Cost-effectiveness case studies

Immunization is one of the most successful public health interventions in preventing suffering and death. Benefits go beyond health and encompass social and economic returns as well. Despite their success, immunization programmes are not always prioritized for continued or increased resources.

It is important therefore that decision-makers and partners appreciate the importance of immunization, not just as a public health intervention but as a national investment that yields socioeconomic returns and health care savings.

How to use this document
This document presents summaries and key findings from a range of cost-effectiveness analyses drawn mainly from evidence published in peer-reviewed journals and official documentation. The summaries can be drawn upon to support your country’s efforts to raise the profile of immunization and ensure continued investment in it within the context of health care prioritization.

Use the summaries as inspiration, to prepare for a meeting or to hand out to stakeholders.

The case studies will help most when they are used to help paint a national picture and a strong country-specific case for continued support in immunization. Present the studies alongside descriptions of the national issues and challenges. If available, supplement them with your own national data. If the same data is not available, consider using other national data that can serve as a proxy.

Contents

• Glossary of terms and abbreviations
• Case studies, grouped into three categories

1. Cost-effectiveness evidence for the introduction of a vaccine:
   • evidence to support the introduction of new vaccines
   • financial burden of vaccine-preventable disease
   • comparisons of costs of the vaccine against costs of treating the disease.

2. Cost-effectiveness evidence for sustaining an existing vaccine:
   • cost-effectiveness evidence supporting the need to sustain a vaccine
   • averted health care costs and societal costs
   • cost-effectiveness evidence showing accumulated benefits of vaccination and reduced costs over time

3. Cost-effectiveness evidence for strengthening an existing vaccine programme:
   • cost-effectiveness evidence supporting the need to increase coverage, eliminate pockets of under-vaccinated communities and groups
   • the cost to health and health services of outbreaks and the cost-effectiveness of avoiding them
Abbreviations

AOM  acute otitis media  
CFR  case-fatality ratio  
DALY  disability-adjusted life year  
GAVI  Global Alliance for Vaccines and Immunisation  
GBD  global burden of disease  
GDP  gross domestic product  
HBV  hepatitis B virus  
Hib  Haemophilus Influenza type b vaccine  
ICER  incremental cost–effectiveness ratio  
IPV  inactivated polio vaccine  
MCV  measles-containing vaccine  
NPNM  non-pneumonia, non-meningitis  
OPV  oral polio vaccine  
PCV  pneumococcal conjugate vaccine  
RVGE  rotavirus gastroenteritis  
QALY  quality-adjusted life years

Glossary of Terms

Cost–effectiveness analysis
Analysis comparing the intervention cost, with the actual or expected health gains (effectiveness).

Cost–effectiveness ratio
Total cost per unit of health gain. It is the outcome of a cost–effectiveness analysis.

Cost-effective intervention
Provides an extra year of healthy life (equivalent to averting one DALY) for less than three times the Gross Domestic Product (GDP). A highly cost-effective intervention does so for less than the GDP.

Disability-Adjusted Life Years (DALYs)
Sum of the years of life lost due to mortality [premature death compared to life expectancy] plus the years of life lost due to disability [less than perfect health]. DALYs averted is a measure of the effectiveness of an intervention.

Disability weight
Multiplier between 0 and 1 that describes the severity of a disease. For DALYs, 1 is equivalent to death and 0 is perfect health. For QALYs, 1 is a state of ideal health and 0 is a state comparable to death.

Discount rate
Multiplier applied to discount future years’ cost and benefits. [Rationale: US$1 in the future is not worth as much as US$1 today – and people prefer to have benefits now rather than in the future].

Economic modelling
Trial simulation using estimated input parameters to predict cost–effectiveness of an intervention where a real-life trial is not possible or not feasible.

Incremental Cost–Effectiveness Ratio (ICER)
Additional cost per unit of health gain. It is the outcome of a cost–effectiveness analysis.

Quality-Adjusted Life Years (QALYs)
Product of life expectancy and a measure of the quality of the remaining life-years. One QALY is a year of perfect health. QALYs gained is a measure of the effectiveness of an intervention.

Sensitivity analysis
Test of the robustness of the cost–effectiveness analysis results. Parameters are changed within a plausible range either one at a time (one-way sensitivity analysis) or many at a time (multiway sensitivity analysis).

