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# Development of standardized inspections in restaurants using visual assessments and microbiological sampling to quantify the risks

G. M. TEBBUTT

*Public Health Laboratory, South Cleveland Hospital, Marton Road, Middlesbrough TS4 3TA*

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SUMMARY

The relationship between visual inspections carried out by environmental health officers and microbiological examination was studied in 89 restaurants. Using 30 variables a standardized inspection procedure was developed and each of the premises was assessed in six main areas – structure and design, cleaning and cleanliness, personal hygiene, risk of contamination, temperature control, and training and knowledge about food hygiene. Selected foods and specimens from hands, surfaces, and wiping cloths were examined. There were significant associations between all six areas of the inspections. The structure and design were significantly related to the combined score from all the other areas ($P < 0{\cdot}001$). There were no highly significant associations between microbiological examination and visual assessments. The microbial contamination of wiping cloths, however, was related to the cleaning and cleanliness ($P = 0{\cdot}005$). Microbial sampling provided additional information to inspections and was a valuable aid. Further development of this risk-assessment approach could provide an effective system for monitoring potential health risks in high-risk food premises.

## INTRODUCTION

For many years inspections of food premises have concentrated on the overall appearance and the physical condition of the buildings. Recent developments have highlighted the need for more structured inspections particularly in premises producing or selling foods which can present a higher microbiological risk. Control programmes are available in hospitals and in some commercial catering businesses [1, 2], in particular those which have adopted a hazard analysis approach [3, 4]. Various attempts have been made to quantify hygiene risks in smaller food businesses. Roberts assessed a variety of premises under the four main headings of practices, cleaning, premises, and training and, depending on the type of premises, identified a risk factor for each of them [5]. This could be used to identify those areas which required urgent action, and as a baseline for future inspections. Recently the Audit Commission, in association with the Institute of Environmental Health Officers, examined over 5000 premises and tried to establish a link between inspections and health risk [6]. The survey suggested that 17% of restaurants had a significant risk. Hygiene awareness and practices, the lack of

effective temperature control, and the likelihood of cross-contamination from equipment were identified as areas of particular concern.

Although end-product sampling may be carried out, much less is known about the microbiological condition of surfaces and equipment. One study of food manufacturers attempted to link the microbiology of foods, hands, and a variety of environmental sites with in-depth inspections of the premises, and found no overall agreement. Some positive associations were found in specific areas but these were of borderline significance [7].

This study has evaluated a comprehensive inspection programme in restaurants based on facilities, practices, and microbiological analysis. From the results obtained it was hoped to identify those parameters which were particularly important in assessing hygiene risks and which could provide the basis for a standardized and effective system for inspecting high-risk premises.

## MATERIALS AND METHODS

### *Premises inspection programme*

All the restaurants were part of hotels or public houses and offered a wide range of home-prepared meals and were examined with the agreement of the proprietor. Preliminary discussions took place with environmental health officers (EHOs) to reduce variation between authorities and individual officers. It was agreed to assess premises in 6 main areas – structure and design (6 variables), cleaning and cleanliness (4 variables), personal hygiene (5 variables), risk of contamination (5 variables), temperature control (6 variables), and training and food hygiene knowledge (4 variables). A multiple-choice form was developed and each of the 30 variables was assessed as very good, good, satisfactory, poor, or unacceptable depending on which of the descriptions provided on the form best matched the appearance or practice being studied. EHOs were provided with a set of guidance notes to help them during the inspections. The six areas were assessed as follows.

*Structure and design*. The overall construction and the type of materials used in the building and for work surfaces were assessed. The layout of the premises and whether or not this facilitated satisfactory workflow and good standards of food hygiene were considered. The standard of repairs and any damage which might hinder cleaning were taken into account.

*Cleaning and cleanliness*. The availability and suitability of cleaning aids and the choice of cleaning agents were assessed. The officer estimated how effective the cleaning programme was likely to be, and looked for evidence of a lack of routine cleaning on various surfaces and items of equipment.

