


MILESTONES
IN PUBLIC HEALTH
ACCOMPLISHMENTS IN PUBLIC HEALTH OVER THE LAST 100 YEARS




Milestones in Public Health

Vaccines and Disease Prevention Module

Saving Millions of Lives

Lectures for Public Health Education



Lecture Outline

1. Impact of Vaccines
2. History of Vaccines
3. Vaccine Science
4. Vaccine Policies and Programs
5. Barriers and Challenges
6. Looking Ahead


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Learning Objectives

- Explain the impact of vaccines and vaccine-preventable diseases
- Describe the history of vaccine development and its impact on population health
- Explain the key scientific basis for the success of vaccines
- Describe the policies, systems, and programs to implement population-based immunization

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Impact of Vaccines

Impact of Vaccines in the 20th C.

Disease	20 th Century Annual Morbidity	2005 Total	% Decrease
Smallpox	48,164	0	100
Diphtheria	175,885	0	100
Pertussis	147,271	25,616	83
Tetanus	1,314	27	98
Polio (paralytic)	16,316	1*	>99.9
Measles	503,282	66	>99.9
Mumps	152,209	314	>99
Rubella	47,745	11	>99.9
Congenital rubella	823	1	99.8
<i>Haemophilus influenzae</i> (<5 years)	20,000 (est)	226 (serotype B or unknown serotype)	99

Atkinson, W., Wolfe, S., Hamborsky, J., & McIntyre, L. (Eds.). (2009). Impact of vaccines in the 20th & 21st Centuries. In *Centers for disease control and prevention: Epidemiology and prevention of vaccine-preventable diseases* (Appendix G: Data and statistics) (11th ed.). Washington, D.C.: Public Health Foundation. Retrieved from <http://www.cdc.gov/vaccines/imz/downloads/green/diseases/impact-of-vaccines.pdf>

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Vaccine-Preventable Diseases

- Anthrax
- Cervical Cancer
- Diphtheria
- Hepatitis A
- Hepatitis B
- *Haemophilus influenzae* type b (Hib)
- Human Papillomavirus (HPV)
- Influenza (Flu)
- Japanese Encephalitis (JE)
- Lyme Disease
- Measles
- Meningococcal
- Monkeypox
- Mumps
- Pertussis (Whooping Cough)
- Pneumococcal
- Poliomyelitis (Polio)
- Rabies
- Rotavirus
- Rubella (German Measles)
- Shingles (Herpes Zoster)
- Smallpox
- Tetanus (Lockjaw)
- Tuberculosis
- Typhoid Fever
- *Varicella* (Chickenpox)
- Yellow Fever

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History of Vaccines: New Vaccines

- 1798 - Smallpox
- 1885 - Rabies
- 1897 - Plague
- 1917 - Cholera
- 1917 - Typhoid vaccine (parenteral)
- 1923 - Diphtheria
- 1926 - Pertussis
- 1927 - Tuberculosis (BCG)
- 1927 - Tetanus

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History of Vaccines: New Vaccines (Cont.)

- 1935 - Yellow Fever
- 1940s - DTP
- 1945 - Influenza
- 1963 - The first measles vaccine licensed
- 1967 - Mumps vaccine licensed
- 1969 - Rubella vaccine licensed
- 1970 - Anthrax vaccine manufactured by the Michigan Department of Public Health
- 1971 - Measles, Mumps, Rubella vaccine licensed (MMR)
- 1981 - Meningococcal polysaccharide vaccine, groups A, C, Y, W135 combined (Menomune)

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History of Vaccines: New Vaccines (Cont.)

- 1982 - Hepatitis B vaccine becomes available
- 1983 - Pneumococcal vaccine, 23 valent
- 1990 - *Haemophilus influenzae* type B (Hib) polysaccharide conjugate vaccine licensed for infants
- 1990 - Typhoid vaccine (oral)
- 1995 - Hepatitis A vaccine licensed
- 1998 - First rotavirus vaccine licensed
- 2004 - Pediarix, a vaccine that combines the DTaP, IPV, and Hep B
- 2006 - RotaTeq is a new rotavirus vaccine from Merck
- 2006 - Gardasil, the first HPV vaccine is approved

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History of Vaccines: Health Outcomes Milestones

- 1977 - Last indigenous case of smallpox (Somalia)
- 1979 - Last case of polio, caused by wild virus, acquired in the United States
- 1980 - Smallpox declared eradicated from the world
- 1999 - Rotavirus vaccine withdrawn from the market as a result of adverse events
- 2003 - Measles declared no longer endemic in the Americas
- 2005 - Rubella declared no longer endemic in the United States

