Effectiveness of vaccination programmes

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EUFMD 2012
"Appliance of Science in
The Progressive Control of FMD"
Jerez de la Frontera, Spain
29 - 31 October 2012

Effectiveness of vaccination programmes

Insights from human vaccination programmes

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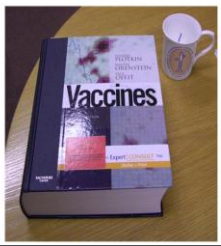
Insights from human vaccination programmes

A HUGE literature !



5th edition

76 chapters

1725 pages

3.6 kilograms

1000s of refs

A few definitions

"Vaccine potency"
Lab measure of vaccine contents - eg PD50 type measures

"Vaccine efficacy"
Reduction in risk (of disease) in vaccinated individuals compared to non-vaccinated (under trial conditions)

"Vaccine effectiveness"
Vaccine efficacy under field conditions

"Vaccine programme effectiveness = impact"
Reduction in disease (morbidity, mortality) attributable to a vaccination programme

A few definitions

"Vaccine potency"
Lab measure of vaccine contents - eg PD50 type measures

"Vaccine efficacy"
Reduction in risk (of disease) in vaccinated individuals compared to non-vaccinated (under trial conditions)

So, if the risk of disease in a trial is
10 % in non vaccinated,
3 % in (equally exposed) vaccinated,
the "vaccine efficacy" is 70 %
ie (10 - 3) / 10 = 0.7

A few definitions

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Reduction in disease (morbidity, mortality) attributable to a vaccination programme

Effectiveness of a vaccine

Depends upon:

- "Quality" of the vaccine (inc. "match")
- Cold chain
- Quality of administration
- Number of doses
- Age at vaccination
- Time since last vaccination
- Level of exposure
- Environmental factors ?

Effectiveness of a vaccine

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Will vary – from place to place, and over time ....

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Unclear relation to lab challenge results

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Will vary – from place to place, and over time ....

Unclear relation to lab challenge results

Can only be assessed by appropriate field studies

Vaccine effectiveness-examples

(% reduction in risk in vaccinees, from field evaluations)

Vaccine	Effectiveness	Comments
BCG	0 - 80 %	Effectiveness generally high versus meningitis but varies greatly versus pulmonary disease. Lower in tropics than in temperate countries For 15 years ?
Pertussis	10 - 40 % 1 doses 30 - 60 % 2 doses 50 - 80 % 3 doses	Effectiveness differs greatly between different vaccines and by outcome (highest against severe disease) Wanes with time
Haemophilus	70 - 95 % 2,3 doses	At least two doses needed
Measles	90 - 95 %	High if given after 9 months Lasts many years (decades)
Rotavirus	20 - 60 % 2 doses	Highest after three doses in wealthy (good hygiene) countries - lower in poor countries

Effectiveness of a vaccination programme

Depends upon:

- **Effectiveness of the vaccine**
- **"Coverage"**
  - Proportion of host population vaccinated
    - by age,
    - by risk group
    - geographic distribution ...
- Other sources of infection etc

Effectiveness of a vaccination programme

Depends upon:

- **Effectiveness of the vaccine**
- **"Coverage"**
  - Proportion of herd protected by vaccination
    - by age
    - by risk group
    - geographic distribution ...
- Other sources of infection etc

"Coverage" particularly difficult for veterinary programmes – Poor records (in general) Rapid population turnover Seroprevalence as a substitute ?

The basic global "vaccination" programme (for humans):

(Started by WHO in 1974)

"EPI"

("Expanded Programme On Immunization")

Basic EPI schedule (from 1970s) Purposefully simple

	Birth (or "first contact")	6 weeks	10 weeks	14 weeks	9 months
BCG	√				
DTP		√	√	√	
Polio (OPV)		√	√	√	
Measles					√

4-week spacing, to optimise boosting

To avoid maternal antibody

Basic EPI schedule (from 1970s) Purposefully simple

	Birth (or "first contact")	6 weeks	10 weeks	14 weeks	9 months
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Three doses necessary

4-week spacing, to optimise boosting

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BCG	√				
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Polio (OPV)		√	√	√	
Measles					√

Three doses necessary

Proportion of 1-year-olds with at least 3 doses DTP by standard measures of "routine coverage"

4-week spacing, to optimise boosting

To avoid maternal antibody

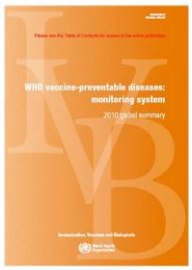
Example of a current schedule (England and Wales, 2012)

