

Changing Dirty Diapers



A 2007 outbreak of shigellosis in Florida affecting 46 children was associated with multiple child-care facilities. The most important risk factor for illness was having a diaper changed.

A 2010 E. coli outbreak at a Vancouver, Washington daycare led to the death of a four-year-old boy and four hospitalizations. Investigators believe risky diapering procedures may have been a factor.

Public Health Reasons

Fecal contamination during diapering is one route of transmission of gastrointestinal disease-causing pathogens. Children in child-care centers commonly excrete intestinal pathogens even if not presenting symptoms. For example, noroviruses can be shed in the feces of children for at least 25 days after symptoms have stopped. Similarly, rotavirus can be shed for 25-57 days after the onset of diarrhea in a child. Continued shedding of pathogens in the feces of asymptomatic children can increase the transmission to healthy individuals.

During diaper changing, the diaper-changing pad or the diaper-changing table may come into contact with dirty diapers and fecal matter. When other children are placed on this common surface, contamination of their hands and clothes may occur. The children may then transmit the pathogens to environmental surfaces (such as shared toys or an eating table) that other children handle. In a study by Jiang et al., a person with clean hands touched a contaminated ball, then touched a clean ball, and passed it down a line of people. The hands of the first three of five participants tested positive for the contaminant.

After children's hands become contaminated, they may introduce pathogens into their bodies with mouthing behavior. Object-to-mouth contact is much greater among children than adults, and viruses and bacteria are more readily transferred from contaminated objects or hands directly to the mouth. Therefore, it is important to use a diapering procedure designed to reduce the risk of transferring pathogens from an infected individual to a healthy one.

Practices

Diaper Changing Procedure

- Wash hands before bringing the child to the diaper changing area (see “Hand Hygiene For Care Providers” fact sheet).
- Gather and bring the necessary items to the diaper changing table if they are not already there:
 - non-absorbent paper liner large enough to cover the changing surface from the child’s shoulders to beyond the child’s feet;
 - a fresh diaper;
 - wipes for cleaning a child's genitalia and buttocks, removed from the container or dispensed so the container will not be touched during diaper changing;
 - clean clothes and a plastic bag for any soiled clothes, if needed;
 - gloves, to be worn before handling the diaper or any soiled items; and
 - when appropriate, a thick application of diaper cream dispensed from the container onto a piece of disposable material such as facial tissue, acquired before commencing with the diaper change.
- Carry the child to the changing table, keeping soiled clothing away from you and any surfaces you cannot easily clean and disinfect after the change.
- Place the child on the diaper-changing surface.
 - Always keep a hand on the child.
 - Remove the child’s shoes and socks, so the child does not contaminate these surfaces with stool or urine during the diaper change.
 - Put soiled clothes in a plastic bag and securely tie the plastic bag to send home.
- Unfasten the diaper, but leave it under the child.
- Lift the child’s legs as needed to use disposable wipes to clean the skin on the child’s genitalia and buttocks.
- Remove stool and urine by wiping from front to back, using a fresh wipe each time.
- Put the soiled wipes into the soiled diaper or directly into a plastic-lined, hands-free, covered trashcan.
- Remove the soiled diaper without contaminating any surface not already in contact with stool or urine.
- Fold the soiled surface of the diaper inward, and put soiled disposable diapers in a plastic-lined, hands-free, covered trashcan. If reusable cloth diapers are used, put the soiled cloth diaper and its contents (without emptying or rinsing) in a plastic bag to give to parents or into a plastic-lined, hands-free, covered can for the laundry service.
- If gloves were used, remove them carefully and put them into a plastic-lined, hands-free, covered trashcan.
- Check for spills under the child. If there are any, use the paper that extends under the child’s feet to fold over the dirty paper so a fresh, unsoiled paper surface is under the child’s buttocks.
- Slide a fresh diaper under the child.

Changing Dirty Diapers

- Use a facial or toilet tissue to apply any necessary diaper creams, discarding the tissue in a covered, plastic-lined, hands-free trashcan.
- Fasten the diaper and replace clothing, socks, and shoes.
- Wash the child’s hands first. Then wash hands (see “Hand Hygiene For Care Providers” fact sheet).

