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Research Note

A Preliminary Evaluation of the Effect of Glove Use by Food Handlers in Fast Food Restaurants

ROBERT A. LYNCH,* MARGARET L. PHILLIPS, BRENDA L. ELLEDGE, SRIDHAR HANUMANTHAIAH, AND DANIEL T. BOATRIGHT

University of Oklahoma Health Sciences Center, Department of Occupational and Environmental Health, 801 N.E. 13th Street, Oklahoma City, Oklahoma 73104, USA

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ABSTRACT

A study was conducted to determine whether the levels of selected microorganisms differed on foods handled by gloved and bare hands at fast food restaurants. Three hundred seventy-one plain flour tortillas were purchased from fast food restaurants and analyzed for *Staphylococcus aureus, Escherichia coli, Klebsiella* sp., coliform bacteria, and heterotrophic plate count bacteria. Approximately 46% of the samples were handled by workers wearing gloves compared with 52% of samples with bare hand contact. Coliform bacteria were found in 9.6% of samples handled by gloved workers and 4.4% of samples handled by bare hands, although this difference was not statistically significant. The distribution of heterotrophic plate count bacteria, a general measure of hygiene, was also higher in samples handled by gloved workers in one restaurant chain. The presence of *E. coli, Klebsiella* sp., and *S. aureus* was detected in one, two, and eight samples, respectively, and there were no significant differences between samples handled by gloved or bare hands. Neither direct contact of the tortilla with the food preparation surface nor gender of the worker affected the level of any organism tested. The observed tendency of food workers to wear the same pair of gloves for extended periods and complacency might account for the apparent failure of gloves to reduce or prevent bacterial contamination. The results further suggest that glove use might be counterproductive because workers might wash their hands less frequently when gloved.

All retail food preparation requires some level of human contact. Hands can come into contact with processing containers, money, raw food, food packaging, cleaning substances, disinfectants, body parts, door handles, sink faucets, and human wastes in any facility, and it has been shown that these types of surfaces are frequently contaminated with pathogenic bacteria *(9, 13, 16).* Because these bacteria are efficiently transferred from contaminated products to hands *(3, 21, 22, 25)* and from hands to food *(1),* the potential for hands to become contaminated is high. The majority of outbreaks associated with food workers involve transmission of the pathogen to food by the food worker's hands *(5, 10, 11),* which frequently have been shown to be contaminated with *Salmonella, Escherichia coli, Staphylococcus aureus* and other bacteria *(6).* Workers have also been shown to arrive at work at food processing facilities with coliform bacteria and *E. coli* on their hands *(8).*

The Federal Food Code prohibits contact between hands and ready-to-eat foods and stresses the minimization of bare hand contact with not-ready-to-eat foods *(24).* States and local jurisdictions have largely adopted this language into their own food codes with minor adjustments; however, few codes prohibit any contact between bare hands and ready-to-eat foods. In actuality, it is difficult to discern from State Food Codes whether glove use is required or not. For example, State Food Codes in Oklahoma and Kansas contain virtually identical language regarding the protection of food contamination from hands *(12, 18).* The only substantive difference is that the Oklahoma Code states ''food employees shall avoid contact with exposed ready-to-eat food with their bare hands,'' whereas the Kansas Code states ''food employees may not contact ready-to-eat foods with their bare hands.'' It could be difficult to comprehend the meaning of these subtle differences in language, but in practice, the State of Kansas requires glove use whereas Oklahoma does not.

There are proponents and detractors for both approaches *(10, 19).* Proponents of glove use cite the obvious barrier between skin and food, the sanitary condition of new gloves, the difficulty of adequate hand sanitation even for motivated employees, added environments for disease-causing organisms such as bandages, and the public perception that food prepared by gloved hands is more sanitary. Detractors of glove use cite the cost of gloves, the inadequacy of gloves if they are not frequently changed, the proven efficacy of hand washing in reducing levels of disease-causing organisms *(2, 4, 17),* and the complacency of glove wearers about strictly following sanitary procedures, such as washing hands.

