

# What Lies Beneath: The Science Behind Contamination

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# Part 1: NSF International Household Germ Study



# NSF International

- NSF International has a long history in working to help ensure safe design and cleaning of equipment or appliances used in food preparation.
- NSF's Commercial Foodservice Equipment Program began in the 1940s, focusing on restaurant equipment.
- NSF's Home Product Certification Program began in 2012, addressing kitchen appliances and tools used in the home.
- In addition to evaluating materials and design, the program evaluates manufacturers' cleaning instructions to help prevent equipment from harboring pathogens that can cause foodborne illness.



## NSF's Applied Research Center

- Provides custom research and development (R&D) services to advance public health in water safety, food safety, as well as healthcare and consumer products.
- Works with academia, industry and regulatory bodies for R&D projects focused on furthering public health in water safety, food safety, pharma, sustainability and consumer goods.



# NSF International Household Germ Study

- Studies have shown that more than 20 percent of foodborne illness outbreaks result from food that was consumed in the home.\*
- NSF International food safety experts point to a number of contributing factors, including improper food storage, handling and preparation.

\*Centers for Disease, Control and Prevention: Tracking and Reporting Food Disease Outbreaks, <http://www.cdc.gov/features/dsfoodborneoutbreaks/>



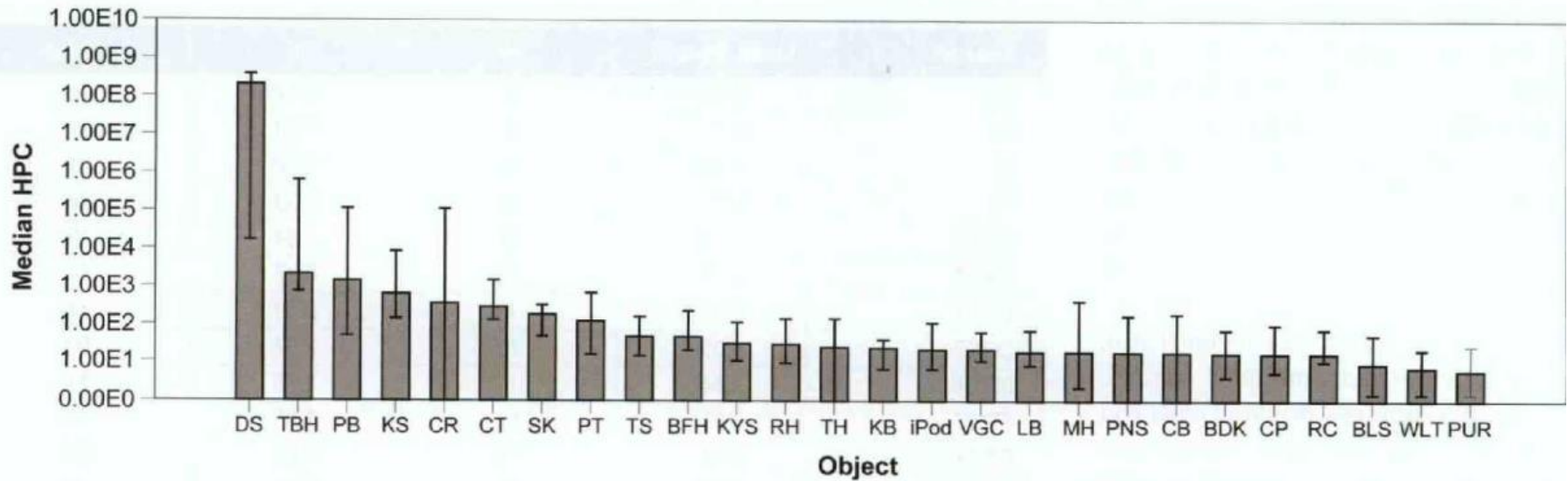
# NSF International Household Germ Study (cont.)

- In NSF's 2011 germ study, NSF scientists found more germs in the kitchen than in the bathroom.
- NSF's focus in the 2013 germ study was specific items in the kitchen (e.g. refrigerator, spatula, can opener, etc.).
- See Figures on next slide.



