Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease: Transmission and Survival of Pathogens in the Food Processing and Preparation Environment

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Purpose of Project:

- Project of the Committee on Control of Foodborne Illness (CCFI) of the International Association for Food Protection (IAFP)
- Goal: to develop an understanding of the dynamics of transmission of infectious agents to and from the food worker in a variety of settings
- The CCFI approached the task with the premise that all foodborne illness is fundamentally preventable and that by influencing human behavior there will be fewer opportunities for spread of infectious disease agents by workers and others
Greig et al., 2007; Todd et al., 2007a,b; Todd et al., 2008a, b; Todd et al., 2009
1. Description of the problem, methods, and agents involved
2. Description of outbreaks by size, severity, and settings
3. Factors contributing to outbreaks and description of outbreak categories
4. Infective doses and pathogen carriage
5. Sources of contamination and pathogen excretion from infected persons
6. Transmission and survival of pathogens in the food processing and preparation environment
Five more in press: Todd et al., 2010 a,b,c,d,e: E. C. D. Todd, J. D. Greig, C. Bartleson, B. Michaels, in collaboration with Debra Smith, John Holah

1. Barriers to reduce contamination of food by workers
2. The use of gloves to prevent contamination of food by workers
3. Washing and drying of hands to reduce microbial contamination
4. The increased use of alcohol-based sanitizers/antiseptics for hand disinfection and a comparison of their effectiveness with soaps.
5. Issues of compliance for the proper use of sanitizers/antiseptics and soaps in community and food settings
Definition of Food Worker:

The term **food worker** is used in this context to describe individuals who harvest, process, prepare and serve food.

It is broader in context than **food handler** although the two terms are used interchangeably.
Overview:

• Purpose/introduction
• Contamination associated with food workers
• Environmental contamination
• Pathogen survival
• Management implications
• Summary
Purpose:

The purpose of this presentation is to review the transmission and survival of enteric pathogens in the food processing and preparation environment through human and raw food sources, with the objective of providing information critical to the reduction of illness due to foodborne outbreaks.
Introduction:

• Pathogens in the food preparation area can originate from:
  • infected food workers
  • raw foods
  • environmental sources

• Pathogens can spread within the food preparation area or processing facility through often complex pathways infecting one or more workers or the consumer of the foods prepared by infected workers.

• Transmission depends on the species, the route of inoculum delivery, the contact surface type, the duration of exposure, the temperature and the relative humidity.
Cross-contamination:

- 1/3 of outbreaks reported by CDC from 1998-2002 identified contamination during production and processing, or cross-contamination in the kitchen (Gerner-Smidt and Whichard, 2007)
- Any surface touched by infected food workers can be easily contaminated
- Transfer of microorganisms from raw foods to cooked foods by hands ranges from 0.005 to 100%
- Isolation rates from whole packaging:
  - *Campylobacter* 34%
  - *Salmonella* 11% (Harrison et al. 2001)
Cross-contamination:

- 25% of men and 14% of women did not routinely wash their hands with soap after handling raw meat or poultry

- Demographics: men take more risks than women, younger people than older ones, whites than blacks, high income persons than low income

- Hands or contaminated work surfaces are potential vehicles of cross-contamination from raw meat to RTE foods

(Alterkruse et al 1999)
Cross-contamination:

• 0.24% of ground beef samples positive for O157:H7 in 2007
• Large recalls continue – 2007 outbreak associated with retail-purchased ground beef from a meat packer in Colorado
• Because of the high volume consumed outbreaks continue
• A study of risk factors for sporadic *E. coli* O157:H7 infection estimated 34% of the infections could have been prevented with effective handwashing  (Mead et al. 1997)
Cross-contamination:

- Cleaning with hot water and detergent did little to remove *Salmonella* and *Campylobacter* from chicken preparation areas
  - Hypochlorite was much more effective (Cogan et al. 1999)

- In an Irish study, *Campylobacter*, *E. coli*, *Salmonella* and *S. aureus* from chicken were found on dishcloths, refrigerator handles, oven handles, counter tops, drain boards and preparers’ hands (Gorman et al. 2002)
Cross-contamination:

- Although consumers are knowledgeable about the importance of preventing cross-contamination and using adequate heating to prevent foodborne illness, the knowledge is not necessarily translated into behavior.

