



Salem's Secrets: A Case Study on Hypothesis Testing and Data Analysis*

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“Scientific research can reduce superstition by encouraging people to think and survey things in terms of cause and effect. Certain it is that a conviction, akin to religious feeling, of the rationality or intelligibility of the world lies behind all scientific work of a higher order.” —Albert Einstein

Part I—Salem's Secrets

There was a chill in the courtroom that day—a chill colder than could be explained by the unbearable winter. It was a cold that started at the back of the neck and lodged deep in the spine. Something evil was afoot. The question was: to whom did that evil belong?

“She killed Goodwife Betty’s baby. She killed it with those evil eyes. I saw her staring, as in a trance, at Betty’s house at sunset one evening last week. Then her cow and her baby died. She also makes poisons in her house. When people won’t take her poison, she sends her spirit to force them by choking them until they swallow it. I see her spirit here now. It is over near Abby. Oh Abby, Abby! Be careful Abby, she has pins and they are red hot! Stop her, she is pricking me! Help me, I am burning... Help me...”

The courtroom hummed with whispers as the spectators watched two young girls, Elisabeth, the speaker, and Abby, her best friend, tear and swat at their arms and legs as if swarmed by invisible bees. Their contortions escalated into convulsive fits, which were so grotesque and violent that witnesses agreed they could not be manufactured. Soon, as if on cue, other girls from Elisabeth and Abby’s circle of friends joined in. The girls collapsed in exhaustion. Dr. William Griggs, the village physician, examined the girls and, finding only bruised skin, made a diagnosis; “... the evil hand is upon them. They are bewitched.”

Hathorne, the magistrate, directed his attention to Sarah Good, the latest woman to be accused of witchcraft in Salem in 1692, and in a powerful voice demanded, “Goodwife, why do you torture these girls so?”

“Sir, I do not hurt them.”

“Who do you employ then to do it?”

