A Survey on Vaccination Status of Slum-Dwelling Children in Dhaka City

A Thesis Report submitted to the Department of Pharmacy, East West University, Bangladesh, in partial fulfillment of the requirements for the degree of M. Pharm in Clinical Pharmacy and Molecular Pharmacology

Submitted by:
Md. Faisal
ID: 2013 – 3 – 79 – 040

Dissertation Supervisor:
Ms. Tilka Fannana
Senior Lecturer
Department Of Pharmacy
East West University

East West University

Declaration by the Research Candidate

I, **Md. Faisal (ID: 2013 – 3 – 79 – 040)**, hereby declare that the dissertation, entitled **"A Survey on Vaccination status of slum-dwelling children in Dhaka city"**, submitted to the Department of Pharmacy, East West University, in the partial fulfillment of the requirement for the degree of M. Pharm in Clinical Pharmacy and Molecular Pharmacology (Masters) is a bona fide record of original research work carried out by me under the supervision and guidance of **Ms. Tilka Fannana**, Senior Lecturer, Department of Pharmacy, East West University. The contents of this dissertation, in full or in parts, have not been submitted to any other institute or University for the award of any degree or Diploma of Fellowship.

_____

Md. Faisal

ID: 2013 – 3 – 79 – 040
Department of Pharmacy
East West University

Certification by the Supervisor

This is to certify that the dissertation, entitled "**A Survey on Vaccination status of slum-dwelling children in Dhaka City**" submitted to the Department of Pharmacy, East West University, in partial fulfillment of the requirements of the Degree of M. Pharm in Clinical Pharmacy and Molecular Pharmacology was carried out by **Md. Faisal** (ID: 2013 – 3 – 79 – 040) under my guidance and supervision and no part of the project has been submitted for any other degree. We further certify that all the sources of information and facilities availed of in this connection duly acknowledged.

_____

Ms. Tilka Fannana

Senior Lecturer

Department of Pharmacy

East West University

Dhaka, Bangladesh

Endorsement by the Chairperson

This is to certify that the dissertation, entitled **"A Survey on Vaccination status of slum-dwelling children in Dhaka City"** submitted to the Department of Pharmacy, East West University is a bona fide research work done by **Md. Faisal** (ID: 2013 – 3 – 79 – 040) under the guidance of **Ms. Tilka Fannana**, Senior Lecturer, in partial fulfillment of the requirement for the degree of M. Pharm in Clinical Pharmacy and Molecular Pharmacology. We further indorse that all the sources of information and facilities availed of in this connection is duly acknowledged.

_____

Dr. Shamsun Nahar Khan

Chairperson & Associate Professor

Department of Pharmacy

East West University

Dhaka, Bangladesh

ACKNOWLEDGEMENTS

At the beginning, I would like to remember the mercy and kindness of Almighty Allah for given me the opportunity to study in this subject and the ability to complete my M. Pharm in Clinical Pharmacy and Molecular Pharmacology including this research appropriately.

I would like to express my sincere thanks and gratitude towards my supervisor **Ms. Tilka Fannana,** Senior Lecturer, Department of Pharmacy, East West University, for her mastermind direction, constant supervision and support, optimistic counseling and continuous guidance to carry out the research work as well as to prepare this dissertation. Her generosity with time and constructive comments were of vital support and were above the call of duty.

I would also like to put forward my most sincere regards & profound gratitude to **Dr. Shamsun Nahar Khan**, Chairperson & Associate Professor, Department of Pharmacy, East West University, for giving me the opportunity to conduct such an interesting project & for facilitating a smooth conduction of my study.

I would like to express my sincere gratitude to my parents and all of friends for their whole hearted inspiration and continuous support which helped me to go along of this research.

DEDICATION

This research paper is dedicated to my beloved parents for their unconditional support

List of Contents

LIST OF TABLES

LIST OF FIGURES

List of Abbreviations

BCG = Bacille-Calmette-Guerin

CDC = Centers for Disease Control and Prevention

CES = Coverage Evaluation Survey

DNA = Deoxy-ribo Nucleic Acid

DPT = Diphtheria, Pertussis and Tetanus

DTaP =Diphtheria, Tetanus acellular Pertussis

EPI = Expanded Program on Immunisation

FVC = Fully Vaccinated Coverage

GAVI = Global Alliance for Vaccine and Immunisation

GIVS = Global Immunization Vision and Strategy

HAV = Hepatitis A Virus

HBV = Hepatitis B Virus

Hib = Haemophilus influenzae type b

HPV = Human Papilloma Virus

IAVI = International AIDS Vaccine Initiative

HIV = Human Immunodeficiency Virus

ICDDRB = International Centre for Diarrhoeal Disease Research, Bangladesh

IG = Immuno-Globulin

IIS = Immunization Information System

IM = Intra-Muscular

IPV = Inactivated Polio Virus

MCV = Measles Containing Vaccine

MDGs = Millennium Development Goals

MMR =Measles-Mumps-Rubella

NNT = Neo-Natal Tetanus

NIAID = National Institute of Allergy and Infectious Diseases

OPV = Oral Polio Virus

PAB = Protection at Birth against tetanus

PCV = Pneumococcal Conjugate Vaccine

VZV =Varicella-Zoster Virus

RNA = Ribo-Nucleic Acid

Td = Tetanus Toxoids and Diphtheria Booster

TdaP =Tetanus-Diphtheria-Acellular Pertussis Booster

TB = Tuberculosis

TT = Tetanus Toxoid

UCI = Universal Child Immunization

UNICEF = United Nations International Children Emergency Fund

USAID = United States Agency for International Development

UTD = Urinary Tract Disease

VAPP = Vaccine-Associated Paralytic Poliomyelitis

VDPV = Vaccine-Derived Polio Virus

cVDPV = Circulating Vaccine-Derived Poliovirus

WHO = World Health Organisation

Introduction

1.1. Overview

Immunizations, also called vaccinations or inoculations, protect children against more than a dozen serious diseases that can cause severe illness, lifelong disabilities, or even death. The best time to immunize children is when they are young. This is because most of the diseases for which vaccinations are available are more common and cause more severe complications in young children. Children who are not immunized until they are older are at increased risk for exposure to disease without protection.

Immunizations work by introducing microorganisms (e.g; bacteria, virus) into the immune system, usually through an injection (shot). The immune system attacks the bacteria or virus, produces antibodies to prevent infection, and learns to recognize the bacteria or virus again if the child is exposed in the future.

Some vaccinations, such as those for measles or hepatitis B, provide lifelong immunity (protection from disease) and others, like tetanus or pertussis (whooping cough) must be periodically re-administered (called booster shots). Parents and caregivers should keep an accurate record of their child's immunizations so they know when he or she is due for a booster shot.

According to the Centers for Disease Control and Prevention (CDC), vaccination coverage increased or remained stable for recommended childhood immunizations in 2013. Coverage ranged from about 73 percent to over 90 percent for individual vaccines. The CDC reported that less than 1 percent of children received no vaccines in 2013. Children living in poverty generally had lower vaccine/booster coverage than those living above poverty level. In many countries throughout the world, rates of immunization are lower than in the United States. Since diseases can spread very quickly, in part, due to air travel, and children may come into contact with people who have not been immunized, the best way to prevent many diseases is through vaccination (Swierzewski, 2008).

1.2. Vaccine

A vaccine is a substance that is introduced into the body to prevent infection or to control disease due to a certain pathogen (a disease-causing organism, such as a virus, bacteria or parasite). According to IAVI (Vaccine Science, International AIDS Vaccine Initiative), the vaccine "teaches" the body how to defend itself against the pathogen by creating an immune response. Unlike traditional pharmaceuticals, vaccines are biologics since they are made from living organisms (biological sources).

Specifically, vaccines are preparations of components derived from a pathogen, they can typically induce a protective effect through one to three very small doses, in the range of micrograms to milligrams. Immunity lasts for an extended period, from one year up to lifetime protection, including prevention of disease and or related sequelae (Exan, 2008).

1.3. Mechanism of Vaccine

Disease-causing organisms to exhibit two distinct types of effects on the body. The first are the obvious effects including symptoms such as fever, nausea, vomiting, diarrhea, rash and many others. second, less obvious, promoting the immune system's response to the infection. As the immune response increases in strength over time, the infectious agents are slowly reduced in number until symptoms disappear and recovery is complete. In general, vaccines are designed to imitate the second effect without the consequences of the first. (Landry & Heilman, 2005)

The following steps summarize how a preventive vaccine can protect an individual from infection or disease:

a) The vaccine introduces a small component or a non-harmful form of the pathogen into the body. This is called the foreign antigen or immunogen.

• "Foreign" indicates that the antigen is not from the person's own body.

• An antigen is defined as any substance that is recognized by a component of the immune system, i.e. antibodies, cells. Antigens are often agents such as invading bacteria or viruses.

• Similarly, immunogens are substances capable of provoking an immune response.

b) The body's immune system produces an immune response to the pathogen by generating antibodies, killer cells, or both.

• In the first type of immune response (known as the humoral response), the body's B-cells

produce antibodies that neutralize and help eliminate antigens in the blood, on epithelial surfaces, and in the fluid that bathes tissues.

• In the second type of immune response (termed the cell-mediated response), specific killer cells called cytotoxic T-cells attack cells in the body that have become infected.

c) A small group of "memory" B-cells and T-cells remain in the body and can quickly initiate a strong immune response, i.e. by producing antibodies, and helping the production of killer T-cells or antibodies, respectively. The next time the real pathogen is encountered, the immune system remembers it and mounts a much larger, quicker response than it would have if the individual had never received the vaccine. This is called "immune memory".

d) This larger, quicker immune response can act in several ways to fight infection and/or disease:

• by stopping replication of the pathogen, so it cannot infect more cells, or

• by producing antibodies that attach to the pathogen, rendering it harmless (humoral response), or

• by producing immune cells that attack and kill other cells that have been infected with the pathogen (cell-mediated response) (French, 2008).

Once a person's immune system is "trained" to resist a specific disease, the person is said to be immune to that disease. Specific immunity refers to a response that is initiated by an antigen (e.g. derived from a pathogen), and in which the immune system remembers each antigen it has previously encountered. Thus, unlike nonspecific defense mechanisms (such as the skin barrier or mucus production), which do not distinguish one infectious pathogen from another, specific immunity permits the body to recognize and defend against invading pathogens. Specific immunity can result from either active or passive immunization, and both modes of immunization can occur by natural or artificial processes. (Ghaffar & Haqqi, 2008).

1.4.Types of Immunity

1.4.1. Active Immunity

The term "active immunity" refers to immunity produced by the body following exposure to antigens. Naturally acquired active immunity occurs when the person is exposed to a live pathogen, develops the disease – with clinical or sub-clinical symptoms – and becomes immune

as a result of the primary immune response (upon first exposure) to the pathogen. In contrast, artificially acquired active immunity can be induced by a vaccine that contains the antigen (administered in the form of live, attenuated or dead pathogens or their components). In this case, the vaccine stimulates a primary immune response against the antigen without causing symptoms of the disease. In this context, it should be emphasized that vaccines are highly specific to the particular disease agent from which they are derived. While active immunity takes longer to develop than passive immunity, it also lasts much longer, and is often lifelong.

1.4.2. Passive Immunity

In the case of "passive immunity", immunity is acquired without the immune system being challenged with an antigen, but rather, by transfer of antibodies from an immune donor (human or animal) to a non-immune individual. Alternatively, immune cells from an immunized individual may be used to transfer immunity. Naturally acquired passive immunity occurs during pregnancy, in which certain antibodies, e.g. immunoglobulin G (IgG), are passed through the placenta (from the maternal into the fetal bloodstream), or via colostral (firstmilk) transfer of immunoglobulin A (IgA). In contrast, artificially acquired passive immunity can be achieved by the injection of antibodies (such as gamma-globulins from other individuals or gamma-globulin from an immune animal) that are not produced by the recipient's cells. This type of approach can provide very rapid, although short-lived, resistance to infection, and is generally used when there is no time to wait for the development of active immunity, or when no effective active vaccine exists. For example, artificial transfer of immunity is practiced in numerous acute situations of infections (diphtheria, tetanus, measles, rabies, etc.), poisoning (insects, reptiles, botulism), and as a prophylactic measure (hypogammaglobulinemia) (Offit, 2007).

1.5. Preparation of vaccine

A live, virulent organism cannot be used as a vaccine because it would induce disease. Hence, the first step in making a vaccine is to isolate or create an organism or component that is unable to cause full-blown disease, but that still retains the antigenicity responsible for inducing the host's immune response. This general approach can be pursued in several ways. (Landry & Heilman, 2005).

In some cases, bacteria or viruses are killed with chemicals or heat-inactivated (killed, inactivated vaccines) or grown in cell culture in order to disable their virulent properties (live, attenuated vaccines). In other cases, the entire pathogen is not required; only the antigens that best stimulate the immune system such as proteins or polysaccharides are used (subunit, acellular vaccines). Understanding vaccines, what they are and how they work, National Institute of Allergy and Infectious Diseases (NIAID) developed strategy, this strategy also includes the use of toxoids (inactivated toxins), i.e. for certain pathogens that secrete harmful chemical toxins that cause illness. Other more recently developed subunit vaccines are known as conjugate vaccines, in which antigens (such as bacterial polysaccharides) are linked to a carrier protein in order to evoke a stronger immune response. Finally, newer investigative approaches involve the use of deoxyribonucleic (or ribonucleic) acid coding for a component of the agent in the vaccine (DNA/RNA vaccines). The DNA or RNA can be transferred using a viral vector in which a non-pathogenic form of a virus is used (recombinant vaccines) (French, 2008).

1.6. Vaccine Types and Immune Responses

Vaccine type	Definition	Immune response	Examples
Killed, inactivated	Pathogen is killed, usually through a chemical process such as formalin	Evokes a robust immune response that mimics most of the responses seen during an infection	• Typhoid vaccine • Salk polio vaccine • Hepatitis A vaccine
Live, attenuated	Pathogen is weakened by genetic manipulations such that growth in the host is limited and does not cause disease; other version of live vaccine is using an organism that is related to the pathogen, but grows poorly, naturally, in humans	Evokes a broad immune response similar to that seen by the host infected with a natural pathogen	• Oral Sabin polio vaccine • Nasal influenza vaccine • Bacille Calmette-Guerin(BCG) vaccine • Varicella vaccine • Rotavirus vaccine
Subunit, acellular	Well-defined part(s) of the organism is purified and used as an antigen (e.g. proteins, peptides, polysaccharides, inactivated toxins)	A fragment of the "whole agent" vaccine can create an immune response	• A cellular pertussis Vaccine

Vaccine Type	**Definition**	**Immune response**	**Examples**
Conjugate	Poorer antigens (such as bacterial polysaccharides) are chemically linked to a carrier protein	Addition of other proteins (via conjugation) confers the immunological attributes of the carrier to the antigen, and thus evokes a stronger immune response ; effective approach for younger children	Haemophilus influenza type b (Hib) conjugate vaccine • Pneumococcal conjugate vaccine • Meningococcal C conjugate vaccine • Meningococcal (A, C, Y, W-135) conjugate vaccine
DNA/RNA	Genetic material from the pathogen enter into human cells and use the cell's "equipment" to produce some protein(s) of the pathogen encoded by the gene(s)	Immune system detects protein as a foreign or harmful antigen, produces an immune response, also will prepare a response against whole pathogen	• AIDS vaccine (in development)
Recombinant	Defined genes are incorporated into plasmid vehicle to allow for the production of large quantities of well-defined proteins	Immune response can be modified and targeted by insertion of specific genetic sequences	• Hepatitis B vaccine • Human Papilloma-virus (HPV) vaccine • AIDS vaccine (in development)

Table 1.1. Vaccine Types and Immune Responses (Landry and Heilman, 2005).

1.7. Immunization programme in Bangladesh

1.7.1. Historical perspective of Expanded Program on Immunization (EPI)

EPI in Bangladesh was launched on April 7, 1979 (World Health Day). As vaccination centres were few and were located mainly in health care facilities in urban areas, the EPI coverage remained less than 2% by 1984. In 1985, the Government of the People's Republic of Bangladesh committed to the Global Universal Child Immunization Initiative (UCI), and began a phase-wise process of EPI intensification from 1985-1990. During this time period, EPI was intensified throughout 476 Upazilas, 92 major Municipalities and 6 City Corporations. EPI was made available to all target groups (infants and pregnant mothers) by 1990.

EPI intensification consisted of establishing the cold chain system from EPI HQ to District and Upazila level and capacity to maintain cold chain down to the vaccination points in rural and urban areas, procuring and managing logistics needs for about 134,000 EPI outreach sites, and providing basic EPI training for thousands of mid-level managers, supervisors and field workers in the public and private sectors.

During the last few years, based on the data on disease burden, new vaccines for selected emerging diseases such as Hepatitis- B and Hemophilus influenza type b (Hib) Disease have been introduced into the EPI schedule. Hepatitis B vaccine was incorporated into the programme with GAVI (Global Vaccine Alliance, an international organisation, bringing together public and private sectors with the shared goal of creating equal access to new and underused vaccines for children living in the world's poorest countries) phase 1 support bundle with injection safety supply later followed by the introduction of Hib antigen (as combined Pentavalent vaccine with GAVI support). Vitamin A supplementation was added to the programme in 1990. In view of enhancing the injection safety auto disable syringes were introduced in to the programme from 2004. Since 1995 to 2010, 18 National immunization days were conducted with very high (around 90%) coverage in Bangladesh in view of eradicating Polio. Measles catch up programme was conducted in 2005 (Government of People's Republic of Bangladesh, 2011-2016).

1.7.2. National Immunization schedule in Bangladesh

According to the current Immunization Schedule for Bangladesh, all the children during their first year of life should be immunize with BCG, OPV, Pentavalent and Measles before reaching the age of one year.

EPI immunization schedule of Bangladesh for children 0 - 1 year of age:

Vaccine	**Disease**	**No. of doses**	**Interval between doses**	**Starting time of doses**	**Route of administration**
BCG	Tuberculosis	1	-	After birth/ If not possible with Penta 1	Intra dermal
Pentavalent	Diphtheria,Pertussis, Tetanus, Hepatitis B, Haemophilus Influenza B	3	4 Weeks	6 weeks of age	IM
PCV	Pneumococcal Pneumonia	3	4 Weeks	6 weeks of age	IM
OPV	Poliomyelitis	4(additional 0 dose at birth)	4 Weeks	6 weeks of age	Oral
MR	Measles Rubella	1	-	After completion of 9 months	Subcutaneous
Measles	Measles	1	-	After completion of 15 months	Subcutaneous

Table 1.2. EPI immunization schedule of Bangladesh for children aged 0 - 1 year (Incepta vaccine limited, 2016).

EPI immunization schedule of Bangladesh for women of child bearing age (15-49 years):

Vaccine	**Disease**	**No. of Dose**	**Starting time of doses**	**Route of administration**
MR	Measles & Rubella	1	At 15 years with the 1st dose of TT	Subcutaneous
TT(Tetanus Toxoid)	Tetanus	5	TT-1: At 15 years	IM
			TT-2: 28 days after TT-1	IM
			TT-3: 6 months after TT-2	IM
			TT-4: 1 year after TT-3	IM
			TT-5: 1 year after TT-4	IM

Table 1.3. EPI immunization schedule of Bangladesh for women of child bearing age (15-49 years) (Incepta vaccine limited, 2016).

1.7.3. Immunization Coverage Performance in Bangladesh

The programme has prevented an estimated 2 million deaths from 1987-2000, and continues to prevent approximately 200,000 deaths each year. The trend of immunization coverage – a key measure of immunization system performance, shows that the Immunization program has strong capacity to reach children with BCG (94%), third dose of Diphtheria-Pertussis-Tetanus (DPT-3) (96%), Polio-3 (96%) and Measles (98%).

However, only 75% of children one year of age are fully immunized with all doses of vaccines which they are supposed to receive during the first year of life. At the same time, significant disparity can be observed regarding the immunization coverage among districts as 13 out of 64 (20%) districts are having DPT-3 coverage less than 80%, and 11 out of 64 (17%) districts are having Measles coverage less than 80%.

These are the key areas that EPI programme need to address in the future in view of achieving and sustaining the vaccine preventable disease control. It is noteworthy that in the past five years, the percentage of fully immunized children has shown a substantial increase (from 64% in 2005 to 75% in 2009).

Tetanus (TT) coverage among pregnant women shows that 93% of children were protected at birth from the number needed to treat (NNT). The TT coverage among 15-49 years women is 97% for TT-1, 95% for TT-2, 86% for TT-3, 70% for TT-4 and 52% for TT-5 (complete protection). Fifty-five out of 64 districts (86%) have TT-2+ coverage (received more than 2 doses of TT at the time of pregnancy) less than 50%. There is therefore a need to ensure that the performance is improved especially for TT vaccination for 15-49 years women and to focus on strengthening the weak districts in view of maintaining the NNT elimination status.

The Coverage Evaluation Survey (CES) 2010 revealed that Fully Vaccinated Coverage (FVC) rate increased by 4 per cent in CES 2010 (from 75 per cent in 2009). Across the country, 79 per cent of the surveyed children aged between 12- 23 months were found to be fully vaccinated before observing their first birthday along with the highest coverage for BCG at 99 percent, DPT3 89 per cent, and measles 85 per cent. Compared to BCG, a marked declination (14 per cent lower) in measles coverage was observed in CES 2010. Over the period between 2005 and 2010, DPT3 coverage increased by 12 per cent while the measles coverage increased by 14 per cent (Government of People's Republic of Bangladesh, 2011–2016).

1.8. Description on Different Types of Vaccines

1.8.1. BCG Vaccine

BCG means Bacillus Calmette–Guérin, historically known as Vaccin Bilié de Calmettee Guérin commonly referred to as Bacille de Calmette et Guérin is a vaccine against tuberculosis. It is prepared from a strain of the attenuated live bovine tuberculosis bacillus named as Mycobacterium bovis, that has lost its virulence in humans. Because the living bacilli evolve to make the best use of available nutrients, they become less well-adapted to human blood and can no longer induce disease when introduced into a human host.

1.8.1.1. History of BCG

The history of BCG is tied to that of smallpox. Jean Antoine Villemin first recognized bovine tuberculosis in 1854 and transmitted it, and Robert Koch first distinguished Mycobacterium bovis from Mycobacterium tuberculosis. Following the success of vaccination in preventing smallpox, established during the 18th century, scientists thought to find a corollary in tuberculosis by drawing a parallel between bovine tuberculosis and cowpox: it was hypothesized that infection with bovine tuberculosis might protect against infection with human tuberculosis. In the late 19th century, clinical trials using M. bovis were conducted in Italy with disastrous results, because M. bovis was found to be just as virulent as M. tuberculosis.

Albert Calmette, a French physician and bacteriologist, and his assistant and later colleague, Camille Guérin, a veterinarian, were working at the Institut Pasteur de Lille (Lille, France) in 1908. Their work included subculturing virulent strains of the tubercle bacillus and testing different culture media. They noted a glycerin-bile-potato mixture grew bacilli that seemed less virulent, and changed the course of their research to see if repeated subculturing would produce a strain that was attenuated enough to be considered for use as a vaccine. BCG strain was isolated after 239 times subculturing during 13 years from virulent strain on glycerine potato medium. The research continued throughout World War I until 1919, when the now avirulent bacilli were unable to cause tuberculosis disease in research animals. They transferred to the Paris Pasteur Institute in 1919. The BCG vaccine was first used in humans in 1921. (Pem et al., 1999).

1.8.1.2. BCG schedule

The BCG vaccine can be anywhere from 0 to 80% effective in preventing tuberculosis for a duration of 15 years. In countries where tuberculosis is common one dose is recommended in healthy babies as close to the time of birth as possible. Babies with HIV/AIDS should not be vaccinated. In areas where tuberculosis is not common, only babies at high risk are typically immunized while suspected cases of tuberculosis are individually tested for and treated. Adults who do not have tuberculosis and have not been previously immunized but are frequently exposed to drug resistant tuberculosis may be immunized as well.

1.8.1.3. Method of administration of BCG

Except in neonates, a tuberculin skin test should always be done before administering BCG. A reactive tuberculin skin test is a contraindication to BCG. Someone with a positive tuberculin reaction is not given BCG, because of severe local inflammation and scarring. BCG is given as a single intradermal injection at the insertion of the deltoid. If BCG is accidentally given subcutaneously, then a local abscess may form that can sometimes ulcerate, and may require treatment with antibiotics immediately, otherwise it could spread the infection causing severe damage to vital organs .Nonetheless, the buttock is an alternative site of administration because it provides better cosmetic outcomes.

1.8.1.4. Adverse effects of BCG Vaccine

BCG immunization generally causes some pain and scarring at the site of injection. The main adverse effects are keloids—large, raised scars. The insertion of deltoid is most frequently used because the local complication rate is smallest. BCG vaccine should be given intradermally. If given subcutaneously, it may induce local infection and spread to the regional lymph nodes, causing either suppurative and nonsuppurative lymphadenitis. Conservative management is usually adequate for nonsuppurative lymphadenitis. If suppuration occurs, it may need needle aspiration. For nonresolving suppuration, surgical excision may be required. Uncommonly, breast and gluteal abscesses can occur due to haematogenous and lymphangiomatous spread. Regional bone infection BCG osteomyelitis or osteitis and disseminated BCG infection are rare complications of BCG vaccination, but potentially life-threatening. (Mahler &Ali, 1955)

In 2007, WHO stopped recommending BCG for infants with HIV, even if there is a high risk of exposure to TB, because of the risk of disseminated BCG infection.