TRIVAC
Tool for estimating the cost-effectiveness of vaccines.
Cost-effectiveness evidence for introducing and sustaining a vaccine

Case study: Italy – Hepatitis B

KEY FINDINGS
An economic evaluation of the clinical impact of hepatitis B immunization in the 20 years following its introduction in Italy in 1991 was conducted. Key findings included the following.

• The first 20 years of the hepatitis B vaccination programme resulted in:
  • reduced burden of hepatitis B virus (HBV) related diseases;
  • return on investment of 1.02 from the National Health Service (NHS) perspective;
  • clinical savings exceeding vaccination costs in 2010

About hepatitis B
Approximately 2 billion people worldwide have been infected with HBV. Of the 360 million people chronically infected, 600 000 die each year from HBV-associated liver cirrhosis or hepatocellular carcinoma.

In endemic areas, HBV transmission mainly occurs perinatally or during early childhood. However, in low endemic areas, transmission mainly occurs later in life through sexual contact or through the use of contaminated needles.

Methods
The authors used a mathematical simulation model to conduct an economic evaluation of the clinical impact of hepatitis B immunization in the 20 years following its introduction in Italy. The authors also projected future benefits that could be expected to be delivered by the programme.

Results

- The study found that hepatitis B incidence declined between 1990 and 2010 by:
  - 100% among children aged 0–14 years
  - 97% among teenagers and adults aged 15–24 years
  - 70% among adults older than 24 years of age
  - 82% in the total population.
- Benefit-to-cost ratio was 0.91 from the societal perspective for the period 1991-2010, and predicted to be 2.47 for the period 1991-2059.
- Projections for 2011–2059 estimated a 77% reduction of costs, from the both the NHS and societal perspectives.

From the NHS perspective, the break-even point was achieved in approximately 2010. Therefore, benefits of the immunization programme will continue to become more evident in the future.

The impact of the immunization programme was far reaching, affecting all age groups within the Italian population.

### Table 1. Total number of cases related to HBV infection in Italy during the 1991-2010 period in the vaccination and no vaccination scenario

<table>
<thead>
<tr>
<th>CLINICAL CASES</th>
<th>NO VACCINATION</th>
<th>VACCINATION</th>
<th>AVOIDED CASES</th>
<th>% REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBV infection</td>
<td>168 930</td>
<td>42 038</td>
<td>126 892</td>
<td>75</td>
</tr>
<tr>
<td>Symptomatic acute HBV infection</td>
<td>43 140</td>
<td>28 520</td>
<td>14 621</td>
<td>34</td>
</tr>
<tr>
<td>Chronic hepatitis B</td>
<td>5 465</td>
<td>1 360</td>
<td>4 105</td>
<td>75</td>
</tr>
<tr>
<td>Compensated cirrhosis</td>
<td>129</td>
<td>59</td>
<td>70</td>
<td>54</td>
</tr>
<tr>
<td>Decompensated cirrhosis</td>
<td>9</td>
<td>4</td>
<td>5</td>
<td>54</td>
</tr>
<tr>
<td>Hepatocellular carcinoma</td>
<td>86</td>
<td>22</td>
<td>64</td>
<td>74</td>
</tr>
<tr>
<td>Liver transplantation</td>
<td>24</td>
<td>7</td>
<td>17</td>
<td>72</td>
</tr>
</tbody>
</table>

### Table 2. Clinical costs during the 1991–2010 period from the NHS perspective in the vaccination and no vaccination scenarios

<table>
<thead>
<tr>
<th>CLINICAL COSTS (1991–2010)</th>
<th>NO VACCINATION</th>
<th>VACCINATION</th>
<th>AVOIDED CASES</th>
<th>% REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptomatic acute HBV infection</td>
<td>572 051 723</td>
<td>362 160 953</td>
<td>209 890 771</td>
<td>37</td>
</tr>
<tr>
<td>Chronic hepatitis B</td>
<td>649 157 949</td>
<td>210 059 569</td>
<td>439 098 380</td>
<td>68</td>
</tr>
<tr>
<td>Compensated cirrhosis</td>
<td>18 485 689</td>
<td>8 914 521</td>
<td>9 571 168</td>
<td>52</td>
</tr>
<tr>
<td>Decompensated cirrhosis</td>
<td>1 193 807</td>
<td>575 700</td>
<td>618 107</td>
<td>52</td>
</tr>
<tr>
<td>Hepatocellular carcinoma</td>
<td>8 330 359</td>
<td>2 830 361</td>
<td>5 499 999</td>
<td>66</td>
</tr>
<tr>
<td>Liver transplantation</td>
<td>3 135 545</td>
<td>1 117 773</td>
<td>2 017 771</td>
<td>64</td>
</tr>
<tr>
<td>Total</td>
<td>1 252 355 072</td>
<td>585 658 877</td>
<td>666 696 195</td>
<td>53</td>
</tr>
</tbody>
</table>
Methods

