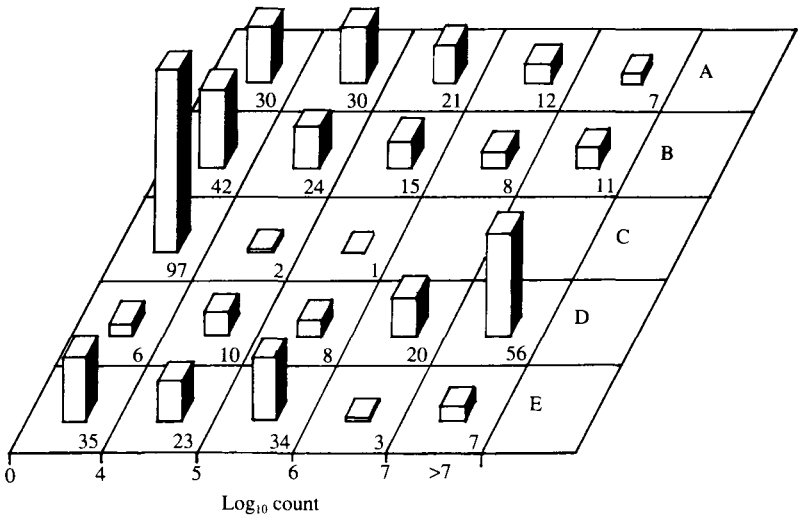

Fig. 1. Distribution of total viable counts for 167 sliced meats (A), 178 processed meats (B), 211 baked pies (C), 80 real-cream cakes (D), and 54 artificial dairy products (E). The number in each square is the percentage of organisms detected in each count range.

better informed about hygiene practices than those who had received no training whatsoever.

Cleaning and disinfection methods

Only one of the premises had a planned cleaning programme. Re-usable wiping cloths were always used, and none of the premises provided separate cloths for cleaning raw and cooked food areas. In eight premises cloths were returned to a dilute hypochlorite solution after each use. All cloths were disinfected daily by soaking in a hypochlorite solution. Food contact surfaces were cleaned with a detergent solution in 12 premises, a hypochlorite solution was used in 5 premises, and a combined detergent and hypochlorite solution was provided in 5 premises.

Microbiological results

Total viable counts were performed on 690 food samples (Fig. 1). High counts were particularly associated with real-cream products, and 76% of samples (61/80) contained greater than 10^6 cfu/g.

Table 2 shows the isolation of *E. coli*, *Staph. aureus* and *S. faecalis* from food samples. *E. coli*, but not *Staph. aureus*, was isolated more often from foods sampled during the warmer months. Although there was no overall correlation between a high total count and the isolation of *E. coli*, *Staph. aureus* or *S. faecalis*, the presence of *E. coli* in sliced meats was strongly associated with high counts ($P < 0{\cdot}01$). *Clostridium perfringens* was isolated from only 1 of 475 food samples.

Table 3 shows the variation in the isolation of *E. coli* from foods obtained from different producers. Large variations were particularly associated with sliced meats. Of 27 samples obtained from producer E, one contained *E. coli* with the count being less than 10/g (index score 0·04), whereas 22 samples from producer

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Table 2. *Frequency of isolation of* E. coli, Staph. aureus *and* S. faecalis *from retail foods*

	% positive								
	E. coli			*Staph. aureus*			*S. faecalis*		
Food type	/g	> 10/g	Samples	⩽ 100/g*	> 100/g	Samples	/g	> 10/g	Samples
Sliced meat	43·4	19·1	251	8·4	0·8	251	10·2	6·0	167
Processed meat	24·1	6·3	316	5·3	1·3	303	9·6	6·2	178
Pies	2·0	0·8	646	2·6	0·2	646	1·4	0·9	214
Real-cream cakes	41·0	13·4	134	6·6	0·7	136	18·8	8·8	86
Artificial dairy foods	51·5	25·7	101	7·1	2·7	113	7·5	5·6	54

* The minimum number of organisms detected by the method was 10 cfu/g.

Table 3. *Contamination with* E. coli *of foods obtained from different premises*

	Meat products				Dairy products			
	Cooked meats		Processed meats		Real-cream		Artificial dairy	
Rank order	Code*	Index† score	Code	Index score	Code	Index score	Code	Index score
1	E	0·04	B	0·09	N	0·14	X	0·50
2	C	0·21	C	0·22	T	0·43	P	0·57
3	B	0·45	H	0·25	P	0·64	S	0·57
4	F	0·47	D	0·27	X	0·67	Q	0·82
5	A	0·50	A	0·28	U	0·75	V	1·29
6	J	0·50	J	0·34	S	0·76	T	1·43
7	D	0·65	L	0·36	Q	0·81	U	1·43
8	H	0·68	M	0·50	R	0·86	R	2·15
9	G	1·16	G	0·74	V	1·23		
10	L	1·23	K	0·81				
11	M	1·53						
12	K	1·93						

* The letters indicate the premises from which foods were obtained. Premises A–M sold meat products and N–X dairy foods. Two of the original premises were excluded because they stopped manufacturing all or some of the foods sampled, and another sold only baked pies.

