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REVIEW ARTICLE

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Vaccinations in Primary Care

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Abstract
Vaccination is amongst the best strategies to improve child survival and reduce morbidity. Vaccines represent the most cost effective and simple intervention to protect against distressing epidemics. There are mortality and morbidity related benefits derived from preventing infectious diseases through vaccination; these include financial benefits by avoiding hospitalization, preventing long-term disability and increased productivity. Ever since the invention of the first vaccine against smallpox by Edward Jenner in 1796, vaccination has become indispensable healthcare intervention and has saved millions of lives. Due to significant scientific progress, many vaccines are available and numerous are anticipated; however, vaccine preventable infectious diseases are still prevalent. Due to rapid pace of developments in the field of vaccination, providers must continue to update their knowledge. The present review is aimed at helping general practitioners understand routine vaccinations, their considerations, issues and side effects.

Keywords Vaccines · Vaccination · Immunization

Introduction

Vaccination is amongst the best and easy to administer strategies and has become indispensable healthcare intervention saving millions of lives. Due to significant scientific progress, more than 70 vaccines are available for use against nearly 30 microorganisms and much more are expected [1, 2]. Most of the developed nations have lowered their vaccine-preventable disease incidence by using vaccinations successfully [3, 4]. Despite the progress, vaccine preventable infectious diseases still cause significant mortality and morbidity in developing and underdeveloped countries [5–7]. Estimates from the Global Alliance for Vaccines and Immunization suggest that >1.5 million/ year children deaths result from infectious diseases that can be prevented by vaccination. Satisfactory immunization coverage is needed to obtain maximum benefits from vaccines through herd effect. In today's age of information technology many parents do have concerns and queries regarding vaccination and related issues [8]; these have to be addressed by the healthcare providers to improve parent satisfaction and adherence. Availability of vaccines [9] and awareness of healthcare providers [10] about vaccine-preventable diseases are the biggest barriers identified in developing countries. Due to rapid pace of developments in the field of vaccination, providers must continue to update their knowledge. The present review is aimed at helping general practitioners understand routine vaccinations, their considerations, issues and side-effects.

Basic Immunology

Immunization is derived from Greek word "immune" meaning "protected". Acquired immunity is the immunity that follows exposure to antigens or exogenous antibodies. Vaccination is the method of inoculating the vaccine/antigen for inducing immunity. The process of acquiring immunity is referred to as "immunization". Immunization is primarily of two different types — active immunization- antigen exposure induces the immune response and passive immunization — when exogenous antibodies are given. During primary infection, pathogenic infectious agents cause disease which is followed by host immune system response, inducing immunity. Immunity ensures disease recovery in the primary infection followed by immune response. Immunity includes production of humoral (antibody response) immunity and cell-mediated

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immunity (CMI). There can be concurrent humoral and CMI immunity that provides protection from same disease recurrence. On the other hand, vaccination introduces antigens of the pathogenic organism, which induces similar immune response minus the disease process. Sero-conversion is the process of change to antibody positive state from antibody negative state. Sero-protection is the stage of protection by antibodies from specific disease.

Vaccines are of different types; live attenuated vaccines include oral polio vaccines, varicella vaccine, and measles vaccine. Inactivated whole cell vaccines include inactivated polio vaccine, pertussis vaccine, rabies vaccine and whole cell typhoid vaccine. Modified exotoxin vaccines called "toxoids" include diphtheria toxoid and tetanus toxoid. Antigen subunit vaccines include *Haemophilus influenza* type b, *Salmonella typhi* polysaccharide antigen and hepatitis B surface antigen.

Vaccination Counseling

1) Schedule –At every vaccine visit the physician should educate about the vaccine nature, doses required, disease that the particular vaccine prevents, possible reactions and follow-up date for the next vaccine.
2) Disease risk and vaccine efficiency –Disease risk can be explained by citing local incidence rates from resources such as scientific publications/ studies. Parents should be explained that the complications from diseases are much higher in younger age group. Parents should also be explained that vaccines do not provide absolute protection although almost all the vaccines offer very high degree of protection.
3) Vaccine safety –Vaccines are generally safe and serious side-effects are very rare; benefit of vaccines outweigh the risk of side-effects.
4) Cost of vaccine –Parents may consider cost while deciding about individual vaccines. Physicians should explain and reiterate that all vaccines are efficacious while they may vary in their cost.

