

Dogma Concerning Smallpox Prior to Eradication Program

- Highly contagious
- Vaccine-induced immunity short-lived
- Need high vaccination coverage to meet herd immunity threshold



SAFER • HEALTHIER • PEOPLE™



Herd Immunity Thresholds for Selected Vaccine-Preventable Diseases†

Disease	R ₀	Herd Immunity	Immunization Levels	
			1999 19-35 months	1997-98 pre-school
Diphtheria	6-7	85%*	83%*	97%
Measles	12-18	83-94%	92%	96%
Mumps	4-7	75-86%	92%	97%
Pertussis	12-17	92-94%	83%*	97%
Polio	5-7	80-86%	90%	97%
Rubella	6-7	83-85%	92%	97%
Smallpox	5-7	80-85%	—	—

*4 doses

† Modified from *Epid Rev* 1993; 15: 265-302, *Am J Prev Med* 2001; 20 (4S): 88-153, *MMWR* 2000; 49 (SS-9); 27-38



SAFER • HEALTHIER • PEOPLE™



Childhood Immunization Levels in US, 1-4 Year Old Children and Reported Cases of Smallpox and Measles

<u>Year</u>	<u>Smallpox</u>	<u>Cases</u>	<u>Measles</u>	<u>Cases</u>
1967	65.6%	0	56.4%	62,705
1968	65.9%	0	58.8%	22,231
1969	?	0	61.4%	25,826
1970	63.7%	0	57.2%	47,351
1971	62.4%	0	61.0%	75,290



SAFER • HEALTHIER • PEOPLE™



Examples of Slow Smallpox Transmission Within a Single Compound

Source	Contacts in addition to index case	Contacts without history of vaccination	Interval between onset of symptoms in index case and onset of symptoms in last compound case
Nigeria (Abakaliki)	21	4	31 days
Nigeria (Abakaliki)	32	14	47 days
Nigeria (Abakaliki)	14	5	51 days
United Rep. of Cameroon (N'Game)	?	4	Approx. 53 days
Nigeria (Adepe-Ipiga)	30	27	Approx. 60 days
Nigeria (Gerere)	24	15	Approx. 80 days

Bull WHO 1975; 52: 209-222



SAFER • HEALTHIER • PEOPLE™



Table 6. Smallpox cases as related to susceptible exposures within a single compound

Source	Susceptibles exposed	Smallpox cases	Cases per 100 susceptibles exposed
Nigeria (Abakaliki)	27	12	44.4
United Rep. of Cameroon (N'Game)	10	4	40.0
Nigeria (Gerere)	45	12	26.2

Bull WHO 1975; 52: 209-222



SAFER • HEALTHIER • PEOPLE™



Secondary Attack Rate for Smallpox Among Unvaccinated Persons †

2° Attack Rate	# Studies
36 - 47	5
73 - 88	3
Average	58

† in Fenner F et al. Smallpox and its Eradication, pp200



SAFER • HEALTHIER • PEOPLE™



Secondary Attack Rates by Pre-exposure Vaccination Status, West Pakistan, Shekhupura District †

Never vaccinated	26/27	96%
Vaccinated within prior 10 years	5/115	4%
Vaccinated >10 years previously	8/65	12%

†From Mack et al, Summarized in Fenner et al. Smallpox and its eradication, pg 688



SAFER • HEALTHIER • PEOPLE™



Duration of Protection †

Age Group	Vaccination in Infancy	Case – Fatality Rate
0-4	Yes	0%
	No	45%
5-14	Yes	0%
	No	10.5%
15-29	Yes	0.7%
	No	13.9%
30-49	Yes	3.7%
	No	54.2%
≥50	Yes	5.5%
	No	50.0%

†From Outbreak in Liverpool, England, 1902-1903
In Fenner F et al. Smallpox and its Eradication, pp53



SAFER • HEALTHIER • PEOPLE™



Case Fatality Rate of Smallpox After Importations into Western Countries During the Period 1950-1971 †

Successfully Vaccinated

Case Fatality Rate

Never	52%
Only after the exposure	29%
0-10 years before exposure	1.4%
11-20 years before exposure	7%
> 20 years before exposure	11%

