

WHY JOHN SNOW STILL MATTERS TO MODERN EPIDEMIOLOGY

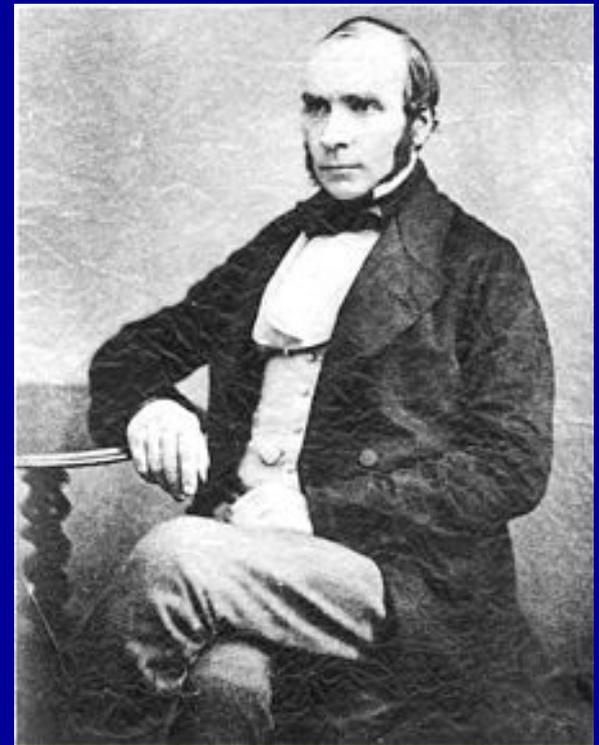
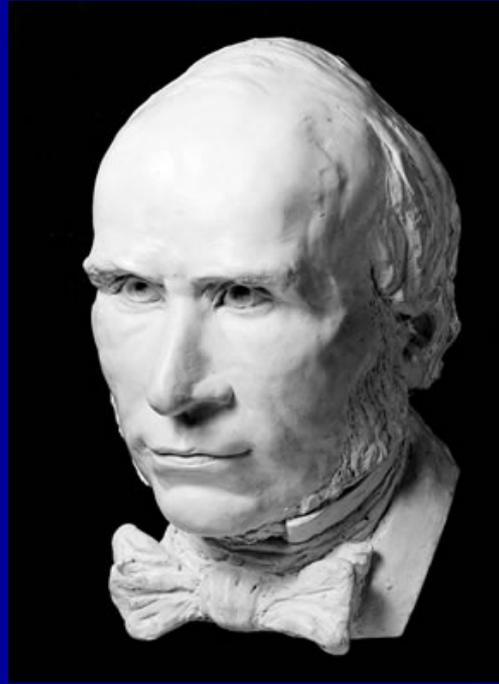
Nigel Paneth MD MPH
Michigan State University

Department of Epidemiology
University of Michigan
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DISCLOSURES

- I have no conflicts to disclose
- This powerpoint will shortly be posted at www.epi.msu.edu/faculty/paneth

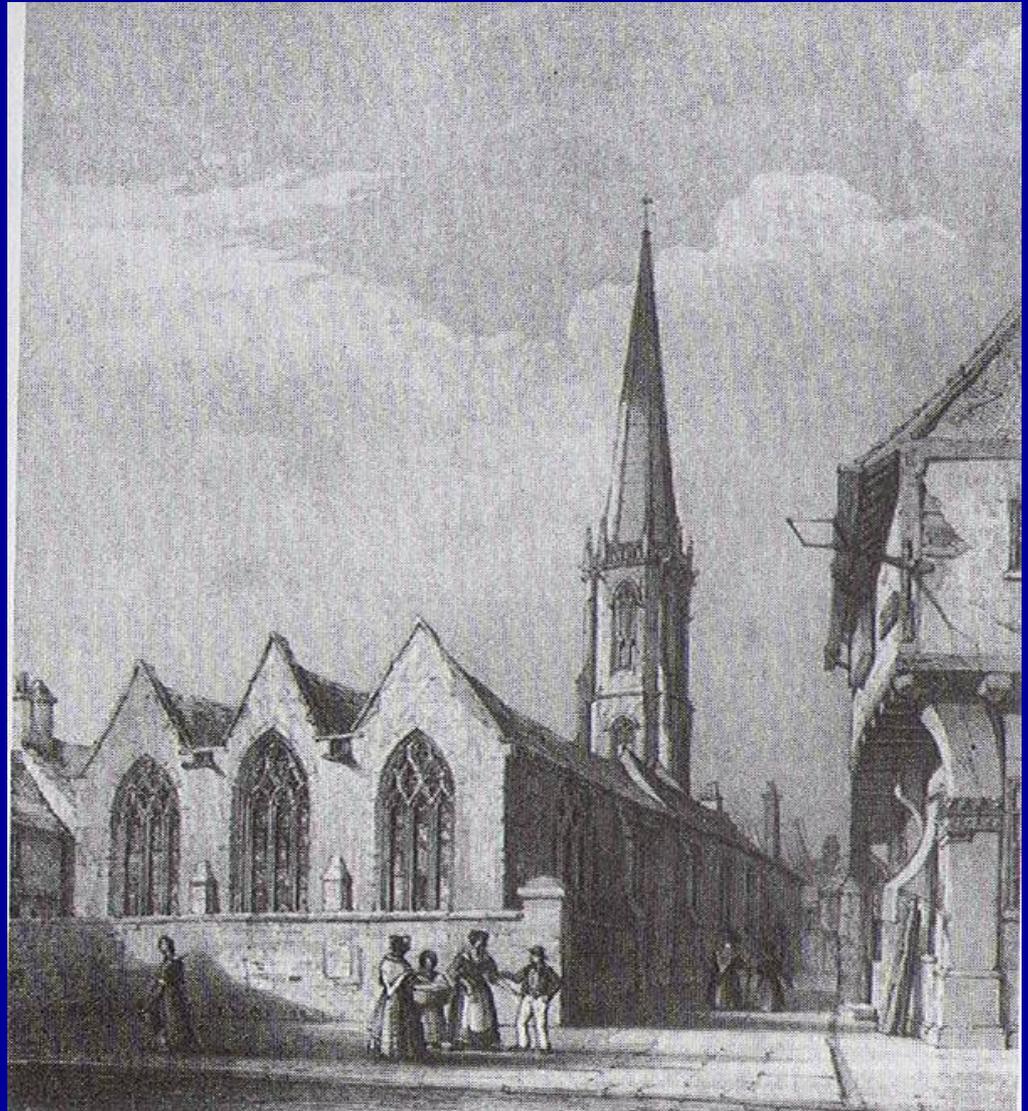
BIOGRAPHY



Born in York in 1813, eldest of nine children of William and Fanny Snow, both from farming villages outside York. Fanny was born out of wedlock.

