Smallpox: Death of a Disease
…its eradication and legacy

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“There has been no greater medical - or humanitarian - miracle in modern times than the eradication of smallpox...(It is the saga of a) day-to-day struggle for international cooperation in a divided world; it offers a winning blue print for the great medical challenges to come.”

David Oshinsky – 2006 Pulitzer Prize in History
Smallpox – most feared disease of history

- Virus -- spreads by face-to-face contact during rash
- Man is the only host
  - A chain of infection going back 3500+ years
  - Only disease for which there are deities
- No treatment; death rate = 25 to 30%
- Permanent immunity after recovery

T’ou-Shen Niang-Niang  Pan-chen
World’s 5 most important historic sites
(from BBC World History Series, Oct. 2012)

• Yellow River, China
• Great African Rift Valley
• Athens, Greece
• Los Alamos, New Mexico
• ?
The Drama of 1796 – Berkeley, England
the world’s first vaccine

Cast of characters --1796
   Edward Jenner
   Blossom
   Sarah Nelmes
   Jimmy Phipps
Vaccinia virus transferred from arm to arm until 1870s
   • Grown on the flank of a calf or sheep until 2002
   • Tissue culture vaccine from 2002

Summary objectives

• To portray the principal clinical features of smallpox, a disease last seen in 1978 but a continuing threat

• To identify the landmarks of the eradication campaign and research contributing to its success

• To highlight the legacies and subsequent opportunities for public health
Day 3

Day 5
Day 9

Confluent smallpox
<table>
<thead>
<tr>
<th>Disease</th>
<th>Start Year</th>
<th>End Year</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hookworm</td>
<td>1909-23</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Yellow fever</td>
<td>1915-32</td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>Yaws</td>
<td>1948-66</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Malaria</td>
<td>1955-73</td>
<td></td>
<td>18</td>
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<tr>
<td>Smallpox</td>
<td>1967-80</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>G. worm infection</td>
<td>1986-?</td>
<td></td>
<td>29+</td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>1988-?</td>
<td></td>
<td>27+</td>
</tr>
</tbody>
</table>
Global smallpox eradication

- World Health Assembly agrees to a proposal to start some sort of global effort

- 1959-1966 National programs encouraged
  - Strategy: mass vaccination (few countries complied)
  - Budget of <$100,000 per year
  - Six staff members

The WHO Eradication Program

Assembly requires DG to submit a plan --1966
- Strategy
  - Mass vaccination to reach 80%
  - Surveillance and containment
- 10 year program --budget of $2.4 million/year
- Objections by delegates
  - Not feasible
  - Demand for no further increases in WHO budget
- 58 votes needed for approval; 60 voted in favor
Program leadership

• Director General believed program would fail
  (malaria eradication was collapsing)

• Demanded an American serve as Director
  • The candidate reluctantly agreed:
    • Limited resources -- ~$50,000 each for 50 countries
      Insufficient even to buy the vaccine required
    • Not all countries interested in participating

The Challenge

• Status of smallpox – 1967
  • >10,000,000 cases
  • 2,000,000 deaths
  • 43 countries reported cases

• Program staff
  • Headquarters – 5 medical; 5 support staff
  • International staff – never more than 150

• Communication – mail, personal contact
1st major regional smallpox conference

Bangkok – December 1967

11 Asian countries
   Indonesia, India, Pakistan, Malaysia,
   Afghanistan, Nepal, Philippines, Viet Nam,
   Laos, Burma, Thailand

Thailand had become smallpox-free in 1962
1898 survey—95% of teen-agers with scars
Smallpox accounted for 90% of all blindness

![Smallpox 1967 map]

- = Endemic countries
- = Others with cases
Vaccine Shortages

- Heat-stable, potent vaccine is essential
  - 300 million doses needed annually
  - 42 labs producing vaccine
  - Labs in Netherlands and Canada test vaccine
    Only 10% meets international standards
- National capacity has to be developed
  - Production manual and research
  - On-site consultant assistance