# HPC Count on Household Objects

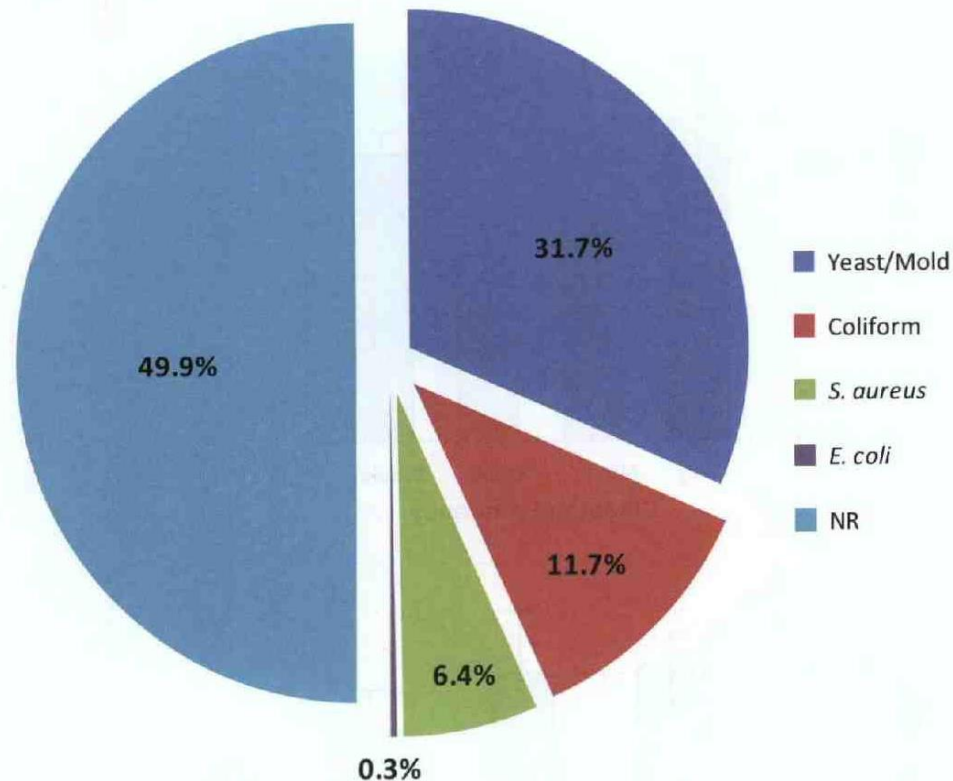
**Median (95% Confidence Interval) Heterotrophic Plate Count Bacteria (HPC) of Different Household Objects Sampled**



HPC values are presented in CFUs/10 cm<sup>2</sup>. DS = dish sponge, TBH = toothbrush holder, PB = pet's bowl, KS = kitchen sink, CR = coffee reservoir, CT = countertop, SK = stove knob, PT = pet's toy, TS = toilet seat, BFH = bathroom faucet handle, KYS = keys, RH = refrigerator handle, TH = toilet handle, KB = keyboard, VGC = video game control, LB = lunch box, MH = microwave handle, PNS = pens, CB = cutting board, BDK = bathroom door knob, CP = cellular phone, RC = remote control, BLS = bathroom light switch, WLT = wallet, PUR = purse.

# Percent breakdown of yeast/mold, coliform, Staph, E. coli

**Percentage of Surfaces Positive for Yeast and Mold, Coliform, *Staphylococcus aureus*, and *E. coli* of the Total Number of Surfaces Sampled**



NR = the percentages of surfaces negative for the above group of microorganisms.

Source: Donofrio et al. *Journal of Env. Health* Sept. 2012





# Methodology

- Germ Study was conducted by NSF International microbiologists July to Oct. '12, results published in Mar. '13.
- Swab kits, which included a swab for each of the 14 kitchen items to be analyzed, were provided to 20 volunteer families throughout greater Detroit.
- Scientific testing swab was saturated with a sterile medium with a neutralizer that helps to pick up germs from surfaces and neutralizes the affect of residual cleaners.