The births of Snow and his 8 younger siblings are recorded in its parish register of All Saints Church in York, where his father was listed as a “laborer” for the first 6 births, and as a “carman” for the last 3.

Snow’s paternal grandparents and infant brother George are buried in the church yard.



THE UPWARDLY MOBILE SNOWS

- By the 1840's, **William** Snow was collecting rent on four properties in York and had purchased a farm in the village of Rawcliffe.
- Seven of Snow's eight siblings survived to adulthood, and several, like John, entered the middle class.
 - **William** ran a temperance hotel before emigrating to Australia
 - **Robert** managed Garforth Colliery, Leeds
 - **Thomas** became vicar of Underbarrow
 - **Mary** and **Hannah** (who both survived into the 20th century) headed the "The Mount" school for girls in York.

EDUCATION AND TRAINING

- Snow left school at 14 and was apprenticed to practitioners in Newcastle and the surrounding countryside for several years.
- He took some medical school courses in Newcastle, and further courses in London.
- He was first certified, by experience and examination, as a **surgeon-apothecary**. This was the certification for most general practitioners, few of whom attended medical school.
- Then, by examination, he was certified as **MD** from the University of London, placing him in the highest medical echelon.

SNOW' S PROFESSIONAL ACTIVITIES

- Began as a general practitioner in London, with a large practice among the poor.
- Frequently attended medical society meetings and presented scientific papers. Wrote 2-3 scientific papers a year throughout his career.
- Gradually increased the amount of time he devoted to anesthesia, eventually becoming financially comfortable.
- Undertook his cholera investigations privately and probably at considerable personal expense.

PERSONAL LIFE

- Never married.
- Brought up in a deeply religious environment, but no evidence of adult involvement in church, and no hint of religion in his writings.
- Took a **temperance** pledge as teenager.
- Became a **vegetarian** early in life and **distilled his own water**.
- Had a strong **Yorkshire accent**, making him hard to understand (in London).
- Was **finned £5** as a teenager for setting off a firecracker outside a church during services.

VIEWS OF SNOW IN HIS LIFETIME

- Snow died of a stroke in 1858, aged 45.
- His anesthesia work was greatly respected, and he was elected president of the Medical Society of London.
- His cholera theories were largely rejected in his lifetime, though some leading figures (Farr, Budd) came close to his views.
- He testified in Parliament for industry, arguing that their unpleasant smells did not cause epidemic disease, which led to scathing criticism in the *Lancet*, and even in more recent times – see *Lilienfeld D: John Snow – the first hired gun? Am J Epidemiol 2000; July 1, 152(1):4-9.*

VIEWS OF SNOW LATER

- The 1866 cholera epidemic (the last big epidemic in the UK) convinced many that cholera was transmitted as Snow described.
- Beginning in the late 1860's one can find many very positive references to Snow's cholera work in British and American literature, which may have fueled water supply improvements in these countries.
- But not so in France and Germany, where Snow's conclusions were resisted into the early 20th century. Hamburg had an 1895 cholera epidemic that killed 10,000 people that was clearly waterborne.

ANESTHESIA

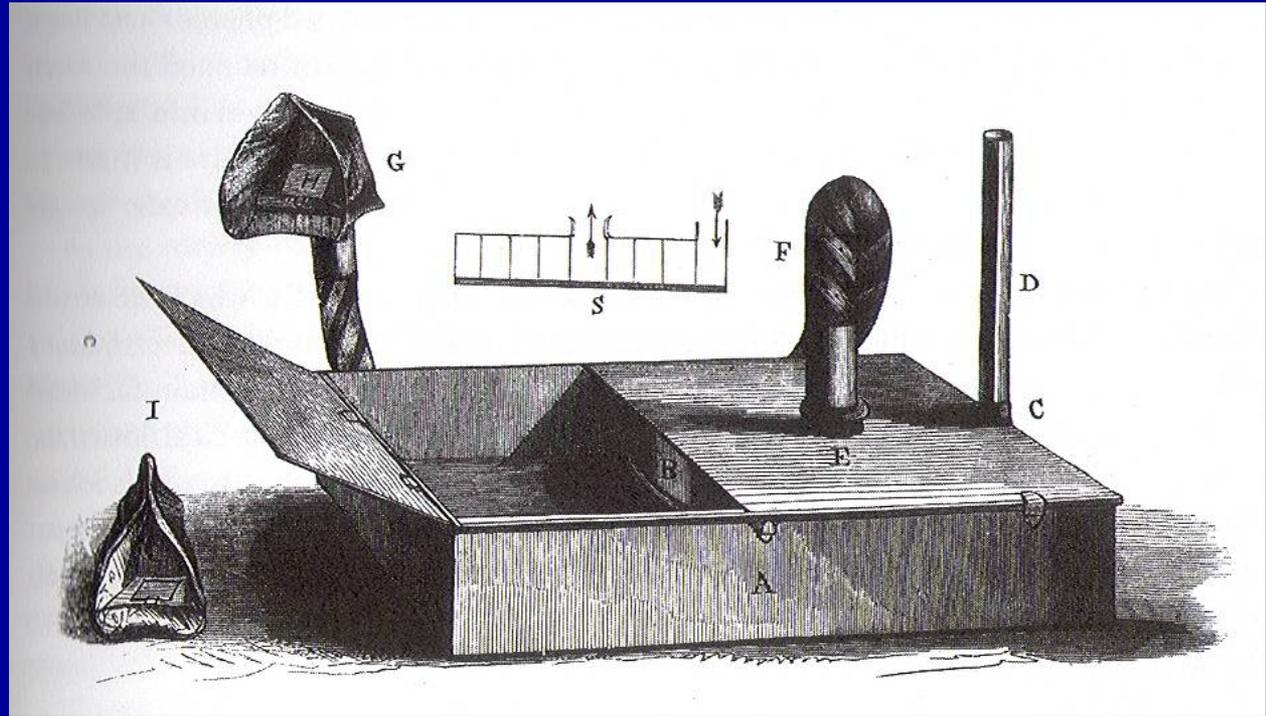
ON THE INHALATION OF VAPOR OF ETHER IN SURGICAL OPERATIONS (1847)

