IMMUNIZATION AND VACCINES

ABSTRACT

Immunization is a critical public health initiative in India aimed at protecting children and adults from life-threatening infectious diseases. It is one of the most effective & cost-efficient way to prevent illness, disability, and death caused by microbes. The Indian government, in collaboration with global health organizations, has implemented various immunization programs to reduce mortality and morbidity rates associated with vaccine-preventable diseases. This chapter explores the principles of immunization, the types of vaccines, and their role in preventing diseases such as measles, polio, influenza, and COVID-19.

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I. INTRODUCTION

Vaccination and immunization are two of the most revolutionary subjects in medicine, which have saved millions of lives from the ravaging forces of infectious diseases worldwide. Vaccination works in such a manner to stimulate the immune system and make it recognize certain pathogens for the long run to fight off diseases which, at one point in human history, used to kill millions. This preventive approach gives immunity not only to people directly but also to other surrounding populations through herd immunity; widespread immunization might shield vulnerable populations, such as infants or immune-compromised patients who could not get vaccinated. It had its rise in the late 18th century with the discovery of a vaccination against smallpox by English physician *Edward Jenner*; this launch marked a milestone for modern methods of vaccination. In due course of time, vaccines were also developed against contagious diseases like poliomyelitis, diphtheria, tetanus, influenza, and so on. With that, the success of being immunized has wiped out Acute Smallpox everywhere, and other diseases caused by viruses, like measles and German measles, happen very rarely nowadays. Despite these achievements, several challenges remain in the efforts to immunize people. Vaccine hesitancy, misinformation, and unequal access to vaccines are just some of the big barriers that get in the way of global health goals. The emergence of new pathogens, such as the COVID-19 virus, has also underlined the need for continuous innovation in vaccine development. [1] [2] [3]

II. IMPORTANT TERMS

Immunization: The process of making an individual resistant to disease, usually through vaccination.

Vaccine: A pharmacological compound that boosts host immunity to a particular infection.

Vaccination: The administration of vaccines into host for boosting immunity against disease. Vaccines are administered via intramuscularly by injection, oral consumption, or by nasal spray.

Vaccine: The word "vaccine," adapted from the Latin word vacca, meaning "cow," is derived from the discovery by Edward Jenner of Variolae vaccinae or cowpox, a disease used to protect against smallpox. A vaccine is a biological preparation that, upon introduction to the body, elicits an immune response to protect the body from specific diseases. It consists of inactivated, weakened, or

parts of a pathogen, like its toxins or surface proteins, which mimic the disease-causing agent. By doing so, the vaccine induces the immune system to manufacture antibodies and/or mount cellular immunity against the infection.

Vaccination plays a critical role in reducing the burden of infectious diseases across the globe. According to the estimates by the WHO, 3.5 to 5 million deaths are prevented each year from infectious diseases because of immunization. It also creates herd immunity and hence reduces the spread among a population and protects persons unable to be medically vaccinated due to various health conditions.

III. HISTORICAL BACKGROUND

Edward Jenner is credited to developing the first vaccine in 1796. he inoculated a 13-year-old boy with the virus that causes cowpox and demonstrated that he was then immune to smallpox. The first vaccine against smallpox was developed based on that idea in 1798. Over succeeding centuries, and up until today, vaccine technology has improved, and vaccines for many diseases have been created. Because of immunization, smallpox was eradicated worldwide in 1979. [4,5]

- In 1800, Louis Pasteur developed the first vaccine in the laboratory for fowl cholera in chickens.
- In 1894, Dr. A.W. Williams isolated a diphtheriae strain that is crucial for the development of an antitoxin for the disease.
- In 1937, Max Theiler, Hugh Smith, and Eugen Haagen build a vaccine against yellow fever.
- In 1939, Pearl Kendrick and Grace Eldering revealed the efficiency of the pertussis vaccine.
- The Salk polio vaccine was developed by Jonas Salk.
- The Sabin polio vaccine was discovered by Albert Sabin.
- In 2006, the First vaccine for *Human Papillomavirus* (HPV) is approved.
- In December 2020, the initial doses of the COVID-19 vaccine were administered. [6]

