The Politics of Smallpox Modeling
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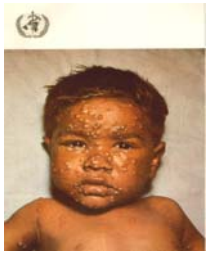
Smallpox Basics

- Pox virus
  - Stable as an aerosol
  - Infectious at low doses
- Human to human transmission through coughing and contaminated items (fomites)
- 10 to 12 day incubation period
- High mortality rate (30%)



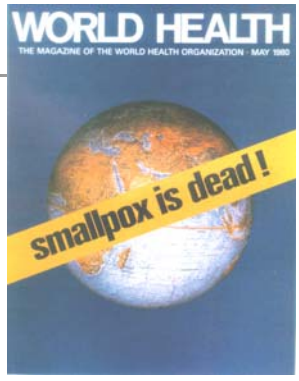
Co-Evolution

- Smallpox infects humans only
  - Could not survive until agriculture
  - No non-human reservoir
  - If at any point no one in the world is infected, then the disease is eradicated
- Infected persons who survive are immune, allowing communities to rebuild after epidemics

Eradication

- Driven by the development of a heat stable vaccine
  - 1947 – last cases in the US
  - Smallpox vaccine was given to everyone in the US until 1972
- Worldwide eradication campaign in the 1970s

1980



Eradication Ended Vaccinations

- Cost Benefit Analysis
  - Vaccine was Very Cheap
  - Program Administration was Expensive
  - Risks of Vaccine Were Seen as Outweighing Benefits
- Stopped in the 1970s

Complications of Vaccination

- Local Lesion
- Progressive/Disseminated Vaccina
  - Deadly
- Encephalitis
- Most common in the immunosuppressed

How Have the Risks of Vaccination Changed Since 1970?

- 1970
  - 1/1,000,000 deaths
  - 5/1,000,000 serious complications
  - Immunosuppression was rare in 1970
- 2004
  - Immunosuppression is common
  - HIV, Chemotherapy, Arthritis Drugs
  - Tolerance for risk is much lower

Post Eradication

- 50%+ in the US have not been vaccinated
- Many fewer have been vaccinated in Africa
- Immunity fades over time
  - Everyone is probably susceptible
  - Perhaps enough protection to reduce the severity of the disease

The Danger of Synchronous Infection

- The whole world may be like Hawaii before the first sailors
- If everyone gets sick at the same time, even non-fatal diseases such as measles become fatal
- A massive smallpox epidemic would be a national security threat
- Is a massive epidemic possible?

The Dark Winter Model

- Johns Hopkins Model - 2001
- Simulation for high level government officials
- Assumed terrorists infected 1000 persons in several cities
- Within a few simulated months, all vaccine was gone, 1,000,000 people where dead, and the epidemic was raging out of control

Response to the Dark Winter Model

- Koopman – worked in the eradication campaign
  - “Smallpox is a barely contagious and slow-spreading infection.”
- Lane – ex-CDC smallpox unit director
  - Dark Winter was “silly.” “There’s no way that’s going to happen.”

Decomposing the Models – Common Factors

- Population at risk
- Initial seed
- Transmission rate
- Control measures under study

Population at Risk

- Total number of people
  - Compartments - how much mixing?
- Immunization status
  - Most assume 100% are susceptible
- Increasing the % of persons immune to smallpox
  - Reduces the number of susceptibles
  - Dilutes the pool, reducing rate of spread

Transmission Rate

- Mixing Coefficient X Contact Efficiency
- Mixing Coefficient
  - The number of susceptible persons an index case comes in contact with
- Contact Efficiency (Infectivity)
  - Probably of transmission from a given contact
  - Can be varied based on the type of contact

Where do the Models Differ?

Transmission Rate is the Key

- < 1 - epidemic dies out on its own
- 1 - 3 - moves slowly and can be controlled without major disruption
- > 5 - fast moving, massive intervention needed for control
- > 10 - overwhelms the system - Dark Winter

What is the Data on Transmission Rate?

- Appendix I
  - http://whqlibdoc.who.int/smallpox/9241561106_chp23.pdf
  - This is all the data that exists
  - The data is limited because of control efforts
- This data supports any choice between 1 and 10

What are the Policy Implications of the Transmission Rate?

Dark Winter - 10

- Can only be prevented by the reinstituting routine smallpox immunization
- Terrible parameters for policy making
  - Huge risk if there is an outbreak
  - Low probability of an outbreak

Kaplan - 5

- Mass immunization on case detection
- Best to pre-immunize health care workers

Metzler/CDC - 2-3

- Contact tracing and ring immunization
  - Trace each case and immunize contacts
  - Immunize contacts of contacts
  - Takes a long time to get the last case

What are the Politics?

