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Vaccines & Immunity

Medicine & Society II

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Directed Student Learning [DSL]

Year Two Semester 1

1) Title : Vaccines and Immunity

Objectives of this Directed Student Learning are:

1) to understand the concept of immunity and vaccination
2) to know the immunisation schedule for children in Malaysia
3) to know the different types of vaccines used in the immunisation schedule
4) to be able to define and understand the concept of cold chain and how it is being managed in the immunization programme in Malaysia

Students are adviced to visit the National Health Service (NHS) Immunisation Information website at **http://www.immunisation.nhs.uk.** Then go to click on sub-topic immunisation under **http://www.immunisation.nhs.uk/article.php/id=78**

Here it explains the concept of 'herd immunity' with illustration. It also has a list of explanation regarding what is vaccine and how it works, types of vaccine, how immunization works and the factors affecting herd immunity.

Students can also visit the website **http://www.wellontheroad.com/immunization.html** to learn about the different types of immunisation available and compare them with the Malaysian's immunisation schedule as given (Appendix A and B – old and new immunisation schedule).

In order to be able to understand the cold chain system involved in vaccination, students are advised to visit the World Health Organisation (WHO) website at **http://www.who.int/vaccines-access/vacman/coldchain/the_cold_chain_.htm**

Here it will introduce you to the concept of cold chain, the process involved in maintaining the cold chain, starting from manufacturing until it reached it's target population.

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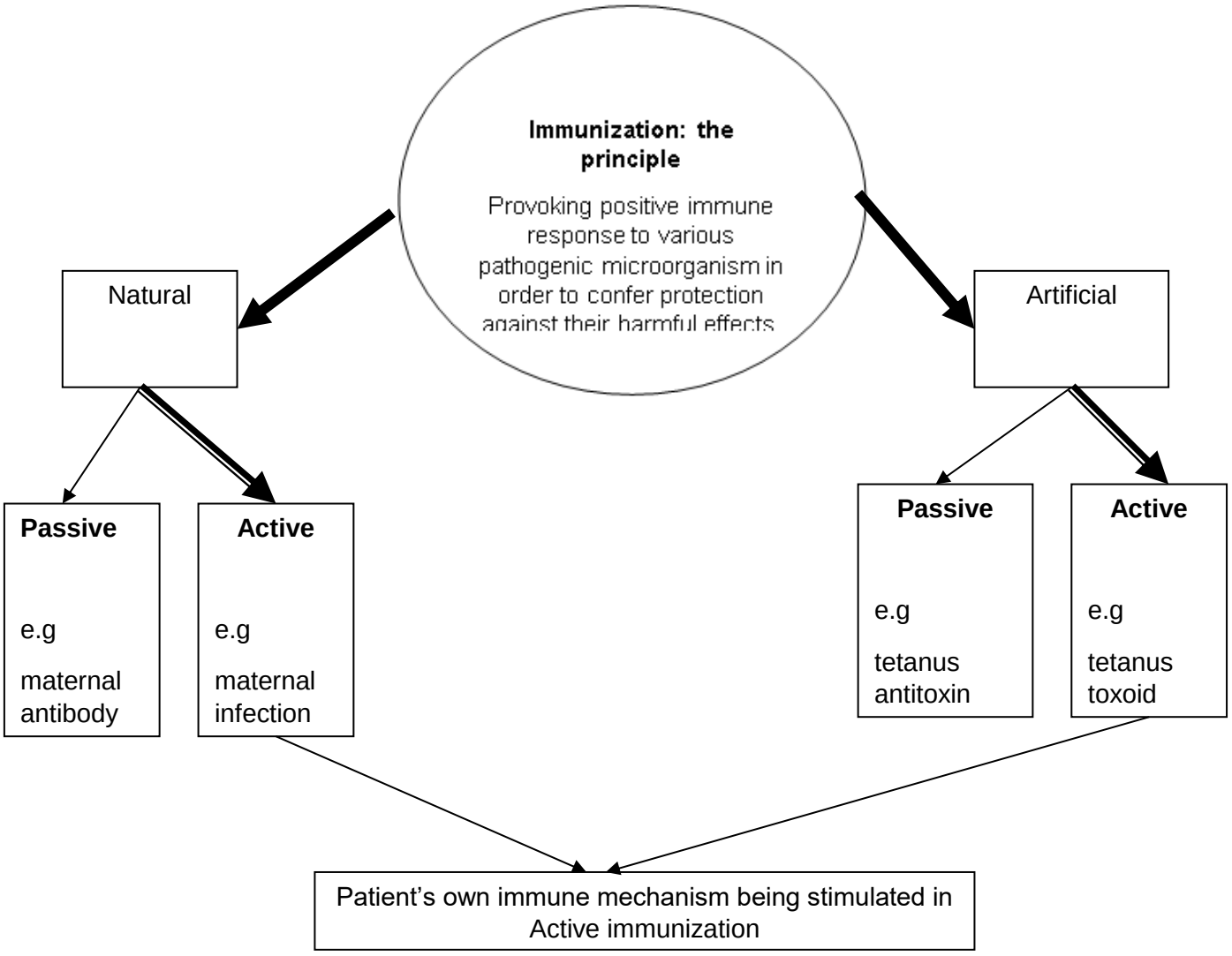
Subject matter: Vaccines and Immunity