## Methodology (cont.)

- Volunteers were instructed to wear gloves and rub the wet swab tip in a turning motion across a designated surface area of each of the 14 items.
  - 1) blender gasket, 2) can opener, 3) flatware storage tray, 4) food storage container with rubber seal, 5) knife block, 6) microwave keypad, 7) pizza cutter, 8) refrigerator ice dispenser, 9) refrigerator insulating seal, 10) refrigerator meat compartment, 11) refrigerator vegetable compartment, 12) refrigerator water dispenser, 13) rubber spatula, 14) strainer



- Volunteers then placed the swab with the sample back into the swab container without touching the tip to anything else to ensure an accurate sample.
- Samples were analyzed by NSF microbiologists for the presence of targeted microorganisms such as *E. coli*, yeast and mold, *Salmonella* and *Listeria*.

# Findings

NSF scientists determined that the six “germiest” items contained the following microorganisms that can cause sickness:

**Refrigerator vegetable compartment:** *Salmonella*, *Listeria*, yeast and mold



**Refrigerator meat compartment:** *Salmonella*, *E. coli*, yeast and mold

**Blender gasket:** *Salmonella*, *E. coli*, yeast and mold

**Can opener:** *Salmonella*, *E. coli*, yeast and mold



**Rubber spatula:** *E. coli*, yeast and mold

**Food storage container with rubber seal:** *Salmonella*, yeast and mold

# Findings (Cont.)

## Percent of Items Positive for Selective Organisms

Potential to Cause Disease			Known to Cause Disease	
Items*	<i>E. coli</i>	Yeast and molds	<i>Salmonella</i>	<i>Listeria</i>
Blender gasket	5%	45%	5%	0%
Can opener	5%	20%	10%	0%
Flatware storage tray	0%	45%	NT	NT
Food storage container with rubber seal	0%	10%	5%	0%
Knife block	0%	30%	NT	NT
Microwave keypad	0%	30%	NT	NT
Pizza cutter	5%	20%	NT	NT
Refrigerator ice dispenser	0%	60%	0%	0%
Refrigerator insulating seal	0%	20%	0%	5%
Refrigerator meat compartment	5%	40%	5%	0%
Refrigerator vegetable compartment	0%	95%	5%	5%
Refrigerator water dispenser	0%	60%	0%	0%
Rubber spatula	10%	35%	NT	NT
Strainer	0%	30%	NT	NT

	<i>E. coli</i>	Yeast and molds	<i>Salmonella</i>	<i>Listeria</i>
Number of items testing positive for an organism	5	14	5	2
Percent of items testing positive for an organism	35.7%	100%	35.7%	14.2%

NT = Not tested for specific organism

\* 20 replicates were evaluated per item



## Findings (Cont.)

- These germs were found on everyday kitchen appliances and tools that come in direct contact with food, especially raw produce, meat, poultry, seafood and ready-to-eat food.
- Volunteers correctly identified items that they thought would harbor the most germs, but they are not always cleaning them thoroughly to prevent illness.

# Examination of Perception vs. Reality

- Before testing all these kitchen items, volunteers were asked to rate the items they thought would have the most germs.
- Asked what they perceived to be the germiest items in the kitchen versus the actual germiest items
  - ranked from highest to lowest in germ count

# Perception vs. Reality

## Volunteers thought:

1. Microwave keypad
2. Can opener
3. Refrigerator meat compartment
4. Refr. vegetable compartment
5. Flatware storage tray
6. Knife block
7. Pizza cutter
8. Rubber spatula
9. Refrigerator insulating seal
10. Ice dispenser

## Actual:

1. Refrigerator water dispenser
2. Rubber spatula
3. Blender
4. Refr. vegetable compartment
5. Refrigerator ice dispenser
6. Refr. meat compartment
7. Knife block
8. Food container rubber seal
9. Can opener
10. Refrigerator insulating seal

# What volunteers thought was dirty but didn't clean properly

- Volunteers thought that the vegetable and meat compartments would rank among the dirtiest items in the kitchen and they were right.
- What many volunteers may not have realized is that the types of germs found in these areas were harmful (such as *E. coli* and *Salmonella*) and come into direct contact with food, especially raw produce.
- What we learned is that 1) it isn't enough to wash your produce, you must also wash the areas where the produce is stored and 2) storing clean and unwashed produce together can be problematic.




