Managing an "Outbreak"

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HISTORY:

In 1854, a cholera epidemic broke out in London, England. At the time, rehydration therapy was not understood, and the fatality rate was fifty percent. Dr. John Snow’s skill in gathering, assessing and depicting the evidence led him to discover not only the cause of this epidemic, but also the mode of cholera transmission and a method of prevention. Dr. Snow accomplished all of this two decades before Pasteur proposed the germ theory of disease.

ANALYSIS:

Examine Dr. Farr’s older analytical approach shown in Figure 1.

1) Do the graphs show visually that an epidemic occurred?
   Yes □ No □

2) Do the statistical graphs in Figure 1 give any insight as to the cause of the epidemic?
   Yes □ No □

3) Do the graphs have a weakness? _________________________________

DISCUSSION:

A weakness of these graphs is that they do not show the population at risk. Without this denominator, we cannot statistically compare the incidence of disease between two time periods. Do these show the cause and effect? How could Dr. John Snow place the data in an appropriate context for determining cause and effect?

PLEASE DO NOT TURN THE PAGE.
FACT: Circle the 6 pumps. One company drew water downstream of this neighborhood. Which pump was theirs? Which handle would you remove?

PLEASE STUDY THIS MAP

FIGURE 2 Review Dr. Snow’s analysis of the cholera epidemic in London, 1854, in relationship to the Broad St. pump.
"The deaths which occurred during this fatal outbreak of cholera are indicated on the accompanying map, as far as I could ascertain them. There are necessarily some deficiencies. The pump in Broad Street is indicated on the map, as well as all the surrounding pumps to which the public had access at the time. It requires to be stated that the water of the pump in Marlborough Street, at the end of Carnaby Street, was so impure that many people avoided using it. And I found that the persons who died near this pump in the beginning of September, had water from the Broad Street pump. With regard to the pump in Rupert Street, it will be noticed that some streets which are near to it on the map, are in fact a good way removed, on account of the circuitous road to it. These circumstances being taken into account, it will be observed that the deaths either very much diminished, or ceased altogether, at every point where it becomes decidedly nearer to send to another pump than to the one in Broad Street."

Snow, J. On the Mode of Communication of Cholera, British Medical Journal, 1854, p. 21

DISCUSSION:

Cholera is one of the ancient scourges of mankind, exacting a toll nearly equal to the Black Death itself. In the London of 1854, when many believed that such epidemics were supernatural things, Dr. John Snow became the first to apply rational thought to the distribution of new disease cases in time and space. In doing so, he established the science of modern epidemiology - the behavior of diseases in populations. When microbiologists had yet to isolate the vibrio and when clinicians were completely helpless, Dr. Snow realized the value of defining the mode of transmission. He dramatically demonstrated that simply removing the handle from the Broad Street water pump could halt the epidemic. His is an example of chance favoring the prepared mind and a discovery obvious only to his successors. Dr. Snow realized that the disease itself suited his purposes: the case was clearly defined and its time of onset could be fixed. He thought to apply data from several municipal water sources, to residential maps of the city, the pipeline patterns of the two drinking water companies, and their water sources from the Thames River – one above and one below the sewage effluent of the city. Figure 2 is a reproduction of a map showing streets, buildings, cases (in bars) and pumps. Locate the six water pumps on the map. From which pump would you remove the handle?

Thought Question: WHAT IS THE GREATEST WEAKNESS OF THIS MAP?

Answer:

___________________________________________________________

PLEASE DO NOT TURN THE PAGE
Answer:
It does not show the distribution of residents (the denominator). Therefore, we do not know the numbers of people at risk, which is a useful basis of measurement for disease behavior in populations. This concept of using persons at risk as a denominator has become the cornerstone for the epidemiology of all forms of disease.

OUTBREAK APPROACH:

There is no precise definition for the terms “outbreak” or “epidemic”. The terms are generally taken to mean an unexpected increase in the rate of appearance of new cases, that is, a noticeable rise in the incidence of cases. This definition does, however, lend itself to a statistical way of deciding what causes an epidemic and then describes an appropriate course of action. The simple protocol described below presents one process used to determine whether such an increased incidence has occurred.