† See Methods for calculation of index scores.

K were contaminated with *E. coli* and 12 of them contained more than 100/g (index score 1·93).

Sixteen per cent of finger-rinse specimens (22/136) contained *E. coli*, and 27% (37/136) contained *Staph. aureus*. None of the staff from whom a sample was collected had touched raw foods without washing their hands, and all were about to start work in cooked food preparation areas. The upper counting limit was 200 cfu/sample, and 9% of specimens which grew *E. coli*, and 15% of specimens from which *Staph. aureus* was recovered exceeded this limit.

Fig. 2 shows the isolation of *E. coli* and *Staph. aureus*, and the total viable counts obtained from cleaned wiping cloths. *E. coli* was isolated from 24 cloths (31%), and of these 10 (13%) contained more than 10^3 cfu. Eight cloths were examined for *Cl. perfringens* and one was positive. At the time of sampling, seven

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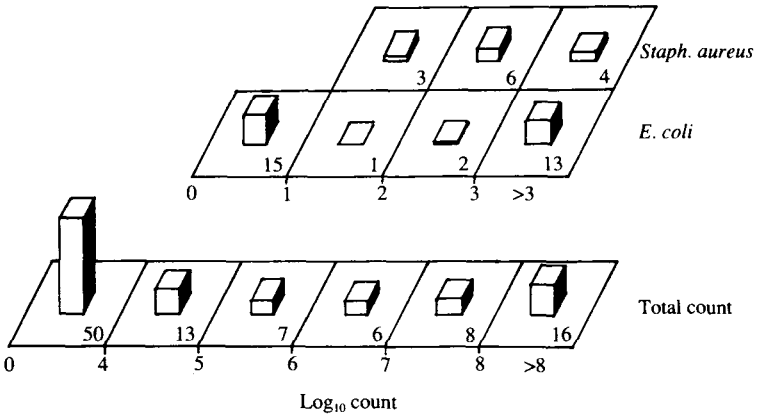

Fig. 2. Detection of *E. coli* and *Staph. aureus* and the distribution of total viable counts for 78 cleaned wiping-cloth samples. The number in each square is the percentage of organisms detected in each count range.

of the cloths which grew *E. coli* were immersed in a solution supposedly containing hypochorite.

Overall 18% (32/181) of the swab samples contained either *E. coli* or *Staph. aureus*. Generally the numbers of organisms that were recovered from swab samples were low, and only eight samples contained more than 100 cfu. Of 39 blades of food-slicing machines sampled, four grew *E. coli*, and *Staph. aureus* was isolated from two blades. Two swab samples collected from chopping boards grew *Cl. perfringens*.

Comparison of visual assessments and microbiological results

In most cases inspection rating scores were not significantly associated with the results of the microbiological examination of foods (74/80 comparisons; Table 4). In six cases the comparisons were considered to be probably significant ($P < 0{\cdot}05$). The isolation of *Staph. aureus* from real-cream and from artificial dairy products was significantly associated with an increased risk of contamination and with poor personal hygiene practices ($P < 0{\cdot}05$ for all four comparisons).

Comparison of the results obtained during the two sampling periods (see Methods) underlined the relatively poor correlation between visual and microbiological results. Only 7 of 20 premises showed similar changes in both parameters during the two periods. Furthermore, of three premises which achieved better inspection ratings during the second period, none showed any improvement in the corresponding microbiological results.

When the results from finger rinses, wiping cloths and swab samples were compared with inspection ratings, the isolation of *E. coli* from wiping cloths in premises selling raw and cooked meats was significantly associated with an increased risk of contamination ($P < 0{\cdot}01$). When the results from hands, cloths and swabs were combined, and were compared with the type of training received and the food hygiene knowledge of staff, the result was probably significant ($P < 0{\cdot}05$).

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Table 4. *Statistical* comparison of visual assessment scores with the microbiological results obtained from the different food types*

Visual inspection heading	Type of food: Sliced meat ($n = 12$) TVC†	Ec	Sa	Sf	Processed meat ($n = 10$) TVC	Ec	Sa	Sf	Real-cream cake ($n = 9$) TVC	Ec	Sa	Sf	Artificial dairy product ($n = 8$) TVC	Ec	Sa	Sf
Overall appearance	–	–	–	+ ($r = 0{\cdot}54$) ($P < 0{\cdot}05$)	–	–	–	–	–	–	–	–	–	–	–	+ ($r = 0{\cdot}66$) ($P < 0{\cdot}05$)
Personal hygiene	–	–	–	–	–	–	–	–	–	–	+ ($r = 0{\cdot}65$) ($P < 0{\cdot}05$)	–	–	–	+ ($r = 0{\cdot}69$) ($P < 0{\cdot}05$)	–
Risk of contamination	–	–	–	–	–	–	–	–	–	–	+ ($r = 0{\cdot}73$) ($P < 0{\cdot}05$)	–	–	–	+ ($r = 0{\cdot}68$) ($P < 0{\cdot}05$)	–
Temperature control	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Training and food hygiene knowledge	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

* Pearson's coefficient of correlation, where n is the number of premises. Significant results are indicated by + with r (coefficient of correlation) and P values in parentheses.