Physicians must give a detailed explanation regarding the possible side-effects and their frequency to the parents prior to immunization, and consent for immunization should be obtained. Proper hand hygiene should be ensured [11]. Auto disable (AD), or disposable needle-syringes should be preferably used and the sharps should be discarded in an identified, sharp proof container immediately after use. A separate needle and syringe should be used for each injection. Single dose vials are preferable, the septum of the multi-dose vial should be cleaned by alcohol wipes before each withdrawal. Mixing different vaccines should be avoided. Sharps should not be recapped to avoid needle-stick injury [12–14].

Pain control and comfort measures can be used to reduce vaccination-associated discomfort.

Due to risk of sciatic nerve injury, gluteal region should be avoided; Anterolateral aspect of the thigh (in children) and deltoid in adolescents is the preferred site for IM injections. Distance between two simultaneous vaccine injections should be 1 in. at least. Rubbing of the vaccination site should be discouraged [15]. Observation for 15 to 20 min following vaccination for possible allergic reaction is recommended. Acetaminophen can be used after DTP vaccine to decrease the pain and fever [16]. Physician should record the name, type, batch number and date of vaccination and any adverse reaction following immunization in the patient's immunization record. Adverse reactions associated with immunization should be properly documented and reported to appropriate health officials and vaccine manufactures. Minimum resuscitative equipment including airway, resuscitation bag and mask, intravenous access related supplies, oxygen supply, IV fluids, injectable epinephrine and hydrocortisone should be readily available in case of need. In case of severe adverse reactions, expert opinion must be sought.

Vaccination Scheduling

Simultaneous administration of multiple vaccines can be done if required, as there is usually no interaction or interference. Four to eight weeks interval should be given between subsequent doses of the same vaccine. The use of a combination vaccine is preferable over individual component vaccines. Inadequate dose or non-standard route immunization should not be counted and age appropriate re-immunization should be done.

Immunization Schedules

A major goal by National Health Policy (2002) is the Universal Childhood Immunization against the diseases which can be prevented by immunization. The Ministry of Health and Family Welfare releases National Immunization Schedule [17] to guide decision-making by healthcare providers for vaccination (Table 1). Indian Academy of Pediatrics publishes guidebooks [18] and vaccine recommendations [19] (Table 2) for immunization that additionally includes vaccines not covered in the National Immunization Schedule; the money for such vaccines has to be paid by parents/ relatives.

Table 1 National Immunization Schedule [17]

S No.	Vaccine	Protection	Number of doses	Vaccination Schedule
1	BCG (Bacillus Calmette Guerin)	Childhood Tuberculosis	1	At birth (up to 1 y if not given earlier)
2	Pentavalent [Diphtheria, Pertussis, Tetanus (DPT), Hepatitis B and *Haemophilus influenzae* b (Hib)]	Diphtheria, Pertussis, Tetanus, Hepatitis B, *Haemophilus influenzae* type B associated Pneumonia and Meningitis	3	Three doses at 6, 10 & 14 wk
3	DPT (Diphtheria, Pertussis and Tetanus Toxoid)	Diphtheria, Pertussis and Tetanus	2	Two booster doses at 16–24 mo and 5 y of age. Three primary doses at 6, 10 & 14 wk are part of *Pentavalent vaccine.*
4	Hepatitis B	Hepatitis B	1	Birth dose for institutional deliveries within 24 h. Three primary doses at 6, 10 & 14 wk are part of *Pentavalent vaccine.*
5	OPV (Oral Polio Vaccine)	Polio	5	Birth dose for institutional deliveries. Three primary doses at 6, 10 & 14 wk and one booster dose at 16–24 mo of age. Given orally.
6	IPV (Inactivated Polio vaccine) $	Polio	1	One dose at 14 wk, along with OPV3. Injectable dose given.
7	Japanese Encephalitis#	Japanese Encephalitis	2	9–12 mo of age and 2nd dose at 16–24 mo
8	Measles	Measles	2	9–12 mo of age and 2nd dose at 16–24 mo
9	Vitamin A	Night Blindness	9	-1st dose at 9 mo -2nd dose at 18th mo -3rd to 9th dose given at 6 monthly interval upto 5 y
10	Rota virus*	Rotavirus diarrhea	3	Three dosses at 6, 10 & 14 wk. Given orally.
11	TT (Tetanus Toxoid)	Tetanus	2	-10 y and 16 y of age -For pregnant woman, two doses given (one dose if previously vaccinated within 3 y)