Albert Bruce Sabin

Jonas Salk

IV. PRINCIPLE OF IMMUNIZATION

Immunization refers to any active or passive interventions intended to provide immunological protection. In order to provide temporary protection from an infectious pathogen or toxin, passive immunization entails administering exogenous immunologically active substances (antibodies derived from immune individuals). Active immunization refers to the induction of immune responses by administration of a specific antigen. Despite a decline in passive immunization strategies in the latter part of the 20th century, interest in passive immunization has increased due to the development and growing stability of monoclonal antibody technology. [7]

Types of Vaccines

The different types of vaccines are –
1. Live attenuated microbe
2. Killed microbe (Inactivated)
3. Microbial extract
4. Toxoids
5. Conjugates

Live, Attenuated Microbial Vaccine: In this type of vaccines, living microbes are attenuated to preclude clinical manifestations of infection. It provides more robust long immunity than killed vaccines. These vaccines should not be administered in immune suppressive individuals. E.g. BCG, MMR Vaccines etc.

Inactivated (killed) Vaccine: Killed vaccines are made by inactivating or killing pathogen either by heat or chemicals. Killed vaccines have advantages

over live attenuated vaccine in that they don't pose risk of infection associated with vaccine. It provides weak or short-lived immunity. Killed vaccines are usually given through the subcutaneous or intramuscular route.E.g. Pertussis vaccine, Typhoid vaccine etc.

Microbial Extract: Microbial extract includes proteins, polysaccharides located on microbial surface. These components extracted or prepared by using recombinant DNA technologies. It provides immunity against majority of infections. Uro-vaxom is an example of a microbial extract vaccine that contains immune inducing components from 18 strains of E. coli.

Toxoid Vaccine: Toxoids vaccines are derivatives of microbial endotoxins. Sometoxins are used in preparation of vaccines after inactivation. They are highly efficacious and safe immunizing agents. Toxoid Vaccine are effective when microbial pathogenicity results from secreted toxins. These vaccines administered via intramuscularly & subcutaneous routes. E.g. DT (Diphtheria toxoid), TT (Tetanus toxoid) vaccines

Vaccine Conjugates: A conjugate vaccine is a type of vaccine that involves linking or "conjugating" a weak antigen (often a polysaccharide) to a stronger, more immunogenic protein. This combination enhances the immune response, especially in infants and young children, who may have an immature immune system. Conjugate vaccines are particularly useful for preventing infections caused by bacteria with a polysaccharide capsule that otherwise might not trigger a strong immune response on their own. [4,8]

Concept of Vaccine Conjugates: The most common and typical defense against the immune system for some bacteria is their carbohydrate part, usually polysaccharides, which are long chains of sugar molecules on their surfaces. These molecules can be recognized by the immune system, but they do not cause any substantial immune response in a small child because their immature immune system is not able to reacting against such complex carbohydrates.

In a conjugate vaccine, the bacterial polysaccharide is chemically linked-or conjugated-to a carrier protein, such as tetanus toxoid or diphtheria toxoid. This protein component of the vaccine is highly immunogenic that tends to stimulate a strong immune response-and thus overcomes the limitations of the polysaccharide alone. Once administered, the immune system is able to recognize both the polysaccharide and the carrier protein, resulting in the production of antibodies that are effective against the pathogen.

Active Immunization: The process involves the stimulation of body defense mechanisms to produce antibodies against an infectious agent. The technique involves administering part of it or an inactivated form of the pathogen into the body. The body's immune system then responds by making antibodies and memory cells; most of them stay in the body to protect against infection. Active immunization is frequently long-lasting and can be rapidly reactivated by revaccination.E.g. Vaccines for measles, mumps, rubella (MMR), and influenza.

Passive Immunization: Passive immunization offers short-term but effective protection against a pathogen. The duration of immunity induced is short, extending around 1-3 weeks. It involves administration of antibodies instead of producing them in their own immune system. Passive immunization widely used during the 1920s and 1930s against human pathogens like *Streptococcus pneumoniae*, *Neisseria meningitides*, and *Haemophilus influenzae*, along with *tetanus* and *diphtheria* bacteria. [9,7]

