An Evaluation of the Collection and Analysis of Epidemiological Data for Support of Food Safety Control Systems

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ABSTRACT

Food-borne disease data collected by three U. K. environmental health departments were used in this study. The data were analyzed using a database designed to rank disease agents, food ingredients, and processing factors which contribute to cases of food-borne disease. The results established changes in patterns of food-borne disease over time, pattern differences between U. K. localities and differences between areas of the United Kingdom and the United States. This type of analysis of epidemiological data provides scientific underpinning for hazard analysis critical control point systems for food safety control. The work highlights the need for a consistent procedure for collection of food-borne disease data and for a national database to facilitate analysis.

Hazard analysis critical control point (HACCP) is an internationally recognized system which can be used to reduce the incidence of food-borne disease (1). When applied in the food industry, it involves the identification of hazards and implementation of controls to reduce the likelihood of a case of food-borne illness in the consumer. Recent European (3) and U. K. (4) food safety legislation has required all food business proprietors to establish a food control system based upon the principles of HACCP as a means of protecting the consumer from food-borne disease and promoting public confidence. HACCP requires the identification of hazards associated with particular foods, processing practices, and preparation practices. The system ensures control of these hazards by the designation of critical control points (CCPs) within the food processing chain. The identification of hazards and CCPs requires a detailed knowledge of the foods and factors which contribute to food-borne disease. This knowledge would also allow an estimate of the contribution of each individual hazard in a food chain to the overall probability of food-borne disease. The most obvious source of such information is the epidemiological data collected during investigation of food-borne disease cases.

In the United Kingdom the routine investigation of food-borne disease cases is carried out by local authority environmental health departments (EHDs) and health authorities. Environmental health officers (EHOs) within each EHD undertake the detailed epidemiological investigations. They are supported by a consultant in communicable disease control offering medical advice and coordinating investigations on behalf of the health authority. EHDs are notified of food-borne disease cases by local authority environmental health departments (EHDs) and health authorities. Environmental health officers (EHOs) within each EHD undertake the detailed epidemiological investigations. They are supported by a consultant in communicable disease control offering medical advice and coordinating investigations on behalf of the health authority. EHDs are notified of possible food-borne disease incidents by medical practitioners, by the Public Health Laboratory Service, and by the general public (2). Suspected and confirmed cases are then investigated by EHOs.

An EHO may confirm that a case or outbreak has occurred by establishing a food history and requiring food and fecal analyses where samples are available. Therefore, in the United Kingdom, EHDs hold epidemiological data relating to suspected and confirmed cases of food-borne illness which could be used in the identification of hazards and the assessment of risks and hence in the development of HACCP systems.

This epidemiological data can be analyzed by means of an appropriate database, such as that developed by the New York State Department of Health’s Bureau of Community Sanitation and Food Protection (BCSFP) (8). The BCSFP database relates the incidence of disease to specified food preparation practices and thus allows the identification of appropriate control actions. Appropriate analysis of the data will also rank the factors which contributed to incidents of food-borne disease and therefore provide an objective basis for construction of HACCP plans. Agents of infection, e.g., Salmonella spp. and Staphylococcus aureus, can be ranked in order of frequency with which they are the confirmed or suspected agents associated with food-borne disease. The practices which have contributed to outbreaks, i.e., contributing factors, such as inadequate cooking or inadequate refrigeration can also be ranked according to the frequency of their association with disease. This ranked list of contributing factors can be used to highlight the most likely hazards and thus identify CCPs required in a HACCP system for a specific food. This type of analysis also facilitates the determination of the overall probability of food-borne disease.

The current view of food-borne disease in the United Kingdom is determined largely by the data collected by
EHDs (2). This paper examines the reliability of such data and their suitability as a basis for the development of HACCP systems. The work reported here applied the New York Department of Health database to analyze U. K. food-borne disease data collected by three local authority EHDs. The results of this analysis were compared with results of the frequently cited investigation carried out in the United Kingdom by Roberts and reported in 1986 (7), with World Health Organisation (WHO) data for the United Kingdom for 1992 to 1993 (9), and with work carried out in the United States (8). Recommendations are made regarding the procedures used currently for the collection of data relating to food-borne illness in the United Kingdom.