- Snow saw the first demonstration of anesthesia in England in December 1846, and quickly recognized its deficiencies.
- He experimented with animals and provided anesthesia to patients, developing methods for safe, effective anesthesia
- In his 1847 monograph, published less than a year after the first demonstration in England, he described a number of key innovations in anesthesia practice that remained the standard of practice until the 1920's.

SNOW'S ANESTHESIA INNOVATIONS

- A system for mixing the anesthetic gas with air
- A system for controlling the vaporization of anesthetic gas by altering its temperature with a water bath
- Use of a mask to deliver the gas/air mixture
- A 5-category clinical scale rating depth of anesthesia
- His insistence that the administration of anesthesia is a separate practice, not to be performed by the surgeon.
- The practice of recording each case with any complications that arose (His anesthesia casebooks from 1853-56 survive).

Snow's 1847 apparatus for administering ether. Inside the tin box is a spiral chamber, where ether (poured in at C) mixes with air (enters through D), and the air-ether mixture reaches the patient through tube F attached to face mask (G and I). A water bath (A) maintains constant temperature of the air-ether mixture



Temperature	40°F	60°F	80°F
Percent Ether	24%	40%	62%

ANESTHETIC PROMINENCE

Snow quickly became the most sought-after anesthesiologist in London, and was even sent for to assist operations in other parts of England.

He twice administered chloroform to Queen Victoria during child birth in the 1850's



Queen Victoria (1819-1901)

CHOLERA

CONTRIBUTIONS TO CHOLERA

Snow was involved in each of the first three cholera epidemics in Europe - 1831-2, 1848-9 and 1853-4.

- 1831: At age 18, Snow was assigned to take care of cholera in the Killington mines. Several examples of cholera transmission in his writings refer to miners.
- 1849: Published an article and a monograph that insisted that cholera was spread **exclusively** by fecal-oral and waterborne transmission. These works permanently set out Snow's basic theory of cholera patho-physiology and propagation.
- 1855: Enlarged his monograph with much new evidence and maps from the London epidemic of 1854, but made no change to his basic theory.

SNOW'S THEORY

- Cholera is entirely a disease of the intestines, killing its victims by massive fluid loss.
- Therefore the disease is caused by something ingested, not inhaled (as in miasma theory)
- The cholera agent has the power to reproduce, because there is a delay (incubation period) between ingestion of the agent and disease onset. He hypothesized that the agent must be “*something like a cell*”
- Transmission of cholera is directly via the fecal-oral route, and is extended by water supplies contaminated with cholera evacuations.
- Foul odors and rotting material (the focus of sanitarians) have nothing to do with cholera transmission.

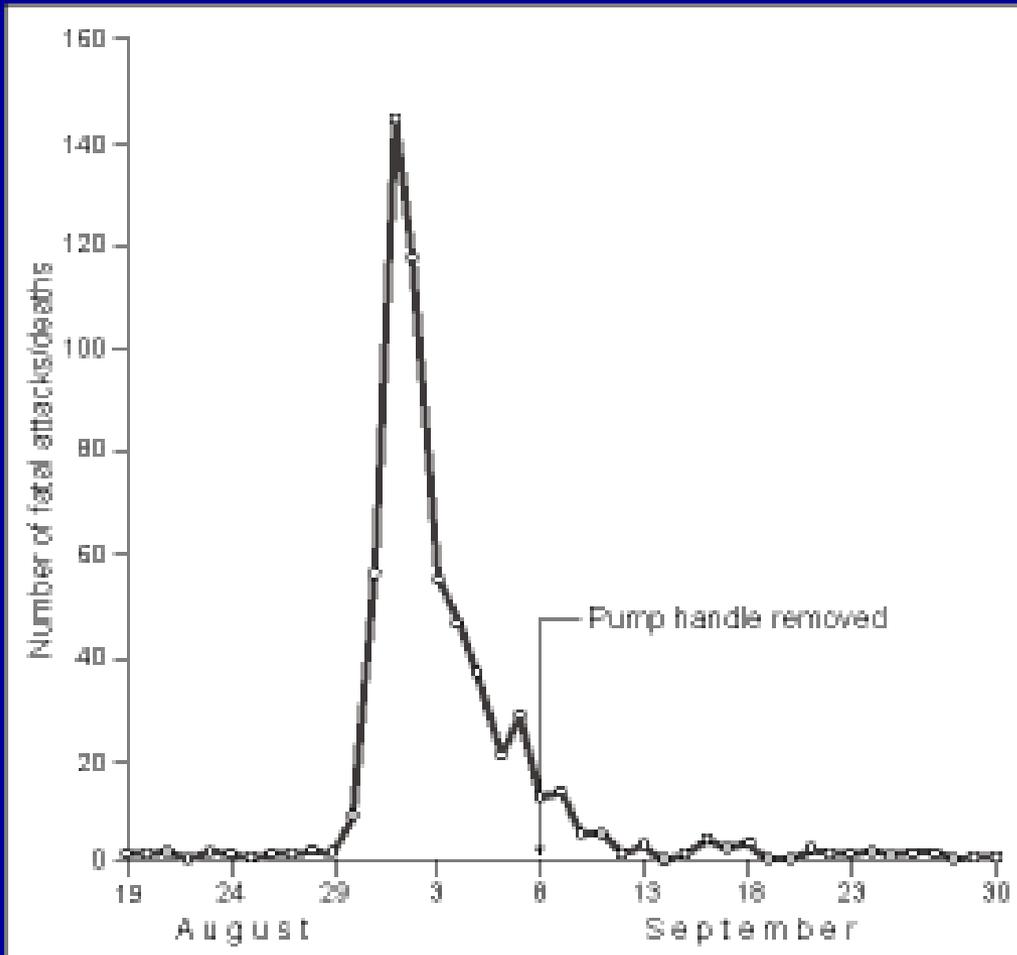
TWO KEY PIECES OF EVIDENCE IN THE 2nd (1855) EDITION OF *THE MODE OF COMMUNICATION OF CHOLERA*