Atkinson, W., Wolfe, S., Hamborsky, J., & McIntyre, L. (Eds.). (2009). Impact of vaccines in the 20th & 21st Centuries. In *Centers for disease control and prevention: Epidemiology and prevention of vaccine-preventable diseases* (Appendix G: Data and statistics) (11th ed.). Washington, D.C.: Public Health Foundation. Retrieved from <http://www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/G/impact-of-vaccines.pdf>

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History of Vaccines: Challenges and Set-backs

- 1964-1965 - 20,000 cases of Congenital Rubella Syndrome occurred during the largest rubella epidemic in the U.S.
- 1976 - Swine Flu: largest public vaccination program in the U.S. to date; halted by association with Guillain-Barré syndrome
- 1989-1991 - Major U.S. resurgence of measles (55K cases compared with low of 1,497 cases in 1983). Two-dose measles vaccine (MMR) recommended

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History of Vaccines: Challenges and Set-backs (Cont.)

- 1999 - Rotavirus vaccine withdrawn from the market as a result of adverse events
- 2001 - September 11 results in increased concern of bioterrorism. The U.S. establishes a plan to re-introduce smallpox vaccine if necessary, a vaccine thought never to be needed again
- 2007 - HIV vaccine trial fails

Atkinson, W., Wolfe, S., Hamborsky, J., & McIntyre, L. (Eds.). (2009). Impact of vaccines in the 20th & 21st Centuries. In *Centers for disease control and prevention: Epidemiology and prevention of vaccine-preventable diseases* (Appendix G: Data and statistics) (11th ed.). Washington, D.C.: Public Health Foundation. Retrieved from <http://www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/G/impact-of-vaccines.pdf>

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Vaccines and Disease Prevention Module

History of Vaccines: The Model of Smallpox

History of Vaccines: The Model of Smallpox

- Smallpox is a viral disease caused by *variola*, an orthopoxvirus
- The virus requires a human host
- Infected individuals develop a systemic disease marked by extensive vesicular skin eruptions

Centers for Disease Control and Prevention. (n.d.). *Emergency preparedness and response: Smallpox basics*. Retrieved from <http://www.emergency.cdc.gov/agent/smallpox/disease/>

Centers for Disease Control and Prevention. (n.d.). *Public health image library (PHIL): Photographs, Illustrations, Multimedia Files*. Retrieved from <http://phil.cdc.gov/phil/quicksearch.asp>

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History of Vaccines: The Model of Smallpox (Cont.)

Centers for Disease Control and Prevention. (n.d.). *Course Overview: Smallpox: Disease, Prevention, and Intervention* [PowerPoint slides]. Washington, D.C.: Public Health Foundation. Retrieved <http://emergency.cdc.gov/agent/smallpox/training/overview/>

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History of Vaccines: The Model of Smallpox (Cont.)

- Mortality rates were up to 30% or more in infected individuals
- Smallpox erupted in periodic epidemics throughout human history and was feared both for its high rate of mortality and life-long scarring of surviving individuals

Centers for Disease Control and Prevention. (n.d).
Emergency preparedness and response: Smallpox basics.
Retrieved <http://www.emergency.cdc.gov/agent/smallpox/disease>

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History of Vaccines: The Model of Smallpox (Cont.)

The eradication of smallpox in 1977 was made possible through a number of steps:

- Development of variolation in China 1000 AD
- Recognition of the *vaccinia* virus (cowpox) as a close relative of *variola*
- Immunization with *vaccinia* by Edward Jenner in 1796

Centers for Disease Control and Prevention. (n.d).
Emergency preparedness and response: Smallpox basics.
Retrieved <http://www.emergency.cdc.gov/agent/smallpox/disease>

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History of Vaccines: The Model of Smallpox (Cont.)

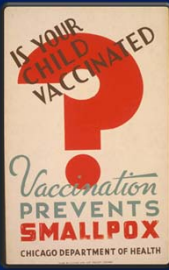
Smallpox was a particularly good candidate for eradication

- Only human hosts (no animal vector)
- Vaccinated humans develop a rapid and long lasting immune response
- The vaccine is inexpensive and easy to distribute and administer
- There is no 'sub-clinical' carrier state or infection

Centers for Disease Control and Prevention. (n.d).
Emergency preparedness and response: Smallpox basics.
Retrieved <http://www.emergency.cdc.gov/agent/smallpox/disease>

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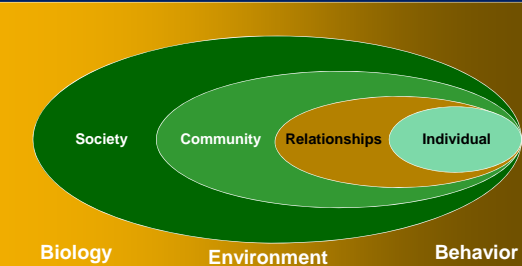
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Vaccine Science: The Ecology of Vaccine Preventable Disease