METHODS

The BCSFP database (8) was used to analyze data on food-borne disease from three local authority EHDs identified as A, B, and C. The most recent year for which complete EHD records were available at the outset of the investigation was 1995. Six EHDs were approached to establish the feasibility of using their records in the database. Only three of the EHDs collected information which was sufficiently detailed and unbiased to be used. The three EHDs selected also had similar numbers of usable food-borne disease cases in 1995, ranging from 41 to 53. Both sporadic cases (i.e., individual cases which are not linked) and outbreaks (i.e., two or more linked cases of the same illness) (2) are included under the term “outbreak” in the BCSFP database (8). The same terminology is adopted in this paper. The term “outbreak” therefore, refers to each occasion on which illness arose from a separate food source regardless of the number of cases involved.

The majority of cases (n = 125) in this study were sporadic or outbreaks involving fewer than four individuals (n = 11). Only two outbreaks involved more than 4 cases, the largest outbreak comprising 17 cases. The data were not therefore biased by large outbreaks and provide a realistic assessment of the information collected by EHDs in the course of their normal epidemiological investigations.

The food-borne disease data taken from the three EHDs had been collected by face-to-face interviews, telephone interviews, or detailed questionnaires completed by the individuals associated with each outbreak. Each of the total of 917 cases recorded by the three EHDs in 1995 was examined, and 200 cases were found to be recorded in sufficient detail (Table 1) to be input to the BCSFP database.

RESULTS

Table 2 shows Salmonella spp. (50%) to be the causal agent most frequently associated with confirmed outbreaks for the three EHDs studied, followed closely by Campylobacter spp. (46.9%). Other agents were responsible for less than 4% of confirmed outbreaks. A causal agent could not be identified in 27.5% of confirmed and suspected outbreaks. Table 3 shows that for EHD A the causal agent most frequently associated with confirmed outbreaks was Campylobacter spp. (74.5%). For EHDs B and C the dominant causal agent was Salmonella spp. (71.4 and 100%, respectively).

Table 4 shows poultry (22.5%) to be the significant ingredient most frequently identified as being associated with confirmed and suspected outbreaks. This was followed by eggs (11.6%) and dairy produce (72%). Other categories of significant ingredients each accounted for less than 6% of suspected and confirmed outbreaks. A significant ingredient was not identified in 43.5% of outbreaks. Table 5 shows that for all three EHDs there was a high percentage of outbreaks where a significant ingredient could not be identified (68.3% for EHD A). For EHD A the significant ingredients most frequently associated with confirmed outbreaks were dairy products (36.8%) and poultry (31.6%). Other categories of significant ingredients each accounted for less than 11% of confirmed outbreaks. For EHDs B and C the ranked orders of significant ingredients were different from that for EHD A. The significant ingredient most frequently associated

<table>
<thead>
<tr>
<th>Heading</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Origin of outbreak, e.g., home, restaurant</td>
</tr>
<tr>
<td>Date of first case</td>
<td>E.g., nausea, vomiting</td>
</tr>
<tr>
<td>Symptoms</td>
<td>Number of days symptoms evident</td>
</tr>
<tr>
<td>Duration</td>
<td>High risk—establishment serves menu items frequently associated with outbreaks, e.g., restaurant</td>
</tr>
<tr>
<td>Risk</td>
<td>Medium risk—establishment serves menu items infrequently associated with outbreaks, e.g., fast food restaurant</td>
</tr>
<tr>
<td>Low risk—establishment serves menu items rarely associated with outbreaks, e.g., bar, tavern</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Incriminated food</th>
<th>Significant ingredient</th>
<th>Method of preparation</th>
<th>Contributing factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food implicated, e.g., chicken casserole</td>
<td>Food category implicated, e.g., chicken</td>
<td>Processing stage implicated, e.g., inadequate cooking</td>
<td></td>
</tr>
<tr>
<td>E.g., heated and served, baked</td>
<td>E.g., bacterial, viral</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Etiology type</th>
<th>Etiology status</th>
<th>Agent and typing</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.g., Escherichia coli O157</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Information from food disease case reports that was entered into the BCSFP database under the headings listed and used in subsequent analysis

