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The occurrence of indicator bacteria on hands and aprons of food handlers in the delicatessen sections of a retail group

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Abstract

Despite an increase in the number of food handlers receiving food hygiene training, a high number of food poisoning outbreaks still occur as a result of improper food handling practices in the retail industry. In this study, samples were collected from the hands and aprons of food handlers in the delicatessen sections of a prominent South African retail group and analysed for the presence of total viable counts (TVC), total coliforms, *Escherichia coli*, members of the family Enterobacteriaceae and *Staphylococcus aureus* in order to assess the levels of contamination and to establish possible relationships. Noteworthy TVC were present on 98% of hands and 84% of aprons sampled and conformed to the national standard of 1£10^{2}cfucm^{i2} without exception. Coliforms were present on 40% of food handler's hands and on 26% of aprons and when compared to the literature which suggests a target value of <2.5cfucm^{i2}, 32% of food handlers exceeded the target with regard to hands and 8% with regard to aprons. *E. coli* was found to only exceed the limit in the case of one food handler. Enterobacteriaceae were present on the hands of food handlers (44%) and on aprons (16%), ranging between 5 and 1.8£ 10^{1}cfucm^{i2} on hands and between 5 and 2.9£10^{1}cfu cm^{i2} on aprons. *S. aureus* counts were present on 88% of hands and 48% of aprons and ranged between negligible and 9.8£10^{1}cfucm^{i2} for hands and up to 6.2£10^{1}cfucm^{i2} for aprons. No signiWcant statistical correlation occurred between the organisms on hands and aprons, indicating that the latter were not likely to be cross-contaminated by hands.

Keywords: Food hygiene; Food handler; Retail industry

1. Introduction

Data on risk factors for food-borne diseases indicate that the majority of outbreaks result from faulty food handling practices (Clayton, GriYth, Price, & Peters, 2002). In an era of frequent travel, safe food handling practices are imperative given the potential for widespread outbreaks of food-borne illness (Lynch, Elledge, GriYth, & Boatright, 2003). Lacking personal hygiene amongst food handlers is one of the most commonly reported practices contributing to food-borne illness and poor hand and surface hygiene is also a signiWcant contributory factor (Cogan, Slader, BloomWeld, & Humphrey, 2002; Collins, 2001). Contamination of surfaces in food premises has been shown to be associated with poor hygiene standards (Powell & Attwell, 1997; Sagoo, Little, GriYth, & Mitchell, 2003). In most countries, food-borne diseases remain a public health predicament in spite of the improvement in hygiene standards, improved food processing practices, education of food handlers and consumer awareness (Domínguez, Gómez, & Zumalacárregui, 2002).

The hands of food handlers can be pivotal as vectors in the spread of food-borne disease due to poor personal hygiene or cross-contamination (Setiabudhi, Theis, & Norback, 1997). According to Taylor, Brown, Toivenen, and Holah (2000) there is evidence from the food industry to show that microorganisms are transferred to the hands in the process of handling food and through poor personal hygiene after visiting the lavatory, resulting in the hands being heavily contaminated with enteric pathogens. The transmission of enteric-related pathogenic microorganisms via the hands of food handlers thus continues to be a problem in the food industry (Barza, 2004). Hand-washing, a simple and eVective way to cut down on cross-contamination, is all too often forgotten (Rippel, 2002). It was reported that 42% of food-borne outbreaks which took place from 1975–1998 in the United States of America had been caused by the hands of food handlers (Ayçiçek, Aydoƒan, Küçükkaraaslan, Baysallar, & Ba$_{O}$ustaoƒlu, 2004).

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The risk of food-borne illness due to contact with hands or surfaces depends on both the level of contamination as well as the probability of transfer and the importance of contaminated surfaces in relation to potential transmission of pathogens to food is apparent in food processing (Den Aantrekker, Boom, Zwietering, & Van Schothorst, 2003; Kusumaningrum, Riboldi, Hazeleger, & Beumer, 2003). Several studies have indicated that various bacteria, amongst others *Staphylococcus aureus*, *Escherichia coli* and *Salmonella* sp., survive on hands and surfaces for hours or even days after initial contact with the microorganisms (Jiang & Doyle, 1999; Kusumaningrum, Van Putten, Rombouts, & Beumer, 2002; Scott & BloomWeld, 1990). These microbiota have been associated with food-borne illness for decades and there is no doubt that they, together with members of amongst others the genera *Listeria*, *Campylobacter*, *Bacillus* and *Clostridium* are the cause of illness and even death to many people each year, at immeasurable economic cost and human suVering (Borch & Arinder, 2002).