* Author for correspondence. Tel: 405-271-2070; Fax: 405-271-1971; E-mail: robert-lynch@ouhsc.edu.

TABLE 1. *Prevalence of microorganisms on food products tested*

Organism	No. positive/ no. tested (%)
E. coli	1/371 (0.3)
S. aureus	8/371 (2.2)
Klebsiella sp.	2/371 (0.5)
Total coliform	24/359 (6.5)

MATERIALS AND METHODS

Sample collection and analysis. The initial goal was to identify a food that was widely consumed, was handled extensively during preparation, would likely enter a facility in sanitary condition, and could be observed by sample collectors during its preparation. After consideration of many different foods, flour tortillas were chosen as a test subject. Our sampling procedure involved ordering a single flour tortilla at each facility and observing the following: gloved or bare hands used by food handler, gender of handler, whether the tortilla was placed on a wrapper or a counter, time to service, and any other notable practices or circumstances. Time to service, used as a surrogate for employee work load at the store, was defined as the interval between when the sample collector entered the service line at the store and when the tortilla was received by the collector. Samples were collected during lunchtime hours (11:00 a.m. to 1:30 p.m.) between May 2003 and August 2003 from chain establishments in the Oklahoma City and Tulsa, Okla., metropolitan areas and in the Wichita, Kans., metropolitan area. Three different chains were sampled in Oklahoma and two in Wichita. Chains 2, 3, and 4 operated in Oklahoma and chains 1 and 3 operated in Wichita. Approximately 140 establishments were sampled in all. Because of the cost, time, and logistics of travel for sample collection, selection of establishments for sampling was not randomized. To obtain roughly equal numbers of gloved and bare hand samples, establishments that used gloves were sampled more often (up 13 times) than establishments that did not use gloves.

Each sample was left in its wrapper, sealed in a sterile container, numbered, and placed in a cooler for holding and transport. Samples were delivered to the laboratory of the Oklahoma City-County Health Department within 4 h of collection, where they were processed and tested for the presence or absence of coliform bacteria, fecal coliform bacteria, *Klebsiella* sp., *E. coli*, and *S. aureus*, and heterotrophic bacteria were enumerated. The analytical procedures followed the U.S. Food and Drug Administration *Bacteriological Analytical Manual* (8th edition) recommendations for food samples *(23).* Sample processing consisted of aseptically removing approximately 25 g of tortilla tissue from each sample and placing it in a sterile glass blender container with 225 ml of phosphate-buffered dilution water followed by culture in appropriate growth media and incubation.

To assess background levels of bacteria on the food items, 82 unopened packages of tortillas were collected from various establishments representing all four chains in both states. In the laboratory, a single tortilla was randomly selected from each package and processed and tested for microorganisms as described above for the field samples.

Statistical analysis. Because the sample collection was not randomized with respect to date and location, it is somewhat problematic to define the ''population'' for which statistical inferences can be drawn from the sampling data. However, because each chain was sampled in rough proportion to its total number of stores in the study areas, the data can be treated at least provisionally as representative across all chains over the period of the study.

TABLE 2. *Univariate analysis of total coliform contamination rate in all establishments*

All chains	Total coliform contamination rate	95% confidence interval	No. of samples[a]
Bare hands	0.044	0.019–0.085	182
Gloved hands	0.096	0.056–0.151	167
Big tortilla	0.078	0.048–0.119	243
Small tortilla	0.028	0.003–0.097	72
Female worker	0.071	0.038–0.118	183
Male worker	0.057	0.027–0.106	157
Served in <2.5 min	0.064	0.035–0.107	203
Served in ≥2.5 min	0.072	0.036–0.125	153
Surface contact	0.065	0.028–0.123	124
No surface contact	0.062	0.034–0.102	225
Background samples	0	0–0.044	82

[a] Samples with ambiguous or incomplete observational data were omitted.

Univariate analysis of the effect of glove use, tortilla size, gender of preparer, time to service, and surface contact on the rate of contamination with coliform bacteria aggregated over all chains was performed by comparing exact 95% binomial confidence intervals computed with the Solver nonlinear optimization tool in Microsoft Excel. Differences between dichotomous factors were considered statistically significant if their confidence intervals did not overlap.

