# Principles of Communicable Diseases Epidemiology

## LECTURE - 3

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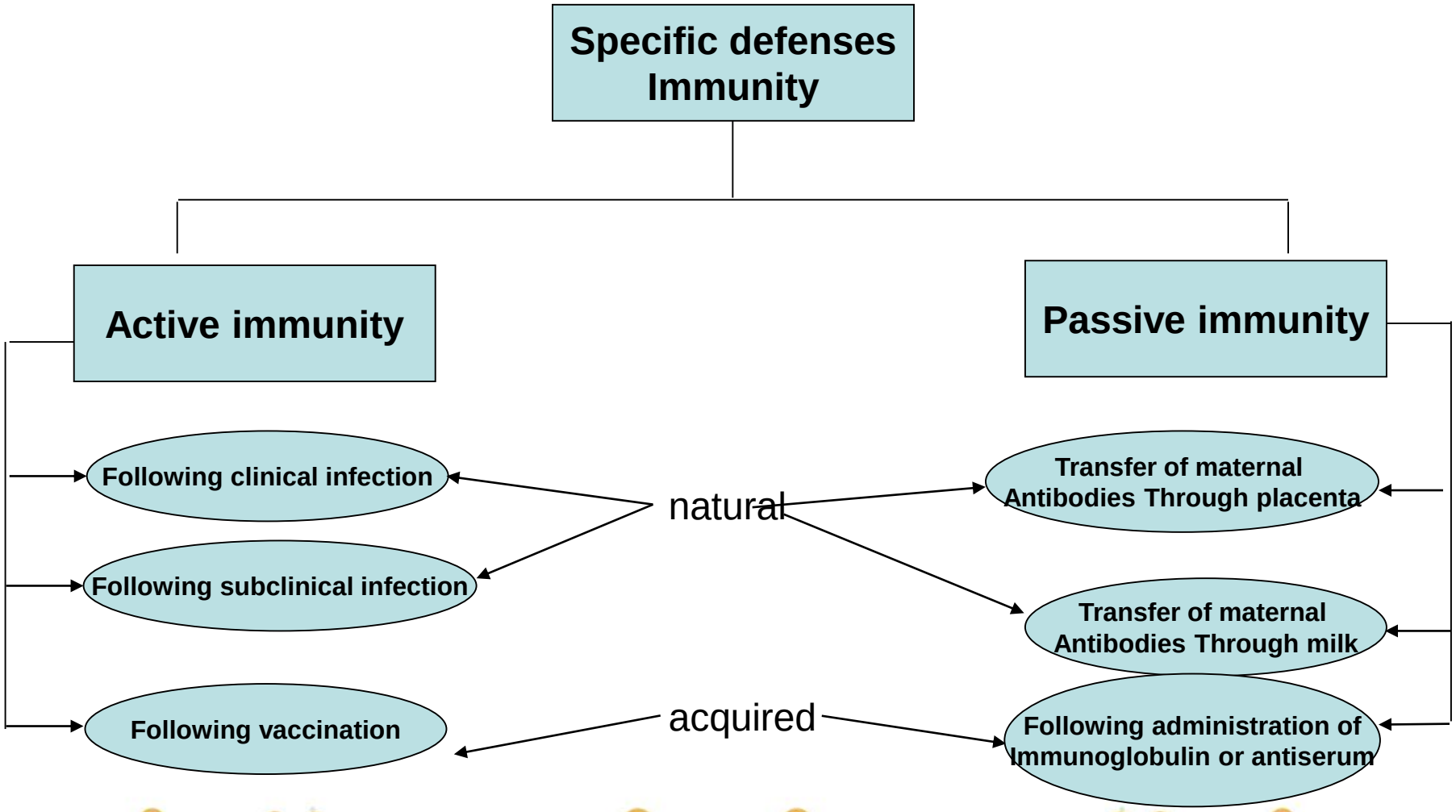

Specific defenses
Immunity
Active immunity
Passive immunity
Following clinical infection
Following subclinical infection
Following vaccination
natural
acquired
Transfer of maternal
Antibodies Through placenta
Transfer of maternal
Antibodies Through milk
Following administration of
Immunoglobulin or antiserum

# Immunization

**Each year, vaccines prevent more than 2.5 million child deaths globally. An additional 2 million child deaths could be prevented each year through immunization .**

# Why are vaccines so special?

- **Vaccines promote health:** unlike many other health interventions, they help healthy people stay healthy, removing a major obstacle to human development.

