

# Chasing the Curve

Outbreak Investigation — study designs, the ten-step field investigation, tools of the trade, and the math behind attack rate, relative risk, and odds ratio.

## STEP 1 • CHOOSING A LENS

# Study Designs

### Experimental

The researcher assigns the exposure.

- Randomized controlled trials
- The strongest evidence for cause and effect
- Rarely usable in a real outbreak — you can't assign disease on purpose

### Observational

The researcher only watches and measures.

- Includes cohort, case-control, cross-sectional, and ecological studies
- What disease detectives actually use in the field
- Must watch for confounding variables

STEP 1 • FOUR WAYS TO OBSERVE

# Four Observational Designs

## Cohort Study

### STARTS FROM

Groups defined by exposure (ate vs. didn't eat)

### MEASURES

New cases over time — incidence

### BEST FOR

Rare exposures, common outcomes

## Case-Control Study

### STARTS FROM

Cases and matched controls

### MEASURES

Odds of past exposure

### BEST FOR

Rare diseases, long latency

## Cross-Sectional Study

### STARTS FROM

One snapshot in time

### MEASURES

Prevalence — existing cases

### BEST FOR

Quick surveys — can't show time order

## Ecological Study

### STARTS FROM

Group-level data, not individual

### MEASURES

Population rates and trends

### BEST FOR

Generating hypotheses — watch for ecological fallacy

## STEP - BY - STEP

# The 10-Step Investigation

- 1 Prepare for field work
- 2 Establish that an outbreak exists
- 3 Verify the diagnosis
- 4 Construct a working case definition
- 5 Find cases systematically
- 6 Describe by time, place, and person
- 7 Develop hypotheses
- 8 Evaluate hypotheses with analytic studies
- 9 Refine hypotheses; run more studies if needed
- 10 Implement control measures and communicate findings

## CASE DEFINITION

# Person, Place, and Time

### Person

Who is affected: age, sex, symptoms, and exposure history of each case

### Place

Where cases occurred: geographic clustering, venue, or neighborhood

### Time

When symptoms began: onset dates and the incubation window

### Cedarwood Banquet — Case Definition

**Confirmed** — Lab-confirmed Salmonella infection and attended the banquet

**Probable** — Vomiting or diarrhea within 72 hours of the banquet, no lab test

**Possible** — Any GI symptom within one week of the banquet

## TOOLS OF THE TRADE

# Six Tools Every Detective Uses

### **Epi Curve**

Histogram of cases by date of onset;  
reveals the outbreak's shape

### **Line Listing**

A spreadsheet with one row per case and  
key variables in each column

### **Spot Map**

Plots each case's location to reveal  
geographic clustering

### **2×2 Table**

Compares attack rates between exposed  
and unexposed groups

### **PFGE / WGS**

Lab fingerprinting that matches bacterial  
strains between patients

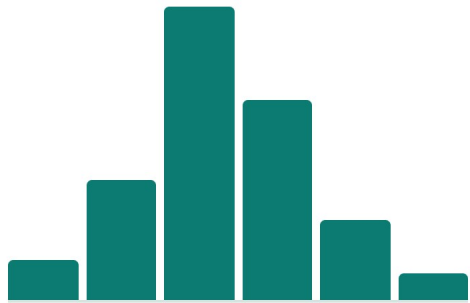
### **PulseNet**

The national database that links matching  
DNA fingerprints across states

## READING THE SHAPE

# Four Epi Curve Shapes

### Point-Source



One sudden exposure — a single peak near one incubation period later.

### Continuous Common-Source



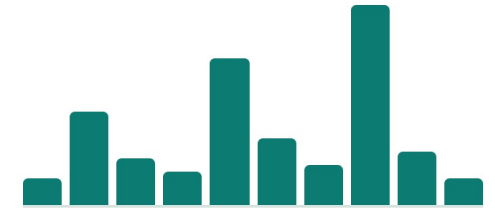
Exposure continues over time — cases climb and plateau until the source is removed.

### Intermittent



The source turns on and off — irregular peaks with no clear pattern.

### Propagated



Person-to-person spread — successive waves, roughly one incubation period apart.

