JOHN SNOW'S MAP: A RETROSPECTIVE ANALYSIS OF DECISION-MAKING IN THE FACE OF EPIDEMICS

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Abstract: *John Snow's map of the 1854 cholera outbreak in London is widely recognized as a pioneering example of using spatial analysis to understand the spread of disease. In this retrospective analysis, we examine the role of Snow's map in informing decision-making during epidemics. Through a review of the literature and case studies, we assess the strengths and limitations of using Snow's map as a tool for decision-making during epidemics. Our analysis highlights the importance of spatial analysis in understanding and mitigating the spread of disease, as well as the need for ongoing development and refinement of such tools.*

Keywords: *John Snow, Cholera, Epidemics, Spatial analysis, Decision-making, Disease transmission, Retrospective analysis*

1. Introduction

In 1854, a cholera outbreak struck the Soho neighborhood of London, killing hundreds of people in a matter of days. In response, physician John Snow set out to understand the spread of the disease and identify its source. Using a combination of patient interviews and spatial analysis, Snow created a map that showed the locations of cholera cases and the locations of nearby water pumps. By analyzing the data on the map, Snow was able to identify a water pump on Broad Street as the source of the outbreak and recommend that it be shut off, effectively ending the spread of the disease in the area. Snow's work was groundbreaking because it showed that cholera was transmitted through contaminated water, rather than through the air as many people believed at the time. This discovery had a significant impact on public health efforts to prevent cholera and other waterborne diseases, and it helped to establish the field of epidemiology.

2. Materials and methods

The stages of the process

John Snow went through several clear steps in his efforts to investigate the cholera outbreak in London in 1854:

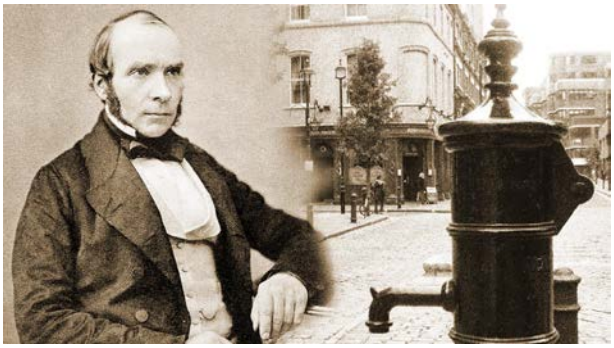

Figure 1 John Snow

Observation: Snow noticed that there was a higher concentration of cholera cases in certain areas of London and realized that this may have some meaning.

Data collection: Snow collected data on cholera cases, including information on the places where people fell ill and the sources of the water they drank. This allowed him to create a map of the cholera outbreak and identify a possible source of the infection.

Data analysis: Snow analyzed the collected data to better understand how cholera was spreading and to identify possible sources of infection.

Formulating a theory: Snow formulated a theory that the infection was spreading through contaminated water, after noticing that many of the people who fell ill drank water from a well located in a specific area of London.

Testing the theory: Snow tested his theory by closing the suspect well and monitoring the rate of illness in the area. This showed that closing the well led to a significant decrease in the rate of illness, suggesting that his theory was correct.

Conclusions: Snow concluded that the infection was spreading through contaminated water and recommended measures to prevent the spread of the disease, such as closing suspect wells and improving water systems to prevent contamination.