A microbial indicator is a microorganism or group of microorganisms that is indicative of the possible presence of pathogens and the detection and enumeration of indicator organisms are widely used to assess the eYcacy of sanitation programmes (Brown et al., 2000; Ingham, Reyes, Schoeller, & Lang, 2000; Moore & GriYth, 2002). Indicator organisms associated with hygiene practices include, amongst others, total viable counts, total coliforms, *E. coli*, members of the family Enterobacteriaceae and *S. aureus* (Department of Health, 2000). Very little data is available, however, in terms of the limits associated with the occurrence of pathogenic bacteria on hands and aprons, particularly in South Africa currently. The only national standard addresses total viable counts (TVC) on working surfaces as prescribed by the Health Regulations (Republic of South Africa, 1999). This study was therefore aimed at investigating the occurrence of indicator bacteria on hands and aprons of food handlers in a retail group and to determine the relationship between the occurrence of organisms on hands and on aprons. Because the retail group studied have not yet fully implemented a hygiene management system such as HACCP, food handlers have not received adequate training on how hand-hygiene would Wt into, for example, a HACCP daily routine. Information obtained in this study was thus used to streamline training modules in terms of transfer of contaminants from hands to aprons and vice versa. The results were furthermore communicated to management in order to indicate the status of food handling practices of food handlers and to highlight the importance of contaminated surfaces in relation to potential transmission of pathogens to food.

2. Materials and methods

2.1. Pilot study

A pilot study was conducted in an outlet which was not included in the actual test sample and involved six food handlers. The purpose of the pilot study was to determine the time requirements and streamline the methodology, as it was important that the time required for collecting the samples was not perceived by the retail outlet managers to be disruptive to the normal work pattern (Walker, Pitchard, & Forsythe, 2003).

2.2. Sampling protocol

Samples from 50 food handlers' hands (indexWngers, thumbs and palms of both the left and the right hands) as well as from their aprons were collected from a random selection in the delicatessen sections of 35 randomly selected outlets of a prominent retail group in the Western Cape Province, South Africa. Samples were collected by the same surveyor on a once-oV basis during working hours (week days between 10:00 and 14:00) without previous notiWcation of nor the date or time of the survey. A total of 300 samples were collected from the hands of food handlers during the serving of ready-to-eat food and a further 300 samples were collected from the aprons of food handlers. The collected samples were stored and transported at 0°C prior to analysis.

2.3. Sampling procedures and enumeration of bacteria

Upon entering each outlet, the manager was informed about the study and the purpose of collecting samples from food handlers' hands and aprons. After random selection of 50% of workers in the delicatessen section, Rodac plates (MERCK) containing selected agar media were used to sample the foreWnger (*S. aureus*), thumb (total coliform count, *E. coli* and Enterobacteriaceae) and palm (total viable count) of the left and right hand of each worker selected. Rodac Plates containing the various media were furthermore used to sample the aprons, focussing on these areas that are predominantly exposed (six samples were collected per apron). Colonies were diVerentiated on appearance and colour. Since no biochemical identiWcation systems were included, results were reported as presumptive only.

Total viable counts: For the enumeration of TVC, Plate Count Agar plates were incubated at 35°C for 24h (MERCK, Germiston, SA).

Total coliforms, E. coli and members of the family Entrobacteriaceae (Blood & Curtis, 1995; De Boer, 1998): Chromocult coliform agar plates were incubated at 35–37°C for 24h and typical coliforms were salmon to red in colour, whilst typical *E. coli* colonies were dark-blue to violet in colour and members of the family Enterobacteriaceae colonies were colourless (MERCK, Germiston, SA). *E. coli* (ATCC 25922) and *Enterobacter aerogenes* (ATCC 15038) were used as positive controls whereas a blank plate was used as negative control.