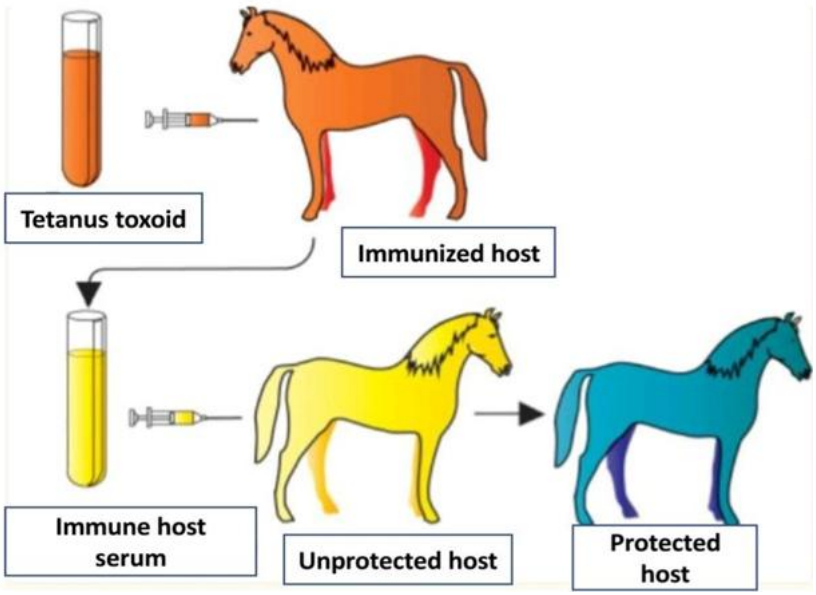

Figure 6: Pricipal of Immunization

Components of Vaccines

Disease	Attenuated microbe	Killed microbe	Microbial extract
Bacterial disease	Typhoid fever	Pertussis Cholera Q fever Typhoid fever	Non infectious culture filtrate of Anthrax species Meningococcal, pneumococcal &

		Plague	haemophilus capsules Pertussis toxoids Tetanus toxoids Diphtherial toxoids
Viral disease	Polio (Sabin) Measles Mumps Rubella Yellow fever etc	Influenza viral particle J. Encephalitis Polio (Salk) Rabies Hepatitis etc	Inactivated HBSAg (Hepatitis B surface Ag)

Examples of Vaccines

1. **Polio Vaccine:** Vaccination is the only effective way to prevent viral poliomyelitis.[4] Polio virus is highly infectious invade on CNS& lead paralysis of extremities. Poliomyelitis is incurable. Both attenuated (Sabin) & killed (Salk)Vaccinesare available for preventing poliomyelitis infection.
   - **Attenuated Polio Vaccine:** Attenuated polio vaccine was made by Albert Bruce Sabin. This is administered orally and life long immunity from Polio virus.

     Dose: 2 drops at birth, intramuscularly 6 weeks, 10 weeks & at 14 weeks
   - **Inactivated Polio Vaccine:** Inactivated Polio vaccine was made by Jonas Salk in 1950s. It is safe for immune suppressive individual & administered by injection only. It provides immunity for short period. [4,9]

2. **MMR Vaccine:** MMR is Measles, Mumps & Rubella. This is live attenuated vaccine & administered in children prior to entering school to prevent infectious diseases such as Measles, Mumps & Rubella. MMR vaccine demonstrates high efficacy but multiple doses are required to boost life long immunity.[11]

3. **DPT Vaccine:** DPT Vaccine is combination of Diphtheriae, Pertussis & Tetanus antigens. It provides immunity against Diphtheria, Pertussis & Tetanus by revolving antibodies. DPT Vaccine administered from age of 6 weeks to 6 years in children intramuscularly.

Doses of DPT Vaccine

- Dose 1 to dose 2 – At 4 weeks
- Dose 2 to dose 3 – At 4 weeks
- Dose 3 to dose 4 – At 6 months; the minimum age for dose 4 is 12 months.
- Dose 4 to dose 5 – At 6 months [12]

4. **BCG Vaccine:** The Bacillus Calmette-Guérin or BCG vaccine is a product by Albert Calmette and Camille Guérin. The BCG vaccine is a live attenuated vaccine used most importantly against tuberculosis infections and also other infections of non-tuberculous mycobacterial origin, which may also include leprosy. It forms part of the routine immunization schedules for newborns in most countries. Administration is normally by intramuscular or intradermalroutes.

5. **Doses:** 0.05 ml for infants under one year of age is administered intradermally. 0.1 ml for persons above one year and adults, intradermally. [13]

6. **Covishield Vaccine:** Covishield is attenuated, recombinant adenovirus vector encoding Covid 19 spike glycoprotein encoding vaccine. The vaccine was developed by Serum Institute of India, Pune. It administered intramuscular & provide long time Immunity against Covid 19 disease.