- The outbreak in Golden Square traced to the Broad Street pump
- The effect of two different water supplies in South London on cholera rates
 - **Southwark and Vauxhall**, whose water came from the Thames at Battersea.
 - **Lambeth**, whose waterworks had been moved upstream to

SNOW'S EVIDENCE THAT THE PUMP WAS THE CHOLERA SOURCE

- Proximity of victims to pump compared to other pumps in region **in walking distance** (Voronoi diagram)
- **Exemption** of some people near the pump
 - Brewery workers (drink beer provided by company)
 - Percussion cap workers (own water supply)
- **Risk to** some people farther from the pump
 - Children who passed the pump to and from school
 - People who preferred Broad street water, including the “Hampstead Widow” who had the pump water carried by wagon to Hampstead, where she and her maid were the only cholera deaths.

SNOW DID NOT STOP THE EPIDEMIC BY HAVING THE PUMP HANDLE REMOVED



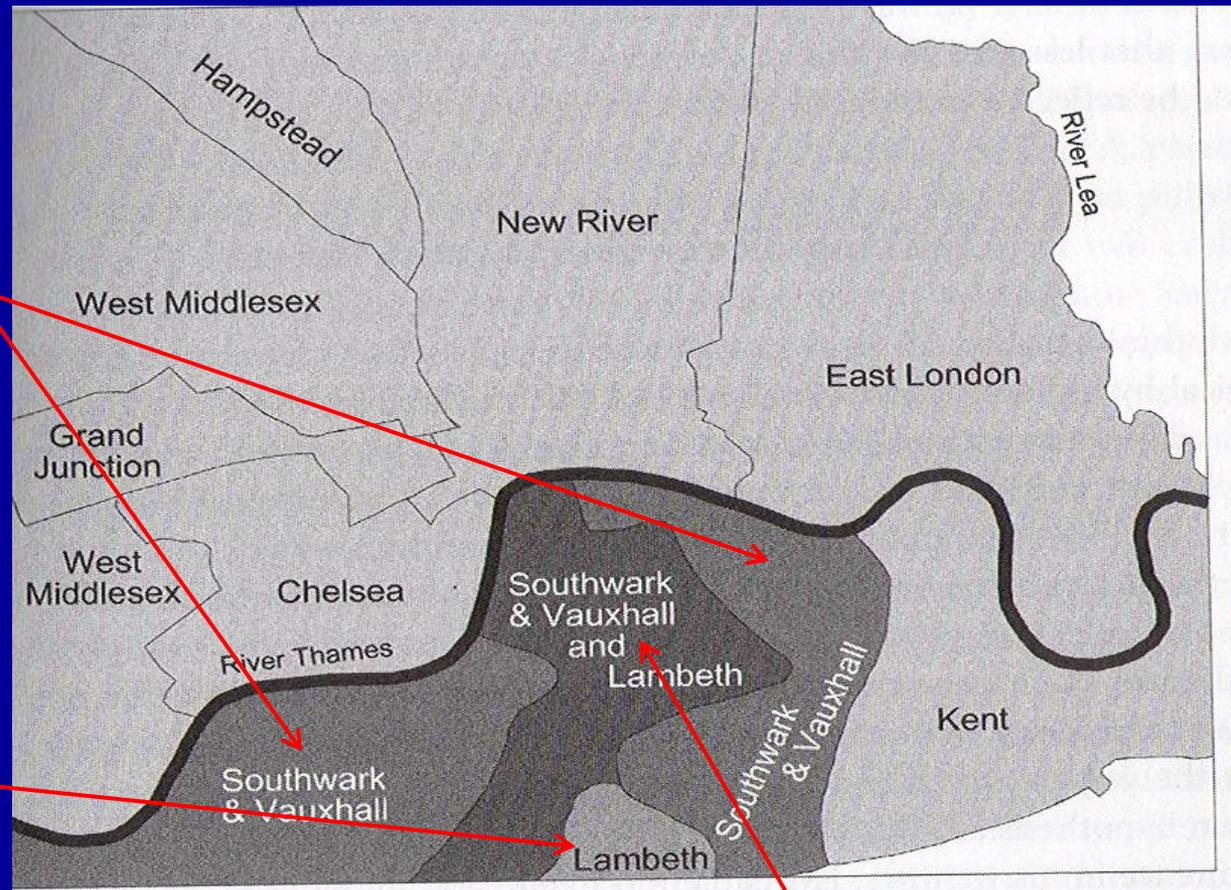
Graph derived from Snow's data on 571 cases belonging to the Broad Street outbreak from 19 August through 30 September.

Broad Street pump handle removed by the Board of Guardians (at Snow's suggestion) on Sept 8th.

Snow pointed out that epidemic was already on the wane

Southwark and Vauxhall water – from the Thames in London, below sewer outlets and therefore fecally contaminated.

Lambeth water – from the Thames well above London, well above sewer outlets, and therefore free of sewage.



Intermixed Area: Area of South London with water from both companies, even on the same street

SNOW'S "GRAND EXPERIMENT"

“No experiment could have been devised which would more thoroughly test the effect of water supply on the progress of cholera... No fewer than 300,000 people, of both sexes, of every age and occupation, and of every rank and station....were divided into two groups....one group being supplied with water containing the sewage of London, and amongst it, whatever might have come from a cholera patient, the other having water quite free from such impurity.”