S. aureus (Baird & Lee, 1995): Baird Parker Agar plates were incubated at 35°C for 24–48h and typical *S. aureus* colonies (black colonies with white margins surrounded by clear zones) were enumerated. The colonies were conWrmed using the coagulase test (Staphytect test kit, Oxoid) (MERCK, Germiston, SA). *S. aureus* (ATCC 25923) was used as positive control and a blank plate as negative control.

2.4. Statistical analysis

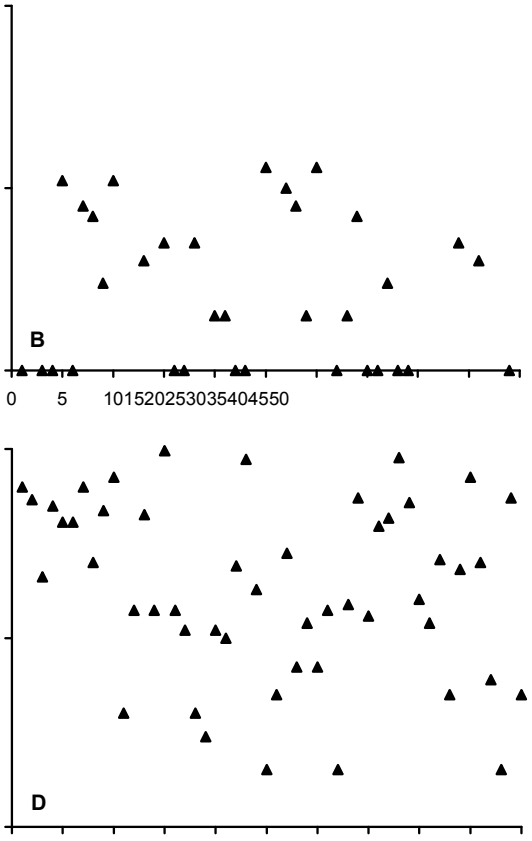
Data were analysed in collaboration with the Department of Biostatistics, University of the Free State using Statistical Analysis Systems (SAS OnlineDoc, 2000). Spearman correlations were calculated between organism counts on the hands and on the aprons, for each organism separately.
Because food handling involves both hands equally, reported data are the means of indexWngers, thumbs and palms per food handler.

3. Results and discussion

3.1. Total viable counts

Noteworthy TVC were detected on the hand palms of the hands (98%) and on the aprons of food handlers (84%). According to the Health Regulations (Republic of South Africa, 1999) a working surface, or any surface which comes into direct contact with food, shall contain no more than 100 viable microorganisms per cm^2 upon analysis. Figs. 1A and 2A show that the TVC for palms as well as for aprons remained below the national standard of 100 viable microorganisms per cm^2 for all 35 outlets, thus based on this guideline, the samples conformed without exception.

TVC on the palms of the hands could be regarded as negligible (one food handler) and the remainder ranged from 5cfucm^{i2} (8% of food handlers) to 8.8£10^1cfucm^{i2} (food handlers 6 and 15). The highest incidences were 8.8£10^1cfucm^{i2} (food handlers 6 and 15); 7.8£10^1 cfucm^{i2} (food handler 32); 5.9£10^1cfucm^{i2} (food handler 1); 5.8£10^1cfucm^{i2} (food handler 4) and 5.1£10^1



