Outline

- Introduction
- Impact of vaccination programmes.
  - Pre implementation
    - Burden of disease
    - Decision about introduction
    - Strategy
  - Post implementation
    - Impact assessment
    - Vaccine efficacy
    - Quality indicators
Vaccination objectives

**Containment**
- Risk group vaccination
  - To reduce mortality and severity

**Elimination**
- Absence of indigenous transmission
  - If infection is introduced, transmission will not be sustained.
- Mass vaccination programme
  - Vaccination cannot be stopped

**Eradication**
- Disease and its causal agent have been removed
  - Worldwide strategy
- Mass vaccination programme
  - Stop vaccination
Eradication / elimination

- No animal reservoir
- The virus cannot survive in the environment for a long time
- Diagnosis techniques are available to detect infection
- An effective, inexpensive vaccine exists
- Immunity is life-long with natural and vaccine infection
- Eliminable diseases: polio, measles, rubella
Mortality attributed to VPV

Causes of 1.7 million vaccine-preventable deaths among children, 2000

Measles mortality vaccination impact

<table>
<thead>
<tr>
<th>Regions</th>
<th>2000</th>
<th>2006</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFR</td>
<td>396,000</td>
<td>36,000</td>
<td>91%</td>
</tr>
<tr>
<td>GLOBAL</td>
<td>757,000</td>
<td>242,000</td>
<td>68%</td>
</tr>
</tbody>
</table>


Vaccination programmes change the VPD epidemiology. This change depends on:

- the vaccine action
- the coverage reached
- presence of a non-human host
- causal agent characteristics
PRE IMPLEMENTATION STEPS

A. Inform about vaccine development
B. Estimate burden
C. Decide about introduction
D. Decide strategy
B. Estimated burden VPD in Spain

- Mandatory notification of diseases and outbreaks (RENAVE).
  - Weekly total number of cases
  - Annual reporting of individualized data
  - Urgent outbreak notification and investigation

- Special Surveillance systems.
  - AFP surveillance
  - Measles
  - Rubella

- Special registries:
  - Neonatal Tetanus and Congenital Rubella Syndrome (CRS)

- Sentinel physician reporting: Flu, varicella.

- Serological studies: expensives.

- Other sources
  - Hospital registries, Mortality registries
  - Special morbidity studies
C. Decide about introduction

1. Is the disease a Public health issue?
2. Vaccine is safe and effective?
3. What is the effect of this new vaccine on the vaccination schedule?
4. What will be the cost-effectiveness?
5. Other aspects to be taken into consideration.
D. Decide immunisation strategy

- Selective immunisation
  - Individuals at risk of exposure
  - Individuals at increase risk from consequences of infections
  - Individuals at increased risk of exposing others (heath care workers)

- Mass immunisation
  - individual protection, herd immunity.
Infectious Disease dynamics

BASIC REPRODUCTION NUMBER \( R_0 \)

Number of secondary cases generated by one primary case, in a completely susceptible population
\[
R_0 = C \times B \times D
\]

EFFECTIVE REPRODUCTION RATIO \( R_e \)

Number of secondary cases generated from a primary case, in a population with immunes and susceptible people
\[
R_e = R_0 \times X
\]

\[
R = R_0 \left( 1 - p \right) \quad p > 1 - 1/R_0 \quad \text{elimination}
\]

\[
pc = 1 - 1/R_0 \quad \text{Critical vaccination coverage: Herd immunity threshold}
\]

Proportion of population that needs to be immunized by vaccination in order to eliminate the infectious agent

\[
R > 1 \quad \text{Epidemic risk}
\]

\[
R < 1 \quad \text{Elimination}
\]
Critical vaccination coverage (Pc) and Ro

- Critical vaccination coverage (Pc) and Basic reproduction number, Ro
- Pc = 1 - 1/Ro
- Measles, pertussis
- Rubella, diphtheria
- Smallpox, polio

Vaccines: Measles, pertussis, Rubella, diphtheria, Smallpox, polio
## Vaccination programme history in Spain