As a medical student you need to comprehend the concept of immunity and the role of vaccines. You must be able to define;

- What is meant by immunity?
- What are the principles of immunization?
- What are the types of immunization?
- How do you differentiate them?
- Give examples of each type of immunization.
- What is the concept of vaccination?
- What is the concept of 'herd immunity'?
- How are vaccines administered?
- What are the factors affecting the herd immunity?

Students should also be able to relate their understanding of immunization to the immunization schedule in Malaysia. Students are expected to know the individual vaccines in the schedule;

- in terms of its role,
- target population,
- its contraindication and
- how the integrity of these vaccines is maintained?



What is a vaccine?

Vaccines stimulate our immune system to produce **antibodies** without us having to become infected with the actual disease.

A dose of vaccine may contain:

- a suspending fluid to carry the vaccine into the body
- preservatives and stabilizers so the vaccine can be stored safely, and
- an **adjuvant** to improve the body's immune response.

How do vaccines work?

There are two types of immunity:

1. **Active immunity**
2. **Passive immunity**.

Vaccines work by generating one of these types.

Active immunity

Active immunity is when a vaccines triggers the immune system to produce **antibodies** against the disease as though the body had been infected with it.

This also teaches the body's immune system how to produce the appropriate antibodies quickly.

If the immunized person then comes into contact with the disease itself, their immune system will recognize it and immediately produce the antibodies needed to fight it.

Passive immunity

Passive immunity is provided when the body is given antibodies rather than producing them itself.

A newborn baby has passive immunity to several diseases, such as measles, mumps and rubella, from antibodies passed from its mother via the placenta.

Passive immunity only lasts for a few weeks or months. In the case of measles, mumps and rubella it may last up to one year in infants – this is why MMR is given just after a child's first birthday.

How are vaccines made?

Vaccine manufacture starts by generating the very organism that produces the disease, the **pathogen**.

Many bacteria, for example, can be grown on **agar gel**. Viruses are mass produced by infecting cells grown in tissue culture.

Then the pathogen must be altered to make sure it doesn't trigger the disease itself. This can be done by:

- weakening, or **attenuating** the pathogen by growing it repeatedly to select a strain which doesn't cause complications of the natural disease. The polio and MMR vaccines are attenuated.
- extracting the part of the pathogen that causes the immune response and using this in the vaccine. The Hib vaccine is made in this way.
- killing the pathogen by heating it or by using **formalin**. The whooping cough vaccine is made in this way.

The treated pathogen can then be combined with the other components (the adjuvant, stabilizers and preservatives) to produce a dose of vaccine.

Scientists are trying to find new ways of producing vaccines, particularly using biotechnology and genetic engineering.

