Outbreak Investigation Case Series

Commercially Distributed Food Vehicles

In-depth, behind-the-scenes analyses of foodborne outbreak investigations

Introduction

This series focuses on investigations of outbreaks caused by commercially distributed food items and detected through pathogen–specific surveillance. The etiologic agents often are *Salmonella*, Shiga toxin-producing *E. coli* (STEC), or *Listeria monocytogenes*, but other pathogens are sometimes responsible. The primary target audience is foodborne disease epidemiologists who investigate (or are training to do so) these types of outbreaks, but others might find this series informative as well.

The primary focus of this series is methods used by epidemiologists (in concert with their co-investigators) to generate, develop, and confirm hypotheses about the outbreak vehicle. Descriptions will generally begin with the detection of a cluster (typically by molecular subtyping of submitted clinical isolates at a public health lab) and end when the food source is identified to a level of certainty/confidence that public health interventions are implemented. While this outbreak occurred when pulsed field gel electrophoresis was the subtyping method used by public health laboratories, the lessons are still applicable now that whole genome sequencing is the subtyping method.

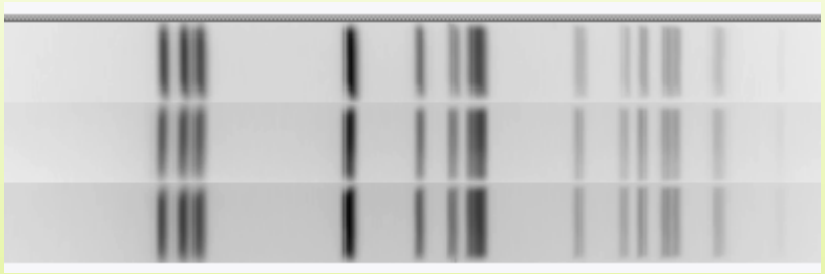
From an epidemiologist's perspective, the overall goal in these types of investigations is to document a sufficiently specific food exposure in a sufficiently high proportion of cases that one can confidently conclude that the food item of interest is the outbreak vehicle. This series will use outbreak examples that detail the exact process and methods that led investigators to that "threshold of confidence" that prompted them to take action. What were the epidemiologists thinking and doing day-by-day, case-by-case, and step-by-step as the investigation progressed, leading up to the attainment of that threshold of confidence? How were leads identified, and how did investigators decide when and how aggressively to follow a particular lead? The nuances, complexities, obstacles, and decision nodes involved in these types of investigations are nearly impossible to fully describe in the limited space of a peer-reviewed manuscript (plus, many excellent investigations are never published). It is our objective to capture all of the important methodological intricacies of selected particularly speedy or effective investigations using a detailed timeline format. We strongly encourage our audience to read the published investigation manuscript (when one exists) before going through our description. We hope that our descriptions will be a useful, educational supplement to the characterization of the investigation.

Salmonella I 4,[5],12:i:- Outbreak Associated with Coleslaw at a Single Restaurant, 2015

March 27 (Day 1 of Investigation)

This story starts with the receipt of 3 clinical *Salmonella* I 4,[5],12:i:- isolates at the Minnesota Department of Health (MDH) Public Health Laboratory (PHL) on March 23, 2015 (submission of clinical *Salmonella* isolates to MDH is mandatory in Minnesota). By March 27, subtyping of the three cases' *Salmonella* isolates by pulsed-field gel electrophoresis (PFGE) revealed that they were indistinguishable. The MDH PHL notified the foodborne epidemiologists, and a cluster investigation was initiated.

The isolates were given the Minnesota subtype designation TM64 (national PulseNet designation JPXX01.1056).



PFGE-*Xba*I

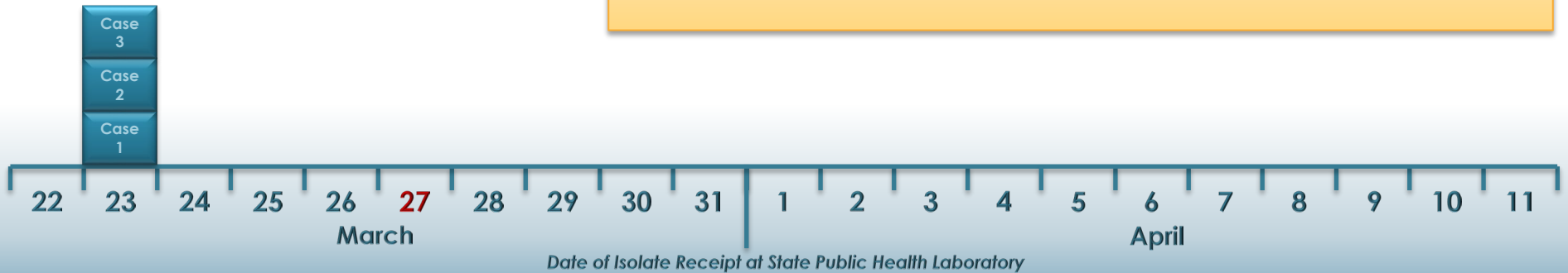
Case 1 TM64

Case 2 TM64

Case 3 TM 64

What are two of the first questions an epidemiologist should consider once receiving these laboratory subtyping results?