## THE CHAIN OF INFECTION

# Triad and Chain

### Agent

The pathogen itself — bacteria, virus, parasite, or toxin

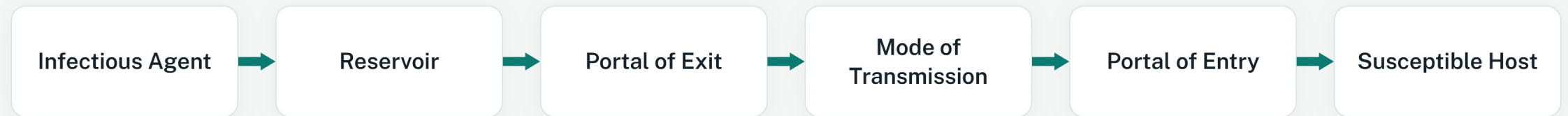
### Host

The person or animal who can become infected — their immunity and susceptibility matter

### Environment

Conditions that bring agent and host together — sanitation, climate, crowding

## BREAK ANY LINK TO STOP THE SPREAD



## HOW IT SPREADS

# Modes of Transmission

### Contact

Direct (touching, bodily fluids) or indirect (contaminated surfaces, fomites)

### Vehicle-Borne

A single contaminated vehicle — food, water, blood, or another common source

### Vector-Borne

Carried by a living organism — mosquitoes, ticks, fleas — mechanically or biologically

**Droplet vs. airborne** — Droplets travel less than about 3–6 feet and fall quickly (the flu). True airborne pathogens ride on tiny particles that can drift much farther and linger in the air (measles, tuberculosis).

CRUNCHING THE NUMBERS

# Attack Rate & Relative Risk

**Attack Rate**

$AR = (ill \div total) \times 100$

The percent of a group that got sick

**Relative Risk**

$RR = AR(exposed) \div AR(unexposed)$

How many times more likely the exposed group was to get sick

**Cedarwood Picnic — Cohort Study**

| Group            | Ill | Well | Total | Attack Rate |
|------------------|-----|------|-------|-------------|
| Ate potato salad | 60  | 40   | 100   | 60%         |
| Did not eat      | 16  | 84   | 100   | 16%         |

**RR = 60% ÷ 16% = 3.75 — people who ate the potato salad were almost 4× as likely to get sick.**

WHEN YOU CAN'T COUNT THE WHOLE POPULATION

# The Odds Ratio

## Odds Ratio

$$OR = (a \times d) \div (b \times c)$$

Used in case-control studies, where you only know exposure among cases and controls — not the whole at-risk population

|          | Exposed | Unexposed |
|----------|---------|-----------|
| Cases    | 42 (a)  | 8 (b)     |
| Controls | 9 (c)   | 16 (d)    |

$$OR = (42 \times 16) \div (8 \times 9) = 672 \div 72 \approx 9.3$$

## Which Formula Do I Use?

**Defined population at risk** — Use Attack Rate & Relative Risk (cohort study).

**Only cases and controls** — Use the Odds Ratio (case-control study).

## PROVING CAUSE

# Koch's Postulates vs. Hill's Criteria

### Koch's Postulates

1. The organism is found in every case of the disease, never in healthy hosts
2. The organism can be isolated and grown in pure culture
3. The cultured organism causes disease when introduced into a healthy host
4. The organism can be re-isolated from that newly infected host

### Hill's Criteria

1. **Strength** — a strong association is less likely to be coincidence
2. **Consistency** — repeated in different studies and populations
3. **Specificity** — a specific exposure links to a specific outcome
4. **Temporality** — the cause precedes the effect
5. **Biological gradient** — more exposure, more disease (dose-response)
6. **Plausibility** — a believable biological mechanism
7. **Coherence** — fits with what's already known
8. **Experiment** — an intervention changes the outcome
9. **Analogy** — similar exposures cause similar effects

## MULTIPLE CAUSES

# The Causal Pie Model

No single cause explains most disease — several component causes act together in a "sufficient cause." A necessary cause (A) must be present, but rarely acts alone.

### SUFFICIENT CAUSE I

**A:** contaminated water source

**B:** crowded conditions

**C:** no chlorination

### SUFFICIENT CAUSE II

**A:** contaminated water source

**D:** low herd immunity

**E:** poor hand hygiene

### SUFFICIENT CAUSE III

**A:** contaminated water source

**F:** contaminated food-prep surface

**G:** inadequate cooking temperature

### Correlation Isn't Causation

Ice cream sales and drowning deaths rise and fall together every year — but ice cream doesn't cause drowning.

**The confounder** — hot weather drives both more ice cream sales and more swimming (and drowning risk).

## QUICK REFERENCE

# Cheat Sheet

### Formulas

$$AR = (ill \div total) \times 100$$

$$RR = AR(exp) \div AR(unexp)$$

$$OR = (a \times d) \div (b \times c)$$

### 10-Step Checklist

1. Prepare
2. Confirm outbreak
3. Verify diagnosis
4. Case definition
5. Find cases
6. Describe (T/P/P)
7. Hypothesize
8. Analytic study
9. Refine
10. Control & report

### Epi Curve Shapes

**Point-source** — one exposure, one peak

**Continuous** — ongoing source, plateau

**Intermittent** — on/off source, irregular peaks

**Propagated** — person-to-person, successive waves

WRAP - UP

**"In God we trust; all others must bring data."**

— W. Edwards Deming

COMING UP NEXT • TOPIC 3

**Stopping the Spread — Patterns, Control & Prevention**