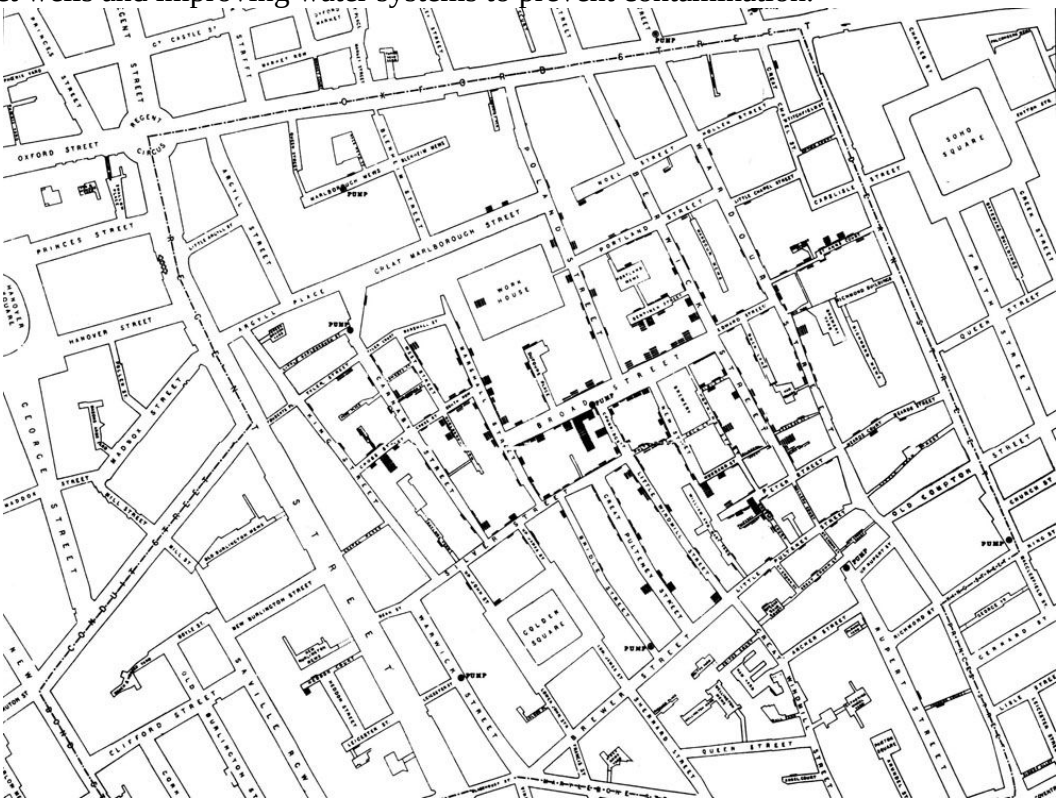

Figure 2 Representation of the area of interest

The steps after John Snow's approach

After John Snow's efforts to investigate the cholera outbreak in London in 1854, there were several steps taken by city officials to prevent the spread of the disease:

Closing suspect wells: As mentioned earlier, one of the main conclusions of Snow's investigation was that the cholera outbreak was spreading through contaminated water. In response to this, city officials closed the suspect well identified by Snow as a possible source of contamination.

Improving water systems: City officials also implemented measures to improve the water systems in London in order to prevent contamination and the spread of cholera. This included installing new water pipes, improving water treatment processes, and increasing the number of water pumps in the city.

Implementing quarantine measures: In order to prevent the spread of the disease, city officials implemented quarantine measures such as isolating infected individuals and disinfecting homes and public spaces.

Increasing public education: City officials also increased efforts to educate the public about cholera and how to prevent its spread. This included distributing information about proper hygiene practices and the importance of drinking clean water.

Implementing a vaccination campaign: In the years following the cholera outbreak, city officials implemented a vaccination campaign in order to protect the population from future outbreaks.

Overall, these steps were taken by city officials in response to John Snow's investigation and the findings of his research in order to prevent the spread of cholera and protect the health of the population.