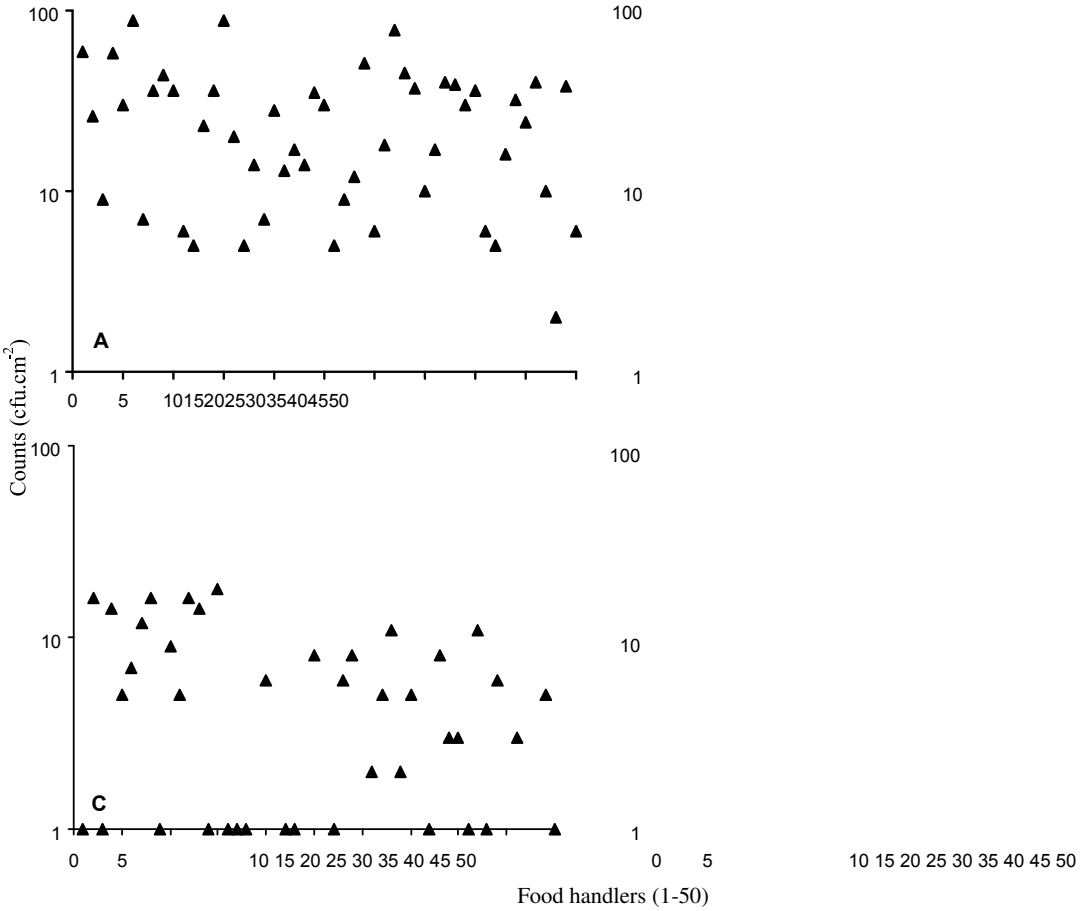


Fig. 1. The patterns of total viable counts (A), total coliforms (B), Enterobacteriaceae (C) and *Staphylococcus aureus* (D) on the hands of food handlers in the delicatessen sections of a retail group. (In cases where $n < 50$ the speciWc organism was not detected.)

