

# Principles of Vaccination

---

Kolářová Marie, EPI  
Autumn 2015

---

The word “vaccine” comes from the Latin word *vaccinus*, which means “pertaining to cows.” What do cows have to do with vaccines? The first vaccine was based on the relatively mild cowpox virus, which infected cows as well as people. This vaccine protected people against the related, but much more dangerous, smallpox virus.

More than 200 years ago (in 1789), Edward Jenner, a country physician practicing in England, noticed that milkmaids rarely suffered from smallpox.

The milkmaids often did get cowpox, a related but far less serious disease, and those who did never became ill with smallpox.

In an experiment that laid the foundation for modern vaccines, Jenner took a few drops of fluid from a skin sore of a woman who had cowpox and injected the fluid into the arm of a healthy young boy who had never had cowpox or smallpox.

Six weeks later, Jenner injected the boy with fluid from a smallpox sore, but the boy remained free of smallpox.

# Dr. Edward Jenner



Dr. Jenner had discovered one of the fundamental principles of immunization.

---

He had used a relatively harmless foreign substance to evoke an immune response that protected someone from an infectious disease.

His discovery would ease the suffering of people around the world and eventually lead to the elimination of smallpox, a disease that killed a million people, mostly children, each year in Europe.

By the beginning of the 20th century, vaccines were in use for diseases that had nothing to do with cows—rabies, diphtheria, typhoid fever, and plague—but the name stuck.

# Remembering an Old Disease

---

## Smallpox



Variola virus, which causes smallpox, was once the scourge of the world. **This virus passes from person to person through the air.**

---

A smallpox infection results in fever, severe aches and pains, scarring sores that cover the body, blindness in many cases, and, often, death. There is no effective treatment.

Although vaccination and outbreak control eliminated smallpox in the United States by 1949, the disease still struck an estimated 50 million people worldwide each year during the 1950s.

**In 1967, the World Health Organization (WHO) launched a massive vaccination campaign to rid the world of smallpox—and succeeded.**

The last natural case of smallpox occurred in Somalia in 1977.

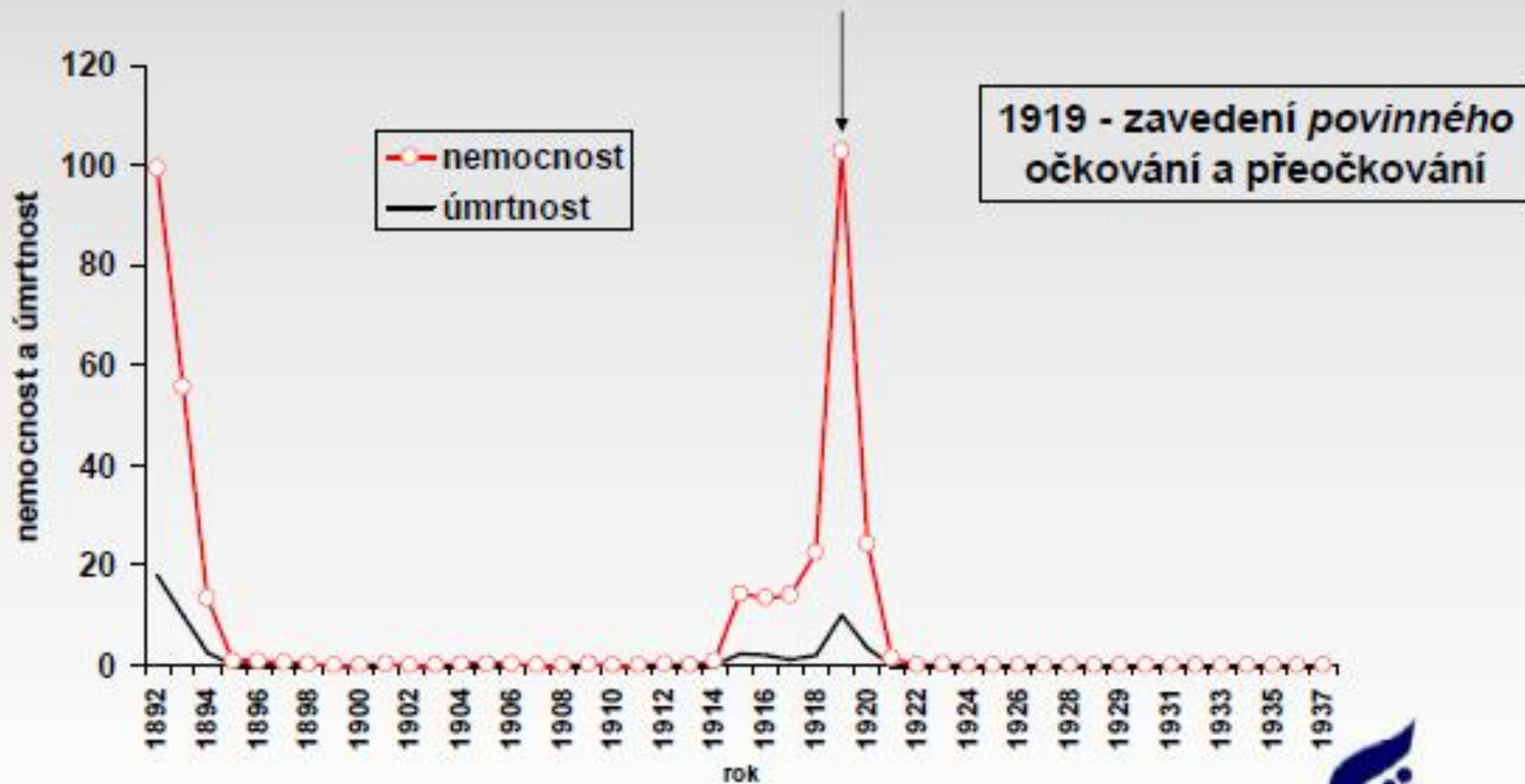
**Ali Maow Maalin**, cook twenty-three of the hospitals in the Somali Merce.

He contracted when he showed the path of the ambulance chauffeur who drove two sick children to camp insulation.

In 1978 was ill photographer Medical School in Birmingham, England. She was killed by a virus that escaped from a neighboring lab.



## Variola, České země, 1892-1937, nemocnost a úmrtnost na 100 000 obyvatel





# Eradication of smallpox

## Czech experts

---



A key figure in the global eradication program smallpox was **prof. MUDr. Karel Raska, MD.**, who drove in the sixties division

Communicative Diseases of the WHO Secretariat in Geneva.

He promoted the establishment of a new, independent units "Eradication of smallpox" and ensure its initial financial and material support, not only in Geneva, but also in regional offices of WHO.

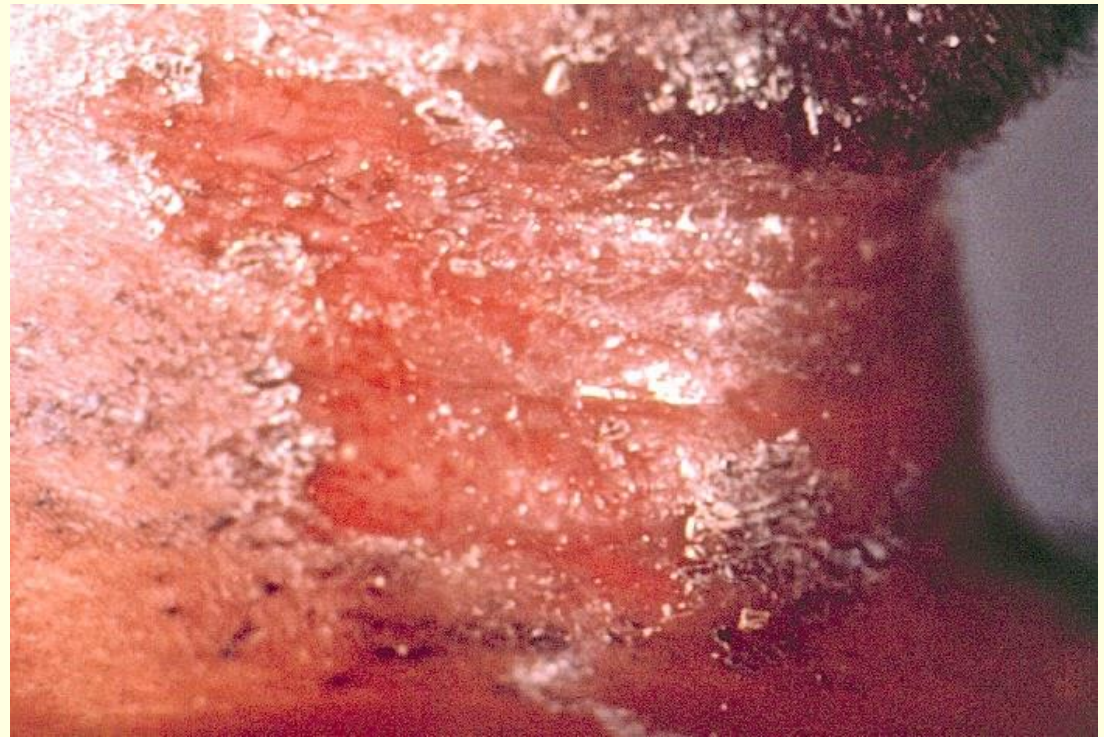
With its support of the program also attended the 20 Czechoslovak health professionals (14 Czechs and Slovaks 6), mainly epidemiologists.

They participated in both the preparation methodology and procedures, thus working directly in infested areas.

# Remembering an Old Disease

## Diphtheria:

---



# Diphtheria:

## Remembering an Old Disease

---

In 1900, diphtheria killed more people in the United States than cancer did.

Caused by the toxic bacterium *Corynebacterium diphtheriae*, this upper airway infection often results in a grayish, thick membrane that grows in the throat and obstructs breathing. Other symptoms include fever, hoarseness, and coughing.

