



Centers for Disease Control and Prevention  
National Center for Environmental Health  
Vessel Sanitation Program

## Health Practices on Cruise Ships: Training for Employees Transcript

### **Microworld**

The Centers for Disease Control and Prevention's Vessel Sanitation Program is proud to bring to you the following session: The Microworld. While this presentation is primarily intended for cruise vessels under the jurisdiction of the Vessel Sanitation Program, it may be used by anyone who is interested in this topic. This session should not be used to replace existing interactive training, but should be used as an adjunct to a comprehensive training program.

The Microworld. Microworld learning objectives. At the end of this session, you will be able to list some of the major pathogens associated with illness, list the major differences between bacteria, viruses, and parasites, identify the areas where microorganisms can be found, draw and label a bacterial growth chart, describe why spores and toxins are a food safety concern, list the growth needs of bacteria, define and list potentially hazardous foods, list the water activity level and pH level under which bacteria will not grow, identify the growth factors that are easiest to control and measure on a cruise vessel, describe the temperature danger zone and its relationship to bacterial growth.

Pathogen. A pathogen is defined as any disease-producing agent.

Pathogen categories. We will be reviewing pathogens in the following categories throughout this session: bacteria, viruses, parasites, and fungi.

Microbes are found. Microbes can be found in a number of areas. These include people. For example, staphylococcus aureus is present on our skin. Shigella species, hepatitis A, and Norovirus can be present in our intestinal tracts. Animals can also carry microbes. Salmonella species, E. coli 0157H7, and parasites can be present on animals or in the gastrointestinal tracts of animals. Pathogens or microbes can also be found in the environment. For example, clostridium perfringens and clostridium botulinum are both present in the soil and can be present on vegetables and produce.

Parasites. Parasites differ from bacteria in that they need a living host to complete their life cycle. And generally, parasites are host-specific. Parasites can be found in soil. They can be found in water. They can be found in the air and animals. Parasites can be acquired through consumption of water, consumption of food, and through contact of a contaminated surface. Parasites. Some examples of parasites can include parasites that cause diseases such as anisakiasis, giardiasis, cryptosporidiosis, trichinosis, and taeniasis.



Centers for Disease Control and Prevention  
National Center for Environmental Health  
Vessel Sanitation Program

**Viruses.** Viruses also differ from bacteria in that they do not reproduce in the food, and they need a living host to replicate. They replicate by entering the cell of the host and taking over the genetic material responsible for reproduction. They can infect all types of cells, including bacteria, fungi, plants, animals, and the living cells within human beings. Viruses can be found in the environment, in water, and in air.

**Viruses.** Viruses can cause viral diseases such as Hepatitis A and Norovirus. There are others as well, which we will not discuss during this presentation.

**Fungi.** Fungi reproduce via spores. They can have a variety of shapes and sizes, and they can include yeast and molds. Generally, fungi are a concern in spoilage of food. Fungi can be beneficial. They can cause spoilage. And some fungi are pathogenic, meaning they can cause disease in humans.

**Bacteria.** Bacteria can be beneficial. For example, we have bacteria in our intestinal tracts which aid in digestion. Bacteria can be used in wastewater treatment to break down sewage, and bacteria can be used in the food industry-- for example, in the production of yogurt. Bacteria in the food industry can also be of concern with respect to spoilage. It can affect the odor, taste, and texture of a food product. Bacteria can also be pathogenic, meaning they are capable of causing disease.

**Bacterial growth chart.** From this bacterial growth chart, we can see that there are four stages of growth, using this growth chart. On the left hand side, we can see the number of organisms from top to bottom as they increase. On the lower portion, we can see time in hours. Phase A is considered the lag phase. This is the phase in which the bacteria is becoming acclimated to the environment, and there really is no reproduction, or the reproduction is negligible. Phase B is the log phase, or logarithmic growth or rapid growth phase. From this point, the bacteria reproduce exponentially-- one become two, two four, four eight, eight 16, on and on. C is a stationary phase. Here is where bacteria stop growing because they have pretty much depleted the nutrient supply and have contaminated their environment with the waste they expel through their cell membrane. D is a rapid decline phase, or the die-off phase. We need to consider what phase of growth do we wish to eliminate, and that would be phase B, the rapid growth or log phase. When considering time as a control, when we take a look at the A phase, the four-hour time as a control requirement in the manual would keep the bacteria in that phase, preventing B or logarithmic growth.

**What bacteria need to grow.** Pretty much bacteria need the same things that we need to grow. They need nutrients, and this is provided by the potentially hazardous food. They need proper pH. They need time to grow, proper temperature to grow, and dependent on the pathogen, either the presence or absence of oxygen. In addition, water activity is very important in bacterial growth. We will be discussing each one of these topics in detail.