A decision analytic model was used to predict the impact of Hib vaccination for the 2009 birth cohort in Belarus and Uzbekistan.

Input parameters included:
• demography and disease burden
• health service utilization and costs
• vaccination coverage and efficacy
• vaccination cost.

About *Haemophilus influenzae* type B

Hib is the most common cause of serious infection and mortality in children under 5 years of age in industrialized countries that do not include Hib vaccination in their routine immunization schedules.

Hib often presents as meningitis, epiglottitis, pneumonia, septic arthritis or osteomyelitis.

Hib is frequently associated with severe neurologic sequelae, even if antibiotics are given promptly.

Vaccines are the only public health tool that can prevent most cases of serious Hib disease.

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Results

Health impact

Hib vaccination is predicted to:
• prevent 3002 cases of Hib disease for the 2009 birth cohort in Uzbekistan and 467 cases in Belarus;
• reduce under-five mortality by 1.1% and 0.3% in Uzbekistan and Belarus respectively.

Cost-effectiveness

• The cost per discounted disability-adjusted life-year (DALY) averted was calculated to be US$ 9323 in Belarus and US$267 in Uzbekistan, making Hib vaccination cost-effective and highly cost-effective respectively.
• Hib vaccination is more cost-effective in Uzbekistan mainly due to the country’s:
  • higher baseline Hib mortality burden
  • lower price of vaccine.

Table 1. Discounted health and economic impact for 2009 birth cohort (0-59 months)

<table>
<thead>
<tr>
<th></th>
<th>BELARUS</th>
<th>UZBEKISTAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hib disease cases averted</td>
<td>467</td>
<td>3,002</td>
</tr>
<tr>
<td>Hib deaths averted</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td>Hib meningitis sequelae cases averted</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td>DALYs averted</td>
<td>152</td>
<td>11,473</td>
</tr>
<tr>
<td>Annual incremental vaccine costs (US$)</td>
<td>1,764,322</td>
<td>4,241,611</td>
</tr>
<tr>
<td>Treatment costs averted (US$)</td>
<td>343,740</td>
<td>1,183,681</td>
</tr>
<tr>
<td>Annual net costs (US$)</td>
<td>1,420,582</td>
<td>3,057,930</td>
</tr>
<tr>
<td>Incremental costs per DALY averted (US$)</td>
<td>9,323</td>
<td>267</td>
</tr>
</tbody>
</table>

Table 2. Cost-effectiveness

<table>
<thead>
<tr>
<th></th>
<th>BELARUS</th>
<th>UZBEKISTAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per discounted DALY averted (US$)</td>
<td>$9,323</td>
<td>$267</td>
</tr>
<tr>
<td>GDP per capita (US$)</td>
<td>$5,560</td>
<td>$1,100</td>
</tr>
<tr>
<td>Cost-Effectiveness [WHO Criteria]</td>
<td>Cost-effective</td>
<td>Highly cost-effective</td>
</tr>
</tbody>
</table>
Cost-effectiveness evidence for introducing and sustaining a vaccine

Case study: Germany – rotavirus

KEY FINDINGS
A study on the impact of rotavirus vaccine was conducted in Germany. Key findings included the following.

Rotavirus vaccination, with low-moderate vaccine uptake in Germany, was associated with:

- 36% reduction in rotavirus-related hospitalization for children less than 24 months in the eastern Federal States;
- 25% reduction in rotavirus-related hospitalization for children less than 24 months in the western Federal States;
- significantly lower incidence of rotavirus-related hospitalization when vaccine uptake is higher and earlier.

The greatest health impact was recorded for infants 6–11 months of age.