†In Fenner F et al. Smallpox and its Eradication, pp53



SAFER • HEALTHIER • PEOPLE™



Smallpox Eradication in West and Central Africa †

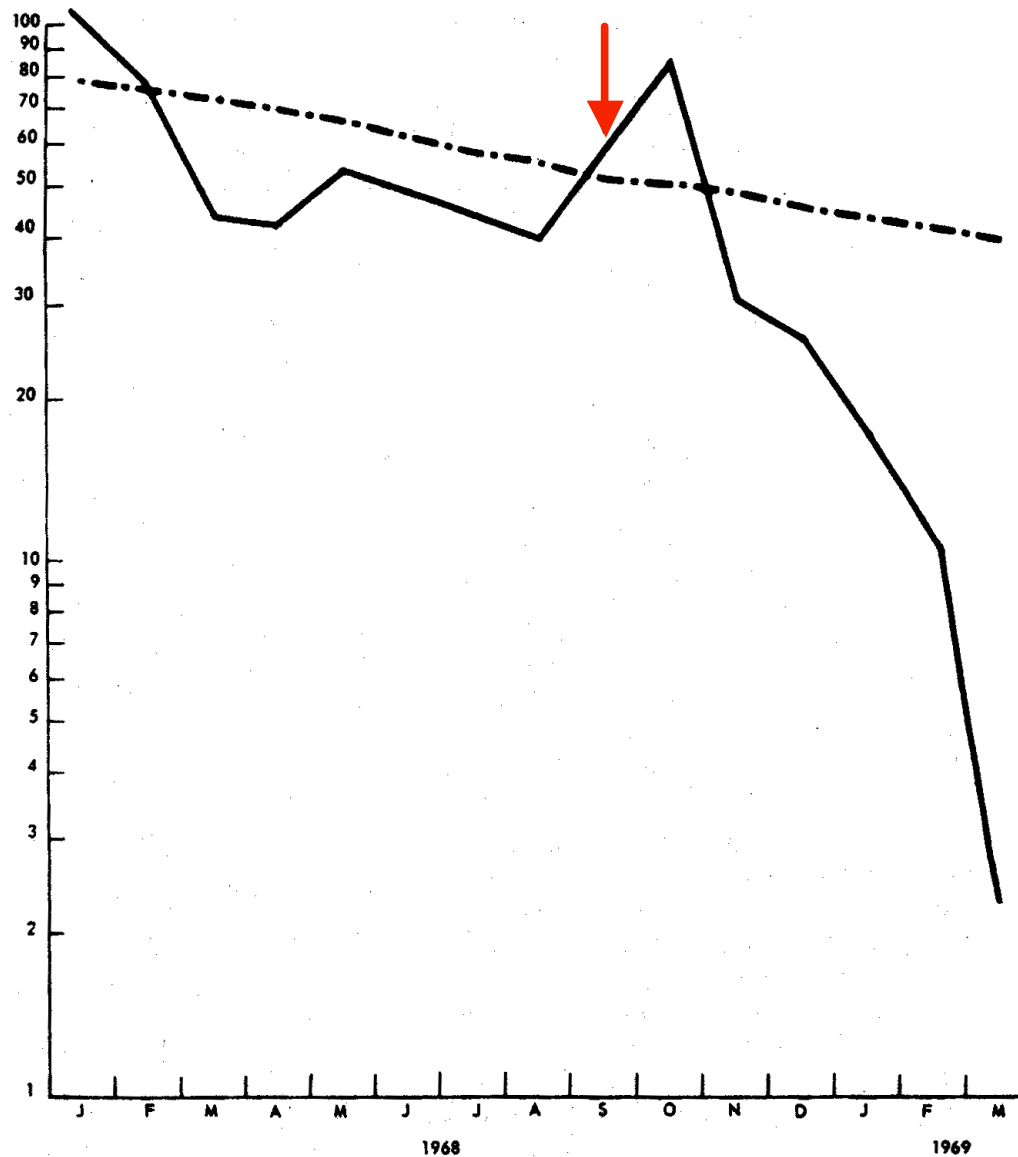


Fig. 9. The percentage of the population not vaccinated in the smallpox eradication programme area (broken line) compared with the ratio (%) of reported smallpox cases to cases expected from the 1960-67 monthly average (solid line). The arrow marks the start of surveillance-containment activities.