Cleaning a Child’s Hands After Diapering

Traditional Handwashing

Use this method for children who can stand alone or be easily and safely supported at a hand sink:

- Wet the child’s hands under clean, running water between 60°F and 120°F (16°C and 49°C).
- Help the child apply soap and rub hands together vigorously for 10 to 15 seconds covering all surfaces of the hands, fingers, and wrists.
- Rinse his hands with clean, warm, running water between 60°F and 120°F (16°C and 49°C).
- Immediately following handwashing, thoroughly dry the child’s hands with one of the following:
 - individual, disposable, paper towels;
 - a continuous towel system that supplies the user with a clean towel;
 - a heated-air hand-drying device; and
 - a hand-drying device that employs an air-knife system that delivers high velocity, pressurized air at ambient temperatures.

Wiping Method

If a child cannot stand or be safely supported at the sink, use the following method to wash the child’s hands:

- wipe the child’s hands with a damp paper towel moistened with a drop of liquid soap;
- wipe the child’s hands with a paper towel wet with clean water; and
- dry the child’s hands by wiping with a clean, dry paper towel.

References

1. American Academy of Pediatrics, American Public Health Association, & National Resource Center for Health and Safety in Child Care and Early Education. 2011. *Standard 3.014 diaper change procedure. Caring for our children: National health and safety performance standards; Guidelines for early care and education programs*. 3rd Edition. Elk Grove, IL: American Academy of Pediatrics, Washington, D.C.; American Public Health Association.
2. Aronson, A. S., & Shope, T. R., eds. 2008. *Managing infectious diseases in child care and schools: a quick reference guide*. 2nd Edition. Elk Grove Village, IL: American Academy of Pediatrics.
3. Bradley, S., Kilpatrick, H., & Silverman, J. 1991. Diapers and day care. *Journal of American Medical Association*, 266 (17): 2371.
4. Jiang, X., Dai, X., Goldblatt, S., Buescher, C., Cusack, T. M., Matson, D. O., & Pickering, L. K. 1998. Transmission in child care settings studied by using a cauliflower virus DNA as a surrogate marker. *The Journal of Infectious Diseases*, 177 (4): 881-888.
5. Kirkwood, C. D. & Streitberg, R. 2008. Calicivirus shedding in children after recovery from diarrheal disease. *Journal of Clinical Virology* 43:346-348.
6. Fraser, K. 2007. Shigella in childcare centers: a citrus county outbreak. Florida Department of Health. http://webcache.googleusercontent.com/search?q=cache:zK6kgAm0JM4J:www.doh.state.fl.us/disease_ctrl/epi/Statewide/Conference_Materials/presentations/28-Fraser.Kim_text.rtf+&cd=1&hl=en&ct=clnk&gl=us&client=firefox-a (accessed October 9, 2012).
7. Nwachuku, N. & Gerba, C. P. 2004. Microbial risk assessment: don't forget the children. *Current Opinion in Microbiology* 7:206-209.
8. Pickering, L. K., Bartlett, A. V., & Woodward, W. E. 1986. Acute infectious diarrhea among children in day care: Epidemiology and control. *Reviews of Infectious Diseases* 8 (4): 539-547.
9. Richardson, S., Grimwood, K., Gorrell, R., Palombo, E., Barnes, G., & Bishop, R. 1998. Extended excretion of rotavirus after severe diarrhoea in young children. *Lancet* 351(9119):1844-1848.

Authors and Acknowledgements

AUTHORS: Cortney Miller, MS, Angela Fraser, PhD, Roman Sturgis, MFA (editor), Xi Chen, MS, Anna Saunders. Department of Food, Nutrition, and Packaging Sciences, Clemson University, Clemson, SC 29634

Published: March 31, 2013 **Revised:** February 27, 2013

This material is based upon work supported by the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-51110-04335, the National Integrated Food Safety Initiative of the Cooperative State Research, Education, and Extension Competitive Grants Program. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

CLEMSON
UNIVERSITY



RTI
INTERNATIONAL

NC STATE UNIVERSITY

Cleaning and Disinfecting Diaper-Changing Surfaces



A 2007 outbreak of shigellosis in Florida affecting 46 children was associated with multiple child-care facilities. The most important risk factor for illness was having a diaper changed.

A 2010 E. coli outbreak at a Vancouver, Washington daycare led to the death of a four-year-old boy and four hospitalizations. Investigators believe risky diapering procedures may have been a factor.