Move to the next page to see what the investigators were thinking…



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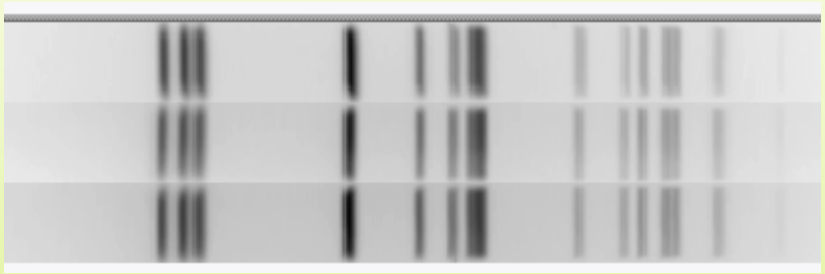


PFGE-*Xba*I

Case 1 TM64

Case 2 TM64

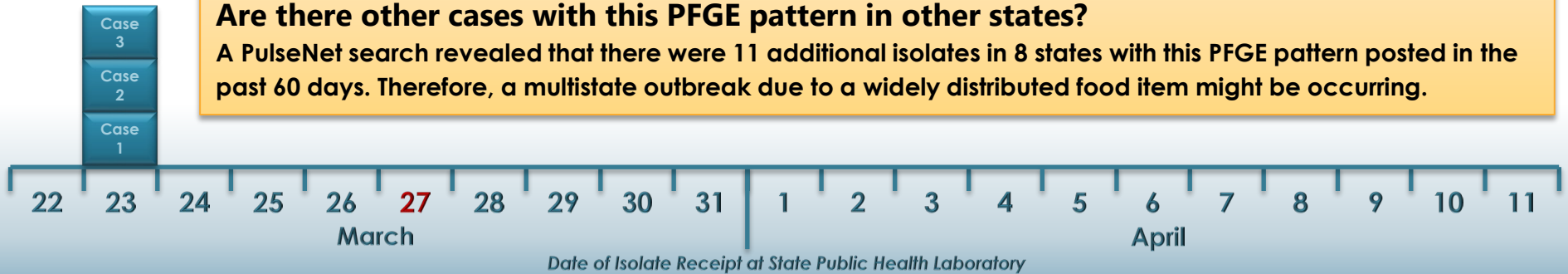
Case 3 TM 64

How common is the PFGE pattern?

This PFGE pattern had been seen previously in Minnesota, but was rare. Nationally, the PFGE pattern comprised 1% of I 4,[5],12:i:- isolates. This suggests that the cluster represents a true common source outbreak; therefore, aggressive follow-up is warranted.

Are there other cases with this PFGE pattern in other states?

A PulseNet search revealed that there were 11 additional isolates in 8 states with this PFGE pattern posted in the past 60 days. Therefore, a multistate outbreak due to a widely distributed food item might be occurring.



MARCH 27 (DAY 1 OF INVESTIGATION)

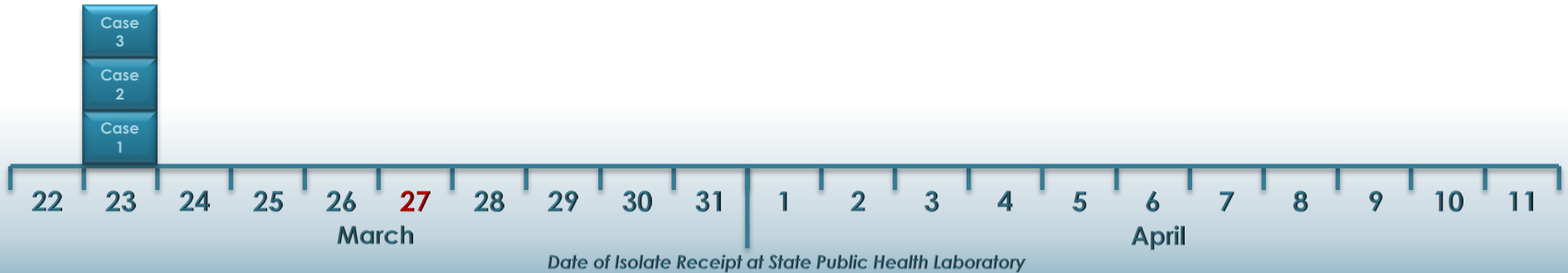
Demographic characteristics of the first three cases in the cluster:

	City	Age (yrs)	Gender	Race/ethnicity
Case 1	St. Paul	35	Male	White/Non-Hispanic
Case 2	Eagan	52	Male	White/Non-Hispanic
Case 3	Eagan	27	Female	White/Non-Hispanic

- St. Paul and Eagan are only 3 miles apart

What do these demographic characteristics along with the epi curve suggest?

Move to the next page to see what the investigators were thinking…



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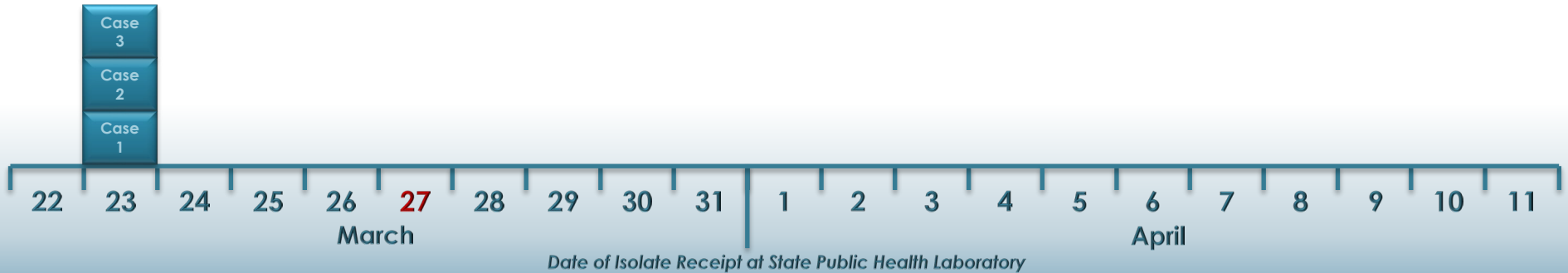
Because the cases are geographically clustered and all of the isolates were received at MDH on the same day, this cluster might represent a point source outbreak associated with an event or restaurant.