1.8.1.5.Contra-indications of BCG Vaccine

a) Immunosuppression: BCG vaccination should not be given to persons who are immunosuppressed (e.g., persons who are HIV infected) or who are likely to become immunocompromised (e.g., persons who are candidates for organ transplant).

b) Pregnancy: BCG vaccination should not be given during pregnancy. Even though no harmful effects of BCG vaccination on the fetus have been observed, further studies are needed to prove its safety. (CDC, 1998)

1.8.2. Diphtheria Vaccine

Diphtheria vaccine is a vaccine used against Corynebacterium diphtheriae, the agent that causes diphtheria. It use has resulted in a more than 90% decrease in number of cases globally between 1980 and 2000.

1.8.2.1. History of Diphtheria

Diphtheria has been infecting humans for centuries. Hippocrates produced the first documented description of diphtheria in the fifth century BC. The disease has been a leader in causing death, especially in children, for many centuries. The bacteria were first identified in the 1880s by F. Loffler. In the 1890s, exotoxins were discovered. The first diphtheria toxoid vaccine was produced in the 1920s. Vaccination programs have decreased the incidence of diphtheria worldwide, however, when vaccination rates drop, infection rates of diphtheria rise and, occasionally, serious outbreaks of the disease occur. For example, in the 1990s, an epidemic in Russia caused about 5,000 deaths according to the World Health Organization's (WHO) statistics, and from about 1993-2003, Latvia reported 101 deaths from diphtheria.

Before the diphtheria vaccination program, there were 100,000 to 200,000 cases of diphtheria each year in the U.S., leading to approximately 15,000 to 20,000 deaths. According to the CDC, less than five cases have been reported in the U.S. in the last 10 years. (CDC, 2011).

1.8.2.2. Diphtheria Schedule

Three initial doses are recommended after which it is about 95% effective. It is effective for about 10 years at which time a booster dose is needed. Immunization may start at six weeks of age with further doses given every four weeks.

1.8.2.3. Side effects of Diphtheria

The diphtheria vaccine is very safe. Significant side effects are rare. Pain may occur at the injection site. A bump may form at the site of injection that lasts a few weeks. The vaccine is safe in both pregnancy and among those who have a poor immune function. (Atkinson & William, 2012).

1.8.2.4. Prevention of Diphtheria

Several combination vaccines are used to prevent diphtheria. This includes with tetanus toxoid (known as dT or DT vaccine) and with tetanus and pertussis vaccine known as DPT vaccine. The World Health Organization has recommended it use since 1974. About 84% of the world population is vaccinated. It is given as a intramuscular injection. The vaccine needs to be kept cold but not frozen.

1.8.3. Pertussis (Whooping Cough) Vaccine

Whooping cough known medically as pertussis is a highly contagious respiratory tract infection caused by the Bordetella pertussis bacterium. This bacteria produce toxins that paralyze parts of respiratory cells, leading to inflammation in the respiratory tract. The incubation period for pertussis is generally between 7-10 days long, but can last more than a month. After symptoms first appear, the disease can take weeks to months to fully run its course.

1.8.3.1. History of Pertussis

B. pertussis was discovered in 1906 by Jules Bordet and Octave Gengou, who also developed the first serology and vaccine. Efforts to develop an inactivated whole-cell vaccine began soon after B. pertussis was cultured that year. In the 1920s, Louis W. Sauer developed a weak vaccine for whooping cough at Evanston Hospital (Evanston, IL). In 1925, Danish physician Thorvald

Madsen was the first to test a whole-cell vaccine on a wide scale. Madsen used the vaccine to control outbreaks in the Faroe Islands in the North Sea. (Baker & Katz, 2004)

1.8.3.2. Pertussis Schedule

For children, the immunizations are commonly given in combination with immunizations against tetanus, diphtheria, polio, and haemophilus influenzae type B at ages two, four, six, and 15–18 months. A single later booster is given at four to six years of age (US schedule). In the UK, pertussis vaccinations are given at 2, 3, and 4 months, with a pre-school booster at 3 years 4 months.

In 2006 the CDC recommended adults receive pertussis vaccination along with the tetanus and diphtheria toxoid booster. In 2011 they began recommended boosters during each pregnancy. In the UK vaccination of pregnant women (between 28 and 38 weeks of pregnancy) is also recommended. (Kline, 2013).

1.8.3.3. Pertussis side effects

Local reactions, such as fever, redness and swelling at the injection site, and soreness and tenderness where the shot was given, are not uncommon in children and adults. These minor local and systemic adverse reactions are much less common with acellular Diphtheria, Tetanus and Pertussis (DTaP) vaccine; however, a determination of more rare adverse effects can only be made when additional data are available following extended use of DTaP.

1.8.3.4. Prevention of Pertussis

The best way to prevent it is through vaccinations. The childhood vaccine is called DTaP. The whooping cough booster vaccine for adolescents and adults is called Tetanus, Diphtheria, Pertussis (Tdap). Both DTaP and Tdap protect against whooping cough, tetanus, and diphtheria. The best way to prevent pertussis (whooping cough) is to get vaccinated. There are vaccines for babies, children, preteens, teens, and adults (Kline, 2014).

1.8.4. Tetanus Vaccine

Tetanus vaccine is a vaccine composed of deactivated tetanus toxins. This vaccine is immunogenic but not pathogenic and is used to prevent an individual from contracting tetanus.

Tetanus vaccine, also known as tetanus toxoid. Tetanus, also known as lockjaw, caused by the bacterium Clostridium tetani which enters the body through open wounds and releases a poison called tetanospasmin. This is a potentially deadly disease because the poison attacks the nervous system blocking nerve signals from the spinal cord to and from the muscles.

1.8.4.1. History of Tetanus

The first vaccine for passive immunology was discovered by a group of German scientists under the leadership of Emil von Behring in 1890. The first inactive tetanus toxoid was discovered and produced in 1924. This vaccine was proven to be successful when it was used to prevent tetanus in the military during World War II. DTP (which is the vaccine for diphtheria, tetanus, and pertussis) was first used in 1930 and was continued until 1991 when it was replaced with a different form which included the acellular pertussis vaccine because of safety concerns. Half of those who received the DTP vaccine had redness, swelling, and pain around the injection site which convinced researchers to find a replacement vaccine.

Two new vaccines were launched in 1992. These combined tetanus and diphtheria with acellular pertussis (TDaP or DTaP) which could be given to adolescents and adults (as opposed to previously when the vaccine was only given to children) (CDC, 2011).

1.8.4.2. Tetanus Schedule

Because DTaP and DT are administered to children less than a year old, the recommended location for injection is the anterolateral thigh muscle. However, these vaccines can be injected into the deltoid muscle if necessary. DTaP occurs in four doses. The first dose should be around two months of age, the second at four months age, the third at six months of age, and the fourth from fifteen months of age to eighteen months of age. There is a recommended fifth dose to be administered to four to six year olds.

TD and TDaP are to be administered to older children, adolescents, and adults so it can therefore be injected into the deltoid muscle. These are boosters and are therefore to be administered at least every ten years. And it is safe to have shorter intervals between a single dose of Tdap and a dose of the Td booster. (Talbot & Elizabeth, 2010)

1.8.4.3. Mechanism of action of Tetanus

The type of vaccination produces artificial active immunity. This type of immunity is generated when a dead or weakened version of the disease enters the body causing an immune response which includes the production of antibodies. This is beneficial to the body because if the disease is ever introduced into the body, the immune system will recognize the antigen and produce antibodies more rapidly (Vaccines & Immunizations, 2011).

1.8.4.4. Prevention of Tetanus

Disease is preventable through injecting multiple doses of vaccines and administering the recommended booster shot every ten years. During childhood five doses are recommended followed by additional doses every ten years. After three doses almost everyone is immune. In those who are not up to date on their tetanus immunization a booster should be given within 48 hours of an injury. In those with high risk injuries who are not fully immunized tetanus antitoxin may also be recommended it is on the World Health Organization's List of Essential Medicines.

1.8.4.5. Side effects of Tetanus

The common side effects include fever, redness, swelling around the injections, and soreness or tenderness around the injection site. There may be body aches and tiredness following the Tdap. Td / Tdap can cause painful swelling of the arm and reactions around the injections site, up to about 3 in 100. In Denmark there are some cases related with serious reactions of vaccination including "heavy edematous local reactions, urticaria, arthralgia, nephrosis, and anaphylactic shock".

1.8.4.6. Complications of Tetanus

Infants younger than six months of age are particularly at risk for complications and death. Complications include pneumonia, seizures, ear infections, and dehydration, rib fracture from coughing is also possible in adult. Common complications in infants is B. pertussis pneumonia, which accompanies by deaths from pertussis. (Talbot & Elizabeth, 2010).

1.8.5. Measles Vaccine

Measles vaccine is a vaccine that is very effective at preventing measles. After one dose 85% of children nine months of age and 95% over twelve months of age are immune. Nearly all of those who do not develop immunity after a single dose develop it after a second dose. When rates of vaccination within a population are greater than 93% outbreaks of measles typically no longer occur; however, they may occur again if rates of vaccination decrease. The vaccine's effectiveness lasts many years. It is unclear if it becomes less effective over time. The vaccine may also protect against the disease if given within a couple of days of being exposed.

1.8.5.1. History of Measles

The first ever trials of measles vaccine were undertaken by David Morley at the Wesley Guild Hospital in Ilesha, Nigeria on his own children.

Dr. Maurice Hilleman at Merck & Co., a pioneer in the development of vaccinations, developed the MMR vaccine in 1971, which treats measles, mumps and rubella in a single shot followed by a booster. One form is called "Attenuvax" with more than 40 peptide sequences. The measles component of the MMR vaccine uses Attenuvax, which is grown in a chick embryo cell culture using the Enders' attenuated Edmonston strain. (Hileman & Maurice, 1992).

1.8.5.2. Measles Schedule

The World Health Organization recommends two doses of vaccine for all children. In countries with high risk of disease the first dose should be given around nine months of age. Otherwise in low risk countries it can be given at twelve months of age. The second dose should be given at least one month after the first dose. This is often done at age 15 to 18 months (WHO, 2009).

The CDC recommends that children aged 6 to 12 months traveling outside the United States receive their first dose of Mumps, Measles & Rubella (MMR) vaccine. Otherwise the first dose is typically given between 12–18 months. A second dose is given by 7 years (on or before last day of year 6) or by Kindergarten entry. Vaccine is administered in the outer aspect of the upper arm. In adults, it is give subcutaneously and a second dose 28 days apart is given. In adults greater than 50 years, only one dose is needed (CDC, 2011).

1.8.5.3. Side effects of Measles

The vaccine is generally safe including in those with HIV infections. Side effects are usually mild and short lived. This may include pain at the site of injection or mild fever. Anaphylaxis has been documented in about one per hundred thousand people. Rates of Guillain–Barré syndrome (a disorder in which the body's immune system attacks part of the peripheral nervous system), autism and inflammatory bowel disease do not appear to be increased.

1.8.5.4. Adverse effects of Measles

Adverse effects associated with the MMR vaccine include fever, injection site pain and, in rare cases, red or purple discolorations on the skin known as thrombocytopenic purpura, or seizures related to fever (febrile seizure). Serious side effects are extremely rare.

There is no evidence of a link between the MMR vaccine and autism. The MMR vaccine does not appear to cause subacute sclerosing panencephalitis.

1.8.5.5. Contraindications of Measles

- Pregnancy: MMR vaccine and its components should not be administered to pregnant women.
- HIV-infected children may receive measles vaccines if their CD4+ lymphocyte count is greater than 15%. (WHO, 2009).

1.8.6. Polio Vaccine

Polio vaccines, are vaccines used to prevent poliomyelitis (polio). One type uses inactivated poliovirus and is given by injection (IPV), while the other type uses weakened poliovirus and is given by mouth (OPV). The World Health Organization recommends all children be vaccinated against polio. The two vaccines have eliminated polio from most of the world, and reduced the number of cases each year from an estimated 350,000 in 1988 to 359 in 2014.

The inactivated polio vaccines are very safe. Mild redness or pain may occur at the site of injection. Oral polio vaccines result in vaccine-associated paralytic poliomyelitis in about three per million doses. Both are generally safe to give during pregnancy and in those who have HIV/AIDS but are otherwise well.

1.8.6.1. History of Polio Vaccine

The first effective polio vaccine was developed in 1952 by Jonas Salk at the University of Pittsburgh, but it would require years of testing. To encourage patience, Salk went on CBS radio to report a successful test on a small group of adults and children on 26 March 1953; two days later the results were published in JAMA. Beginning 23 February 1954, the vaccine was tested at Arsenal Elementary School and the Watson Home for Children in Pittsburgh, Pennsylvania. Salk's vaccine was then used in a test called the Francis Field Trial, led by Thomas Francis; the largest medical experiment in history. The test began with some 4,000 children at Franklin Sherman Elementary School in McLean, Virginia, and would eventually involve 1.8 million children, in 44 states from Maine to California. The Salk vaccine had been 60–70% effective against PV1 (poliovirus type 1), over 90% effective against PV2 and PV3, and 94% effective against the development of bulbar polio. Soon after Salk's vaccine was licensed in 1955 children's vaccination campaigns were launched (Hinman, 1984).

1.8.6.2.Types of polio vaccines

1.8.6.2.1. Inactivated polio vaccine (IPV)

Inactivated polio vaccine (IPV) was developed in 1955 by Dr Jonas Salk. Also called the “Salk vaccine”, IPV consists of inactivated (killed) poliovirus strains of all three poliovirus types. IPV is given by intramuscular injection and needs to be administered by a trained health worker. The inactivated polio vaccine produces antibodies in the blood to all three types of poliovirus. In the event of infection, these antibodies prevent the spread of the virus to the central nervous system and protect against paralysis.

1.8.6.2.2. Attenuated or oral polio vaccine (OPV)

The oral polio vaccine (OPV) was developed in 1961 by Albert Sabin. Also called "trivalent oral polio vaccine" or "Sabin vaccine", OPV consists of a mixture of live, attenuated (weakened) poliovirus strains of all three poliovirus types. OPV produces antibodies in the blood to all three types of poliovirus. In the event of infection, these antibodies protect against paralysis by preventing the spread of wild poliovirus to the nervous system.

OPV also produces a local, mucosal immune response in the mucous membrane of the intestines. In the event of infection, these mucosal antibodies limit the replication of the wild poliovirus inside the intestine. This intestinal immune response to OPV is thought to be the main reason why mass campaigns with OPV can rapidly stop person-to-person transmission of wild poliovirus.

1.8.6.3. Polio Schedule

The World Health Organization recommends three or four doses starting at two months of age. It can be begun earlier but then additional doses are needed. Children get 4 doses of IPV at these ages: 2 months, 4 months, 6-18 months, and a booster dose at 4-6 years. OPV has not been used in the United States since 2000 but is still used in many parts of the world (Aylward, 2006).

1.8.6.4. Side effects of Polio Vaccine

The inactivated polio vaccines are very safe. Mild redness or pain may occur at the site of injection. Oral polio vaccine results in vaccine-associated paralytic poliomyelitis in about three per million doses. They are generally safe to give during pregnancy and in those who have HIV/AIDS but are otherwise well.

1.8.6.5. Adverse effects of Polio Vaccine

A potential, but rare, adverse effect of the oral polio vaccine (OPV) is its known ability to recombine to a form that may cause neurological infection and cause paralysis. Clinical disease, including paralysis, caused by vaccine-derived poliovirus (VDPV) is indistinguishable from that

caused by wild polioviruses. This is believed to be a rare event, but outbreaks of vaccine-associated paralytic poliomyelitis (VAPP), caused by a circulating vaccine-derived poliovirus (cVDPV), have been reported, and tend to occur in areas of low coverage by OPV, presumably because the OPV is itself protective against the related outbreak strain (Schonberger et al., 1984).

1.8.7. Rubella Vaccine

Rubella vaccine is a vaccine used to prevent rubella. Effectiveness begins about two weeks after a single dose and around 95% of people become immune. Countries with high rates of immunization no longer see cases of rubella or congenital rubella syndrome. When there is a low level of childhood immunization in a population it is possible for rates of congenital rubella to increase as more women make it to child bearing age without either vaccination or exposure to the disease. Therefore, it is important for more than 80% of people to be vaccinated.

1.8.7.1. History of Rubella

The first rubella vaccine—a live, attenuated vaccine—was licensed in 1969. It was developed by the prolific vaccine researcher Maurice Hilleman, using rubella virus obtained from Division of Biologics Standards scientists Paul Parkman and Harry Meyer. Other companies in both the United States and Europe licensed their own rubella vaccines. Hilleman's rubella vaccine was used in the combination measles-mumps-rubella (MMR) vaccine, which was licensed in 1971.

In 1979, an improved live rubella vaccine superseded Hilleman's in the United States. Developed by Stanley A. Plotkin, MD, the RA27/3 vaccine had been used in Europe for years and offered superior protection against the disease. It also replaced the original rubella vaccine in the MMR combined shot, and is still used today. (CDC, 2015).

1.8.7.2. Rubella Schedule

There are two main ways to deliver the rubella vaccine. The first is initially efforts to immunize all people less than forty years old followed by providing a first dose of vaccine between 9 and 12 months of age. Otherwise simply women of childbearing age can be vaccinated.

While only one dose is really needed often two doses are provided as it usually comes mixed with the measles vaccine.

It theoretically should not be given during pregnancy. However, more than a thousand women have been given the vaccine when they did not realize that they were pregnancy and no negative outcomes occurred. Testing for pregnancy before giving the vaccine is not needed.

1.8.7.3. Side effects of Rubella

Side effects are generally mild. They may include fever, rash, and pain and redness at the site of injection. Joint pain may be reported at between one to three weeks following vaccination in women. Severe allergies are rare. The rubella vaccine is available either by itself or in combination with other vaccines. Combinations include with measles and mumps vaccine (MMR vaccine) and measles, mumps and varicella vaccine (MMRV vaccine) (WHO, 2011).

1.8.8. Hepatitis B vaccine

Hepatitis B vaccine is a vaccine that prevents hepatitis B. The first dose is recommended within 24 hours of birth with either two or three more doses given after that. This includes those with poor immune function such as from HIV/AIDS and those born premature. In healthy people routine immunization results in more than 95% of people being protected.

Blood testing to verify that the vaccine has worked is recommended in those at high risk. Additional doses may be needed in people with poor immune function but are not necessary for most people. In those who have been exposed to the hepatitis B virus but not immunized, hepatitis B immune globulin should be given in addition to the vaccine. The vaccine is given by injection into a muscle.

1.8.8.1. History of Hepatitis-B Vaccine

The hepatitis B virus was discovered in 1965 by Dr. Baruch Blumberg who won the Nobel Prize for his discovery. Originally, the virus was called the "Australia Antigen" because it was named for an Australian aborigine's blood sample that reacted with an antibody in the serum of an American hemophilia patient.

Working with Dr. Blumberg, microbiologist Irving Millman helped to develop a blood test for the hepatitis B virus. Blood banks began using the test in 1971 to screen blood donations and the risk of hepatitis B infections from a blood transfusion decreased by 25 percent. Four years after discovering the hepatitis B virus, Drs. Blumberg and Millman developed the first hepatitis B vaccine, which was initially a heat-treated form of the virus. (Hepatitis B Foundation, 2009).

1.8.8.2. Hepatitis-B Schedule

Hepatitis B vaccine is available for all age groups to prevent HBV infection. The vaccination schedule most often used for adults and children has three intramuscular injections, the second and third administered 1 and 6 months after the first. Recombivax HB® has been approved as a two dose schedule for aged 11-15 years and Twinrix® has also been approved as a four dose accelerated schedule.

1.8.8.3. Side effects of Hepatitis-B Vaccine

Serious side effects from the hepatitis B vaccine are very uncommon. Pain may occur at the site of injection. It is safe for use during pregnancy or while breastfeeding. It has not been linked to Guillain-Barre syndrome. The current vaccines are produced with recombinant DNA techniques. They are available both by themselves and in combination with other vaccines.

1.8.8.4. Precaution of Hepatitis-B Vaccine

Recipient should not get the vaccine if they had a severe allergic reaction to an earlier dose or are allergic to yeast, because yeast is used to make the vaccine. (WHO, 2009).

1.9. Introduction of other Vaccines

1.9.1. Hepatitis A Vaccine

Hepatitis A is an acute illness caused by a virus (HAV) transmitted through the faecaloral route. It is characterized by jaundice, dark urine, fever, anorexia, and abdominal discomfort, with the symptoms related to age. Infection with HAV does not become chronic. Most people recover after a few weeks. Severe complications are rare, but the risk of death increases with age, and case fatality may range from zero in children under 5 years old to 1.5% in people aged over 60.

The first dose should be given at 12-23 months of age. Children who are not vaccinated by two years of age can be vaccinated at later visits. Hepatitis A vaccine is recommended for healthy international travelers age 12 months or older; the first dose of Hepatitis A vaccine should be administered as soon as travel is considered. A shot called immune globulin (IG) can be considered in addition to hepatitis A vaccine for older adults, immune-compromised persons, and persons with chronic liver disease or other chronic medical conditions who are traveling within two weeks. (Vaccines.gov, 2016).

1.9.2. Influenza Vaccine

Influenza, commonly called "flu", is a respiratory illness caused by a virus. The name is Italian for "influence", the word used by 16th century Italians to denote several illnesses believed to be caused by "the heavens" or "the stars". Symptoms of influenza last about a week on average, and include fever, sore throat, headache, aches and pains, chills, loss of appetite, and fatigue. About 30–50% of infected people have few or no symptoms. Children and elderly people are particularly vulnerable to infection and to the risk of developing severe complications, which may require hospital care. In the United States, up to 40 000 influenza-related deaths have been reported in severe influenza seasons. Worldwide, influenza infections are responsible for between 250 000 and 500 000 deaths a year on average.

The CDC recommends that everyone except children under the age of six months should receive the seasonal influenza vaccine. (CDC, 2015)

1.9.2.1. Haemophilus Influenzae Type B (Hib) Vaccine

Haemophilus influenzae type B vaccine is a vaccine used to prevent Haemophilus influenzae type b (Hib) infection. In countries that include it as a routine vaccine, rates of severe Hib infections have decreased more than 90%. It has therefore resulted in a decrease in the rate of meningitis, pneumonia, and epiglottitis.

It is recommended by both the World Health Organization and Centers for Disease Control and Prevention. Two or three doses should be given before six months of age. The first dose is recommended around six weeks of age with four weeks between doses. If only two doses are used, another dose later in life is recommended. It is given by injection into a muscle.

Severe side effects are uncommon. About 20 to 25% of people develop pain at the site of injection while about 2% develop a fever. There is no clear association with severe allergic reactions. The Hib vaccine is available by itself, in combination with the diptheria/tetanus/pertussis vaccine, and in combination with the hepatitis B vaccine, among others. All Hib vaccines that are currently used are conjugate vaccine (Hib Vaccination Position Paper, 2013).

1.9.3. Meningococcal Vaccine

The meningococcus (Neisseria meningitidis), is a major cause of meningitis and is permanently present (endemic) in every country in the world. It is also present, as a colonizing bacterium, in the nose and throat tissues of about 10–25% of the world's population – the healthy carriers. For reasons that are not clear, in a small number of these healthy carriers, the organism becomes invasive and, in most cases, the resulting disease is meningitis. In 5% to 15% of cases, the clinical disease is pneumonia or, more alarmingly, a severe blood infection (fulminant septicaemia) or joint infection (septic arthritis). Early symptoms of meningococcal disease include high fever, headache, stiff neck, nausea and vomiting.

Work on a vaccine against the meningococcus began in the 1890s. The early meningococcal vaccines, developed between 1900 and the 1940s, were effective enough to elicit an immune response but not pure enough to avoid untoward reactions in vaccine recipients (Plotkin et al., 2008).

1.9.4. Mumps Vaccine

Mumps vaccines are vaccines which prevent mumps. When given to a majority they decrease complications at the population level. Effectiveness when 90% of a population is vaccinated is estimated at 85%.Two doses are required for long term prevention. The initial dose is recommended between the age of 12 and 18 months of age.

Mumps can be prevented with MMR (measles-mumps-rubella) vaccine. MMR vaccine prevents most, but not all, cases of mumps and complications caused by the disease. Two doses of the vaccine are 88% (range: 66-95%) effective at preventing mumps; one dose is 78% (range: 49%−92%) effective.

The first vaccine against mumps was licensed in the United States in 1967. By 2005, mumps rates declined by more than 99% thanks to high two-dose vaccination coverage among children (Hviid et al., 2008).

1.9.5. Pneumococcal Vaccine

The bacterium Streptococcus pneumoniae, also known as the pneumococcus, is a leading cause of severe disease and deaths in children under five years old. According to unpublished WHO estimates, in 2000 there were 14.5 million episodes of severe pneumococcal disease and more than 800 000 deaths (of which 88 000 were HIV-related) among children in this age group. Children under five, people with depressed immune systems, smokers, and elderly people are among the population groups at highest risk of pneumococcal disease. The total number of annual deaths attributable to this bacterium, including adults and children, is about 1.6 million, according to WHO estimates.

The first pneumococcal vaccine was developed in the 1980s. Their use can prevent some cases of pneumonia, meningitis, and sepsis. There are two types of pneumococcal vaccines: conjugate vaccines and polysaccharide vaccines. They are given either by injection into a muscle or just under the skin (WHO, 2012).