*Personal hygiene*. The facilities for hand washing, in particular the appearance and accessibility of wash-hand basins, the presence of suitable soap, a satisfactory water supply, the hand-drying method, and the frequency of hand washing. The appearance of hands and nails and the presence of hand jewellery, other than a wedding ring, were noted. The suitability and cleanliness of protective clothing and hair coverings, and the frequency with which they were changed were recorded.

*Risk of contamination*. The separation of raw and cooked foods was checked in storage, preparation, and retail areas. The officer determined whether or not

separate surfaces and equipment were available for raw and cooked foods. Food-handling practices were checked, and the likelihood of direct contact with high-risk foods was estimated. The measures which had been taken to protect food from a variety of external sources of contamination (pests, pets, and the general public) were taken into account.

*Temperature control.* Cooking and reheating of foods were assessed according to the length of time given and the temperatures achieved. The storage temperature of high-risk foods was measured, and the amount of time foods were kept outside the recommended temperature range was assessed. Ideally such foods should be kept below 3 °C or above 70 °C, and below 10 °C or above 63 °C was considered as satisfactory. The suitability and accuracy of temperature-controlled equipment were checked, and any abuses were noted.

*Food hygiene knowledge and training.* The officer determined what proportion of the food handlers had received formal or informal instruction in food hygiene. Formally-trained staff were those who had attended a course of instruction approved by the local authority. Management attitude towards staff retraining was also taken into consideration. A basic set of ten multiple-choice questions was used to assess knowledge of food hygiene principles and practices. These were set out on a separate form and two food handlers in each of the premises were asked to complete a form at the time of the first inspection.

*Collection of specimens*

In each of the premises two samples of sliced roast meats, a seafood (almost always prawns), a prepared salad, and cream were sampled at weekly intervals for 4 weeks. Whenever possible the temperature of the food was recorded at the time of collection. During each visit agar-contact plates (Oxoid Columbia Agar containing 1% Tween 80) were used to sample finger tips, and to sample a food surface and an item of equipment. Only staff working with cooked or ready-prepared foods and only surfaces or equipment in use with these types of foods were sampled. Reusable wiping cloths were placed in plastic bags. Twenty millilitres of Minimal Recovery Diluent containing 0·4% sodium thiosulphate were added, and the contents were mixed thoroughly. After collection samples were kept in cool-boxes, and transported to the laboratory as soon as possible.

*Microbiological examination of specimens*

Approximately 10 g of food was weighed, sufficient diluent added to form a 1/10 dilution, and the sample homogenized. Using a spiral-plating machine 50 $\mu$l were spread onto CLED agar, the plate incubated for 48 h at 30 °C, and the colonies counted using an image-analysis system (Seescan Imaging Ltd, Cambridge). A further 1 ml of the food suspension was spread onto MacConkey agar, and the culture incubated overnight at 37 °C. Colonies which resembled coliform bacilli were identified as *Escherichia coli* by standard methods.

Agar-contact plates were incubated for 3 h at 37 °C, replicated onto MacConkey agar, and both plates were incubated overnight at 37 °C. On contact plates growth was classified as scanty (25 or fewer colonies), light (up to 75 colonies), moderate (up to 200 colonies), and heavy (confluent or almost confluent growth). Colonies on MacConkey agar were identified as *E. coli*. For cloths as much fluid as possible

was expressed from the cloth, and the fluid examined as described for food suspensions.

*Scoring system and statistical analysis*

During inspections each of the 30 variables was placed into one of the five categories (from very good to unacceptable). When assessing the structure and design the categories were scored on a scale 15,12,8,4, and 0, and those for variables in all other areas were scored as 10,8,5,2, or 0. For each of the premises a percentage score was calculated for each of the six main areas of the inspection and an overall inspection score was obtained.