Vaccination methods

- Research to find faster, better methods
  - Bifurcated needle—multiple puncture vaccination
    - One-fourth as much vaccine required
    - Training time -- 15 minutes
    - Easily sterilized and reused
    - Cost -- $5 per thousand
- Target for coverage – 80%
  - Evaluation teams
Surveillance-containment strategy

- Operational plan
  - Surveillance – weekly report from every health unit
  - Teams – to investigate and contain all outbreaks
  - Epidemiological research on smallpox
    - The textbooks prove to be wrong
      “Smallpox spreads like a prairie fire”-- wrong
      “Revaccination is needed every 3 to 5 years”-- wrong
Smallpox 1973

- Red = Endemic countries
- Blue = Others with cases
India -- the pivotal challenge
1973-75

- India – the “home of smallpox”?
  - Population – 550,000,000
  - Surveillance-containment strategy--not working
  - June 1973 – search every village—later, every house
    - 130,000 health staff in 10 days
    - Results of first search – October
  - Spring 1974 – the darkest days
    - Gas crisis + strikes by airlines, railway; floods, famine
    - India explodes a nuclear device
  - Containment methods tightened

Indian Independence Day
August 15, 1975

Prime Minister Indira Ghandi

- Salutes India on its 28th Anniversary of Freedom
- Announces India’s freedom from smallpox for the first time in its written history
The last strongholds

Ethiopia and Somalia

- **Ethiopia**
  - Country – about the size of Thailand
  - Largely highland – over 5000 feet
  - Health facilities serve 5% of 30 million people
  - Travel largely by donkey and on foot
  - Emperor is assassinated; Marxist take-over
    - No foreign staff outside of Addis except smallpox teams
  - Civil war, floods, kidnapping, hostages, famine
- **Somalia** – the final chapter
Ali Maalin - 26 October, 1977
World Health Assembly --1980

- Declares solemnly that the world and all its peoples have won freedom from smallpox
- Smallpox vaccination should be discontinued in every country

- Thirty-third World Health Assembly, 8 May 1980

The legacy – 1974 --the Vaccine Era begins

- The genesis
  - African vaccinators average 500/day with cooperative village leadership
    One year: 4 person team = 400,000 vaccinations
  - Smallpox – the only nation-wide vaccination program in developing countries
  - Smallpox unit sponsors international meeting to advocate for a broadened agenda
Expanded Program on Immunization-1974

- WHO global program for vaccination for all children -- smallpox, measles, DPT, polio
- Surveillance of vaccine-preventable diseases
- UNICEF and Rotary make this a high priority
- Target: 1990 – 80% coverage

Vaccine coverage (%) -- the Americas

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<td>DTP*</td>
<td>50</td>
<td>74</td>
<td>91</td>
<td>92</td>
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<tr>
<td>Measles-rubella</td>
<td>51</td>
<td>80</td>
<td>92</td>
<td>93</td>
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<tr>
<td>Polio*</td>
<td>57</td>
<td>75</td>
<td>90</td>
<td>92</td>
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<tr>
<td>HepB*</td>
<td>--</td>
<td>--</td>
<td>70</td>
<td>88</td>
</tr>
<tr>
<td>Hib*</td>
<td>--</td>
<td>--</td>
<td>75</td>
<td>90</td>
</tr>
</tbody>
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* 3 Doses

Transmission interrupted:
Polio (1991); Measles (2001); Rubella (2009)
EPI – 40 years after its beginning

Global vaccine coverage DPT, measles, polio, tuberculosis
1974 – 5%
2014 – 83%
Hepatitis B and H. influenzae – in 190 countries
also: Rotavirus, yellow fever, pneumococcal, rubella
For the future: malaria, AIDS, cervical cancer, Ebola,
dengue, tuberculosis, chikungunya, Lassa, Marburg
Surveillance and monitoring
700 laboratories in 184 countries for surveillance of measles and other diseases
Coda

• From Smallpox: Death of a Disease:

“We are only beginning to realize the potential of public health...It is a field begging for fresh, resourceful ideas and a new generation of professionals who are not constrained by ‘knowing’ what can’t be done. So it was with so many who contributed so much to making smallpox eradication a possibility.”