$ At the present in six states- Assam, Bihar, Gujarat, M. P., Punjab and U.P., and in the process of expansion

In endemic districts

* Phased introduction, at present in Andhra Pradesh, Haryana, Himachal Pradesh and Orissa from 2016

Brief Overview of Individual Vaccines

BCG Vaccine

BCG induces cell-mediated immunity and is more effective against hematogenous spread of *Mycobacterium tuberculosis* than against the development of pulmonary tuberculosis. About 0.1–0.4 million live bacilli are present in each recommended dose (0.1 ml). The BCG vaccine is a vacuum packed freeze-dried lyophilized multi-dose vial and is light and heat sensitive. Reconstitution should be done by normal saline and the reconstituted vaccine can be used for 4 h after which the vial should be discarded. It can be stored for up to a year at 2–8^0 C. BCG should be given intradermaly with a 26G needle and a tuberculin syringe at left shoulder. The site can be cleaned using normal saline.

As BCG is given intradermally, a wheal of about 0.5 cm develops at the vaccination site. The wheal subsides soon and there is no visible transformation for 2–3 wk, after which a papule develops and increases to a size of 0.4–0.8 cm in 4–6 wk. This papule then ulcerates and leaves a scar in 6–12 wk. The ideal time for BCG vaccination is at birth although it can be given till 5 y of age. Repeat vaccination should be advised in children who do not show any change at the BCG injection site within 3 mo. BCG vaccination related axillary lymphadenopathy is reasonably common. It needs to be given intradermally to avoid spread to lymph nodes, causing suppurative and non suppurative lymph adenitis. It should be avoided during pregnancy. It reduces the risk of contracting TB by about 50%, and appears to have maximum effect in preventing miliary and hematogenic spread of TB.

Adverse Reactions

Persistence of ulcer, secondary infection, ipsilateral axillary/cervical lymphadenopathy, abscess and disseminated BCG infection are some rare complications.

Table 2 IAP immunization timetable 2016 [19]