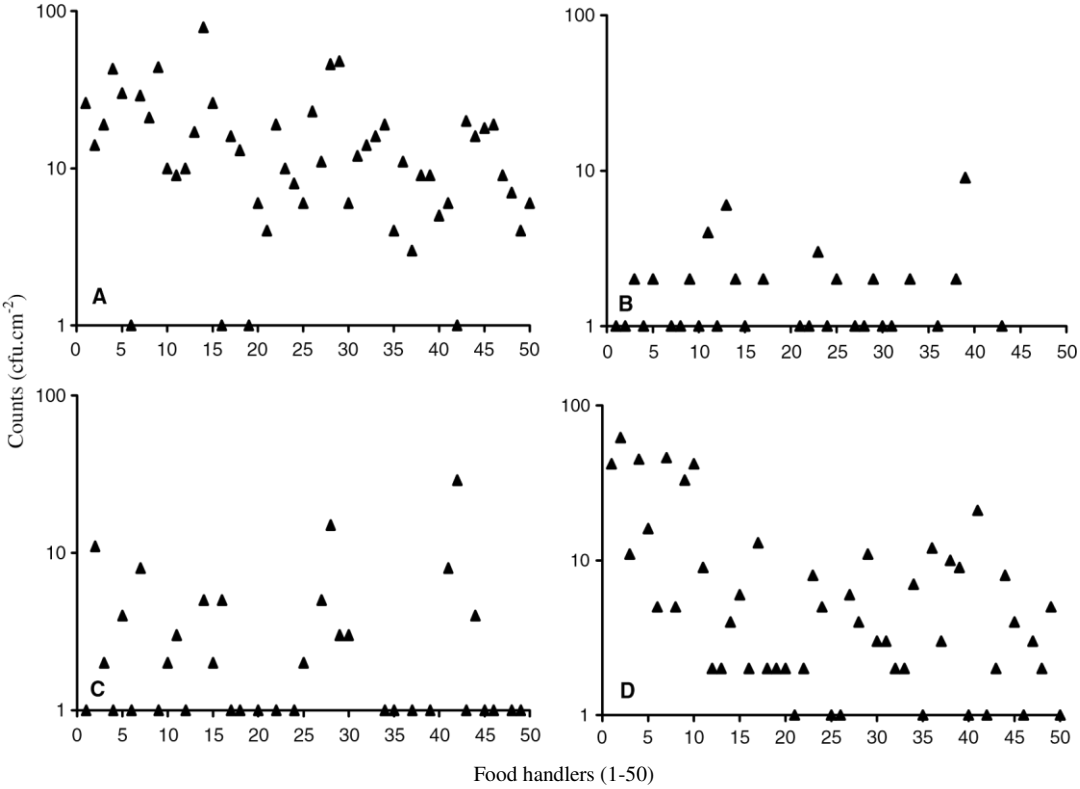


Fig. 2. The patterns of total viable counts (A), total coliforms (B), Enterobacteriaceae (C) and *Staphylococcus aureus* (D) on aprons of food handlers in the delicatessen sections of a retail group. (In cases where $n < 50$ the speciWc organism was not detected.)

cfucm^{i2} (food handler 29). The remainder of the food handlers' hands were shown to have TVC of below 5.0£ 10^{1}cfucm^{i2}, thus only 12% of the food handler's hands exceeded counts of 5.0£10^{1}cfucm^{i2} (Fig. 1A).

Counts on aprons were negligible (8 food handlers) and the remainder ranged from 5cfucm^{i2} (food handler 40) to 7.9£10^{1}cfucm^{i2} (food handler 14). Aprons proved to have lower TVC, not exceeding 5.0£10^{1}cfucm^{i2} except for food handler 14 whose apron had a count of 7.9£10^{1} cfucm^{i2} (Fig. 2A). The highest counts were 7.9£10^{1}, 4.8£10^{1} and 4.6£10^{1}cfucm^{i2}, respectively.

According to Martínez-Tomé, Vera, and Murcia (2000) the hands of food handlers as well as their protective clothing should be kept clean and food handlers should avoid contact with food whenever possible. For many foods, especially those that are ready-to-eat, the cleanliness of food contact surfaces is likely to be identiWed as being critical to food safety (Moore & GriYth, 2002). It should be kept in mind, however, that it is virtually impossible to exclude all microbiota from food-related surfaces except if such surfaces are sterilized—this would be unnecessary as well as unpractical.

3.2. Total coliforms, E. coli and members of the family Enterobacteriaceae

The detection of coliforms is widely used as a means of measuring the eVectiveness of sanitation programmes, their presence indicating a substantially increased risk of the presence of pathogens (Moore & GriYth, 2002). According to Moore and GriYth (2002) no surface speciWcations for coliforms, after disinfection, are commonly available and general microbial target values of <2.5cfucm^{i2} have been suggested and have been found to be attainable for a range of surfaces.