- **Vaccines have an extensive reach:** they protect individuals, communities, and entire populations.

- **Vaccines have rapid impact:** the impact of most vaccines on communities and populations is almost immediate.

For example, between 2000 and 2008, vaccination reduced global deaths from measles by 78% (from 750 000 deaths to 164 000 deaths per year

- **Immunization:** is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine. Vaccines stimulate the body's own immune system to protect the person against subsequent infection or disease.

- **Immunization procedure called vaccination and the immunizing agent called vaccine.**

# IMMUNIZING AGENTS

**The immunizing agents may be classified as vaccine, immunoglobulin and antisera.**

## Vaccines

**A vaccine is a biological preparation that improves immunity to a particular disease .**

**A vaccine typically contain an agent that resembles a disease –causing microorganism , and is often made from weakened or killed forms of the microbe or its toxins.**

**The agent stimulates the body's immune system . Vaccines can be prophylactic or therapeutic .**

# Characteristics of Effective Vaccines

- **Safety**
- **Protection**
- **Long-lasting effects**

**Cost Inexpensive to produce and deliver**

- **Administration easy to deliver with no side-effects**

**When scientists create vaccines, they consider:**

- **How the immune system responds to the germ**
- **Who needs to be vaccinated against the germ**
- **The best technology or approach to create the vaccine**

**There are several types of vaccines, including:**

- **Inactivated vaccines**
- **Live-attenuated vaccines**
- **Messenger RNA (mRNA) vaccines**
- **Subunit, recombinant, polysaccharide, and conjugate vaccines**
- **Toxoid vaccines**
- **Viral vector vaccines**

# TYPES OF VACCINES

## Live attenuated (LAV)

- Tuberculosis (BCG)
- Oral polio vaccine (OPV)
- Measles
- Rotavirus
- Yellow fever

## Inactivated (killed antigen)

- Whole-cell pertussis (wP)
- Inactivated polio virus (IPV)

## Subunit (purified antigen)

- Acellular pertussis (aP),
- *Haemophilius influenzae* type B (Hib),
- Pneumococcal (PCV-7, PCV-10, PCV-13)
- Hepatitis B (HepB)

## Toxoid (inactivated toxins)

- Tetanus toxoid (TT),
- Diphteria toxoid

# TYPES OF VACCINES

## 1-LIVE VACCINE:

**Only small pox vaccine is no more in uses at present.**


**A young Bangladeshi girl infected with smallpox (1973). Due to the development of the smallpox vaccine, the disease was officially eradicated in 1979.**

# 2- LIVE ATTENUATED VACCINE:

**a virulent vaccine, virulent pathogenic organisms can not be used as such, but so treated to become attenuated and a virulent, but remain antigenic.**

# Available live attenuated vaccines are:

**BCG** Use for prevention of TB

**OPV (oral polio vaccine)** (Sabin)

**Measles**

**MMR(measles, mumps, rubella)**

**Rubella**

# Rotavirus vaccine

**A rotavirus vaccine protects children from rotaviruses, which are the leading cause of severe diarrhea among infants and young children.**

**Rota virus vaccine is a live, oral pentavalent vaccine that contains five rotaviruses.**


**In general, live attenuated vaccines are more potent immunizing agents than killed vaccines, the reasons being :**

**(I ) live organisms multiply in the host and the resulting antigenic dose is larger than what is injected.**

**(ii) live vaccines have all the major and minor antigenic components.**

(iii) live vaccines occupy certain tissues of the body, as for example, intestinal mucosa by the oral polio vaccine.