The life cycle of a vaccination programme

How an immunization programme works:

1. When no immunizations are being given against a disease, the number of people catching it is high. People's attention is focused on the disease and its effects.
2. When an immunization programme against it begins, the number of people catching the disease goes down. Some of those people may experience side effects from the vaccine, though these are usually mild.
3. As more and more people are immunized, the threat of the disease becomes much less, and the disease effectively disappears.
4. Attention turns naturally from worry about the disease to concern about possible side effects of the vaccine.
5. People start to question if the immunization is necessary and whether the vaccine is safe.
6. Some people stop being immunized.
7. Now that fewer people are being immunized, the disease starts to spread again. People are reminded of how bad the disease is and turn to immunization to avoid it.
8. As more and more of the population get immunized, hopefully the disease disappears altogether and the immunization programme can be discontinued.

   Look at this animation to see a demonstration of this process.

What is herd immunity?

If enough people in a community are immunized against certain diseases, then it is more difficult for that disease to get passed between those who aren't immunized.

This is known as herd immunity.

Herd immunity does not apply to all diseases because they are not all passed on from person to person. For example, tetanus can only be caught from spores in the ground.

For more detail, go to Factors affecting herd immunity or view the animation demonstrating this concept.

Factors affecting herd immunity – Environmental factors

People living in crowded conditions, such as inner cities, are more at risk of catching some diseases than people living in the country because they have more close contact with other people.

There are also seasonal increases in diseases. Meningitis and flu, for example, are more likely to occur during the winter months.

Factors affecting herd immunity – Strength of a person's immune system

People whose immune systems are not working well, either because they have a disease or because of treatment they are receiving for it, may not be able to have the immunizations.

They are therefore at greater risk of catching the diseases for which we immunize.

Factors affecting herd immunity – How infectious the disease is

We can look at measles as an example.

Measles is highly infectious. If everyone stopped being immunized against measles, then almost everyone would catch it.

We know that we need at least 90% of children to be immune to stop the disease being spread.

If 95% of children are protected by MMR, then we can eliminate not just measles, but mumps and rubella as well.

In Finland this has already been achieved.

Meningitis, on the other hand, is less infectious.

Up to a quarter of young adults may carry the bugs in their nose and throats but the number of actual cases is relatively low.

Different vaccines:

Diphtheria-Tetanus-acellular Pertussis (DTaP); Diphtheria-Tetanus-Pertussis (DTP); Diphtheria-Tetanus (DT) Vaccines

DTaP vaccine is a routine childhood immunization in the USA. This is a 5-dose series starting at 2 months of age and finishing at 4-6 years of age. It is frequently given in combination with *Haemophilus influenzae* (Hib) vaccine. It is never administered after the 7th birthday. Following completion of the DTaP, DTP, or DT series (by the 7th birthday), **Td vaccine** is given at 11-12 years of age if at least 5 years have elapsed since the last dose of DTaP, DTP or DT.

Diphtheria is a serious disease characterized by a very sore throat, difficulty breathing, paralysis, and heart failure. It is very rare in the USA because of the high immunization rates in children and young adults. Pertussis, or whooping cough, may be a serious disease, especially in infants. It is characterized by choking and coughing - often prolonged. It is highly contagious. Tetanus, or lockjaw, is a very serious disease that may follow a cut, burn, or wound. It causes serious muscle spasms and frequently ends in death. In the USA it is a very rare disease because almost all children and young adults have received the vaccine.

***Haemophilus influenzae* type b (Hib) Vaccine**

Hib vaccine is a routine childhood immunization in the USA. This is a 4-dose series (it may be a 3-dose series depending on the brand of Hib vaccine used) starting at 2 months of age and finishing at 12-15 months of age. Many health care providers give this vaccine in combination with DTaP vaccine. It is not generally recommended for children after the 5th birthday.