In this study, total coliforms were negligible on the hands (thumbs) of 60% of food handlers and counts ranged between 2cfucm^{i2} (8% of food handlers) and 1.3£10^{1}cfucm^{i2} (food handlers 25 and 30) (Fig. 1B). The highest occurrences were 1.3£10^{1}, 1.1£10^{1}cfucm^{i2} (food handlers 5 and 10, respectively) and 1.0£10^{1}cfucm^{i2} (food handler 27). With regard to aprons, total coliform counts were undetectable on 74% of aprons of food handlers sampled and counts ranged between 2cfucm^{i2} (18% of food handlers) and 9cfucm^{i2} (food handler 39) (Fig. 2B). When comparing the coliform counts found in this study to the suggested general microbial target value of <2.5cfucm^{i2} after cleaning (Moore & GriYth, 2002), 32% of food handlers exceeded the target with regard to coliforms found on hands and 8% exceeded the target with regard to coliforms isolated from aprons of food handlers.

According to De Wit and Rombouts (1992), *E. coli* is normally absent from hands and the presence of *E. coli* is thought to give a better indication of faecal contamination (enteric pathogens in particular) than the entire group of Enterobacteriaceae. *E. coli* was detected on the hands (thumbs) of one food handler (data not shown). This particular individual, who had amongst the highest occurrences of total coliforms on his/her hands (1.1£10^{1} cfucm^{i2}), also showed the presence of *E. coli* (8cfucm^{i2}) (Fig. 1B). No *E. coli* were detected on the aprons of food handlers in any of the 35 outlets. According to Legnani, Leoni, Berveglieri, Mirolo, and Alvaro (2004), the limit for *E. coli* on surfaces is 1cfucm^{i2} and because *E. coli* is an acknowledged indicator for faecal contamination as well as for the possible presence of enteric pathogens (Gill, McGinnis, & Badoni, 1996), the presence of this organism on one respondent is notable. It should be kept in mind that, although not analysed in this study, the isolated *E. coli* could comprise strains such as entero-haemorrhagic *E. coli* O111 or even *E. coli* O157:H7.

For the purposes of this study, Enterobacteriaceae were deWned as, amongst others, members of the genera *Salmonella*, *Shigella*, *Yersinia*, *Proteus* and *Klebsiella* (excluding total coliforms and *E. coli*) and therefore present a holistic view of the presence of these organisms on hands and aprons of food handlers (Nel, Lues, Buys, & Venter, 2004). Enterobacteriaceae counts were not detected on hands (thumbs) of 56% of food handlers while counts ranged between 5cfucm^{i2} (10% of food handlers) and 1.8£ 10^{1}cfucm^{i2} (food handler 15) (Fig. 1C). One particular food handler, who had the highest occurrence of Enterobacteriaceae on hands, also showed the highest occurrence of TVC. A study done by De Wit and Rombouts (1992) indicated that the presence of Enterobacteriaceae on hands is not a good indicator of personal and toilet hygiene, as it appeared that hands might be contaminated with Enterobacteriaceae regardless of toilet use and that the numbers of Enterobacteriaceae on hands were reduced after stools by hand washing; therefore the number of contaminated hands would be very low and furthermore the number of faecal microorganisms would be very small. Members of the Enterobacteriaceae were not detected on 84% of food handler's aprons. With regard to the remainder of the food handlers, counts ranged between 5cfucm^{i2} (6% of food handlers) and 2.9£10^{1}cfucm^{i2} (Fig. 2C).

3.3. Staphylococcus aureus

S. aureus is the predominant species involved in staphylococcal food poisoning outbreaks, which follow the handling of cooked foods by persons who carry enterotoxigenic staphylococci in their nares or on their skin (Angelillo, Viggiani, Rizzo, & Bianco, 2000; Portocarrero, Newman, & Mikel, 2002). Staphylococci are ubiquitously distributed in man's environment and strains present in the nose often contaminate the back of hands, Wngers and face and nasal carriers could therefore easily become skin carriers (Desmarchelier, Higgs, Mills, Sullivan, & Vanderlinde, 1999;

García, Francisco, & Moreno, 1986; Genigeorgis, 1989; Gorman, BloomWeld, & Aley, 2002). Microorganisms on the human skin can be divided into two groups: permanent and transitory; and the only pathogenic microorganism in the permanent group of bacteria associated with the human skin is *S. aureus*. Further, because of the resident character of this microorganism, it is not possible to Wx an acceptable contamination level for *S. aureus* after proper hand washing (Ayçiçek et al., 2004).