Table 2. Combined totals of food-borne disease outbreaks from three EHDs with causal agents ranked by numbers of outbreaks

<table>
<thead>
<tr>
<th>Agent</th>
<th>Confirmed and suspected outbreaks</th>
<th>Confirmed outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Salmonella spp.</td>
<td>50.0</td>
<td>36.2</td>
</tr>
<tr>
<td>Campylobacter spp.</td>
<td>46.0</td>
<td>33.3</td>
</tr>
<tr>
<td>Unknown</td>
<td>38.0</td>
<td>27.5</td>
</tr>
<tr>
<td>Shigella spp.</td>
<td>2.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Giardia spp.</td>
<td>1.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>
TABLE 3. Number of food-borne disease outbreaks from EHDs A, B, and C with significant ingredients ranked by numbers of outbreaks

<table>
<thead>
<tr>
<th>EHD</th>
<th>Agent</th>
<th>Confirmed and suspected outbreaks</th>
<th>Confirmed outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
</tr>
<tr>
<td>A</td>
<td>Campylobacter spp.</td>
<td>38.0</td>
<td>71.7</td>
</tr>
<tr>
<td>A</td>
<td>Salmonella spp.</td>
<td>10.0</td>
<td>18.9</td>
</tr>
<tr>
<td>A</td>
<td>Shigella spp.</td>
<td>2.0</td>
<td>3.8</td>
</tr>
<tr>
<td>A</td>
<td>Unknown</td>
<td>2.0</td>
<td>3.8</td>
</tr>
<tr>
<td>A</td>
<td>Giardia sp.</td>
<td>1.0</td>
<td>1.9</td>
</tr>
<tr>
<td>B</td>
<td>Salmonella spp.</td>
<td>22.0</td>
<td>53.7</td>
</tr>
<tr>
<td>B</td>
<td>Unknown</td>
<td>10.0</td>
<td>24.4</td>
</tr>
<tr>
<td>B</td>
<td>Campylobacter spp.</td>
<td>8.0</td>
<td>19.5</td>
</tr>
<tr>
<td>B</td>
<td>Escherichia coli</td>
<td>1.0</td>
<td>2.4</td>
</tr>
<tr>
<td>C</td>
<td>Salmonella spp.</td>
<td>44.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

with confirmed outbreaks for EHD B was poultry (60.0%) followed by eggs (25.0%). For EHD C the ranked order was eggs (61.5%) followed by poultry (23.0%). Other categories of significant ingredients each accounted for less than 8% of confirmed outbreaks for EHDs B and C.

Table 6 shows that the contributing factor most frequently associated with confirmed and suspected outbreaks was inadequate cooking (13.8%) followed by cross contamination (6.5%) and inadequate refrigeration (3.6%). Other contributing factors together accounted for less than 5% of outbreaks. In 73.2% of confirmed and suspected outbreaks, a contributing factor was not identified. For EHD A the contributing factor most frequently associated with confirmed outbreaks was cross contamination (61.5%) followed by inadequate cooking (30.8%) and inadequate refrigeration (7.7%) (Table 7). The ranked orders of contributing factors were different for EHDs B and C. The contributing factors most frequently associated with confirmed outbreaks for

TABLE 4. Combined total of food-borne disease outbreaks from three EHDs with significant ingredients ranked by numbers of outbreaks