Because the heterotrophic plate counts (HPCs) for all chains varied over a broad range, the cumulative distributions of HPC data were plotted to allow convenient qualitative comparison between chains. The vertical axis of the plot shows the counts per milliliter on a log scale for a given sample data point, and the horizontal axis shows the cumulative percentage of the data that have HPC values less than that data point. Unquantified results (<100 or >50,000 counts per ml) were used in the determination of cumulative percentiles but were omitted from the plots.

RESULTS AND DISCUSSION

Three hundred seventy-one samples were collected; 46% were handled by gloved hands and 52% had bare hand contact (eight samples were handled in a different fashion, such as a worker wearing one glove). Glove use was 93% for the 172 samples from Kansas, whereas in Oklahoma, glove use was 4.7% for the 191 samples collected. The rate of detection of potentially pathogenic microorganisms was low overall (Table 1). Because the numbers of organisms were not enumerated, it is difficult to discern the level of risk presented by these findings. No potentially pathogenic microorganisms were detected on the background samples.

Only the coliform bacteria occurred frequently enough to warrant statistical analysis of the effects of potential risk factors (Table 2). Statistically significant differences from background were found only for samples from gloved hands and for large tortillas. No statistically significant differences were found between any of the dichotomous risk factors. However, the point estimates of the contamination rate in samples from gloved hands (9.6%) and samples from

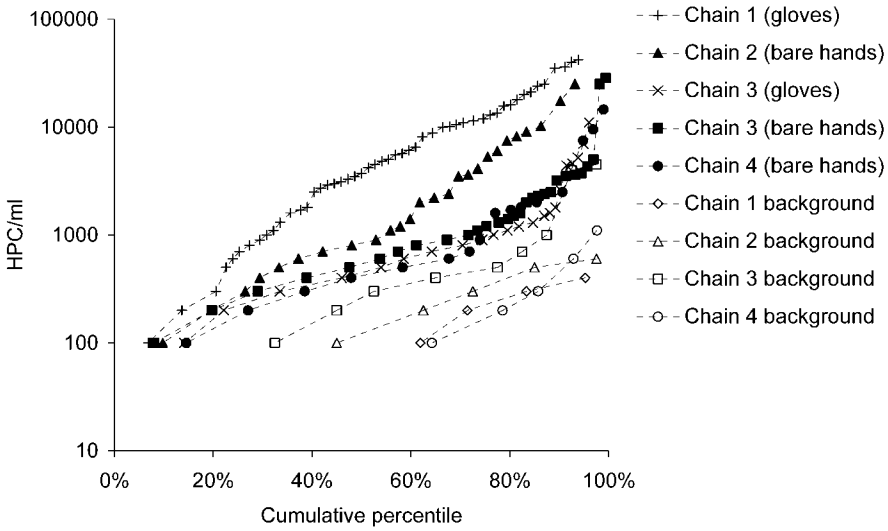

FIGURE 1. *Cumulative distribution of bacterial counts from all chains.*

bare hands (4.4%) fell outside each others' 95% confidence intervals, suggesting that a true underlying difference is not unlikely. On the basis of the contamination rate observed in this study for bare hand contact across all chains, a sample size of about 500 bare hands and 500 gloved hands would be needed to detect a doubling of the contamination rate at a significance level of 0.05 with a power of 0.80.

Cumulative distribution plots of HPC (Fig. 1) indicated differences in general levels of bacterial contamination among food samples from the four chains. Chain 1, which used gloves, tended to have higher bacterial counts than the other chains; however, no difference was found between the distributions of the HPC data from samples from chain 3 handled with gloves or with bare hands. Chain 2 also showed a tendency toward higher bacterial counts than chains 3 or 4. Differences in work practices and the layout of the food handling areas, rather than differences in glove use, could account for these results.