Investigation Outline:

Step 1: Define and identify a case.

What criteria define a case? This process is arbitrary. Syndromes may be preferred to culture results. A process may be defined broadly and be specific. It may be defined narrowly and be specific. This initial step usually balances sensitivity and specificity:

- Pneumonia = fever (sensitive)
- Pneumonia = fever + cough
- Pneumonia = fever + cough + CXR infiltrate (specific)

CULTURE PROBLEMS:

Infection - Culture probable presence of an organism with a constellation of signs and symptoms. Colonization - Culture proven presence of an organism without signs or symptoms of disease (usually a normal phenomenon that does not represent disease). Bacteria may be same genus and species but different clones.

Investigate suspicious patients for evidence of infection by using previously defined set of signs and symptoms.

Step 2: Establish the existence of the increased incidence by gathering data meeting case criteria. Interview all involved. Keep notes.

Tabulate cases: If there are less than 20, try a table first, not a graph…but be careful.

Determine rates of infection:

<table>
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<th>LOCATION</th>
<th>4H</th>
<th>9A</th>
</tr>
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<tbody>
<tr>
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<td></td>
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<tr>
<td></td>
<td>10</td>
<td>4</td>
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<td>5</td>
</tr>
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<td></td>
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<td>7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>36</td>
<td>28</td>
</tr>
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</table>

FIGURE 4 Note: Assume a constant denominator
Step 3: Determine the rates.  
Analyze and interpret the data  
Present the data: Graphics

The quality of statistical graphics can be tricky. Graphs have the potential to present data in a misleading manner. An excellent graph will show the data, provoke the viewer to think about the substance of the data (and not merely its presentation), avoid distorting data, present many numbers, encourage the viewer to compare different pieces of data, and serve a clear purpose, (Tufte, 1997)

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th></th>
<th>II</th>
<th></th>
<th>III</th>
<th></th>
<th>IV</th>
<th></th>
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<td></td>
<td>X</td>
<td>Y</td>
<td>X</td>
<td>Y</td>
<td>X</td>
<td>Y</td>
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<tr>
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<tr>
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<td>8.77</td>
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<td>7.11</td>
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<td>7.0</td>
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<td></td>
<td>5.0</td>
<td>5.73</td>
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</tbody>
</table>

N = 11  
mean of X's = 9.0  
mean of Y's = 7.5  
equation of regression line: Y = 3 + 0.5X  
standard error of estimate of slope = 0.118  
t = 4.24  
sum of squares X - X̄ = 110.0  
regression sum of squares = 27.50  
residual sum of squares of Y = 13.75  
correlation coefficient = .82  
r² = .67

Look at the data set in Figure 5 carefully. Are these four groups of numbers essentially identical?

Yes [ ]  No [ ]

DISCUSSION: Are the data sets comparable?

________________________________________________________________________

________________________________________________________________________

Turn the page to compare the different graphical displays that are possible using this data set.
Cases increase with time generally

Cases increase; then decrease with time

Cases linearly increase with time with one outlier

Cases are around the same time with one outlier

Step 4: Analyze and interpret the data by placing the data in an appropriate context to establish cause and effect. Tables vs. Graphs

Determine the rates of infection:

a.) The importance of rate: NO raw numbers.

b.) Calculate the rate of infection as a ratio of cases per 1000 patient days on the ward of interest.
   1. Procedures
   2. Location
   3. Time

c.) Calculate a comparison rate for the previous year or time unit on the same ward/unit.
   I.e. infection rate 1997 - 0.5 cases/1000 patient days
   Infection rate 1998 - 1.0 cases/1000 patient days

Step 5: Review your results. Do they make sense? If not, execute other studies such as traceback procedures, laboratory studies and/or environmental investigations.

What is the statistical significance of the rate increase?