MARCH 27 (DAY 1 OF INVESTIGATION)

Team Diarrhea had already interviewed the first Minnesota case on March 26 with the Standard Questionnaire for STEC and *Salmonella* Cases:

- He reported eating Fresh Express pre-packaged spring mix from Target.

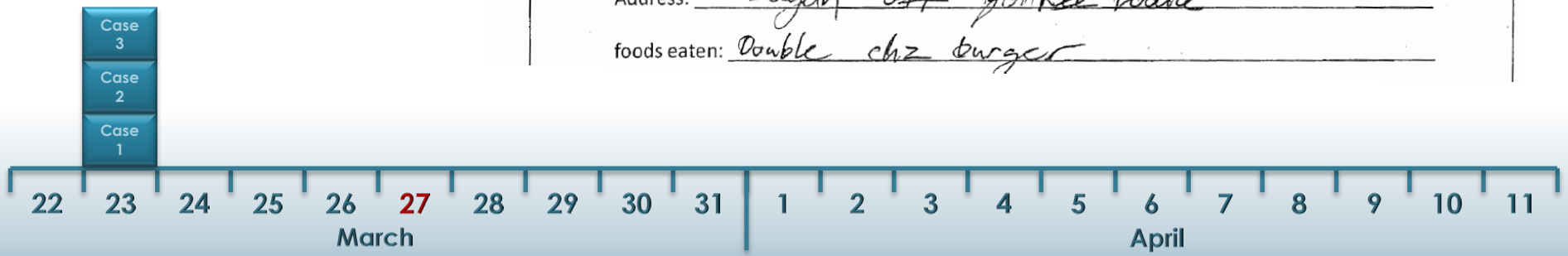
Item (Fruits cont.)	Ate	Did not eat	May have eaten	How prepared	Variety or brand	Date purchased	Grocery store where purchased	Date eaten	Restaurant where eaten (include address)
VEGETABLES									
Prepackaged salad	X			spring Mix	Fresh express	/ /	Target	/ /	

- He reported eating at several restaurants in Eagan during the week before his illness onset.

Did you eat any food or beverages from any restaurants, coffee shops, cafeterias, delis, or food stands/street vendors during the seven days before your illness? Yes ☒ No ☐

1. Name: Burger's & Bottles Date: 3/11/15 Time: _____
   Address: Eagan
   foods eaten: Wisconsin Chz Curd Burger - Fries
2. Name: KFC Date: 3/10/15 Time: _____
   Address: Eagen off yankee Doodle
   foods eaten: buffet, chx, biscuits, slaw, Mashed taters & gravy
3. Name: Dairy Queen E Date: 3/9 or 3/10 Time: _____
   Address: Eagan - off yankee Doodle
   foods eaten: Double chz burger

- On March 27, he called back to report that two co-workers who ate with him at Burgers and Bottles were ill and provided contact information for them.

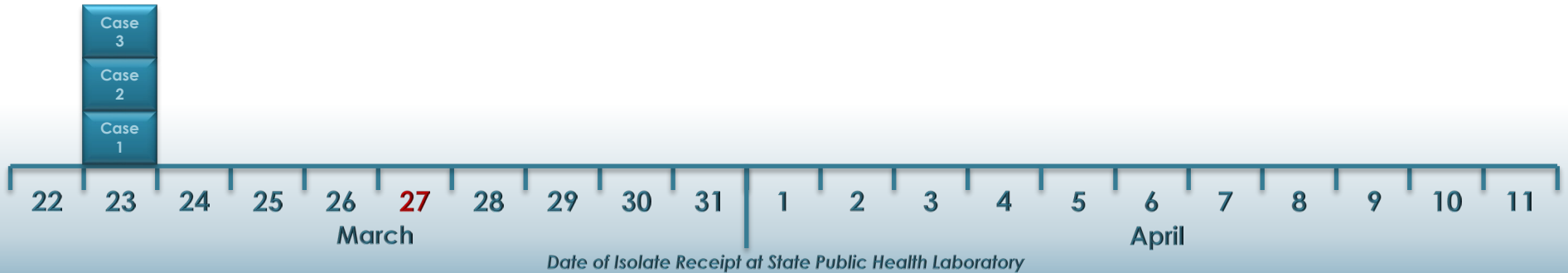


MARCH 27 (DAY 1 OF INVESTIGATION)

Team Diarrhea interviewed the co-workers of the first Minnesota case.

- A co-worker became ill with vomiting and diarrhea on 3/15/2017 after eating at Burgers and Bottles with Case 1 on 3/11/2017. He denied eating at KFC and Dairy Queen.

- A second co-worker became ill with diarrhea and fever on 3/16/2017 after eating at Burgers and Bottles on 3/11/2017 with Case 1. He also reported eating at the same KFC location as Case 1 during the week prior to his illness onset and agreed to submit a stool specimen for testing.



MARCH 27 (DAY 1 OF INVESTIGATION)

Team Diarrhea was able to interview the second Minnesota case on March 27 at 4:00 p.m. with the Standard Questionnaire for STEC and *Salmonella* Cases. Several attempts to interview the third case were unsuccessful.

