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Major article

Hygienic conditions in child-care facilities in North Carolina and South Carolina: An integrated microbial and observational study

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Background: In the United States almost one-quarter (23%) of children younger than age 5 years participate in some form of out-of-home child care; these children are 2.3-3.5 times more likely to contract acute gastrointestinal illness.

Methods: Observational investigations were done to understand the hygienic conditions and practices of 40 child-care facilities in North Carolina and South Carolina. These data were compared with microbiological indicator data (aerobic plate counts and coliform counts) collected from selected surfaces in each facility. Results from the two data sets were analyzed using nonparametric statistical methods to reveal potential risk factors for enteric disease transmission.

Results: Statistically significant differences ($P \leq .05$) in surface microbial counts were observed when comparing family child-care homes versus centers and between facilities participating in the Child and Adult Care Food Program and those that do not participate. Facilities without written surface cleaning or food preparation policies had statistically significantly higher microbial counts on surfaces.

Conclusions: Our unique study, which combined observational and microbiological data, provided revealing information about the relationship between hygiene indicators and sanitary practices in child-care facilities in the southeastern United States.

Reliance on out-of-home child care in the United States has increased dramatically since the 1940s. During World War II, only 8.6% of mothers with children younger than age 18 years were in the workforce. Today, 67% of mothers with children younger than age 6 years work outside the home and 61% of children in this age group receive nonparental care, half of which is center-based, whereas the other half is home-based care.[1] The close and frequent personal contact between children and between children and their care providers in child-care settings provides many opportunities for pathogens to spread, particularly those that cause acute gastrointestinal illness (AGI). In a comprehensive review of reported outbreaks between 1996 and 2006, Lee and Greig[2] identified 75 AGI outbreaks in the child-care environment, 93.4% of which were caused by bacteria and viruses in near equal proportions; the rest (6.6%) were attributed to parasitic protozoa. Episodes of AGI associated with child care are estimated to cost $2.3 billion each year.[3]

Children in child care are reported to be 2.2-3.5 times more likely to get diarrhea, a common symptom of AGI, than those cared for in their own homes.[4] Many outbreaks in child-care settings are related to child-to-child or child-to-care provider transmission; however transmission related to the contamination of environmental surfaces and staff hands may also play an important role. Other studies that have sought to evaluate the importance of environmental contamination as a risk factor for AGI have used two approaches. In the first, investigators sought to determine the presence and amount of microbial contamination on the hands of child-care workers, and/or on common, high-touch nonporous surfaces, such as diaper-changing tables and toys. Most of these studies used classic microbiological indicators as proxies for general cleanliness or adequate hygienic conditions

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(eg, fecal coliforms).[5-8] In only two studies was pathogen detection applied, and these focused on the presence of viruses, specifically influenza A virus and rotaviruses, as evaluated using molecular techniques.[9,10]

Survey studies are the second major approach used to study risk factors for AGI in child-care environments. These studies are usually designed to evaluate the degree of compliance with pertinent regulatory provisions[11-13] or compliance with key hygiene interventions (eg, hand washing, diaper changing, and food preparation).[14,15] In those studies, data were collected by direct observation,[16,17] questionnaires,[11,12] interviews with staff,[14,15] or by focus groups.[13]

Both microbiological and survey study designs have their own advantages and disadvantages. It is generally recognized that when used alone, neither is very effective in establishing causal relationships for AGI transmission. Aside from 1 study,[6] microbiological and survey study designs are rarely done in conjunction with one another, nor are the data analyzed to determine if microbiological data are associated with disease risk, human behavior, and/or adherence to recommended practices or procedures. Clearly, a research study integrating both approaches would maximize the utility of the findings, enabling better understanding of potential risk factors for microbial contamination in child-care settings. The aim of our study was to determine if there were significant relationships between concentrations of key microbiological indicators (eg, total aerobic bacteria and coliform counts) and hygienic conditions in child-care facilities.