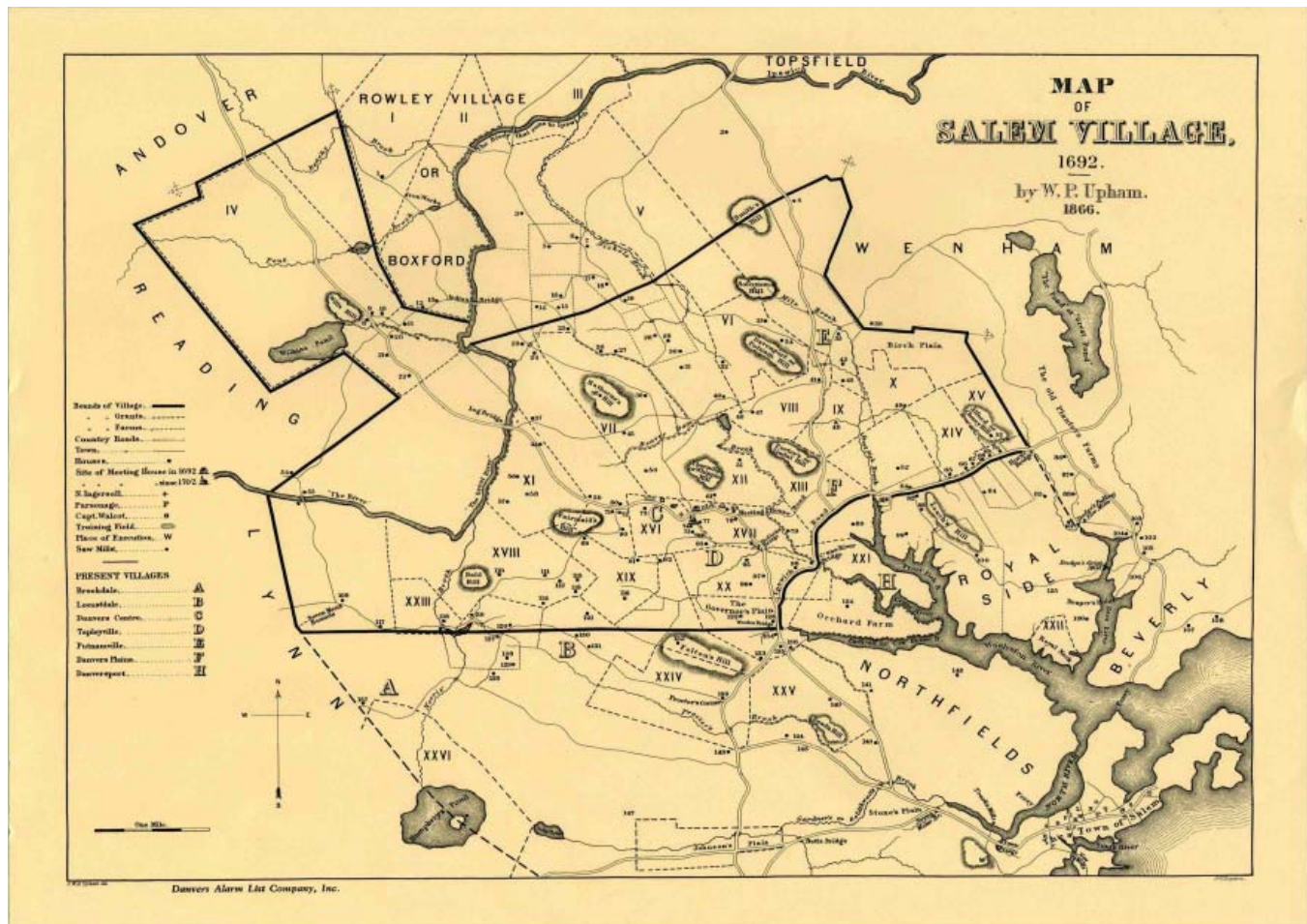
*Note: This case study, although based on an actual historical event, is fiction. The dialogue is fabricated by the authors from background material, in particular translations of actual depositions given in *The Salem Witchcraft Papers* (Boyer and Nissenbaum, 1977). Dr. William Griggs was the village physician at the time of the Salem witchcraft trials. Abigail Williams and Elisabeth Parris were among the first girls to be affected; Sarah Good was one of the first to be accused.

“I employ nobody.”

“And what say you of the poisons you keep at your home?”

“They are nothing more than good broths. When a child is to be born to a woman of this village... my broths bring them ease.”

Figure 1. Salem Village 1692.



“What evil spirit directs you in the making of these broths?”

“No spirit good sir, I am falsely accused.”

Scenes such as this were not uncommon in New England in the early colonial days. It is commonly known by most that a group of young girls in Salem were the initial catalyst that led to accusations of witchcraft against more than 200 people. These accusations resulted in the execution of twenty persons.

Question 1—What do you think caused the girls to behave this way?

To understand the phenomena at Salem, it is necessary to understand the culture and community of the time. In general, colonial life was hard. Rich farmable land was scarce, and any food it yielded was a result of strenuous physical labor. Diet was poor, deficient in essential nutrients and vitamins. Often colonists,

including children of a young age, worked from first light until after dark. Disease and death rates were high. It was not uncommon for families to suffer the loss of children.

The year spanning 1691–1692 was not a particularly good one for the Puritans, with an unusually severe winter and a rainy spring. As a result, the harvest that year was extremely poor. In addition, many families escaping the Indian Wars of Maine had moved into the northwest side of the area known as Salem, an area called Salem Village. This situation forced farmers to “utilize their swampy, sandy, marginalized land” (Matossian, 1982) for rye production and families in the community to share crops. Compounding these ills was a perceived imbalance in social status and power, the “haves” of the east side of town in direct conflict with the “have nots” of the village. Salem Villagers were disgruntled by having to pay taxes to, and serve in, the militia for Salem Town without receiving any direct benefit, namely a church of their own. In addition, Salem was factionalized by the leadership of two strong men (Parris of the Village and Proctor of the Town). The original/core group of girl accusers was kin of the Parris family.