- Case 2 also reported eating prepackaged salad purchased from Cub Foods, but was unable to provide the variety or brand name.

Item (Fruits cont.)	Ate	Did not eat	May have eaten	How prepared	Variety or brand	Date purchased	Grocery store where purchased	Date eaten	Restaurant where eaten (include address)
VEGETABLES									
Prepackaged salad	X					/ /	Cub	/ /	

- He reported eating at the same KFC in Eagan and denied eating at Burgers and Bottles.

Did you eat any food or beverages from any restaurants, coffee shops, cafeterias, delis, or food stands/street vendors during the seven days before your illness? Yes ☒ No ☐ or 3/14/15

1. Name: KFC Date: 3/13/15 Time: ~1200

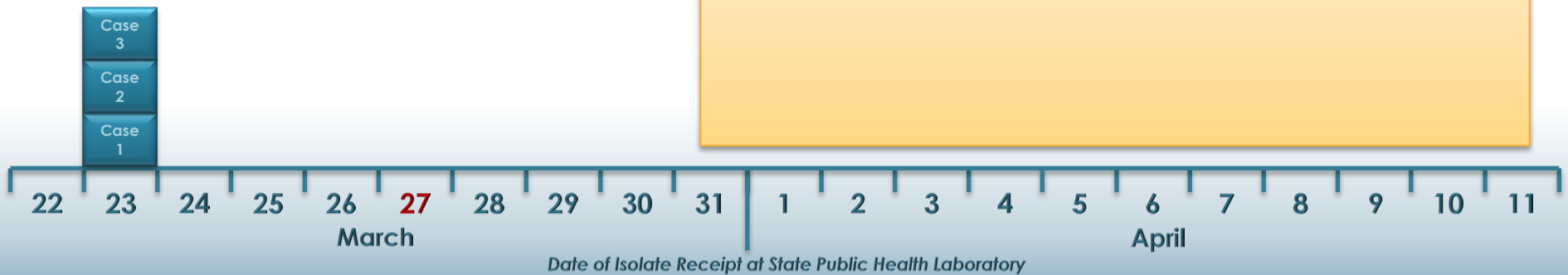
Address: off Yankee Doodle Rd in Eagan, MN

foods eaten: 4 piece dark meat w/ original breading, coleslaw, mashed potatoes + gravy

- He didn't report any other exposures in common with Case 1.

What are you thinking at this point?

Move to the next page to see what the investigators were thinking…



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Did you eat any food or beverages from any restaurants, coffee shops, cafeterias, delis, or food stands/street vendors during the seven days before your illness? Yes ☒ No ☐ or 3/14/15

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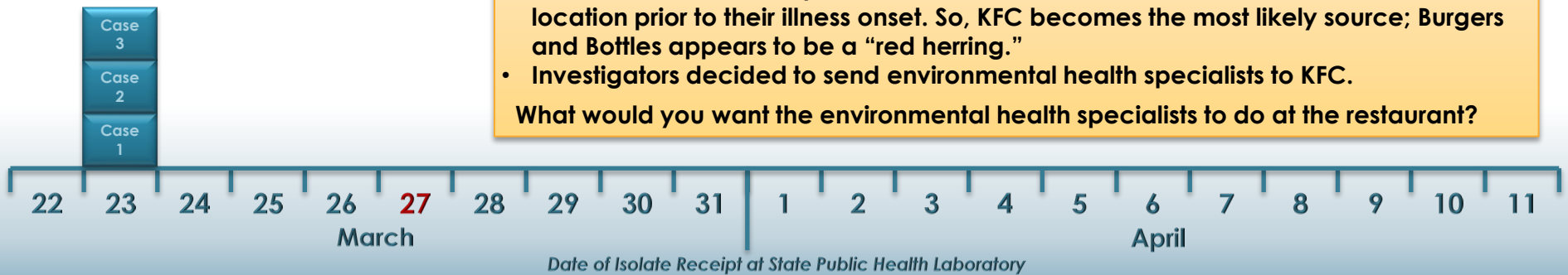
foods eaten: 4 piece dark meat w/ original breading, coleslaw, mashed potatoes + gravy

- He didn't report any other common exposures with the first case.

Assessment:

- **Both laboratory-confirmed cases who were interviewed report consuming prepackaged salad, but one case wasn't able to provide additional details like brand or variety, making it difficult to evaluate this exposure.**
- **Both cases also reported eating at the same location of KFC within several days of each other. Additionally, one of the first case's ill co-workers also ate at this location prior to their illness onset. So, KFC becomes the most likely source; Burgers and Bottles appears to be a "red herring."**
- **Investigators decided to send environmental health specialists to KFC.**

What would you want the environmental health specialists to do at the restaurant?



March 27 (Day 1 of Investigation)

MDH environmental health specialists visited KFC in Eagan to conduct an environmental assessment of food preparation and handling procedures, assess employee illness by interviewing all staff, collect environmental samples, and gather credit card receipts to help identify additional patrons.