Method

Incidence rates of rotavirus-related hospitalizations were compared before (2004-2006) and in the seasons after (2008/09-2010/11) the vaccine was available on the German market.

A retrospective questionnaire survey was used to assess the vaccine coverage.

Rotavirus cases were identified through the national mandatory disease reporting system.

Results

A low-moderate uptake was observed (rotavirus vaccination was not introduced into the national immunization schedule in Germany until 2013).

The study population was stratified into eastern Federal States (EFS) and western Federal States (WFS) – because of the remarkable difference in vaccine uptake. (Rotavirus vaccine uptake was consistently higher in EFS).

About rotavirus

Rotaviruses are the most common cause of severe diarrhoeal disease in young children worldwide. They are also the cause of gastroenteritis and dehydration.

Worldwide, it causes an estimated 453 000 deaths in children below 5 years of age annually.

In the European Region deaths are rare, but there are 87 000 hospitalizations annually, which result in high health care costs.

There are two available rotavirus vaccines, Rotarix and RotaTeq, which are both considered safe and effective at preventing gastrointestinal disease.

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Note: the incidence of rotavirus was also higher in EFS, however regression analysis demonstrated that the vaccination impact would be similar in both regions with similar coverage (that is, the difference in incidence of rotavirus-related hospitalization between the two regions is not accounted for by the difference in rotavirus incidence).
Cost-effectiveness evidence for the introduction of a vaccine

Case Study: Croatia – PCV

KEY FINDINGS
A cost-effectiveness study on the introduction of Pneumococcal Conjugate Vaccine (PCV) was conducted in Croatia. Key findings included the following.

Pneumococcal vaccination in children aged less than 5 years in Croatia in the period 2014–2033 was predicted to:
- prevent 36,000 episodes of pneumococcal illness;
- prevent 3650 outpatient visits, 100 hospital admissions and 1 death each year;
- reduce by 50-60% incidence of pneumococcal meningitis and the number of children with long term disabilities due to meningitis;
- reduce health service expenditure for treating pneumococcal illnesses by US$ 6–7 million;
- cost the government US$ 50–55 million to introduce;
- be potentially cost-effective at vaccine price less than US$ 20 per dose.

Methods
PCV10 and PCV13 were compared to a scenario assuming no vaccination for 20 birth cohorts of children over the period 2014–2033 using a static cohort model (TRIVAC).

Input parameters included:
- demography and disease burden
- health service utilization and costs
- vaccination coverage and efficacy
- vaccination cost.

About Streptococcus pneumoniae
These bacteria cause a wide range of diseases including meningitis, pneumonia, sinusitis and otitis media.

Worldwide, about 14.5 million episodes of serious pneumococcal disease occur each year, and it is the most important cause of vaccine-preventable deaths in children younger than 5 years.

The two available pneumococcal conjugate vaccines [PCV], PCV10 and PCV13, target either 10 or 13 of the most prevalent serotypes respectively, which cause over 70% of serious pneumococcal disease in children.
Results

Health benefits

- Each year, in children less than 5 years of age either vaccine is estimated to prevent about:
  - 1800 pneumococcal cases
  - 100 hospital admissions
  - 1 death

<table>
<thead>
<tr>
<th>HEALTH OUTCOME</th>
<th>NO VACCINE</th>
<th>PCV 10</th>
<th>PCV 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumococcal cases in children less than 5 years</td>
<td>680 474</td>
<td>36 348</td>
<td>36 931</td>
</tr>
<tr>
<td>Outpatient visits</td>
<td>1 360 359</td>
<td>72 381</td>
<td>73 497</td>
</tr>
<tr>
<td>Inpatient admissions</td>
<td>3 365</td>
<td>1 808</td>
<td>2 086</td>
</tr>
<tr>
<td>Deaths &lt; 5 years</td>
<td>27</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>Children with permanent disability</td>
<td>15</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>DALYs Lost</td>
<td>1 297</td>
<td>559</td>
<td>643</td>
</tr>
</tbody>
</table>

Table 1. Discounted health benefits (20 cohorts vaccinated over the period 2014–2033)

Economic benefits

For the period 2014–2033, about 600 disability-adjusted life years (DALYs) would be prevented.

Over 20 years, either vaccine would avert costs amounting to approximately:
- US$ 6–7 million (government perspective)
- US$ 10–11 million (societal perspective).