Most diphtheria deaths resulted not from blocked airways but from the paralyzing **toxin** the bacterium secretes, which can cause the heart or other organs to fail.

During the 1990s, an average of only three diphtheria cases among U.S. residents were reported each year.

Diphtheria: Remembering an Old Disease

Diphtheria once was a major cause of illness and death among children.

---

- The U.S. recorded 206,000 cases of diphtheria in 1921, resulting in 15,520 deaths. Starting in the 1920s, diphtheria rates dropped quickly in the U.S. and other countries that began widely vaccinating.

Between 2004 and 2008, **no cases** of diphtheria were recorded in the U.S.

- However, the disease continues to play a role globally.

In 2011, 4,887 cases of diphtheria were reported worldwide to the World Health Organization (WHO), but many more cases likely go unreported.

- The case-fatality rate for diphtheria has changed very little during the last 50 years. The overall case-fatality rate for diphtheria is 5%–10%, with higher death rates (up to 20%) among persons younger than 5 and older than 40 years of age.
- Before there was treatment for diphtheria, the disease was fatal in up to half of cases.

# In the EU/EEA.

---

The reported number of cases of diphtheria remains low.

During 2009–2013, 102 cases of diphtheria were reported in the EU/EEA with 55 cases of *C. diphtheriae*. There has been an increase in the number of *C. diphtheriae* cases reported at EU level since 2011.

Latvia is the only EU Member State that reports indigenous transmission.

In a recent European study, ten European countries each screened between 968 and 8551 throat swabs from patients with upper respiratory tract infections for *C. diphtheriae* during 2007–2008.

Six toxigenic strains of *C. diphtheriae* were identified: two from symptomatic patients in Latvia and four from Lithuania (two cases, two carriers).

Among the toxigenic isolates, the Sankt Petersburg epidemic clone that caused large diphtheria outbreaks in Russia and the NIS\* countries in the 1990s was still in circulation .

Carriage rates among household contacts of a laboratory-confirmed case may be as high as 25% .

# A case of diphtheria in Spain

15 June 2015

---

The detection, management and public health response to the first case of diphtheria in Spain in nearly 30 years has highlighted challenges for preparedness against diphtheria in the European Union.

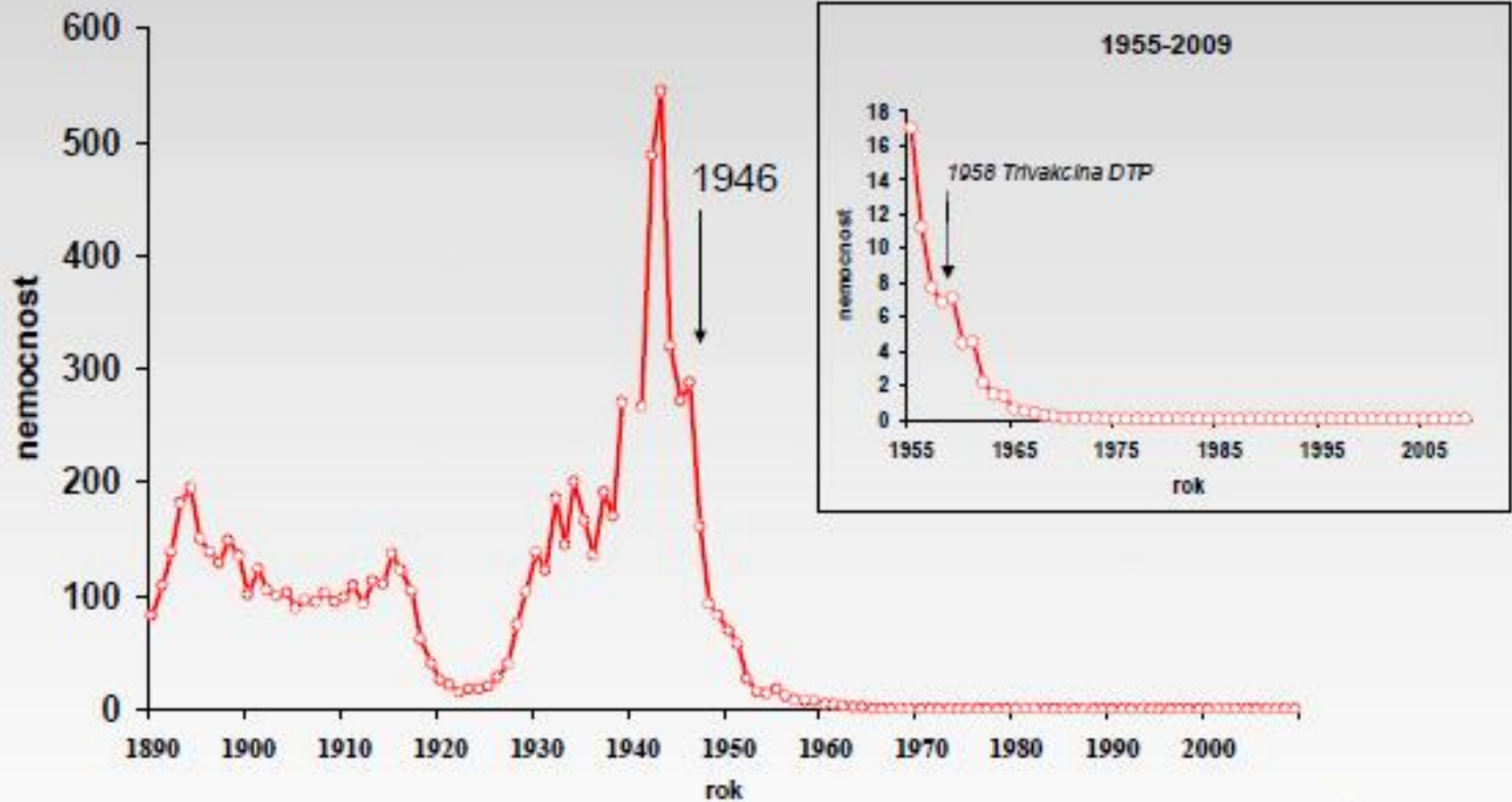
The case is a 6-year-old unvaccinated child. A case of diphtheria in an unvaccinated individual within a highly protected population is not unexpected, because vaccinated people can be asymptomatic carriers of toxigenic *C. diphtheriae*.

The challenges for diphtheria case management, preparedness and public health response experienced in Spain are shared by many EU Member States. The most urgent critical issue is the shortage of diphtheria antitoxin (DAT) for immediate use when clinicians suspect diphtheria.

DAT must be given as early as possible to be effective, often on the suspicion of diphtheria before a laboratory confirmation.

EU Member States have for a number of years reported difficulties with sourcing and maintaining adequate stockpiles of DAT for emergency use, a problem they share with many countries around the world. EU Member States have on occasion been forced to arrange emergency deliveries of DAT for patients with diphtheria.

## Záškrt, České země, 1890-2009, nemocnost na 100 000 obyvatel



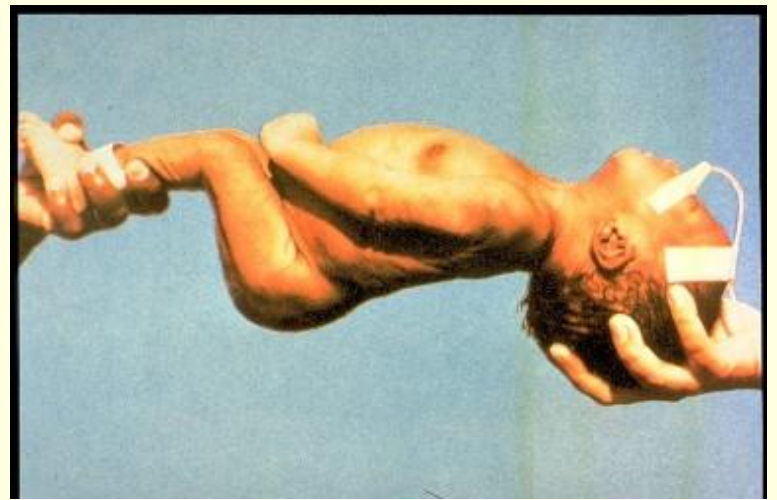
Státní zdravotní ústav



# Remembering an Old Disease

## Tetanus:

---





# TETANUS DISEASE

---

- Tetanus, commonly called lockjaw, is caused by a bacterium that is mostly present in soil, manure, and in the digestive tracts of humans and animals. Tetanus bacteria enter the body through a wound - sometimes as small as a pinprick or deep scratch but most often through a deep puncture wound or laceration such as those made by rusty nails or dirty knives. Such wounds are difficult to clean adequately and, if tetanus bacteria were present on the nail or knife, the bacteria can remain deep in the wound where they can grow and produce several toxins that attack the body's red and white blood cells and central nervous system. Tetanus bacteria do not grow well in the presence of oxygen, which is why deep puncture wounds are a perfect environment for them to grow in.

# TETANUS DISEASE

---

- The incubation period for symptoms of tetanus to begin can range from one to three weeks. The first symptoms are likely to be headache, irritability, fever, chills, and muscular stiffness of the jaw and neck. As the poison increases and spreads, the body becomes rigid and locked in spasm with head drawn back, legs and feet extended, arms stiff, hands clenched and the jaw unable to open with difficulty in swallowing. The stomach muscles also become rigid and convulsions may occur.