(iv) There may be other mechanisms such as the persistence of latent virus.

**Such vaccines produce a durable immunity , but not always as long as that of natural infection.**

**Live attenuated vaccines should not be administered to persons with immune deficiency diseases or to persons whose immune response may be suppressed because of leukemia, lymphoma or malignancy or because of therapy with corticosteroids, alkylating agents, anti - metabolic agents, or radiation.**

**Pregnancy is another Contraindication.**

**When two live vaccines are required they should be given either simultaneously at different sites or with an interval of at least 3 weeks.**

**In the case of live vaccines, immunization is generally achieved with a single dose.**

**The exception is polio vaccine which needs three or more doses to be given at spaced intervals to produce effective immunity.**

# 3-INACTIVATED VACCINES (killed vaccine)

**live attenuated vaccines can not be prepared for some infectious diseases, where killed organisms are used.**

**Though inactivated (by heat& chemicals), they are antigenic and stimulate immune response.**

**TAB (ENTERICA), Pertussis, cholera, Salk (parenteral) for polio, hepatitis A and rabies vaccine.**

**They tend to provide a shorter length of protection than live vaccines, and are more likely to require boosters to create long-term immunity.**

**The only absolute contraindication to their administration is a severe local or general reaction to a previous dose.**

**Inactivated vaccines are used to protect against:**

**Hepatitis A**
**Flu (shot only)**
**Polio (shot only)**
**Rabies**

# 4-Subunit, recombinant, polysaccharide, and conjugate vaccines

**Subunit, recombinant, polysaccharide, and conjugate vaccines use specific pieces of the germ—like its protein, sugar, or capsid (a casing around the germ).**

**Because these vaccines use only specific pieces of the germ, they give a very strong immune response that's targeted to key parts of the germ. They can also be used on almost everyone who needs them, including people with weakened immune systems and long-term health problems.**

**One limitation of these vaccines is that you may need booster shots to get ongoing protection against diseases.**

**These vaccines are used to protect against:**

**Hib (Haemophilus influenzae type b) disease**
**Hepatitis B**
**HPV (Human papillomavirus)**
**Whooping cough (part of the DTaP combined vaccine)**
**Pneumococcal disease**
**Meningococcal disease**
**Shingles**

**Cellular fractions:** **prepared from extracted cellular fractions, e.g., meningococcal vaccine from polysaccharide of the cell wall, They are available for:**

**meningococcal, pneumococcal, & homophiles influenza vaccine (Hib)**
**Hepatitis B poly peptide vaccine (new).**

**Polysaccharide vaccine prevents disease, but cant prevent carrier state**

***SURFACE – ANTIGEN VACCINE (subunit)*** **: protein subunit –rather than introducing an inactivated or attenuated microorganism to immune system, a fragment of it can create an immune response.**

**Examples include the subunit vaccine against *Hepatitis B virus* that is composed of only the surface proteins of the virus ; two forms were prepared for HBV :**

***Plasma- derived hepatitis B vaccine, made of Hbs Ag, prepared from healthy Hbs Ag carriers.**

- **Yeast – recombinant hepatitis B vaccine; Hbs Ag needed to prepare the vaccine is produced by recombinant DNA in yeast cell, it is the vaccine used at present.**

- **Virus –like particle (VLP) vaccine against human papilloma virus (HPV).**

# TOXOIDS

**Some bacterial diseases are not directly caused by a bacterium itself, but by a toxin produced by the bacterium.**

**They are detoxicated exotoxins preparations which stimulate formation of humoral antitoxin immunity.**

**Diphtheria toxoids & tetanus toxoids are widely used for active immunization, each by itself or in combinations (DPT& DT) ,Pertussis toxoids ( less reaction), Cholera toxoid ;oral , against cholera exotoxin, which is the major pathogenic factor of cholera vibrios.**