For total counts on foods and cloths less than $10^4$ c.f.u./g was scored as 5, between $10^4$ and $10^5$ as 4, up to $10^6$ as 3, up to $10^7$ as 2, up to $10^8$ as 1, and more than $10^8$ as 0. For *E. coli* between 10 and $10^2$ c.f.u. was scored as 3, up to $10^3$ as 1, and more than $10^3$ as 0. On contact plates none or scanty growth was scored as 5, light growth as 4, moderate growth as 2, and heavy growth as 0. For *E. coli* between 1 and 9 colonies were scored as 4, up to 50 colonies as 2, up to $10^2$ colonies as 1, and more than $10^2$ colonies as 0. For all specimens where *E. coli* was not detected a score of 5 was given. Percentage scores were calculated for total counts from foods, for total counts from the environment (combined results from hands, surfaces and cloths), for *E. coli* from foods, and for *E. coli* from the environment. An overall microbiological score was also obtained for each of the premises.

Pearson's correlation coefficient was used to investigate bivariate dependencies, significant levels and 95% confidence intervals being calculated[8]. Inter-authority variations were analysed by ANOVA, and some relationships between inspections and microbiology variables were explored using multivariate methods. Because *E. coli* could have contributed to the total amount these variables may not be strictly independent. In practice the part played by *E. coli* was very small and statistical analysis of both variables was considered justified.

## RESULTS

Of 100 premises 11 were excluded because either an insufficient range of foods was offered or some foods were not available at the time of the inspections.

*Visual inspections*

Structure and design. Of 534 assessments in the 89 premises 33 (6·2%) were scored as poor (Table 1). None was unacceptable. The poor results were most often associated with non-existent or bad planning. This resulted in facilities which were poorly accessible and in bad workflow organization.

*Cleaning and cleanliness.* Table 2 shows that 37 (10·4%) of the 356 assessments were unsatisfactory. Poor cleaning, with the build-up of food residues in several areas, was the most common fault (17/89 premises).

Information about cleaning cloths was obtained from 82 premises. In most, the same cloth was used in raw and cooked food areas, and although separate cloths were claimed to be used in 23 premises, only 3 provided cloths which were colour coded. Most cloths were cleaned daily by soaking in a hypochlorite solution, others were boiled and some were laundered. In six premises cloths were discarded each week, or earlier if heavily soiled, and apart from being rinsed occasionally, none

Table 1. *Assessment of the structure and design in the 89 restaurants*

| Variable studied | Category* (and % of results in category) Good | Satis-factory | Poor | Unac-ceptable |
|---|---|---|---|---|
| (1) Design<br>Purpose built or conversion/ adaptation/unplanned<br>Layout and workflow patterns/ use of space | 42 (47·2) | 35 (39·3) | 12 (13·5) | 0 |
| (2) Construction<br>Compliance and Building Regulation Standards<br>Durability/suitability/ease of cleaning | 63 (70·7) | 22 (24·7) | 4 (4·5) | 0 |
| (3) Facilities<br>Heating/lighting/ventilation<br>Facilities for washing equipment/accessibility | 47 (52·8) | 35 (39·7) | 7 (7·9) | 0 |
| (4) Food-surface materials<br>Suitability/durability/ease of cleaning | 60 (67·4) | 28 (31·5) | 1 (1·1) | 0 |
| (5) Repairs<br>Standard and level of disrepair | 58 (65·2) | 23 (25·8) | 8 (9) | 0 |
| (6) Compliance with food-hygiene regulations | 44 (49·4) | 44 (49·4) | 1 (1·1) | 0 |
| Combined score | 314 (58·8) | 187 (35·0) | 33 (6·2) | 0 |

* Results which had been scored as very good or good were combined in this table.

Table 2. *Assessment of cleaning and cleanliness in the 89 restaurants*

| Variable studied | Category* (and % of results in category) Good | Satis-factory | Poor | Unac-ceptable |
|---|---|---|---|---|
| (1) Programme<br>Choice of agents/likely effectiveness/frequency | 53 (59·5) | 26 (29·2) | 9 (10·1) | 1 (1·1) |
| (2) Aids<br>Disposable/reusable condition/ frequency of cleaning | 33 (37·0) | 46 (51·6) | 10 (11·2) | 0 |
| (3) Visual evidence<br>Standard of cleaning (age/ quantity of food residue) | 54 (60·7) | 18 (20·2) | 17 (19·1) | 0 |
| (4) Compliance with food-hygiene regulations | 40 (44·9) | 49 (55·1) | 0 | 0 |
| Combined score | 180 (50·6) | 139 (38·6) | 36 (10·1) | 1 (0·3) |