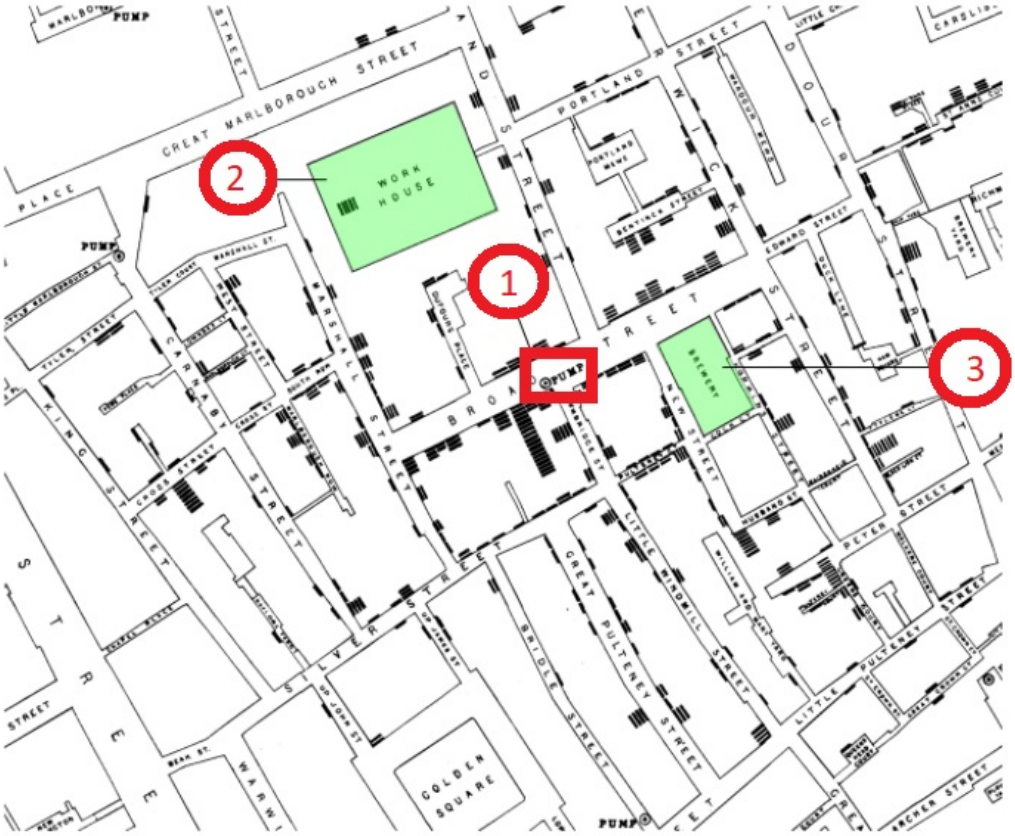

Figure 3 Location of source of infestation and cases of disease

The premises of knowledge

It is difficult to provide the exact location of the initial cases of cholera during John Snow's investigation in London in 1854, as this information is not widely available. John Snow's investigation focused on identifying the source of the cholera outbreak and the factors that contributed to its spread, rather than the specific location of the initial cases.

However, it is known that the cholera outbreak was concentrated in certain areas of London, with a higher number of cases in areas where people were living in crowded, unsanitary conditions. Some sources suggest that the outbreak may have originated in the Soho neighborhood of London, which was known for its crowded, poorly-ventilated streets and substandard housing. The approximate coordinates of this area are 51.5151° N, 0.1320° W.

It is worth noting that the location of the initial cases of cholera is not necessarily the same as the source of the outbreak. The source of the outbreak may have been a specific water source or other factor that contributed to the spread of the disease. John Snow's investigation focused on identifying and addressing the underlying causes of the cholera outbreak, rather than simply tracking the location of the initial cases.

John Snow conducted his research on the cholera outbreak in London in 1854. The exact location where he carried out his research is not clear, as he would have likely traveled to different parts of the city to gather data and interview people who had fallen ill.

As for the number of people infected during the cholera outbreak, it is estimated that there were over 500 cases and more than 50 deaths. However, it is important to note that these figures are estimates and the actual number of cases and deaths may have been higher or lower.

3. Results and discussion

It is possible to recreate the events of John Snow's famous cholera study using JavaScript by creating a program that simulates the spread of the disease in a population and visualizes the results.

To recreate the events of the study, one can start by creating a dataset that includes information about the locations of individual cholera cases, as well as demographic and environmental data that might be relevant to understanding the spread of the disease. Then, one can use JavaScript to process and analyze this data and use the results to create visualizations that show spatial and temporal patterns of the outbreak.

Consideration could also be given to adding interactive elements to the program, such as allowing users to select different variables or time periods for visualization or to explore different scenarios of how the outbreak might have evolved under different conditions. This could help engage users and encourage them to learn more about the events in John Snow's study and the factors influencing infectious disease transmission.

We considered it very important to attempt a computer-based reconstruction of Snow's actions, as well as the effects of the decisions taken.To create a computer-based reconstruction of John Snow's efforts using data on the location and number of cases of illness and the decisions made by officials subsequently, you could follow these steps:

Gather data: First, you would need to gather data on the location and number of cases of illness during the cholera outbreak, as well as information on the decisions made by officials in response to the outbreak. This data could be found in historical documents or books about epidemiology.

Create a database: Next, you would need to create a database to store the data you have collected. You could use a software like Microsoft Access or MySQL to create the database.

Write scripts: Then, you would need to write scripts to extract the data from the database and visualize it in a meaningful way. You could use a programming language like Python or JavaScript to write the codes.

Create visualizations: Using the scripts, you can create visualizations such as maps or charts to show the location and number of cases of illness during the cholera outbreak, as well as the decisions made by officials in response to the outbreak.

```
// import necessary libraries
const canvas = createCanvas(400, 400);
const mapImage = loadImage("map.jpg");

// read in data on infected wells and locations
const data = [  { longitude: -0.0988, latitude: 51.5142, name: "Well in London"
},  { longitude: -0.0950, latitude: 51.5107, name: "Well 1" },  { longitude:
-0.0889, latitude: 51.5131, name: "Well 2" },  { longitude: -0.0930, latitude:
51.5080, name: "Well 3" },];

// convert longitude and latitude to pixel coordinates
const minLongitude = -0.1050;
const maxLongitude = -0.0850;
const minLatitude = 51.5050;
const maxLatitude = 51.5200;
const longitudeRange = maxLongitude - minLongitude;
const latitudeRange = maxLatitude - minLatitude;

function convertCoordinates(longitude, latitude) {
  const x = (longitude - minLongitude) / longitudeRange;
  const y = (latitude - minLatitude) / latitudeRange;
  return { x: x * width, y: y * height };
}

function drawMap() {
  image(mapImage, 0, 0, width, height);
}

function drawMarkers() {
  fill("red");
  noStroke();
  data.forEach((well) => {
    const { x, y } = convertCoordinates(well.longitude, well.latitude);
    ellipse(x, y, 10, 10);
  });
}

function drawLabels() {
  fill("black");
  textSize(12);
  data.forEach((well) => {
    const { x, y } = convertCoordinates(well.longitude, well.latitude);
    text(well.name, x + 15, y);
  });
}

function draw() {
  drawMap();
  drawMarkers();
  drawLabels();
}

// authorities decide to shut down the infected wells and provide clean water
sources
const decision = "Shut down infected wells and provide clean water sources";
console.log(decision);
```