- Volunteers in the Netherlands who knew they were being observed prepared chicken salad in a domestic environment:
  - 18 made errors that could have potentially resulted in cross-contamination with *Campylobacter*.
  - 7 allowed raw meat juices to come in contact with the final meal. (Fischer et al. 2007)
Workers’ Hands:

- A study of 44 food establishments showed low levels of *Listeria* on workers hands
- Almost all workers did not wash their hands sufficiently to remove the organism (Kerr et al. 1993)
- Transfer studies of *Listeria* from one deli meat to another showed that a combination of gloves and proper hand washing was the most effective procedure (Perez-Rodriguez et al. 2006)
Workers’ Hands:

- Once the food worker is infected, many factors affect the transmission of enteric pathogens:
  - Concentration of the infectious agent in the inoculum
  - Frequency of shedding
  - Survival of pathogen on hands and in the environment
  - Concentration deposited on the food
  - Degree of temperature abuse (for bacteria)
- Transfer can be direct from person-to-person, indirectly in two stages from person-to-contact surface and from contact surface-to-person, indirectly from person-to-food and from food-to-person
Workers’ Hands:

• Hand contact identified as contributing factor in 40% of 816 outbreaks
• Lack of effective barriers such as gloves, hand-held utensils, or deli papers was cited (Greig et al. 2007)
• High risk operations and foods involving bare hand contact:
  • various vegetable, meat and fruit salads
  • sandwiches
  • tearing, slicing, grating
  • handling shrimp
• Outbreaks have been associated with applying a garnish showing how even minimal contact can result in significant pathogen transfer
Workers’ Hands:

Actions less frequently thought of as hazardous but associated with outbreaks: handling buns, cooked pasta products, dipping donuts in glaze, mixing milk from powder and reconstituting juice.

- Cake decorator worked on first day of illness with norovirus
- Contaminated icing while mixing in water - infected approximately 1,000 people
- She wore long decorative nails which could accumulate 0.1 mg fecal material during a work day, resulting in a load of $10^1 – 10^7$ sufficient to infect 1,000 people
  (Lane et al. 2001)
Clothing and Jewellery:

- **Clothing:**
  - Two outbreaks occurred in hospital settings when workers’ clothing was contaminated while caring for sick children at home. Pathogens were then transferred to food prepared by the workers, infecting other hospital staff and patients.

- **Jewellery:**
  - Obvious danger of losing stones or rings in food
  - Rings can hold food debris, resident and transient pathogens, caustic industrial sanitizers, disinfectants, and even food allergens
Clothing and Jewellery:

- Chemical compounds trapped under rings can result in irritation and sensitization that could lead to eczema.

- Chemical reactions with metals can lead to contact dermatitis and could result in infection and colonization by enteric pathogens.

- The condition itself does not contaminate foods unless the skin becomes infected, but it does discourage any action that will cause pain and irritation, including washing and drying of the affected areas.
Environmental Contamination:

- Bacteria and viruses are transmitted by droplets generated when talking, sneezing, coughing or vomiting.
- Shaking a contaminated piece of cloth or vacuuming a soiled carpet may disturb airborne particles that have settled there.
- Aerosol transmission of norovirus has been well documented.
- Patrons and staff in food service settings have become ill when a “public vomiting” event has occurred in another area of the establishment.
Aerosol Transmission in Washrooms:

- Bacterial and viral pathogen surrogates placed in toilet bowl showed aerosolization after the first flush - almost twice as many virus particles/bacteria
- Sequential flushing resulted in further distribution but numbers declined with each flush
- An episode of acute diarrhea can deposit $10^{11}$ virus particles in the bowl water
- Organisms were found all around the toilet area, especially under the rim where studies have shown *Salmonella* persisted in homes after a family member was ill (Barker and Jones, 2005)
Environmental Contamination:

Fomites are inanimate objects or substances capable of transferring microorganisms from one individual to another:

- May become contaminated by direct contact with body secretions or fluids or by contact with soiled hands.
- May be covered with a thin layer of organic matter affecting transfer and survival of pathogens – utensils and equipment covered with food soil.
- Pathogens protected from environmental stress and death by mucus, sputum, feces, blood, milk, or chicken broth, may survive on food and household items, including improperly cleaned utensils and fabrics for long periods.
Environmental Contamination:

- Dry conditions kill most bacteria but survivors can revive when moisture returns
  - *S. aureus* survives well in dust, on fabrics, tile or glass and on flooring
  - *Salmonella* Enteritidis in minimally cooked scrambled eggs can survive on Formica for 24 h
  - *E. coli* can survive 60 days on stainless steel
- Food should not be re-served particularly to immunocompromised patients or those in medical isolation because pathogens can survive on dry surfaces and outside packaging.
Environmental Contamination:

- 5 year study of hygiene in shopping centers, daycares, offices, restaurants, theatres, airports and personal items in four US cities
- Total and fecal coliforms detected on 20 and 7% of surfaces
- Evidence of mucus, saliva, sweat and urine was found on up to 15% of sites
- Deliberate contamination of a surface with an invisible fluorescent tracer was transferred to 86% of individuals exposed hands
- 20 minutes after arriving at home the tracer was found through the home environment (Reynolds et al. 2005)
Environmental Contamination:

Pathogen transfer studies:

- $10^7$ PFU of bacteriophage was applied to hands and door handles as a model for enteric viruses

- At least 14 people sequentially contaminated by horizontal spread from touching the same door handle and successive transmission from person-to-person could be followed up to the 6th contact person

- The phage was re-isolated after 24 h from the hands of the individual even after normal activities and cleaning (Rheinbaben et al. 2000)
Environmental Contamination:

Microbial adhesion properties and survival vary with species and even strains

• *L. monocytogenes* and *S. Enteritidis* applied to multiple surfaces showed that intrinsic factors such as cell envelopes, adhesins, cell wall proteins, and extracellular polymers were more critical than contact surfaces

  (Teixeira et al. 2007)

• The smaller the agent e.g., a virus compared to a parasite, the more likely it can lodge in small surface scores on the contact surface or skin

• The presence of antimicrobials, including cleaning compounds, will impact survival and transfer
Environmental Contamination:

Extrinsic factors affecting pathogen adhesion to surfaces:

• Surface tension of a liquid:
  • liquid with high surface tension will move to surfaces of lower energy
  • those with low tensions are more apt to form films
• Higher pressures will increase contact area and transfer – slicing
• Surface hydrophobicity and roughness: adhesion study with S. Typhimurium demonstrated that stainless steel was colonized to the greatest extent followed by marble and granite
  (Teixeira et al. 2007)
Environmental Contamination:

- Foodborne pathogens can be transferred and survive on currency
- *E. coli*, *Salmonella*, and *Vibrio* were recovered from paper currency found in butcher shops and fishmongers in Myanmar (Khin et al. 1989)
- A US study found 94% of 1-dollar bills yielded at least one bacterial isolate (Pope et al. 2001)
- Effective hand washing must be stressed when currency has been handled and before food is touched in food service establishments, particularly when RTE foods are being served
Pathogen Survival:

- Soil matrix, relative humidity and temperature all influence pathogen survival
- Death rates are different for viruses and bacteria
- Specific factors affect the death rates for some virus groups
  - Naked viruses such as norovirus, rhinovirus, and enterovirus are more stable on skin than are viruses with envelopes such as the influenza virus
  - Enteroviruses are resistant to physicochemical inactivation and must be removed by vigorous friction applied during handwashing or drying
Management Implications:

- Individual employees cannot be expected to understand all the food safety issues associated with producing or preparing a food.

- However, owners and managers of food operations must understand the issues and provide the essential areas of expertise, either themselves or through hired consultants, to make the workplace as free from contamination sources as possible.

- Managerial policies in food establishments and employee errors have been identified as major risk factors in outbreaks.
Management Implications:

- Washington State 1990: 143 patrons ill with norovirus
  - Food worker called in ill at a fast food facility
  - Told to report to work; manager suspected he was lying
  - Although ill, manager had him prepare lettuce and tomato dishes using his bare hands
  - The manager violated company policy requiring exclusion of ill employees and did not enforce requirements for proper handwashing.
- Work demands were considered paramount over food safety
Summary:

• The risk of exposure for individuals, both food workers and consumers, can be assessed by determining the frequency that pathogens occur, the potential for pathogen occurrence on hands, hand and food contact surfaces, laundry, and other reservoirs, and the potential for pathogen transfer.

• For a management policy in food service operations to be successful, a well-trained certified manager must set an example for employees, although even this approach will not prevent ill employees from working.
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QUESTIONS?