1.9.6. Rabies Vaccine

Rabies vaccine is a vaccine used to prevent rabies. There are a number of vaccines available that are both safe and effective. They can be used to prevent rabies before and for a period of time after exposure to the virus such as by a dog or bat bite. The immunity that develops is long lasting after three doses. Doses are usually given by injection into the skin or muscle. After exposure vaccination is typically used along with rabies immunoglobulin. It is recommended that those who are at high risk of exposure be vaccinated before potential exposure. Vaccines are effective in humans and other animals. Vaccinating dogs is very effective in preventing the spread of rabies to humans. (Nunnally & Brain, 2014)

Rabies vaccines may be safely used in all age groups. About 35 to 45 percent of people develop a brief period of redness and pain at the injection site. About 5 to 15 percent of people may have fever, headaches, or nausea. After exposure to rabies there is no contraindication to its use. Most vaccines do not contain thimerosal. Vaccines made from nerve tissue are used in a few

countries, mainly in Asia and Latin America, but are less effective and have greater side effects. Their use is thus not recommended by the World Health Organization.

The first rabies vaccine was introduced in 1885, which was followed by an improved version in 1908. Millions of people globally have been vaccinated and it is estimated that this saves more than 250,000 people a year. (WHO, 2011).

1.9.7. Rotavirus Vaccine

Discovered in 1973, rotaviruses are the most common cause of severe diarrhoeal disease in young children throughout the world. Virtually all children under three years of age are infected in both industrialized and developing countries. Most disease episodes consist of a mild attack of watery diarrhoea, accompanied by fever and vomiting. In about 1 in every 75 cases, however, the infection produces severe, potentially fatal dehydration. Globally, more than two million children are hospitalized for rotavirus infections every year. According to WHO 2004 estimates, 527 000 children under five years old die every year from rotavirus disease. Nearly two-thirds of these deaths occur in just 11 countries, with most 23% of total rotavirus deaths in India (WHO, 2013).

1.9.8. Typhoid Vaccine

Typhoid fever, also known as enteric fever, is caused by one of the most virulent bacteria to attack the human gut. Commonly spread via contaminated water and food, the causative bacterium, Salmonella typhi, thrives in unsanitary conditions, particularly where clean water is lacking. Through the gut, the organism infects the bloodstream, altering brain function in some cases, and often resulting in death. Before the advent of antibiotics, the symptoms of typhoid fever – typically, persistent high fever, abdominal pain, malaise, and headache – usually lasted several weeks and in many cases culminated in death (WHO, 2008).

There are two types that are widely available: Ty21a (a live vaccine given by mouth) and Vi capsular polysaccharide vaccine (an injectable subunit vaccine).They are about 30 to 70% effective for during the first two years depending on the specific vaccine in question. The first typhoid vaccines were developed in 1896 by Almroth Edward Wright, Richard Pfeiffer, and Wilhelm Kolle. Due to side-effects newer formulations are currently recommended (Anwar et al., 2014).

1.9.9. Varicella Vaccine

Varicella, commonly known as chickenpox, is caused by the varicella-zoster virus (a member of the herpesvirus family), which was first identified in 1952. The same virus, when reactivated from a latent state in nerve cells causes another disease – herpes zoster, or shingles. In most populations, varicella is a disease of children, and herpes zoster a disease of elderly people. However, the epidemiology of disease can vary, especially in tropical countries where infection and varicella may occur more often in older age groups.

The chickenpox vaccine first became commercially available in 1984. One dose of vaccine prevents 95% of moderate disease and 100% of severe disease. Two doses of vaccine is more effective than one. If given to those who are not immune within five days of exposure to chickenpox it prevents most cases of disease. Vaccinating a large portion of the population also protects those who are not vaccinated. It is given by injection just under the skin. (CDC, 2015).

1.9.10. Yellow fever vaccine

Yellow fever is a viral haemorrhagic fever caused by a virus transmitted to humans and non-human primates by the bite of a mosquito. After a few days of being bitten by an infected mosquito, sub-clinical infection, non-specific illness, or influenza-like symptoms can develop. The latter can culminate in the vomiting of blackish blood, one of the two hallmark symptoms of the disease. A few days later, in about 15% of cases, bleeding occurs from several sites, accompanied by painful convulsions and failure of several organ systems, notably the liver, kidneys, and heart. This stage is also marked by jaundice – the second hallmark symptom – which colours the skin a deep yellow. About 20–50% of people with severe disease die from the disease. Children and elderly people run the greatest risk of death from yellow fever (Staphles et al., 2015).

Yellow fever vaccine came into use in 1938. The vaccine can be used to control outbreaks of disease. It is given either by injection into a muscle or just under the skin. Yellow fever vaccine is generally safe. This includes in those with HIV infection but without symptoms. Mild side effects may include headache, muscle pains, pain at the injection site, fever, and rash. Severe allergies occur in about eight per million doses, serious neurological problems occur in about

four per million doses, and organ failure occurs in about three per million doses. It is likely safe in pregnancy and therefore recommended among those who will be potentially exposed. It should not be given to those with very poor immune function (Norrby, 2007).

1.10. Immunization Coverage in the Developed Countries

UNICEF and WHO conduct an annual review of national or territorial immunization reports to determine the most accurate levels of coverage. The resulting estimates are based on reported (administrative) data, household surveys and government estimates as reported annually in the WHO/UNICEF Joint Reporting Form on Immunization, as well as data from the scientific and technical literature. Child immunization measures the percentage of children ages 12-23 months old who received vaccinations before 12 months or at any time before the survey.

1.10.1. United States

According to the statistics of World Health Organization (WHO) and UNICEF in 2011, the infant mortality rate (per 1,000 live births) is around 6. The under-five mortality rate (per 1,000 live births) is 8. The national coverage rates of immunization of DPT1 (first dose of diphtheria and tetanus toxoid with pertussis vaccine) is 98%, DPT3 (third dose of diphtheria and tetanus toxoid with pertussis vaccine) is 94%, Hep-B3(third dose of hepatitis-B vaccine) is 91%, Hib3 (third dose of Haemophilus influenza type B vaccine) is 88%, MCV (Measles Containing vaccine) is 90%, pol3 (third dose of polio vaccine) is 94%.

1.10.2. Canada

According to the statistics of WHO & UNICEF in 2011; the infant mortality rate (per 1,000 live births) is 5. The under-five mortality rate (per 1,000 live births) is 6. The national coverage rates of immunization of DPT1 is 98%, DPT3 is 95%, Hep-B3 is 70%, Hib3 is 95%, MCV (Measles Containing vaccine) is 98%, pol3 is 99%.

1.10.3. Australia

Among all of the total population, the infant mortality rate (per 1,000 live births) is 4. The under-five mortality rate (per 1,000 live births) is 5. The national coverage rates of immunization of DPT3, DPT1, Hep-B3, Hemophilus influenza type-B (Hib3), pol3 is 92% & MCV is 94% in 2011.

1.10.4. Russia

WHO & UNICEF estimates that the infant mortality rate (per 1,000 live births) is 10, under-five mortality rate (per 1,000 live births) is 12. The national coverage rates of immunization of BCG is 95%, DPT1, DPT3, Hep-B3, pol3 is 97%, & MCV is 98%.

1.10.5. United Kingdom

WHO & UNICEF estimates that the infant mortality rate (per 1,000 live births) is 4. The under-five mortality rate (per 1,000 live births) is 5. The national coverage rates of immunization of DPT1 is 98%, DPT3 is 95%, Hib3 is 95%, pol3 is 95% & MCV is 90%.

1.10.6. Norway

WHO & UNICEF estimates the infant mortality rate (per 1,000 live births) is 3. The aged under-five mortality rate (per 1,000 live births) is also 3. The national coverage rates of immunization of DPT1 is 99%, DPT3 is 94%, Hib3 is 95%, polio3 is 94% & MCV is 93%.

1.10.7. France

WHO & UNICEF estimates that the infant mortality rate (per 1,000 live births) is 3. The aged under-five mortality rate (per 1,000 live births) is 4. The national coverage rates of immunization of DPT1, DPT3 is 99%, Hep-B3 is 65%, Hib3 is 97%, polio3 is 99% & MCV is 89%.

1.11. Immunization Coverage in Developing Countries

1.11.1. Bangladesh

According to WHO and UNICEF statistics in 2011, of all the total population, the infant mortality rate (per 1,000 live births) is 37. The under-five mortality rate (per 1,000 live births) is 46. The routine EPI vaccines financed by government is 30%. The national coverage rates of immunization of BCG is 95%, DPT1 is 99%, DPT3 is 96%, Hepatitis-B3 is 96%, Hib is 96%, polio3 is 96%, MCV(Measles containing vaccine) is 96% & PAB (protection at birth against tetanus) is 94%. The percentage of immunization coverage is increasing dramatically as per year goes on.

1.11.2. Afghanistan

According to WHO and UNICEF statistics, the infant mortality rate (per 1,000 live births) is 73. The under-five mortality rate (per 1,000 live births) is 101. The national coverage rates of

immunization of BCG is 68%, DPT1 is 86%, DPT3 is 66%, Hepatitis-B3 is 66%, Hib is 66%,pol3 is 66%, MCV is 62% in 2011.

1.11.3. Bhutan

WHO & UNICEF estimates that in 2011, the infant mortality rate (per 1,000 live births) is 42. The under-five mortality rate (per 1,000 live births) is 54. The national coverage rates of immunization of BCG is 95%, DPT1 is 98%, DPT3 is 95%, Hepatitis-B3 is 95%, Hib is 66%,pol3 is 66%, MCV is 62% & PAB (protection at birth against tetanus) is 89%.

1.11.4. India

According to WHO and UNICEF statistics, the infant mortality rate (per 1,000 live births) is 47. The under-five mortality rate (per 1,000 live births) is 61. The national coverage rates of immunization of BCG is 87%, DPT1 is 83%, DPT3 is 72%, Hepatitis-B3 is 47%, pol3 is 70%, MCV is 74% & PAB is 87%.

1.11.5. Nepal

According to WHO and UNICEF statistics, the infant mortality rate (per 1,000 live births) is 39. The under-five mortality rate (per 1,000 live births) is 48. The national coverage rates of immunization of BCG is 97%, DPT1 is 96%, DPT3 is 92%, Hepatitis-B3 is 92%, Hib3 is 92%, pol3 is 92%, MCV is 88% & PAB is 82%.

1.11.6. Myanmar

According to WHO and UNICEF statistics, the infant mortality rate (per 1,000 live births) is 48. The under-five mortality rate (per 1,000 live births) is 62. The national coverage rates of immunization of BCG is 93%, DPT1, DPT3 is 99%, Hepatitis-B3 is 92%, Hib3 is 52%, pol3, MCV is 99% & PAB is 93%.

1.11.7. Maldives

According to WHO and UNICEF statistics, the infant mortality rate (per 1,000 live births) is 9. The aged under-five mortality rate (per 1,000 live births) is 11. The national coverage rates of immunization of BCG is 98%, DPT1 is 97%, DPT3 is 96%, Hepatitis-B3 is 96%, pol3 is 96%, MCV is 96% & PAB is 95%.

1.11.8. Sri Lanka

According to WHO and UNICEF statistics, the infant mortality rate (per 1,000 live births) is 11. The aged under-five mortality rate (per 1,000 live births) is 12. The national coverage rates of immunization of BCG, DPT1, DPT3, Hepatitis-B3, Hib3, pol3, MCV is 99% & PAB is 95%.

1.11.9. Pakistan

According to WHO and UNICEF statistics, the infant mortality rate (per 1,000 live births) is 59. The aged under-five mortality rate (per 1,000 live births) is 72. The national coverage rates of immunization of BCG is 85%, DPT1 is 88%, DPT3, Hepatitis-B3,Hib3, MCV is 80%, pol3 & PAB is 75%. (Immunization summary, 2013).

1.12. Importance of Vaccination Worldwide

Vaccines have recently been recognized by the British Medical Journal as one of the greatest medical advances of the past 160 years, having saved hundreds of millions of lives since their introduction (Worboys, 2007).

Indeed, vaccination is generally considered as one of the greatest public health achievements in industrialized countries during the 20th century, reducing morbidity and mortality from a broad range of vaccine-preventable diseases. With the exception of clean, safe drinking water, no treatment has rivaled immunization in reducing mortality rates (Plotkin et al., 2004).

Along with enormous improvements in sanitation and hygiene, immunization is also credited with the significant increase in life expectancy observed in the past century. Vaccine use has resulted in the global eradication of smallpox and regional elimination of polio and measles, and has essentially eliminated most infectious diseases causing mortality in infants and children (Rappuoli, 2007).

1.13. Global Benefits of Vaccination

In 1974, only 5% of the world's children received vaccination(s); by 2005, 75% were immunized, saving about three million lives a year. (Iglehard, 2005).

Collectively, over 5.9 million deaths are prevented annually through vaccination against nine major infectious diseases [varicella, diphtheria, tetanus, pertussis, Haemophilus influenza type b (childhood), hepatitis B, measles, polio, and tuberculosis]. (Ehreth, 2003).

An unprecedented global vaccination campaign against smallpox has spared the global community of over 350 million new smallpox victims and some 40 million deaths from the disease. Other than for recent concerns regarding bio-terrorism, the relative balance of benefits and risk indicates there is no longer a need for smallpox vaccination in the post smallpox-eradication era.

Since 2001, more than 190 countries and territories have been polio-free and the disease now exists in only about 20 countries, all in the regions of Southeast Asia and Sub-Sahara Africa. Since 1988, the number of cases reported to WHO has declined by 99% (CDC, 2001).

In the period from 2000 to 2006, targeted immunization campaigns helped reduce the number of global deaths caused by measles by 68%, from 757,000 to 242,000, with a corresponding 91% reduction in Africa (WHO, 2007).

While vaccines have played a vital role in preventing infectious diseases – thereby improving individual wellbeing and quality of life – vaccines also offer tremendous value to society as a whole. In essence, immunization does more than just protect individuals; it protects entire populations by preventing the spread of disease from one person to another. Hence vaccination is a collective activity that can protect an entire group of people, and can also cross boundaries between countries and continents, resulting in a global impact. High immunization rates in one country benefit other countries, and high rates in one generation benefit the next generation to follow. The social value of vaccines also includes reductions in disease outbreaks, and population (and thus economic) growth through reduced mortality (Exan, 2008).

Immunization provides not only immense medical benefits (both at the individual and societal level), as outlined above, immunization programs have been widely recognized as among the

best investments in health, based on extensive analyses of both cost-savings and cost-effectiveness (Chabot et al., 2004).

Vaccines are also known to offer additional economic benefits, through reduced hospitalization and/or decreased need for expensive treatment (resulting from infection), and by improving workplace productivity. Thus vaccines play a pivotal role in the sustainability of healthcare systems, while helping to realize the full economic growth potential of a population free of disease. In particular, since many vaccines save the lives of infants, children and young adults – who represent our greatest resource and hope for the future – immunization offers tremendous potential for maximizing economic prosperity in the decades to come (Szucs, 2005).

Literature Review

2.1. Routine vaccination coverage in low- and middle-income countries: further arguments for accelerating support to child vaccination services

The Expanded Programme on Immunization was introduced by the World Health Organization (WHO) in all countries during the 1970s. Currently, this effective public health intervention is still not accessible to all. This study evaluated the change in routine vaccination coverage over time based on survey data and compares it to estimations by the WHO and United Nations Children's Fund (UNICEF). Immunization played an important role in achieving the United Nations Millennium Development Goal 4 of reducing under-five mortality by two-thirds between 1990 and 2015.

This study indicated that the coverage of routine vaccinations in low- and middle-income countries was inadequate to meet the targets set by the WHO and UNICEF to achieve at least 90% vaccination coverage by 2015. The results provided a strong support for further efforts to improve current vaccination levels and to optimize the use of existing resources. High quality data to measure progress was needed and should be prioritized at national and global levels. Improved program monitoring was vital in identifying populations at risk of vaccine coverage failures and epidemics. (Tao et al., 2013)

2.2. Immunization Coverage in India

Immunization against common childhood diseases had been an integral component of mother and child health services in India since adoption of the primary health care approach in 1978 being reinforced by the Declaration of Health Policy in 1983. The focus of this paper was to examine the status and performance during 1980-2004 of the child immunization programme in India, U.P. and Uttarakhand and to suggest policy and programmes for realization of the goals of universal immunization services. Data sources on immunization coverage used for this study include secondary data from the National Family Health Surveys and RCH Surveys in U.P. Uttarakhand and all over India.

The analysis revealed that a large number of children who have contact with services providers were missed out of subsequent services. There was a wide gap between routine data and survey data. Almost every other child in Uttarakhand and U.P was incompletely protected and one out every of three children is a dropout from the immunization programme. Uttarakhand had not reached the goal of universal immunization coverage despite a focused and intense immunization programme since 1985. (Sharma, 2007)

2.3. Immunization status and socio demographic characteristics: the mediating role of beliefs, attitudes, and perceived control

This study examined how immunization related beliefs, attitudes and perceived control mediate up-to-date immunization among various socio-demographic groups. Statewide estimation of immunization rates among children up to the 2 years were obtained via a multistage cluster sample. In persons interviews were conducted with 4832 parents. Information about immunization was obtained from official records or from health care providers.

Differences in immunization among socio demographic groups were mediated by beliefs about objective barriers to immunization, protection, medical contraindication, safety concerns, distrust, and natural immunity. Protection beliefs contributed to positive attitudes towards immunization; beliefs in natural immunity and safety concerns contributed to negative attitudes. These findings provide a basis for educational campaigns by specifying which beliefs should be bolstered (because they facilitate proper immunization) and which should be targeted for change (because they hinder proper immunization) in various socio demographic groups. (Prislin et al., 1998)

2.4. Immunization status and risk factors of migrant children in densely populated areas of Beijing, China

The study was done to properly evaluate the immunization status and determine risk factors of migrant children in 23 densely populated towns and townships in Beijing. A household cluster sampling survey was implemented and standard face-to-face interviews were conducted with 1820 migrant children aged 12–35 months. Demographic characteristics of the child and primary

caregiver, the child's migrant characteristics, the primary caregiver's knowledge and attitude toward immunization, information about immunization services provided by the local clinic, and the child's immunization history were obtained. Weighted up-to-date (UTD) and age-appropriate immunization rates for the following four vaccines were assessed: three doses of diphtheria, tetanus and pertussis combined vaccine (DTP); three doses of oral poliomyelitis vaccine (OPV); three doses of hepatitis B vaccine (Hep B); and one dose of Measles-containing vaccine (MCV). Weighted UTD and age-appropriate immunization rates for the overall series of these four vaccines (the 3:3:3:1 immunization series) were also estimated.

For each antigen, the weighted UTD immunization rate was above 83%, but the age-appropriate immunization coverages for HepB, OPV, DPT, and MCV were only 45.6%, 49.6%, 50.8% and 54.7%, respectively. The 1st dose was most likely to be invalid or delayed within Hepatitis B, OPV and DPT series. For the 3:3:3:1 immunization series, the weighted UTD and age-appropriate immunization rates were 78.1% and 20.5%, respectively. Immunization status of migrant children tended to be homogenous within a village and therefore, multi-level model was more appropriate for assessing risk factors. Besides demographic characteristics, several other factors were significantly associated with age-appropriate immunization coverage. The frequency and duration of clinical immunization sessions significantly influenced the UTD immunization rate but not the age-appropriate immunization rate. The degree of the primary caregiver's satisfaction with clinic services and convenience to vaccination clinic had no impact on the child's immunization status. (Sun et al., 2010)

2.5. Immunization Status of Adoptees from China, Russia, and Eastern Europe

All adoptees from China, Russia, or Eastern Europe who presented written evidence of 3 or more DPT (diphtheria/pertussis/tetanus) vaccines in the country of origin were tested for protective titers against diphtheria and tetanus. Adoptees with fewer than 3 DPT vaccines in the country of origin and adoptees who had received any vaccines in the U.S. were excluded. Median age of vaccinated children was 3 years. Median number of DPT vaccines was 4(mean=3.9). Among 17 adoptees who had received all DPT vaccines in Chinese, Russian, or Eastern European orphanages, only 12% had protective titers to diphtheria and tetanus. Among 9 adoptees who had lived in the local community before being transferred to a Chinese, Russian, or Eastern European

orphanage, 78% had protective titers to diphtheria and tetanus ($p<0.05$). Overall, despite written evidence of age-appropriate immunization, only 35% of Chinese, Russian, or Eastern European adoptees exhibited protective titers to diphtheria and tetanus.

Reasons for these unexpectedly poor results were unclear. Falsification of written immunization certificates, decreased potency of vaccine lots used in orphanages, or blunting of the immune response due to prolonged institutionalization may each contribute. However, based on this small pilot study, pediatricians should consider repeating all immunizations in adoptees from China, Russia, or Eastern Europe who have written evidence of fewer than 3 DPT immunizations. If 3 or more DPT immunizations are documented in the country of origin, adoptive parents may be offered the choice of beginning the entire series again or of measuring DPT titers. These strategies should ensure protection of Chinese, Russian, and Eastern European adoptees against diphtheria and tetanus. (Hostetter & Johnson, 1998)

2.6. Immunization Status and Birth Order

The study was reviewed to determine whether an association exists between immunization status and birth order. The study was examined on a basis of medical record review of immunization dates for matched siblings and it was done on a pediatric clinic at a university medical center. A total of 892 children (446 sibling pairs of firstborn and second born children) born between 1983 and 1991 who received regular pediatric care at the clinic. Median ages at which firstborn children and their second born siblings had been immunized with the initial four doses of diphtheria and tetanus toxoids and pertussis vaccines (DTP1, DTP2, DTP3, and DTP4) and the initial dose of measles-mumps-rubella vaccine; point prevalence of firstborn and second born children up-to-date with all immunizations at each month of life to 2 years of age.

Between 5 and 12 months of life, the percentage of second born children who were fully immunized was significantly lower than the percentage of fully immunized firstborn children (P values ranging from <.0001 to <.05). Firstborn children were much more likely than their second born siblings to have been immunized on time with DTP2 (z=3.80, P=.0001) and DTP3 (z=3.31, P=.0009). Overall, DTP2 immunizations were given at median ages 10 days later, and DTP3 immunizations, 20 days later to second born children than to their firstborn siblings. In

addition, late immunization of a firstborn child was found to increase the risk that a second born sibling would also be immunized late. Second born children were likely to be immunized later than first born children. Second born children with an older sibling who was immunized late are at particular risk for delayed immunizations. (Schaffer et al., 1995)

2.7. Immunization Status and Child Survival in Rural Ghana

For three decades, the Expanded Programme on Immunization (EPI) has been promoted as one of the key child health interventions in developing countries. Vaccines for six childhood diseases (diphtheria, measles, pertussis, poliomyelitis, tetanus, and tuberculosis) have been shown to be efficacious in preventing disease-specific morbidity and mortality, yet not all commentators are convinced that the EPI reduces all-cause child mortality. Numerous studies have found that measles vaccination programs substantially reduce all-cause child mortality, but recent findings from Guinea-Bissau suggest that diphtheria, pertussis, and tetanus (DPT) vaccine may increase all-cause child mortality.

The present study used five years of data from the Navrongo Demographic Surveillance System, a longitudinal population registration system in northern Ghana, to examine all-cause mortality among vaccinated and unvaccinated children under 5 years of age. The data indicated that coverage by one Bacillus Calmette-Guérin (BCG) shot, three sets of polio drops, and three DPT shots reduced mortality between ages 4 and 8 months by nearly 90 percent. Complete coverage by all EPI antigens reduced mortality between ages 9 and 59 months by 70 percent. BCG, polio, and DPT vaccines without measles vaccination reduced mortality by 40 percent. The independent reduction in mortality associated with measles vaccination was 50 percent. The data added to a growing body of evidence that suggests that measles vaccination programs reduce all-cause mortality substantially beyond the proportion of deaths caused by measles. These results indicated a need for further research in developing countries on the all-cause mortality impact of these vaccines, in particular DPT vaccine. (Nyarko et al., 2001)

2.8. Global immunization: status, progress, challenges and future

Vaccines have made a major contribution to public health, including the eradication of one deadly disease, small pox, and the near eradication of another, poliomyelitis. Through the introduction of new vaccines, such as those against rotavirus and pneumococcal diseases, and

with further improvements in coverage, vaccination can significantly contribute to the achievement of the health-related United Nations Millennium Development Goals. The Global Immunization Vision and Strategy (GIVS) was developed by WHO and UNICEF as a framework for strengthening national immunization programmes and protect as many people as possible against more diseases by expanding the reach of immunization, including new vaccines, to every eligible person. This paper briefly reviewed global progress and challenges with respect to public vaccination programmes.

The most striking recent achievement has been that of reduction of global measles mortality from an estimated 750,000 deaths in 2000 down to 197,000 in 2007. Global vaccination coverage trends continued to be positive. In 2007 most regions reached more than 80% of their target populations with three doses of DPT containing vaccines. However, the coverage remained well short of the 2010 goal on 90% coverage, particularly in the WHO region of Africa (estimated coverage 74%), and South-East Asia, (estimated coverage 69%). Elements that have contributed to the gain in immunization coverage include national multi-year planning, district-level planning and monitoring, re-establishment of outreach services and the establishment of national budget lines for immunization services strengthening. (Duclos et al., 2009)

2.9. Immunization Status of Children of Employees in a Large Corporation

This study was done to assess immunization levels for children of employees of a large corporation. The study was designed on the basis on a male survey of a random sample of employees on the immunization history of one child per family. The information of this survey was taken from the US employees of Johnson & Johnson. A total number of 1500 employees with children were evaluated and they were born between 1984 and 1991.