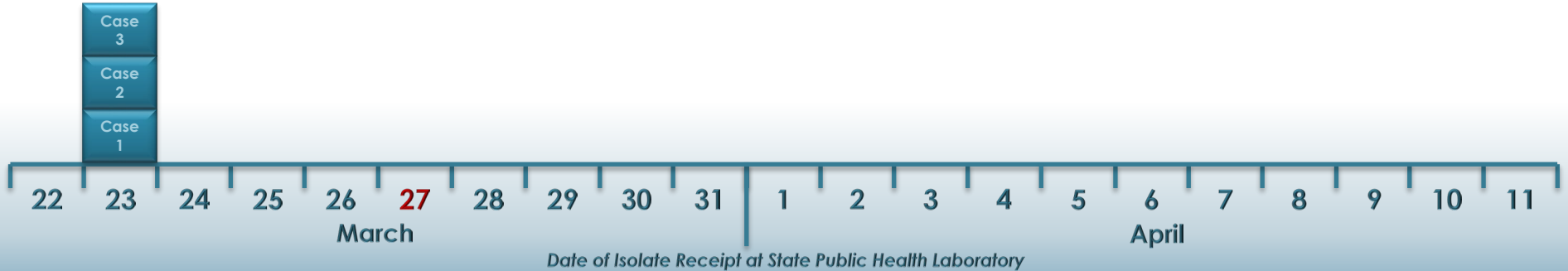
Later that evening, environmental health specialists reported that the environmental assessment revealed multiple opportunities for cross-contamination from raw chicken; specifically, standing chicken juice on the cooler floor and immediately outside the cooler adjacent to a cracked floor drain.

All 15 employees were interviewed and none reported recent gastrointestinal illness.

Twelve environmental samples were collected for *Salmonella* culture.

Floor drain and raw chicken pieces

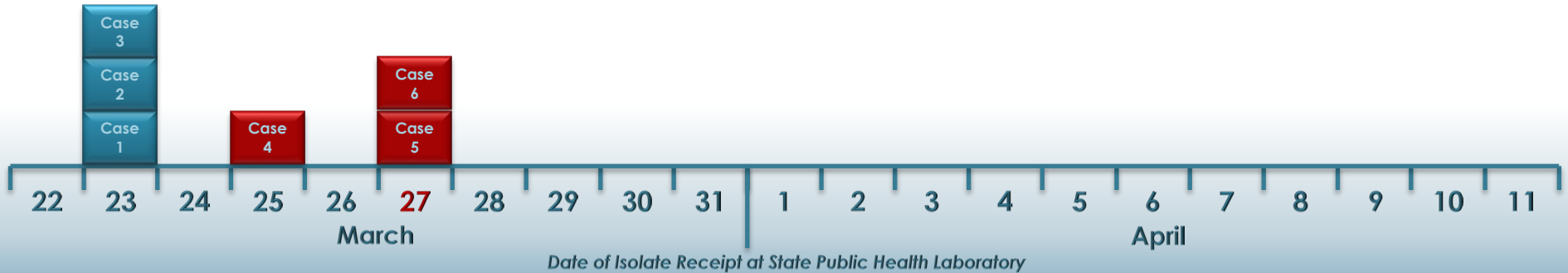
Racks with raw chicken in walk-in cooler



March 27 (Day 1 of Investigation)

The PHL reported 3 additional *Salmonella* isolates from the same geographic area (Cases 4-6 shown in red below). The serotypes and PFGE subtypes of these isolates were not yet known.

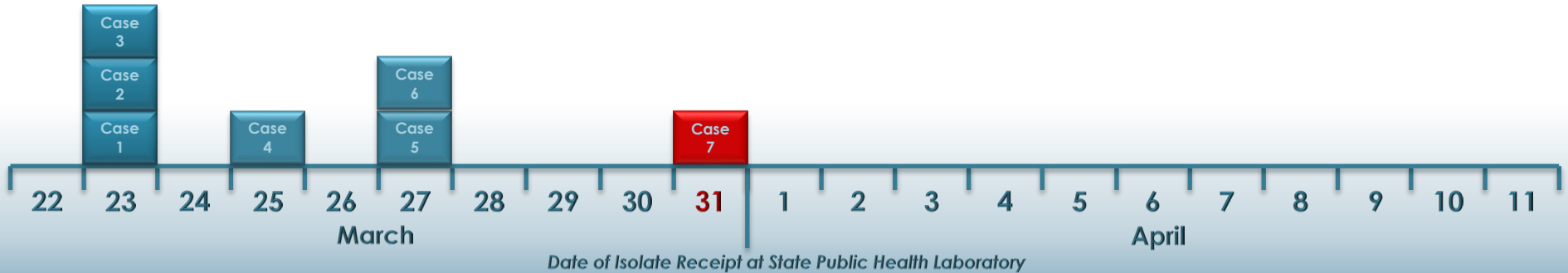
Environmental health reported that patrons only needed to sign receipts for orders over $20, and names were not printed on the bottom of the receipt. Thus, only 15 receipts with signatures were provided by the restaurant, which limited the number of additional patrons that could be identified using credit card receipts. Investigators also decided to call cases back to ask to interview cases' meal companions in an attempt to get additional non-ill controls for a case-control study.



March 31 (Day 5 of Investigation)

The PHL reported that the three additional *Salmonella* cases from that geographic area (Cases 4-6) matched the outbreak PFGE pattern and that one additional *Salmonella* case from that geographic area had been received (Case 7).

Cases 5 and 6 were interviewed by Team Diarrhea and reported eating at the same location of KFC on March 10 and 11.



April 6 - April 10 (Days 11-15 of Investigation)

Two additional cases that had isolates with matching PFGE patterns were received on March 31 and April 6. Finally, the ill meal companion of Case 1 submitted a stool specimen on April 10, and this specimen yielded the outbreak strain of I 4,[5],12:i:-.

A question about eating at KFC was added to the routine standard questionnaire for the cases that had not yet been reached. In the end, all nine cases with the outbreak strain reported eating at KFC in Eagan, with meal dates from March 10 through March 13.