<table>
<thead>
<tr>
<th>Significant ingredient</th>
<th>Confirmed and suspected outbreaks</th>
<th>Confirmed outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Unknown</td>
<td>60.0</td>
<td>43.5</td>
</tr>
<tr>
<td>Poultry</td>
<td>31.0</td>
<td>22.5</td>
</tr>
<tr>
<td>Eggs</td>
<td>16.0</td>
<td>11.6</td>
</tr>
<tr>
<td>Dairy</td>
<td>10.0</td>
<td>7.2</td>
</tr>
<tr>
<td>Beef</td>
<td>7.0</td>
<td>5.1</td>
</tr>
<tr>
<td>Fin fish</td>
<td>4.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Pork</td>
<td>4.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Other significant ingredient</td>
<td>3.0</td>
<td>2.2</td>
</tr>
<tr>
<td>No specific ingredient</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Shellfish</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Starchy foods</td>
<td>1.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>

*a*, confirmed outbreaks not attributed to a specific significant ingredient; **, significant ingredient not ranked for confirmed outbreaks.

TABLE 5. Numbers of food-borne disease outbreaks from EHDs A, B, and C with significant ingredients ranked by numbers of outbreaks

<table>
<thead>
<tr>
<th>EHD</th>
<th>Significant ingredient</th>
<th>Confirmed and suspected outbreaks</th>
<th>Confirmed outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
</tr>
<tr>
<td>A</td>
<td>Unknown</td>
<td>33.0</td>
<td>62.3</td>
</tr>
<tr>
<td>A</td>
<td>Dairy</td>
<td>7.0</td>
<td>13.2</td>
</tr>
<tr>
<td>A</td>
<td>Poultry</td>
<td>7.0</td>
<td>13.2</td>
</tr>
<tr>
<td>A</td>
<td>Beef</td>
<td>2.0</td>
<td>3.8</td>
</tr>
<tr>
<td>A</td>
<td>Eggs</td>
<td>2.0</td>
<td>3.8</td>
</tr>
<tr>
<td>A</td>
<td>Other significant ingredient</td>
<td>1.0</td>
<td>1.9</td>
</tr>
<tr>
<td>A</td>
<td>No specific ingredient</td>
<td>1.0</td>
<td>1.9</td>
</tr>
<tr>
<td>B</td>
<td>Poultry</td>
<td>15.0</td>
<td>36.6</td>
</tr>
<tr>
<td>B</td>
<td>Unknown</td>
<td>12.0</td>
<td>29.3</td>
</tr>
<tr>
<td>B</td>
<td>Eggs</td>
<td>6.0</td>
<td>14.6</td>
</tr>
<tr>
<td>B</td>
<td>Pork</td>
<td>2.0</td>
<td>4.9</td>
</tr>
<tr>
<td>B</td>
<td>Dairy</td>
<td>2.0</td>
<td>4.9</td>
</tr>
<tr>
<td>B</td>
<td>Beef</td>
<td>2.0</td>
<td>4.9</td>
</tr>
<tr>
<td>B</td>
<td>Shellfish</td>
<td>1.0</td>
<td>2.4</td>
</tr>
<tr>
<td>B</td>
<td>Other seafood</td>
<td>1.0</td>
<td>2.4</td>
</tr>
<tr>
<td>C</td>
<td>Unknown</td>
<td>15.0</td>
<td>34.1</td>
</tr>
<tr>
<td>C</td>
<td>Poultry</td>
<td>9.0</td>
<td>20.5</td>
</tr>
<tr>
<td>C</td>
<td>Eggs</td>
<td>8.0</td>
<td>18.2</td>
</tr>
<tr>
<td>C</td>
<td>Finfish</td>
<td>4.0</td>
<td>9.1</td>
</tr>
<tr>
<td>C</td>
<td>Beef</td>
<td>3.0</td>
<td>6.8</td>
</tr>
<tr>
<td>C</td>
<td>Pork</td>
<td>2.0</td>
<td>4.5</td>
</tr>
<tr>
<td>C</td>
<td>Starchy foods</td>
<td>1.0</td>
<td>2.3</td>
</tr>
<tr>
<td>C</td>
<td>Dairy</td>
<td>1.0</td>
<td>2.3</td>
</tr>
<tr>
<td>C</td>
<td>Other significant ingredient</td>
<td>1.0</td>
<td>2.3</td>
</tr>
</tbody>
</table>

*a*, confirmed outbreaks not attributed to a specific significant ingredient; **, significant ingredient not ranked for confirmed outbreaks.