Only 45.2% and 55.3% of the study children at ages 2 and 6 years were current for all recommended immunizations (65.1% and 70.3%, respectively, excluding the Haemophilus influenzae type b vaccine). Using the minimum standard required by many states for school entry, the coverage level at age 6 years was 90.4%. Factors associated with higher immunization rates at age 2 years were the corporate health plan (choices), higher pay level, greater parental formal education, white race, and knowing when to initiate immunization. Lower immunization

rates at age 2 years were associated with delayed receipt of the first dose of diphtheria, tetanus, and pertussis vaccine, use of city or county clinics, employee-reported barriers of difficulty leaving work, and provider access problems, but not cost of services. After adjusting for the effects of other variables through logistic regression, race, pay level, and plan choice were no longer significant. (Fielding et al., 1994)

2.10. Immunization Status and Reasons for Immunization Delay Among Children Using Public Health Immunization Clinics

The study was observed to determine whether children attending local health department clinics were being immunized in a timely manner, and to investigate the reasons for children not being immunized on schedule. The study was done based on a cross-sectional research design and this survey was taken place at Five Salt Lake City/County Health Department immunization clinics in Utah. The participants were all patients presenting to the clinics for immunization from November 1990 to March 1991 when minor illness is prevalent. The data were gathered through interview and questionnaire.

The results of this study suggested that **c**hildren were mostly white; they came from two-parent households with reasonably high incomes and high parental education level. Only four children were denied vaccination, all for inappropriate timing. None were denied for illness. More than 75% had postponed bringing their children in for immunization. The most common reason given for delay was minor illness in the child. Even in this "low-risk" population, parental misperception regarding immunizations is a significant, contributing factor to low immunization rates. Public educational programs directed at increasing parental knowledge must be developed. (Abborts & Osborn, 1993)

2.11. The immunization programme in Bangladesh: impressive gains in coverage but gaps remain

The paper reviewed the achievements in tetanus immunization coverage and child immunization in Bangladesh. It used data from the 1993-94 Bangladesh Demographic and Health Survey to identify and examine the programmatic and non-programmatic factors that influence the

coverage of tetanus (TT) immunization during pregnancy and full immunization among children 12-23 months old in rural Bangladesh. The purpose of this analysis was to identify the areas that need further programme attention.

The logistic regression results showed that the coverage of TT immunization was significantly associated with proximity to outreach clinics and the presence of a health worker in the community. Home visits by health family planning field workers and the proximity to outreach clinics and larger influences on TT coverage of poorer households compared to those better-off. The effect of distance to static clinics varied by regions. Among children, full immunization coverage (coverage of all BCG, DPT1, DPT2, DPT3, Polio1, Polio2, Polio3) was significantly associated with distance to outreach clinics, the greater the distance to the clinics, the less the likelihood of immunization. (Jamil et al., 1999)

2.12. Factors affecting acceptance of complete immunization coverage of children under five years in rural Bangladesh

This article established the hypothesis that predisposing, enabling and household needs influence the complete vaccination status of children. Data from the 2004 Bangladesh Demographic and Health Survey (N= 3530) was used. The data was analyzed using descriptive and multiple logistic regression methods. The full vaccination rate increased with an increase in the previous birth interval and the education level of the mother. Women with the highest wealth index were significantly more likely to fully immunize their children. Distance from health facility, parity, mother's age, mass media, children's sex and tetanus toxoid injection were also significantly positively associated with full vaccination. The findings reflected that, irrespective of need, only children from higher economic or educational groups can afford to be fully vaccinated in rural Bangladesh. In other words, predisposing, enabling and need factors appear to have a strong association with full immunization coverage.

In this paper, a number of predisposing, enabling and need factors were examined that influence the acceptance of complete vaccination coverage for children younger than five years of age in rural Bangladesh. The study highlighted an inadequate full immunization coverage in Bangladesh. Approximately 62% of children under age five were fully immunized in Bangladesh and substantial differences in complete vaccination rates were found for children in urban and rural areas (around 6%). This was probably partly due to the general distribution of healthcare facilities in the country, which tends to disproportionately favor urban areas. It was also attributed to the lack of awareness of the importance of vaccination among mothers in rural areas in comparison to those in urban areas. (Rahman & Nasrin, 2010)

2.13. Coverage of Child Immunization in Rural Hard-to-reach Haor Areas of Bangladesh: Acceptability of Alternative Strategies

Immunization is essential to achieve the Millennium Development Goals (MDGs) of substantially reducing child mortality rates. Results of some studies suggested that the coverage of child immunization was low in hard-to-reach areas of Bangladesh. Alternative strategies for improving the immunization coverage in those remote areas had not been assessed. The study was conducted to assess the status of childhood vaccination coverage in rural hard-to-reach haor areas of Bangladesh and also to assess the acceptability of selected alternative strategies in those areas. The acceptability study was carried out in a remote hard-to-reach haor (low-lying) upazila of Sunamgonj district under Sylhet division during September-November 2006. The World Health Organization (WHO) recommended 30 cluster-sampling methodology was used for determining the sample size. Seven children aged 12-23 months were selected from each cluster. Data were collected through a survey, in-depth interviews, group discussions, and observations of vaccination sessions. The chi-square tests were performed to compare the coverage in the study area with the national coverage. To ascertain the status of child immunization coverage by socioeconomic status, univariate and bivariate analyses were performed. Qualitative data collected through in-depth interviews and group discussions were first transcribed and then translated into English. Data were then analyzed using content analysis.

The complete immunization coverage among children aged 12-23 months was significantly lower in the hard-to-reach areas compared to the national coverage level. The drop-out rate was significantly higher in the hard-to-reach areas compared to the national level. The overall rate of invalid doses in the upazila was also higher (9%) compared to the national level (7%). Results of bivariate analysis showed that, as expected, children with more educated parents were more likely to have complete immunizations. The findings also showed that complete immunization was significantly higher among children of parents who had exposure to mass media than those who had not. The coverage of child immunization in the hard-to-reach haor areas was low, and a number of strategies were acceptable for implementation for improving the coverage in those areas. Before implementing the alternative strategies in the hard-to-reach areas, the feasibility and effectiveness of the acceptable strategies need to be tested to identify evidence-based strategies for scaling up in all hard-to-reach areas of Bangladesh. (Uddin et al., 2008)

2.14. Childhood immunization coverage in Zone 3 of Dhaka City: the challenge of reaching impoverished households in urban Bangladesh

A household survey of 651 children aged 12-23 months in Zone 3 of Dhaka City carried out in 1995 revealed that 51% of them had fully completed the series of childhood immunizations. Immunization coverage in slum households was only half that in non-slum households. Apart from residence in a slum household, other characteristics strongly associated with the completion of the entire series of childhood immunizations included the following: educational level of the mother, number of children in the family household, mother's employment status, distance from the nearest immunization site, and number of home visits from family-planning field workers.

The findings were pointed to the need to improve childhood immunization promotion and service delivery among slum populations. Two promising strategies for improving coverage were to reduce the number of missed opportunities for immunization promotion during encounters between health workers and clients, and to identify through visits to households those children who need additional immunizations. In the long run, increasing the educational level of women

will provide a strong stimulus for improving childhood immunization coverage in the population. (Perry et al., 1998)

2.15. Child immunization coverage in urban slums of Bangladesh: impact of an intervention package

The study assessed the impact of an EPI (Expanded Programme on Immunization) intervention package, implemented within the existing service delivery system, to improve the child immunization coverage in urban slums of Dhaka, Bangladesh. This intervention trial used a pre- and post-test design. An intervention package was tested from September 2006 to August 2007 in two urban slums. The intervention package included: (a) an extended EPI service schedule; (b) training for service providers on valid doses and management of side-effects; (c) a screening tool to identify immunization needs among clinic attendants; and (d) an EPI support group for social mobilization. Data were obtained from random sample surveys, service statistics and qualitative interviews. Analysis of quantitative data was based on a 'before and after' assessment of selected immunization-coverage indicators. Qualitative data were analysed using content analysis.

Ninety-nine percent of the children were fully immunized after implementation of the interventions compared with only 43% before implementation. Antigen-wise coverage after implementation was also significantly higher compared with before implementation. Only 1% drop-out was observed after implementation of the interventions while it was 33% before implementation. At baseline, a significantly higher proportion of children of non-working mothers (75%) were fully immunized compared with children of working mothers (14%). Although the proportion of fully immunized children of both non-working and working mothers was significantly higher at endline, fully immunized children of working mothers dramatically improved at endline (99%) compared with baseline (14%). The findings suggested the effectiveness of a 'package of interventions' in improving child immunization coverage in urban slums. However, further research was needed to fully assess the effectiveness of the package, to assess the individual components in order to identify those that make the biggest contribution to coverage, and to assess the sustainability of this package within the existing service delivery system, particularly on a wider scale. (Uddin et al., 2009)

Aims & Objectives of the Study

- To examine and evaluate the immunization status of slum-dwelling children aged under five years in Dhaka city
- To study the factors affecting the status of childhood immunization of slum-dwelling areas in Dhaka city
- To identify the strategies that can improve immunization status in our study areas.

Significance of the Study

Immunization is the process of stimulating the body's immunity against certain infectious diseases by administering vaccines. Immunization is one of the main health interventions to prevent childhood morbidity and mortality. Improving the health of the extremely-poor people is essential for improving the health of the public more generally and for promoting equity. Disease, illness, and mortality are disproportionately concentrated among the extremely poor. Extreme poverty is very much linked to poor environmental conditions, such as crowding and lack of clean water and sanitation, poor nutritional status as a result of poverty and lack of food, and frequent childbearing, and all these contribute to a greater burden of diseases. Furthermore, the extremely poor often lack resources, which are essential for preventing or treating diseases. They lack access to basic health services, lack awareness of the importance of their timely use, lack the time and money needed to use health services, and often need to address other more pressing issues. One of the most basic of all health services is immunization.

In many cases, children living in urban slums and rural remote areas have less access to immunization. This immunization gap represents a devastating toll on the world's population. Every year, there are three million unnecessary premature deaths because too many children have not been given vaccines that could have saved their lives. This is not only a health issue, it is an issue of fundamental equity and human rights. The immunization gap also exists within Bangladesh. Although 71% of children aged 12-23 months are fully immunized, the immunization coverage is still low in some areas, particularly in urban slums. A study conducted in slum areas of Dhaka city showed that the proportion of fully-immunized children aged 12 months was only 54%. Furthermore, in Dhaka city, a persistent gap exists in the coverage of those living in slum households compared to those living in better-off circumstances.

In this study, I want to assess the immunization coverage of slum-dwelling children living in the areas of Dhaka city in Bangladesh and also to assess & identify the acceptability of selected strategies among healthcare providers that can help to improve the immunization coverage in those areas.

Methodology

3.1. Types of Study

This study was survey based and it involves the analysis of the data collected from the caregiver of the child of the slum-dwelling areas to find out the vaccination status of the recipient.

3.2. Place of Study

This study has been taken place in the slum-dwelling areas of Banasree, Kalshi & Mirpur-10, 11&12 no. sectors of Dhaka city.

3.3. Study Population

This study was conducted through face to face conversation with the caregiver of the child discussing about the vaccination coverage or status of the recipient. A total number of 300 slum-dwelling children were involved in this study but the information was taken from the caregiver of the child.

3.4. Inclusion Criteria

i. This study was taken from the children of slum-dwelling areas whose age are under 5 years old
ii. Both sexes were included in this study irrespective of their religion and occupation

3.5. Exclusion Criteria

i. Children of above 5 years old from slum-dwelling study areas were excluded in this study
ii. Children living outside of study areas were not considered in this study.

3.6. Study Tool

To make this study demographic information of the children of slum-dwelling areas was collected through a standard questionnaire which was made with the help of my research supervisor. This survey was carried out by directly interviewing the caregiver of the child where each caregiver was being informed about the purpose of the study and then noted down their answer of my question according to the standard questionnaire format.

3.7. Study period

My survey period was started from July 2015 and finished in May 2016. To complete the study in time, a work schedule was prepared depending on different tasks of the study. Two months were spent for selection of topic and development of the protocol. Subsequent months were spent on data collection, analysis & report writing.

3.8. Data analysis

After data collection all the filled up questionnaires were checked and cross-checked in order to correct inconsistent information and coding. After checking, the data were entered and then organized, tabulated and results were calculated & prepared by using Microsoft Excel 2007. The results were expressed graphically in percentages. The results were shown in column and pie charts. The quality and accuracy of data was maintained through continuous supervision in order to eliminate errors.

3.9. Ethics

This study was done without conflicting any ethical issues. Ethical consideration was checked by the research supervisor with research policy of the East West University.

Results

4.1. Prevalence of Different Age Ranges in Slum-Dwelling Children

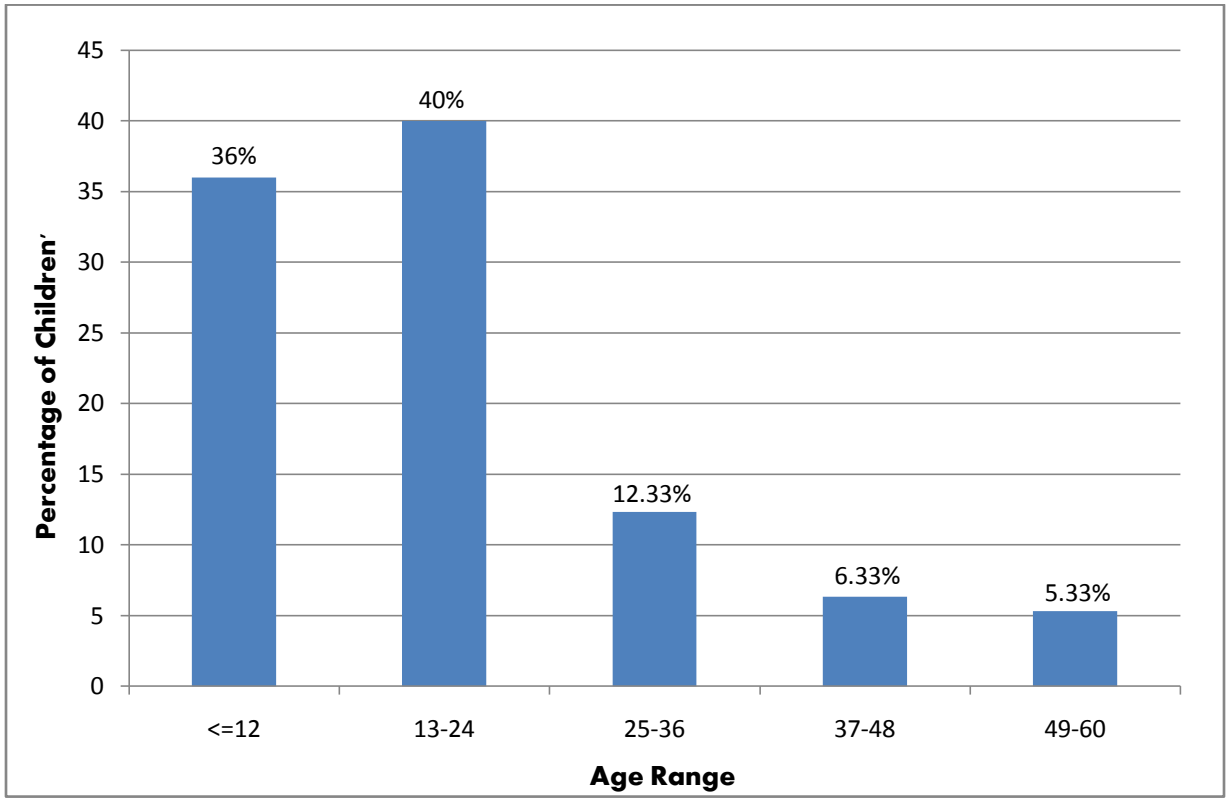

Figure 4.1. Prevalence of Different Age Ranges in Slum-Dwelling Children

During this study period, majority of children were within the age range of 13-24 months old (40%) and minority of children were within 49-60 months old (5.33%). The other different age ranges of slum-dwelling children were <=12 months old (36%), 25-36 months old (12.33%) and 37-48 months old (6.33%).

4.2. Prevalence of Gender

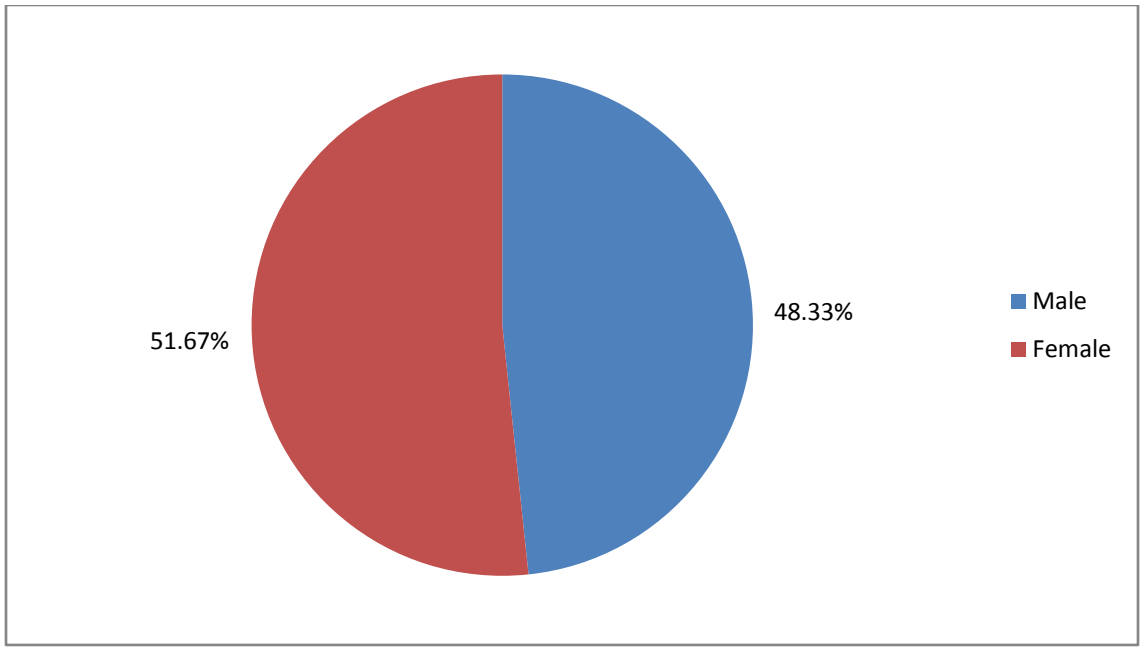

Figure 4.2. Prevalence of gender

Majority of subjects were females (51.67%) and there were 48.33% males.

4.3. Prevalence of Different Religion

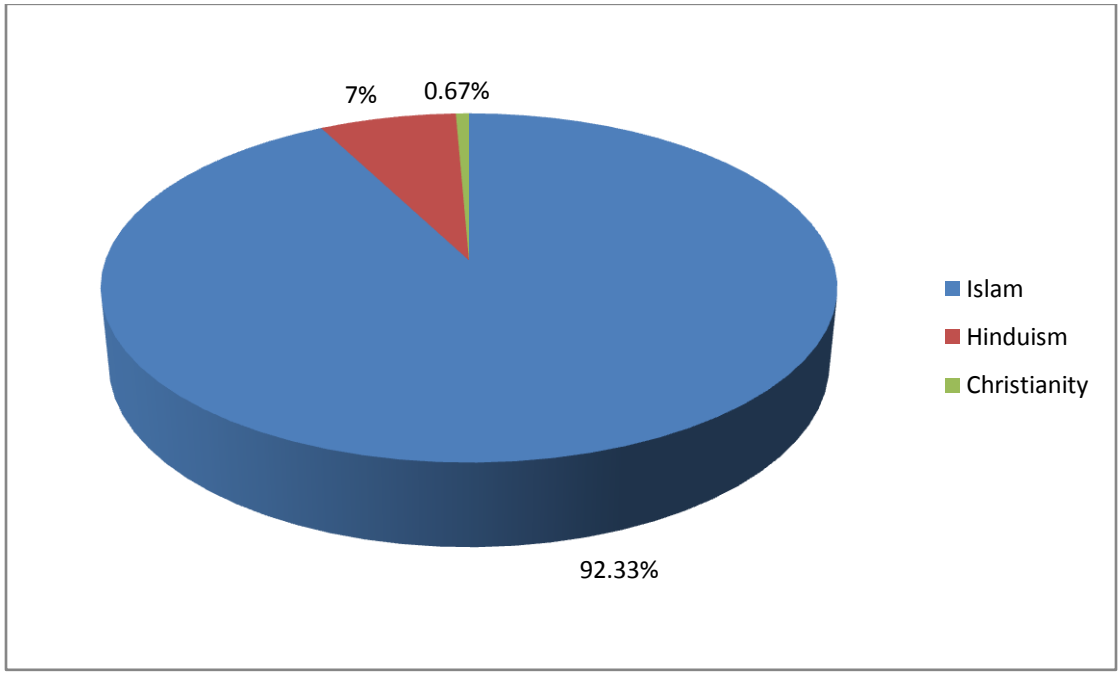

Figure 4.3. Prevalence of different religion

In this survey, majority of slum-dwelling children religion belonged to Islam (92.33%). The other children were Hindu (7%) and Christian (0.67%).

4.4. Prevalence of Respondents (Relationship) Giving Vaccination Information of the Child

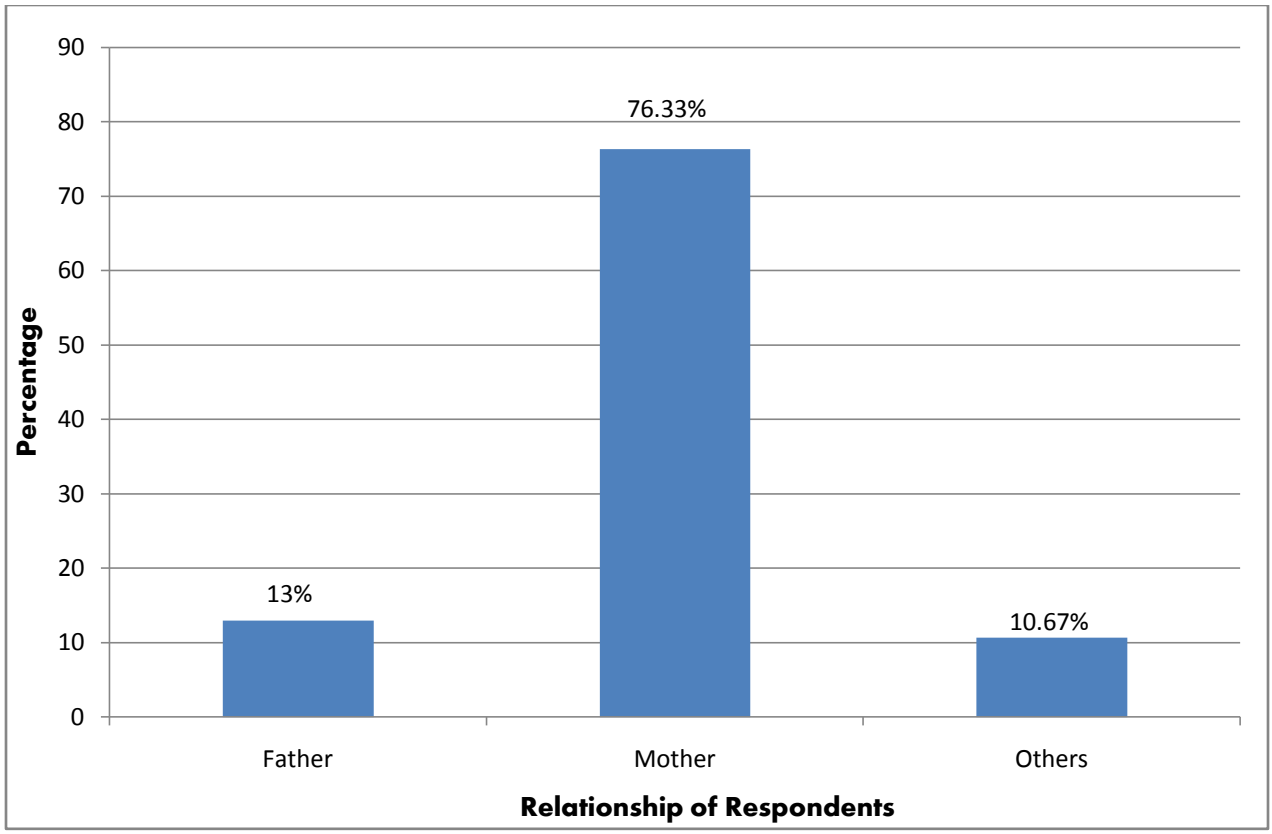

Figure 4.4. Prevalence of Respondents (Relationship) Giving Vaccination Information of the Child

Information of majority respondents in this survey were taken from child's mother (76.33%) and 10.67% were taken from others who were the child's uncle or aunt. 13% of the children's information was taken from father.