# What volunteers thought was clean but wasn't

- Many volunteers didn't consider their blender a germy item, but in reality, it was the third germiest item in the kitchen.
- The refrigerator water dispenser didn't make their list at all, but both the water and ice dispensers proved to be areas of concern for yeast and mold, a problem for those with allergies.
- The food storage container never made the list, but later the data revealed it was one of the germiest items in the kitchen.



# Lessons Learned

- Follow manufacturers' directions when it comes to cleaning and sanitizing kitchen tools and appliances.
    - Blenders need to be disassembled, and the gasket pulled apart from the base, to be cleaned.
- 
- Refrigerator vegetable and meat compartments need to be cleaned and sanitized regularly.
  - Like all kitchen tools, can openers need washing and sanitizing after each use and rubber spatulas that are detachable should be pulled off the handle to be cleaned.
  - Rubber seals in food storage containers should be thoroughly cleaned.
  - Detailed cleaning instructions for kitchen items included in the study are available on NSF International's [website](#).

# At-Risk Populations

- These germ study findings are most concerning for households with at-risk populations such as children, pregnant women, the elderly or those with a compromised immune system (from illness).



# Part 2: Surface contamination



# Pathogen Survival in the Refrigerator

- Refrigerator vegetable and meat compartments need to be cleaned and sanitized regularly.
- Storing food in contaminated storage containers or using water, ice or tools with high counts of yeast and mold may lead to food spoilage at a faster rate.
- For those with allergies to yeast and mold, these actions may lead to an allergenic response.

# Pathogen Survival on Surfaces

- Some viruses and bacteria can live/survive from 20 minutes up to days on surfaces like doorknobs and tables.
- Follow manufacturer's directions when cleaning and sanitizing kitchen tools and appliances. Remember to disassemble before cleaning.
- Proper hand washing is key to help prevent the spread of germs: Thoroughly scrub hands w/ warm water with soap for 20 seconds before rinsing and drying with a clean towel.

# Bacterium Discovered

- NSF discovered new bacterium - *Klebsiella michiganensis* on a bathroom toothbrush holder in 2011 household germ study.



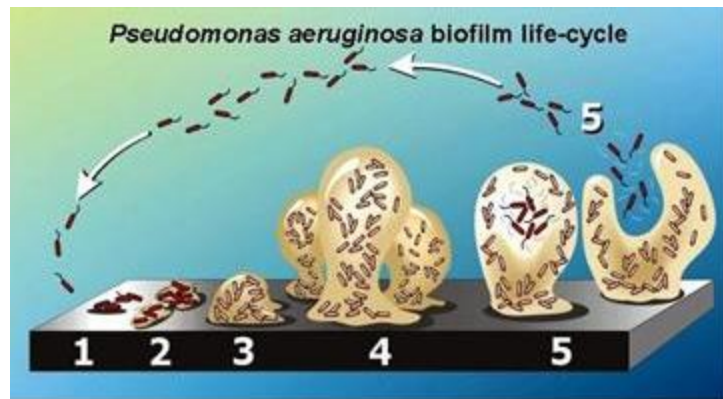
- Same family as E. coli and Klebsiella pneumonia
- *K. michiganensis* has a capsule structure with a slimy surface that helps it attach to mucus membranes and evade immune system responses, which may lead to infection because the bacterium is difficult to break down.
- Published finding in *Curr. Microbiol.* in January 2013.

## *Klebsiella michiganensis*

- Finding this bacterium in a toothbrush holder is particularly concerning due to the possibility of fecal matter contamination on products used for oral care.
- Sticky bacteria like *K. michiganensis* can attract other bacteria to join together in biofilm communities which are a common cause of persistent infections.
- These biofilms can form on surfaces such as human and animal tissues, metal and plastic and are more resistant to disinfection and removal than single bacteria.