# TETANUS DISEASE

---

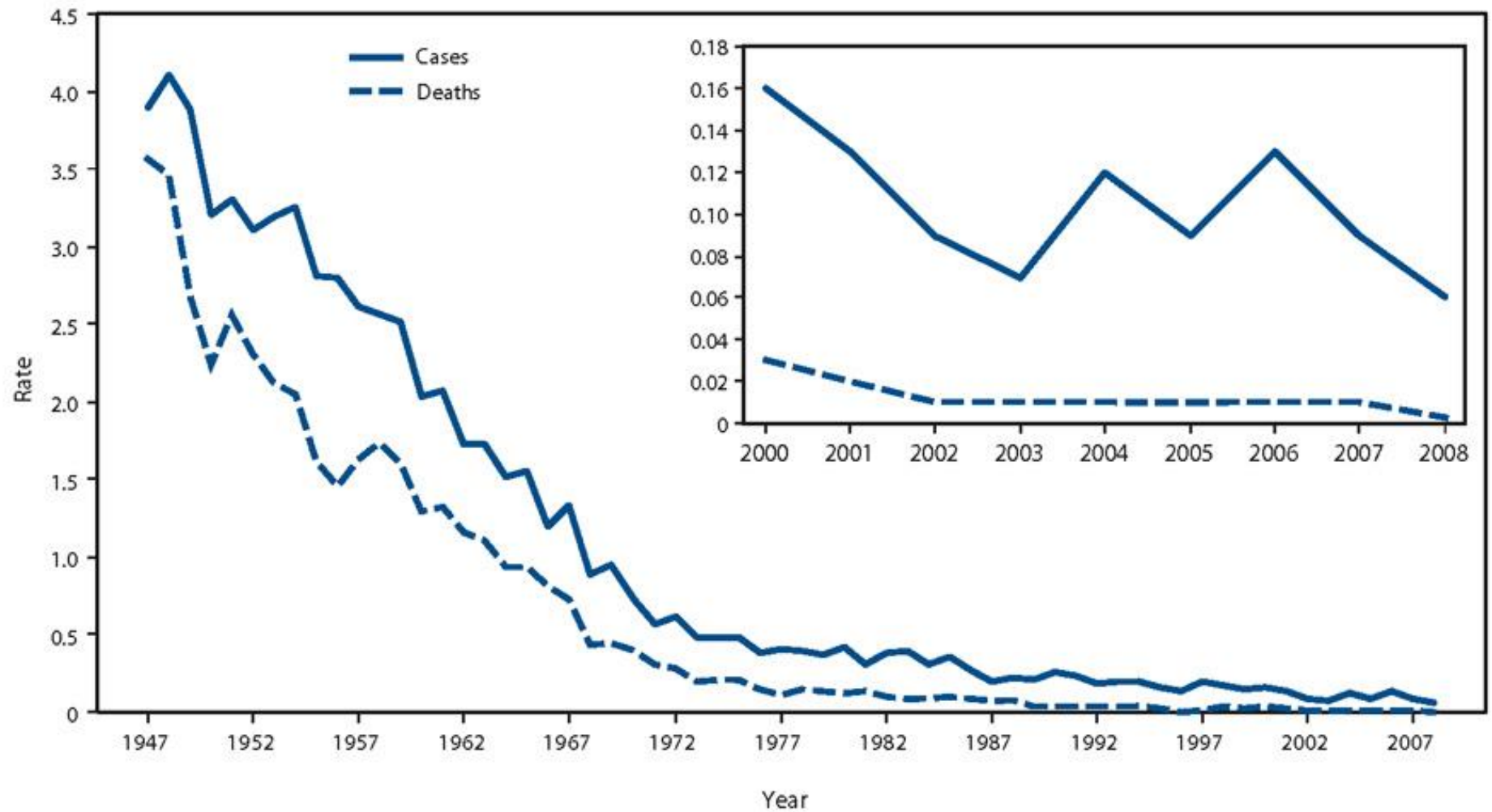
- In 1948 there were 601 cases of tetanus reported in the U.S., the highest number of cases reported in one year. In 2002 there were 25 cases of tetanus and 3 deaths reported in the U.S. Tetanus is a much more serious problem in underdeveloped countries, especially among newborn babies born in unsanitary conditions whose umbilical cords can become infected with tetanus.

# TETANUS DISEASE

---

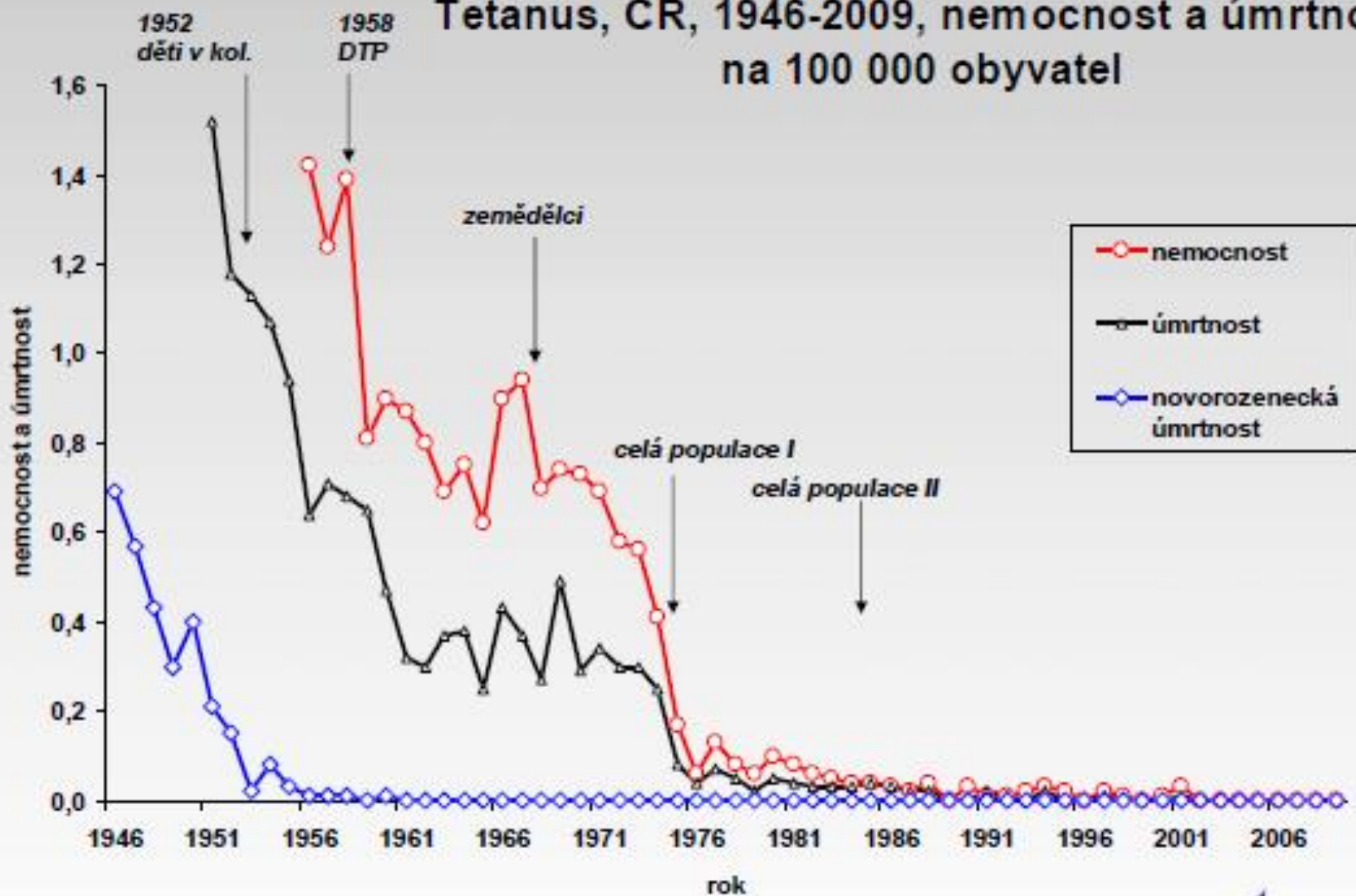
- **TETANUS VACCINE:** The most common reactions reported to occur following DT vaccine include swelling and pain at the injection site; sleepiness; irritability; vomiting; loss of appetite; persistent crying; and fever.
- Paleness, cold skin, collapse, rash, and joint pain have also been reported.
- In 1994 the Institute of Medicine concluded that there is compelling scientific evidence to conclude that tetanus, DT and Td vaccines can cause Guillain-Barre syndrome including death; brachial neuritis; and death from anaphylaxis (shock).

# Tetanus—United States, 1947-2008



\* Per 1 million population.