THE NORMAL LAW OF ERROR STANDS OUT IN THE EXPERIENCE OF MANKIND AS ONE OF THE BROADEST GENERALIZATONS OF NATURAL PHILOSOPHY IT SERVES AS THE GUIDING INSTRUMENT IN RESEARCHES IN THE PHYSICAL AND SOCIAL SCIENCES AND IN MEDICINE AGRICULTURE AND ENGINEERING IT IS AN INDISPENSABLE TOOL FOR THE ANALYSIS AND THE INTERPRETATION OF THE BASIC DATA OBTAINED BY OBSERVATION AND EXPERIMENT

<table>
<thead>
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<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
</table>

N.B. Two standard deviations = 95% of the population.

- Statistician W.J. Youden

FIGURE 7 Selecting a time interval is critical!

FIGURE 8 Review Point: If p < .05, the rate increase is statistically significant. Statistical significance (p<.05) suggests that 95% of the time this is not a chance occurrence.
a.) Set up a 2x2 table of the comparative rates:

\[
\begin{array}{ccc}
\text{Chi-square} & 2003 & 2004 \\
(t-1) (ad-be)^2 & a & b \\
(v_1/v_0/h_1/h_0) & c & d \\
\end{array}
\]

b.) Use \( x^2 \) (chi square) test when possible. Calculate a "p" value to determine the statistical significance of the rate increase. (Figure 9)

c.) A "p" value less than 0.05 indicates that the rate increase is significant (not likely the result of chance alone).

d.) Use computer site: http://www.unc.edu/~preacher/chisq/chisq.htm provided by Kristopher Preacher from the University of North Carolina at Chapel Hill.

e.) Present the data: TABLE

<table>
<thead>
<tr>
<th>2003</th>
<th>2004</th>
<th>P &gt; .16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Patient-days</td>
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<td>1000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2003</th>
<th>2004</th>
<th>P &lt; .05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>23</td>
<td>33</td>
</tr>
<tr>
<td>Patient-days</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

STEP 6: “CRAFT” = Conclusion, Recommendation, Action, and Follow Through

Decide a course of action based on the 'p' value

C. Re-evaluate:
Determine crew rates of infection and 'p' values if new cases emerge. Consider a new definition of a case.

A. Educate:
Inform the staff and increased incidence of disease exists.

B. Follow:
Monitor ward/unit for new infections

D. Analyze evidence of an outbreak

**CONCLUSION**
Analysis – search for reasons for the increased infection incidence.
Personally investigate possible sources for the increased disease incidence
The investigation focuses on:

- **People** - who cares for the patients? Is there a common caretaker?
- **Places** - where are the afflicted patients located? Is there something about this area that is causing these infections? (i.e. air handling equipment and Legionnaires disease)
- **Things** - common supplies/instruments used in the care of the patients?

Formulate an action plan - what must be done to prevent further infections?
Once the source of the increased incidence of infection is hypothesized, create a detailed action plan to avoid more cases containing the following components:

- The task(s) to be completed.
- The persons responsible for completing each task.
- A date by which the action must be completed.

<table>
<thead>
<tr>
<th>ACTION</th>
<th>RESPONSIBLE PARTY</th>
<th>COMPLETION DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move patients from Unit 5A to 2A</td>
<td>5A nurse manager</td>
<td>9/20/09</td>
</tr>
<tr>
<td>Decontaminate/ replace 5A air conditioning unit</td>
<td>Building maintenance</td>
<td>10/1/09</td>
</tr>
</tbody>
</table>

*FIGURE 12 Example based on an increased incidence of Legionnaires disease associated with air handling equipment.*

**STEP 6: Follow through**

Re-evaluate the ward/unit to assure that infection incidence has returned to baseline.
If rate still increased, with population “p” less than 0.05, re-analyze for possible source (people, places, things).

In summary, a good investigation begins and ends with the following steps *(CRAFT)*:

- **Conclusion**, **Recommendation**, **Action**, **Follow Through**