Age (completed weeks/months/years)	Vaccines	Comments
Birth	BCG OPV 0 Hep-B 1	Administer these vaccines to all newborns before hospital discharge
6 wk	DTwP 1 IPV 1 Hep-B 2 Hib 1 Rotavirus 1 PCV 1	**DTP:** • DTaP vaccine/combinations should preferably be avoided for the primary series • DTaP vaccine/combinations should be preferred in certain specific circumstances/conditions only • No need of repeating/giving additional doses of whole-cell pertussis (wP) vaccine to a child who has earlier completed their primary schedule with acellular pertussis (aP) vaccine-containing products **Polio:** • All doses of IPV may be replaced with OPV if administration of the former is unfeasible • Additional doses of OPV on all supplementary immunization activities (SIAs) • Two doses of IPV instead of 3 for primary series if started at 8 wk, and 8 wk interval between the doses • No child should leave the facility without polio immunization (IPV or OPV), if indicated by the schedule • See footnotes under figure titled IAP recommended immunization schedule (with range) for recommendations on intradermal IPV **Rotavirus:** • 2 doses of RV1 and 3 doses of RV5 & RV 116E • RV1 should be employed in 10 & 14 wk schedule, 10 & 14 wk schedule of RV1 is found to be more immunogenic than 6 & 10 wk schedule
10 wk	DTwP 2 IPV 2 Hib 2 Rotavirus 2 PCV 2	**Rotavirus:** If RV1 is chosen, the first dose should be given at 10 wk
14 wk	DTwP 3 IPV 3 Hib 3 Rotavirus 3 PCV 3	**Rotavirus:** • 2 doses of RV1 are recommended. • If RV1 is chosen, the 2nd dose should be given at 14 wk
6 mo	OPV 1 Hep-B 3	**Hepatitis-B:** The final (3rd or 4th) dose in the HepB vaccine series should be administered no earlier than age 24 wk and at least 16 wk after the first dose.
9 mo	OPV 2 MMR-1	**MMR:** • Measles-containing vaccine ideally should not be administered before completing 270 d or 9 mo of life; • The 2nd dose must follow in 2nd y of life; • No need to give stand-alone measles vaccine
9–12 mo	Typhoid Conjugate Vaccine	• Currently, two typhoid conjugate vaccines, Typbar-TCV® and PedaTyph® are available in Indian market; either can be used • An interval of at least 4 wk with the MMR vaccine should be maintained while administering this vaccine
12 mo	Hep-A 1	**Hepatitis A:** • Single dose for live attenuated H2-strain Hep-A vaccine • Two doses for all inactivated Hep-A vaccines are recommended
15 mo	MMR 2 Varicella 1 PCV booster	**MMR:** • The 2nd dose must follow in 2nd year of life • However, it can be given at anytime 4–8 wk after the 1st dose **Varicella:** The risk of breakthrough varicella is lower if given 15 mo onwards
16 to 18 mo	DTwP B1/DTaP B1 IPV B1 Hib B1	The first booster (4^{th}th dose) may be administered as early as age 12 mo, provided at least 6 mo have elapsed since the third dose. **DTP:**

Table 2 (continued)

Age (completed weeks/months/years)	Vaccines	Comments
		• 1st & 2nd boosters should preferably be of DTwP • Considering a higher reactogenicity of DTwP, DTaP can be considered for the boosters
18 mo	Hep-A 2	**Hepatitis A:** 2nd dose for inactivated vaccines only
2 y	Booster of Typhoid Conjugate Vaccine	• A booster dose of Typhoid conjugate vaccine (TCV), if primary dose is given at 9–12 mo • A dose of Typhoid Vi-polysaccharide (Vi-PS) vaccine can be given if conjugate vaccine is not available or feasible; • Revaccination every 3 y with Vi-polysaccharide vaccine • Typhoid conjugate vaccine should be preferred over Vi- PS vaccine
4 to 6 y	DTwP B2/DTaP B2 OPV 3 Varicella 2 MMR 3	**Varicella:** The 2nd dose can be given at anytime 3 mo after the 1st dose. **MMR:** The 3rd dose is recommended at 4–6 y of age.
10 to 12 y	Tdap/Td HPV	**Tdap:** is preferred to Td followed by Td every 10 y **HPV:** • Only 2 doses of either of the two HPV vaccines for adolescent/preadolescent girls aged 9–14 y; • For girls 15 y and older, and immunocompromised individuals 3 doses are recommended • For two-dose schedule, the minimum interval between doses should be 6 mo • For 3 dose schedule, the doses can be administered at 0, 1–2 (depending on brand) and 6 mo

Oral Polio Vaccine

Oral polio vaccine (OPV) is the vaccine of choice for polio eradication in India. One year before trivalent OPV was used which is now replaced by bivalent OPV (1 and 3 subtypes). It contains more than 1 million live attenuated poliovirus types 1 and 3. Following OPV, the attenuated vaccine viruses establish infection in the intestines, which is followed by an immune response. Seroconversion following 3OPV doses is average 73% and 70% for Types I & III respectively which necessitates multiple doses for safe coverage. Routine OPV doses are supplemented by "Pulse Polio doses" yearly on National and subnational Immunization Days (NIDs and sNIDs respectively) till 5 y of age. OPV should be stored in the freezer at the clinic level. Mild diarrhea is not a contraindication to OPV administration.

Adverse Reactions

Vaccine Associated Paralytic Poliomyelitis (VAPP) is one of the dreaded rare complication of OPV vaccines.