Puritans were fervently religious and believed strongly in the balance of good and evil. To them, the devil was “a physical being who was incarnate, there to seduce them from the path of righteousness” (Woolf, 2000). When the march to the gallows struck Salem in 1692, it struck hard. The litmus test for bewitching was not substantial: the mere accusation of spectral evidence (victims would “see” a witch touching, pinching, or otherwise harming them) was sufficient to place a citizen in jeopardy. Likewise, one could earn the title of witch when the “passing by” of a person’s house or the “fixing a gaze” upon someone correlated with the stillbirth of a child or the death of a domestic animal.

Question 2—In the opening passage, what “evidence” did the girls provide for the presence of witches/witchcraft? (List this information in column 1 of your data management sheet—see page 10.)

Question 3—Assume you are living in Salem in 1692. Develop a hypothesis based on your observations. (Remember that a hypothesis must be supported by scientific evidence.)

Question 4—Reflect for a moment on this concept of evidence. How do we define “evidence” in science? Does the girls’ evidence pass scientific muster?

Part II—Mass Hysteria

For over 100 years, the prevailing belief was that the Salem tragedy was a direct result of mass hysteria, a condition in which a large group of people exhibit similar physical or emotional symptoms not attributable to any physiological cause. The Salem girls as a group experienced an array of unusual symptoms. In the absence of a clear medical diagnosis, and based on the limited technology of the time, the doctor who examined the girls pronounced them bewitched.

Collective human behaviors, however, are more common than many people realize. Some are simply the crazes and fads that often affect teenagers and other social groups. Others are bizarre, such as the example given below that occurred in the early 1900s when several students were convinced their penises were shrinking. Many, though, are less innocuous, and involve severe symptoms of illness. Below are listed some selected examples of mass hysteria events spanning several centuries.

Table 1. Mass Hysteria Events Throughout History

Mass Hysteria Event	Year	Summary
Southern Europe, especially Italy	1200s–1800s	Symptoms such as headache, giddiness, twitching, and delusions, culminating in frenzied dancing, in response to perceived bites from a tarantula spider.
Milan, Italy	1630	Several people executed after being pronounced guilty of spreading poison throughout the city in cooperation with the Devil.
Szechwan, China	1907	Twenty students convinced their penises were shrinking.
Newark, NJ	1938	Following radio broadcast of H.G. Wells' <i>War of the Worlds</i> dramatizing a "gas raid from Mars," mass panic occurred, involving thousands. Several were treated at hospitals for shock.
West Bank, Jordan	1983	Nearly a thousand people, mostly young females, afflicted with headaches, fainting, dizziness, and abdominal pain. Initially attributed to poison gas.
Kosovo, Yugoslavia	1990	Outbreak of flu-like symptoms such as headache, dizziness, and respiratory distress that persisted for weeks among thousands of mostly adolescent Albanians. Initially attributed to poisoning by Serbs.
Central Falls, RI	1991	Seventeen middle school students and four teachers with rapid onset of an array of symptoms such as dizziness, pain, vomiting, and chills. Initially attributed to chemical spill or toxic gas exposure.
A large midwestern university	1996	Sixty-nine college students and workers treated for shortness of breath, eye and skin irritation, and general feelings of illness. Initially attributed to a dusty substance in the snack bar.
McMinnville, TN	1998	Following a "gasoline-like" smell detected in a classroom, close to 200 students and staff members experienced headache, nausea, shortness of breath, and dizziness.
Amman, Jordan	1998	More than 800 students in 1 st –10 th grades displayed a variety of symptoms such as fever, chest tightness, chills, and feeling faint following tetanus-diphtheria vaccination.

Have your thoughts regarding the events at Salem changed after examining this table? Reflect on the observations you listed in column 1 of your data management sheet.

Part III—Ergot: A Toxic Fungus

Question 1: Incidences of witchcraft are found universally among cultures of this time, but none had the devastating impact that Salem's had. What other factors may have contributed to the phenomena at Salem?