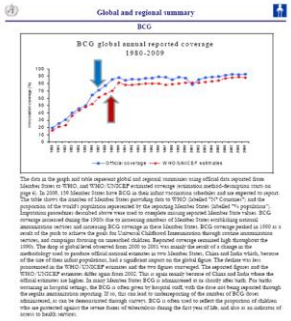
Vaccine	Birth ("high risk")	2 months	3 months	4 months	12-13 months	3-4 years	12-13 years (girls)	13-18 years
BCG	√							
DTaP		√	√	√		√		
IPV		√	√	√		√		√
Hib		√	√	√	√			
PCV		√		√	√			
MenC			√	√	√			
MMR					√	√		
HPV							√	
Td								√

BCG = bacillus Calmette Guerin
DTaP = diphtheria, tetanus, acellular pertussis
IPV = Inactivated (killed) polio (trivalent)
Hib = Haemophilus influenza B
PCV = Pneumococcal conjugate
MenC = Meningococcus type C
MMR = measles, mumps, rubella
HPV = Human papilloma virus
Td= Tetanus and diphtheria toxoids

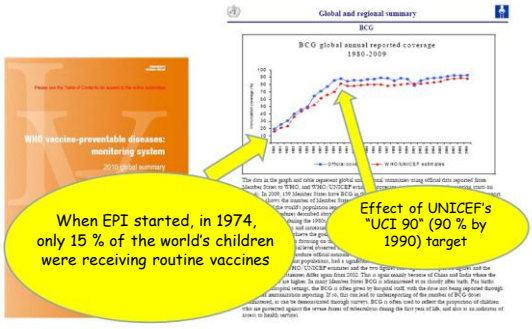
Examples of coverage and impact monitoring

Vaccine coverage

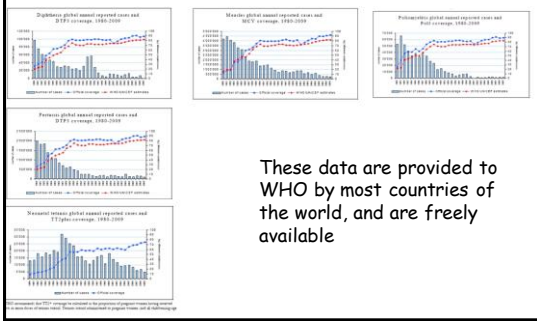




Vaccine coverage



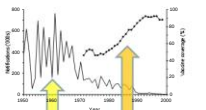
Impact: linking of vaccine coverage and disease surveillance data



These data are provided to WHO by most countries of the world, and are freely available

Impact: eg at national level

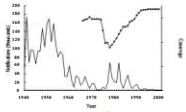
Measles, UK



Measles incidence (routine notifications)

Vaccine coverage (% of each cohort with "MMR")

Pertussis, UK

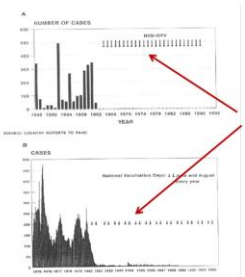


Impact: eg at national level

Polio in:

Cuba

Brasil



Campaigns in all children under 5

Programme evaluation

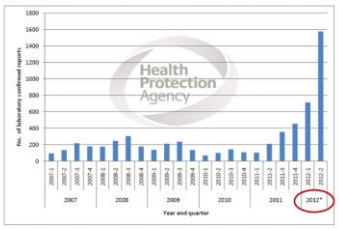
"Herd immunity" thresholds have NOT proved useful for programme evaluation

They are, in general, "optimistic"

Examples of vaccine effectiveness monitoring

.....and responses

Something is happening, now, with pertussis (whooping cough), in several countries …



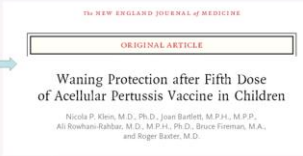
England and Wales

lab-confirmed cases, by quarter, 2007 - 2012

inc 10 infant deaths in 2012

California, USA

September 13 2012


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Waning Protection after Fifth Dose of Acellular Pertussis Vaccine in Children

Nicola P. Klein, M.D., Ph.D., Joan Bartlett, M.P.H., M.P.P., Ali Rowhani-Rahbar, M.D., M.P.H., Ph.D., Bruce Fireman, M.A., and Roger Baxter, M.D.

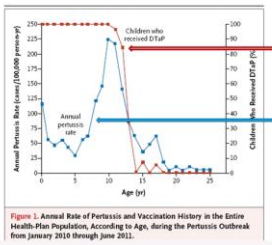


Figure 1. Annual Rate of Pertussis and Vaccination History in the Entire Health-Plan Population, According to Age, during the Pertussis Outbreak from January 2010 through June 2011.