4.5. Prevalence of Different Age Ranges of the Father

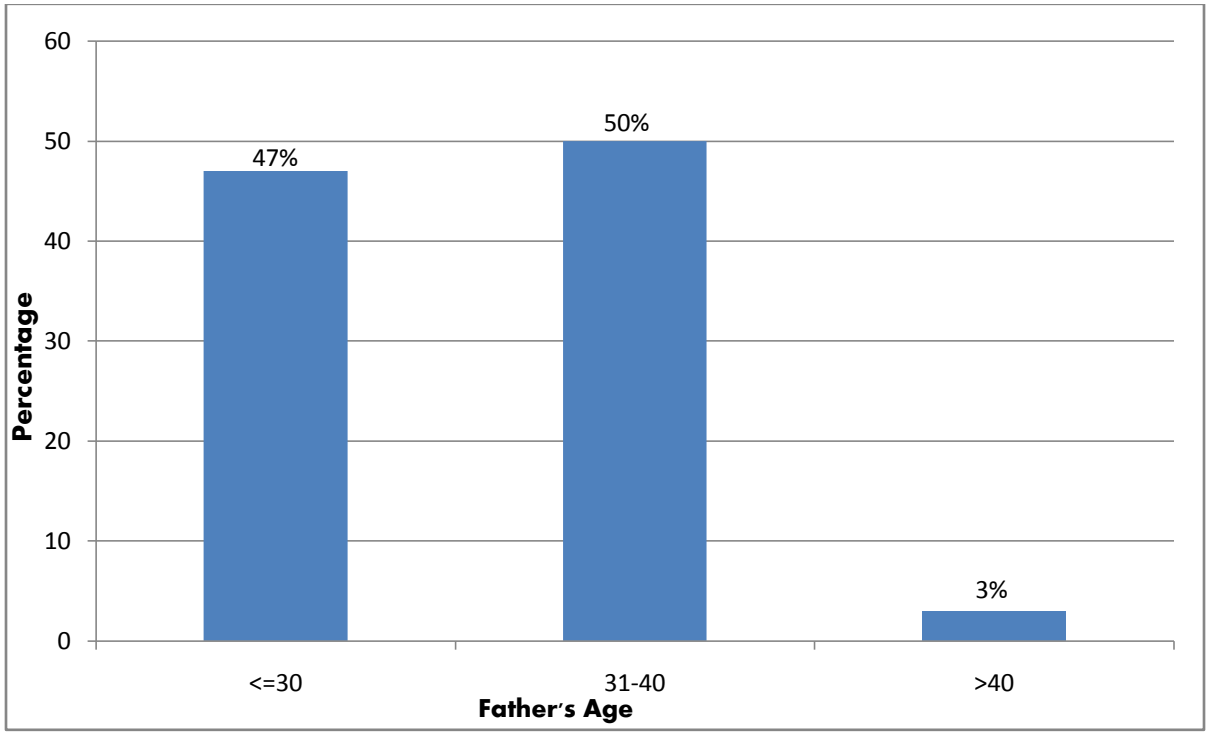

Figure 4.5. Prevalence of Different Age Ranges of the Father

Majority of the fathers age range were within 31-40 years old (50%). 47% of fathers were <=30 years and 3% were above 40 years old.

4.6. Prevalence of Different Age Ranges of the Mother

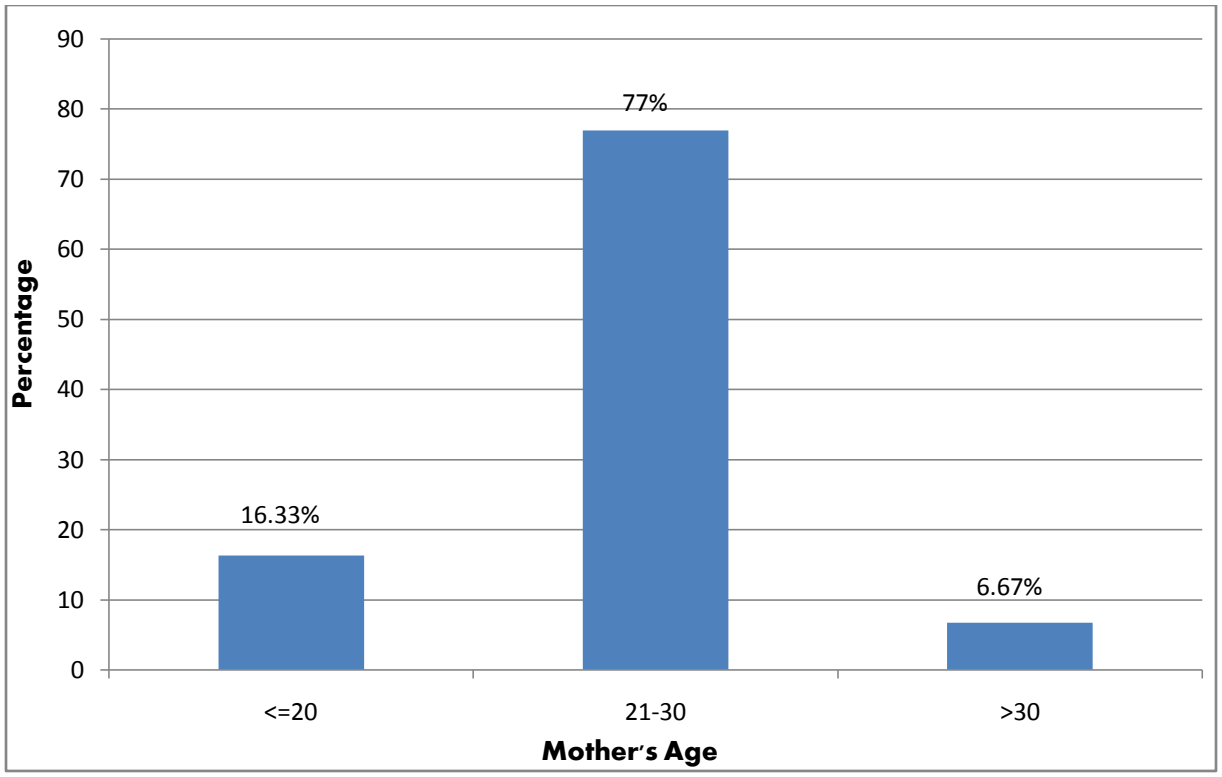

Figure 4.6. Prevalence of Different Age Ranges of the Mother

Majority of the mothers age range were within 21-30 years old (77%). 16.33% of mothers were <=20 years and 6.67% were above 30 years old.

4.7. Prevalence of Different Levels of Fathers Educational Status

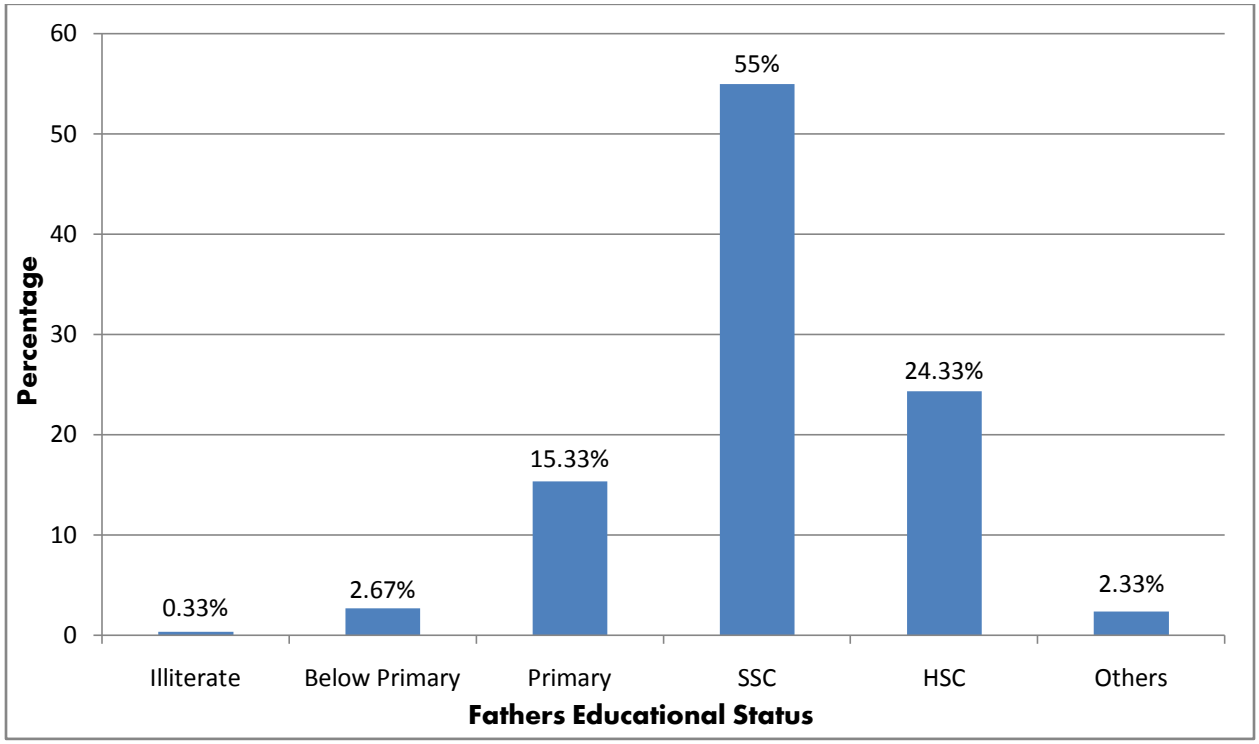

Figure 4.7. Prevalence of Different Levels of Fathers Educational Status

Majority of the fathers educational background were SSC (55%) and minority were illiterate (0.33%). 24.33% were HSC, 15.33% were primary, 2.67% were below primary and 2.33% were others who were graduated.

4.8. Prevalence of Different Levels of Mothers Educational Status

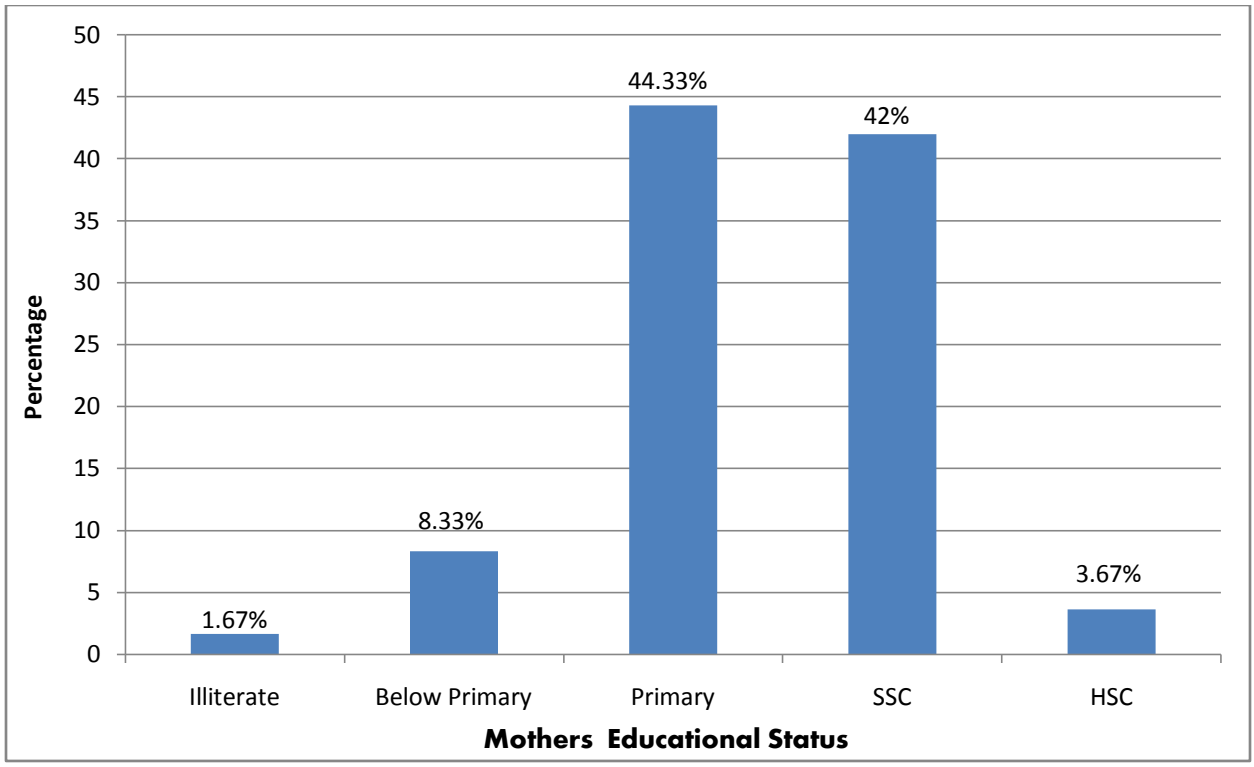

Figure 4.8. Prevalence of Different Levels of Mothers Educational Status

Majority of the mothers educational background were primary (44.33%) and minority were illiterate (1.67%). 42% mothers were SSC, 8.33% were below primary and 3.67% were HSC.

4.9. Prevalence of Occupational Status of Father

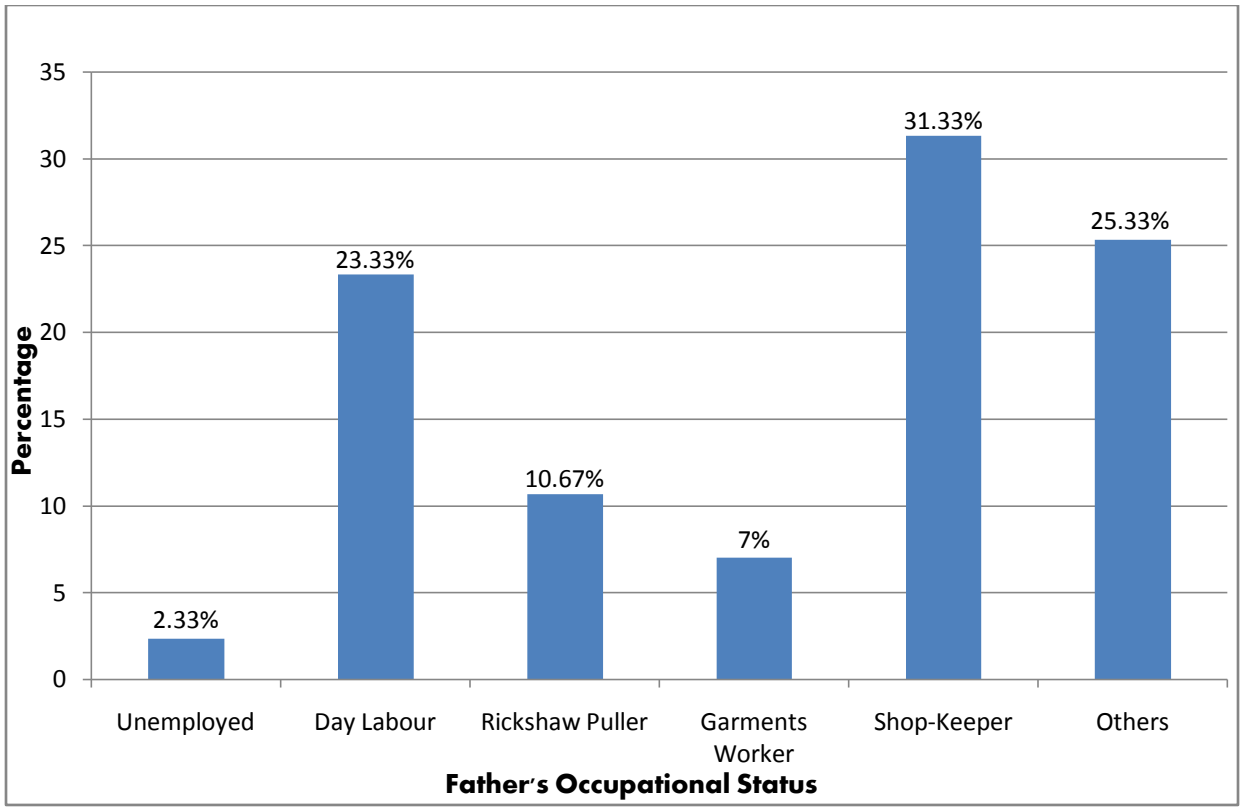

Figure 4.9. Prevalence of Occupational Status of Father

Majority of slum-dwelling children's father's occupation were shop-keepers (31.33%) and the minority were unemployed (2.33%). The other occupations were business (25.33%), day labors (23.33%), rickshaw pullers (10.67%) and garments workers (7%).

4.10. Prevalence of Occupational Status of Mother

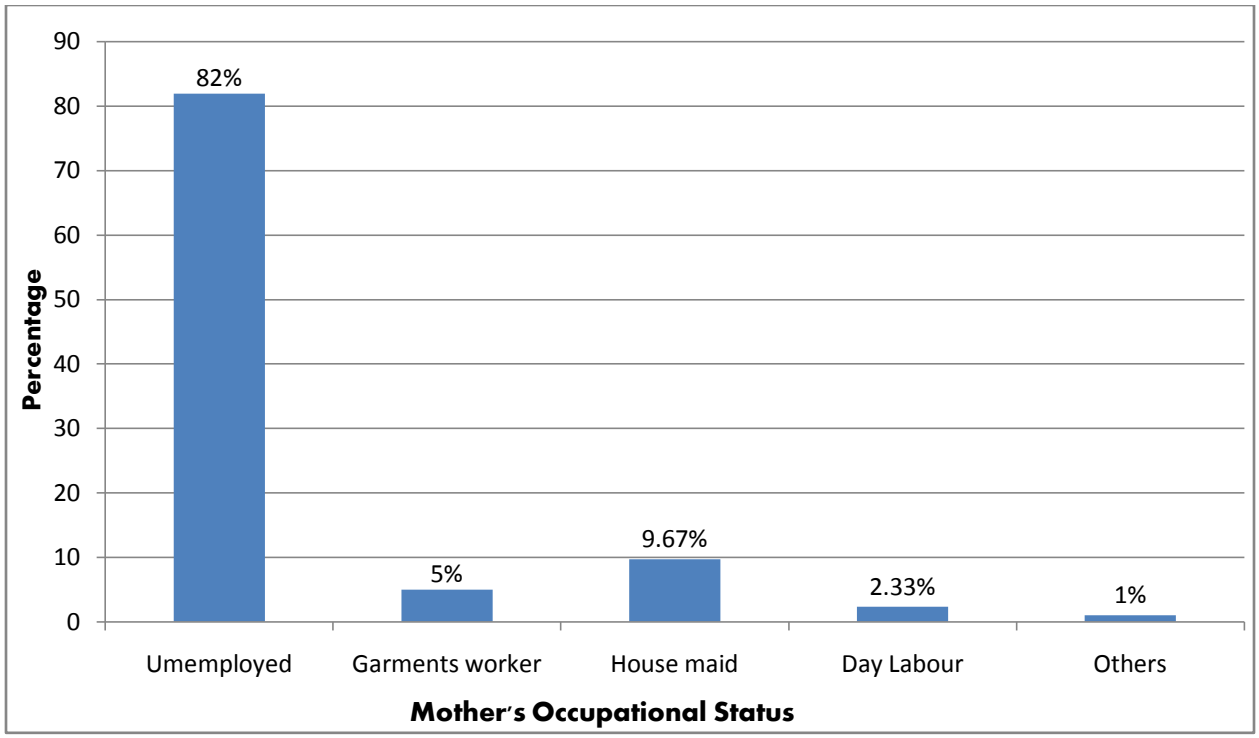

Figure 4.10. Prevalence of Occupational Status of Mother

The majority of slum-dwelling children's mother's were unemployed or housewife (82%) and minority were others (1%) which was teaching. The other mother's were found to be housemaids (9.67%), garments workers (5%) and day laborers (2.33%).

4.11. Monthly Income of the Family

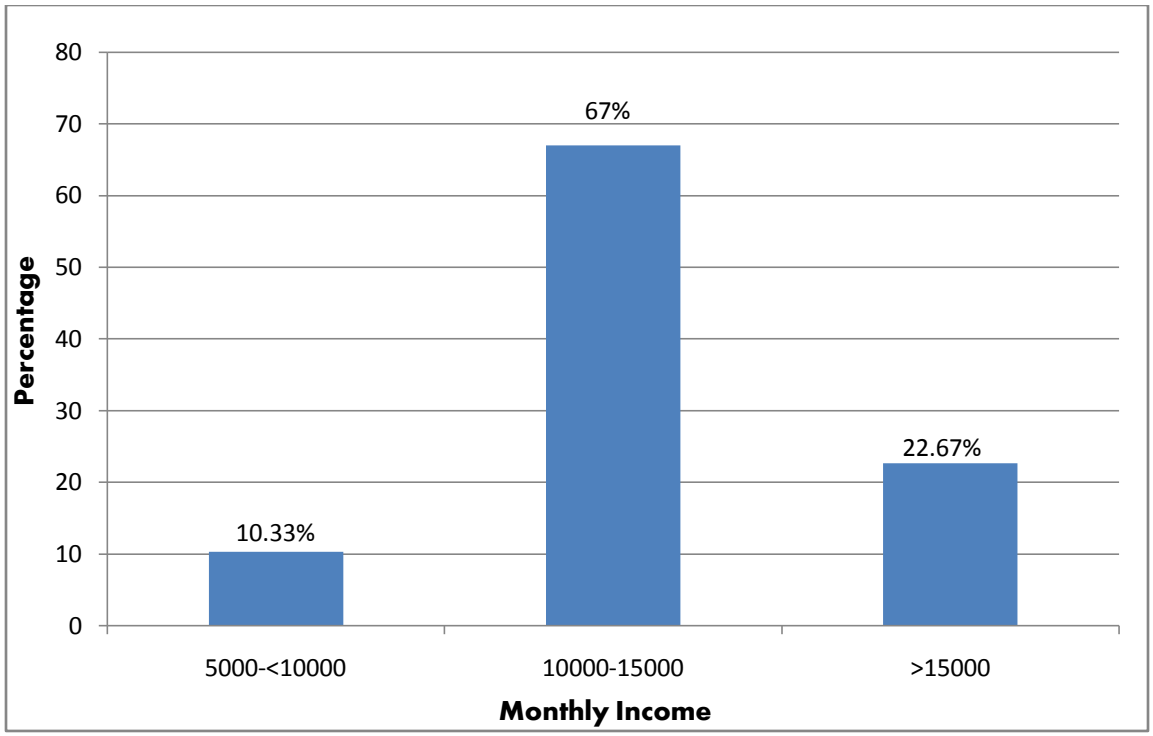

Figure 4.11. Monthly Income of the Family

Majority of the monthly income of slum-dwelling family were within the range of Tk. 10000-15000. 22.67% of families had income above Tk. 15000 and 10.67% families had income in the range 5000-<10000.

4.12. Prevalence of the Birth Order of Child

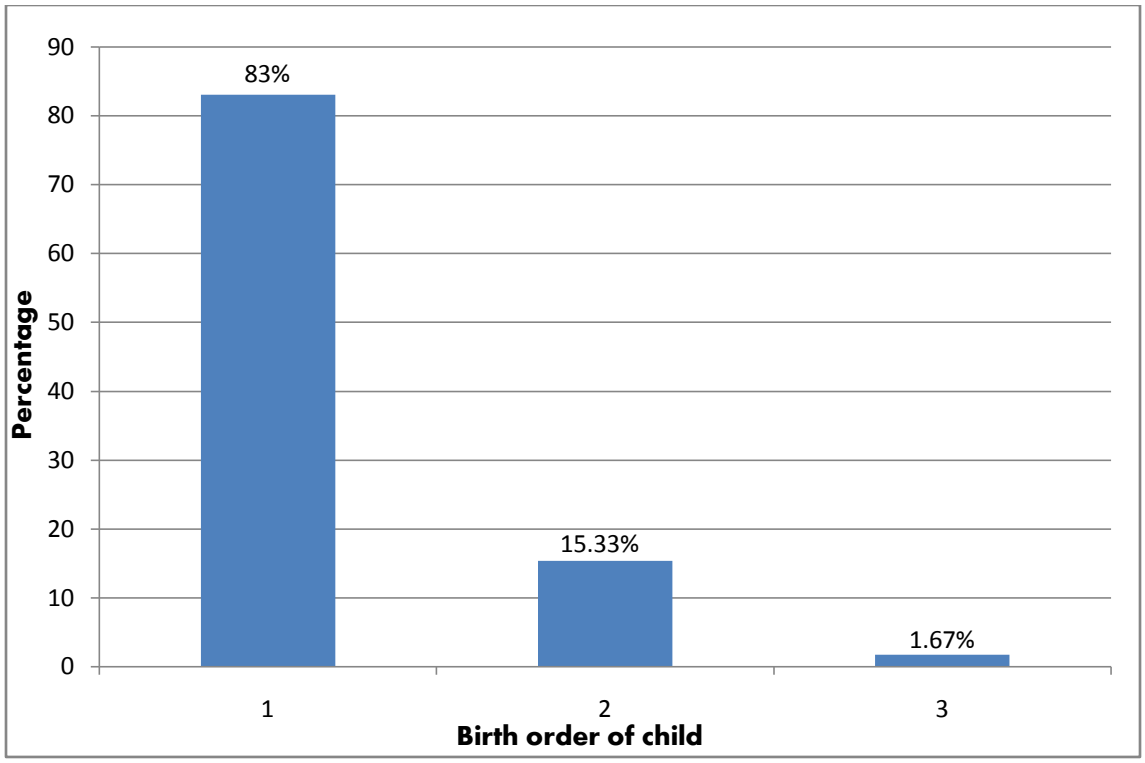

Figure 4.12. Prevalence of the Birth Order of Child

From this survey, majority of the slum-dwelling children were 1st birth order (83%). 15.33% of children had 2nd birth order and 1.67% of children had 3rd birth order.