CHOLERA DEATH RATES BY WATER SUPPLY IN THE INTERMIXED DISTRICTS

WATER SUPPLY	CHOLERA DEATH RATE	RELATIVE RISK
SOUTHWARK AND VAUXHALL	71 per 10,000	14.2
LAMBETH	5 per 10,000	1.0

As the cholera epidemic continued, this relative risk began to decline as the point-source epidemic became propagated. But it never dropped below 5.0 in any of Snow's calculations

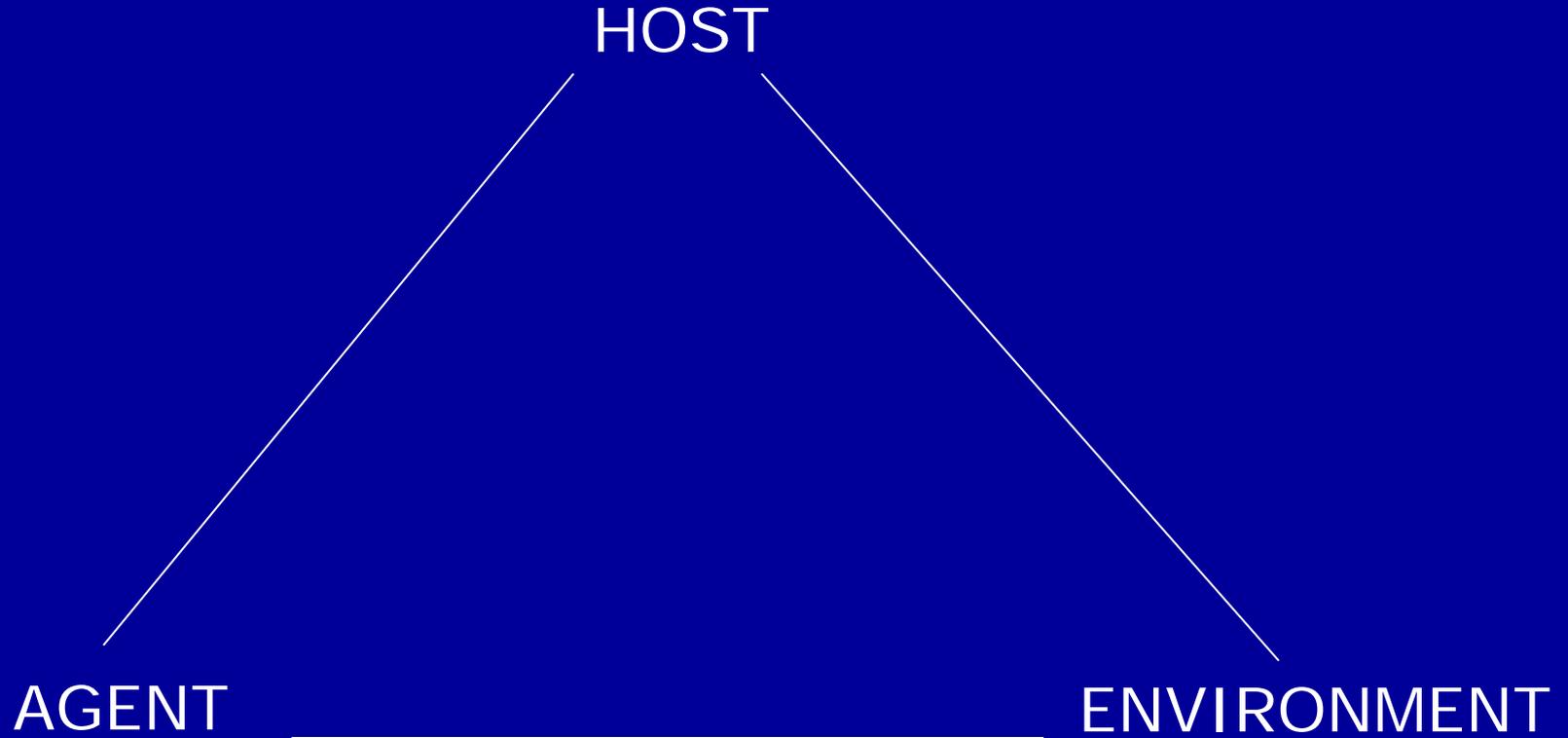
CONNECTION BETWEEN ANESTHESIA AND EPIDEMIOLOGY

- Snow's knowledge of anesthetic gases made him skeptical of miasma theory, which asserted airborne transmission from rotting matter.
- He could not see how these gases ("emanations", "vapors") could act at a distance.
- His skepticism of airborne cholera transmission was more often rejected by other physicians than his support of waterborne transmission, which was accepted by many, but not as an **exclusive** mode of transmission.