Inactivated Polio Vaccine (IPV)

IPV is formalin-killed virus cultured in human diploid/ monkey kidney cells. IPV is highly immunogenic with 90–95% and 99% sero-conversion rates after 2 and 3 doses respectively. IPV is used in combination with many other vaccines without any change in efficacy. IPV is administered as three dose schedule, 6–10-14 wk. OPV should be administered to those children who receive IPV at birth and on NIDs and sNIDs.

Adverse Reactions

The IPV vaccine is safe. It has small amount of polymyxin B, neomycin and streptomycin which may cause allergic reactions in sensitive individuals.

DTPw Vaccine

Diphtheria toxoid, tetanus toxoid and whole cell pertussis vaccine (DTPw) is given intramuscularly. DTP has a 5 dose course including 3 in infancy and 2 boosters at 18 and 60 mo. The whole cell or acellular DTP vaccines can be given till 7 y of age, after which Tdap or Td must be given. The dose is 0.5 ml IM and should be stored at 2–8°C. It should not be frozen, and should be discarded if frozen accidentally.

Precaution Scenarios

Cases with convulsion history after previous DTPw vaccination, neurological illness which is either progressive or evolving, an episode of inconsolable and persistent cry for >3 h after prior DTPw vaccination, fever >40.5°C or hypotonic – hypo responsive episode in 48 h of prior DTPw vaccination and seizures in 72 h of prior DTPw vaccination should be referred for expert advise.

Adverse Reactions

Fever and local pain and redness are some of the frequent side-effects. Some infrequent but possible side-effects including hyperpyrexia – fever >40.5 °C, convulsions, hypotonic – hypo responsive episode, persistent inconsolable cry can occur and expert advise should be sought in case of any serious complication.

Acellular Pertussis Vaccine (DTPa)

DTPa is less reactogenic, with comparable efficacy to the DTPw vaccine. DTPa can be considered at parental request or history of adverse reaction with the previous dose of DTPw. It is available in most of the combination vaccines. The dose of 0.5 ml IM is recommended.

Precaution Scenarios

Anaphylaxis reaction after DTP vaccine and encephalopathy within 7 d of DTPw dose, would be a contraindication for any future pertussis vaccine including DTPw and DTaP. DT can be given in cases with encephalopathy following pertussis vaccine but in cases of anaphylaxis after DTwP, all vaccines containing diphtheria pertussis and tetanus should be avoided.

Adverse Reactions

DTPa vaccine has less incidence of fever, redness and pain at injection site.

Tetanus Toxoid

Tetanus vaccine (TT) is efficient and heat stable and has toxoid content of 5 LF. After completion of the DPT series, boosters of tetanus of TT should be administered at 10 y, 16 y and followed up every 10 y. For unimmunized pregnant women, 2 TT doses, 1 mo apart with the second dose being minimum two weeks before birth prevents neonatal tetanus. Single booster dose is recommended for pregnancies in 5 y after the two primary doses and two doses of TT after 5 y. For unimmunized children, primary TT schedule would include three TT doses, each 4 wk apart. The dose of 0.5 ml IM is recommended.

Td Vaccine (Tetanus Toxoid with Reduced Diphtheria Dose)

Td vaccine has the regular tetanus toxoid dose (5 LF) with reduced diphtheria dose of two diphtheria toxoid units. Td is recommended in children 7 y or older.

Measles Vaccine

Measles vaccine is a live attenuated vaccine and it is followed by a sub-clinical infection which results in immunity. Measles vaccine is freeze-dried with a 2-y shelf life and should be stored frozen. Reconstituted vaccine must be used within four hours. Strict asepsis should be ensured while reconstituting or drawing the doses as the vaccine is preservative free. Measles vaccine must be given subcutaneously.

Adverse Reactions

In some cases, fever with macular rash after 7–10 d of vaccination may develop.

MMR Vaccine

MMR is more preferred instead of single antigen measles vaccine. It comes as a single/multi-dose vials. Measles/MMR vaccines are lyophilized, light sensitive and must be frozen for ensuring long-term efficacy. After reconstitution it should be used within four hours. Unimmunized adolescent girls and healthcare workers should have MMR vaccines, if susceptible, based on antibody titers. It is given 0.5 ml SC in the anterolateral thigh/upper arm.