† Bull WHO
1975; 52:
209-222

Figure 1. Typical Temperature Chart of Patient With Smallpox Infection

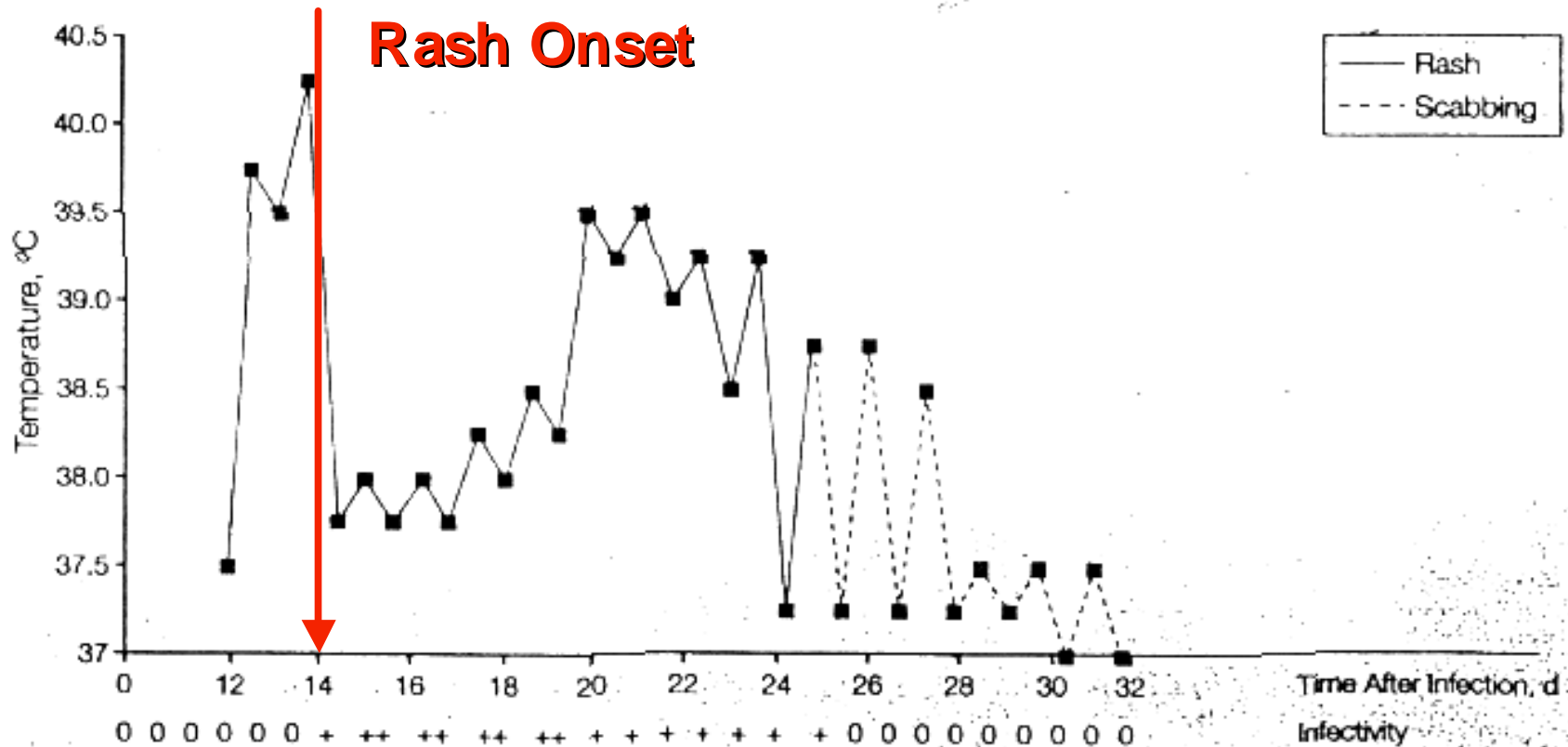


Chart shows approximate time of appearance, evolution of the rash, and magnitude of infectivity relative to the number of days after acquisition of infection.^{3,26,29}