Public Health Reasons

Dirty diapers containing fecal matter can be the source of pathogens that cause gastrointestinal illness. Children in child-care centers commonly excrete intestinal pathogens even if not presenting symptoms. For example, noroviruses can be shed in the feces of children for at least 25 days after symptoms have stopped. Similarly, rotavirus can be shed for 25-57 days after the onset of diarrhea in a child. Continued shedding of pathogens in the feces of asymptomatic children can increase the transmission to healthy individuals.

Surfaces and fomites play an important role in the spread of pathogens. During diaper changing, the diaper-changing pad or the diaper-changing table may come into contact with dirty diapers and fecal matter. Many pathogens can survive for long periods of time on environmental surfaces. For example, noroviruses can survive up to 42 days at room temperature when dried onto a surface. When child-care providers and children come in contact with contaminated diaper-changing surfaces, pathogens may be transmitted from the surfaces to their hands or clothes, and then they may spread pathogens to other children and the child-care environment. In a study by Jiang et al., a person with clean hands touched a contaminated ball, then touched a clean ball, and passed it down a line of people. The hands of the first three of five participants tested positive for the contaminant.

It is important to clean and disinfect surfaces in and around the diaper-changing area because classroom objects in close proximity to diaper-changing areas can become contaminated, making them a source of gastrointestinal pathogens. Both sanitizers and disinfectants are products regulated by the Environmental Protection Agency (EPA). However, there are some differences in the two. Disinfectants are used on hard inanimate surfaces and objects to destroy or irreversibly inactivate infectious fungi, viruses, and bacteria, but not necessarily their spores. Sanitizers are used to reduce, but not necessarily eliminate, bacteria from the inanimate environment to levels considered safe as determined by public health codes or regulations. When cleaning diaper-changing areas, it is important to use a disinfectant.

Practices

Clean and disinfect *all* surfaces in the diaper-changing area every time a diaper is changed.

Cleaning

- Clean any visible soil from the changing surface using a reusable cloth or a paper towel dipped in warm water and a detergent.
- Rinse surfaces with warm to hot water to remove cleaning products and suspended debris.

Disinfecting

- Wet the entire changing surface with a disinfectant that is appropriate for the surface material you are treating. Follow the manufacturer's instructions for use.
- Let the solution stand for the contact time given on the label. Make sure there is enough disinfecting solution on the surface that it does not dry up before the recommended contact time ends.
- Be sure to get disinfectant on all areas of the changing table and other surfaces in the diaper-changing area.
- Let surfaces air dry before using.

Recommended Disinfectants

See EPA list of registered products effective against noroviruses. Follow product labels for use and dilution:

- Ethyl or isopropyl alcohol (70-90%)
- Sodium hypochlorite (5.25-6.15% household bleach diluted 1:10)
- Phenolic germicidal detergent solution
- Iodophor germicidal detergent solution