Centers for Disease Control and Prevention  
National Center for Environmental Health  
Vessel Sanitation Program

Potentially hazardous foods. Potentially hazardous foods are basically the nutrients that bacteria require to grow. If we take a look at the slide, we can see very obvious examples of potentially hazardous foods. From the left to the right in the upper row we can see meats, poultry, fish, and eggs. On the next one, we can see cured meats such as cold cuts and hams. The next one we can see dairy products, which include milk, cheese, and various other items made from milk. Moving on to the lower row, we can see baked potatoes. While raw potatoes are not considered a potentially hazardous food, any food of plant origin that is heat treated would be considered a potentially hazardous food, including baked potatoes. On the next one, we can see a bowl of cooked rice. Again, raw rice would not be considered a potentially hazardous food. However, once this rice is cooked, or any other grain is cooked, it is considered to be a potentially hazardous food capable of supporting the rapid growth of bacteria. On the next one, we can see both a whole melon and a cut melon. While a whole melon is not considered to be a potentially hazardous food, a cut melon is. Once the melon is cut, it needs to be kept out of the danger zone or used within four hours. On the next slide, we can see sprouts. Because of the way sprouts are grown in a moist environment, they are capable of supporting the rapid growth of bacteria and are considered to be potentially hazardous foods. On the final one, we can see oil and garlic. Each one on their own or individually would not be considered to be a potentially hazardous food. However, an oil and garlic preparation is considered to be potentially hazardous. Indeed, there have been outbreaks associated with oil and garlic preparations, and the illness caused was botulism.

Oxygen. Dependent on the pathogen, there is a requirement either for oxygen or an aerobic environment, the absence of oxygen, an anaerobic environment, or some form or phase in between.

pH scale and foods. The pH scale runs from zero to 14. Seven is considered to be a neutral pH, and water generally has a neutral pH unless there are dissolved minerals which may affect the pH. Most of the foods we consume are on the acidic end of the pH scale. If we take a look at this slide, we can see lemon has a pH of 2.0 to 2.6, ketchup has a pH of 3.89 to 3.92, watermelon has a pH of 5.18 to 5.6, and finally, cooked rice has a pH of 6.0 to 6.7. To repeat, most of the foods that we consume have a pH of below seven and are considered to be slightly or very acidic.

Water activity. Water activity is basically the molecules that are available for the pathogenic bacteria. It is really not an indication of the moisture of a food. Water activity can be affected by the addition of sugar or by the addition of salt, for example, when we salt cure fish or sugar cure ham. A water activity level below 0.85 is considered non-potentially hazardous. So any food with a water activity below that level would not be capable of supporting the rapid growth of bacteria. The water activity level for water is 1.0. This is the highest water activity level.



Centers for Disease Control and Prevention  
National Center for Environmental Health  
Vessel Sanitation Program

**Time and temperature.** Bacteria need time and temperature to grow. The pathogenic bacteria that make us sick generally need time in the temperature danger zone, which is 41 degrees Fahrenheit, or five degrees Centigrade, to 140 degrees Fahrenheit, or 60 degrees Centigrade. Additionally, they need time. If foods are kept in the danger zone, the maximum allowable time is four hours. This again, going back to the bacterial growth chart, keeps the bacteria in the lag phase.

**Bacterial spores.** Some bacteria produces spores. These spores contain all the genetic material of the bacteria. They can survive disinfection, sanitization, cooking, and freezing. And indeed, many of the bacteria that produce spores are present in the ground and survive the freezing and thawing of seasonal changes.

We will now take a brief pause from the lecture portion of this presentation to demonstrate how spores can survive the cooking process.

We will now demonstrate how spores can survive the cooking process by demonstrating with chicken stew. The ingredients for chicken stew include chicken, vegetables, including potatoes, onions, and carrots. When we add the chicken to the chicken stew, we must also consider that pathogenic bacteria such as campylobacter and salmonella can be included. When we add the vegetables, we can consider that pathogenic microorganisms such as clostridium perfringens will also be added. Clostridium perfringens is a spore former, and in addition to the vegetative cells, we would also have spores in this product. We are now going to cook the chicken stew to the required cooking temperature based on the chicken, which is 165 degrees Fahrenheit for 15 seconds. We will place the pot on the stove and cook this food. When we cook the food, we have eliminated the campylobacter or salmonella which may be present in the food, which is associated with chicken. We will also eliminate clostridium perfringens, but only the vegetative cell or the bacteria. As we can see, the spores produced by this bacteria are left behind, because the spores survive the cooking process. When we serve this food the first day, no one becomes ill, because there are no pathogenic bacteria in this food. While the spores remain, the spores would not make anyone ill. If we take this food off the stove and take the leftovers and place them under refrigeration and cover this pot, which would be improper, because we always want to cool uncovered so that the heat may dissipate-- we do not pour this into shallow pans; we do not attempt to do rapid cooling-- what we will have on the next day is the vegetative cell returning. And indeed, we would have many more vegetative cells. If we serve this food without reheating it, or if we reheat it but not to 165 degrees Fahrenheit for 15 seconds, individuals served this food on subsequent meals may become ill. While we can reheat this food to 165 degrees Fahrenheit for 15 seconds and eliminate the bacteria that grew under cooling, we do not want to rely on reheating alone. We want to follow every step correctly-- cooking, cooling, and reheating.