The cost per DALY averted would be US$ 69 000–77 000. In Croatia, 3 x GDP per capita (i.e. the WHO-recommended cost-effectiveness threshold) is around US$ 40 000, therefore routine vaccination with PCV in Croatia is unlikely to be cost-effective unless:
- the vaccine is priced at US$ 20 per dose or less;
- the disease burden is higher than estimated;
- the burden of pneumococcal disease in older age groups is considered.

Figure 1. US$ per DALY averted for PCV10 with variable input parameters
Cost-effectiveness evidence for the introduction of a vaccine

Case study: Georgia – PCV¹

**KEY FINDINGS**

A cost-effectiveness study of Pneumococcal Conjugate Vaccine (PCV) introduction in Georgia produced the following key findings.

- PCV introduction in Georgia is predicted to:
  - prevent 4 deaths and 717 cases of acute otitis media per year;
  - prevent 533 cases of pneumonia per year;
  - result in treatment cost savings of US$ 2.14 million;
  - have a net cost of US$ 2.3 million;
- Introduction of PCV10 vaccine in Georgia was estimated to be cost-effective based on WHO criteria² even in the worst-case scenario tested.

**Methods**

A cost-effectiveness analysis on the introduction of PCV10 in Georgia was conducted from the Government’s perspective.

The analysis was conducted using a TRIVAC decision-analytic model time horizon of 10 years, 2014 to 2023. The introduction of PCV10 was compared to a scenario of no PCV vaccination.

Input parameters included:
- demographics and disease burden
- vaccine efficacy and coverage
- health services utilization and costs
- vaccine programme costs.

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Results

Health impact

Table 1: Aggregated outcomes prevented due to PCV programme for 10 cohorts

<table>
<thead>
<tr>
<th>DEATHS</th>
<th>CASES AOM</th>
<th>ADMISSIONS (PNEUMONIA)</th>
<th>ADMISSIONS (SP. MENINGITIS)</th>
<th>ADMISSIONS (SP. NPNM SEPSIS)</th>
<th>MENINGITIS SEQUELAE</th>
<th>DALY (ALL DISEASES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>7,170</td>
<td>5,325</td>
<td>87</td>
<td>508</td>
<td>17</td>
<td>1,438</td>
</tr>
</tbody>
</table>

AOM: acute otitis media; NPNM: non-pneumonia non-meningitis; DALY: disability-adjusted life-years.

Economic Impact

Table 2. Costs of the PCV10 programme 2014 to 2023

<table>
<thead>
<tr>
<th>TOTAL COSTS OF PCV PROGRAMME</th>
<th>TREATMENT COSTS</th>
<th>TOTAL NET COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>US$ 4.44 MILLION</td>
<td>US$ 2.14 MILLION</td>
<td>US$ 2.30 MILLION</td>
</tr>
</tbody>
</table>

Conclusion

PCV vaccination in Georgia would be very cost-effective by WHO criteria in most scenarios modelled. The cost per DALY averted is US$ 1599 from the Government perspective.

In the worst-case scenario modelled, the introduction of PCV10 in Georgia would still be cost-effective.
Evidence for sustaining a vaccine

Case Study: United Kingdom - measles

KEY FINDINGS
A study of the short-term impact of measles infection on health-related quality of life was conducted in the United Kingdom during 2012 and 2013. Key findings included the following.

• 2366 cases of measles resulted in an estimated **23 110 age-adjusted days of lost productivity** during the 12 month period of the study.
• For each measles patient who fully recovered, on average, about:
  • **10 days** were taken off school or work and their carer took **7 days** off;
  • **4 nights** were spent in hospital (if hospitalized);
  • **4 contacts** with a health care professional were reported during the period of infection.

Method

All eligible confirmed cases of measles from 1 June 2012 to 31 May 2013 were invited to participate in a postal survey.

The survey included the EuroQol EQ-5D-3L questionnaire to assess the impact on HRQoL (health-related quality of life) and additional questions about direct and indirect impact of measles infection.

The EuroQol scoring algorithm produces a health utility specific to the individual’s health state. These utilities are then used in combination with the duration of symptoms to generate the Quality-Adjusted Life Years or Days lost (QALYs or QALDs).