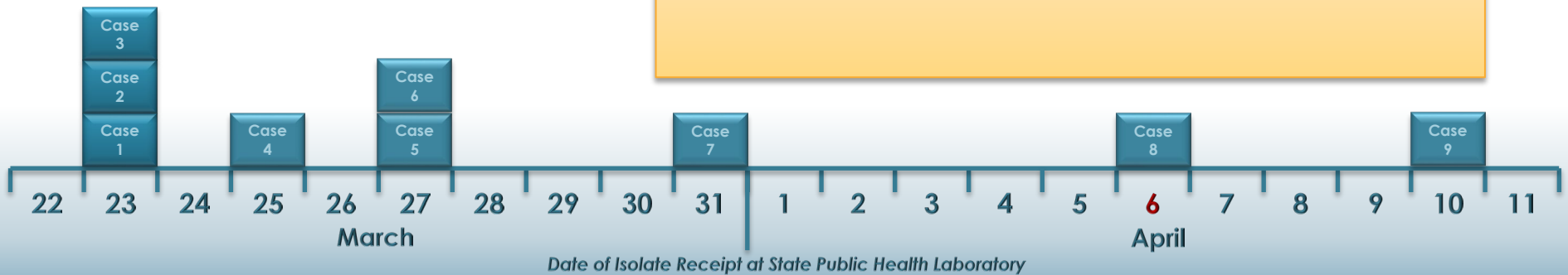
Investigators were able to interview only two non-ill controls identified from credit card receipts and five non-ill controls by calling case meal companions; these subjects were used to conduct a case-control study:

Case-Control Study Results Using Traditional Sources of Controls

Food	Cases (n=9) No. (%)	Controls (n=7) No. (%)	Odds Ratio	95% CI	P value
Coleslaw	7 (78)	6 (86)	0.58	0.04 – 8.15	1.0
Biscuit	3 (33)	3 (43)	0.67	0.09 – 5.13	1.0
Chicken	7 (78)	6 (86)	0.58	0.04 – 8.15	1.0

What are you thinking at this point?

Move to the next page to see what the investigators were thinking…



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Chicken	7 (78)	6 (86)	0.58	0.04 – 8.15	1.0

Assessment:

- **The traditional case-control study lacked the power to adequately evaluate food exposures due to the limited number of non-ill controls. As a result, investigators decided to use an additional source of data to evaluate potential associations with foods.**

April 10 (Day 15 of Investigation)

Investigators requested detailed transaction records from KFC for the implicated meal dates (March 10-13). The records did not contain patron contact info.

These transaction records were used to provide control data for a case-control study. Each transaction was treated as a single control, even though meals of multiple persons may have been on one receipt. Transactions with buffet sales were excluded since specific food item information could not be inferred.

In the example below, the transaction was counted as 1 control subject who ate a chicken leg, chicken thigh, mashed potato & gravy, mac and cheese, coleslaw, and a biscuit.