(Red line) - proportion of children who received only acellular pertussis vaccine

(Blue line) incidence of pertussis peaking between 8 and 12 years of age… (This is unusual !)

UK policy change …
From The Guardian ,
Friday 28 September 2012


Pregnant women to be offered whooping cough jab

Sarah Boseley
Health editor

All pregnant women will be offered vaccination against whooping cough from today in an urgent effort by the government to halt the surge in deaths of small babies.

Medical experts from across the UK have died from whooping cough in the first eight months of this year – up from seven in the whole of 2011.

In England and Wales, between January and August this year, there were 1,014 cases of whooping cough in all ages, which is three times more than for the whole of last year. The deaths are in newborn babies, who have not yet reached the age

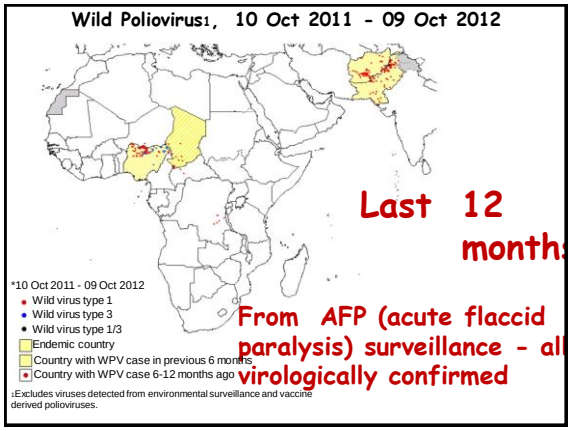
'Clearly we don't want pregnant women taking medication of any form unless it is necessary' Prof Sally Davies

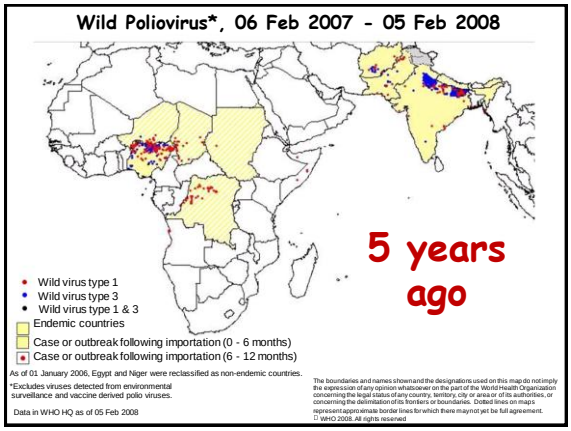
-to increase maternal immunity… and thus protect very young infants

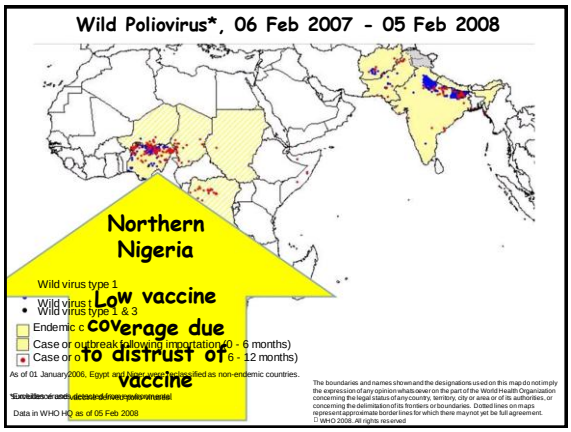
Polio

Global eradication initiative, since 1988

(350,000 cases in 1988)


Wild Poliovirus1, 10 Oct 2011 - 09 Oct 2012
Last 12 months
From AFP (acute flaccid paralysis) surveillance - all virologically confirmed
*10 Oct 2011 - 09 Oct 2012
Wild virus type 1
Wild virus type 3
Wild virus type 1/3
Endemic country
Country with WPV case in previous 6 months
Country with WPV case 6-12 months ago
1Excludes viruses detected from environmental surveillance and vaccine derived polioviruses.


