

## Chocolate Factory\*

Dr. Derrick Chang of the CDC is alerted by PulseNet, the national molecular subtyping network for food-borne disease surveillance. PulseNet has identified an increase of genetically identical *Salmonella typhimurium* in the United States. This increase shows 120 isolates from 23 states in the last 60 days.

### What is causing this outbreak?

Dr. Chang initiates a case-control study with representatives of the state health departments that had reported *S. typhimurium* infections. Fifteen items, suspected as possible vehicles of infection on the basis of the individual case investigations, are listed. State officials determine whether each suspect item was used or consumed by the infected person within the 3 days before onset of illness. The family of each patient identifies two neighborhood controls, of the same age and gender as the patient. Controls were asked the same questions as patients, except that they were questioned about the use or consumption of the 15 suspect items during the previous month. Some of the data collected are shown in the table.

Foil-Wrapped Chocolate Balls	Ill	Controls
Ate	38	12
Did not eat	7	79

### Calculate the relative risk for this food item.

Illness due to *S. typhimurium* infection has a high association with consumption of foil-wrapped chocolate balls (relative risk = 9.3). Dr. Chang initiates environmental testing and traceback to locate the source of contamination. From questioning families and examining store invoices investigators identify the specific chocolate item (identified by the manufacturer's code number). State health department laboratories find that at least 22 of these chocolate samples contain *S. typhimurium*.

### How will Dr. Chang find the source of contamination?

The following ingredients are combined in the manufacturing of milk chocolate: cacao beans, cocoa butter (fat pressed out of the cacao bean), sugar, lecithin, vanillin, and salt. Cacao beans from Ghana, Nigeria, Brazil, and Ecuador are blended and roasted for 30 minutes at 125°C. The beans are then air cooled and ground. In the mixing room, the dry ingredients (salt, sugar, and ground beans) are blended and then mixed with the Brazilian cocoa butter in 3-ton batches for molding. The factory microbiologist is responsible for ensuring that the raw ingredients are free of pathogens when they enter the factory. In the past, she has rejected coconut milk and eggs that tested positive for *Salmonella*. She recently rejected a peanut

shipment that tested positive for mycotoxins. Dr. Chang asks the factory microbiologist to culture selected items in the production line. Her results are shown in the table.

	Number of samples	Number + <i>S. typhimurium</i>
Raw material storage area	56	0
Bean roasting room	16	2
Beans	14	0
Cocoa butter	9	0
Lecithin	7	0
Vanillin	1	0
Raw bean room	11	2
Mixing room	14	0
Trash room	7	0
Janitorial equipment	10	0
Chocolate molds	62	2
Tap water	5	0
Production line chocolate samples	25	0

### Now where will Dr. Chang look?

The beans seem to be the most likely source of the bacteria. Dr. Chang asks how the beans are harvested and stored. He is told that after harvest, cacao beans are fermented at the farm in wooden boxes that are often covered with banana leaves. He is also told there has been only one recorded incidence of *Salmonella* contamination of the raw beans. Hearing this, Dr. Chang suspects that contamination must have occurred in the room at the factory where the raw beans are kept. Looking at the room, Dr. Chang spots a discolored area on an overhead pipe in the bean room. No one has noticed the leak. The quality control microbiologist swabs the discolored area which grows *Salmonella*.

### What characteristics of chocolate prevent microbial growth?

The low moisture, high fat, and high sugar content of chocolate does not favor bacterial growth, but it does significantly increase the heat resistance of bacteria. Consequently, bacteria may survive roasting. To address the risk posed by *Salmonella*, all food safety agencies have pursued an ongoing strategy to reduce the prevalence of the pathogen in the food chain. However, despite all the efforts, the number of salmonellosis cases remains high.

\*In G. Tortora, B. Funke, C. Case, *Microbiology*, 11<sup>th</sup> ed. (Pearson, 2013)