Microbiological Analysis of Food Contact Surfaces in Child Care Centers

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Received 6 March 2008/Accepted 16 September 2008

A study of six child care centers was conducted to assess the microbiological quality of three food contact surfaces (one food serving surface and two food preparation surfaces) and one non-food contact surface (diaper changing surface) to determine the effectiveness of cleaning and sanitization procedures within the facilities. Aerobic plate counts (APCs) and Escherichia coliiform counts of 50-cm² areas on all surfaces were determined using standard microbiological swabbing methods. Samples were taken three times a day (preopening, lunchtime, and following final cleanup) twice per month for 8 months in each child care center (n = 288 sampling times). Mean log APCs over the survey period were 1.32, 1.71, 1.34, 1.96, 1.50, and 1.81 log CFU/50 cm² for the six centers. Mean coliform counts were 0.15, 0.40, 0.33, 1.41, 0.28, and 1.12 CFU/50 cm² for the same centers. Coliforms were detected in 283 of 1,149 (24.7%) samples, with counts ranging from 1 to 2,000 CFU/50 cm², while E. coli was detected in 18 of 1,149 (1.6%) samples, with counts ranging from 1 to 35 CFU/50 cm². The findings of this study demonstrated that the extent of bacterial contamination was dependent on the center, time of day, and the area sampled. While no direct correlation between contamination and illness can be made, given the high risk of food-borne illness associated with children, microbial contamination of food contact or non-food contact surfaces is an aspect of food safety that requires more attention. Emphasis on training and the development of modified standard sanitation operating procedures for child care centers are needed to reduce potential hazards.

Child care centers have become an integral part of today’s society. The Children’s Defense Fund reported that, in 2000, 60% of all preschoolers, toddlers, and infants attended child care centers daily (http://www.childrensdefense.org/site/PageServer?pagename=research_national_data_child_care_basics). Sixty-five percent of mothers in the labor force have children under age 6, and 78% have children between ages 6 and 13. Additionally, 51% of mothers with infants (children under age 1) are in the labor force (13). While child care centers provide a necessary and important service, they may serve as a focal point for certain types of infectious diseases. For example, Todd et al. (12) suggested that child care centers were particularly vulnerable to food-borne illness outbreaks because the caregivers were often involved in food preparation, serving, and cleaning up after infants and young children. Children attending child care are generally at higher risk for gastrointestinal tract illnesses than other youth (15). According to the Centers for Disease Control and Prevention (CDC), food-borne illness causes approximately 5,000 deaths each year and approximately one-third of those are children (4). Outbreaks of Shigella sonnei gastroenteritis in child care centers have been reported in eight states by the CDC since 2001 (2, 3). Spread of the bacterium was likely from person to person through poor hygiene of workers or inadequate sanitation (2). Todd et al. (12) reported four outbreaks in day care centers associated with a Salmonella sp., norovirus, probable norovirus (small round structured virus), and Shigella. The largest occurred in Sweden in 1999, with 195 cases of norovirus in 30 day care centers arising from pumpkin salads brought in by a caterer. Because child care centers are an important part of society, there is a need to assess ongoing sanitation of potential food contact and non-food contact surfaces within these facilities.

Food contact surfaces are a major concern for food service facilities in controlling the spread of food-borne pathogens. The physical environment of a child care center may influence factors such as hygiene and food preparation, both of which may in turn play roles in the transmission of infectious disease among children (10). Food service areas are considered critical to health, and therefore the bacteriological quality of these surfaces as well as non-food service surfaces in child care centers must be assessed. Although many cases of food-borne illness have been attributed to inadequate cooking, temperature abuse, and the use of contaminated raw ingredients, cross-contamination between raw and cooked foods via food contact surfaces also has been identified as a significant risk factor (5). Environmental microbiological studies have suggested that the use of easily cleaned surfaces could help reduce environmental contamination and thus its role in the transmission of disease.

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in child care centers (10). Studies also have shown that both the contact surface and the level of organic matter can influence the survival of food-borne pathogens on food contact surfaces (5, 6). The objective of this study was to survey the bacteriological contamination on selected food contact and non-food contact areas in child care centers to develop a baseline for future comparisons.

MATERIALS AND METHODS

Sampling sites and surface selections. A microbiological survey was conducted in six Knoxville-Knox County, TN, child care facilities. The facilities were selected at random from all child care centers in the area. Three centers with >100 children (large) and three centers with ≤50 children (small) were selected. Each child care center was tested twice monthly over the course of an 8-month period for a total of 16 sampling periods per center. Four areas within the child care centers were sampled: one food service area (classroom or cafeteria surface), one diaper changing area, and two food preparation areas (two separate locations in the food preparation area or kitchen). All surfaces were assayed three times daily, including preopening (prior to 6:30 a.m.), during lunch (11:00 a.m. to ca. 1:00 p.m.), and following final snack time and cleanup of the day (ca. 3:00 p.m. to 4:30 p.m.), to monitor the microbiological quality of each surface throughout the day.