Transaction Record

Meal date and time

Meal items

```
Thu Mar 12 12:36:31 2015
[redacted]  Reg#:2  Rcpt#:1915

1 3 Pc Ml Or D          $7.99
   1 Leg                $0.00
   2 Thigh              $0.00
   1 Msh/Grvy Sm        $0.00
   1 Mac & Chez S       $0.00
   1 Biscuit Sm I       $0.00
1 3 Pc Ml Or D          $7.99
   1 Leg                $0.00
   2 Thigh              $0.00
   2 Coleslaw Sm        $0.00
   1 Biscuit Sm I       $0.00

Subtotal               $15.98
TAX                     $1.14
Gross Receip           $17.12
Cash                    $0.00
Credit Card            $17.12
Change Due              $0.00
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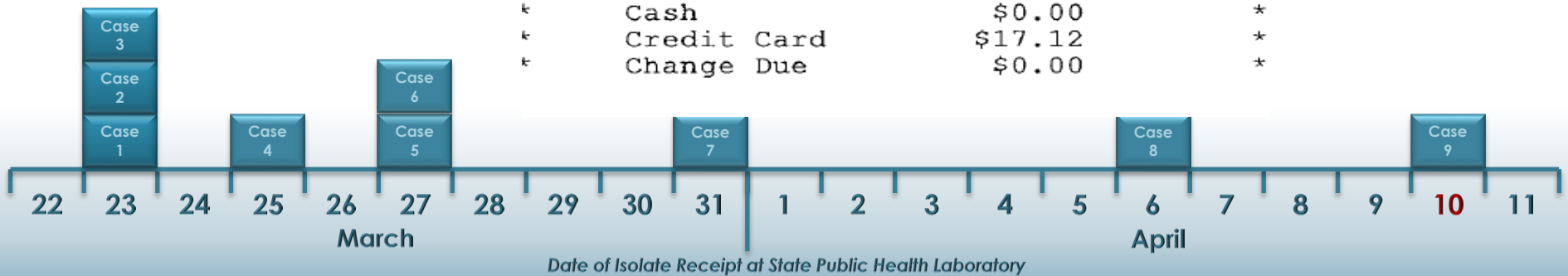


April 11 (Day 16 of Investigation)

Results of the new analysis were available on April 11. Only coleslaw was significantly associated with illness:

Augmented Case-Control Study Results Using Transaction Record Controls

Food	Cases (n=9) No. (%)	Controls (n=395) No. (%)	Odds Ratio	95% CI	P value
Coleslaw	7 (78)	101 (26)	10.2	2.08 – 49.8	0.002
Biscuit	3 (33)	244 (62)	0.31	0.08 – 1.26	0.096
Chicken	7 (78)	376 (95)	0.18	0.03 – 0.91	0.074

Alternatively, the transaction records could be used to estimate the background consumption rate of food items at this KFC location and put into in a binomial model. To the right are the binomial results for coleslaw in Epi Info 7, using the information from the transaction records to estimate that the background consumption rate for coleslaw in this KFC is 26%. Using this approach, the probability that at least 7 of 9 cases would have eaten closeslaw at KFC by chance was 0.0017.

StatCalc - Binomial

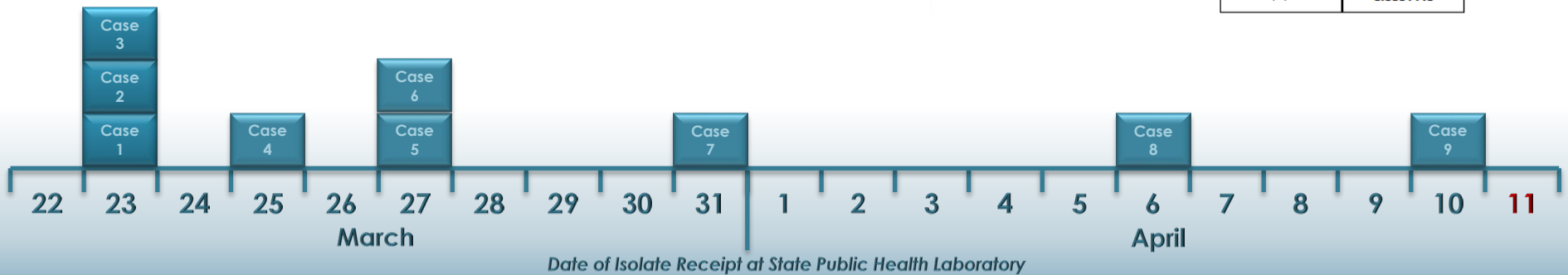
Binomial - Proportion vs. Standard

Numerator: 7

Total observations: 9

Expected percentage: 26 %

Probability that the number of case	
< 7	0.9982721
<= 7	0.9998555
= 7	0.0015834
>= 7	0.0017279
> 7	0.0001445



APRIL 11 (DAY 16 OF INVESTIGATION)

Investigators faced several challenges in using restaurant transaction records as a source of controls in an analytic study.

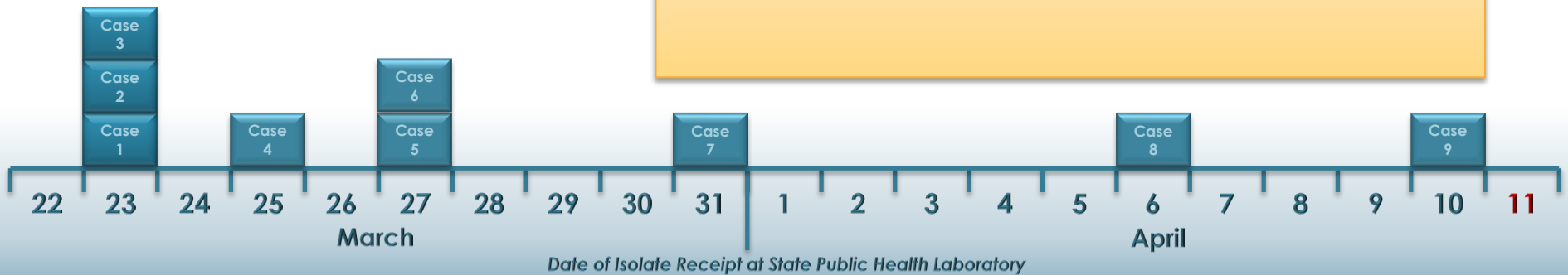
- They were not able to determine the illness status of the individuals who ate the food on the transaction records. As a result, they were forced to assume that they were not ill. This could have caused misclassification and potentially biased study results towards the null hypothesis of not finding a statistical association between a food item and illness.
    - If the outbreak had a very high attack rate, this could have prevented investigators from finding an association with coleslaw.
- They also were not able to determine how many individuals ate food from each transaction, so each transaction was treated as a single control. This too would bias results towards the null.
- Because both of the major biases of this approach were towards the null, statistically significant results that were found were likely to be meaningful.

Investigators had also been communicating with partners in other states that had PFGE matches identified by PulseNet.

- They wanted to evaluate the possibility that this could be a distributed food outbreak from an ingredient in the coleslaw.
- However, none of the cases outside Minnesota reported eating at KFC or consuming coleslaw.
- Cases could have been associated with the same source of raw chicken or could have been unrelated sporadic cases.

What step should the investigators take now to help evaluate the analytic study's finding that coleslaw is associated with illness?

Move to the next page to see what the investigators were thinking…



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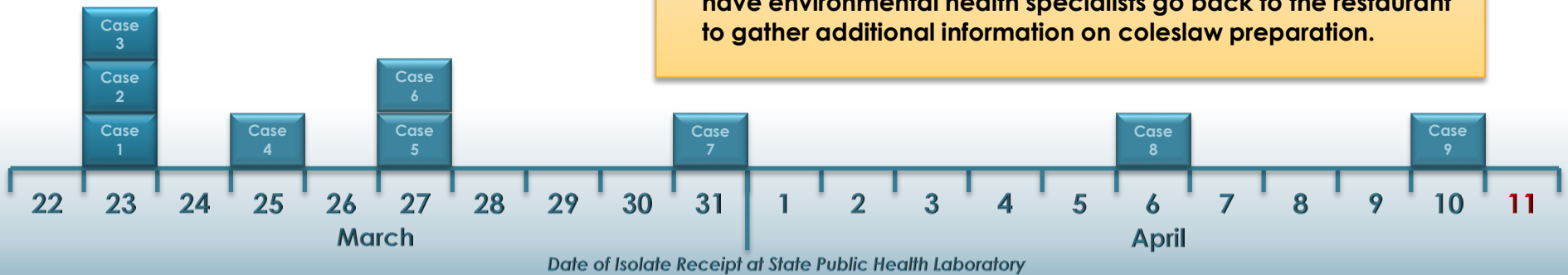
- However, none of the cases outside Minnesota reported eating at KFC or consuming coleslaw.
- Cases could have been associated with the same source of raw chicken or could have been unrelated sporadic cases.

Assessment:

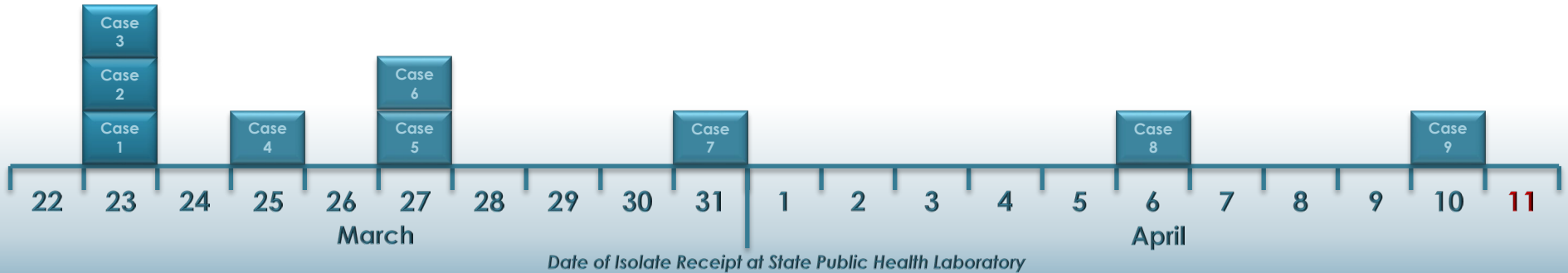
- **Look at the environmental health assessment to determine if there were findings that support coleslaw as the vehicle.**