# Tetanus, ČR, 1946-2009, nemocnost a úmrtnost na 100 000 obyvatel



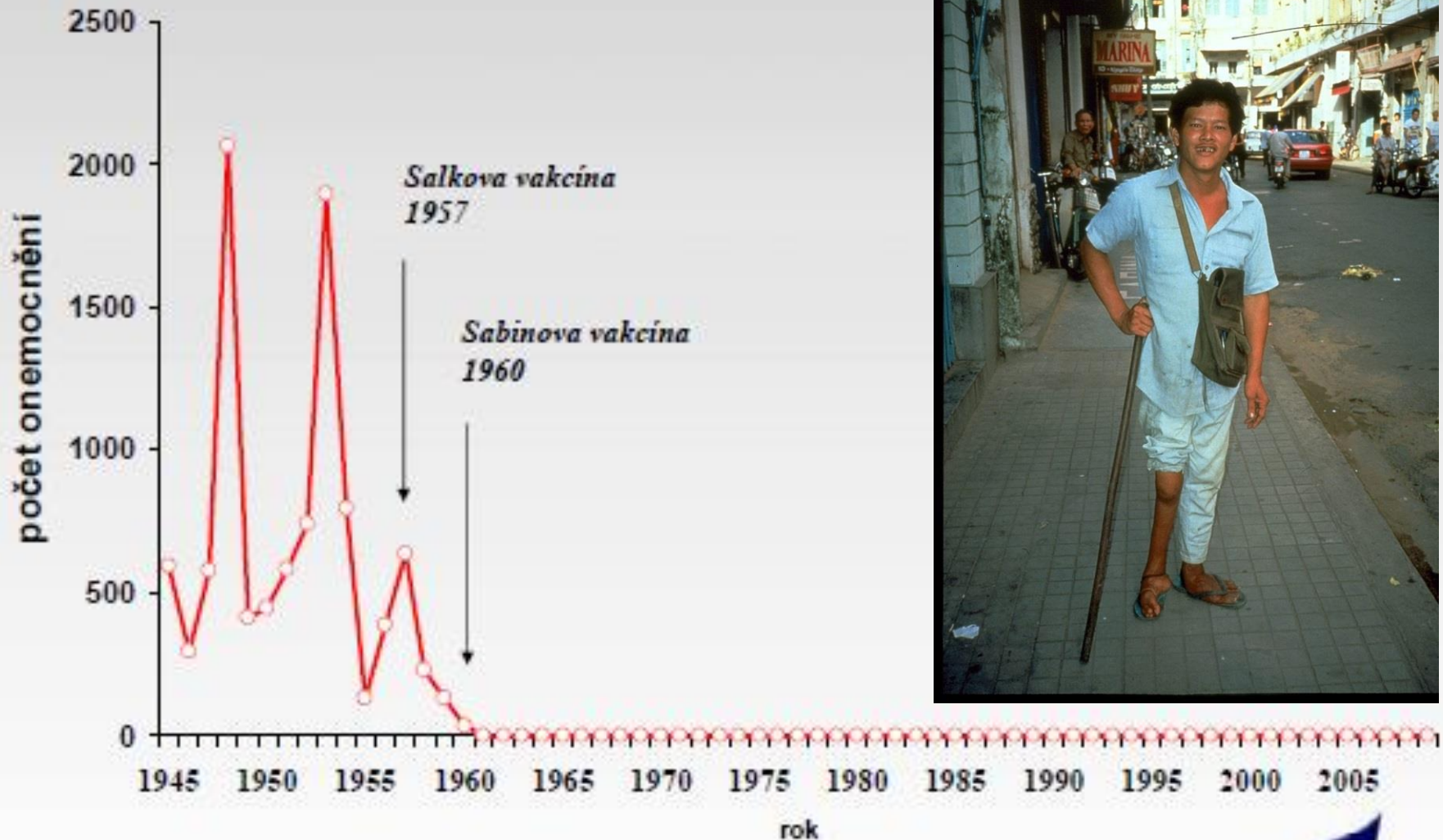
# Remembering an Old Disease

## Poliomyelitis:

---

The highly infectious poliovirus, the cause of polio, once crippled 13,000 to 20,000 people every year in the United States. In 1 out of 200 cases, this virus attacks the spinal cord, paralyzing limbs or leaving victims unable to breathe on their own. In 1954, the year before the first polio vaccine was introduced, doctors reported more than 18,000 cases of paralyzing polio in the United States. Just 3 years later, vaccination brought that figure down to about 2,500. Today, the disease has been eliminated from the Western Hemisphere, and public health officials hope to soon eradicate it from the globe. In 2001, only 537 cases of polio were reported worldwide, according to WHO.

# Polio (A80), Česká republika, hlášená onemocnění 1945-2009





# Polio eradication

In 1988, the forty-first World Health Assembly adopted a resolution for the worldwide eradication of polio, the Global Polio Eradication Initiative (GPEI). Since then, the number of cases has fallen by over 99% from an estimated 350 000 to 416 reported cases in 2013.

In 2014, only three countries in the world remained polio-endemic: Nigeria, Pakistan and Afghanistan. In 2015 to date, two countries have together reported 37 cases: Pakistan (29 cases) and Afghanistan (eight cases), all due to wild poliovirus type 1.

The last natural circulation of WPV2 was in India in 1999 and the last WPV3 case was detected in Nigeria in November 2012.

- Since then, WPV1 has been the only circulating wild type virus.

The last case of endemic paralytic polio in the WHO European Region (i.e. with the source of the infection originating in the Region) was reported in Turkey in November 1998,

and the Region was declared polio-free in June 2002.

The most recent outbreaks linked to importations into the WHO European Region occurred in 2010 in Tajikistan and in 2013–2014 in Israel where WPV1 was circulating in the environment without causing clinical cases .

~~The most recent polio outbreaks in what today constitutes EU/EEA were in the Netherlands in 1992, in a religious community opposed to vaccination,~~

and in 2001, when three polio cases were reported among Roma children in Bulgaria .

On 5 May 2014, WHO declared the international spread of wild poliovirus in 2014 a Public Health Emergency of International Concern (PHEIC) following the confirmed circulation of wild poliovirus in several countries and the documented exportation of wild poliovirus to other countries.

The Polio Eradication and Endgame Strategic Plan 2013–2018 sets out the actions required for a polio-free world by 2018 and beyond.

# Outbreak of circulating vaccine-derived poliovirus type 1 (cVDPV1) in Ukraine

2 September 2015

---

**Two cases of paralytic poliomyelitis** caused by circulating vaccine-derived poliovirus type 1 (cVDPV1) were confirmed in Ukraine on 28 August 2015.

The cases, a 4-year-old child and a 10-month-old infant, had onset of paralysis on 30 June and 7 July respectively and the positive stool samples were collected from 5–10 July 2015.

The genetic similarity between the isolates indicates active transmission of cVDPV1.

Both children are from the Zakarpatskaya oblast [region], in southwestern Ukraine, bordering Romania, Hungary, Slovakia and Poland.

Ukraine has been at high risk of vaccine-preventable diseases outbreaks for several years due to persistent low routine vaccination coverage.

# Pertussis

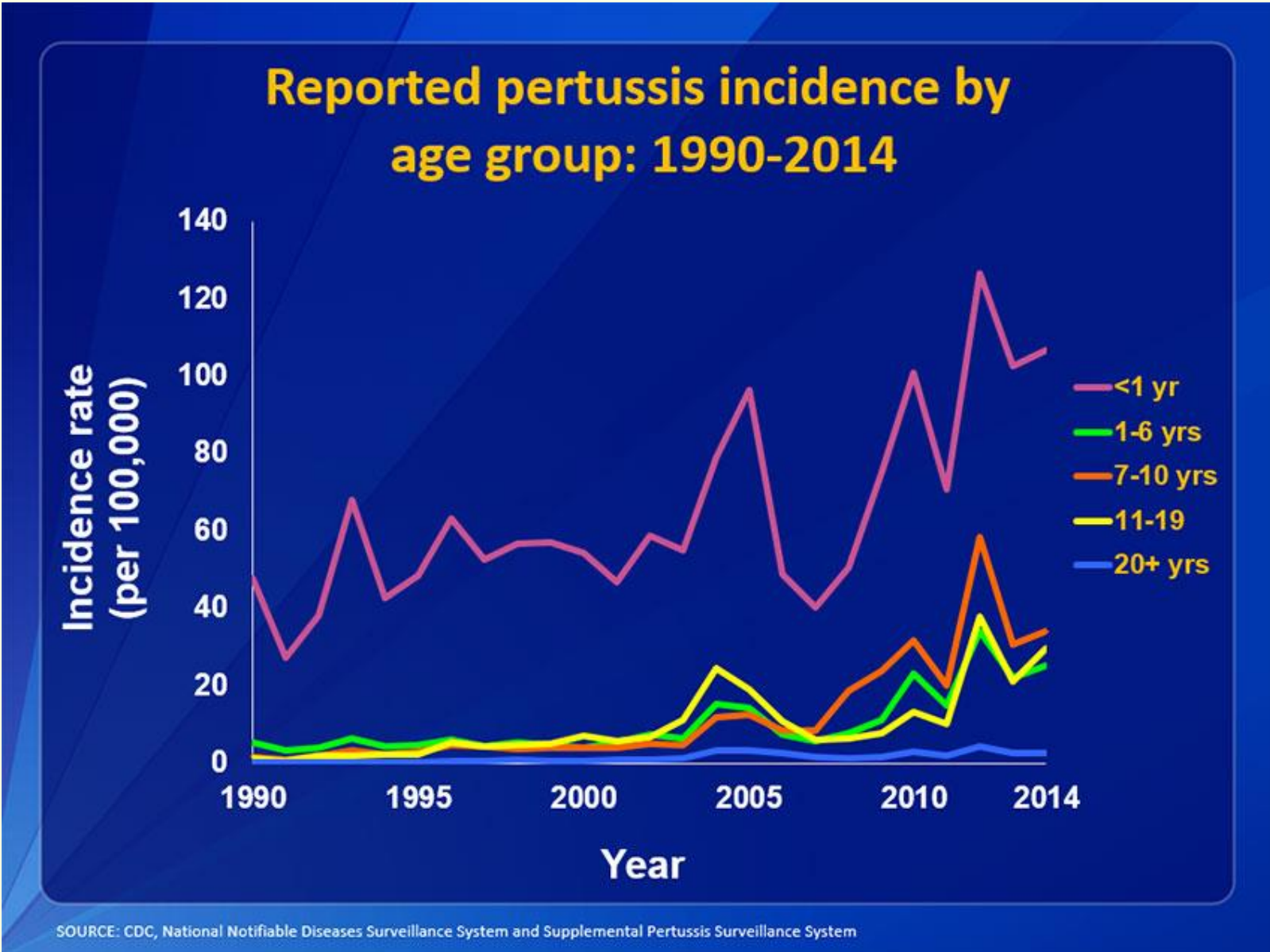
---

Pertussis is an acute bacterial infection of the respiratory tract, caused by the bacterium *Bordetella pertussis*. The disease is characterised by a severe cough, which can last two months or even longer.