**Toxins.** Some pathogenic bacteria produce toxins. Few of these toxins are destroyed by heat. An example of a bacteria that produces a toxin that can be destroyed by heat is



Centers for Disease Control and Prevention  
National Center for Environmental Health  
Vessel Sanitation Program

clostridium botulinum. This toxin is destroyed by cooking foods to 80 degrees Centigrade or 176 degrees Fahrenheit. We do not, however, want to rely on cooking to destroy this potentially fatal toxin. Most toxins are not destroyed by heat. These include the toxin produced by staphylococcus aureus, and toxins such as seafood toxins, plant toxins, and aflatoxins.

Growth factors and pathogens. From this slide, we can see a list of pathogens and the temperature range requirements, pH range requirements, and water activity levels needed. Let's review a few. Staphylococcus aureus. Staphylococcus aureus requires a temperature range of seven to 45 degrees Centigrade, or 44.6 to 113 degrees Fahrenheit. While this pathogenic bacteria grows through this entire temperature range, it grows poorly on either end of the range. Additionally, the pH range for this pathogenic microorganism is 4.2 to 9.3. Again, the growth of this bacteria would be more rapid in the center of this pH range. And the water activity level required for this bacteria is above 0.86. Campylobacter jejuni. Campylobacter jejuni requires a temperature range of 25 degrees Centigrade to 42 degrees Centigrade, or 77 degrees Fahrenheit to 107.6 degrees Fahrenheit. The pH range needed for this bacteria is 5.5 to eight. It is not clear what the required water activity level is for this bacteria.

pH and pathogens. From this slide, we can see two tables. One table is meant to show food items and the pH range for each individual food item. And the other table shows the pathogen and the required pH range. If we take a look at rice, rice has a pH range of 6.0 to 6.7. Let's take a look at the pathogen table and see what pathogenic bacteria can grow in the pH range of 6.0 to 6.7. If we take a look at the pathogens from Bacillus cereus all the way down to E. coli, we can see that every one of these bacteria can grow very well in the pH range of 6.0 to 6.7. Again, rice is a potentially hazardous food once it has been cooked.

Control of environment. We're now going to match the columns from the left to the right. Salt curing. If we take a look at salt curing and consider what factor in the environment we are controlling, we can see adding salt is going to control the water activity level. And if we add enough salt to our product, we can reduce the water activity level to below 0.85, which would make that food non-potentially hazardous, or not capable of supporting the rapid growth of bacteria. Acidifying. When we acidify a food, the factor in the environment that we change is the pH. A pH below 4.6 is not capable of supporting the rapid growth of bacteria. Vacuum packaging. When we vacuum package a product, we remove the air, creating an anaerobic environment. Many bacteria need the presence of oxygen to grow. Vacuum packaging is not allowed on cruise vessels under the jurisdiction of the Vessel Sanitation Program, and any vacuum-packaged foods must be obtained from a commercial supplier that is licensed to vacuum package. Dehydrating. Dehydrating again affects the water activity level. Blast chilling, blast freezing. Blast chilling and blast freezing both affects time and temperature. The chilling or freezing part reduces the temperature, and the blast part means that this is done very rapidly.



Centers for Disease Control and Prevention  
National Center for Environmental Health  
Vessel Sanitation Program

What you can control and measure easily. While you would be able to add a sufficient amount of lemon juice, lime juice, vinegar, or another acidifier to a food to reduce the pH level to below 4.6, you must ask yourself how can you measure that? It takes very precise equipment to measure the pH of a food. You can also dehydrate a food by either putting it in a dehydrator and reducing the water activity level to below 0.85, but again it takes very precise equipment to measure water activity levels. We can, however, make an adjustment to temperature very easily by using equipment already present on the vessel--refrigeration units, blast chillers, freezers, and even something as simple as an ice bath. Again, how would we measure that? Very simply, we would use thermometers or food temperature measuring devices to ensure that the foods are out of the danger zone. So what can you do? And what can you do easily and measure easily? You can affect time and temperature.

Time and temperature control. Cook foods rapidly. Cool foods rapidly. Re-heat foods rapidly. Remember that each of these steps, cooking, cooling, and reheating, brings the food through the danger zone. Again, these must all be done rapidly.

This concludes the session The Microworld. Resources and references. For further information, please visit [www.cdc.gov](http://www.cdc.gov). For information on the Vessel Sanitation Program, please visit [www.cdc.gov/nceh/vsp](http://www.cdc.gov/nceh/vsp). For information on the Food and Drug Administration, please visit [www.fda.gov](http://www.fda.gov). In that Web site, you can search for the Bad Bug Book for additional information on factors that affect the growth of pathogenic bacteria. For information on the United States Department of Agriculture, please visit [www.usda.gov](http://www.usda.gov).