EHD B were inadequate cooking (75.0%) followed by inadequate refrigeration (12.5%) and preparation several hours in advance (12.5%). For EHD C the ranked order was inadequate cooking (85.7%) followed by the category of other contributing factors (14.3%).

TABLE 6. Combined total of food-borne outbreaks from three EHDs with contributing factors ranked by frequency of involvement in outbreaks

<table>
<thead>
<tr>
<th>Factor</th>
<th>Confirmed and suspected outbreaks</th>
<th>Confirmed outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Unknown</td>
<td>101.0</td>
<td>73.2</td>
</tr>
<tr>
<td>Inadequate cooking</td>
<td>19.0</td>
<td>13.8</td>
</tr>
<tr>
<td>Cross contamination</td>
<td>9.0</td>
<td>6.5</td>
</tr>
<tr>
<td>Inadequate refrigeration</td>
<td>5.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Other contributing factor</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Preparation hours in advance</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Inadequate reheating</td>
<td>1.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>

*a*, confirmed outbreaks not attributed to a specific contributing factor.
patterns of food consumption, the nature of food-borne disease outbreak investigations in the United States, or methodological difficulties in the isolation of the organism. Only 2% of outbreaks included in the WHO report for 1992 to 1993 (9) based on national totals were attributable to Campylobacter spp. The fact that the data in the WHO report and the work reported here cover different years is unlikely to account for the large difference in prevalence and ranking of causal agents. This indicates that either the national cumulative figures used by WHO do not reflect the situation in individual localities or the occurrence of specific food disease agents is changing more rapidly than previously thought (6).

**Significant Ingredient.** The food vehicle implicated in an outbreak is termed the significant ingredient. In 43.5% of outbreaks the significant ingredient was not identified. Table 4 shows that the significant ingredient most frequently implicated in outbreaks was poultry (40.4% of confirmed outbreaks), followed by eggs (28.8% of confirmed outbreaks), and dairy products (17.3% of confirmed outbreaks). No other category of ingredients accounted for more than 10% of confirmed outbreaks. The placement of poultry and eggs at the top of the ranking of significant ingredients is the same as that in the WHO report based on data for 1992 to 1993 (9). However, the remainder of the significant ingredients are ranked differently. For example, dairy products constitute 17.3% of outbreaks reported here and are placed third in the ranked order. In contrast, the WHO findings placed these products fifth in the ranking of significant ingredients (4.4% of outbreaks). This suggests that there may have been a change in significant ingredients associated with food-borne disease since the 1992 to 1993 period covered by the WHO report or, more likely, highlights a difference between national and local data.

The significant ingredients identified in this study are ranked in a different order from those reported by Weingold et al. (8). In that study shellfish were found to be the significant ingredient in the majority of confirmed outbreaks (19.7%), followed by finfish (7.2%) and beef (7.1%). Poultry and eggs were ranked fourth and fifth, respectively, in contrast to the rankings in our findings (Table 4). This could be a consequence of different food consumption patterns in New York State and the United Kingdom that were covered by the WHO report or, more likely, highlights a difference between national and local data.