References

1. American Academy of Pediatrics, American Public Health Association, & National Resource Center for Health and Safety in Child Care and Early Education. 2011. *Standard 3.2.1.4 diaper change procedure. Caring for our children: National health and safety performance standards; Guidelines for early care and education programs*. 3rd Ed. Elk Grove Village, IL: American Academy of Pediatrics, Washington, D.C.; American Public Health Association.
2. Aronson, A. S. & Shope, T. R. eds. 2008. *Managing infectious diseases in child care and schools: a quick reference guide*. 2nd Edition. Elk Grove Village, IL: American Academy of Pediatrics.
3. Bradley, S., Kilpatrick, H., & Silverman, J. 1991. Diaper and day care. *Journal of American Medical Association* 266 (17): 2371.
4. Doultree, J. C., Druce, J. D., Birch, C. J., Bowden, D. S., & Marshall, J. A. 1999. Inactivation of feline calicivirus, a Norwalk virus surrogate. *Journal of Hospital Infections* 41:51–57.
5. Escudero, B. I., Rawsthorne, H., Gensel, C., & Jaykus, L. A. 2012. Persistence and transferability of noroviruses on and between common surfaces and foods. *Journal of Food Protection* 75(5):927-935.
6. Fraser, K. 2007. Shigella in childcare centers: a citrus county outbreak. Florida Department of Health. http://webcache.googleusercontent.com/search?q=cache:zK6kgAm0JM4J:www.doh.state.fl.us/disease_ctrl/epi/Statewide/Conference_Materials/presentations/28-Fraser.Kim_text.rtf+&cd=1&hl=en&ct=clnk&gl=us&client=firefox-a (accessed October 9, 2012).
7. Ekanem, E. E., DuPont, H. L., Pickering, L. K., Selwyn, B. J., & Hawkins, C. M. 1983. Transmission dynamics of enteric bacteria in day-care centers. *American Journal of Epidemiology* 118:562-72.
8. Jiang, X., Dai, X., Goldblatt, S., Buescher, C., Cusack, T. M., Matson, D. O., & Pickering, L. K. 1998. Transmission in child care settings studied by using a cauliflower virus DNA as a surrogate marker. *The Journal of Infectious Diseases* 177 (4): 881-888.
9. Kirkwood, C. D., & Streitberg, R. 2008. Calicivirus shedding in children after recovery from diarrheal disease. *Journal of Clinical Virology* 43:346-348.
10. Richardson, S., Grimwood, K., Gorrell, R., Palombo, E., Barnes, G., & Bishop, R. 1998. Extended excretion of rotavirus after severe diarrhoea in young children. *Lancet* 351(9119):1844-1848.
11. U.S. Environmental Protection Agency. 2009. EPA's registered antimicrobial products effective against norovirus (norwalk-like virus). http://www.epa.gov/oppad001/list_g_norovirus.pdf (accessed October 1, 2012).

Authors and Acknowledgements

AUTHORS: Cortney Miller, MS, Angela Fraser, PhD, Roman Sturgis, MFA (editor), Xi Chen, MS, Anna Saunders. Department of Food, Nutrition, and Packaging Sciences, Clemson University, Clemson, SC 29634

Published: March 31, 2013 **Revised:** February 28, 2013

This material is based upon work supported by the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-51110-04335, the National Integrated Food Safety Initiative of the Cooperative State Research, Education, and Extension Competitive Grants Program. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.



Designated Space and Equipment for Diaper Changing



A 2010 E. coli outbreak at a Vancouver, Washington daycare led to the death of a four-year-old boy and four hospitalizations. Investigators believe risky diapering procedures may have been a factor.

A 2007 outbreak of shigellosis in Florida affecting 46 children was associated with multiple child-care facilities. The most important risk factor for illness was having a diaper changed.

Public Health Reasons

Physical factors, such as diaper-changing equipment, sinks, and toilet availability play a role in the transmission of pathogenic microorganisms. Surfaces that are porous, cracked, or damaged increase the likelihood that pathogens will escape disinfection and allow transmission. Frequently contacted surfaces, such as diaper-changing stations, are at greater risk of transmitting pathogens.

Although many child-care providers have received training on hand-hygiene, the deficiencies in equipment surface and diapering locations in child-care centers may also affect the transmission of pathogenic microorganisms. Also, classroom objects in close proximity to diaper-changing areas can become contaminated. Contaminated objects are a source of gastrointestinal pathogens.

Kotch et al. found that high-quality equipment, characterized by seamless, impermeable countertops and touchless faucets and cabinet doors, are associated with significantly fewer episodes of diarrhea among children and fewer sick days among staff. Improved staff hygiene, sanitation, and disinfecting behavior as well as state-of-the-art diapering and food-preparation equipment are necessary for optimal prevention of gastrointestinal illness.

Practices

Diaper-Changing Areas

These areas must:

- *never* be located in food preparation areas
- *never* be used for temporary placement of food or utensils
- be washable, with all surfaces, including the walls and floors, made of a nonporous material with no cracks or crevices that are difficult to clean and disinfect

Designated Space and Equipment for Diaper Changing

- be designed to prevent contamination of surfaces during, and as a result of, the diaper-changing process
- have at least one diaper-changing table per infant (<1 years old) or toddler (1-4 years old) group to allow sufficient time for changing diapers and for cleaning and disinfecting between uses
- be conveniently located
- take into account whether caregivers must provide simultaneous supervision of other children in the group (the diaper-changing table must be positioned to allow caregivers/teachers to maintain constant sight and sound supervision of other children)
- be used only by those children in one group/class (diaper-changing tables must not be placed between or shared between classrooms)
- be organized to maximize the opportunity for one-on-one time between the child and the teacher/caregiver
- not have carpets, porous fabrics, or other surfaces that can trap soil and potentially contaminate materials