<table>
<thead>
<tr>
<th>Year</th>
<th>Schedule vaccine</th>
<th>New incorporations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963</td>
<td>OPV (3)</td>
<td>IPV (2004)</td>
</tr>
<tr>
<td>1965</td>
<td>DPT (3) + OPV (3) + Measles</td>
<td>DPaT</td>
</tr>
<tr>
<td>1979</td>
<td>Rubella</td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>DPT (3) + VPO (3) + MMR (1)</td>
<td>MMR</td>
</tr>
<tr>
<td>1996</td>
<td>DPT (3) + OPV (3) + MMR (2) + Hep B (3)</td>
<td>HVB</td>
</tr>
<tr>
<td>1998</td>
<td>DPT (3) + OPV (3) + MMR (2) + HVB (3) + Hib (3)</td>
<td><em>H. influenzae</em> type b</td>
</tr>
<tr>
<td>2000</td>
<td>DPT (3) + OPV (3) + MMR (2) + HVB (3) + Hib (3) + Men C (3)</td>
<td>Meningitis menigcocócica C</td>
</tr>
<tr>
<td>2004</td>
<td>Varicella</td>
<td></td>
</tr>
</tbody>
</table>
POST IMPLEMENTATION
Programme evaluation

A. Impact assessment: Direct and indirect effects
- Incidence
- Age distribution patterns
- Severity
- Causal agents variability
- Trends

\[ \begin{align*}
\text{Time series} & \\
\text{Burden of disease} & \\
\text{Mathematical models} & 
\end{align*} \]

B. Vaccine efficacy assessment:
- Vaccine coverage surveillance
- Studies on vaccine efficacy (outbreak investigation; surveillance data: screening method)

C. Surveillance system quality assessment: quality indicators
General effects of routine vaccination

Direct effects

- **SUSCEPTIBLE** → **vaccination** → **IMMUNE**
  - Reduce risk of infection
  - ↓ incidence and mortality
  - The probability of contracting the disease is reduced → **Herd immunity**
### A. Vaccination programme impact morbidity. Spain

Source: Nacional Centre for Epidemiology

<table>
<thead>
<tr>
<th>Year of Highest incidence</th>
<th>Year 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cases</td>
</tr>
<tr>
<td>Pertussis</td>
<td>1985</td>
</tr>
<tr>
<td>Tetanus</td>
<td>1983</td>
</tr>
<tr>
<td>Diphteria</td>
<td>1940</td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>1959</td>
</tr>
<tr>
<td>Measles</td>
<td>1983</td>
</tr>
<tr>
<td>Rubella</td>
<td>1983</td>
</tr>
<tr>
<td>Mumps</td>
<td>1984</td>
</tr>
</tbody>
</table>
A. Vaccination programme impact mortality. Spain

<table>
<thead>
<tr>
<th>Disease</th>
<th>Prevac year</th>
<th>Prevac mortality</th>
<th>mortality 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>total</td>
<td>total</td>
</tr>
<tr>
<td>Pertussis</td>
<td>1960</td>
<td>133</td>
<td>1</td>
</tr>
<tr>
<td>Tetanus</td>
<td>1960</td>
<td>419</td>
<td>4</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>1960</td>
<td>139</td>
<td>0</td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>1960</td>
<td>208</td>
<td>0</td>
</tr>
<tr>
<td>Measles</td>
<td>1975-80</td>
<td>39</td>
<td>0</td>
</tr>
<tr>
<td>Rubella</td>
<td>1975-80</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Mumps</td>
<td>1975-80</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Tetanus mortality: in the elderly people, > 65 years old

Source: Nacional Centre for Epidemiology

1963 OPV

Source: Nacional Centre for Epidemiology
Directs effects:
Measles, rubella and mumps. Incidence and coverage.
Spain 1982-2007

Source: National Centre for Epidemiology

Direct effects: Smallpox

- 1796 Jenner discovers vaccine.
- 1864: manufacturing and vaccination.
- 1958 WHO Eradication plan

- Ring vaccination, isolation and contact follow-up. It was stopped transmission and the disease has been eradicated.