Wild Poliovirus*, 06 Feb 2007 - 05 Feb 2008
5 years ago
Wild virus type 1
Wild virus type 3
Wild virus type 1 & 3
Endemic countries
Case or outbreak following importation (0 - 6 months)
Case or outbreak following importation (6 - 12 months)
As of 01 January 2006, Egypt and Niger were reclassified as non-endemic countries.
*Excludes viruses detected from environmental surveillance and vaccine derived polio viruses.
Data in WHO HQ as of 05 Feb 2008


Wild Poliovirus*, 06 Feb 2007 - 05 Feb 2008
Northern Nigeria
Low vaccine coverage due to distrust of vaccine
Wild virus type 1
Endemic c
Case or o 6 - 12 months)
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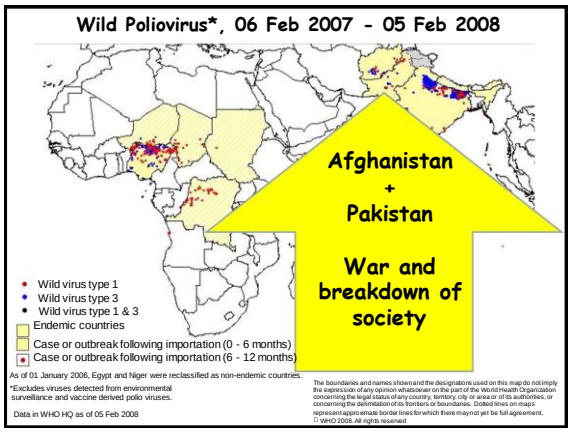
Data in WHO HQ as of 05 Feb 2008


Wild Poliovirus*, 06 Feb 2007 - 05 Feb 2008
Afghanistan + Pakistan
War and breakdown of society
Wild virus type 1
Wild virus type 3
Wild virus type 1 & 3
Endemic countries
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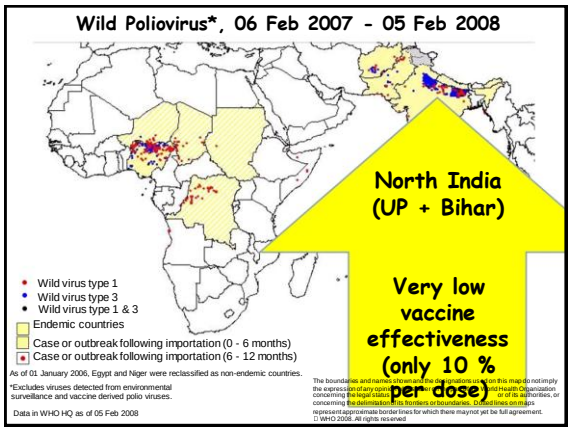
Wild Poliovirus*, 06 Feb 2007 - 05 Feb 2008
North India (UP + Bihar)
Very low vaccine effectiveness (only 10 % per dose)
Wild virus type 1
Wild virus type 3
Wild virus type 1 & 3
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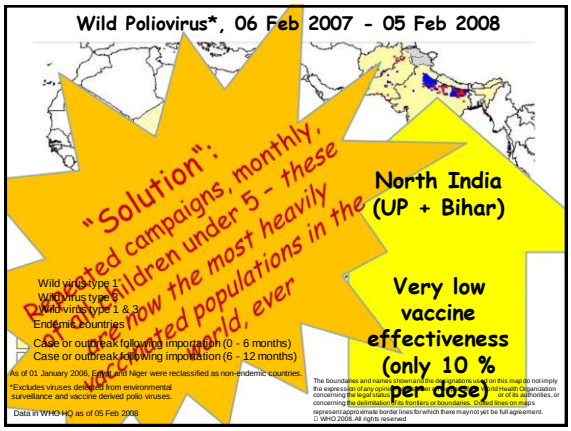
Wild Poliovirus*, 06 Feb 2007 - 05 Feb 2008
"Solution": repeated campaigns, monthly, for children under 5 – these now the most heavily infected populations in the world, ever
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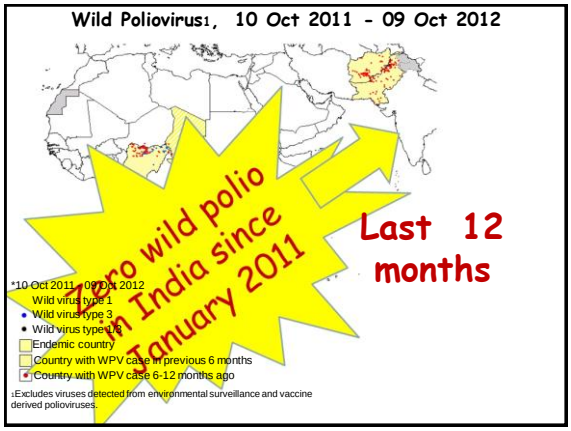

"Conclusion"

Optimising effectiveness of a vaccination programme requires rigorous surveillance and analysis of

- disease trends,
- vaccine "coverage",
- vaccine performance,

(and costs)

and appropriate response