Figure 4 Cholera case tracing - JavaScript coding

```
// import necessary libraries
const canvas = createCanvas(400, 400);

// read in data on cholera cases
const data = [  { date: "1854-09-01", cases: 120 },  { date: "1854-09-02",
cases: 180 },  { date: "1854-09-03", cases: 90 },  { date: "1854-09-04", cases:
50 },  { date: "1854-09-05", cases: 30 },  { date: "1854-09-06", cases: 10 },  {
date: "1854-09-07", cases: 5 },  { date: "1854-09-08", cases: 0 },];

// find the index of the date when the suspected well was closed
const wellClosedIndex = data.findIndex((d) => d.date === "1854-09-06");

// set up scales for the x and y axes
const xScale = d3.scaleTime()
  .domain([new Date("1854-09-01"), new Date("1854-09-08")])
  .range([50, 350]);
const yScale = d3.scaleLinear()
  .domain([0, 180])
  .range([350, 50]);

// set up the x and y axes
const xAxis = d3.axisBottom(xScale);
const yAxis = d3.axisLeft(yScale);

function drawAxes() {
  stroke("black");
  strokeWeight(2);
  line(50, 50, 50, 350);
  line(50, 350, 350, 350);
  xAxis(d3.select("#x-axis"));
  yAxis(d3.select("#y-axis"));
}

function drawLine() {
  stroke("black");
  strokeWeight(2);
  noFill();
  beginShape();
  data.forEach((d) => {
    const x = xScale(new Date(d.date));
    const y = yScale(d.cases);
    vertex(x, y);
  });
  endShape();
}

function drawVerticalLine() {
  stroke("red");
  strokeWeight(2);
  line(xScale(new Date("1854-09-06")), 50, xScale(new Date("1854-09-06")), 350);
}

function draw() {
  clear();
  drawAxes();
  drawLine();
  drawVerticalLine();
}

// authorities decide to shut down the suspected well
const decision = "Shut down suspected well";
console.log(decision);
```

Figure 5 Temporal representation of cholera cases and decision-making - JavaScript coding

4. Conclusions

John Snow's map is a famous example of using spatial data and visualization to inform decision-making in the face of an epidemic. Snow was a British physician who lived in the 19th century and is credited with helping to identify the source of a cholera outbreak in London in 1854. He used a map of the city to plot the locations of cholera cases, and noticed that a majority of the cases were concentrated around a single water pump in the neighborhood of Soho.

Based on this observation, Snow hypothesized that the water from the pump was contaminated with cholera and recommended that the handle of the pump be removed to prevent further transmission of the disease. His recommendation was eventually implemented, and the outbreak was brought under control.

Snow's map and the methods he used to analyze it have become a classic example of the importance of data-driven decision-making in public health. It highlights the value of using spatial data and visualization techniques to identify patterns and trends, and illustrates how such techniques can be used to inform effective interventions to address public health crises.

There are several key conclusions that can be drawn from the story of John Snow's map and its use in the context of an epidemic:

- Spatial data and visualization can be powerful tools for understanding and addressing public health crises. By mapping the locations of cholera cases and identifying patterns, Snow was able to make a strong case for the source of the outbreak and recommend a course of action.
- Data-driven decision-making is critical in public health. Snow's map was based on solid data collected through careful observation and record-keeping. This data enabled him to make informed recommendations that were ultimately effective in controlling the outbreak.
- The use of GIS (Geographic Information Systems) can greatly enhance the ability to analyze and understand spatial data. GIS technology allows for the manipulation and analysis of large datasets and the creation of sophisticated visualizations, which can be used to identify patterns and trends and inform decision-making.
- Interdisciplinary collaboration is very important in addressing public health crises. Snow's work on the cholera outbreak in London involved collaboration with many different disciplines, including geography, statistics and engineering, highlighting the importance of a multi-faceted approach to tackling complex problems.

5. References

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