# Messenger RNA vaccines—also called mRNA vaccines

**This technology was used to make some of the COVID-19 vaccines. mRNA vaccines make proteins in order to trigger an immune response. mRNA vaccines have several benefits compared to other types of vaccines, including shorter manufacturing times and, because they do not contain a live virus, no risk of causing disease in the person getting vaccinated.**

**mRNA vaccines are used to protect against:**

**COVID-19**

# Viral vector vaccines

**Some vaccines recently used for Ebola outbreaks have used viral vector technology, and a number of studies have focused on viral vector vaccines against other infectious diseases such as Zika, flu, and HIV. Scientists used this technology to make COVID-19 vaccines as well.**

**Viral vector vaccines use a modified version of a different virus as a vector to deliver protection. Several different viruses have been used as vectors, including influenza, vesicular stomatitis virus (VSV), measles virus, and adenovirus, which causes the common cold. Adenovirus is one of the viral vectors used in some COVID-19 vaccines being studied in clinical trials. Viral vector vaccines are used to protect against:**

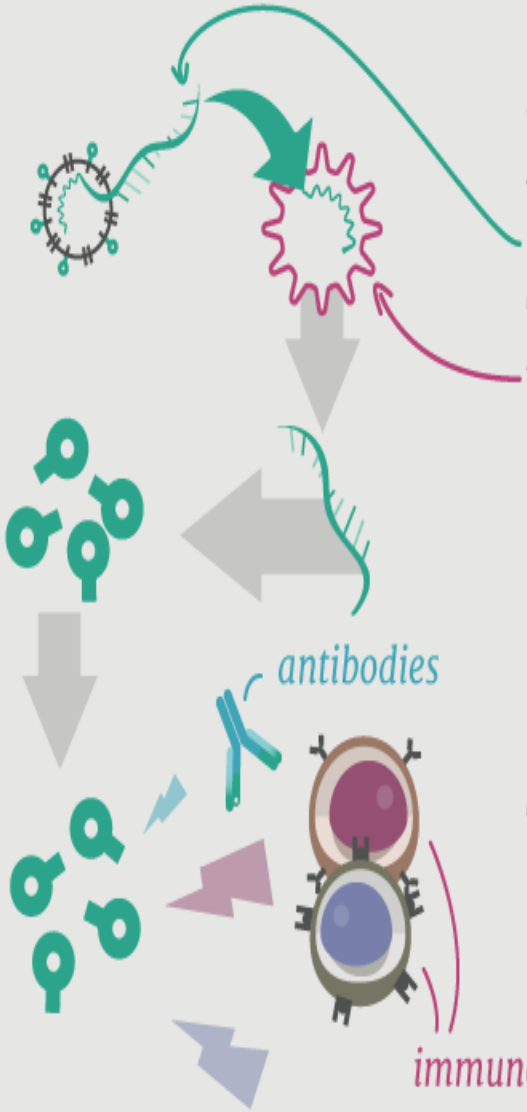
**COVID-19**

*Types of SARS-CoV-2 vaccines for COVID-19*

# Viral vector vaccines

British Society for immunology

www.immunology.org




Use an unrelated harmless virus, modified to deliver **SARS-CoV-2 genetic material**. The delivery virus is known as a **viral vector**.

Our cells use the genetic material to make a specific SARS-CoV-2 protein, which is recognised by the immune system to trigger a response.

This response builds immune memory, so your body can fight off SARS-CoV-2 in future.

## Considerations

Generate strong immune response.

May need to be stored at specific low temperatures.