Sample preparation for microbiological analysis. The sampling area was delineated with a sterile stainless steel template which exposed a surface area of 50 cm². All surfaces were swabbed using separate Quick Swabs (3M Microbiology, St. Paul, MN), which contain Letheen neutralizing broth. Sampling was performed by swabbing the area in accordance with the manufacturer’s instructions. After sampling, the swabs were marked with an identification code and placed in food storage bags in an insulated tote bag and transported to the Food Microbiology Laboratory at The University of Tennessee within 15 to 45 min of sampling. Samples were stored at 4°C until testing, and all samples were analyzed within 1 h of arrival at the laboratory.

Microbiological counts. Each swab solution (1 ml) was plated on aerobic count Petrifilm plates (3M Microbiology), and plates were incubated at 32°C for 48 h. Upon the completion of incubation, plates were counted on a standard colony counter.

Sampling procedures for Escherichia coli and coliform counts were done in a similar manner to that for the aerobic plate counts (APC). After surface swabbing was completed, 1 ml of swab solution was plated and incubated at 32°C for 24 to 48 h according to the manufacturer’s instructions on E. coli/Petrifilm count Petrifilm plates (3M Microbiology). Results for all counts were reported as the number of CFU per 50 cm².

Analysis of variance for log APC (Table 1) showed no significant effect of date of sampling (P > 0.23), suggesting the centers were consistent in their log APC over the span of the experiment. Some of the studied centers systematically (P < 0.0001) exhibited higher log APC, with an average 0.6 log difference between maximum and minimum counts (Table 2). The time of the day for sampling over all the studied centers was statistically significant (Table 3). While sampling location did not have a significant effect itself (Table 4), significant center-area interaction was observed (P = 0.0395), suggesting the difference between maximum and minimum counts (Table 2).

RESULTS

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Coliform counts were significantly different among child care centers (P < 0.0001) and consistent during the experiment.

TABLE 3. Mean bacterial counts on surfaces in child care centers by time of sampling (n = 384 for each time) a

<table>
<thead>
<tr>
<th>Time</th>
<th>Mean APC (log CFU/50 cm²)</th>
<th>Mean coliform count (log CFU/50 cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preopening</td>
<td>1.61 †</td>
<td>0.51‡</td>
</tr>
<tr>
<td>Lunch</td>
<td>1.68‡</td>
<td>0.84§</td>
</tr>
<tr>
<td>Postcleanup</td>
<td>1.50‡</td>
<td>0.46§</td>
</tr>
</tbody>
</table>

 a Different symbols within columns indicate significant differences by the Tukey test (α = 0.05).
child care centers may be due to a number of factors, including personnel hygiene, cleaning and sanitizing practices, and design and/or construction of facilities. For example, the availability of hand washing facilities could be a factor. Allwood and others (1) investigated the availability of hand washing facilities in 123 retail food establishments and determined that inaccessibility of hand washing facilities had an impact on the frequency of hand washing. Only 68 (55%) of the retail food establishments in the study were fully equipped with proper and accessible hand washing facilities. Petersen and Bressler (10) performed an environmental microbiological study in child day care centers where hands of caregivers within the centers were sampled. The authors concluded that hands are a major contributor to fecal contamination and that hand washing facilities should be readily available to staff and children. All centers in the study used the same sanitization practice, i.e., use of a diluted hypochlorite bleach solution in a spray bottle to treat surfaces. Differences between preparation methods, time of storage prior to making new solutions, and cleaning steps prior to use of sanitizing solution were found. Other factors could have involved separation of functions. Thompson (11) studied the control and transmission of infectious diarrhea in child care settings. The author concluded that the design and construction of child care centers were of importance and indicated that the separation of diaper changing and toilet areas from food handling and eating areas is desirable. In the present study one center was equipped with a designated cafeteria. While it was in a group with the lowest APC and coliform counts, two other centers without cafeterias also had the same counts. Therefore, separation of areas is not absolutely necessary to maintain low counts throughout the center as long as adequate sanitation is maintained.

Sampling times for the centers were preopening, during lunch, and postcleanup. For lunchtime, samples were made randomly without regard to what activity was occurring, i.e., food preparation, food serving, etc. Therefore, it was anticipated that the lunch sampling time would produce higher microbiological counts than the other two sampling times. Results showed that mean log APC obtained at preopening and lunchtime were significantly higher ($P < 0.05$) than those following final cleanup of the day. An average 1.61 log CFU was observed for the three sampling times, with a maximum 0.18 log CFU difference between maximum counts at lunchtime and postcleanup. Therefore, while there was a significant difference, it was not a large practical difference. A significant interaction between time of sampling and center ($P < 0.0107$)
was detected (Table 1), meaning that the log APC recorded at preopening, lunchtime, and final cleanup did not follow similar trends in all centers studied, with most (four of six) exhibiting maximum counts when samples were taken near lunchtime. Similarly, coliform counts were highest at lunchtime. However, the time-center interaction was significant ($P < 0.027$; Table 1), with two of the six centers having the highest coliform counts at preopening and four of the six centers having the lowest coliform counts postcleanup. These findings can be attributed to the fact that, during lunchtime, there is increased traffic and activity within the centers. This findings are in agreement with a study by Haysom and Sharp (7), who reported that contamination levels in domestic kitchens varied during the day but peaked during meal preparation. As expected, following the final cleanup of the day, the lowest mean log APC and coliform counts were detected. There was an increase in mean log APC from the end of the day to the start of the next day, which may indicate surfaces were being contaminated after the centers are cleaned and sanitized. Again however, while there was a significant difference, it was of little practical significance.