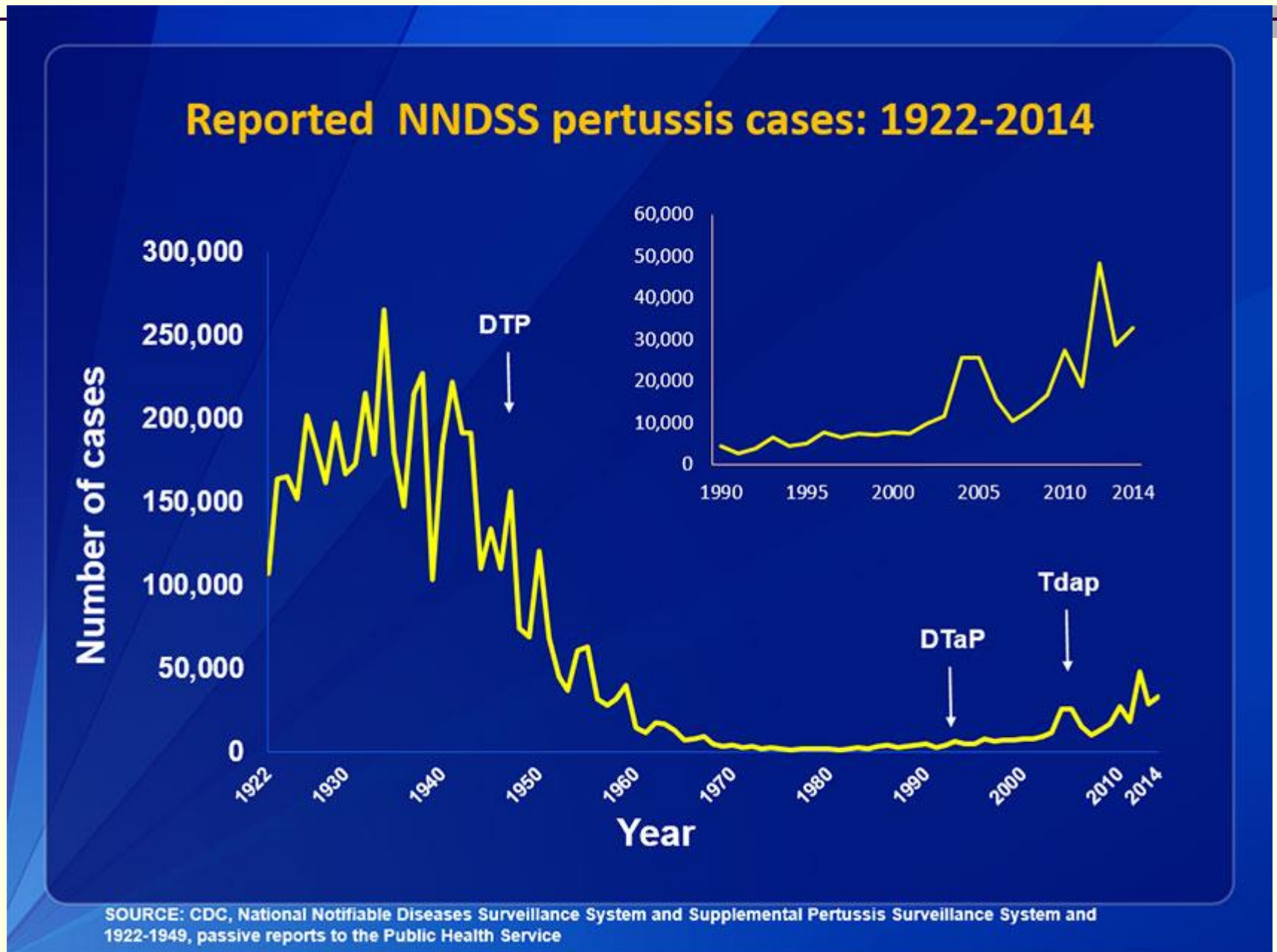
Humans are the only reservoir. Infected adults usually have only mild symptoms, but can shed bacteria for weeks. Following infection (by inhalation of droplets), susceptible individuals develop symptoms after an incubation period of about 10 days. The typical paroxysmal cough is usually seen in young children. Babies less than six months old may not cough, but they manifest dyspnea and paroxysmal asphyxia and are the most likely to die of the disease unless they receive suitable treatment.

Affected children are also exposed to complications such as pneumonia, atelectasia, weight loss, hernia, seizures, encephalopathy (probably due to hypoxia). Antibiotics may reduce the duration of the disease, especially if administered in its early stages.

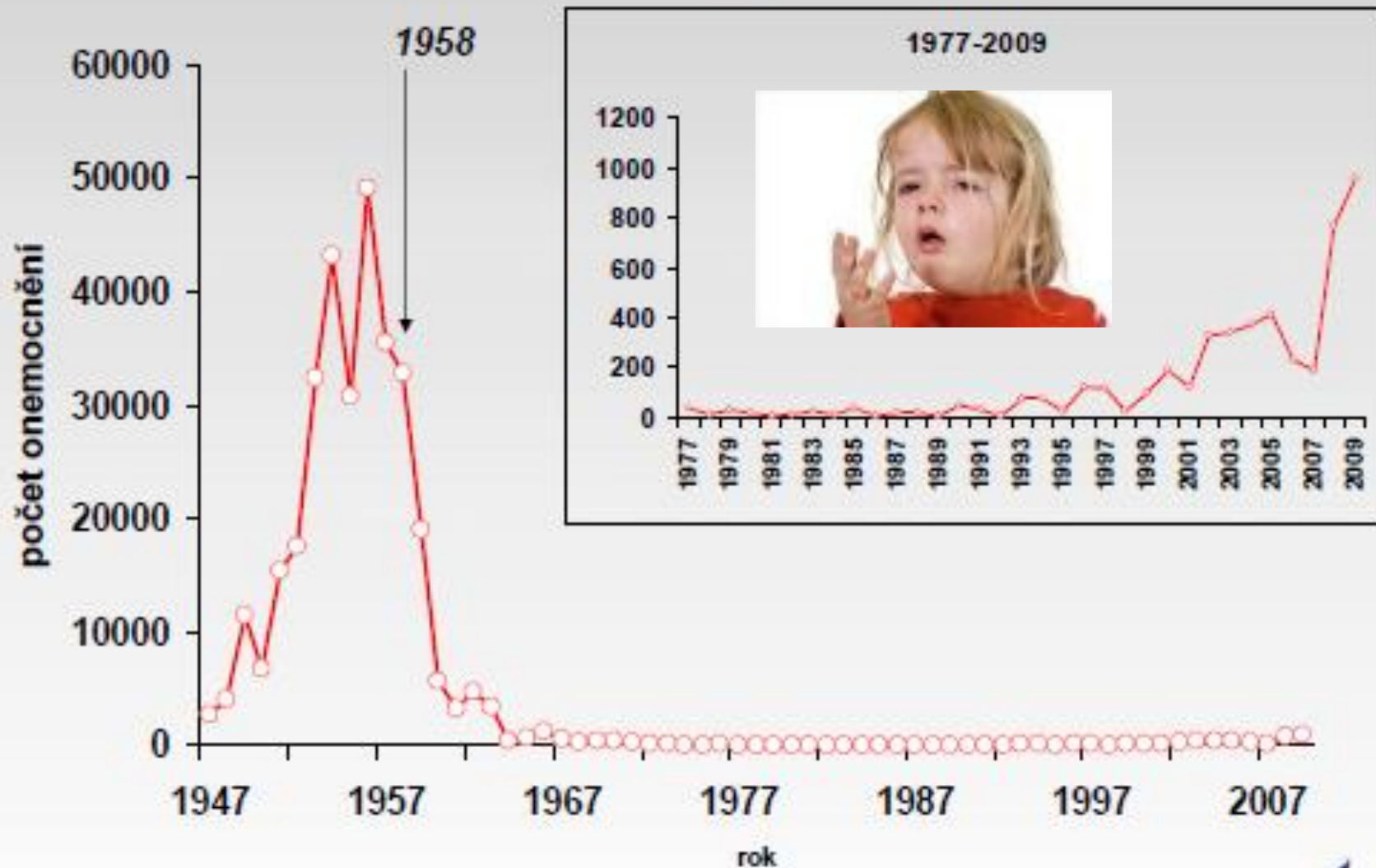
This graph shows reported pertussis incidence (per 100,000 persons) by age group in the United States from 1990–2014. Infants aged <1 year, who are at greatest risk for serious disease and death, continue to have the highest reported rate of pertussis. School-aged children 7 to 10 years continue to contribute a significant proportion of reported pertussis cases.



This graph illustrates the number of pertussis cases reported to CDC from 1922 to 2014. Following the introduction of pertussis vaccines in the 1940s when case counts frequently exceeded 100,000 cases per year, reports declined dramatically to fewer than 10,000 by 1965. During the 1980s pertussis reports began increasing gradually, and by 2014 more than 32,000 cases were reported nationwide.



# Dávivý kašel - pertuse (A37.0), Česká republika, 1947-2009



# Measles

During the 12-month period from July 2014 to June 2015, **a total of 4 224 cases** was reported by 30 EU/EEA countries. Twenty-three countries reported consistently throughout this period.

- **Germany** accounted for **58.2%** of the cases reported during this period.

In 10 of the countries reporting consistently, the measles notification rate was less than one case per million population, including six countries which reported zero cases during the 12-month period.

The diagnosis of measles was confirmed by positive laboratory results (serology, virus detection or isolation) in 63.4% of all cases.

Of all cases, 89.2% had a known vaccination status and of these, **83.8% were unvaccinated**.

In the target group for routine childhood MMR vaccination (1–4-year-old children), 76.9% of the cases were unvaccinated.

**One measles-related death was reported during the period July 2014–June 2015**, and eight cases were complicated by acute measles encephalitis.