Haemophilus influenzae type b disease is a serious, contagious bacterial infection. Before the availability of the Hib vaccine in 1987, *Haemophilus influenzae* was the leading cause of bacterial meningitis among children under 5 years of age in the USA. *Haemophilus influenzae* infection may also cause pneumonia, ear infections, sinus infections, and other severe infections. Because infection with Hib is rare after 5 years of age, older children and adults do not routinely need this vaccine.

Hepatitis B Vaccine

Hepatitis B vaccine is a routine immunization for all children and adolescents in the USA who are 18 years of age and younger. Hepatitis B vaccine is a 3-dose series with 1 month recommended between dose 1 and 2, and 5 months recommended between dose 2 and 3. The duration of protection is many years and there is no specific booster recommendation at this time.

In May, 2001 the FDA licensed and approved a new combination hepatitis A and hepatitis B vaccine for adults 18 years of age and older. It is recommended for persons who are, or will be, at risk of infection with hepatitis A and B viruses. It is administered in 3 doses, 1 each at 0, 1, and 6 months. At this time, the cost of the vaccine is not covered by any medical insurance plan

Hepatitis B is a serious viral infection of the liver transmitted by blood, blood products, objects contaminated with blood, and sexual contact. It can also be transferred from mother to infant at the time of birth, but it is not transmitted by breastfeeding. Hepatitis B infection can cause chronic liver disease, including cancer of the liver. When an infant contracts the disease at birth, it will cause a chronic carrier state up to 90% of the time and serious liver disease up to 25% of the time.

Influenza Vaccines

The Vaccine
There are two types of influenza vaccine:

1. Injectable, inactivated (killed) influenza vaccine, sometimes called the "flu shot" has been used for many years, and is injected into the shoulder.
2. Live, intranasal influenza vaccine (trade name FluMist™) is licensed for use in the 2005 - 2006 influenza season (October - March). It is sprayed into the nostrils rather than injected into the muscle. Both vaccines are the same formulation. Protection develops about 2 weeks after either vaccine and may last up to one year.

Influenza Vaccine Availability
The *injectable "flu shot"* will be available at our "Flu Express" for Camino Medical Group patients only. Contact the **Camino Medical Group** for specific times and dates.

The *intranasal influenza vaccin*e will be available only at the Camino Medical Group Travel Clinic at 325 North Mathilda Avenue, Sunnyvale, CA, 94085 (408 733-4380). The clinic is a walk-in clinic with no appointment needed. The hours are 9 a.m. - 11:30 a.m. and 1:30 p.m. - 3:30 p.m. Monday through Friday. It is not a covered service under any health care insurance, so the patient is responsible for payment.

The Disease
Influenza is a highly contagious respiratory disease. It is caused by a virus that spreads from person-to-person. It is a particularly serious disease in people with chronic disease, residents of long-term care facilities, pregnant women, and children 6 months to 18 years of age receiving chronic aspirin therapy. Influenza causes an average of 36,000 deaths each year in the U.S., mostly among the elderly. Many candidates for influenza vaccine are also candidates for pneumococcal vaccine.

Who Should Be Vaccinated?
An annual influenza vaccine is *recommended* for:

- People 50 years of age and older
- Healthy children 6 - 23 months of age
- Residents of long-term care facilities
- People with long-term health problems, such as heart disease, lung disease, asthma, kidney disease, diabetes, anemia, etc.
- People with weakened immune systems, such as HIV/AIDS, or patients undergoing treatment with steroids, chemotherapy or radiotherapy
- People 6 months to 18 years of age on long-term aspirin treatment
- Pregnant women
- Physicians, nurses, family members, or anyone else coming in close contact with people at risk of serious influenza.

An annual influenza vaccine is *encouraged* for:

- Household contacts and out-of-home caretakers of infants from 0 - 23 months of age
- People who provide essential community services
- People at high risk for flu complications who travel to the Southern hemisphere between April and September, or who travel to the tropics or in organized tourist groups at any time

- People living in dormitories or under other crowded conditions, to prevent outbreaks
- Anyone else who wants to reduce their chance of catching influenza.