## Examples in human use

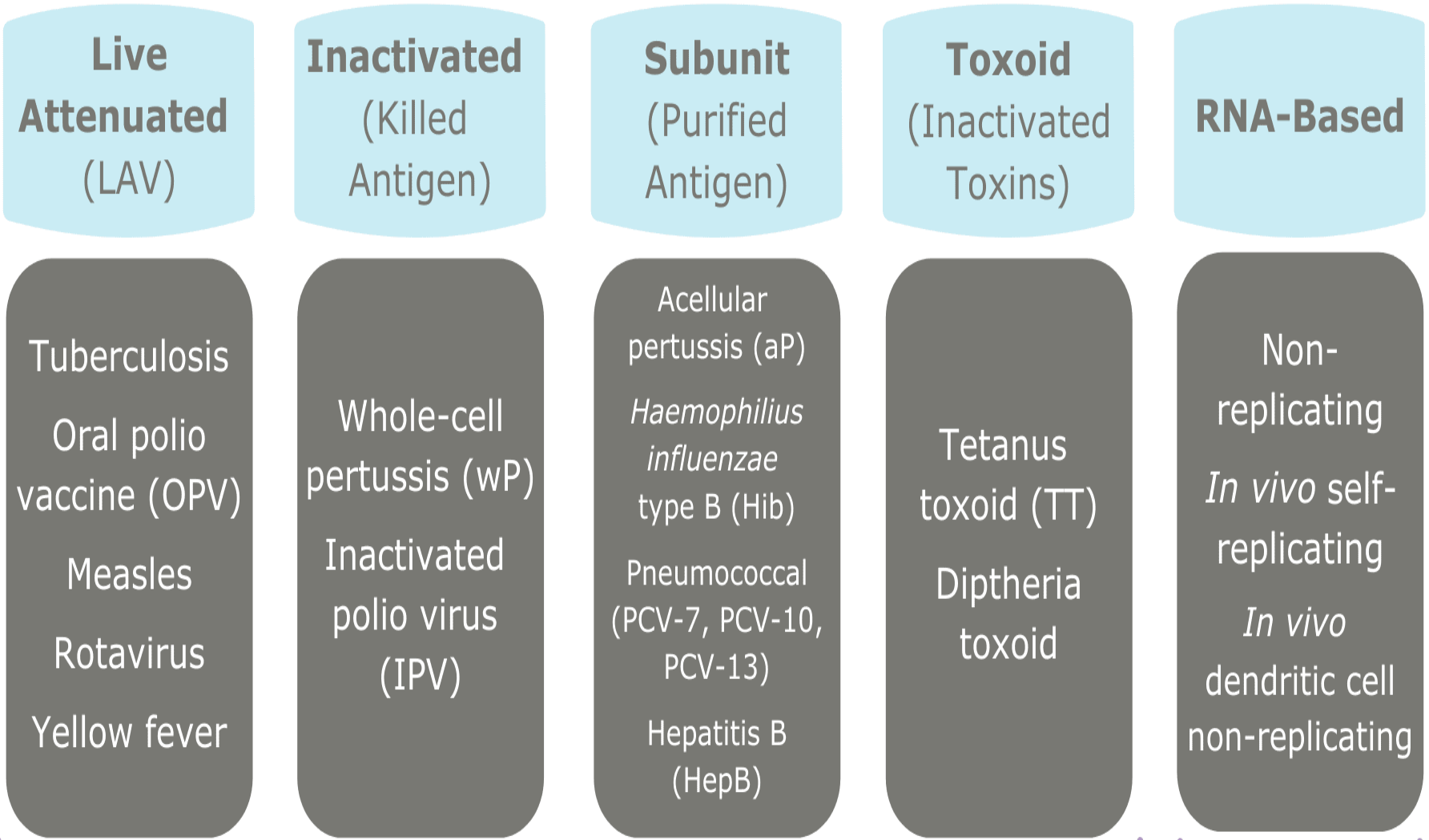
University of Oxford/AstraZeneca COVID-19 vaccine

Ebola vaccine

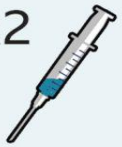
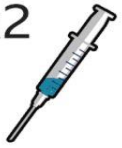
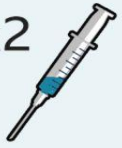
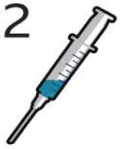
## In clinical trials for COVID-19