Fig. 1D indicates that *S. aureus* were isolated from the hands (indexWngers) of 88% of the population sampled. Levels ranged from undetectable to 9.8£10^{1}cfucm^{i2}. The highest occurrences was 9.8£10^{1}cfucm^{i2} (food handler 15); 9.0£10^{1}cfucm^{i2} (food handler 38) and 8.8£10^{1} cfucm^{i2} (food handler 23). Food handler 15 had the highest count of *S. aureus*, the highest TVC (8.8£10^{1}cfucm^{i2}) as well as the highest Enterobacteriaceae count (1.8£ 10^{1}cfucm^{i2}).

S. aureus was undetectable on 52% of food handlers' aprons (Fig. 2D). Counts ranged between 5cfucm^{i2} (8% of food handlers) and 6.2£10^{1}cfucm^{i2} (food handler 2). The highest counts were 6.2£10^{1}cfucm^{i2} (food handler 2); 4.6£10^{1}cfucm^{i2} (food handler 7); and 4.5£10^{1}cfucm^{i2} (food handler 4). According to Moore, GriYth, and Fielding (2001) an inadequately cleaned surface can, if in contact with food, lead to cross-contamination and contribute to a product's microbial load, which might result in a decreased shelflife. Furthermore, cross-contamination was identiWed as an important contributory factor in 39% of general food-borne disease outbreaks recorded in the UK (Moore et al., 2001).

Figs. 3 and 4 represent the distribution of total viable counts, total coliforms, Enterobacteriaceae and *S. aureus*, using box plots. With regard to microbial contamination on hands, TVC and *S. aureus* appeared relatively similar in terms of their prevalence, 25th and 75th percentile distribution (Fig. 3). The mean TVC were between 3 and 5cfucm^{i2} and the 75th as well as the 95th percentiles on hands exceeded the suggested microbial target value of <2.5cfucm^{i2}. In general, the microbial contamination on hands of food handlers appeared higher than the microbial contamination on aprons (Fig. 4). In the latter case total

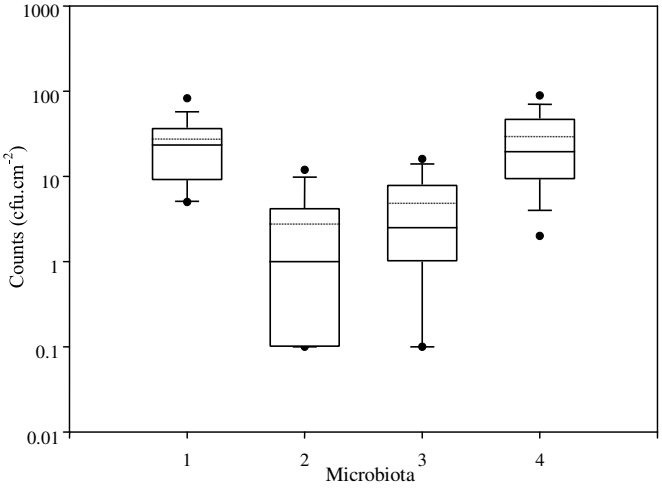


Fig. 3. Microbial contamination on hands of food handlers: each box plot represents the 5th and 95th percentiles (dots below and above box), the 25th and 75th percentiles (bottom and top of box), the median (solid line inside box), the mean (dotted line) and the standard deviation (short solid lines outside box) of total viable counts (1), total coliforms (2), Enterobacteriaceae (3) and *Staphylococcus aureus* (4).