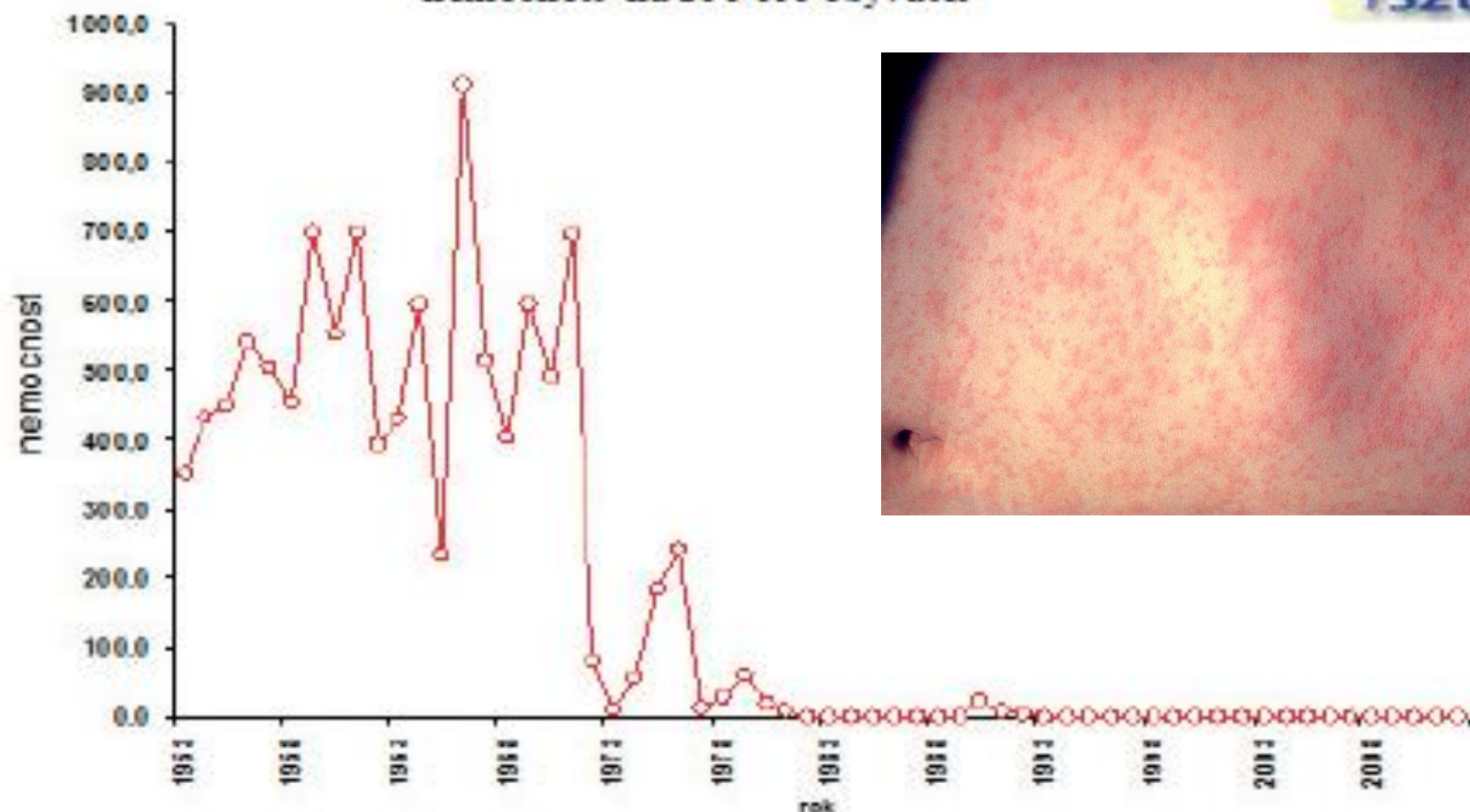
Since the previous report, outbreaks of measles have been detected in several countries in the WHO European Region: Austria, Belarus, Lithuania, Denmark, Norway, the United Kingdom, France, Sweden and Belgium.

Outside of Europe, measles outbreaks are reported from the Democratic Republic of Congo, Guinea, Sudan, South Sudan, Brazil, Australia, Mali, Algeria, Chile, Peru, Cameroon, Taiwan, Iraq and Malaysia.

## Graf č. 5 Zvládnutí spalniček očkováním

Dokud bylo očkování nepovinné, patřily spalničky mezi nejčastější příčiny smrti u dětí do 5 let. Jednalo se hlavně o navazující zápaly plic, průdušnice, mozku nebo srdečního svalu. Jedna dávka očkovací látky se ukázala jako nedostatečná, proto bylo zavedeno očkování druhou dávkou.

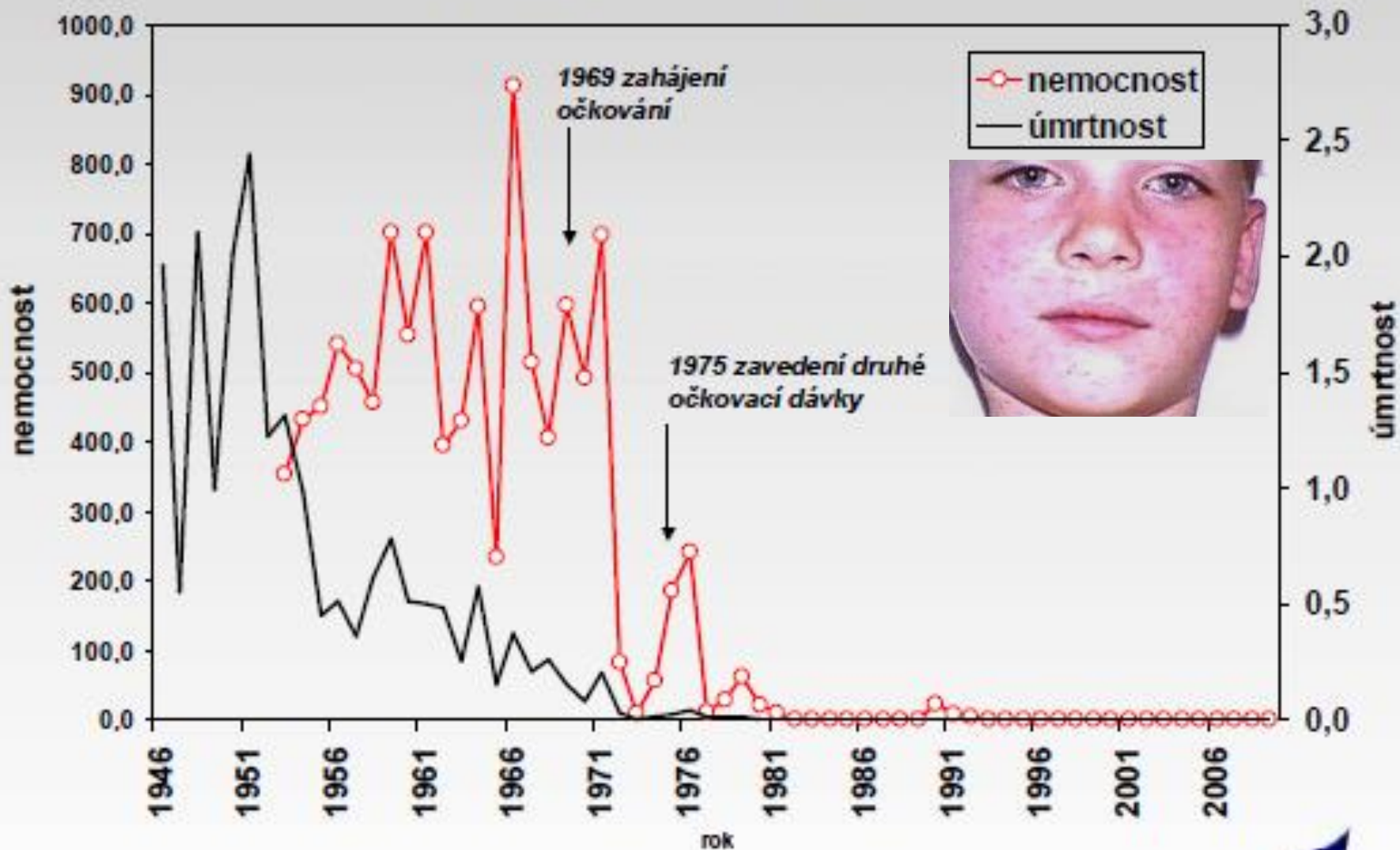
Spalničky, Česká republika, 1953-2012,  
nemocnost na 100 000 obyvatel