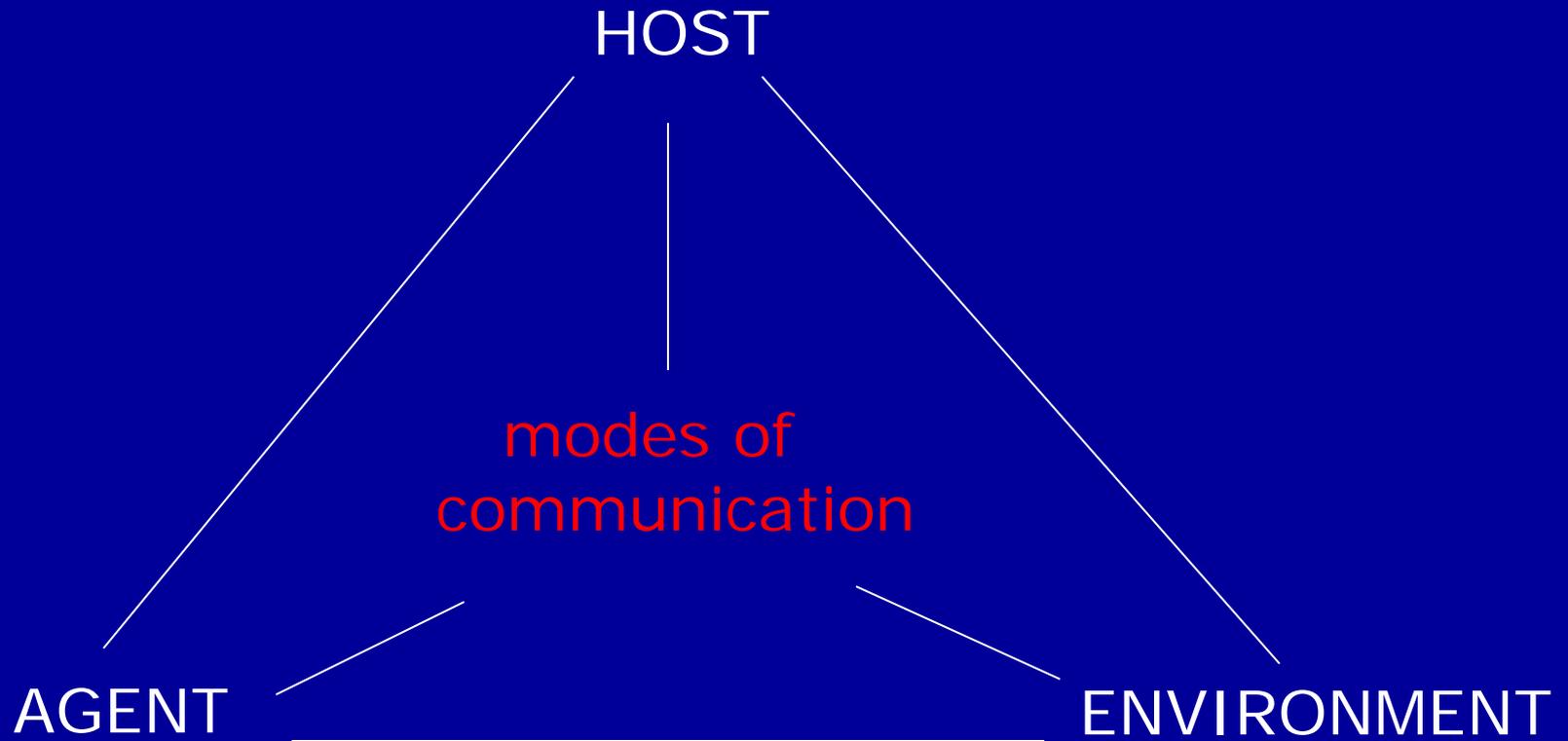
THE COMMON THEME IN SNOW'S WORK

MODE OF COMMUNICATION

THE TRIAD OF ANALYTIC EPIDEMIOLOGY



THE TRIAD OF ANALYTIC EPIDEMIOLOGY



USE OF THE TERM MODE OF COMMUNICATION BY SNOW

Snow used in the phrase in the title of all three of his major cholera works

1. *On the **Mode of Communication** of Cholera.* London: Churchill, 1849
2. *On the Pathology and **Mode of Communication** of Cholera.* London Medical Gazette. 1849;44:745-52,923-29.
3. *On the **Mode of Communication** of Cholera, 2nd ed, much enlarged.* London: Churchill: 1855

SNOW WAS VIRTUALLY UNIQUE IN USING THE TERM **MODE OF COMMUNICATION**

No other book on cholera in the Wellcome Historical Library Catalog (books published in medicine prior to 1860) contains Mode of Communication in the title.

The only book on any topic using that expression was by Francis Adams (1796-1861). *On the construction of the placenta, and the **mode of communication** between the mother and the foetus in utero.* London: Wilson and Ogilvy, 1849.

MODE OF COMMUNICATION WAS NOT THE FOCUS OF 19TH CENTURY CHOLERA RESEARCH

- **Macro-level** - Most sanitarians focused on environmental and weather conditions.
- **Micro-level** - Some investigators looked for the agent (Swayne and Brittan fungoid theory; Paccini, Hassall)
- Snow was unique in his day in examining the **processes** that linked the putative agent to the host, i.e. in investigating the **mode of communication** of cholera.
- Later in the century, Von Pettenkoffer claimed an alternative mode of communication that required cholera evacuations to incubate in soil before becoming communicable.

MODES OF COMMUNICATION DEFINED

- Modes of communication are the **processes that bring host and agent together** in the real world.
- Risk factors for disease operate at different ecological levels – societal, neighborhood, individual, cellular; Modes of communication are the **connections** between risk factors operating at different ecological levels.
- While host and agent can be studied in the laboratory, modes of communication require going into the **field**.
- Modes of communication can be seen as **population-level mechanisms** of disease, and they can be as stable as cellular-level mechanisms.

Time curve of two cholera epidemics: London, 1854 and Haiti, 2010-11.