   Doses: Two doses of 0.5 ml each at 12 to 16 weeks of interval

7. **Covaxin:** Covaxin is India's first indigenous COVID-19 vaccine developed by Bharat Biotechin collaboration with the Indian Council of Medical Research (ICMR). Covaxin is an inactivated killed vaccine, provide Immunity for short duration against Covid 19.

   Dose: 2 doses of 0.5 ml intramuscularly at 4 weeks of interval, A booster dose may also offer at 4-6 months for the high-risk groups (older adults, health workers). [14]

8. **Rabies Vaccine:**Human rabies vaccine is a killed vaccine developed by Lieutenant-Colonel Sir David Semple in India.Vaccine administered intramuscularly prior to exposure or within latent period after exposure to prevent disease.[15]

National Immunization Schedule

The National Immunization Schedule represents a set of guidelines developed by health authorities, such as national public health agencies or ministries of health. These guidelines outline the doses of different vaccines recommended for infants, children, adolescents, and even adults in a given country. It aims at achieving immunity against infectious diseases, reducing mortality, and improving the health status among the general population. In many countries, the NIS is updated regularly based on emerging health data, new vaccines, and advances in immunization science.

Age	Vaccine	Disease Prevented	Route of Administration
Birth	BCG	Tuberculosis	Intradermal
	Hepatitis B (1st dose)	Hepatitis B	Intramuscular
	OPV (Oral Polio Vaccine) (1st dose)	Polio	Oral
6 Weeks	DTP (Diphtheria, Tetanus, Pertussis) (1stdose)	Diphtheria, Tetanus, Pertussis	Intramuscular
	IPV (Inactivated Polio Vaccine) (1st dose)	Polio	Intramuscular
	Hib (*Haemophilus influenzae* type b) (1st dose)	*Haemophilus influenzae* type b infections	Intramuscular
	Hepatitis B (2nd dose)	Hepatitis B	Intramuscular
	Rotavirus (1st dose)	Rotavirus gastroenteritis	Oral
	Pentavalent vaccine (1st dose)	Diphtheria, Tetanus, Pertussis, Hepatitis B, *Haemophilus influenzae* type b	Intramuscular
10 Weeks	DTP (2nd dose)	Diphtheria, Tetanus, Pertussis	Intramuscular

	IPV (2nd dose)	Polio	Intramuscular
	Hib (2nd dose)	*Haemophilus influenzae* type b infections	Intramuscular
	Pentavalent vaccine (2nd dose)	Diphtheria, Tetanus, Pertussis, Hepatitis B, *Haemophilus influenzae* type b	Intramuscular
14 Weeks	DTP (3rd dose)	Diphtheria, Tetanus, Pertussis	Intramuscular
	IPV (3rd dose)	Polio	Intramuscular
	Hib (3rd dose)	*Haemophilus influenzae* type b infections	Intramuscular
	Pentavalent vaccine (3rd dose)	Diphtheria, Tetanus, Pertussis, Hepatitis B, *Haemophilus influenzae* type b	Intramuscular
9-12 Months	MMR (Measles, Mumps, Rubella) (1st dose)	Measles, Mumps, Rubella	Subcutaneous
	Vitamin A (1st dose)	Vitamin A deficiency	Oral
	JE (Japanese Encephalitis) (1st dose)	Japanese Encephalitis	Intramuscular
16-24 Months	DTP (Booster dose)	Diphtheria, Tetanus, Pertussis	Intramuscular
	MMR (2nd dose)	Measles, Mumps, Rubella	Subcutaneous
	Hepatitis A (1st dose)	Hepatitis A	Intramuscular
	Vitamin A (2nd dose)	Vitamin A deficiency	Oral
5-6 Years	DTP (Booster dose)	Diphtheria, Tetanus, Pertussis	Intramuscular

	OPV (Booster dose)	Polio	Oral
10-16 Years	Tetanus and Diphtheria (Td) (Booster dose)	Tetanus, Diphtheria	Intramuscular

V. CONCLUSION

The immunization plays a critical role in protecting public health by ensuring that individuals receive the appropriate vaccines at the recommended ages. The national immunization schedule helps to prevent outbreaks of infectious diseases, reduces the burden on healthcare systems, and contributes to global disease control efforts.

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