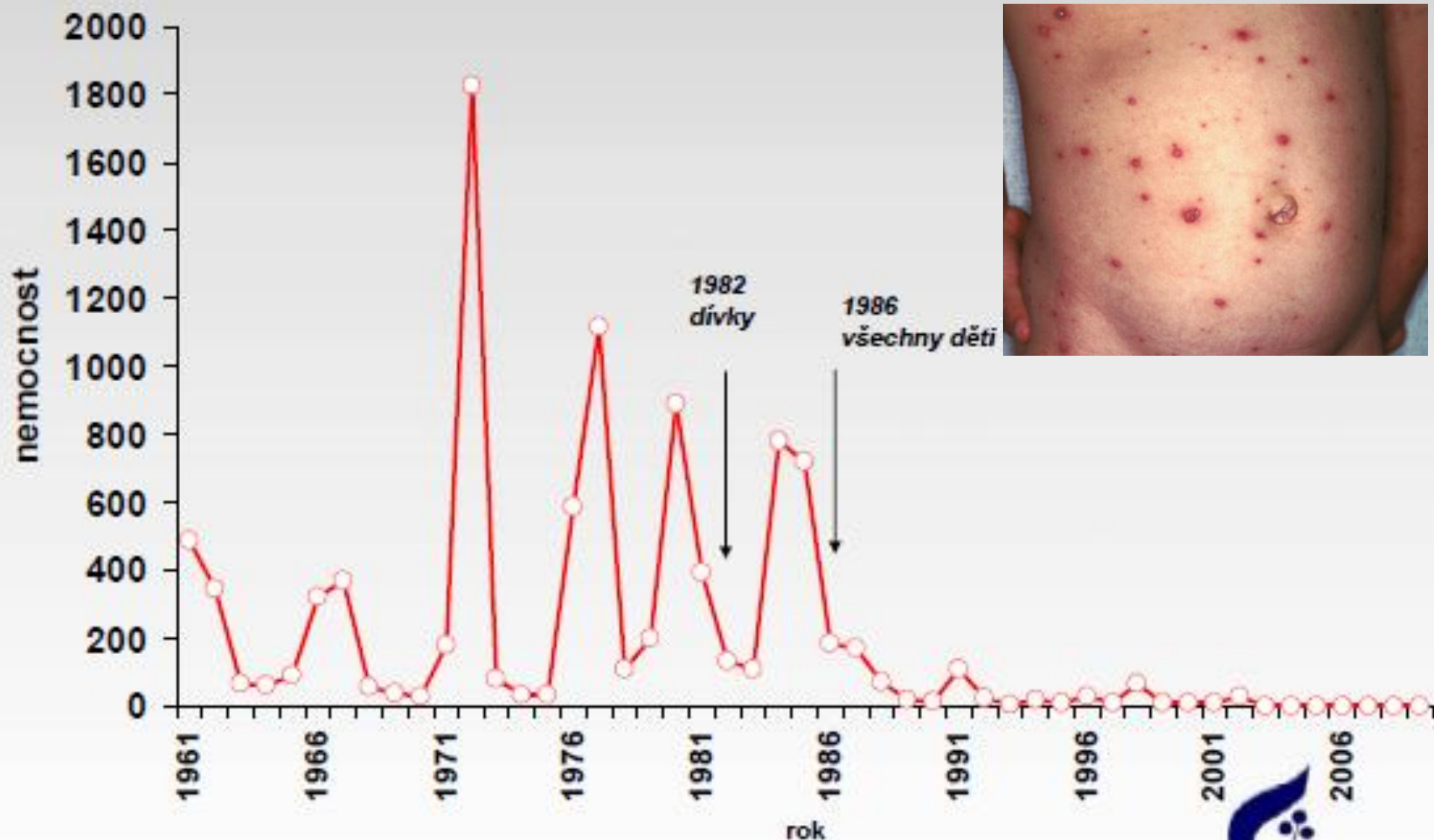
© Ministerstvo zdravotnictví České republiky 2014



# Spalničky, nemocnost a úmrtnost, ČR, 1953-2009 nemocnost a 1946-2009 úmrtnost na 100 000 obyvatel



# Zarděnky, Česká republika, 1961-2009, nemocnost na 100 000 obyvatel



# Rubella

- Twenty-eight EU/EEA countries reported a total of 2 808 rubella cases during the period July 2014 to June 2015.
- In 18 of the countries reporting consistently, the rubella notification rate was less than one case per million population, including 11 countries reporting zero cases during the 12-month period.
- **Poland** accounted for 93.9% of all reported rubella cases in the 12-month period.

The highest number of cases was observed in 5–9- and 1–4-year-olds. **28.5% of the cases were unvaccinated.**

However, this figure needs to be interpreted with caution as only 37 cases were confirmed through laboratory testing.

- No outbreaks of rubella have been detected by epidemic intelligence since the last report.

# MUMPS

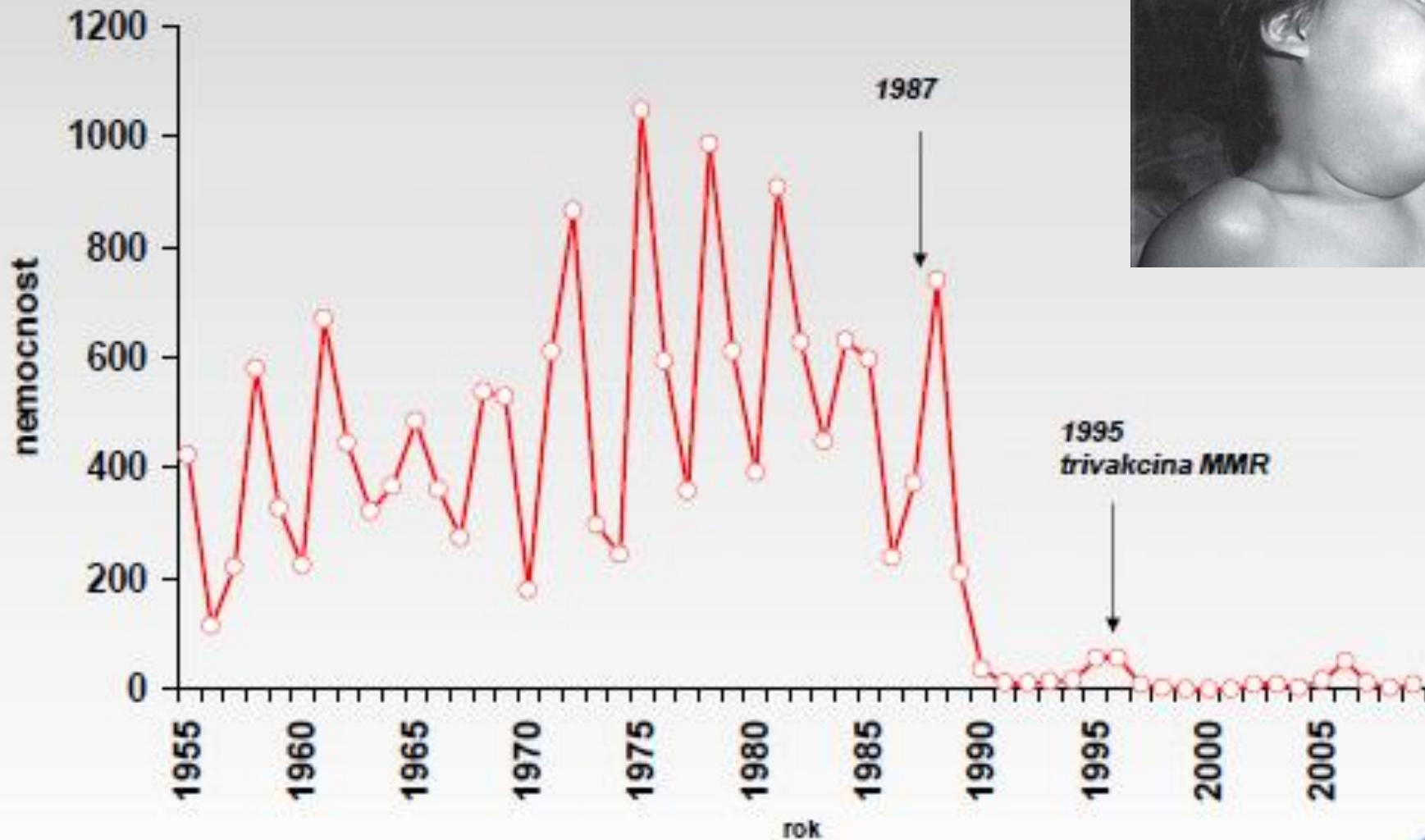
---

Mumps is an acute illness caused by the mumps virus. It is characterised by fever and swelling of one or more salivary glands (mumps is the only cause of epidemic infectious parotitis).

Humans are the only reservoirs of the virus, which is transmitted from person to person via droplets and/or saliva. Following infection, the incubation period lasts on average 16–18 days. Salivary glands apart, other organs may be involved and symptoms might include infection in the testicles (in post-pubertal males), prostate gland, thyroid gland, and pancreas. Brain involvement is frequent, but mostly without symptoms. Brain infection is believed to occur in only one in 10 000 cases, but it often leads to death.

Mumps is preventable by a vaccine, which is most often administered in association with anti-rubella and anti-measles vaccines (MMR).

# Příušnice, ČR, 1955-2009, nemocnost na 100 000 obyvatel



# ***Haemophilus influenzae* type b (Hib).**

---

Other familiar diseases that vaccines protect against include chickenpox, hepatitis A and B, and ***Haemophilus influenzae* type b (Hib)**. Hib causes meningitis, an inflammation of the fluid-filled membranes that surround the brain and spinal cord. Meningitis can be fatal, or it can cause severe disabilities such as deafness or mental retardation. This disease has nearly disappeared among babies and children in the United States since the Hib vaccine became widely used in 1989.