Jannsen, Cansino, Gamaleya

# Types of Vaccines



# How some of the Covid-19 vaccines compare

| Company | Type | Doses | How effective* | Storage | Cost per dose |
|---|---|---|---|---|---|
| **Oxford Uni-AstraZeneca** | Viral vector (genetically modified virus) | x2  | 62-90% | Regular fridge temperature | £3 ($4) |
| **Moderna** | RNA (part of virus genetic code) | x2  | 95% | -20C up to 6 months | £25 ($33) |
| **Pfizer-BioNTech** | RNA | x2  | 95% | -70C | £15 ($20) |
| **Gamaleya (Sputnik V)** | Viral vector | x2  | 92% | Regular fridge temperature (in dry form) | £7.50 ($10) |

*preliminary phase three results, not yet peer-reviewed

Source: Respective companies, WHO

# The future of vaccines

- **DNA vaccines are easy and inexpensive to make—and they produce strong, long-term immunity.**

- **Recombinant vector vaccines (platform-based vaccines) act like a natural infection, so they're especially good at teaching the immune system how to fight germs.**

# Combination Vaccines

**Combination vaccines take two or more vaccines that could be given individually and put them into one shot.**

**Combination vaccines defines as “a product whose components can be equally divided into independently available routine vaccines.”**

**What are some examples of combination vaccines?**
**DPT**
**MMR**
**DT**
**DTaP-Hib-polio**
**DTaP-hepatitis B- IPV**
**DTP-HB-Hib –IPV**

# Advantages of combination vaccines

1. Fewer injections
2. Reduced trauma to the infant
3. Higher rates of compliance with complex vaccination schedules[3,4]
4. Better vaccine coverage[5]
5. Timely vaccination – vaccination schedule completed on time[5]
6. Reduced administration costs
7. Lower storage space requirements
8. Allows incorporation of new vaccines into immunization schedules[7]

# SYSTEMS OF ACTIVE IMMUNIZATION

**Primary ( first time) immunization & booster immunization or revaccination, are to maintain protective immune level, if necessary.**

**1-Primary immunization : giving either single dose or more than one dose with proper spacing in between doses, according to nature of vaccine.**

**One- dose primary immunization stimulates formation of protective immunity either:**

- **Producing a form of innocent infection; certain viral vaccines.**
- **Forming a focus of infection, at site of inoculation, that stimulates the immune response, and continues for so long as the focus exists, BCG.**

**Single dose vaccine: MEASLES, MUMPS, RUBELLA, MMR, BCG, PLAGUE.**

**Multiple –dose primary immunization: for efficiently protective immune response, in toxoids & certain vaccines , it is necessary to fulfill :**

- **Giving a suitable NO. Of doses, usually (3), sometimes 2, and occasionally 4, according to preparation, but for rabies vaccine more doses are given.**

- **Proper spacing of doses, varies may be 4 weeks (TAB, CHOLERA), 8weeks (DPT, OPV,). Less spacing than the optimum lowers the immune response, but longer spacing would not affect the response.**

Multiple dose vaccine/ toxoids: DPT, DT, OPV, HB VACCINE, TAB, CHOLERA VACCINE.

2. Booster immunization as long as an individual or particular group is exposed to the risk of infection, it is necessary to give a booster dose after a suitable interval, to maintain a satisfactory level of immunity.

Protective period of full primary & booster immunization:

- short period of some months; cholera & plague vaccines which are protective for about 6M.
- 3- 5 years: DPT, Tetanus toxoids
- 5 or more years : BCG
- Solid, life time immunity: Measles, MMR, Mumps no booster doses are needed).

## What are the factors determining effectiveness of active immunization in prevention of a particular infectious disease in the community?

### 1-Vaccine or toxoids:

* **Protective (immunologic) value.**

* **How handled since prepared until used, including the cold chain.**

* **For organisms characterized by frequent antigenic changes – influenza vaccine must be prepared from the prevailing organisms of out break or epidemic.**

**2-Process of immunization:** requirements of primary & booster immunization, or revaccination, including doses, spacing & route of administration must be fulfilled.