The Social-Ecological Model



Adapted from: Dahlberg LL, Krug EG. Violence a global public health problem. In: Krug E, Dahlberg LL, Mercy JA, Zwi AB, Lozano R, eds. World Report on Violence and Health. Geneva, Switzerland: World Health Organization; 2002:1-56. Retrieved from: http://www.who.int/violence_injury_prevention/publications/violence_2002.pdf

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Infectious Disease Transmission

Transmission of any infectious disease will be linked to one or more of the following factors:

- Host susceptibility
- Mechanism of spread (air, vector, fomite, etc.)
- Virulence of organism
- Host environment

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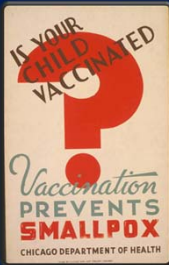
Barriers to Decreasing Disease Transmission

- Increases in host susceptibility due to changes in demographics and behavior
- Microbial adaptation and change (e.g. drug resistance)
- Emergence of new diseases
- Breakdown of public health measures
- International travel and commerce
- Changes in the environment, technology, and industry

Cohen, M. L. (2000). Changing patterns of infectious disease. *Nature*, 406(6797), 762-767. doi:10.1038/35021206

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Vaccines and Disease Prevention Module

Vaccine Science: Advancements

CHICAGO DEPARTMENT OF HEALTH

Immunology and Vaccine Development




Centers for Disease Control and Prevention. (n.d.). Public Health Image Library (PHIL): Photographs, Illustrations, Multimedia Files. Retrieved from <http://phil.cdc.gov/phil/quicksearch.asp>

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Immunologic Concepts

The human immunological systems has two major components:

- Humoral immunity
- Cellular immunity

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Humoral Immunity

- Based upon the production of antibodies by B-cells of the immune system
- All cells and organisms present antigens to the outside world. An antigen could be a protein or another complex molecule on the surface of a cell or organism
- Antibodies are small proteins that are produced to target specific antigens

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Cellular Immunity

- Based upon the presence of a variety of immunologically active cell types including:
 - Antigen processing cells (eg. macrophages)
 - T cells (for instance CD 4 helper)
- And various products of these cell types
 - Cytokines
 - Interleukins

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Development of an Immune Response to an Immunogen

After exposure to an immunogen (any substance that induces an immune response, like a vaccine):

- Primary Immune Response
 - Latent phase- usually about one week
 - Exponential phase of antibody production
 - Plateau phase of antibody production
- Secondary Immune Response (occurs upon re-exposure to the same immunogen, even many years later)
 - Usually very rapid
 - Depends on a variety of factors including the nature of the immunogen
 - Protective of the exposed host in most cases, but not all

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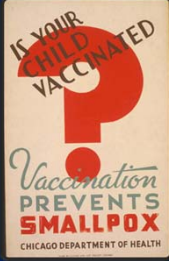
Types of Vaccines

- Live (attenuated) Vaccines
- Killed (inactivated) Vaccines
- Toxoid Vaccines

Atkinson, W., Wolfe, S., Hamboreky, J., & McIntyre, L. (Eds.). (2009). Impact of vaccines in the 20th & 21st Centuries. In *Centers for disease control and prevention: Epidemiology and prevention of vaccine-preventable diseases* (Appendix G: Data and statistics) (11th ed.). Washington, D.C.: Public Health Foundation.
Retrieved from <http://www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/G/impact-of-vaccines.pdf>

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Vaccine Policies and Programs

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History of Vaccines: Policy Milestones

- 1959 - World Health Assembly passes initial resolution calling for global smallpox eradication
- 1964 - Advisory Committee on Immunization Practices (ACIP), designed to provide CDC with recommendations on vaccine use, holds 1st mtg
- 1986 - The National Childhood Vaccine Injury Act establishes a no-fault compensation system for those injured by vaccines and requires adverse health events following specific vaccinations be reported and those injured by vaccines be compensated

<http://www.cdc.gov/vaccines/pubs/vacc-timeline.htm>

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History of Vaccines: Policy Milestones (Cont.)

- 1988 - Worldwide Polio Eradication Initiative launched, supported by WHO, UNICEF, Rotary International, CDC and others
- 1991 - Hep B vaccine recommended for all infants
- 1994 - Vaccines for Children (VFC) program established to provide access to free vaccines for eligible children at site of usual source of care
- 1995 - First harmonized childhood immunization schedule endorsed by ACIP, the American Academy of Family Physicians, and the American Academy of Pediatrics is published

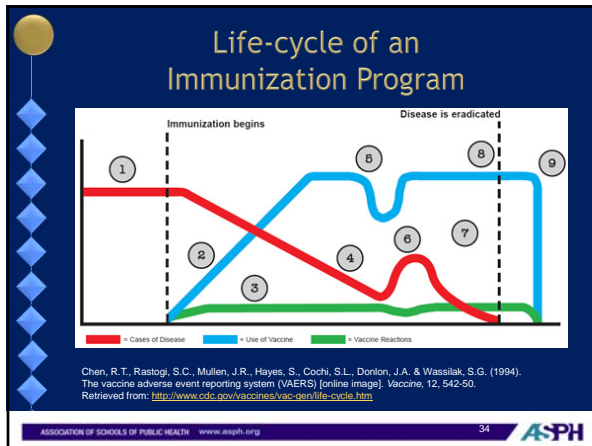
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History of Vaccines: Policy Milestones (Cont.)