Adverse Reactions

Fever and rash can occur in some vaccine recipients. Mumps vaccine associated mild aseptic meningitis, although rare, can happen and it is usually mild and with full recovery.

Rubella Vaccine

Rubella vaccine is generally given as a combination with measles and mumps (MMR/MR) and can also be given as a monovalent single vaccine. It is a live attenuated vaccine with good efficacy and provides long-term protection. It is given 0.5 ml SC in the anterolateral thigh/upper arm.

Hepatitis-B Vaccine

Hepatitis-B vaccine is a highly effective recombinant DNA vaccine. This vaccine should be kept at 2–8 °C, and should not be frozen. It should be given IM at a dose of 0.5 ml for children and 1 ml for adults.

Hepatitis B vaccine can be administered at birth, 4–6 wk & 3–6 mo or can be given with other vaccines as a combination at 6, 10 & 14 wk. Antenatal HbsAg should be done to identify the babies who would require hepatitis B immunoglobulin prophylaxis to prevent vertical transmission. Birth dose of Hepatitis B should be given in cases of uncertain HbsAg status and those with high risk.

Typhoid Vaccines

The Vi-Capsular Polysaccharide Vaccine

This vaccine is a purified Vi-capsular polysaccharide with efficacy of 50–60% in children and not very effective for infants and children <2 y of age [18]. This vaccine can be administered at a dose 0.5 ml IM or SC. It can be stored at 2–8^0 C and should not be frozen.

Adverse Reactions Mild local pain and swelling.

Conjugated Vi-Capsular Vaccine

This vaccine is conjugated with Tetanus toxoid. In a phase III trial, there was seroconversion of 98.0% at 42 d after one dose [18]. This vaccine has comparable side-effects to Vi-Capsular polysaccharide vaccine. This vaccine can be administered IM or SC. It can be stored at 2–8 °C and should not be frozen.

Oral Live Attenuated Ty21a Vaccine

It is a live attenuated vaccine which is supplied as an enteric coated capsule with efficacy between 50 and 60% and provides immunity by producing gut immunity locally and needs to be repeated every 3 to 5 y. Antibiotics should be avoided 3 d before and 7 d after the vaccine administration. This vaccine is currently unavailable in India. The vaccine capsule needs to be swallowed intact and hence can be given to only older children (>5 y of age). The vaccine is given on an empty stomach in three sittings, on alternate days. This vaccine can be stored at a 2–8 °C.

Hib Conjugate Vaccines

It is a conjugate vaccine with high efficacy. The schedule for Hib vaccination is 3 doses for infants <6 mo, 2 doses for 6–12 mo and 1 dose for 12–15 mo and booster at 18 mo, single dose if the child is above 15 mo. No vaccine is required for children more than 5 y. There should be at least 4 wk gap between consecutive doses. It can be stored at 2–8 °C. Hib should be administered prior to splenectomy in sickle cell disease patients.

Adverse Reactions

Mild local pain and swelling.

Varicella Vaccine

This highly effective vaccine should be offered to all susceptible healthy (>12 mo age) individuals with suboptimal varicella antibody titers. If given before 13 y, single dose would be sufficient but in patients above 13 y of age, two doses at least 4 wk apart are necessary. Varicella vaccine is not given to infants < 12 mo of age. For preventing breakthrough infections, two doses of vaccine at an interval of 3 mo is recommended. This vaccine can be stored at 2–8 °C. It can be given 0.5 ml SC. It is photosensitive and should be shielded from light. After reconstitution, it should be used in 30 min.

Adverse Reactions

These include fever, rash, local site pain with redness and swelling. Contraceptive advise should be given and pregnancy be avoided till 4 wk post vaccination in women of child bearing age.

Hepatitis A Vaccine

Hepatitis A vaccines (HAV) are highly effective and are available as inactivated as well as live vaccine. Inactivated vaccine is administered by a 2 dose schedule, 6 mo apart, whereas, live vaccines are given as single dose because of better single dose efficacy. Both vaccines are administered IM. It can be given to children, HAV seronegative travelers and patients with chronic liver diseases and their contacts. This vaccine should be kept at 2–8 °C.