The mean log APC for areas within centers were not significantly different, while the diaper changing area had the lowest coliform counts (Table 4). There was an expectation that the diaper changing areas may have higher bacterial counts than other areas; however, this was not the case. The overall mean coliform count for diaper changing areas was low (0.44 log CFU/50 cm²). Using Rodac plates, Petersen and Bressler (10) reported that the mean APC for restaurant tabletops was approximately 1.39 log CFU/50 cm² and the total coliform count was 0.68 log CFU/50 cm². In contrast to the results of Yepiz-Gomez et al. (14), the frequencies of coliform and E. coli detection were much lower in child care centers (24.6% and 1.6%, respectively) than in restaurants and bars (70% and 20%, respectively).

The surfaces sampled during the study (i.e., food serving, diaper changing, and food preparation areas) were made of various materials, including plastic laminate, acrylic solid surface, stainless steel, plastic-covered pads, and grouted ceramic tile. The only area with the same surface material in all centers was the food serving area, which was plastic laminate. Therefore, the log APC data were analyzed for this area and surface. Center 1 had significantly lower counts than the other centers (Table 5). The difference may have been because of the condition of the surface, i.e., presence of scratching, cuts, etc.; however, no evaluation of condition was done because of the subjectivity of such an assessment. More likely, the cleaning and sanitizing program of center 1 was more effective than those of the other centers.

The overall frequency of coliform-positive samples by time within an area was lowest for the food preparation areas following cleanup (5.0%; Table 6). For the food serving area the lowest number of positive coliform samples was found at preopening (5.5%). For the diaper changing area, the preopening and postcleanup samples were approximately equal. Positive E. coli samples were collected in the diaper changing area throughout the day. The next most prevalent E. coli site was at lunch on one of the food preparation areas; however, the maximum count of this site was 2 CFU E. coli/50 cm². Results indicate that, while the diaper changing area may have a generally low mean APC and coliform count, the potential incidence of E. coli is greater than for other areas.

The purpose of this study was to determine the level of bacterial contamination on food contact and non-food contact surfaces in child care centers. Without such information, it is impossible to determine the extent of bacterial contamination in child care centers and if it is actually a problem. Additionally, this information is important to determine if systems designed to improve the cleaning and sanitizing in such centers are having an effect. The findings of the study illustrate that bacterial contamination is present on food contact surfaces and non-food contact surfaces of child care centers but that counts are generally low and there is a low incidence of indi-

### Table 6: Frequencies of Coliform- and E. coli-positive samples in child care centers by sampling time and area sampled

<table>
<thead>
<tr>
<th>Organism(s) and time</th>
<th>Food serving area ($n^a = 289$)</th>
<th>Diapering area ($n = 288$)</th>
<th>Food preparation area ($n = 575$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%) of positive samples</td>
<td>Range $^b$</td>
<td>No. (%) of positive samples</td>
</tr>
<tr>
<td>Coliforms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preopening</td>
<td>16 (5.5)</td>
<td>1–133</td>
<td>19 (6.6)</td>
</tr>
<tr>
<td>Lunch</td>
<td>36 (12.5)</td>
<td>1–2,000</td>
<td>31 (10.8)</td>
</tr>
<tr>
<td>Postcleanup</td>
<td>24 (8.3)</td>
<td>1–354</td>
<td>20 (6.9)</td>
</tr>
<tr>
<td>E. coli</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preopening</td>
<td>0 (0)</td>
<td></td>
<td>2 (0.7)</td>
</tr>
<tr>
<td>Lunch</td>
<td>0 (0)</td>
<td></td>
<td>3 (1.0)</td>
</tr>
<tr>
<td>Postcleanup</td>
<td>1 (0.3)</td>
<td>7</td>
<td>4 (1.4)</td>
</tr>
</tbody>
</table>

$^a$ $n$, total number of samples for each area.

$^b$ Range of coliforms or E. coli bacteria/50 cm² or actual count for area.
cators such as coliforms and *E. coli*. Results indicated that factors such as the center itself (e.g., personnel, cleaning protocols), areas within the center, and time of day can have an effect on the level of bacterial contamination present. All of these are directly or indirectly related to sanitation. Effective cleaning and sanitizing of food contact and non-food contact surfaces in child care centers are critical if cross-contamination is to be reduced. It is concluded that development of a set of standard sanitary operating procedures such as those used by the food industry and food service industry should be developed to assist child care center staff (directors, cooks, and teachers) with effective cleaning and sanitizing of surfaces to reduce potential hazards.

**ACKNOWLEDGMENT**

Funding for this project was provided by the United States Department of Agriculture Cooperative States Research, Education and Extension Service National Integrated Food Safety Initiative, grant no. USDA 2003-51110-02078.

**REFERENCES**