- **If the initial environmental health assessment doesn't have sufficient information to evaluate this, it would be appropriate to have environmental health specialists go back to the restaurant to gather additional information on coleslaw preparation.**



April 11 (Day 16 of Investigation)

With the epidemiological study finding that coleslaw was statistically associated with illness, MDH environmental health specialists visited KFC again to gather additional information on how the coleslaw was prepared.

The employee who made coleslaw daily also performed miscellaneous cleaning tasks earlier each day which included spraying cooler racks holding raw chicken (see picture on earlier page) and discarding raw chicken fluid into a floor drain (below, picture on the left). He did this while wearing the same clothing that was worn during the coleslaw prep. Elbow length gloves were used to mix coleslaw in a large plastic bin (below, middle picture) but the employee's clothing could easily have been contaminated by the chicken spray, leading to contamination of the coleslaw



Epilogue

In this outbreak, nine *Salmonella* I 4,[5],12:i:- cases were identified in Minnesota. No cases were hospitalized. The use of transaction records helped investigators to identify the outbreak vehicle when there were not enough controls available via traditional sources (credit card receipts and well meal companions). A thorough environmental health assessment supported the epidemiologic findings by identifying a likely mechanism of cross-contamination of the coleslaw from raw chicken. This was key in demonstrating that this was a single restaurant outbreak due to on-site food handling deficiencies, rather than a broader outbreak associated with a distributed coleslaw ingredient. Some of the temporally associated PFGE matching cases in other states could have been sporadic cases associated with the same source of raw chicken, or they could have been completely unrelated. Whole genome sequencing might have been useful in answering this question.

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Summary of Key Investigation Lessons:

- The **PFGE subtype** of isolates in this cluster was **rare**, which **indicated** that this cluster represented a **common source outbreak** and warranted aggressive follow-up.

  See: CIFOR Guidelines for Foodborne Disease Outbreak Response Chapter 4.2.9.2

- The **epidemiologic curve and demographic characteristics of the cases can give clues** to the outbreak setting. The geographic and temporal clustering suggested a point source associated with a restaurant or event.
- Early in cluster investigations such as this, it is a good idea to systematically ask all cases objective questions about all of the restaurants mentioned by any of the first few cases. Only around half of cases will remember and report the outbreak restaurant in an open-ended interview.

  See: CIFOR Guidelines for Foodborne Disease Outbreak Response Chapter 5.2.4.1.2

- Restaurant transaction records can be used as a source of control data when traditional sources of non-ill controls are unavailable or insufficient. Analytic studies like **case-control studies and binomial model comparisons** using background food consumption rates **can be used to assess potential associations** between reported foods and illness, and can help focus detailed environmental health assessments. See: CIFOR Guidelines for Foodborne Disease Outbreak Response Chapter 5.2.4.1.5
- The use of transaction records in this way has potentially important biases, but these would bias towards the null. This could mask associations, but when statistically significant associations are found they are likely to be meaningful.
- A detailed environmental health assessment supported the epidemiologic findings; together they painted a clear picture of what happened to cause this outbreak.
- An environmental health assessment conducted as part of an outbreak investigation should not be just a traditional inspection. A more detailed and focused assessment, ideally guided by the epidemiologic findings, should be able to explain how and why the outbreak happened.

  See: CIFOR Guidelines for Foodborne Disease Outbreak Response Chapter 5.2.4.1.6

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