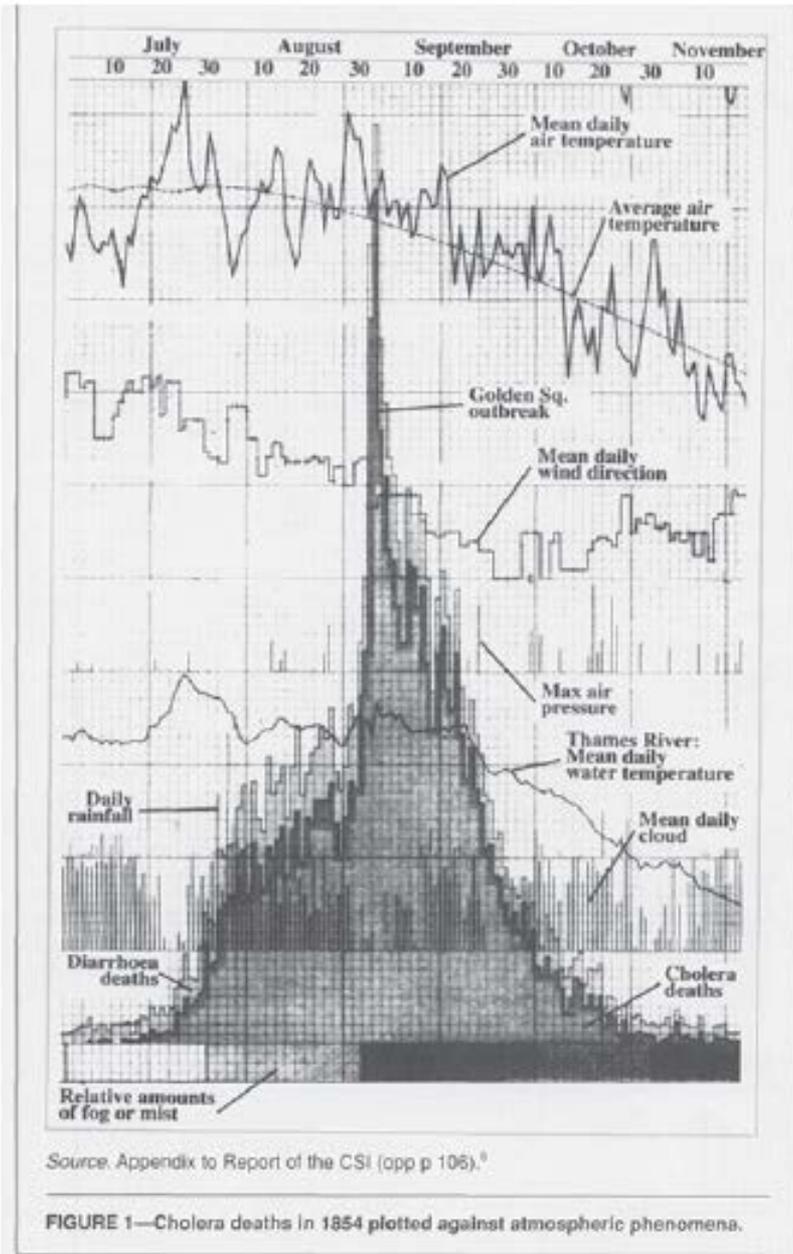
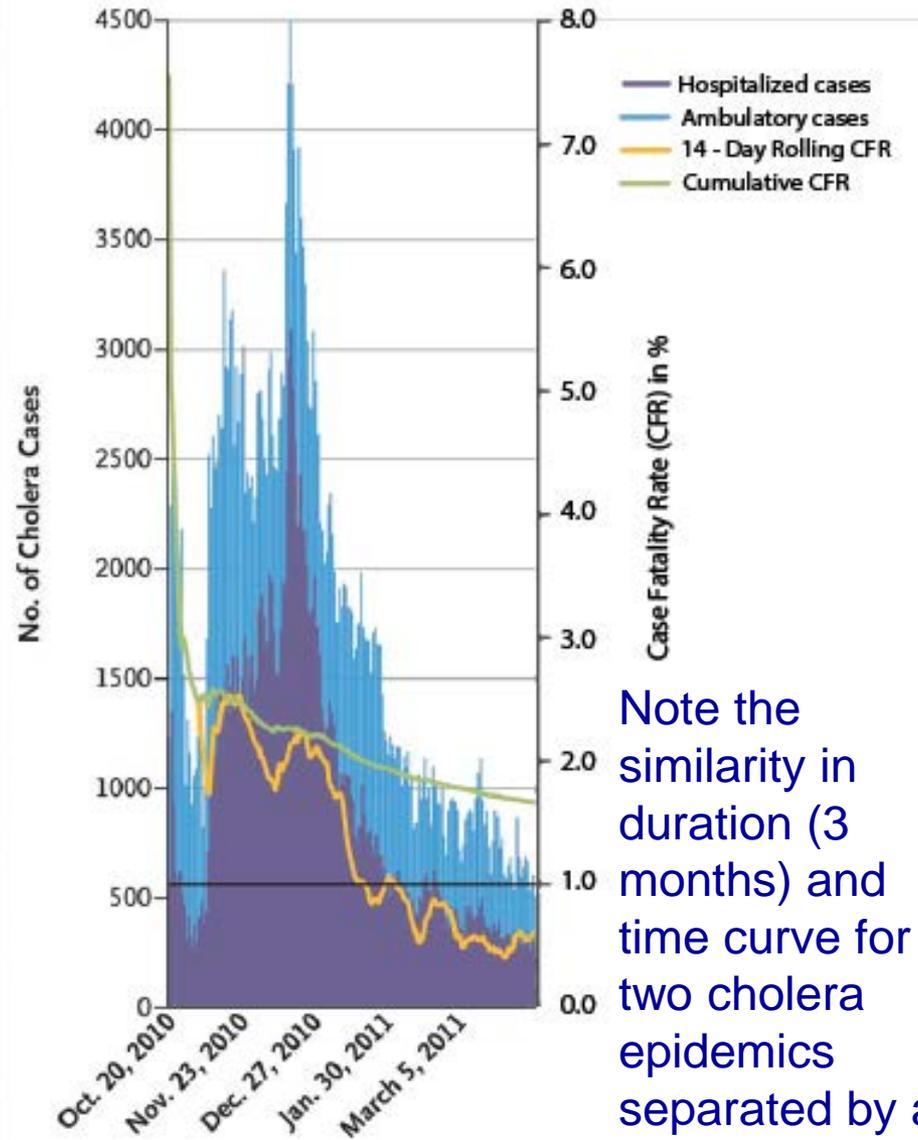


FIGURE 1—Cholera deaths in 1854 plotted against atmospheric phenomena.



Note the similarity in duration (3 months) and time curve for two cholera epidemics separated by an ocean and 150 years

ADVANTAGES OF FOCUSING ON MODES OF COMMUNICATION IN DISEASE CONTROL

- Host and agent are **structures**. Modes of communication are **processes**.
- Host and agent are **nouns**. Modes of communication are **verbs**.
- Host and agent are **static**. Modes of communication are **dynamic**
- This dynamic quality of modes of communication offers opportunities for disease prevention. In the control of infectious diseases, understanding mode of communication has been more important than knowing the agent of disease. Modes of communication also extend beyond infectious diseases.