Candidates for the intranasal vaccine include:

- School-aged children 5 years or older
- People in large families
- Adults in frequent contact with school-aged children (including family members and teachers)
- Adults in frequent contact with other adults (including working adults, travelers and college students).

The Side Effects

Although vaccines, like medications, are capable of causing serious side effects, the risk from an influenza (injectable or intranasal) vaccine is extremely small. The injectable influenza vaccine may cause fever, aches, or minor soreness, redness, or swelling at the injection site within 1-2 days after vaccination. The intranasal vaccine is a live vaccine and may cause, in children 5 - 17 years of age, runny nose, nasal congestion, fever, headache, muscle aches, abdominal pain or occasional vomiting. In adults, occasional runny nose, nasal congestion, sore throat, headache cough, chills, or tiredness/weakness may occur.

Measles-Mumps-Rubella (MMR) Vaccines

MMR vaccine is a routine childhood immunization in the USA. This is a 2-dose series given initially on or after the 1st birthday and again at 4-6 years of age, but it is acceptable to give the 2 doses any time with as little as 1 month between them. The MMR vaccine should not be given during pregnancy, and female patients should not become pregnant for at least 1month after immunization. For babies age 6-11 months traveling to countries where measles is endemic (e.g., India), a single dose of monovalent measles vaccine (MMR is acceptable) is recommended. If the vaccine is given at age 6-11 months, a routine MMR is still recommended at age 1 year or as soon after as practical.

Measles, mumps and rubella (German measles) are highly contagious, viral diseases that are rare in the USA because of the high level of childhood immunization rates. Immunization of adolescents and young adults with a rubella-containing vaccine is especially important in preventing congenital rubella syndrome (CRS).

Polio Vaccines

Oral polio vaccine (OPV) is no longer recommended as a routine vaccine in the USA; only injectable polio vaccine is used. OPV is no longer manufactured in the USA. It is still widely used in the rest of the world.

Polio vaccine is a routine childhood immunization in the USA. This is a 4-dose series starting at 2 months of age and finishing at 4-6 years of age. To eliminate the risk of serious side effects of the oral polio vaccine (OPV), injectable polio vaccine (IPV) is the recommended vaccine for all doses of the series. There is no recommendation for routine booster immunization for children or adults after completion of the 4-dose series.

Polio is a serious viral infection that was very common before the introduction of polio vaccine in 1955. Since that time, polio has essentially disappeared in the USA. No wild (infectious) case of polio has been reported in the USA during the last 20 years and there has not been a case of wild polio in the entire Western Hemisphere in almost 10 years. However, an outbreak of poliomyelitis is occurring in the Dominican Republic and Haiti. Since July 2000, a total of 3 laboratory-confirmed cases due to vaccine-derived poliovirus type 1 have been identified and an additional 16 persons with acute flaccid paralysis are now under investigation in the Dominican Republic. In Haiti, a single laboratory-confirmed case of paralytic polio has been reported.

It is still expected that polio, like smallpox before, will be eradicated worldwide within the next 5 years.