† Microbiological results were total viable counts (TVC), *E. coli* (Ec), *Staph. aureus* (Sa), and *S. faecalis* (Sf).

DISCUSSION

Despite the growth of supermarkets selling a whole range of foods, the small producers examined here had a busy local trade. None of them had a quality control facility. We did not deliberately select premises for this survey, and all local producers agreed to participate. We could not have carried out such a detailed investigation without the prior consent and co-operation of the management of the premises concerned. Although some changes during the study were inevitable, and some modifications were necessary following inspections by environmental health officers, we do not believe that any of these changes significantly reduced the validity of the results.

We found, as did Roberts (1), that the quantification of visual inspection reports and microbiological results helped us to assess the ongoing performance of the premises. As far as possible inspections were comprehensive, but in the light of experience other factors may need to be included in the programme. Because samples were collected over a long period of time and a variety of microbiology parameters was tested, the results probably provided a reasonably accurate picture of the microbial quality of foods sold by the producers. However, we have not directly assessed food safety, and high counts or the presence of specific indicator bacteria may not be related to the presence of some food-borne pathogens such as salmonellas.

Although refrigeration, used properly, greatly reduces spoilage and health hazards, none of the premises studied here carried out routine temperature checks on refrigerators or foods. We found some variation in refrigerator and food-surface temperatures, and would recommend tighter control on temperatures for chilled storage. Recently Hobbs & Roberts have recommended that chilled foods should be kept at 4 °C (6).

It is perhaps not surprising that staff with recent formal training in food hygiene should be better informed about hygiene practices than those who received no instruction or were taught only as part of their work. We cannot be certain, however, that this theoretical knowledge was always translated into good working practice. Unfortunately many proprietors considered that formal training was impracticable or irrelevant in small businesses, and yet the risks of cross-contamination are increased in these premises where separate areas and personnel cannot be provided for the preparation of raw and cooked products.

Overall our results from the five types of foods were similar to those obtained by others (7–9). As no attempt was made to resuscitate bacteria shocked by high or low temperature or damaged by cleaning processes, we, like others, may have underestimated the numbers and types of bacteria present. Except for baked pies, which consistently had low counts, the degree of bacterial contamination was associated with both the type of food and the premises in which it was produced. Some manufacturers consistently produced good results whereas others repeatedly failed to do so.

Although environmental contamination was low, this could be expected to increase during the working day. Wiping cloths were a particular hazard. Dry cloths had low counts, but those left damp overnight were often heavily contaminated. Although some premises kept cloths immersed in disinfectant

solution during the day, some of these cloths were contaminated. A simple method of checking for disinfectant activity, such as starch-iodide paper strips for hypochlorites (10), might be useful. The preparation of cleaning solutions was often left to chance, and accurate dilutions were not prepared. Manufacturers rarely gave adequate information on the container, and often they did not provide suitable means of preparing working-strength dilutions. Proprietors were reluctant to replace cloths by paper, because this would be more expensive, and would create a waste disposal problem. Fabric cloths were considered to be stronger and more absorbent than paper.

Cross-contamination by cooked-meat slicing machines is well documented (11). The risk is increased in premises where cooked meats are sliced on demand, particularly if meats are left at room temperature longer than is necessary and are touched by hands before and after slicing. We identified some of these practices in more than half of the premises selling sliced meats. Our finding that 10% of cleaned machines were contaminated with *E. coli* suggests a failure to remove accumulated food debris by the cleaning procedure or recontamination by a dirty wiping cloth.

In general agreement with others, we found no overall relationship between microbiological examination and the results of visual assessments (3, 4). In some specific areas significant relationships were found. With one exception these occurred at the 'probably significant' level, and further work is needed to confirm these findings. Our results for *Staph. aureus* in dairy foods did show a positive correlation with poor personal hygiene and with an increased risk of cross-contamination. These findings provide further evidence that food handlers can be important in food-borne disease caused by *Staph. aureus*. (12). We also found that the presence of *E. coli* in wiping cloths in premises selling raw and cooked meats was strongly associated with an increased risk of cross-contamination ($P < 0{\cdot}01$). Our finding that cloths were used to clean in both raw and cooked food areas combined with their infrequent and inadequate cleaning suggests that this is a valid association.

The safety and quality of commercially produced foods are largely determined by the treatment they receive, and by the control of re-contamination after processing. Although microbiological results failed to predict the standard of working practices in the premises, the results provided valuable support for environmental health officers. Changes in food hygiene standards in premises could be monitored by the introduction of a properly integrated system of microbiological examinations and visual inspections. This approach would provide a real chance of improving hygiene practices in commercial food premises and reducing the incidence of food-borne disease associated with them.

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