Overall, the results of this study suggest that use of gloves by food handlers does not reduce bacterial contamination of foods and might even increase the risk of microbial contamination. The doubling of the rate of coliform detection for all samples handled by workers with gloved versus bare hands and the quadrupling of this rate of detection for a single restaurant chain is suggestive of a lack of attention to good glove use practices. During this study, we observed several instances in which previously used gloves were reused, and we never observed glove wearers changing gloves in the midst of food preparation. Given the levels of surface bacteria that have been reported in food service settings, it is not surprising that organisms were transferred to the foods that were tested.

Similar studies in the United Kingdom that analyzed bacterial levels on hamburgers, chicken sandwiches, and cooked rice *(14, 15)* from take-out foods found *E. coli* and *S. aureus* in some samples. For hamburgers, *E. coli* was found at approximately the same frequency as was seen in this study (<1%); however, this study found *S. aureus* in 2.2% of samples compared with <1% in the U.K. study. The Public Health Laboratory in the United Kingdom has published guidelines for acceptable levels of a number of bacteria in take-out foods *(7, 20)*. On the basis of these criteria, most of the foods that we sampled did not contain HPC bacteria at high enough levels to be considered as less than satisfactory, although it should be noted that 50,000 organisms was the upper detection limit of the laboratory method and 10 samples exceeded this value. Because potentially pathogenic bacteria were not enumerated in this study, it is not possible to ascertain whether these guidelines were exceeded.

This study was limited by its scope and analytical techniques. Because of the low incidence of detection of potentially pathogenic bacteria, the sample size in this study was too small for a doubling of the incidence to be statistically significant at $P < 0.05$. The sample was limited to four chains in three metropolitan areas, and selection of establishments for sampling was not randomized, which limits the ability to generalize the findings. In addition, only a portion of the tortilla was sampled for testing, so it is possible, although perhaps unlikely, that the area of the tortilla tested was not touched during handling by food service personnel. In addition, the representativeness of the samples to overall contamination rate could be questioned because the ordering of plain tortillas seems to have been viewed as an unorthodox request; therefore, samples might have been handled differently from other foods.

The method described in this paper provides a model for future studies to determine whether the use of gloves is effective in preventing the transfer of pathogens to food. The debate continues as to whether food is prepared more safely by workers using bare hands or those wearing gloves. Both food managers and employees prefer glove use because it is easier to check for compliance, although in practice, it has often been found that glove use provides a false sense of security because food handlers misuse gloves or neglect washing their hands when gloves are worn.