# Invasive Haemophilus influenzae disease

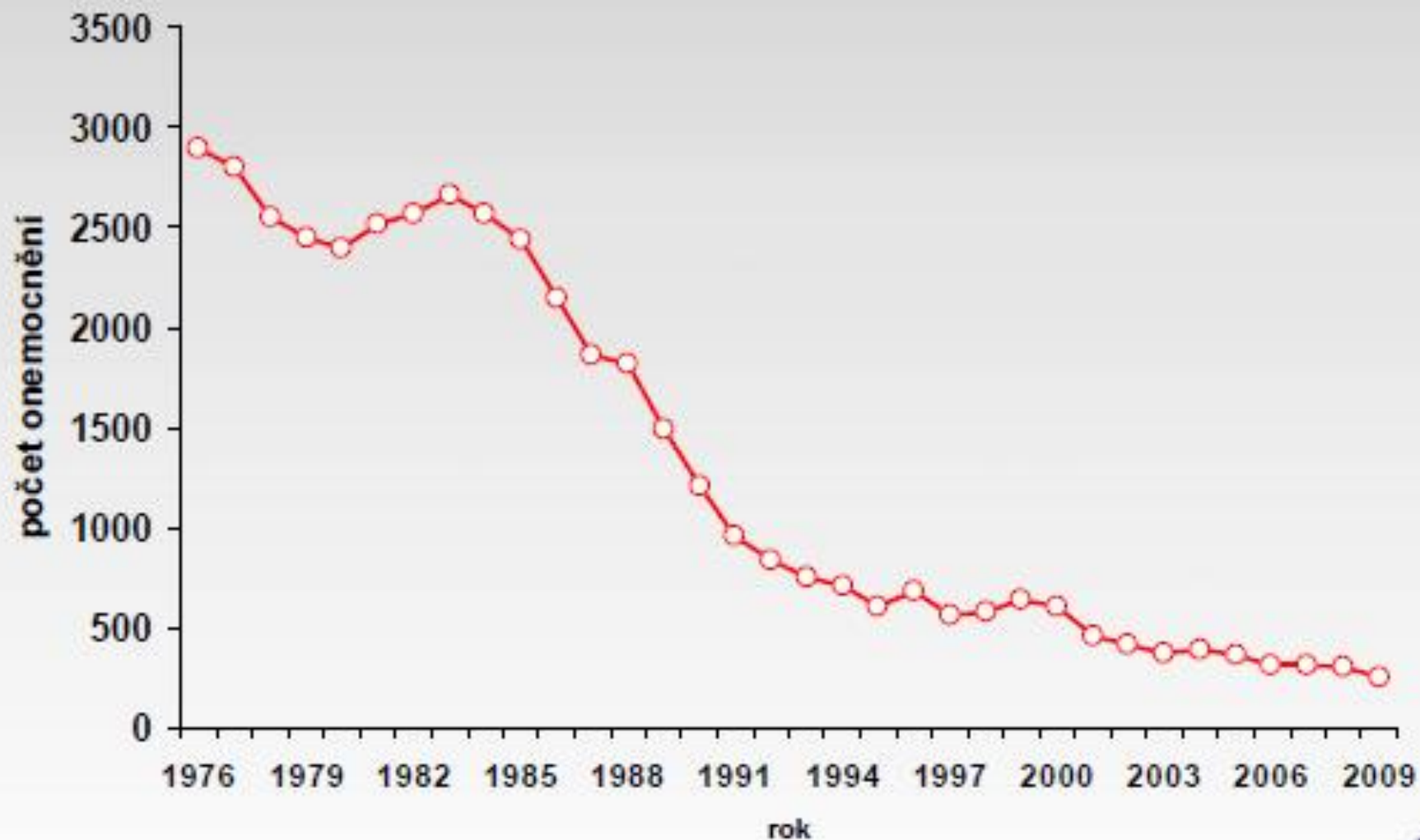
Invasive Haemophilus influenzae disease has become rare; the notification rate in Europe was 0.49 per

100 000 population, with a slightly ascending trend which may be attributed to improved surveillance in most countries.

- Country-specific rates were highest in northern Europe and in the United Kingdom; age-specific rates were highest in children under one year and adults aged 65 years or over.
- The national immunisation schedules of all EU/EEA countries include the Hib vaccine, which has led to a
  - progressive reduction of type b serotype infections.
- Even though there appears to be a trend towards an increase in disease due to non-capsulated (nontypeable) strains, European data is too scarce to draw conclusions on serotype replacement.
- Continued monitoring of strains, together with their associated clinical syndromes, is essential for assessing the effect of interventions.

**In 2012**, 2 545 confirmed cases of invasive Haemophilus influenzae disease (all serotypes) were reported by 27 countries, 24 of which have surveillance systems with national coverage. Belgium, France and Spain reported data from sentinel surveillance and therefore had to be excluded from the notification rates analysis, while no confirmed cases were reported from Malta for 2012.

## Akutní hepatitida B (B16), Česká republika, 1976-2009, počet hlášených nových onemocnění





# Vaccine-Preventable Infectious Diseases:

- ❖ Anthrax
- ❖ Bacterial meningitis
- ❖ Chickenpox
- ❖ Cholera
- ❖ Diphtheria
- ❖ Haemophilus influenzae type b
- ❖ Hepatitis A
- ❖ Hepatitis B
- ❖ Influenza
- ❖ Measles
- ❖ Mumps
- ❖ Pertussis
- ❖ Pneumococcal pneumonia
- ❖ Polio
- ❖ Rabies
- ❖ Rubella
- ❖ Tetanus
- ❖ Yellow fever

# Immunity

---

- Self vs. nonself
- Protection from infectious disease
- Usually indicated by the presence of antibody
- Very specific to a single organism

# Principles of Vaccination

---

- Protection produced by the person's own immune system
- Usually permanent
- Protection transferred from another person or animal
- Temporary protection that wanes with time

# Passive Immunisation

---

- Transfer of antibody produced by one human or other animal to another
- Temporary protection
- Transplacental most important source in infancy

# Sources of Passive Immunity

---

- Almost all blood or blood products
- Homologous pooled human antibody (immune globulin)
- Homologous human hyperimmune globulin
- Heterologous hyperimmune serum (antitoxin)

# Monoclonal Antibody

---

- Derived from a single type, or clone, of antibody-producing cells (B cells)
- Antibody is specific to a single antigen or closely related group of antigens
- Used for diagnosis and therapy of certain cancers and autoimmune and infectious diseases

# Active Immunisation

---

- A live or inactivated substance (e.g., protein, polysaccharide) capable of producing an immune response
- Protein molecules (immunoglobulin) produced by B lymphocytes to help eliminate an antigen

# Contraindications

---

## ■ Generally

- ❖ Acute illness
- ❖ Reaction after last vaccination
- ❖ Anaphylactic reactions
- ❖ Recovery time
- ❖ Incubation period of some infectious diseases
- ❖ Pregnancy
- ❖ Immunosuppression – therapy
- ❖ Hemoblastosis and other oncologic disease



# Contraindications

---

- Specific

- ❖ Depends on the types of vaccine (exempl.- allergic reaction on the some substances)

# Application

---

- Under aseptic conditions !

- ❖ i.m.
- ❖ s.c.
- ❖ intradermal (epidermis)
- ❖ p.o.
- ❖ scarification
- ❖ .....

After application - 30 min - under oversight !

# Reaction after application

---

- Fysioloical reaction

- ❖ Local

- erythema, swelling, soreness ...

- ❖ Generally

- higher temperature, fever, tiredness, hedeache,
- pain of the muscles, joints,
- Indigestion

- Alergic reaction

# Vaccination

---

- Active immunity produced by vaccine
- Immunity and immunologic memory similar to natural infection but without risk of disease

# Live Attenuated Vaccines

---

- Attenuated (weakened) form of the "wild" virus or bacterium
- Must replicate to be effective
- Immune response similar to natural infection
- Usually effective with one dose\*

# Live Attenuated Vaccines

---

- Severe reactions possible
- Interference from circulating antibody
- Fragile – must be stored and handled carefully

# Live Attenuated Vaccines

---

- Viral

measles, mumps,  
rubella, vaccinia,  
varicella, yellow fever,  
intranasal influenza,  
(oral polio)  
(rotavirus)

- Bacterial

BCG, oral typhoid

# Inactivated Vaccines

---

- Cannot replicate
- Less interference from circulating antibody than live vaccines
- Generally require 3-5 doses
- Immune response mostly humoral
- Antibody titer diminishes with time





# Inactivated Vaccines

---

- Subunit                    hepatitis B, influenza,  
  acellular pertussis,  
  (Lyme) (HPV)
- Toxoid                      diphtheria, tetanus

# Polysaccharide Vaccines

---

- pneumococcal
- meningococcal
- *Salmonella* Typhi (Vi)
  
- *Haemophilus influenzae* type b
- pneumococcal
- meningococcal

# Pure Polysaccharide Vaccines

---

- Not consistently immunogenic in children <2 years of age
- No booster response
- Antibody with less functional activity
- Immunogenicity improved by conjugation

---

# **Immunisation in Czech Republic**

# Regularly vaccination – (refunding the state)

---

- (TBC) form 2010 only by indicated group
- Diphtheria, Tetanus, Pertussis, Hemophilus influenzae B, Poliomyelitis, Viral hepatitis B (VHB),
- Morbilli, Rubeola, Parotitis epidemica
  
- Inluenza, Pneumoccus  
(for specific groups – by low )
- VHB (healths workers )

**TBC**

only - indication

**Di,Te,P(a),  
Hib, VHB,IPV**

from 13th week 3 times in 1 year (each after 1 months)  
4th dosis 6th months after 3th dosis

**MMR**

1st dosis from 15th months  
2nd dosis from 6th to 10th months after 1st dosis

**Di,Te,P(a)**

5 years

**Di,Te,P(a),IPV**

10 years

**VHB**

12 years

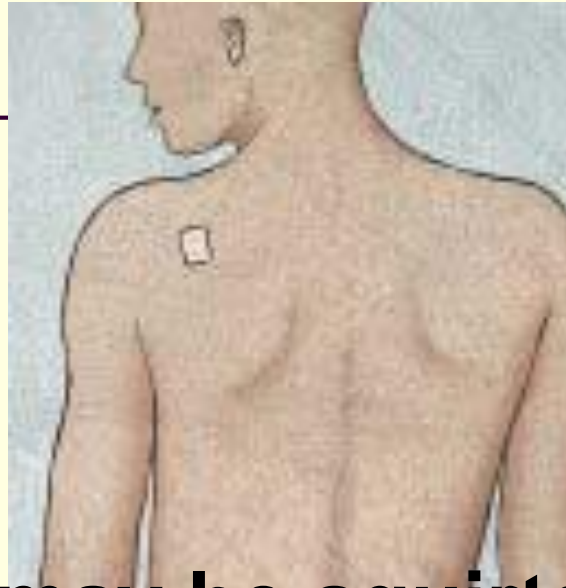
**Te**

25 years, revaccination each after 10 - 15 years

Poznámka: TBC , Di (Diphtheria), Tetanus (Te), P (Pertussis), Hib (Haemophilus influenzae b), HB (VHB),  
IPV (poliomyelitis), MMR (measles, mumps, Rubella).

<u>Illness</u>	<u>The beginning of vaccination</u>
Variolla	1919
Diphtheria	1946
TBC	1953
Tetanus	1956
Pertussis	1958
Poliomyelitis	1960
Morbilli	1969
Parotitis	1987
Rubella	1982 (12 years girls) 1986 (2 years children)
Haemophilus influenzae b	2001
VHB	2001





**Future vaccines may be squirted up the nose, worn as a patch, or eaten at the dinner table.**