Containers For Soiled Diapers

- The receptacles must be washable, plastic-lined, and tightly covered, with a firm fitting cover that does not require touching to open.
- The receptacles must be provided within an arm's reach of the diaper-changing table (i.e., the care provider does not have to walk away from the table to dispose of the diaper).
- Separate containers must be used for disposable diapers, cloth diapers (if used), and soiled clothes and linens.
- All containers must be inaccessible to children and must be tall enough to prevent children from reaching into the receptacle or from falling into the containers.
- The containers must be placed in an area that children cannot enter without a care provider's supervision.
- The soiled diaper container must be labeled to show its intended contents.
- Soiled diaper containers must be cleaned daily to keep them free from build-up of soil, pathogens, and odor (see "Cleaning and Disinfecting High-touch Surfaces" fact sheet).
- The following types of soiled diaper containers must *not* be used:
 - those that require the user's hand to push the diaper through a narrow opening
 - those with exterior surfaces that must be touched with the hand
 - those with exterior surfaces that are likely to be touched with a soiled diaper while the user is discarding it
 - those that have lids with handles

Handwashing Sinks

- Handwashing sinks must be provided within the diaper-changing area.
- They must be within a few steps of the changing area. Every effort must be made to minimize the distance between the changing tables and handwashing sinks.
- A minimum of one handwashing sink must be available for every two changing tables.
- Handwashing sinks must not be used for bathing a child or removing smeared fecal material from clothes, toys, or any other items.
- Shared access to soap and disposable towels at areas with more than one sink is acceptable if the location of these is fully accessible to all sinks.

Changing Tables

Diaper-changing tables must be:

- made of moisture-proof, nonabsorbent, smooth surfaces that do not trap soil and are easily disinfected
- sturdy
- at a convenient height (between 28” and 32” high) for use by caregivers
- equipped with railings or barriers that extend at least 6 inches above the change surface
- free of restraining straps or any other objects that pose an additional challenge to cleaning and disinfecting after each diaper change
- nonporous, kept in good repair, and cleaned and disinfected after each use to remove visible soil and microorganisms (See “Cleaning and Disinfecting Diaper Changing Surfaces” fact sheet)

References

1. American Academy of Pediatrics, American Public Health Association, & National Resource Center for Health and Safety in Child Care and Early Education. 2011. *Caring for our children: National health and safety performance standards; Guidelines for early care and education programs*. 3rd Ed. Elk Grove Village, IL: American Academy of Pediatrics; Washington, DC; American Public Health Association.
2. Aronson, A. S., & Shope, T. R. eds. 2008. *Managing infectious diseases in child care and schools: a quick reference guide*. 2nd Ed. Elk Grove Village, IL: American Academy of Pediatrics.
3. Centers for Disease Control and Prevention (CDC). 2012. National Center for Health Statistics. <http://www.cdc.gov/nchs/> (accessed October 30, 2012).
4. Ekanem, E. E., DuPont, H. L., Pickering, L. K., Selwyn, B. J., & Hawkins, C. M. 1983. Transmission dynamics of enteric bacteria in day-care centers. *American Journal of Epidemiology* 118:562-72.
5. Kotch, J. B., Isbell, P, Weber, D. J., Nguyen, V., Savage, E., Gunn, E., Skinner, M., Fowlkes, S., Verk, J., and Allen, J. 2007. Hand-washing and diaper equipment reduce disease among children in out-of-home child care centers. *Pediatrics* 120 (1): e29-36.
6. Laborde, D. J., Weigle, K. A., Weber, D. J., & Kotch, J. B. 1993. Effect of fecal contamination on diarrheal illness rates in day-care centers. *American Journal of Epidemiology* 138:243–255.
7. Muldoon, K. 2010. Vancouver child's illness spirals into deadly grip of *E. coli*. *Oregon Live*. http://www.oregonlive.com/news/index.ssf/2010/04/vancouver_childs_illness_spira.html (accessed October 2, 2012).