Adverse Reactions

Mild local pain and swelling.

Pneumococcal Vaccines

Pneumococcal vaccines are presently available in unconjugated and conjugated forms that provide serotype specific immunity. Unconjugated polysaccharide vaccine has poor immunogenicity specially in patients less than 2 y, hence it is recommended only in high risk groups including asplenia, nephrotic syndrome, chronic illness, sickle cell disease, HIV and any immune-deficiency diseases and revaccination should be done after 5 y. Pneumococcal conjugate vaccines provide excellent

serotype protection and are available as either 13 or 10 valent vaccines. They are given in infancy following a 3-dose schedule and a 15–18 mo booster. These vaccines should be stored at 2–8 °C. Doses of conjugate and unconjugated vaccine are the same, 0.5 ml IM or SC.

Adverse Reactions

Mild local pain and swelling, low-grade fever.

Rabies Vaccines

The currently available rabies vaccines are highly effective and are Cell culture vaccines (CCV). They are classified as per the type of cells used for culture. All CCVs have similar efficacies and they include Purified Duck Embryo Vaccine (PDEV), Purified Chick Embryo Cell Vaccine (PCECV), Purified Vero Cell Vaccine (PVRV) and Human Diploid Cell Vaccine (HDCV). The vaccines are lyophilized and must be stored at 2–8 °C and can be used till 6 h post-reconstitution.

Post-exposure prophylaxis (PEP) schedule includes vaccination on 0 d (day of first vaccination), 3rd d, 7th d, 14th d and 30th d. An additional 90th d dose can be given to immunocompromized patients. PEP should be urgently given to any person who experiences warm-blooded animal bite or any other substantial contact. In case of bites from pets that have completed rabies vaccination schedule, the pets should be closely observed for at least 10 d and if the pet displays any sign of illness, the patient should promptly receive complete PEP. All category 3 bites should be treated with Anti-Rabies immunoglobin (RIG) and complete PEP vaccine schedule.

Meningococcal Vaccines

Meningococcal vaccines are of two types: Meningococcal protein conjugate polysaccharide vaccines (MCV) and Meningococcal polysaccharide vaccines (MPSV).

Quadri-valent MCV vaccine is available at present in India. MCV vaccine has A, C, Y and W-135 polysaccharide conjugated with diphtheria toxoid. This vaccine is given as a single dose 0.5 ml IM. Single dose of MCV is recommended for 1–29 y age group. MPSV provide serotype specific immunity and are bi-valent (A + C) or quadri-valent (A, C, Y, W-135) lyophilized vaccines which should be stored at 2 to 8 °C. MCV do not have good response rates in children less than 2 y and thus should be given to older children/ adults.

Influenza Vaccine

Influenza vaccines are of two types: live attenuated influenza vaccines (LAIV) and inactivated vaccines (Trivalent –TIV and Quadrivalent -QIV). TIV is available in India.

Schedule for TIVs: Children aged 6 mo to 9 y should be given two doses with a gap of atleast 4 wk in between the doses. Dose of 0.25 ml is recommended for children <3 y and 0.5 ml for adults. IAP has recommended seasonal influenza vaccine (TIV) only for the category of 'high-risk children'. The vaccine protection peaks at around 4 wk and falls to