- Vaccinated people can transmit disease.
  - 1978: Fatal case in a laboratory in United Kingdom.
  - 1979: WHO → Smallpox eradication Certificate
  - 1980: WHA decided STOP VACCINATION
Transmission of virus vaccinia

Vulvar Vaccinia Infection After Sexual Contact with a Military Smallpox Vaccinee --- Alaska, 2006

On October 10, 2006, an otherwise healthy woman visited a public health clinic in Alaska after vaginal tears that she had first experienced 10 days before became increasingly painful. The patient reported having a new male sex partner during September 22--October 1, 2006. A viral swab specimen from a labial lesion of the woman was submitted to the Alaska State Virology Laboratory (ASVL) for viral culture. The viral isolate could not be identified initially and subsequently was sent to CDC on January 9, 2007, where the isolate was identified as a vaccine-strain vaccinia virus. After vaccinia was identified, investigators interviewed the woman more closely and learned that her new sex partner was a male U.S. military service member stationed at a local military base. Further investigation determined that the service member had been vaccinated for smallpox 3 days before beginning his relationship with the woman. This report describes the clinical evaluation of the woman and laboratory testing performed to identify the isolate. Health care providers should be aware of the possibility of vaccinia
Indirect effects
General effects of routine vaccination

a) Lengthening of epidemic cycle
b) The population infected is older
c) Disease and complications are more severe
d) Seasonal pattern changes
e) Stops Transmission: no cases
Indirects effects

a) Lengthening of epidemic cycle

pre-vaccine, 1971-1982

post-vaccine, 1987-2007

Peña-Rey I et al. Epidemiología del sarampión en España. 5º Monografía de la Sociedad Española de Epidemiología.
Indirects effects

b) Increasing susceptibles in older age groups

before vaccination

after vaccination

vacunación
Indirect effects

b) Increasing susceptibles in older age groups

Source: Nacional Centre for Epidemiology
Indirects effects

d) Seasonal pattern changes

Prevac period, 1971-1982

Pos-vac period, 1982-2007

Measles 1971-1982
Seasonal component

Measles 1987-2007
Seasonal component

Peña-Rey I et al. Epidemiología del sarampión en España. 5º Monografía de la Sociedad Española de Epidemiología.
Indirects effects

e) Stop transmission

Confirmed and compatible cases by onset

B. Screening method to estimate effectiveness of mumps vaccine by vaccination cohort. Spain 2005-2007

Screening method*: surveillance data

Farrington:
EV = 1-(pcv*(1-ppv)/(1-pcv)*ppv))

PCV = Proportion of vaccinated cases
PPV = Proporción de vacunados poblacional

<table>
<thead>
<tr>
<th>Grupo edad</th>
<th>PPV</th>
<th>PCV</th>
<th>EV</th>
<th>I.C. 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15m</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16m-4a</td>
<td>0,97</td>
<td>0,64</td>
<td>0,947</td>
<td>0,92</td>
</tr>
<tr>
<td>5-9a</td>
<td>0,94</td>
<td>0,67</td>
<td>0,866</td>
<td>0,75</td>
</tr>
<tr>
<td>10-14a</td>
<td>0,89</td>
<td>0,76</td>
<td>0,596</td>
<td>0,31</td>
</tr>
<tr>
<td>15-19a</td>
<td>0,84</td>
<td>0,67</td>
<td>0,598</td>
<td>0,35</td>
</tr>
<tr>
<td>20-24a</td>
<td>0,61</td>
<td>0,33</td>
<td>0,685</td>
<td>0,49</td>
</tr>
</tbody>
</table>

Source: MV Martínez de Aragón. National Centre for Epidemiology. Not published data
C. Quality indicators for elimination

For WHO European region

- The number of countries with a measles incidence of <1/1000000
- The number of countries with a rubella incidence of <1/1000000
- The number of countries with a CRS incidence of <1/100000 live births
- The number of countries with MCV1 coverage of >95% at national level and >90% in all districts

For one country:

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of sites reporting weekly ≥ 80%</td>
<td>84%</td>
<td>84%</td>
<td>79%</td>
<td>74%</td>
<td>89%</td>
<td>58%</td>
</tr>
<tr>
<td>Percentage of cases with adequate specimens and laboratory results ≥ 80%</td>
<td>91%</td>
<td>98%</td>
<td>97%</td>
<td>97%</td>
<td>88%</td>
<td>84%</td>
</tr>
<tr>
<td>Percentage of cases with laboratory results within 7 days of detection ≥ 80%</td>
<td>30%</td>
<td>91%</td>
<td>89%</td>
<td>86%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>% outbreaks investigated</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>...</td>
</tr>
</tbody>
</table>
In Conclusion…

- Major impact on infectious disease control
- Elimination/eradication of diseases does not require complete vaccination coverage
- High coverage modifies infectious diseases epidemiology: increases epidemic periods increases age at infection
- Programmes evaluation
VACCINATION AND DISEASE CONTROL

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Episouth 4th June 2008