* Results which had been scored as very good or good were combined in this table.

was cleaned during this period. Food-contact surfaces were cleaned after each use in 27 premises and surfaces in 38 premises were cleaned at the end of each session or at specified intervals during the day. Cleaning frequencies were not specified in the remaining premises, and surfaces were cleaned when it was considered

Table 3. *Assessment of personal hygiene in the 89 restaurants*

| Variable studied | Category* (and % of results in category) Good | Satis-factory | Poor | Unac-ceptable |
|---|---|---|---|---|
| (1) Hand-washing facilities | | | | |
| Accessibility/physical condition/cleanliness | 32 (35·9) | 40 (44·9) | 11 (12·4) | 6 (6·7) |
| Suitability cleanser/hand drying method/nail brush | | | | |
| (2) Hand washing | | | | |
| Frequency (especially after specific activities) | 36 (40·4) | 28 (31·5) | 18 (20·2) | 7 (7·9) |
| (3) Protective clothing including hair covering | | | | |
| Suitability/cleanliness/frequency changed | 67 (75·2) | 19 (21·3) | 3 (3·4) | 0 |
| (4) Food handler | | | | |
| Appearance/poor hygiene practices | 62 (69·7) | 25 (28·1) | 2 (2·2) | 0 |
| (5) Compliance with food-hygiene regulations | 39 (43·8) | 49 (55·1) | 1 (1·1) | 0 |
| Combined score | 236 (53·0) | 161 (36·2) | 35 (7·9) | 13 (2·9) |

* Results which had been scored as very good or good were combined in this table.

necessary by the staff. A detergent solution was used for cleaning in 36 premises. a combined detergent and hypochlorite solution was provided in 35 premises. and in 13 premises a hypochlorite solution was used. Some cutting boards were put in a dishwasher.

*Personal hygiene*. Of 445 assessments 35 were classified as poor (7·9%) and 13 (2·9%) was unacceptable (Table 3). Dirty and poorly accessible wash-hand basins were the most common faults. and these were often associated with infrequent hand washing. Plain bar soap was provided in 44 premises, and a liquid soap. 18 of which contained a bactericidal agent, was used in 41 premises. No soap was available in four premises. Although paper was preferred for hand drying. staff in 29 premises were provided with a communal towel.

*Risk of contamination*. Table 4 shows that 63 (14·2%) of assessments were judged as poor and 13 (2·9%) as unacceptable. Handling high-risk foods was the most common fault, this was observed in 46 premises. The risk was increased further where staff frequently transferred between raw and cooked food areas and in premises where these areas were not separated.

*Temperature control*. Overall 65 assessments (12·5%) were poor and 3 (0·6%) were unacceptable (Table 5). Food temperatures were measured in 76 premises and in 24 of these the temperature of at least some high-risk foods was between 10 and 63 °C. Prolonged storage of foods at an incorrect temperature was identified as a problem in 20 premises, and prepared salads in particular were often kept at ambient temperature for long periods.

*Training and food hygiene knowledge*. Training was considered to be unsatisfactory if none of the staff had been formally trained. This occurred in 20 premises and in 3 of these staff had received no training whatsoever (Table 6).

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Table 4. *Assessment of the risk of contamination in the 89 restaurants*

| Variable studied | Category* (and % of results in category) Good | Satis-factory | Poor | Unac-ceptable |
|---|---|---|---|---|
| (1) Physical separation of raw and cooked foods<br>Storage/processing/preparation/ retail areas | 43 (48·3) | 41 (41·6) | 4 (4·5) | 1 (1·1) |
| (2) Staff and facilities<br>Increased risks due to shared equipment/areas/staff in raw and cooked food areas | 28 (31·5) | 52 (58·4) | 7 (7·9) | 2 (2·3) |
| (3) Handling methods<br>Likelihood of direct contact with high-risk foods | 10 (11·2) | 33 (37·1) | 36 (40·4) | 10 (11·2) |
| (4) Non-microbial contamination<br>Protection from public/insects/ rodents | 43 (48·3) | 33 (37·1) | 13 (14·6) | 0 |
| (5) Compliance with food-hygiene legislation | 30 (33·7) | 56 (62·9) | 3 (3·4) | 0 |
| Combined score | 154 (34·6) | 215 (48·3) | 63 (14·2) | 13 (2·9) |

* Results which had been scored as very good or good were combined in this table.