Reinstituting Routine Vaccinations

- We cannot even get people to get flu shots, which is perfectly safe
- No chance that any significant number of people will get the smallpox vaccine after the failure of the campaign to vaccinate health care workers
- Would require a massive federal vaccine compensation program

Mass Vaccinations Post-Outbreak

- Pros
  - Limits the duration of the outbreak to the time necessary to do the immunizations, could be two weeks with good organization
  - Eliminates the chance of breakout
- Cons
  - Lots of complications and deaths from the vaccine
  - Requires massive changes in federal vaccine plans

Contract Tracing and Ring Immunizations

- Pros
  - Limits the vaccine complications
  - Does not require hard policy choice to immunize everyone
- Cons
  - Requires lots of staff
  - Requires quarantine
  - Requires lots of time
  - Chance of breakout

Political Choices are Hidden in the Models

- Federal policy is based on a low transmission rate
  - Is that justified by the data?
  - Is the potential upside risk too great with this assumption?
- Dark Winter is based on a high rate
  - Do anything and pay anything to avoid bioterrorism
  - Convenient for bioterrorism industries

Which Model Do You Want to Rely On?

Appendix I

Table from, Fenner, F., et. al., Smallpox and its eradication, WHO (1988) at page 1077.

Table 23.4 Europe: smallpox outbreaks by generation

Serial number	Year	Importing country	Number of imported cases	Indigenous generation						Total number of cases	Infections acquired in hospitals or by other health staff	
				1	2	3	4	5	6		Number of cases	Number of deaths
1	1958	Federal Republic of Germany	1	10	6	3	0	0	0	20	19	2
2	1959	United Kingdom	1	0	0	0	0	0	0	1	0	0
3	1959	German Democratic Republic	1	0	0	0	0	0	0	1	0	0
4	1959	USSR	a	1	0	0	0	0	0	1	0	0
5	1959	USSR	1	19	23	3	0	0	0	46	19	1
6	1960	United Kingdom	1	0	0	0	0	0	0	1	0	0
7	1961	Spain	1	13	3	0	0	0	0	17	13	2
8	1961	Federal Republic of Germany	1	2	1	0	0	0	0	4	1	0
9	1961	USSR	1	0	0	0	0	0	0	1	0	0
10	1961	Belgium	1	0	0	0	0	0	0	1	0	0
11	1961	USSR	1	0	0	0	0	0	0	1	0	0
12	1961	Federal Republic of Germany	1	2	1	2	0	0	0	6	2	2
13	1961	Federal Republic of Germany	1	3	20	6	3	0	0	33	19	1
14	1961	United Kingdom	1	1	0	0	0	0	0	2	1	0
15	1961	United Kingdom	1	1	1	0	0	0	0	3	0	0
16	1961	United Kingdom	1	10	3	0	0	0	0	14	13	5
17	1962	United Kingdom	1	0	0	0	0	0	0	1	0	0
18	1962	United Kingdom	1	1	6	18	1	18	2	47	26	16
19	1962	Poland	3	11	19	0	0	0	0	33	0	0
20	1962	United Kingdom	1	2	0	0	0	0	0	3	0	0
21	1963	Sweden	1	4	10	7	1	2	2	27	15	2
22	1963	Poland	1	2	4	26	44	20	3	100	46	4
23	1963	Switzerland	1	0	0	0	0	0	0	1	0	0
24	1965	Federal Republic of Germany	1	1	0	0	0	0	0	2	0	0
25	1967	Federal Republic of Germany	1	1	0	0	0	0	0	2	0	0
26	1967	Czechoslovakia	1	0	0	0	0	0	0	1	0	0
27	1967	Federal Republic of Germany	1	0	0	0	0	0	0	1	0	0
28	1967	United Kingdom	1	1	0	0	0	0	0	2	0	0
29	1968	United Kingdom	1	0	0	0	0	0	0	1	0	0
30	1968	Belgium	1	0	0	0	0	0	0	1	0	0
31	1969	Germany	1	17	2	0	0	0	0	20	19	4
32	1970	Denmark	1	1	0	0	0	0	0	2	0	0
33	1972	Yugoslavia	1	11	140	24	0	0	0	176	84	18
34	1973	United Kingdom	1	0	0	0	0	0	0	1	0	0
Total			35	114	239	89	49	40	7	573	277	57

[a] Infection said to have been transmitted on a carpet.

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