Authors and Acknowledgements

AUTHORS: Cortney Miller, MS, Angela Fraser, PhD, Roman Sturgis, MFA (editor), Xi Chen, MS, Anna Saunders. Department of Food, Nutrition, and Packaging Sciences, Clemson University, Clemson, SC 29634

Published: March 31, 2013 **Revised:** February 27, 2013

This material is based upon work supported by the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-51110-04335, the National Integrated Food Safety Initiative of the Cooperative State Research, Education, and Extension Competitive Grants Program. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.



NC STATE UNIVERSITY

Disposing of Dirty Diapers



Public Health Reasons

Microorganisms can be transmitted to people and other surfaces from droplets leaking from a child's diaper, as well as the improper disposal of a soiled diaper, such as placing a soiled diaper on the ground. These microorganisms can include gastrointestinal pathogens. Because infants (younger than 12 months old) are especially effective carriers of enteric pathogens (pathogens present in the human gastrointestinal tract), soiled diapers increase microbial pathogens in solid waste and impact human health. Storing and handling soiled diapers increases the potential for contamination and the spread of infection. Barlett et al. studied the association of hygiene behavior indicators with persistent diarrhea of young children. They found that six behavioral indicators maintained significant association with persistent diarrhea in young children. Three of those indicators were associated with dirty diapers: the presence of a fecally soiled diaper on the floor, the presence of feces in the play area, and a child wearing a fecally soiled diaper.

Practices

After Changing A Diaper

- Fold the soiled surface of the diaper inward.
- Put soiled, disposable diapers in a plastic-lined, covered, hands-free receptacle.
- The hands-free receptacle must be within arm's reach of the child-care provider.
- Soiled diapers do not have to be individually bagged before disposal.
- See "Vomiting and Fecal Episodes" fact sheet for proper methods of disposing fecal waste, including diapers.

Cloth Diapers

- Do not rinse or dump cloth diapers at the child-care facility.
- Soiled cloth diapers must be stored in a labeled container with a tight-fitting lid provided by an accredited commercial diaper service or in a sealed plastic bag for removal by the family.
- Send the sealed plastic bag home with the child at the end of the day.
- The containers or sealed diaper bags of soiled cloth diapers must be placed out of reach of children, and away from food or toys.

References

1. American Academy of Pediatrics, American Public Health Association, & National Resource Center for Health and Safety in Child Care and Early Education. 2011. *Caring for our children: National health and safety performance standards; Guidelines for early care and education programs*. 3rd edition. Elk Grove Village, IL: American Academy of Pediatrics; Washington, D.C.; American Public Health Association.
2. Aronson, A. S., & Shope, T. R. eds. 2008. *Managing infectious diseases in child care and schools: a quick reference guide*. 2nd Edition. Elk Grove Village, IL: American Academy of Pediatrics.
3. Barlett, A. V., Hurtado, E., Schroeder, D. G., & Mendoez, H. 1992. Association of indicators of hygiene behavior with persistent diarrhea of young children. *Acta Paediatrica* 81 (s383): 66-71.
4. Centers for Disease Control and Prevention (CDC). 2012. National Center for Health Statistics. <http://www.cdc.gov/nchs/> (accessed October 30, 2012).
5. Gerba, C. P., Tamimi, A. H., Pettigrew, C., Weisbrod, A. V., and Rajagopalan, V. 2011. Sources of microbial pathogens in municipal solid waste landfills in the United States of America. *Waste Management and Research* 29 (8): 781-790.
6. Muldoon, K. 2010. Vancouver child's illness spirals into deadly grip of *E. coli*. *Oregon Live*. http://www.oregonlive.com/news/index.ssf/2010/04/vancouver_childs_illness_spira.html (accessed October 10, 2012).

Authors and Acknowledgements

AUTHORS: Cortney Miller, MS, Angela Fraser, PhD, Roman Sturgis, MFA (editor), Xi Chen, MS, Anna Saunders. Department of Food, Nutrition, and Packaging Sciences, Clemson University, Clemson, SC 29634

Published: March 31, 2013 **Revised:** February 27, 2013

This material is based upon work supported by the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-51110-04335, the National Integrated Food Safety Initiative of the Cooperative State Research, Education, and Extension Competitive Grants Program. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

CLEMSON
UNIVERSITY



RTI
INTERNATIONAL

NC STATE UNIVERSITY