Table 5. *Assessment of temperature control in the 89 restaurants*

| Variable studied | Category* (and % of results in category) Good | Satis-factory | Poor | Unac-ceptable |
|---|---|---|---|---|
| (1) Cooking<br>Efficiency and operational control of process | 60 (67·4) | 26 (29·2) | 3 (3·4) | 0 |
| (2) Reheating<br>Process control (temperature check before serving) | 27 (30·3) | 54 (60·7) | 8 (9·0) | 0 |
| (3) Real-time measurements† (surface probe)<br>High-risk foods | 25 (32·8) | 27 (35·5) | 24 (31·6) | 0 |
| (4) Storage<br>Foods kept outside recommended/ statutory‡ limits | 40 (44·9) | 29 (32·6) | 17 (19·1) | 3 (3·4) |
| (5) Equipment<br>Performance of temperature control appliances | 49 (55·1) | 32 (36·0) | 8 (9·0) | 0 |
| (6) Abuses of equipment<br>Practices which reduce operating efficiency | 68 (76·4) | 16 (18·0) | 5 (5·6) | 0 |
| Combined score | 269 (48·8) | 184 (35·3) | 65 (12·5) | 3 (0·6) |

* Results which had been scored as very good or good were combined in this table.
† Food temperature measurements were obtained in 76 premises.
‡ Between 10 and 63 °C – Food Hygiene (General) Regulations 1970.

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Table 6. *Assessment of training and knowledge in the 89 restaurants*

| Variable studied | Category* (and % of results in category) Good | Satis-factory | Poor | Unac-ceptable |
|---|---|---|---|---|
| (1) Training | | | | |
| Formal/informal/none (including combinations) | 42 (47·2) | 27 (30·3) | 17 (19·1) | 3 (3·4) |
| (2) Retraining | | | | |
| Interval since training/ availability of retraining | 25 (28·1) | 22 (24·7) | 36 (40·4) | 6 (6·7) |
| (3) Knowledge of food-hygiene principles | 46 (51·7) | 30 (33·7) | 13 (14·6) | 0 |
| (4) Knowledge of food hygiene practices | 38 (42·3) | 45 (50·6) | 6 (6·7) | 0 |
| Combined score | 151 (42·4) | 124 (34·8) | 72 (20·2) | 9 (2·5) |

* Results which had been scored as very good or good were combined in this table.

Table 7. *Microbiological results obtained from selected foods in 89 restaurants*

| Type of food | No. of foods examined | $Log_{10}$ count/g (and % in count range) < 4·00 | 4·01–5·00 | 5·01–6·00 | 6·01–8·00 | > 8·00 |
|---|---|---|---|---|---|---|
| Sliced meat | 702 | 287 (40·9) | 131 (18·7) | 83 (11·8) | 100 (14·2) | 101 (14·4) |
| Seafood | 323 | 134 (41·5) | 41 (12·7) | 60 (18·6) | 44 (13·6) | 44 (13·6) |
| Prepared salad | 339 | 44 (13·0) | 47 (13·9) | 78 (23·0) | 86 (25·4) | 84 (24·8) |
| Cream | 335 | 156 (46·6) | 30 (9·0) | 28 (8·4) | 28 (8·4) | 93 (27·8) |

Staff were more likely to have a poor knowledge of food-hygiene principles (13 premises) than they were of practices (6 premises).