Claviceps purpurea is the genus and species name of a toxic fungus that grows as a parasite on many grains, particularly rye. In rainy, wet weather, all plants become more vulnerable to fungi. Because rye also grows best in damp weather, it is particularly susceptible to fungal growth. When *Claviceps* spores germinate, they form distinct dark, hard structures called sclerotia. These sclerotia are commonly known as ergots, thus the term ergot poisoning, or ergotism. Within the ergots is produced a poisonous brew of fungal toxins, ingestion of which can lead to severe illness or death. Ergot fungal toxins are particularly stable and are not destroyed by boiling or baking (Bennett and Bentley, 1999).

Two forms of ergotism exist: convulsive and gangrenous. The convulsive form has the greatest effect on the central nervous system, leading to seizures, insomnia, and insatiable appetite. In the gangrenous form, blood flow to the extremities is restricted; in severe cases, this can lead to blackened tissue and subsequent bloodless limb loss. Either form of ergotism may cause tingling, itching, alternating perception of hot and cold temperatures, hallucinations, perceptual disturbances, and gastrointestinal upset. In addition, people under the influence of ergot derivatives are known to be highly suggestible (Matossian, 1982).

Several factors play a role in the severity of ergot poisoning. Nutritional status, in particular vitamin A deficiency, is one such factor (Bennett and Klich, 2003). Age and sex play a role as well, and ergotism preferentially seems to affect teenage females (Bennett and Bentley, 1999; Caporael, 1976). Humans are not the only species to suffer from ergot poisoning; farm animals can be affected as well.

Question 2: In column 2 of your data management sheet, list evidence that the events at Salem could have been caused by ergot poisoning.

Question 3: After reading Parts II and III of the case study, develop a second hypothesis, different from your first, explaining the events at Salem. Record this hypothesis on your data management sheet.

Figure 2. Ergot



Part IV—Data Interpretation

Table 1 is extracted from an article written by Nicholas Spanos and Jack Gottlieb on ergotsim and the Salem witch trials published in 1976 in *Science*. Spanos and Gottlieb collected these data by reading through the *Records of Salem Witchcraft* (Woodward, 1864; reprinted 1969) and making note of the frequency of symptoms suffered by witnesses outside of the original group of girls. At the time of the trials, the adult population of Salem was estimated to be 215 persons; no estimate is provided for the child population.

Table 2. Frequency of Symptoms

Reported sufferers	RSW vol. & page*	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Total
W. Allan	I:38	o	o	o	o	o	o	o	o	o	o	1	o	o	o	o	o	1
J. Bayley	I:113	o	o	o	o	o	o	o	o	o	o	1	o	1	1	o	1	4
S. Bittford	I:108	o	o	o	o	o	o	1	o	o	o	1	o	o	o	o	o	2
A. Booth	II:180	o	o	o	o	o	o	o	o	o	o	1	o	o	o	o	o	1
J. Childen	I:92	o	o	o	o	o	o	o	o	o	o	1	o	o	o	o	o	1
G. Cory	I:55	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	1	1
J. Doritch	I:262 and II:179	o	o	o	o	o	o	o	?	o	o	1	o	1	o	o	o	3
B. Gould	II:178	o	o	o	o	1	o	o	o	o	o	1	o	1	o	o	o	3
J. Holton	I:71	o	o	o	o	o	o	o	?	o	o	o	o	o	o	o	o	1
J. Hughes	I:38	o	o	o	o	o	o	o	o	o	o	1	o	o	o	o	o	1
J. Indian	I:64	o	o	o	o	o	o	o	1	o	o	1	o	o	o	o	o	2
T. Indian	I:44	o	o	o	o	o	o	o	?	o	o	1	o	o	o	o	o	2
E. Keysar**	**	o	o	o	o	o	o	o	o	o	?	1	o	o	o	o	o	2
M. Pope	I:59	o	o	o	o	o	o	o	1	o	o	1	o	o	1	o	o	3
H. Putnam	I:275	o	o	o	o	o	o	o	o	o	o	1	o	o	o	o	o	1
J. Putnam	I:95	o	o	o	o	o	o	o	?	o	o	o	o	o	o	o	o	1
W. Putnam	I:96	o	o	o	o	o	o	1	o	o	o	o	o	o	o	o	o	1
D. Wilkins	II:7	o	o	o	o	o	1	o	o	o	o	o	o	o	o	1	o	2
R. Wilkins	II:5	o	o	o	o	o	o	o	?	o	o	1	o	o	o	1	o	3
S. Wilkins	II:3	o	o	o	o	1	o	o	o	o	o	1	o	o	1	o	o	3
E. Woodwell	II:178	o	o	o	o	o	o	o	o	o	o	1	o	o	o	o	o	1
Total		o	o	o	o	2	1	2	7	o	1	16	o	3	3	2	2	39