4.13. Prevalence of the Primary Caregiver of Child

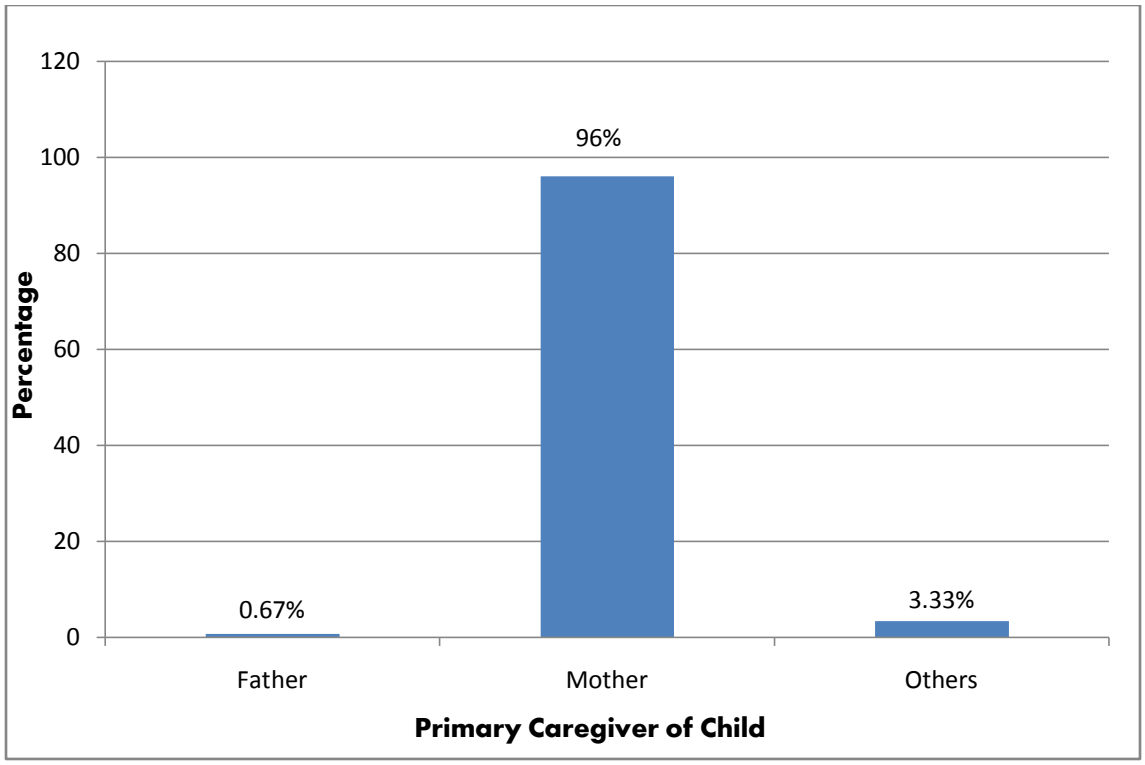

Figure 4.13. Prevalence of the Primary Caregiver of Child

96% of children had mother as caregiver and minority of children (0.67%) had father as caregiver. The other caregivers were found to be child's grandmother and aunt (3.33%).

4.14. Knowledge of Vaccination from Caregiver's point of view

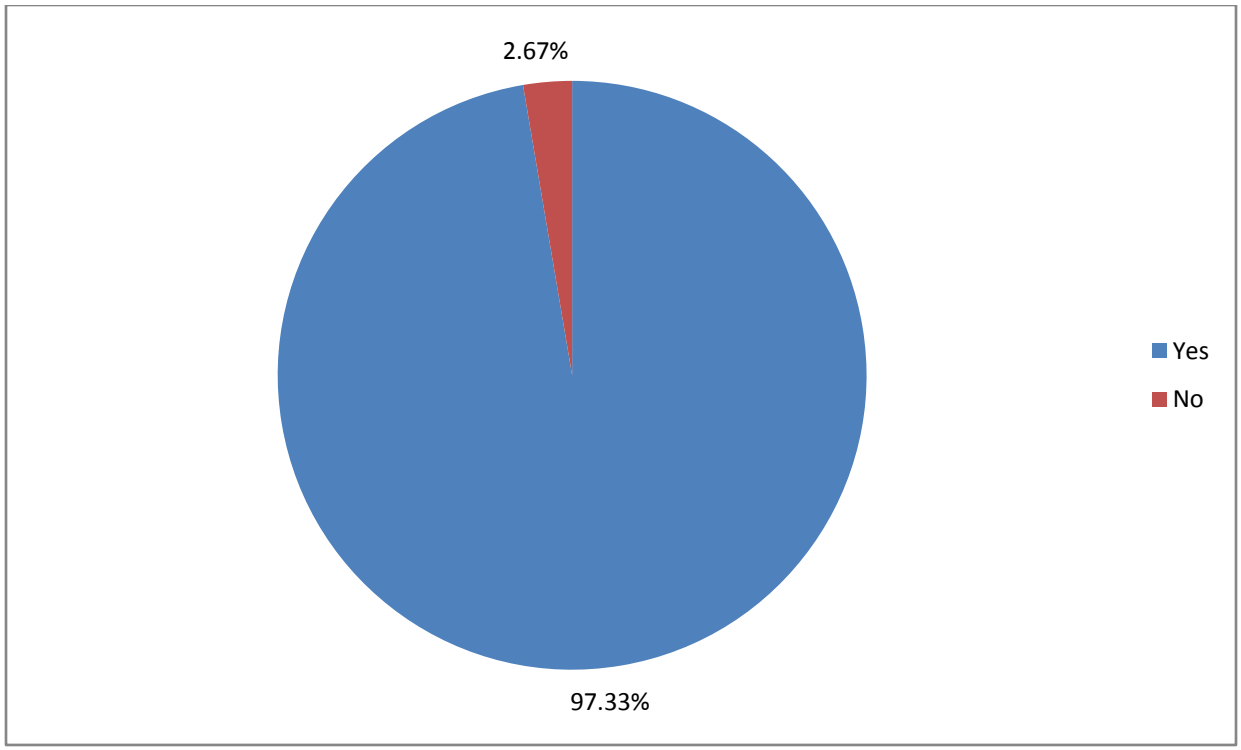

Figure 4.14. Knowledge of Vaccination from Caregiver's point of view

From this survey, majority number of the caregiver knew about vaccination (97.33%) and others (2.67%) did not know or had no idea about it.

4.15. Different Information Sources Regarding Vaccination

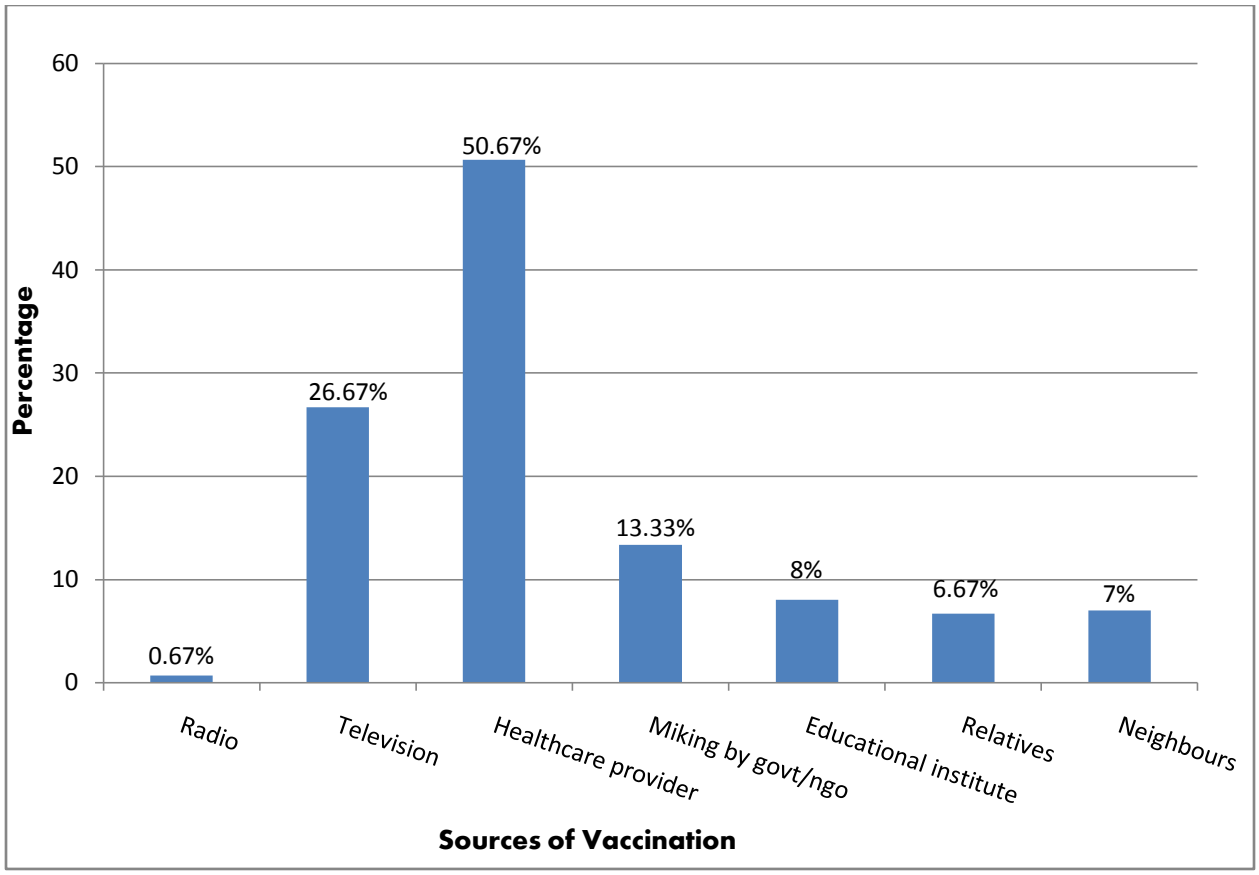

Figure 4.15. Different Information Sources Regarding Vaccination

Majority of respondents knew about vaccination from health care providers (50.67%) and minority got information from radio (0.67%). Others got information from television (26.67%), announcements or miking by government or NGOs (13.33%), educational institute (8%), neighbours (7%) and relatives (6.67%).

4.16. Status of Vaccination Card

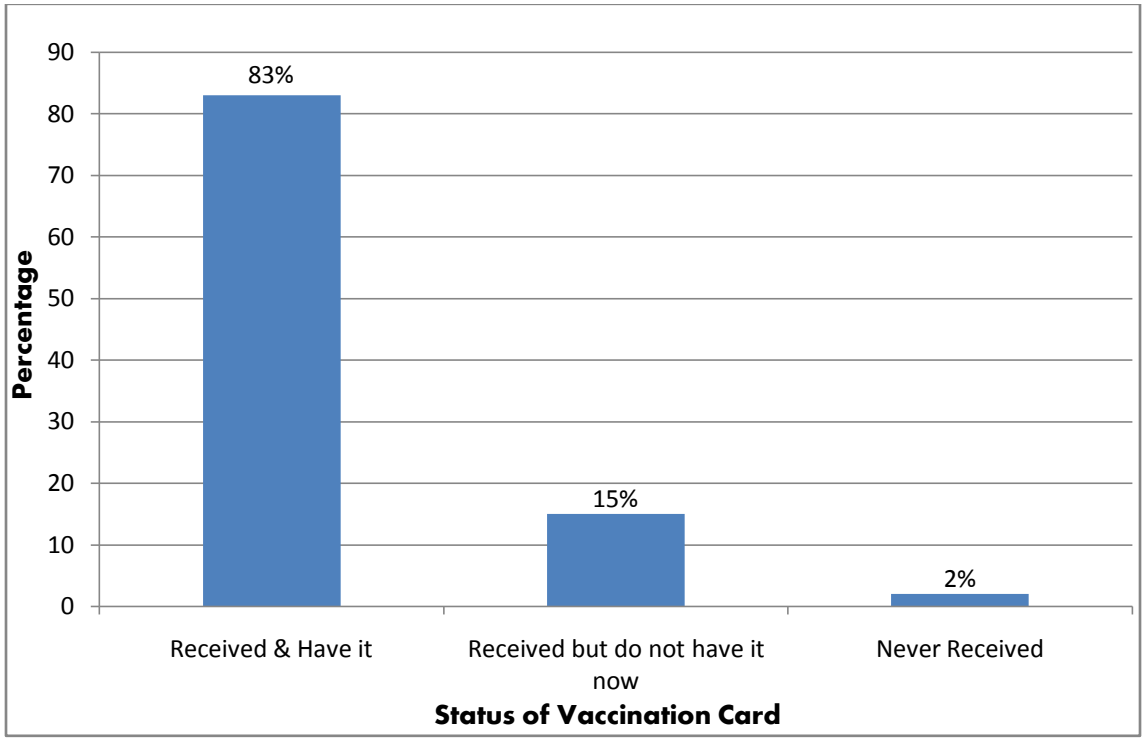

Figure 4.16. Status of Vaccination Card

Majority caregiver of respondents received the vaccination card & had it with them (83%). 15% caregivers received the card but couldn't find out now or lost it and 2% never received the card.

4.17. Prevalence of Different Reasons Behind Vaccination

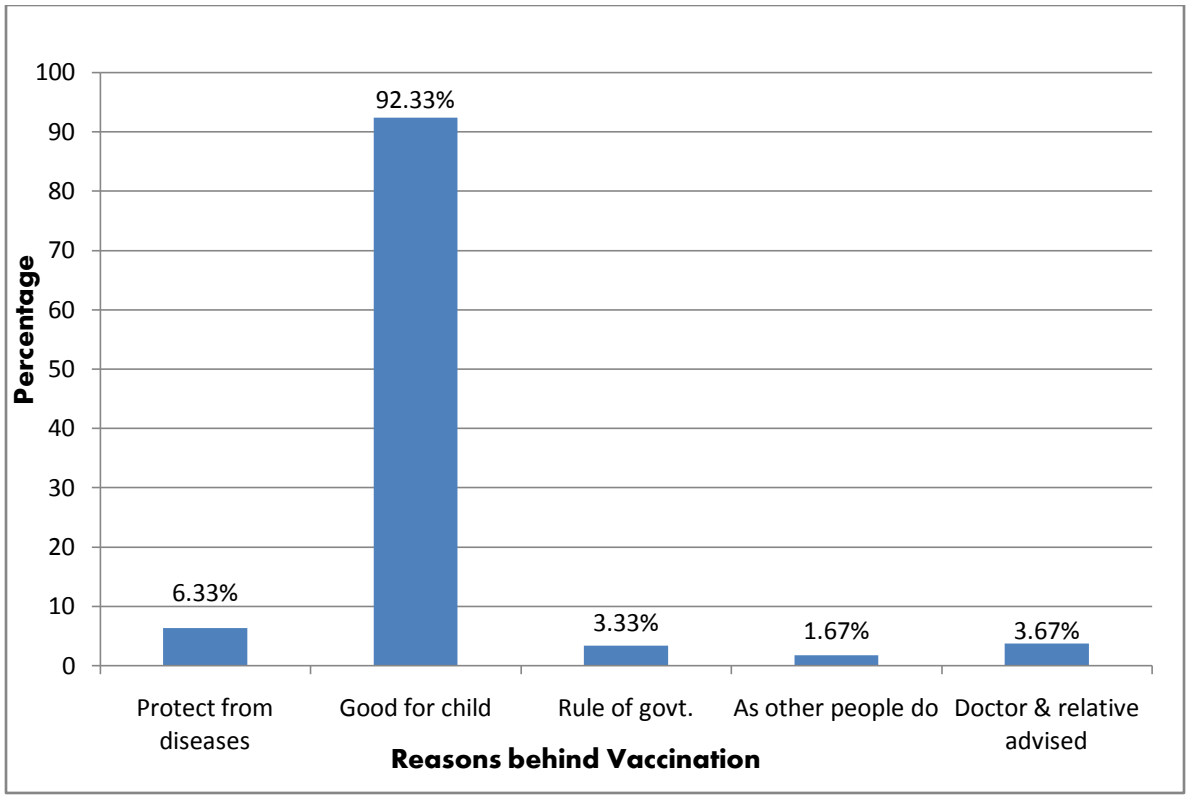

Figure 4.17. Prevalence of Different Reasons Behind Vaccination

Majority of caregivers believed that vaccination was good for child (92.33%) and minority did it as other people did (1.67%). Other reasons were protect from diseases (6.33%), doctor & relative advised (3.67%) and the rule of government (3.33%).

4.18. Prevalence of Different Adverse Effects After Taking Immunization Dose

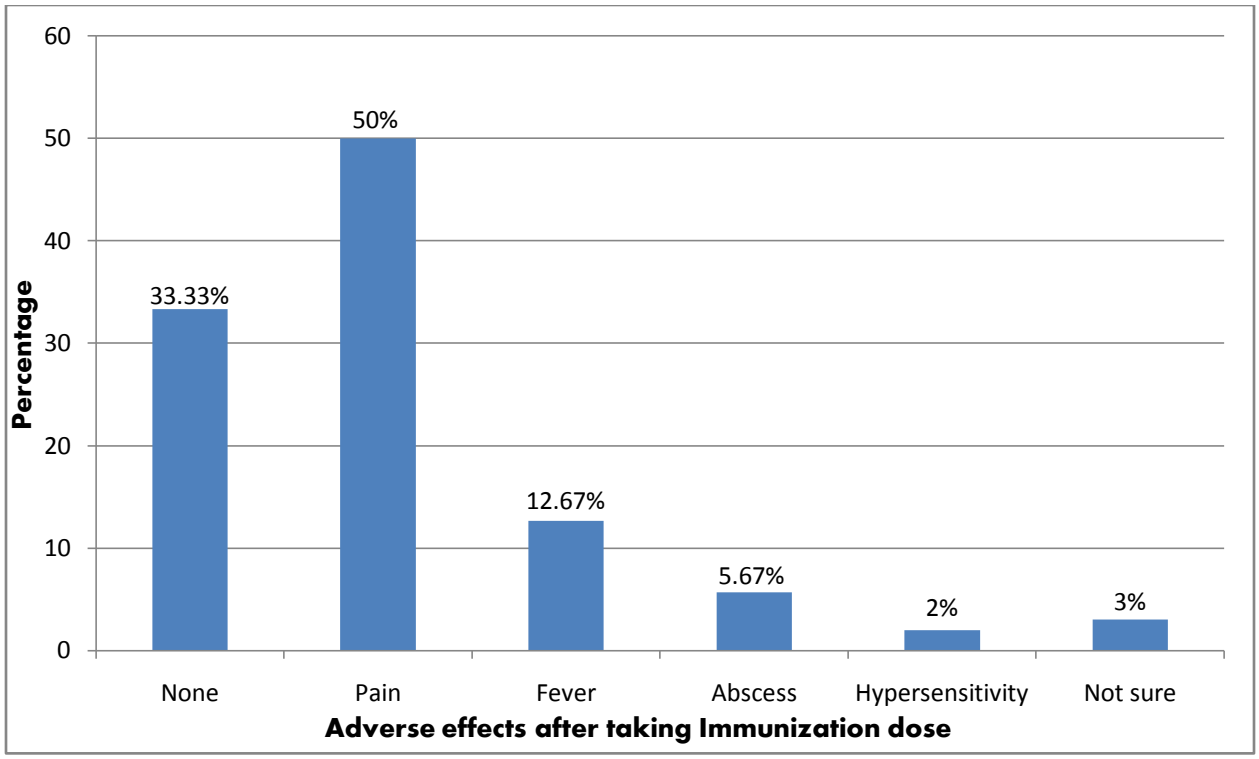

Figure 4.18. Prevalence of Different Adverse Effects After Taking Immunization Dose

Most caregivers had complained about the adverse effects after taking immunization dose. Majority caregivers complained about pain (50%) and minority complained about hypersensitivity (2%). Other adverse effects were fever (12.67%), abscess (5.67%), and 3% caregivers were not sure about the adverse effect. Among all of these adverse effects, 33.33% caregivers said that they had not observed any adverse effect after giving immunization dose to their child.

4.19. Vaccination Status of the Recipient

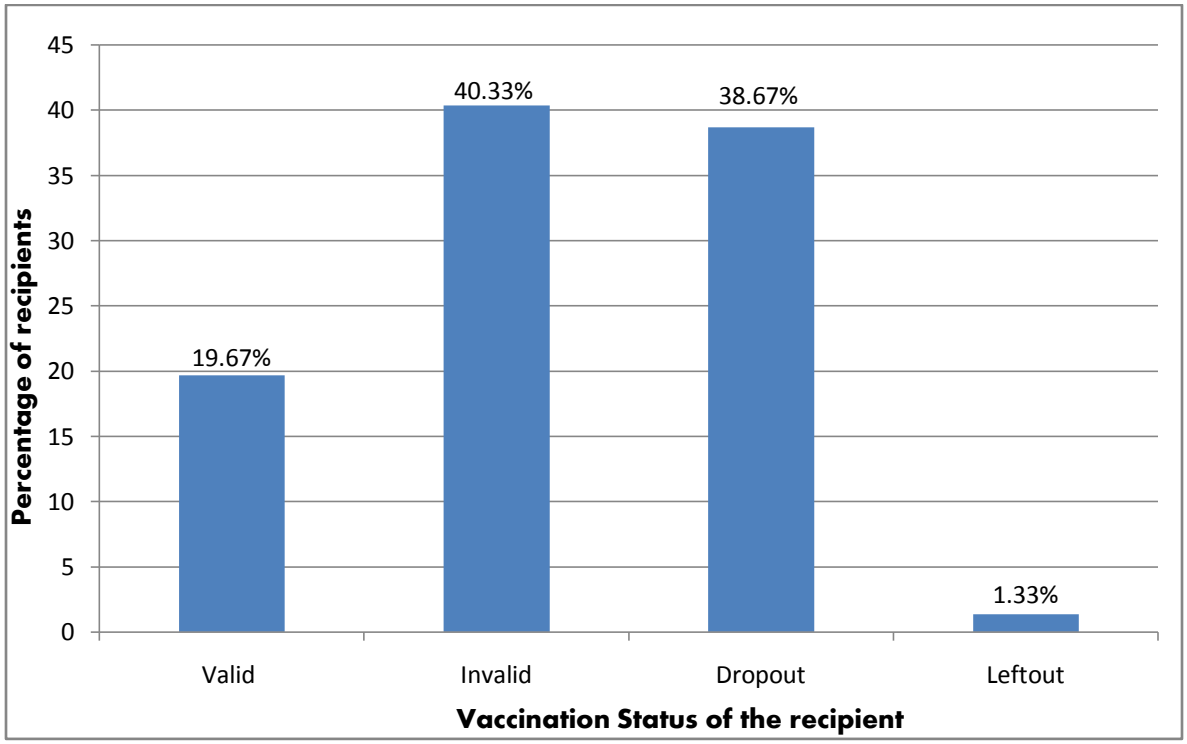

Figure 4.19. Vaccination Status of the Recipient

Majority of the children were invalid dose recipients (40.33%) and minority were valid dose recipients (19.67%). 38.67% of recipients dropped out whereas 1.33% did not receive any vaccination dose and were considered as left out.

4.20. Prevalence of Different Drop-out Causes

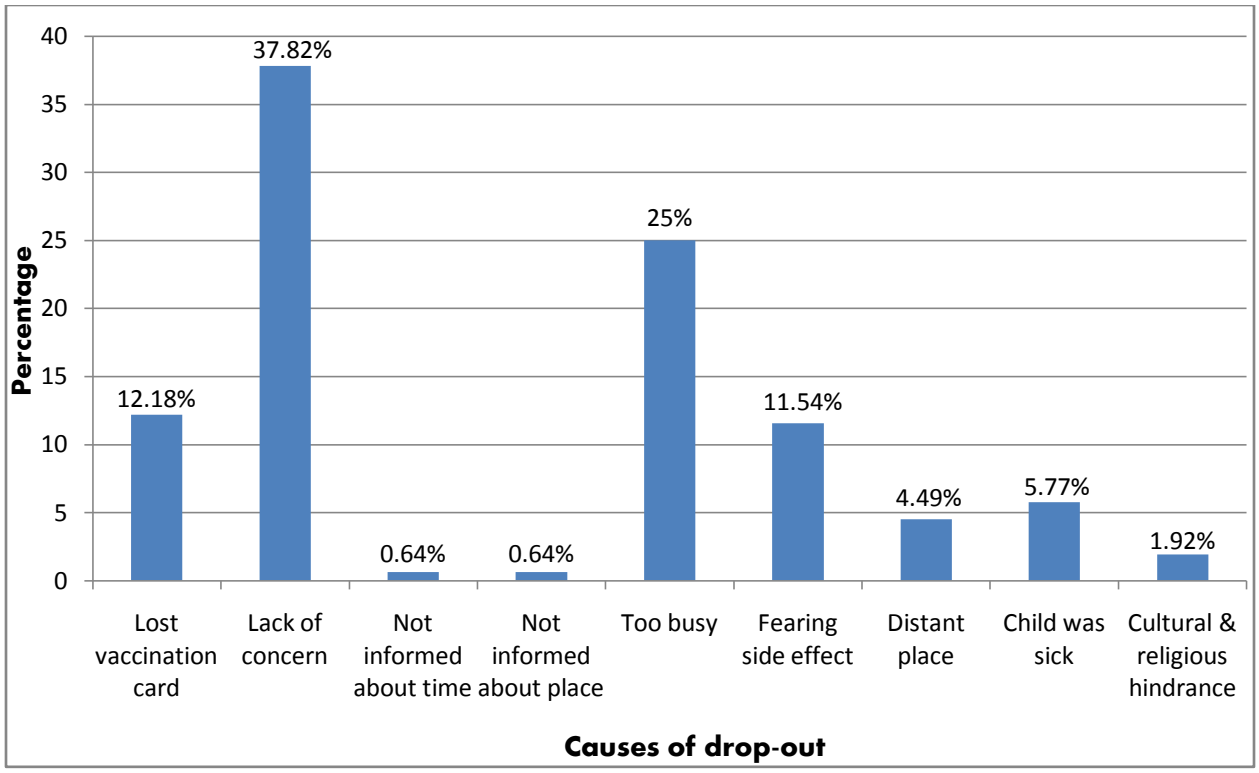

Figure 4.20. Prevalence of Different Drop-out Causes

For the case of drop-out recipient, major reason was lack of concern (37.82%) and the minor reason were not informing about time & place (0.64%) of the vaccination centre. The other causes were being too busy (25%), losing vaccination card (12.18%), fearing side effect (11.54%), sickness of child (5.77%), place being distant (4.49%) and cultural & religious hindrance (1.92%).