Modified from JAMA, June 9, 1999--Vol 281, No. 22 . 2129



SAFER • HEALTHIER • PEOPLE™



Smallpox Eradication in West and Central America†

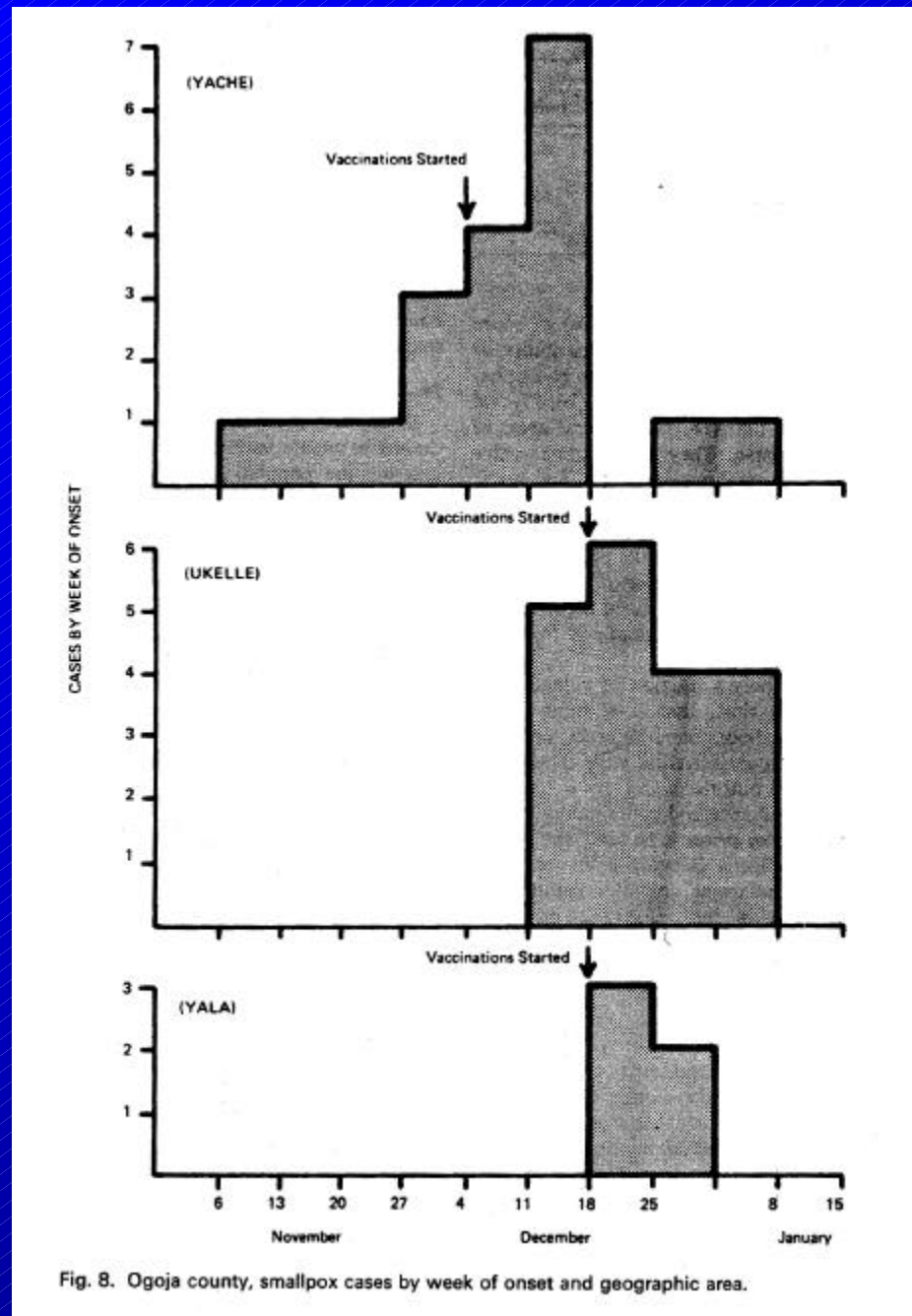


Fig. 8. Ogoja county, smallpox cases by week of onset and geographic area.

Bull WHO
1975; 52:
209-222

Effects of Post Exposure Vaccination †

	<u>2° Attack Rate</u>
Primary vaccination post exposure	29.5%
Never vaccinated	47.6%
1° vaccination ≤ 10 days post exposure	75.0
Never vaccinated	96.3
Vaccinated or revaccinated ≤ 7 days	1.9
Post exposure	21.8

† in Fenner F et al. Smallpox and its Eradication, pp 591



SAFER • HEALTHIER • PEOPLE™



Cases by Week of Onset in 75 Infected Families, Khulna Municipality†

	No. of Cases	%
Weeks 3 – 4	60	62.5
Weeks 5 – 6	28	29.2
Weeks ≥ 7	8	8.3
Total	96	100.0

† Am J Epidemiology 1974; 99: 291-302



SAFER • HEALTHIER • PEOPLE™



Source Tracing of India's Last Smallpox Outbreaks by State and Territory, 1973-1975†

# of States and Territories	28
# with smallpox, 1973-1975	27
# with source from last outbreak	25

† From Jezek Z., Ward NA, Basa RN: Smallpox Eradication in India, World Health Organization, New Delhi 1977, pp 391-392



SAFER • HEALTHIER • PEOPLE™



Rates of Complications of Smallpox Vaccination Per Million Doses, USA, 1968†, ††

	<u>All doses</u>	<u>Primary doses</u>
Post-Vaccinal Encephalitis	1.1	2.9
Progressive Vaccinia	0.8	0.9
Eczema Vaccinatum	8.9	10.4
Accidental Infection	13.6	25.4
Death	0.6	1.1

† Excludes contact cases

† † From N. Engl J Med, 1969; 281: 1201-1208



SAFER • HEALTHIER • PEOPLE™



Strategies for Smallpox Eradication

- High coverage rate
- Mass campaigns



SAFER • HEALTHIER • PEOPLE™



Rate of Protection Afforded by Vaccination †

Range 90.7 – 97.1

† in Fenner F et al. Smallpox and its Eradication, pp 591



SAFER • HEALTHIER • PEOPLE™