MODE OF COMMUNICATION IN THE HISTORICAL CONQUEST OF INFECTIOUS DISEASES

AGENTS OF DISEASE DISCOVERED IN THE FINAL QUARTER OF THE 19TH CENTURY (1873-1900)

MAJOR EPIDEMIC DISEASES

1. Tuberculosis
2. Typhoid Fever
3. Cholera
4. Malaria
5. Bubonic Plague
6. Leprosy
7. Pneumococcal pneumonia
8. Diphtheria
9. Pertussis

OTHER IMPORTANT DISEASES

1. Anthrax
2. Shigellosis
3. Meningococcal disease
4. Gonococcal disease
5. Brucellosis
6. Actinomycosis

DID DISCOVERY OF MICROBIAL AGENTS OF DISEASE IMPROVE PUBLIC HEALTH?

- **PRIOR TO 1900**
 - Diphtheria/Tetanus antitoxins (1890)
 - Typhoid fever vaccine (1897)
- **1900 TO 1930**
 - Anti-bacterial vaccines: BCG, Diphtheria/Tetanus (1920's)
 - First anti-malarials since quinine (plasmoquine, 1925)
- **1930-1950**
 - Sulfonamides (1937)
 - Penicillin (1942)
 - Streptomycin for Tuberculosis (1948)

FOUR MODES OF COMMUNICATION DISCOVERED IN THE 19TH CENTURY

1. PHYSICAL CONTACT OR TRUE CONTAGION
2. THE FECAL-ORAL ROUTE (and its corollary - water supplies as vehicles of enteric disease)
3. THE ASYMPTOMATIC CARRIER
4. ARTHROPOD VECTORS

THE KEY DISCOVERIES

1. PHYSICAL CONTACT - Semmelweis discovered that puerperal sepsis is transmitted manually from the autopsy room to the delivery room (1848)
2. FECAL-ORAL – Snow for Cholera (1848), and Budd for typhoid fever (1856)
3. THE ASYMPTOMATIC CARRIER – Park and Beebe in NYC for diphtheria (1893); Reed, Shakespeare and Vaughan for typhoid fever (1900); Wechselbaum for meningococcus and Wickman for polio (both 1905)
4. ARTHROPOD VECTORS – At least six distinct arthropod vectors were discovered between 1878-1909.

ARTHROPOD VECTOR DISCOVERIES

DATE	DISEASE	VECTOR	DISCOVERER
1878	FILARIASIS	Mosquito	Patrick Manson
1895	SLEEPING SICKNESS	Tse Tse fly	Robert Bruce
1895	MALARIA	Anopheles mosquito	Ronald Ross
1900	YELLOW FEVER	Aedes mosquito	Walter Reed
1906	PLAGUE	Rat/flea cycle	Indian Plague Commission
1909	TYPHUS	Louse	Charles Nicolle

IMPACTS OF MODE OF COMMUNICATION DISCOVERIES IN 19TH/EARLY 20TH CENTURY

- Greatly reduced death rates from puerperal sepsis by having birth attendants rinse their hands with chloride of lime.
- Greatly reduced death rates from typhoid fever and cholera by 1900 in cities who could prevent sewage intake to water supplies.
- Reduction of yellow fever deaths from 1,500 to zero in one year in Havana following mosquito control measures. (Mosquito eradication permitted construction of the Panama Canal by control of yellow fever and malaria)
- Understanding the role of lice permitted control of typhus, the great disease of armies, in WW I.

MODE OF
COMMUNICATION IN
CONTEMPORARY
EPIDEMIOLOGY

WHAT PROCESSES BRING HOST AND
AGENT TOGETHER IN TODAY'S
WORLD?

HUMAN BEHAVIORS ARE
PROMINENT

- **Addictive behaviors**

Smoking, a behavior driven by nicotine addiction, brings a carcinogenic agent into contact with human lung tissue.

- **Sexual behavior**

Specific sexual behaviors promote transmission of HIV.

- **Personal care behaviors**

Use of tampons, especially the Rely brand, conveyed a staphylococcal exotoxin causing toxic shock syndrome.

- **Culturally determined customs**

The practice of putting babies to sleep on their backs promotes, in some unknown way, the risk of SIDS.

In all of the above examples, disease was controlled by public health measures put into place before the agent was identified

THE MODE OF COMMUNICATION OF CANNABIS DEPENDENCE

(Courtesy of my colleague Jim Anthony PhD)

Separate the process of becoming cannabis dependent into three steps

1. How likely is someone to be offered the opportunity to try cannabis?
2. If offered the opportunity, how likely is someone to try cannabis?
3. If someone tried cannabis, how likely was that person to become cannabis dependent?

PUBLIC HEALTH STRATEGIES CAN BE BUILT AROUND
ANY OF THESE STEPS

ESTIMATED CUMULATIVE INCIDENCE

	MALES	FEMALES	RR	P VALUE
EXPOSURE OPPORTUNITY	78%	68%	1.15	<.01
USE, GIVEN EXPOSURE OPPORTUNITY	72%	72%	1.0	NS
CANNABIS DEPENDENCE BY AGE 30, GIVEN USE	14%	6%	2.33	<.01

Data from: Van Etten ML, Anthony JC: Male-female differences in transitions from first drug opportunity to first use: searching for subgroup variation by age, race, region, and urban status. J Womens Health Gen Based Med 2001 Oct;10(8):797-804.

CONCLUSIONS

- Snow was the first biomedical scientist to introduce the concept of **mode of communication** into thinking about the etiology of disease.
- In doing so, he set an example for what to prioritize in epidemiologic research and what to set aside for the time being (agent identification, host characteristics, weather patterns)
- While the history of infectious diseases emphasizes the great microbial discoveries, public health advances depended more on understanding and intervening in the **processes that brought host and agent together**. This is true also of non-infectious diseases.

A QUESTION FOR ALL OF US

How can we hasten the pace of public health advances by identifying new modes of communication of diseases?