About measles

Measles is a highly contagious viral disease. It can cause serious complications, including blindness, encephalitis and death.

Measles caused an estimated 2.6 million deaths globally each year before widespread vaccination was introduced.

Vaccination costs less than US$1 per child.

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Results

Impact on health-related quality of life

About 80% of measles cases reported either some or severe problems for each dimension of health assessed.

Measles resulted in 0.019 QALYs lost per patient (95% confidence interval: 0.016 – 0.022) – which is equivalent to 6.9 QALDs.

The overall burden of disease in the United Kingdom (2366 confirmed cases) in the 12 month period from 1 June 2012 was estimated to be:
- 44.2 QALYs lost
- 23,110 days of lost productivity (including carers).

Table 1: Impact of measles infection on the duration of symptoms, time off school or work and hospitalization

<table>
<thead>
<tr>
<th></th>
<th>ALL CONFIRMED MEASLES CASES</th>
<th>AGED UNDER 7 YEARS</th>
<th>AGED 7-12 YEARS</th>
<th>AGED 13 YEARS AND OVER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean duration of perceived symptoms [days]</td>
<td>13.8</td>
<td>12.8</td>
<td>13.5</td>
<td>14.4</td>
</tr>
<tr>
<td>Individuals reporting time off work or school (%)</td>
<td>63.1 %</td>
<td>37.1 %</td>
<td>88.0 %</td>
<td>74.1 %</td>
</tr>
<tr>
<td>Mean time off work or school [days]</td>
<td>9.6</td>
<td>8.6</td>
<td>9.1</td>
<td>10.1</td>
</tr>
<tr>
<td>Individuals reporting time off work for primary caregivers (%)</td>
<td>39.6 %</td>
<td>44.3 %</td>
<td>40.0 %</td>
<td>31.5 %</td>
</tr>
<tr>
<td>Mean time off work for primary caregivers [days]</td>
<td>7.3</td>
<td>7</td>
<td>7.7</td>
<td>7.2</td>
</tr>
<tr>
<td>Individuals reporting at least one night in hospital (%)</td>
<td>36.5 %</td>
<td>32.9 %</td>
<td>8.0 %</td>
<td>45.4 %</td>
</tr>
<tr>
<td>Mean number of nights spent in hospital</td>
<td>4.2</td>
<td>4</td>
<td>4</td>
<td>4.4</td>
</tr>
</tbody>
</table>
Evidence for strengthening an existing vaccination programme

Case study: Italy – measles

KEY FINDINGS
A study of two measles outbreaks in Lazio, Italy was conducted. Key findings included the following:

• Despite high overall coverage within the population, pockets of unvaccinated communities create a risk for disease outbreaks.
• The outbreaks started in groups with low vaccine coverage (Roma/Sinti community, secondary school students).
• None of the 102 Roma/Sinti cases were vaccinated against measles. 5.5% of the 347 remaining cases had received one dose of measles containing vaccine.
• Four healthcare professionals developed measles.
• About 60% of the 449 cases required hospitalization.

Methods
Two measles outbreaks in the period June 2006 – August 2007 were investigated using data from the regional Public Health Agency and National Institute of Health.

Measles vaccine coverage has historically been low in Lazio, but after a national measles elimination plan, overall coverage had increased from 83.9% (2003) to 90.7% (2007).

About measles
The measles virus is highly infectious. Measles can lead to serious complications such as death, blindness, encephalitis, pneumonia and severe diarrhoea.

Measles incidence increased by 348% in the WHO European region between 2007 and 2013 due to immunity gaps.

Results

The first outbreak started in the Roma/Sinti population, and was transmitted to the general population.

The second outbreak started in a secondary school and affected mainly adolescents and adults in the general population.

Vaccination status and age distribution

None of the Roma/Sinti cases were vaccinated against measles. Most cases in the Roma/Sinti group were aged 1-4 years. In the general population, most cases were aged 15-19 years and there was a higher percentage of vaccinated subjects, especially among young children.

Conclusion

Despite high overall coverage within the population, pockets of unvaccinated communities create a risk for disease outbreaks.