Tetanus-Diphtheria (Td) Vaccine

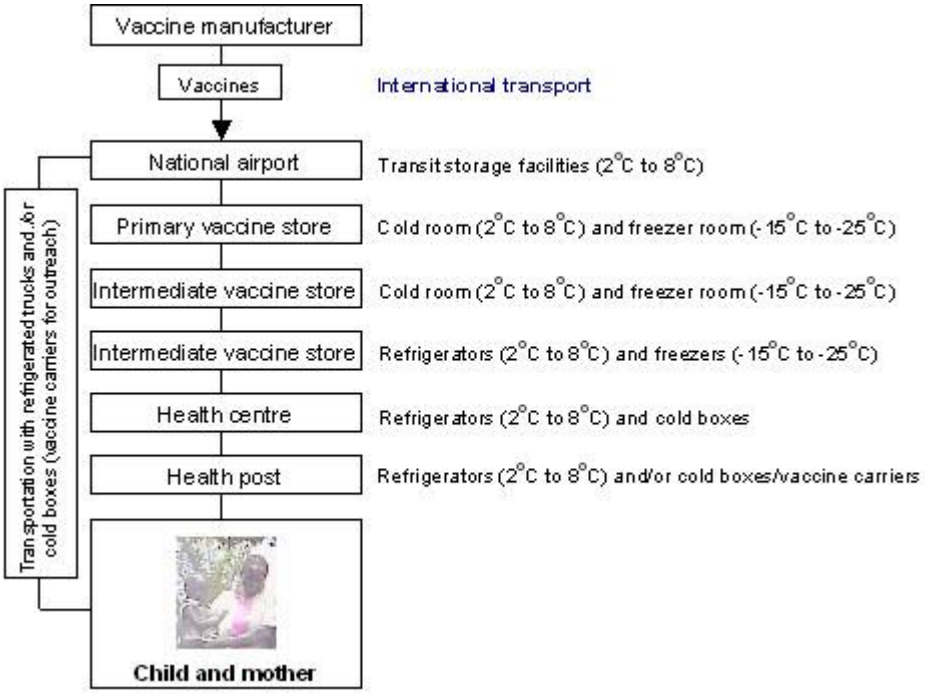
Td vaccine is a routine childhood immunization in the USA for those 7 years of age and older. Following completion of the **DTaP**, DTP, or DT series (by the 7th birthday), Td is given at 11-12 years of age if at least 5 years have elapsed since the last dose of DTaP, DTP or DT. Subsequent Td boosters are recommended every 10 years.

Tetanus, or lockjaw, is a very serious disease that may follow a cut, burn or wound. It causes serious muscle spasms and frequently ends in death. Diphtheria is a serious disease characterized by a very sore throat, difficulty breathing, paralysis, and heart failure. Both diseases are very rare in the USA because of the high immunization rates in children and young adults.

The cold chain

All vaccines are sensitive biological substances and all will lose their potency – that is, their ability to give protection against disease - with time. This loss of potency becomes faster as vaccines are exposed to higher temperatures. In order to maintain their quality, all vaccines must be continuously stored at the appropriate temperature from the time they are manufactured up until the moment of use. Once vaccine potency is lost, it cannot be regained or restored, and without proper care, any vaccine may eventually lose all its potency. If this occurs, the vaccine will no longer provide any protection against the target disease and is then useless. In some cases, heat exposure leading to loss of vaccine potency may also cause the vaccine to become more reactogenic.

The system used for keeping and distributing vaccines in good condition is called the 'cold chain'. This consists of a series of storage and transport links, all of which are designed to keep the vaccine at the correct temperature until it reaches the user. A typical cold chain system for vaccine is shown below.



Different vaccines require different storage conditions, and what is correct for one vaccine may be dangerous for another, so it is vital to know the **correct storage conditions** for each vaccine used. Diluents for vaccines are less sensitive to storage conditions than vaccines, and so are normally not kept in the vaccine cold chain. However they may be kept in the cold chain under certain conditions if space permits. (Also see **vaccine reconstitution and administration**)

The recommended equipment for storage (cold rooms, refrigerators, freezers) and transport (cold boxes, vaccine carriers) has to comply with a **set of performance standards** defined by WHO and UNICEF. **Stock management procedures** have been established so that vaccines are not stored longer than necessary at the central, regional and district levels of the cold chain.

For immunodeficient children, the recommended schedule is shown below:

Table 3 Recommended Immunisation Schedule for Immunodeficient Children

Immunistion	Immunosuppresive therapy	HIV	Sibling/Close Contacts
BCG	No	Yes	Yes
Hep B	Yes	Yes	Yes
DPT	Yes	Yes	Yes
OPV	No	Yes [IPV (killed vaccine)]	Yes (IPV)
Hib	Yes (3 + Booster dose)	Yes (3 + Booster dose)	Yes (3 + Booster dose)
Measles	No	Yes (Asymptomatic)	Yes
MMR	No	Yes (Asymptomatic)	Yes