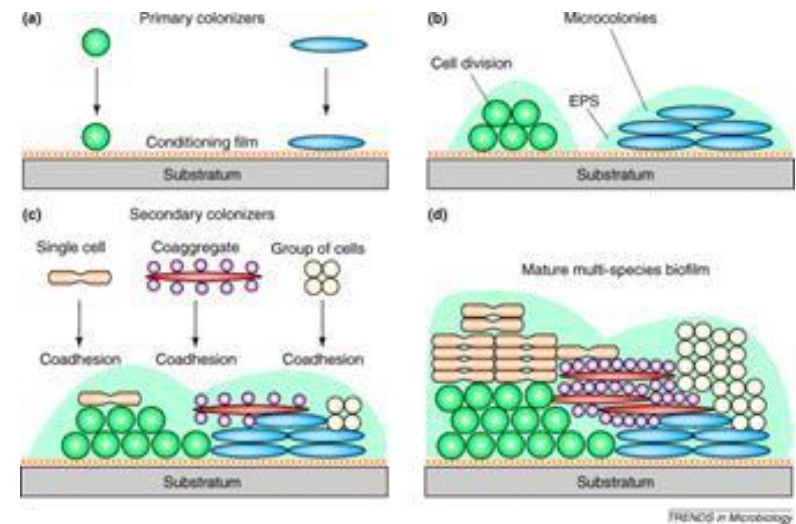


# Biofilms



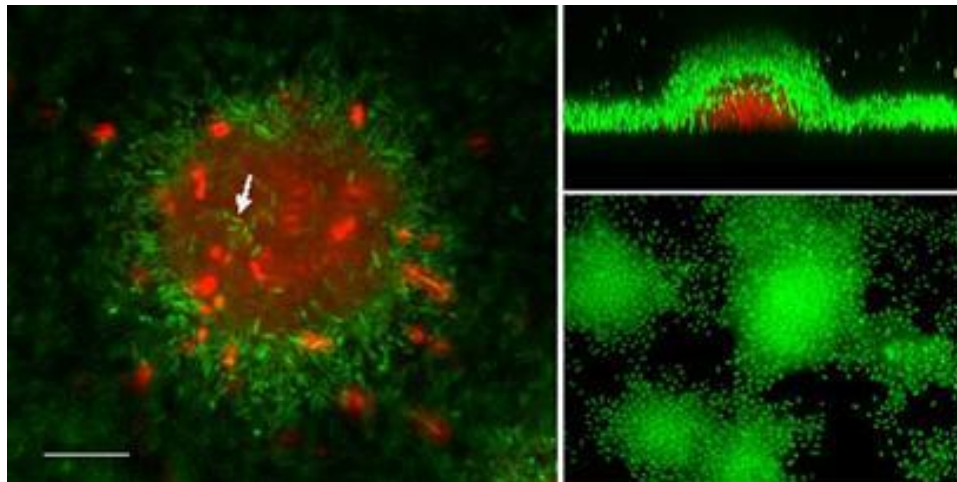
Schematic representation of biofilm development. Stage 1, Reversible attachment; 2, Irreversible attachment; 3, Maturation I; 4, Maturation 2; 5, Dispersion.

**Figure 1.** *Pseudomonas aeruginosa* biofilm life-cycle.



**Figure 2.** Coaggregation

Image from Alexander H. Rickard: E-mail The Corresponding Author, 1, Peter Gilbert<sup>1</sup>, Nicola J. High, 2, Paul E. Kolenbrander, 3, and Pauline S. Handley, 2003. Bacterial coaggregation: an integral process in the development of multi-species biofilms, Trends in Microbiology Volume 11, Issue 2, February 2003, Pages 94-100



**Figure 3.** Live/Dead<sup>®</sup> staining in x-y and x-z aspect of a biofilm microcolony.

## Biofilms (continued)

- **Resistance to Antimicrobics**
  - Biofilms may be 1000 times more resistant to antibiotics (cleaners, disinfectants, sanitizers) compared to planktonic cells.
  - May be due to degradation of the agent or exposure/penetration issues
- Physical treatment, in combination with antimicrobial treatment, is recommended

## Key Takeaways

- Warm and moist environments tend to be breeding grounds for microorganisms
- Sponges and coffee reservoirs, which may not be cleaned as frequently as they should be, were in the top 10 germiest places in the home.
- Smooth, cold surfaces tend to harbor fewer germs.
- Be mindful of biofilms

THANK YOU!

Questions?

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