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REFERENCES

1. Bidawid, S., J. M. Farber, and S. A. Sattar. 2000. Contamination of foods by food handlers: experiments on Hepatitis A virus transfer to food and its interruption. Preventing potential risks of foodborne outbreaks in food service operations. *Appl. Environ. Microbiol.* 66: 2759–2763.
2. Charbonneau, D. L., J. M. Ponte, and B. A. Kochanowski. 2000. A method of assessing the efficacy of hand sanitizers: use of real soil encountered in the food service industry. *J. Food Prot.* 63:495–501.
3. Chen, Y., K. M. Jackson, B. P. Chea, and D. W. Shaffner. 2001. Quantification and variability analysis of bacterial cross-contamination rates in common food service tasks. *J. Food Prot.* 64:72–80.
4. Curtis, V., and S. Cairncross. 2003. Effect of washing hands with soap on diarrhea risk in the community: a systematic review. *Lancet Infect. Dis.* 3:275–281.
5. Daniels, N. A., L. Mackinnon, S. M. Rowe, N. H. Bean, P. M. Griffin, and P. S. Mead. 2002. Foodborne disease outbreaks in United States schools. *Pediatr. Infect. Dis. J.* 21:623–628.
6. De Wit, J. C., and E. H. Kampelmacher. 1981. Some aspects of microbiological contamination of hands of workers in food industries. *Zentral. Bakteriol. Mikrobiol. Hyg. 1 Abt. Orig. B* 172:390–400.
7. Gilbert, R. J., J. de Louvois, T. Donovan, C. Little, K. Nye, C. D. Ribeiro, J. Richards, D. Roberts, and F. J. Bolton. 2000. Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. *Comm. Dis. Publ. Health.* 3:163–167.
8. Gill, C. O., and J. C. McGinnis. 2003. Microbiological effects of hand washing at a beef carcass-breaking facility. *J. Food Prot.* 66: 493–496.
9. Griffith, C. J., R. Malik, R. A. Cooper, N. Looker, and B. Michaels. 2003. Environmental surface cleanliness and potential for contamination during handwashing. *Am. J. Infect. Cont.* 31:93–96.
10. Guzewich, J., and M. P. Ross. 1999. Evaluation of risks related to microbiological contamination of ready-to-eat food by food preparation workers and the effectiveness of interventions to minimize those risks. U.S. Food and Drug Administration. Available at: http://www.cfsan.fda.gov/~ear/terisk.html. Accessed 15 October 2004.
11. Hillers, V. N., L. Medeiros, P. Kendall, G. Chen, and S. DiMascola. 2003. Consumer food-handling behaviors associated with prevention of 13 foodborne illnesses. *J. Food Prot.* 66:1893–1899.
12. Kansas Administrative Regulations. 28–36. Kansas Department of Health and Environment. Food Service Establishments, Food Vending Machine Companies and Lodging Establishments. Available at: http://www.kdhe.state.ks.us/regs/. Accessed 15 October 2004.
13. Kassa, H., B. Harrington, M. Bisesi, and S. Khuder. 2001. Comparisons of microbiological evaluations of selected kitchen areas with visual inspections for preventing potential risk of foodborne outbreaks in food service operations. *J. Food Prot.* 64:509–513.
14. Little, C. L., J. Barnes, and R. T. Mitchell. 2002. Microbiological quality of take-away cooked rice and chicken sandwiches: effectiveness of food hygiene training of the management. *Comm. Dis. Public Health* 5:289–298.
15. Little, C. L., I. A. Gillespie, and R. T. Mitchell. 2001. Microbiological contamination of ready-to-eat burgers sampled anonymously at the point of sale in the United Kingdom. *Comm. Dis. Public Health* 4:293–299.
16. Mattick, K., K. Durham, M. Hendrix, J. Slader, C. Griffith, M. Sen, and T. Humphrey. 2003. The microbial quality of washing-up water and the environment in domestic and commercial kitchens. *J. Appl. Food Microbiol.* 94:842–848.
17. Montville, R., Y. Chen, and D. Schaffner. 2002. Risk assessment of hand washing efficacy using literature and experimental data. *Int. J. Food Microbiol.* 73:305–313.
18. Oklahoma Administrative Code. Title 310—Oklahoma State Department of Health. Chapter 256. Food Service Establishments. Available at: www.sos.state.ok.us/oar/oar_welcome.htm. Accessed 15 October 2004.
19. Paulson, D. S. 1997. Foodborne disease. Controlling the problem. *J. Environ. Health* 59(9):15–19.
20. Public Health Laboratory Service. 2000. Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. *Comm. Dis. Public Health* 3:163–167.
21. Rusing, P., S. Maxwell, and C. Gerba. 2002. Comparative surface-to-hand and fingertip-to-mouth transfer efficiency of gram-positive bacteria, gram-negative bacteria, and phage. *J. Appl. Microbiol.* 93: 585–592.
22. Scott, E., and S. F. Bloomfield. 1990. The survival and transfer of microbial contaminants via cloths, hand and utensils. *J. Appl. Bacteriol.* 68:271–278.
23. U.S. Department of Health and Human Services. 2001. Food and Drug Administration. Center for Food Safety and Applied Nutrition. Bacteriological analytical manual online. January 2001. USDHHS. Washington, D.C. Available at: http://www.cfsan.fda.gov/~ebam/bam-toc.html. Accessed 15 October 2004.
24. U.S. Department of Health and Human Services. 2001. Public Health Service. Food and Drug Administration. 2001 Food Code. USDHHS, Washington, D.C.
25. Zhao, P., T. Zhao, M. P. Doyle, J. R. Rubino, and J. Meng. 1998. Development of a model for evaluation of microbial cross-contamination in the kitchen. *J. Food Prot.* 61:960–963.