- 1999 - FDA recommends removing mercury from all products, including vaccines. Efforts are begun to remove thimerosal, a mercury-based additive, from vaccines
- 2000 - Worldwide measles initiative launched; 800,000 children still die from measles annually. Measles declared no longer endemic in the United States
- 2001 - September 11 results in increased concern of bioterrorism. The United States establishes a plan to re-introduce smallpox vaccine if necessary, a vaccine thought never to be needed again

Centers for Disease Control and Prevention. (2006). Vaccines Timeline: 50 Years of Vaccine Progress. In CDC: Vaccines & Immunizations Publications. Retrieved from <http://www.cdc.gov/vaccines/pubs/vacc-timeline.htm>

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- ### Vaccine Policy and Program Development
- Problem or Threat Identification
 - Policy Setting
 - Program Development
 - Vaccine Research and Development
 - Vaccine Production
 - Vaccine Distribution and Delivery
 - Surveillance
 - Program Evaluation
- Centers for Disease Control and Prevention (2010). Vaccines and Immunizations. Retrieved from: <http://www.cdc.gov/vaccines/default.htm>
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- ### Vaccine Delivery System: National Policies & Programs
- National Vaccine Program Office
 - Inter-agency collaboration
 - Centers for Disease Control and Prevention (CDC)
 - National Immunization Program (NIP)
 - National Center for Infectious Diseases (NCID)
 - National Institutes of Health (NIH)
 - National Institute of Allergy and Infectious Diseases (NIAID)
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Guidelines

- World Health Organizations (WHO)
- U.S. Government:
 - Advisory Committee on Immunization Practices (ACIP)
 - US Preventive Services Task Force (USPSTF)
- National Organizations
 - American Academy of Pediatrics (AAP)
 - American Academy of Family Physicians (AAFP)
 - Infectious Disease Society of America

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Barriers and Challenges

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Vaccine Coverage Levels in U.S.

Vaccine	1995	2008
DTP4+	78.5	84.9
Polio3+	87.9	93.6
MMR*	87.6	91.5
Hib3+	91.7	86.7
Varicella	NA	90.6
PCV3+	NA	80.6
HepB3+	68	93.3

Centers for Disease Control and Prevention. (2010). National immunization survey Q3/2008-Q2/2009. [Excel report]. Retrieved from http://www.cdc.gov/vaccines/stats-surv/nis/tables/0800/tab02_and09_ipo.xls

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Barriers to Vaccination

- Knowledge Deficits (patients and providers)
 - Complexity of vaccination schedule
 - Parental refusal
- Poor Access to Health Care
 - Fragmented care
 - Lack of insurance
- Vaccine Shortages
- Lack of Mandatory Vaccination Policies (e.g. for school attendance)

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Challenges to Eradication of Vaccine-Preventable Diseases

- Disease Prevalence
 - Resurgence of old diseases
 - New & Virulent Strains
- Disease Transmission
 - Living Conditions
 - Global Travel
- Disparities in Access to Care and Vaccines

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Overcoming Barriers and Challenges to Vaccination

- Improve Access to Vaccines
- Push for Education and Behavior Change
- Mandate Vaccinations
- Develop Combined Vaccines

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Overcoming Barriers: Access

- Access to Primary Care and Immunization Clinics
- Financial Access/Insurance

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Overcoming Barriers: Education and Behavior Change

- Importance of Vaccinations
- Dispel Myths
- Education on Existing Policy
- Education on Disease Transmission

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Overcoming Barriers: Policy Strategies

- Access
- Mandated Vaccinations


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Overcoming Barriers: Science and Technology

- Increase Efficiency of Production and Distribution
- Decrease Frequency of Administration
 - Combined vaccines
- Increase Effectiveness
- Decrease Adverse Effects
- Improve Surveillance and Communication

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Looking Ahead

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Emerging Threats

- Old Enemies
 - Anthrax, Pandemic Flu
- New Threats
 - West Nile, SARS, Ebola

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Advances in Vaccine Research

- Developing New Delivery Systems
- Targeting New Diseases
 - Infections: HPV, HIV, SARS, Hepatitis C, West Nile, etc.
 - Cancers

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