4.21. Preferred Time Schedule for Vaccination

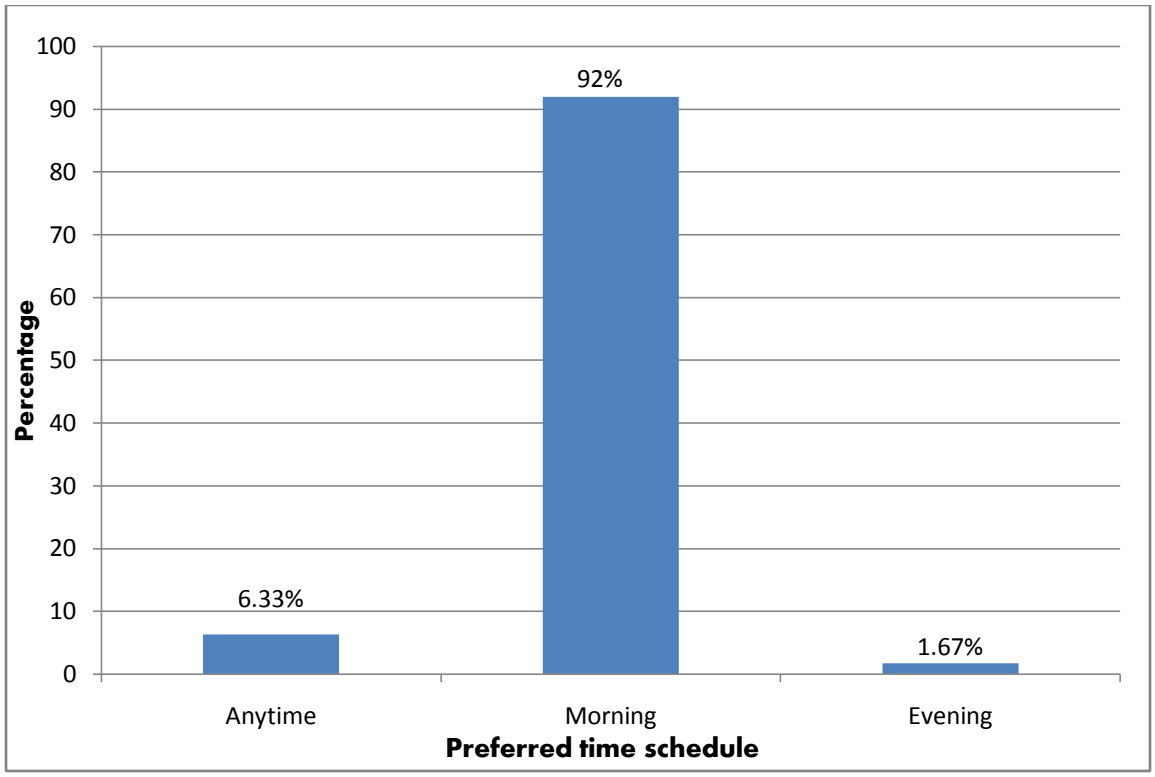

Figure 4.21. Preferred Time Schedule for Vaccination

Majority of caregivers preferred morning time schedule (92%) for vaccination. 6.33% caregivers preferred anytime and 1.67% preferred evening time.

4.22. Reasons Behind Preferring Morning Schedule

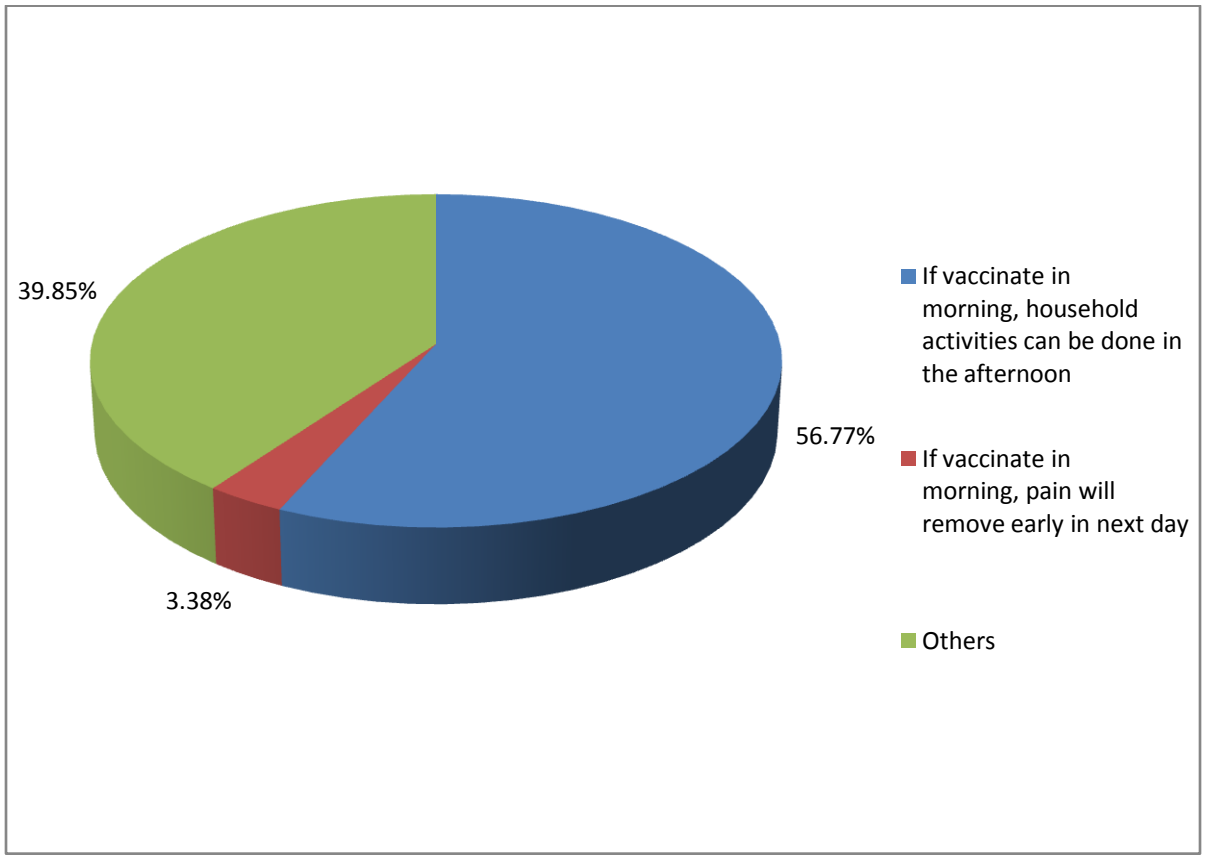

Figure 4.22. Reasons Behind Preferring Morning Schedule

The main reason that caregivers had preferred morning schedule to vaccinate their child because the household activities could be done in the afternoon (56.77%). 39.85% caregivers said that the vaccination schedule of the centre is generally given at morning session and 3.38% stated that if they vaccinate their child in morning, pain will remove early the next day.

4.23. Reasons Behind Preferring Evening Schedule

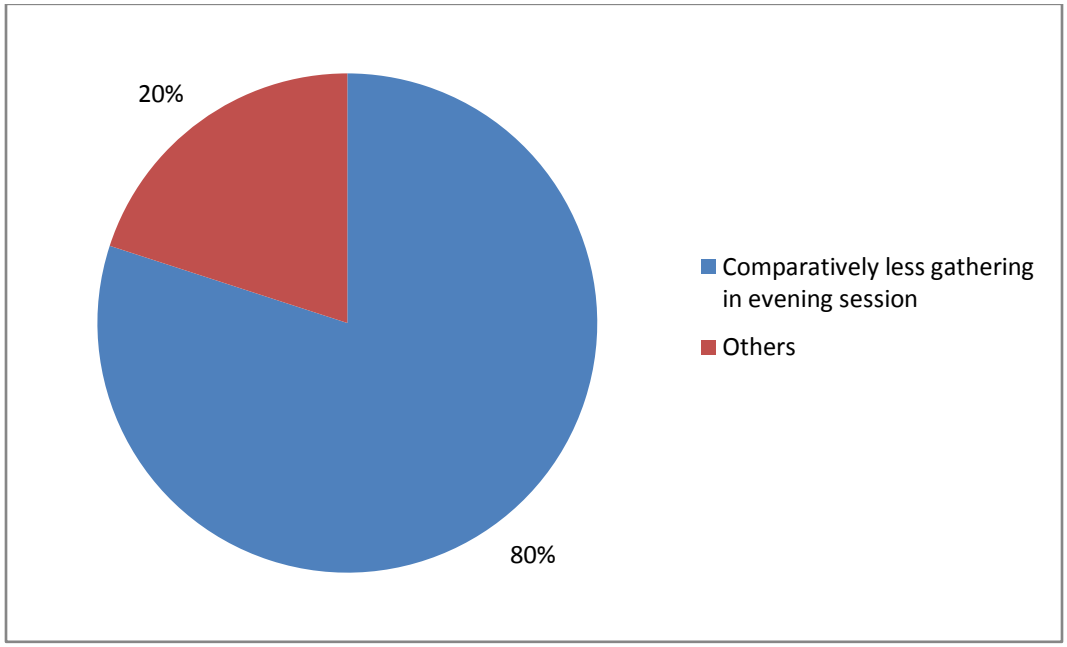

Figure 4.23. Reasons Behind Preferring Evening Schedule

The main reason for majority caregivers for preferring evening schedule were comparatively less gathering (80%) in the centre and 20% stated that the vaccination centre schedule was given at evening time.

4.24. Choice of Vaccination Place

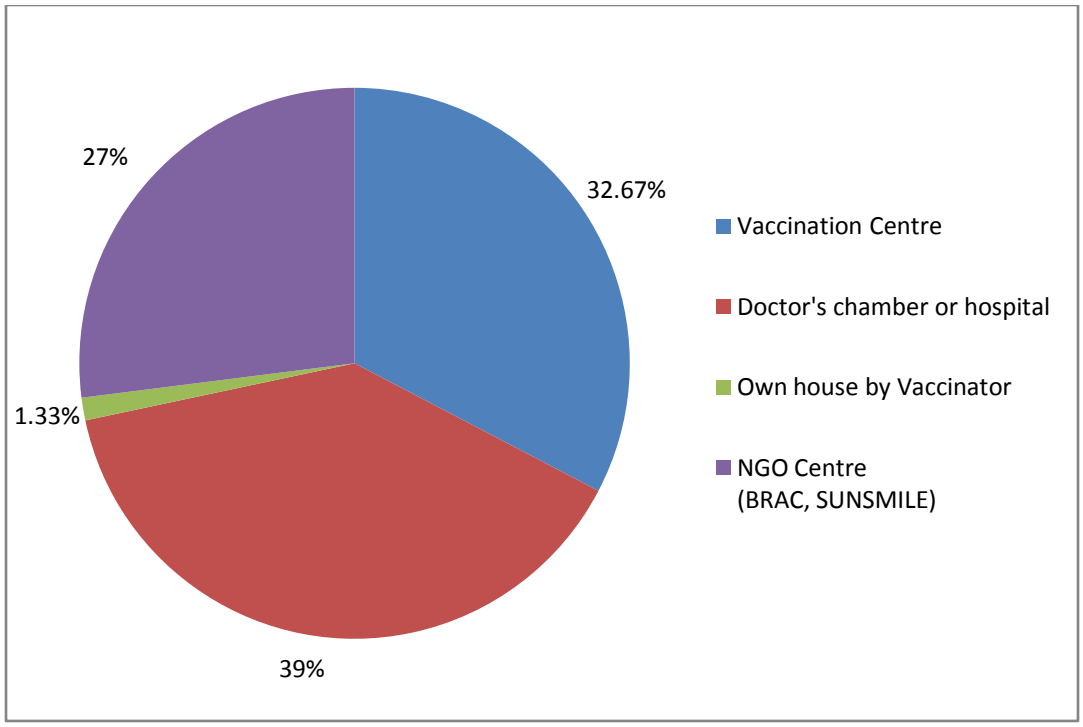

Figure 4.24. Choice of Vaccination Place

Most caregivers preferred doctor's chamber or hospital as their choice of vaccination place (39%). 32.67% caregivers preferred vaccination centre, 27% preferred NGO centre such as BRAC, Sunsmile etc. and 1.33% stated that they preferred vaccinator to come home and vaccinate their child.

4.25. Common Problems Faced During Vaccination

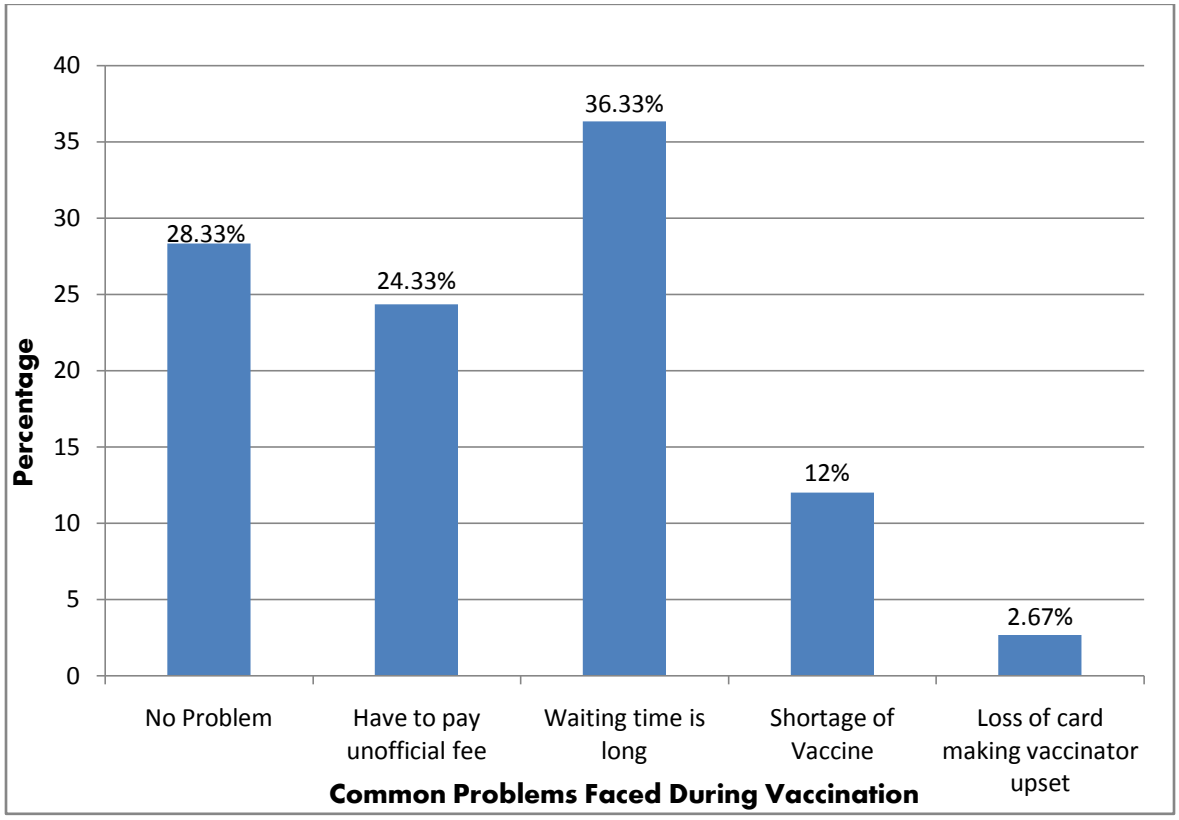

Figure 4.25. Common Problems Faced During Vaccination

Most caregivers had faced different problems during vaccination. The major common problem was long waiting time (36.33%) and the minor common problem was loss of vaccination card making vaccinator upset (2.67%). The other common problems were paying unofficial fee (24.33%) and shortage of vaccine (12%). 28.33% caregivers stated that they had faced no problem during vaccination.

4.26. Different Suggestions to Achieve Full Immunization

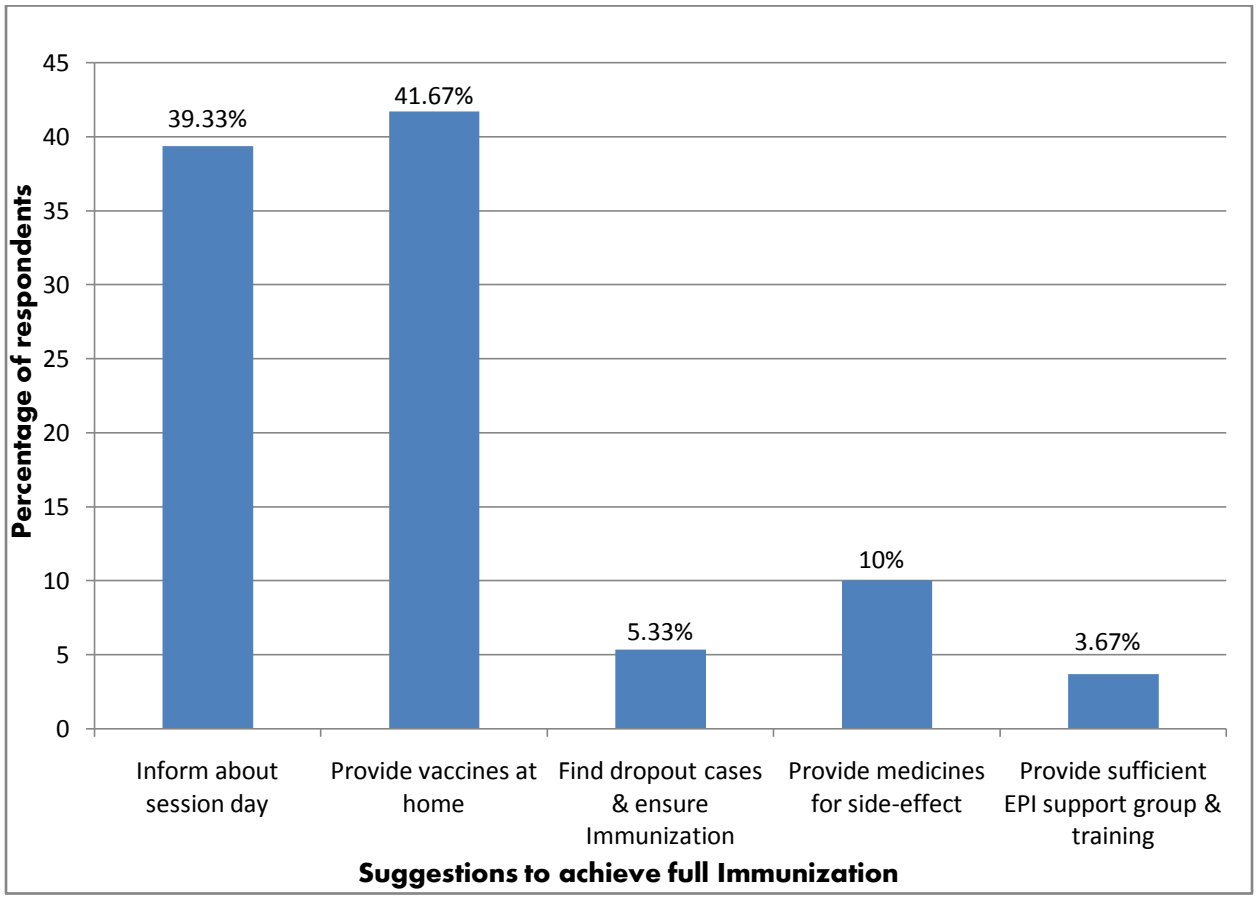

Figure 4.26. Different Suggestions to Achieve Full Immunization

The caregivers had given different suggestions to achieve full immunization. Majority caregivers suggested about providing vaccines at home (41.67%) and minority suggested about providing sufficient EPI support group & training (3.67%). The other suggestions were informing about session day (39.33%), providing medicines for side-effect (10%) and finding drop-out cases to ensure immunization (5.33%).

4.27. Status of Childhood Immunization of the Mother

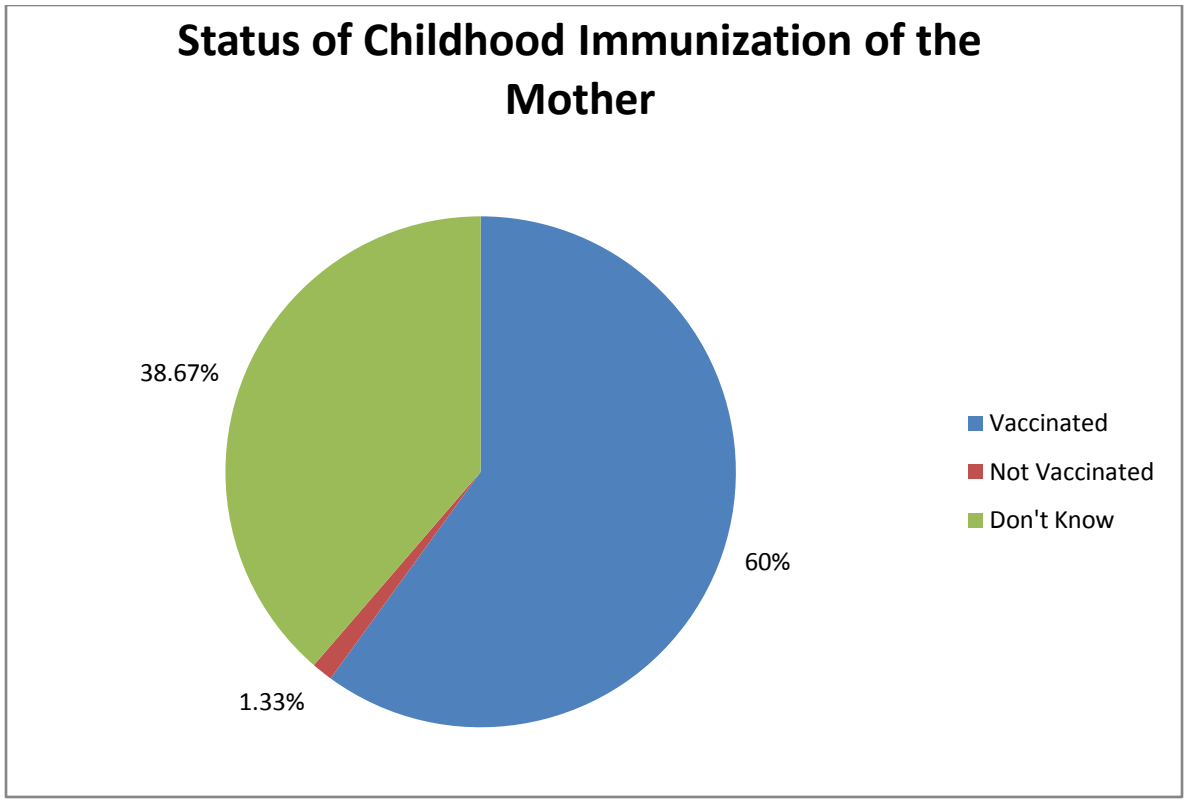

Figure 4.27. Status of Childhood Immunization of the Mother

Majority of the mothers stated that they were fully vaccinated during childhood (60%). 38.67% mother's did not knew about their childhood vaccination whether they had received it or not and 1% of the mother was not vaccinated.