## 3-Vaccination coverage:

Vaccination coverage is the percent of at risk or susceptible individuals, or population who have been fully immunized against particular diseases by vaccines or toxoids.

To be significantly effective in prevention of disease on mass or community level at least a satisfactory proportion (75% or more) of the at risk population must be immunized.

## Why an actively immunized individual may get disease when exposed to infection?

1-Causes related to the vaccine/ toxoids & process of immunization : inactivation of live attenuated vaccine used; not using updated vaccine of antigenic ally changing organisms, moderate protective value of vaccine

2- Host factors:

* Unsatisfactory or impaired immune response .

* Serum antibody level at time of immunization; the higher the level, less immune response to active immunization & vice versa.

| Age &dose | Vaccine |
|---|---|
| After birth(1st week | BCG, OPV (0 dose) , HBV-1 ( within 24hr ) |
| 2 Months<br>1st dose | ( الخماسي)[ Panta -1] (DwPT+ Hib , HBV)& Rota virus &<br>OPV-1+ Pneumococcal(PCV13-1) |
| 4Months<br>2nd dose | Panta-2 [DwPT, Hib , HBV] , IPV-1<br>Rota virus-2<br>OPV-2+ Pneumococcal<br>(PCV13-2) |
| 6Months<br>3rd dose | [D wPT, Hib , HBV] . IPV-2, OPV-3 + Pneumococcal(PCV13-3) |
| 9Months | Measles vaccine + vit A (100.000 IU) |
| 12 Months | MMR |
| 18 Months | [ DwPT +Hib] الرباعيTetra<br>MMR , OPV 1st booster , vit A ( 200.000IU ) |
| 4- 6 Years | DwPT الثلاثي<br>( 2ND booster dose), OPV, Vit A(200.000IU) |

# HAZARDS OF IMMUNIZATION

**No immune response is entirely free from the risk of adverse reactions or remote squeal.**

**The adverse reactions that may occur may be grouped under the following heads:**

1. **Reactions inherent to inoculation**
2. **Reactions due to faulty techniques**
3. **Reactions due to hypersensitivity**
4. **Neurological involvement**
5. **Inflammatory reactions**
6. **Others**

# Ways of achieving satisfactory immunization coverage

- ✓ **Efficient immunization service; urban and rural**
- ✓ **Health awareness and cooperation of the public**
- ✓ **Periodic mass immunization campaigns, to cover those who missed regular immunizations**
- ✓ **Outreach programs in rural and migrant areas, and home visits**

# Application of active immunization

- **Infants and children expanded immunization program (schedule)**
- **Active immunization for adult females(**MMR vaccine is given in adolescence girls, Tetanus toxoid in pregnancy
- **Vaccination for special occupations**
- **Vaccination for special life styles**
- **Vaccination for special environmental situations**

**All should receive hepatitis B vaccine**

- **Vaccinations for special health status persons**
- **Vaccinations in travel**
- **Vaccines against bioterrorism : Anthrax**

**Small pox**
**plague**

## ❑Vaccination for special occupations

- **Health care workers:** hepatitis B, influenza, MMR, polio
- **Public safety personnel** (police, fire fighters) **and staff of institutions for the developmentally disabled:** hepatitis B, influenza
- **Vets and animal handlers:** rabies, plague and anthrax
- **Sewage workers:** DT, hepatitis A, polio, TAB
- **Food handlers:** TAB
- **Military troops and camp dwellers:** pneumococcal, meningococcal, influenza, BCG (for non reactors), tetanus.

## ❑ Vaccinations for special health status persons.

- **Immuno-compromised persons ( Leukemia, lymphoma, HIV, malignancy…)**
- **Hemodialysis and transplantation should receive the following vaccines according to their situation:**
- **HBV, Influenza, Pneumococcal vaccines**

## ❑ Vaccinations in travel:

**Haj for instance necessities meningococcal vaccination from all over the world , TAB, YF from places like south Africa, and cholera from places like India.**