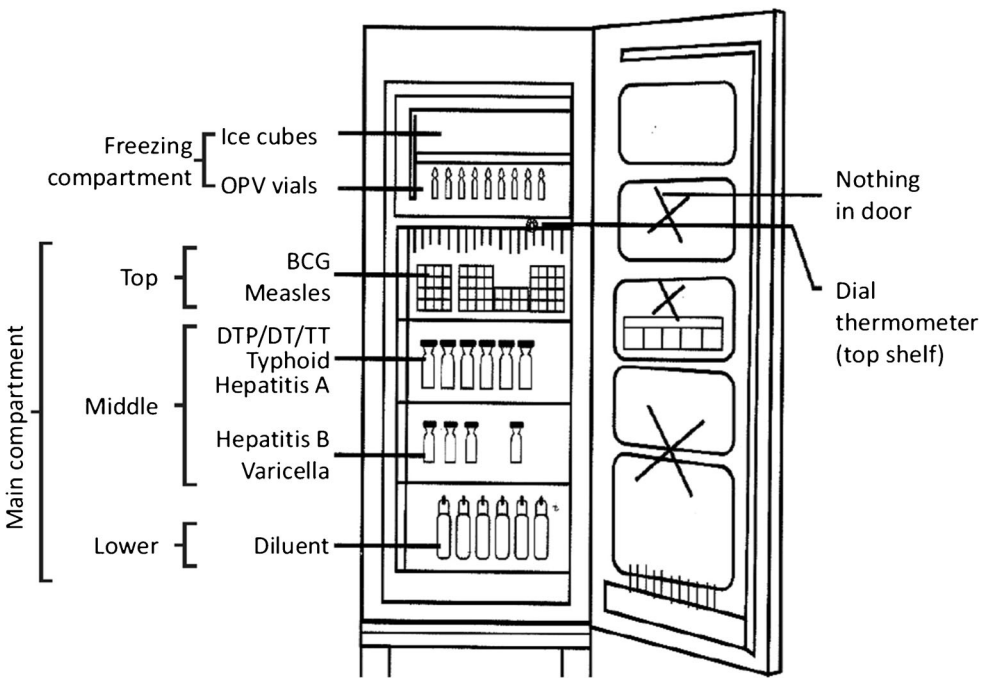

Fig. 1 Vaccine storage in domestic refrigerator

50% by 6 mo. Yearly vaccination is required to achieve continued protection.

Adverse Reaction Mild local pain and swelling, fever and malaise.

Human Papilloma Virus Vaccines

HPV vaccines are recombinant DNA vaccines and are of two types: quadrivalent and bivalent.

Quadrivalent vaccine, which is available in India, contains serotypes 16, 18, 6 and 11. The bivalent vaccine contains serotypes 16 and 18.

IAP's recommendation is to offer HPV vaccine to females between 9 to 15 y, two doses at 0 and 6 mo and to those over 16 to 45 y, three doses at 0, 1 or 2 and 6 mo. HPV vaccine would offer best protection if administered before sexual debut. Both vaccines offer comparable serotype specific efficacy.

Vaccine Storage

Appropriate temperature control is the most critical factor in ensuring the potency of vaccines. Vaccines are heat and cold sensitive. Also, every exposure to normal temperature would cause degradation of vaccine potency. Live vaccines are most heat susceptible. Additionally, few vaccines are also susceptible to light. Thus in order to obtain desired efficacy, we should store vaccines as recommended and care should be taken to follow individual vaccine storage recommendations.

Recommended Storage of Vaccines in a Domestic Refrigerator [18] (Fig. 1)

Freezer compartment can be used to store OPV. Top shelf can be used to store BCG, measles and MMR. Middle shelf can be used for DTwP, DTaP, DT, TT, Tdap, combination vaccines, IPV, HPV, typhoid, hepatitis A, Hib, PCV, influenza and rotavirus vaccines. Lower shelf can be used for Hepatitis B and varicella. Crispator can be used for storing diluents. Vaccines should never be kept in the refrigerator door or the baffle tray.

Upcoming Vaccines and Further Directions

Several vaccines are in various stages of development; these include vaccines for malaria, cholera, tuberculosis, HIV and others. A vaccine is needed urgently against malaria, because of the prevalence of malaria in developing countries including India. Similarly, a vaccine against Japanese Encephalitis, which is in use, should be made compulsory in states with high prevalence.

Further Reading Readers are encouraged to refer to IAP Guidebook on Immunization 2013–-2014 published by Indian Academy of Pediatrics [18] for more comprehensive description of recommended vaccines.

Contributions VS drafted the manuscript, revised the manuscript and consented to the final manuscript as submitted; RCS conceptualized and planned the review, modified and edited the manuscript for important intellectual points, consented to the final manuscript and will act as guarantor for this paper.

Compliance with Ethical Standards

Conflict of Interest None.

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