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**Contributing factors.** In over 70% of the outbreaks investigated, the contributing food preparation factor could not be identified (Table 6). Where the contributing factor is known, inadequate cooking (57.1%) and cross contamination (32.1%) were the most frequent practices associated with outbreaks. The WHO report for 1992 to 1993 (9) placed inappropriate storage (28.4%), inadequate heat treatment (27%), and cross contamination (22.7%) as the most frequently occurring factors, a set of rankings which is similar to that of our findings. The New York State study (8), however, placed inadequate refrigeration (23.9%), contami-

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**TABLE 7. Combined total of food-borne outbreaks from EHDs A, B, and C with contributing factors ranked by frequency of involvement in outbreaks**

<table>
<thead>
<tr>
<th>EHD</th>
<th>Contributing factor</th>
<th>Confirmed and suspected outbreaks</th>
<th>Confirmed outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number %</td>
<td>Number %</td>
</tr>
<tr>
<td>A</td>
<td>Unknown</td>
<td>40.0 75.5 *</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Cross contamination</td>
<td>8.0 15.1 8.0 61.5</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Inadequate cooking</td>
<td>4.0 7.5 4.0 30.8</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Inadequate refrigeration</td>
<td>1.0 1.9 1.0 7.7</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Unknown</td>
<td>27.0 65.9 *</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Inadequate cooking</td>
<td>8.0 19.5 6.0 75.0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Inadequate refrigeration</td>
<td>3.0 7.3 1.0 12.5</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Preparation hours in advance</td>
<td>1.0 2.4 1.0 12.5</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Inadequate reheating</td>
<td>1.0 2.4 ** **</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Cross contamination</td>
<td>1.0 2.4 ** **</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Unknown</td>
<td>34.0 77.3 ** **</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Inadequate cooking</td>
<td>7.0 15.9 6.0 85.7</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Other contributing factor</td>
<td>2.0 4.5 1.0 14.3</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Inadequate refrigeration</td>
<td>1.0 2.3 ** **</td>
<td></td>
</tr>
</tbody>
</table>

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*a.*, confirmed outbreaks not attributed to a specific contributing factor; **,** contributing factor not ranked for confirmed outbreaks.
nated ingredients (22%), and inadequate cooking (20%) at the top of its ranked list.

Our findings also contrast with those of Roberts (7), who found preparation too far in advance to be the most frequent factor, followed by storage at ambient temperature and inadequate cooling. Undercooking occurred as the sixth most likely contributing factor.

**Local differences in the United Kingdom.** The observations reported here are further complicated when the data are disaggregated for individual EHDs. Comparison of data from the three EHDs used shows that they differ from one another and from the cumulative figures to which they contribute. In EHD A, 74.5% of outbreaks were attributed to *Campylobacter* spp., whereas in EHD B, 25.0% were attributed to *Campylobacter* spp. and in EHD C no outbreaks were attributed to *Campylobacter* spp. Generalized, national figures could mask significant local trends in the distribution of agents of food-borne disease. The differences in ranked orders of significant ingredients for the respective EHDs in Table 5 also highlight the differences between local and cumulative data. A similarly inconsistent pattern is evident in the assignment of contributing factors to outbreaks (Tables 6 and 7). Data from additional EHDs may not eliminate the inconsistencies observed.

**Use of epidemiological data to support food safety control systems.** Hazard analysis critical control point is now assuming a major role in the European Union and U. K. legislation governing control of food safety. There is therefore a clear need for a definitive, reliable source of underpinning information on causal agents, ingredients, and contributing factors which is amenable to constant review and updating (5). This information is necessary to provide the objective scientific basis for identification of hazards and CCPs upon which HACCP systems are constructed.

This study demonstrates that current food safety control systems are based upon information which is limited, is often conflicting, and can also become outdated rapidly. It highlights the need for an imposed detailed national procedure for collection of data. These data would then be amenable to analysis by means of a database system such as the BCSP.

A national database would provide the scientific basis necessary to underpin HACCP-based systems of food safety control in the United Kingdom and would enable the food industry to react quickly to changes in the pattern of food-borne disease. The information provided by a database of the type used in this study would allow calculation of the contribution that each stage in the food chain makes to the overall probability of the occurrence of food-borne disease.

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