Table 1. Sources of outbreaks

<table>
<thead>
<tr>
<th></th>
<th>FIRST OUTBREAK</th>
<th>SECOND OUTBREAK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serotype</td>
<td>D4</td>
<td>B3</td>
</tr>
<tr>
<td>First Reported cases</td>
<td>Roma/Sinti population</td>
<td>Secondary school</td>
</tr>
</tbody>
</table>

Table 2. Sources of outbreaks

<table>
<thead>
<tr>
<th></th>
<th>ROMA/SINTI</th>
<th>NON-ROMA/SINTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>102</td>
<td>347</td>
</tr>
<tr>
<td>% received one dose measles-containing vaccine</td>
<td>0 %</td>
<td>5.5 %</td>
</tr>
<tr>
<td>Median age of cases (years)</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>% cases aged 0-4 years</td>
<td>70 %</td>
<td>23 %</td>
</tr>
<tr>
<td>% cases aged less than 15 years</td>
<td>90 %</td>
<td>49 %</td>
</tr>
</tbody>
</table>

Figure 1. Number of reported measles cases by month in Lazio

Figure 2. Number of reported measles cases by age group

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Evidence for strengthening an existing vaccine programme

Case study: Germany – measles

KEY FINDINGS
A study of the costs of a measles outbreak in a region of Germany was conducted. Parental reasons in the case of non-vaccinated children were also explored. The key findings included the following.

- An accumulation of non-immune individuals led to an outbreak of 1749 cases in North Rhine-Westphalia in 2006.
- Targeted efforts such as school-based catch-up campaigns for older age groups are needed to close immunity gaps to prevent outbreaks.
- Most cases occurred in the city of Duisburg (614 cases), where
  - at least 80% of cases were reported as having received no vaccinations;
  - almost 3000 school days and about 300 work days were missed by patients with measles;
  - 95 patients were hospitalized for a total of 775 days;
  - each measles case cost about €520 (including the cost to the local public health office).

Methods
A school-based retrospective cohort study was conducted during the initial phase of the 2006 measles outbreak in North Rhine-Westphalia (NRW).

Overall coverage with two-dose measles-containing vaccine (MCV) in 2005 in NRW was 74.7%.

All cases notified in the worst-affected city, Duisburg, were invited to participate by interview or questionnaire. 81% of 614 cases in Duisburg were interviewed. The median age of interviewed measles cases was 11 years.

About measles
The measles virus is highly infectious. Measles can lead to serious complications such as death, blindness, encephalitis, pneumonia and severe diarrhoea.

Measles incidence increased by 348% in the WHO European Region between 2007 and 2013 due to immunity gaps.
Results

Coverage

- 94% were unvaccinated or had only received one dose of MCV.
- Among the key reasons for under-vaccination were that parents had forgotten, they rejected vaccination, or a doctor had advised against vaccination.

Health

- Complications reported:
  - 19% otitis media
  - 7% pneumonia
  - 0.6% encephalitis
  - 2 deaths.

Economy

- Measles patients missed 2,854 school days and 301 work days
- Healthcare provider costs for the 614 measles patients in Duisburg were estimated at €229,000.

Table 1. Reasons for non-vaccination (reported by parents of measles patients in the Duisburg 2006 outbreak)

<table>
<thead>
<tr>
<th>Reason for not being vaccinated</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents forgot about the vaccination</td>
<td>36.4</td>
</tr>
<tr>
<td>Parents rejected the vaccination</td>
<td>27.8</td>
</tr>
<tr>
<td>Doctor recommended against vaccination (inappropriately)</td>
<td>16.5</td>
</tr>
<tr>
<td>Doctor recommended against vaccination (appropriately)</td>
<td>0.3</td>
</tr>
<tr>
<td>Child was less than 12 month</td>
<td>13</td>
</tr>
<tr>
<td>Vaccination was not offered</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2. Health care costs, Duisburg measles outbreak 2006

<table>
<thead>
<tr>
<th>Costs</th>
<th>€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs for hospitalization</td>
<td>178,329</td>
</tr>
<tr>
<td>Outpatient consultations</td>
<td>27,528</td>
</tr>
<tr>
<td>Laboratory tests</td>
<td>20,826</td>
</tr>
<tr>
<td>Antibiotic treatment</td>
<td>2,440</td>
</tr>
<tr>
<td>Total</td>
<td>229,123</td>
</tr>
</tbody>
</table>

Figure 1. Reported measles cases by age group, North Rhine-Westphalia region, Germany, 2011 and 2006