MATERIALS AND METHODS

Sample and surface selection

A total of 508 child-care facilities (115 in North Carolina and 393 in South Carolina) were contacted to participate in the study. Eighteen North Carolina and 22 South Carolina child-care facilities agreed to participate and were visited by a team of trained data collectors from September 2010 through February 2011. Most facilities ($n = 31$; 77.5%) were classified as centers and 9 (22.5%) as homes. Environmental samples were collected from common high-touch surfaces (eg, faucet and refrigerator handles, toys, diaper-changing areas, and eating tables) as well as the hands of care providers and food workers. Each facility was visited once and the average number of samples taken per visit was 16 (range, 10-20 samples). To maintain confidentiality, all sampling data were coded and the analyst conducting the microbiological testing was blinded to sample identity.

Observer interrater reliability testing was conducted with the 7 data collectors via a 5-minute video exercise where data collectors audio-recorded surfaces touched by a child-care provider as well as her location as she moved around different areas in a room (eg, handwashing and diaper-change area). Each data collector was required to be at least 85% accurate to the gold standard observer.[18,19] The gold standard observer in this study was an RTI Research consultant who had prior practice observing and recording surfaces in 3 child-care facility classrooms. All observers passed the interrater reliability after the second round of testing.

Design and implementation of the survey instruments

At the beginning of the site visit, directors of participating facilities were given a brief (10 minutes) questionnaire to complete while the trained data collectors conducted an audit of facility activities. Questionnaire items were adapted from a survey of demographic and food safety training information previously collected from child-care center directors in Texas and Iowa[13] and from a survey of restaurant food safety training and policies previously administered to restaurant managers in 6 states.[20] As shown in Table 1, the questionnaire included the following sections: training, facility policies, facility characteristics, and employee and child health. Items about employee and child health were adapted from health log questions used in another previously published child-care study.[21]

For each facility, data collectors completed audits in up to two classrooms (eg, 1 infant room and 1 toddler room) and the food preparation area. The audit form was designed to assess the hygienic conditions of the rooms and was based on North Carolina and South Carolina environmental health regulations for child-care centers.[22,23] If the regulations were different for the two states, then we used the more restrictive regulation as the basis for the audit item included on the form. During the audit, information was also collected on characteristics, practices, and procedures, including but not limited to child-care provider ratios, diaper trashcan and hand-hygiene practices, and written procedures for cleaning and food preparation. Each audit form consisted of a checklist in which data collectors checked “Yes” for compliance, “No” for deviation, or “NA” for “not applicable.” Space was also provided to describe deviations or to provide other comments.

To ensure questionnaire items were interpreted as intended and audit forms captured the appropriate information, both were pretested in 5 child-care facilities in North Carolina before data collection began. Following the pretest, minor changes were made to both instruments to improve readability and enhance understanding of the items.

Surface and hand sample acquisition procedure

Environmental sampling was done using the 10 mL Swab-Sampler Letheen Broth (3M, St Paul, Minn). Flat surfaces, such as food serving and diaper-changing areas, were delineated into 100 cm^2 areas using a 10 $\times$ 10 cm flexible cardboard template (Weber Scientific, Hamilton, NJ). Irregular surfaces, such as toys or faucet and refrigerator handles, were swabbed over the entire area without the aid of a template. The swab was first pressed on the interior wall of the vial to release excess moisture and swabbed over the target area, reversing direction with each stroke. This procedure was repeated twice using different swabbing directions for each replicate. The swab was then deposited back in the Letheen Broth tube, sealed, and placed on ice packs in an insulated cooler.

Sampling of the hands of child-care staff (ie, care providers and food workers) was done in accordance with the method of Kampf et al.[22] Briefly, the fingertips of each hand were dipped into a Petri plate (9 cm diameter) containing 10 mL Tryptic Soy Broth (Thermo Fisher Scientific, Lenexa, KS). Participants were instructed to rub their fingertips gently together for a period of 1 minute. The sampling fluid for each hand was then aseptically transferred in its entirety to sterile capped plastic vials and placed on ice packs in an insulated cooler. All environmental and hand samples were collected after the environmental audits were completed. All samples (hand and surface) were shipped to North Carolina State University for microbial analysis that was initiated within 24 hours (usually 12-18 hours) after sample collection. The study protocol was reviewed and approved by the institutional review boards for North Carolina State University, Clemson University, and RTI International’s Committee for the Protection of Human Subjects.

Microbial indicator analysis assays

The Petrifilm Aerobic Count method (3M) was used in accordance with manufacturer instructions to enumerate total aerobic