*Microbiological tests*

Total counts were performed on 1699 foods (Table 7). Although high counts were sometimes found in all four types of foods, these occurred more often in salads and creams with 24·8% and 27·8% respectively containing more than $10^8$ c.f.u./g. The mean food temperatures at the time of sampling were 12·4 °C for salads, 8 °C for cooked meats, 7·7 °C for cream, and 7·3 °C for seafoods (excluding those sampled when still frozen). Among creams 74·1% of ultra-heat treated samples and 25·6% of pasteurized creams contained less than $10^4$ c.f.u./g. *Escherichia coli* was detected in 1·5% of creams (all pasteurized), in 10·3% of cooked meats, in 10·2% of seafoods, and in 12·4% of salads. More than $10^3$ c.f.u./g were found in 3·7% of meats, 2·8% of seafoods, and in 5·0% of salads.

Table 8 shows the bacterial contamination of finger tips, food surfaces and equipment, and cloths. Overall *E. coli* was detected on 5·1% of hands, 9·8% of surfaces, and in 37·6% of cloths. Bacterial contamination of cloths was particularly high with 38·5% having total counts greater than $10^8$ c.f.u. and 32·6% contained more than $10^3$ c.f.u. of *E. coli*.

*Statistical analysis*

Four premises were excluded from the analysis because paper and not reusable cloths was used for cleaning surfaces. There were positive correlations between

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Table 8. *Microbiological results from wiping cloths, finger-tips, and surfaces*

| Sample | No. tested | $Log_{10}$ count/cloth (and % in count range) | | | | | *Escherichia coli* $log_{10}$ count/cloth | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | < 4·00 | 4·01–5·00 | 5·01–6·00 | 6·01–8·00 | > 8·00 | Not found | 1·01–2·00 | 2·01–3·00 | > 3·00 |
| Cloths | 340 | 57 (16·8) | 34 (10·0) | 51 (15·0) | 67 (19·7) | 131 (38·5) | 212 (62·4) | 0 | 17 (5·0) | 111 (32·6) |
| | | Growth on contact plate | | | | | *Escherichia coli* count after replication | | | |
| | | None or scanty | Light | Moderate | Heavy | | Not found | 10 | 11–50 | 51–100 | > 100 |
| Fingers | 710 | 175 (24·6) | 185 (26·1) | 190 (26·8) | 160 (22·5) | | 674 (94·9) | 9 (1·3) | 10 (1·4) | 5 (0·7) | 12 (1·7) |
| Surface | 700 | 151 (21·6) | 148 (21·1) | 166 (23·7) | 235 (33·6) | | 631 (90·0) | 9 (1·3) | 14 (2·0) | 10 (1·4) | 36 (5·1) |



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Table 9. *Statistical comparison between inspection results and the combined scores from microbiological examination*

| Inspection variable | Pearson coefficient of correlation after analysis against combined microbial score |
|---|---|
| Structure/design | −0·11 |
| Cleaning/cleanliness | 0·15 |
| Personal hygiene | 0·13 |
| Risk of contamination | −0·024 |
| Temperature control | 0·16 |
| Training/knowledge | −0·072 |
| Combined inspection score | 0·028 |

* For $N = 85$ a correlation coefficient of at least 0·21 was required if the value was considered to be significantly different from zero.

Table 10. *Statistical analysis of the microbiological results*

| First variable | Second variable | Pearson coefficient of correlation | Level of significance ($P$) | 95% confidence interval |
|---|---|---|---|---|
| TVC from foods | TVC from environment | 0·30 | 0·005 | 0·09 to 0·48 |
| | *E. coli* from foods | 0·38 | < 0·001 | 0·18 to 0·55 |
| | *E. coli* from environment | 0·23 | 0·031 | 0·02 to 0·42 |
| TVC from environment | *E. coli* from environment | 0·50 | < 0·001 | 0·32 to 0·64 |
| *E. coli* from food | *E.coli* from environment | 0·62 | < 0·001 | 0·47 to 0·74 |
| | TVC from environment | 0·43 | < 0·001 | 0·24 to 0·59 |
| TVC from food and environment | *E. coli* from food and environment | 0·54 | < 0·001 | 0·37 to 0·68 |

all six main inspection areas. A positive link was found between the structure and design of premises and the combined score of the other five main variables ($r = 0·52$ with a 95% confidence interval from 0·34 to 0·66. $P < 0·001$). The standard of training and knowledge about food hygiene were related to the combined score of the other main variables ($r = 0·44$ with a 95% confidence interval from 0·25 to 0·60. $P < 0·001$). There was significant variability between authorities in the combined inspection scores ($F$ test. $P = 0·025$). Taken individually each of the inspection variables except temperature control and training varied significantly between authorities.