Key: Symptoms of witnesses (other than the afflicted girls) who testified against the accused witches.

A: vomiting; B: diarrhea; C: livid skin; D: permanent contractures; E: pain in extremities; F: death; G: temporary muscle stiffness; H: convulsions; I: ravenous appetite; J: perceptual disturbances (not including apparitions); K: apparitions; L: sensations of hot and cold; M: skin sensations (biting and pinching); N: stomach pain; O: choking sensations; P: temporary inability to speak; 1: symptom reported; o: symptom not reported; ?: symptom questionable.

* RSW stands for *Records of Salem Witchcraft*, compiled by W.E. Woodward in 1864–85.

** This testimony comes from Boyer & Nissenbaum, 1972, page 75.

After reviewing the data from this table, use the information it provides and your observations from columns 1 and 2 of your data management sheet to prepare an argument in support of either one of your hypotheses. Consider the following questions:

Question 1: What do the data suggest? What symptoms are reported in high frequency? In low frequency? What patterns exist?

Question 2: Consider who was afflicted; what other health information was reported in 1692?

Question 3: Why did the idea of witchcraft occur here and now? Is this situation unique?

Part V—The Societal Frame: What Is the Secret of Salem?

Review the data from your data management sheet and then answer the questions below.

Question 1. In the beginning, did you think the girls at Salem were bewitched? Faking?

Question 2. Did your group acknowledge or dismiss the idea of mass hysteria with respect to Salem? Did you consider the social dynamics of the time in your thinking?

Question 3. After reading about the events of Salem, did your thinking about what happened change as you progressed through the material? How many times?

Question 4. If a similar set of symptoms was presented today, do you think the result would be similar? Why or why not? In other words, how does who we are and what we know change what we interpret?

Question 5. What questions still remain? What other information would help you decide what happened at Salem?

Part VI—Classroom Extension

Further research one of these topic extensions to this case study. Choose one of the following questions to develop into a one-page essay.

Question 1. How does public health reporting differ today from reporting in the 1600s?

Question 2. What can you infer from this case about the general safety of the world's food supply in 1692? Today?

Question 3. If you, as a member of the Department of Public Health, were informed of a group of people seemingly afflicted with a similar set of symptoms, what might be your initial thoughts and course of action?

Question 4. Ergot derivatives today are used to treat migraine headaches and alleviate bleeding after childbirth. How is it possible that such toxic substances can have therapeutic uses?

Question 5. If Salem had had a well-defined government in 1692, would the “March to the Witches Gallows” have occurred?

Question 6. The testimony of the children at Salem was accepted without question. Children often make accusations of many kinds of abuse by adults. Should such accusations be accepted at face value?

Question 7. Will it ever be possible to prove that the events at Salem were attributable to a specific cause? Why or why not? What is the difference between correlation and causation?

Further Reading

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Data Management Sheet

Observations from Part I:	Observations from Part III:
Data Interpretation:	
Hypothesis 1:	
Hypothesis 2:	
Final Conclusion:	