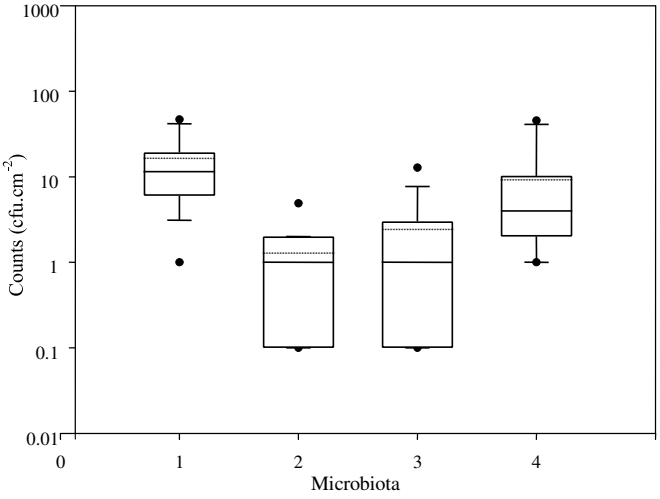


Fig. 4. Microbial contamination on aprons of food handlers: each box plot represents the 5th and 95th percentiles (dots below and above box), 25th and 75th percentiles (bottom and top of box), the median (solid line inside box), the mean (dotted line) and the standard deviation (short solid lines outside box) of total viable counts (1), total coliforms (2), Enterobacteriaceae (3) and *Staphylococcus aureus* (4).

viable counts and total coliforms remained within acceptable target values and the 95th percentiles of TVC and *S. aureus* were in the same range, whereas total coliforms and Enterobacteriaceae counts had similar 25th percentiles and medians. In general, organism counts remained relatively low throughout this study and their distribution as illustrated by the box plots were well below 100cfucm^{i2}.

3.4. The use of gloves

During a survey done at the same localities, it was observed that food handlers wore protective clothing, including gloves, when customers were served (Van Tonder & Lues, 2004). However, no or very little documented evidence exists that food served by gloved hands is safer than food served by bare hands, which have been subjected to eVective hand washing. When retail food personnel use gloves while serving food, they should realise that microorganisms adhere to the surfaces of gloves and thus, when not changed frequently, could be sources of cross-contamination similar to unwashed hands (Snyder, 1997). However, gloves have the added disadvantage that if individuals do not wash their hands before putting on gloves, both the interior and exterior of the gloves become contaminated. Hand-washing is often neglected or omitted when gloves are used and organisms on the hands could multiply rapidly inside the moist and warm environment of the gloves (Ayçiçek et al., 2004).

3.5. Relationships between the occurrence of organisms on hands and aprons

Spearman correlations were calculated, using SAS/STAT (1989), between organism counts on the hands and on the aprons of food handlers (Table 1). This was done in order to establish whether cross-contamination was apparent between hands and aprons. Although *S. aureus* had the highest positive correlation between counts on the hands and on the aprons (*r*D0.56), a correlation of 0.7 and higher is regarded as a strong correlation. However, taking into account the signiWcant *P*-value of 0.0001, one should assume that a moderate correlation between *S. aureus* on the hands and the aprons of food handlers is of consequence.

Table 1
Relationships between organism counts on hands and aprons

Organism	Correlation[a]
Total viable count	0.26 (*P* D 0.07)
Total coliform count	0.22 (*P* D 0.13)
Enterobacteriaceae	0.24 (*P* D 0.10)
Staphylococcus aureus	0.56 (*P* D 0.0001)

[a] Spearman's correlations between organism counts on hands and aprons.

In conclusion, with regard to coliforms, 32% of hands and 8% of aprons exceeded the suggested general microbial target value after cleaning of <2.5cfucm^{i2} suggested by Moore and GriYth (2002). Because the delicatessens deal with ready-to-eat foods and is thus regarded as a high-risk area, the cleanliness of food contact surfaces is likely to be critical to food safety and the prevention of cross-contamination. This emphasises the importance of adequate cleaning and sanitation. Throughout the study, counts remained much lower on aprons than on hands of food handlers and therefore the latter are more likely to pose a higher risk of cross-contamination to food than aprons. Taking into consideration the limited data available regarding the limits associated with the organisms isolated in this study and the fact that the suggested *E. coli* limit was only exceeded by one food handler, the relatively low numbers of organisms found indicate that the majority of respondents complied with proper hand-washing practices.

It was, however, alarming that in two instances (food handlers 10 and 15) these individuals had relatively high counts of all the organisms investigated in this study—one of which tested positive for the presence of *E. coli*. Although the majority of food handlers thus reXected a sound knowledge and practice of personal and process hygiene, experience has learnt that it takes only one event of contamination with undesirable pathogenic microbiota to have disastrous consequences.