When the results from inspections and the combined score from microbiological examination were studied, no significant associations were found (Table 9). However the assessment of cleaning and cleanliness was significantly related to both the microbiological contamination of wiping cloths ($r = 0·30$ with a 95% confidence interval between 0·09 and 0·48. $P = 0·005$) and the presence of *E. coli* in the environment ($r = 0·22$ with a 95% confidence interval between 0·005 and 0·41, $P = 0·04$).

Bivariate analysis of microbiological results revealed a number of relationships (Table 10). A particularly strong link was identified between *E. coli* in foods and the presence of this organism in the environment. In contrast to inspection

variables the combined microbiology scores did not significantly vary between authorities.

## DISCUSSION

Although the inspections were standardized and the premises were carefully chosen, significant inter-authority variations were identified. These probably had a variety of causes but some may have been due to differences in interpretation by EHOs. None of the authorities consistently scored higher or lower than any of the others and there was no clear evidence of bias between them. As new food legislation emphasizes the importance of standardized inspections, measures are needed to ensure that variation between officers is reduced to a minimum.

As each of the premises was visited on several occasions some changes in working practices were inevitable, but none was considered sufficient to reduce the overall validity of the results. Some officers considered that practices could not have been reliably assessed by fewer visits. Although it could have led to some changes during the study the prior consent and co-operation of the management was considered essential.

The survey by the Audit Commission [6] linked the physical condition of the buildings with the overall safety risk. This study has combined physical condition with design and workflow organization and has shown that these were strongly related to a combination of all other inspection variables. This finding suggests that EHOs, as part of their inspection, should consider whether or not the available space is used to best advantage and whether or not workflow patterns are acceptable or could be improved. Both factors may be important in reducing the overall risk associated with the premises.

Formal training and awareness of food-hygiene principles and practices were linked to better inspection assessments. Other work has also identified a link between training and health risk [8]. These results provide further support for the introduction of compulsory training for food handlers. Many local authorities already provide basic training on a voluntary basis., but the Audit Commission study showed that 50% of restaurants still provided poor training.

No close link was established between microbiological examination and visual assessments. The possibility that other microbial parameters would have identified a positive link is unlikely but cannot be ruled out. Other work [9] has reported that *E. coli* and total colony counts were valuable markers for ready-to-eat foods. Direct examination for food-borne pathogens is possible but is unlikely to provide a sensitive early-warning system of health risk. Although sampling of end products is common, the selective examination of the kitchen environment, as described here, provided a complementary and perhaps better overall picture of potential risks. The finding that cleaning standards were significantly related to the presence of *E. coli* in environmental specimens adds weight to this argument. These results, however, were of borderline statistical significance and the possibility that they were due to random fluctuations in the data could not be ruled out.

The increased risk from reusable wiping cloths and poor cleaning was highlighted in this study. A strong positive association was found between contaminated cloths and the presence of *E. coli* in foods. As cleaning was rarely controlled, it is

not surprising that bacteria should be spread on cloths to foods via surfaces and hands. Greater control of cleaning methods is essential in high-risk food premises. Written cleaning plans are important, and the use of nylon brushes or paper for applying properly prepared cleaning agents to surfaces should be considered.

Public concern and the increasing complexity of new food legislation mean that EHOs are likely to spend more of their time examining food premises. Inspections, like those carried out here, should concentrate on quantifying potential health risks. On the whole this approach was welcomed by EHOs, but more standardization in both methodology and interpretation are needed. This programme would also require more EHOs and better funding for it to be successful.

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