4.28. Status of the Mother Receiving Tetanus Immunization

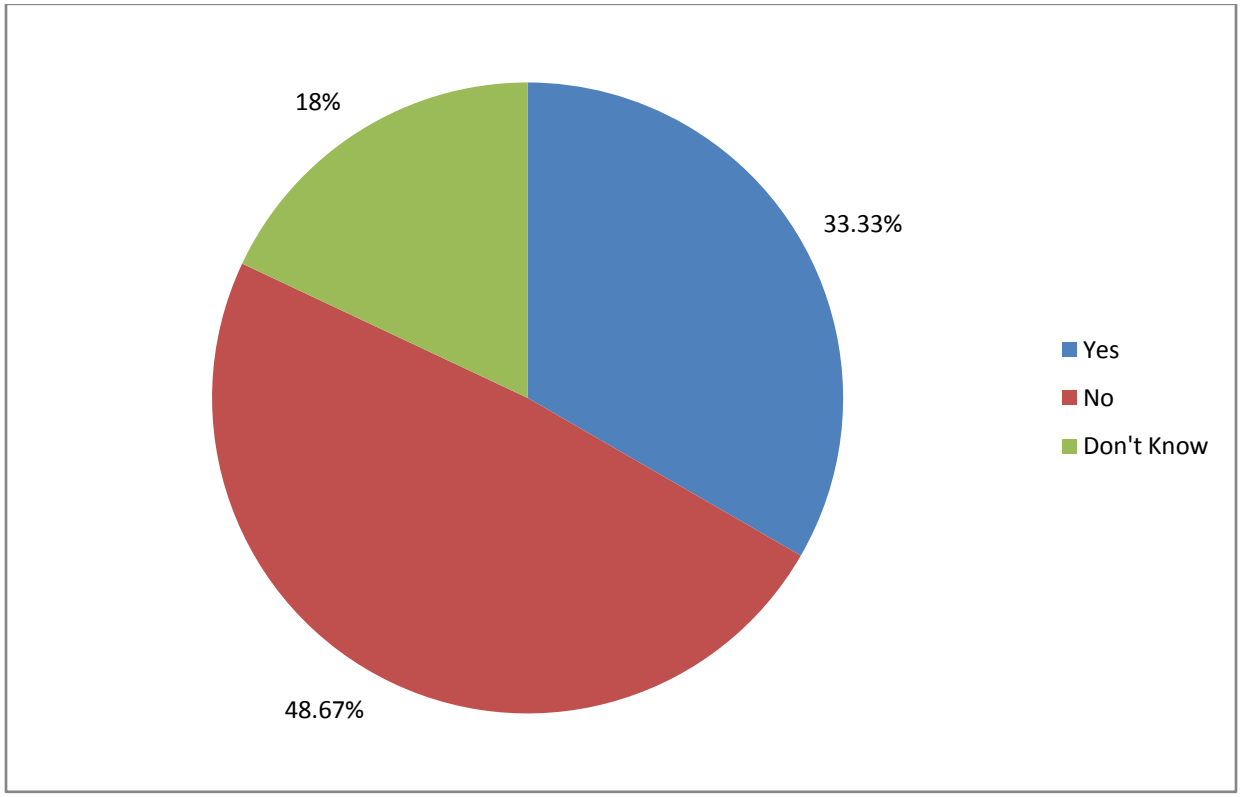

Figure 4.28. Status of the Mother Receiving Tetanus Immunization

Majority of mothers did not receive tetanus vaccine (48.67%). 33.33% stated that they had received it after marriage and 18% did not know whether they had received it or not.

4.29. Childhood Immunization Status of the Father

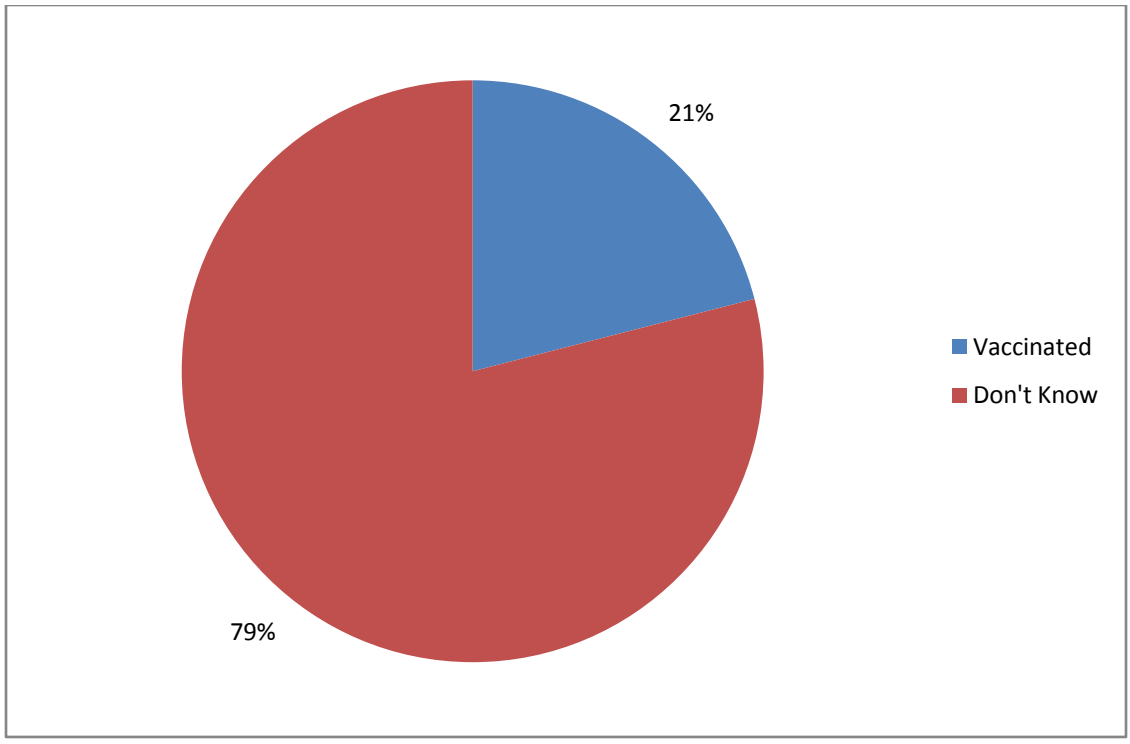

Figure 4.29: Childhood Immunization Status of the Father

Majority of fathers did not know whether they had received childhood immunization or not (75.67%) and 21% stated that they were fully vaccinated during childhood.

4.30. Immunization Status of the Sibling

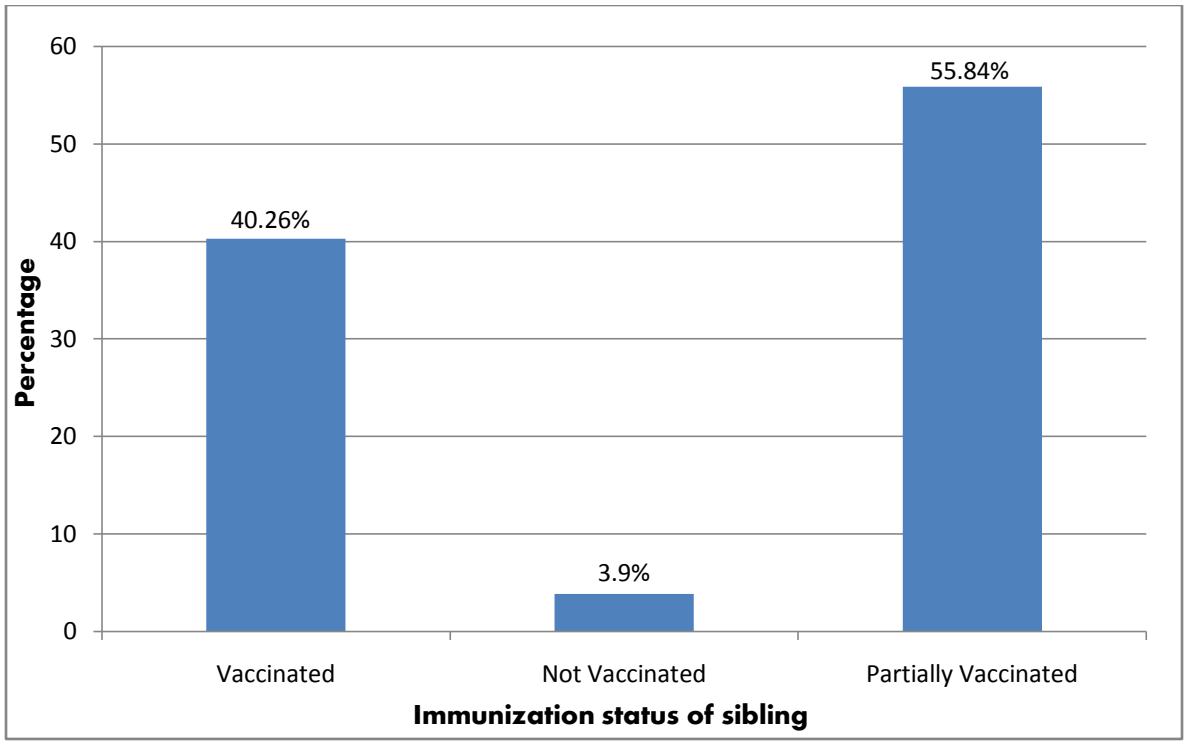

Figure 4.30. Immunization Status of the Sibling

Majority of siblings were partially vaccinated (55.84%). 40.26% of siblings were fully vaccinated and 3.9% were not vaccinated.

Discussion

The results of this study suggested that the vaccination status of slum-dwelling children was only 19.67% valid which means that they had received the full doses of vaccines according to the EPI schedule. Majority status of the children in study areas were found to be invalid and drop-out as the main reason was lack of concern (37.82%). The other reasons were being too busy (25%), losing vaccination card (12.18%), fearing side-effects (11.54%), sickness of child (5.77%), place being distant (4.49%), cultural & religious hindrance (1.92%) and not informing the caregivers about time & place of the vaccination centre (0.64%). Common problems faced by the caregivers during vaccinating their child at vaccination centre included long waiting time in the vaccination centre (36.33%), paying unofficial fee to the vaccinators (24.33%), shortage of vaccine (12%) and losing vaccination card making vaccinator upset (2.67%). These problems must be tackled from government level to increase vaccination coverage. Different adverse effects were also found after taking immunization doses given by the vaccinator in the vaccination centre. Adverse effects like pain (50%), fever (12.67), abscess (5.67%) and hypersensitivity (2%) were observed.

Most of the caregivers knew about vaccination (97.33%) and also received the vaccination card and had it with them (83%). Majority of the caregivers stated that the reason behind vaccination was it being good for child (92.33%) and minority preferred to do it by following other people (1.67%). Other reasons were protection from diseases (6.33%), advice of doctors & relatives (3.67%) and the rule of government (3.33%). In a study conducted in Vienna General Hospital, Austria, the reasons for receiving vaccination were self-protection (87.5%), prevention of epidemics (54.5%), protection of others (55.4%) and of patients (42.9%). (Harrison et. al., 2016)

Majority of the caregivers preferred morning time schedule to vaccinate their child (92%) in the vaccination centre. 6.33% caregivers preferred anytime and 1.67% preferred evening time. These preferences of caregivers must be taken into account to form strategies to increase vaccination coverage.

The majority of caregivers suggested providing vaccines at home (41.67%) to achieve full immunization. The other suggestions were informing about session day (39.33%), providing

medicines for side-effects (10%) and finding drop-out cases to ensure immunization (5.33%) and providing sufficient EPI support group & training (3.67%).

In this study there was a significant relation between the children's valid status of vaccination doses they had received and parents' educational background. In case of father education, 71.43% of children of graduate fathers had valid immunization status. The respective numbers for HSC and SSC completed fathers were 28.17% and 16.88% respectively. In case of mother education, 54.55% children of HSC completed mothers had valid immunization status and 18.18% children of SSC completed mothers had valid immunization status. In a study conducted in India, when both parents' had no education, the proportion of children who were vaccinated was 33.9%, when the parents' had completed primary education level, the proportion of children who were vaccinated was increased to 51.30% and when the parents' had completed secondary or higher education level, the proportion of children who were vaccinated was very much higher to 70.1%. (Rammohan et al., 2012)

We also found that the children's vaccination status was more valid of parents who were younger. 22.7% of children of fathers age under or equal to 30 years old had more valid immunization status and but in case of mothers age, 30% children of mothers age above 30 years had more valid immunization status than the mother of less than or equal to 20 years (28.57%).

In case of the parents' occupation, 42.86% children of unemployed fathers and 33.33% children of mothers being garments workers and teachers had more valid immunization status.

If the gender of the child is considered, 19.31% and 20% of children had valid immunization status when the children were male and female respectively.

In case of status of receiving the vaccination card, 21.69% children's vaccination status was found to be valid when the caregivers received the vaccination card and had it with them. 11.11% children's vaccination status was valid when the caregivers had received the vaccination card but couldn't find out or lost the card when it was told to be shown in the study period.

In case of status of tetanus vaccine of the mother, 29% children's vaccination status was valid when the mothers received the full doses of tetanus vaccine. 15.75% children's vaccination status was valid when the mothers did not receive the doses of tetanus vaccine and 12.96%

children's vaccination status was valid when the mothers did not know whether they had received the doses of tetanus vaccine or not. In a study conducted in Turkey, the women who did not receive a single dose of tetanus vaccine, the percentage of their fully immunized children was 19.7% and the women who had received two or more doses of tetanus vaccine the percentage of their fully immunized children was 60.5%. (Esen et al., 2007)

According to the Directorate General of Health Services (DGHS), a survey in Dhaka city found that the proportion of fully-immunized children in slums aged 12 months was only 54%. (DGHS, 2007). In our study the fully immunized children of slum-dwelling areas in Dhaka city was found to be 60% which was close to the above study.

The limitations of this study were that the immunization status of father, mother and siblings were taken orally as the vaccination card was not shown. In this study, demographic factors such as education, age of both parents, status of vaccination card retention and status of tetanus vaccine of the mother plays a role in influencing the children's immunization coverage.

Conclusion

Immunization has been one of Bangladesh's greatest public health success stories. It has prevented an estimated 2 million deaths from 1987-2000, and continues to prevent approximately 200,000 deaths each year. However, in order to ensure that all children of Bangladesh benefit equitably from this intervention, a strategic, i.e., long-term approach to planning and implementation is essential. The services of immunization should be developed in a systematic way. The vaccinators should be paid sufficient salaries and reimbursement of expenses so that they do not need to charge 'unofficial' fees. Improved counseling about side-effects and their treatment, along with minimizing the waiting times for clients should also improve the use of immunization services among those people especially living in slum-dwelling areas. In addition, proper training of the vaccinators is essential in order to improve the quality of the vaccination program. However, an added challenge and opportunity is needed to strengthen the coordination of the primary health care providers to ensure that routine EPI logistics; including auto-disable (AD) syringes, safety boxes and accessories for maintaining vaccination, injection safety, record keeping and reporting forms are made available in adequate quantities at all levels.

References

Abborts, B. & Osborn, L.M. (1993) Immunization Status and Reasons for Immunization Delay Among Children Using Public Health Immunization Clinics. *Am J Dis Child*. 147 (9).p. 965-968.

Anwar, E., Goldberg, E., Fraser, A., Acosta, C.J., Paul, M. & Leibovici, L. (2014) Vaccines for preventing typhoid fever. *The Cochrane database of systematic reviews*. 1 (2).p.1-17

Atkinson, W. & William, H. (2012) Diphtheria Epidemiology and Prevention of Vaccine-Preventable Diseases. *Public Health Foundation.* 2(1). p. 215–230.

Atkinson, W., Hamborsky, J., McIntyre, L. & Wolfe, S. (2008) Epidemiology and Prevention of Vaccine-Preventable Diseases. *Vaccines.* 63(2).p.1-23

Aylward, R.B. (2006) Eradicating polio: today's challenges and tomorrow's legacy. *Annals of Tropical Medicine and Parasitology.* 100 (5–6).p. 401–413.

Baker, J.P. & Katz, S.L. (2004) Childhood vaccine development: an overview. *Pediatrics. Res.* 55 (2).p. 347–356.

CDC. (1998) Development of new vaccines for tuberculosis: recommendations of the Advisory Council for the Elimination of Tuberculosis (ACET). *MMWR. Morb. Mortal. Wkly. Rep.* 47 (13).p. 320-357

Chabot, I., Goetghebeur, M.M. & Grégoire, J.P. (2004) The Societal Value of Universal Childhood Vaccination, *Vaccine.* 22 (1).p. 199–209.

Cono, J. & Alexander, L.N. (2002) Poliomyelitis. *Vaccine-Preventable Disease Surveillance Manual.* 34(1).p. 299-301

Centers for Disease Control and Prevention (CDC). (2006) Update on vaccine-derived polioviruses. *MMWR Morb. Mortal. Wkly. Rep.* 55 (40).p. 1093–1097.

Demicheli, V., Rivetti, A., Debalini, M.G. & Pietrantonj, C. (2012) Vaccines for measles, mumps and rubella in children. *Cochrane Database Syst Rev.* 2(1).p. 1-20

Directorate General of Health Services (DGHS). (2007) EPI coverage evaluation survey. Dhaka: Expanded Programme on Immunization, *Ministry of Health and Family Welfare, Government of Bangladesh*

Duclos, H. et al. (2009) Global immunization: status, progress, challenges and future. *BMC International Health and Human Rights*. 9 (1).p. 212-219.

Ehreth, J. (2003) The Global Value of Vaccination, *Vaccine* 21(1).p. 596-600.

Fielding, H. et al. (1994) Immunization Status of Children of Employees in a Large Corporation. *JAMA*. 271(7).p. 525-530.

Fine, P. & Carneiro, I. (1999) Transmissibility and persistence of oral polio vaccine viruses: implications for the global poliomyelitis eradication initiative. *Am J Epidemiol* 150 (10).p. 1001-1021.

Ghaffar, A. & Haqqi, T. (2013) *Immunization, Microbiology and Immunology*. [Online]. Available from: http://pathmicro.med.sc.edu/ghaffar/immunization.htm [Accessed 17 April 2015]

Gross, F., Cary, P., Sepkowitz, R. & Kent, A. (1998) The Myth of the Medical Breakthrough: Smallpox, Vaccination, and Jenner Reconsidered. *International Journal of Infectious Diseases.* 3(1).p. 54–60.

Government of People's Republic of Bangladesh. (2016) *A Comprehensive Multi-Year Plan of the National Immunization Program of Bangladesh*.

Haemophilus influenzae type b (Hib) Vaccination Position Paper (2013) *Wkly Epidemiol Rec* 88 (39).p. 413–426.

"Haemophilus b conjugate vaccines for prevention of Haemophilus influenzae type b disease among infants and children two months of age and older. (1991) *MMWR Recomm Rep.* 40(1).p. 1–7.

Hernán, M.A., Jick, S.S., Olek, M.J. & Jick, H. (2004) Recombinant hepatitis B vaccine and the risk of multiple sclerosis: a prospective study. *Neurology*. 63 (5).p. 838–842.

Hilleman, J. & Maurice, R. (1992) Past, Present, and Future of Measles, Mumps, and Rubella Virus Vaccines. *Pediatrics.* 90(1).p. 149-153.

Hinman, A.R. (1984) Landmark perspective: Mass vaccination against polio. *JAMA* 251(22).p. 2994–6.

Hostetter K.M. & Johnson E.D. (1998) Immunization Status of Adoptees from China, Russia, and Eastern Europe. *Pediatric Research*. 43(1).p. 147–147.

Hviid, A., Rubin, S. & Mühlemann, K. (2008) Mumps. *The Lancet*. 371 (9616).p. 932–944.

Iglehard, J.K. (2005) Financing Vaccines: In Search of Solutions That Work. *Health Affairs*. 24(3).p. 594-595.

Immunization Summary (2011) *A statistical reference containing data through 2011(The 2013 edition).*

Jamil, H. et al. (1999) The immunization programme in Bangladesh: impressive gains in coverage but gaps remain. *Health policy and planning*. 14(1).p. 49-58.

Kline, J.M., Lewis, W.D., Smith, E.A., Tracy, L.R., & Moerschel, S.K., (2013) Pertussis: a reemerging infection. *American Family Physician.* 88 (8).p. 507–14.

Landry, S. & Heilman, C. (2005) Future Directions in Vaccines: The Payoffs of Basic Research, *Health Affairs*. 24 (3).p. 758-769.

Mahler, H.T. & Ali, P.M. (1955) Review of mass B.C.G. project in India. *Ind J Tuberculosis.* 2 (3).p. 108–16.

Mikaeloff, Y., Caridade, G., Rossier, M., Suissa, S. & Tardieu, M. (2007) Hepatitis B Vaccination and the Risk of Childhood-Onset Multiple Sclerosis. *Archives of Pediatrics & Adolescent Medicine.* 161 (12).p. 1176–1182.

Nunnally, K.B., Turula, E.V. & Sitrin, D.R. (2014) *Vaccine Analysis: Strategies, Principles, and Control.* [Online]. Medical Microbiology: Springer Berlin Heidelberg. Available from: http:// http://link.springer.com/book/10.1007%2F978-3-662-45024-6. [Accessed: 6/5/2015]

Norrby, E. (2007) Yellow fever and Max Theiler: the only Nobel Prize for a virus vaccine. *J. Exp. Med.* 204 (12): 2779–84.

Nyarko, P., Pence, B. & Debpuur, C. (2001) Immunization Status and Child Survival in Rural Ghana. *International Journal of Epidemiology.* 24(1): 1-29.

Perry, R. et al. (1998) Childhood immunization coverage in Zone 3 of Dhaka City: the challenge of reaching impoverished households in urban Bangladesh. *Bull World Health Organ*. 76(6).p. 565-73.

Prislin, R. et al. (1998) Immunization status and socio demographic characteristics: the mediating role of beliefs, attitudes, and perceived control. *American Journal of Public Health*. 88(12): p.1821-1826.

Rahman & Nasrin. (2010) Factors affecting acceptance of complete immunization coverage of children under five years in rural Bangladesh. *Salud Publica Mex*. 52(2).p. 134-40.

Rammohan, A., Awofeso, N. & Fernandez, R.C. (2012) Paternal education status significantly influences infants' measles vaccination uptake, independent of maternal education status. BMC Public Health. 8(12).p. 336-351.

Rappuoli, R. (2007) Bridging the Knowledge Gaps in Vaccine Design. *Nature Biotechnology*. 25 (12) p.1361-1366.

Schaffer & Szilagyi. (1995) Immunization Status and Birth Order. *Arch Pediatr Adolesc Med*. 149(7).p.792-7.

Schonberger, L., Kaplan, J., Kim-Farley, R., Moore, M., Eddins, D. & Hatch, M. (1984) Control of paralytic poliomyelitis in the United States. *Rev. Infect. Dis.* 6(2).p. 424–6.

Smith, D.R. & Leggat, P.A. (2005) Pioneering figures in medicine: Albert Bruce Sabin--inventor of the oral polio vaccine. *The Kurume medical journal*. 52 (3).p. 111–116.

Staples, J.E., Bocchini, J.A., Rubin, L. & Fischer, M. (2015) Yellow Fever Vaccine Booster Doses: Recommendations of the Advisory Committee on Immunization Practices. *Morbidity and mortality weekly report.* 64 (23).p. 647–50.

Sun, M., Ma, R., Zeng, Y., Luo, F., Zhang, J. & Hou, W. (2010) Immunization status and risk factors of migrant children in densely populated areas of Beijing, China. *Vaccine*. 3; 28(5):1264-74.

Swierzewski, J. (2008) *Overview of childhood immunizations.* [Online]. Available at: http://www.healthcommunities.com/childhood-immunizations/children/overview-of-child-vaccines [Accessed: 14 August 2015]

Szucs, T. D. (2005) Health Economic Research on Vaccinations and Immunization Practices – An Introductory Primer. *Vaccine.* 23(1): p2095–2103.

Tao, W., Petzold, M., & Forsberg, B.C. (2013) Routine vaccination coverage in low- and middle-income countries: further arguments for accelerating support to child vaccination services. *Glob Health Action*. 6(2): 112-119.

Uddin, M.J., Larson, C.P., Oliveras, E., Khan, A.I., Quaiyum, M.A. & Saha, C.N. (2009) Coverage of Child Immunization in Rural Hard-to-reach Haor Areas of Bangladesh: Acceptability of Alternative Strategies. *Asia Pac J Public Health.* 21(1):8-18.

Uddin, M.J., Larson, C.P., Oliveras, E., Khan, A.I., Quaiyum, M.A., & Saha, C.N. (2010) Child immunization coverage in urban slums of Bangladesh: impact of an intervention package. *Health Policy Plan.* 25(1):50-60.

WHO. (2014) *BCG vaccine*. [Online]. Available from: http://www.who.int/biologicals/areas/vaccines/bcg/en/ [Accessed: 14th December, 2014]

WHO. (2008) *Typhoid vaccines position paper.* [Online]. Available from: http://www.who.int/immunization/policy/position_papers/typhoid/en/ [Accessed: 8th Februauy, 2008]

WHO. (2014) *Varicella and herpes zoster vaccines.* [Online]. Available from: http://www.who.int/immunization/position_papers/WHO_pp_varicella_herpes_zoster [Accessed: 10th June, 2014]

WHO. (2013) *Vaccines and vaccination against yellow fever*. [Online]. Available from: http://www.who.int/immunization/newsroom/news_WHO_position_paper_yellow_fever/en/ [Accessed: 5th July 2013]

Worboys, M. (2007) Conquering Untreatable Diseases. *British Med J*. 334(1).p. 1-20

Zuckerman, J. N. (2006) Protective efficacy, immunotherapeutic potential, and safety of hepatitis B vaccines. *Journal of Medical Virology*. 78 (2).p. 169–177.

Questionnaire

01. Name of the child: _____ 02. Age: _____months/years

03. Gender of the child: ☐ Male ☐ Female

04. Religion of the child ☐ Muslim/Islam ☐ Hinduism ☐ Christianity ☐ Buddhism

05. Relationship of Respondent with the child: ☐ Father ☐ Mother ☐ Others: _____

06. Information of the Parents:

Criteria	Father	Mother
Age (years)		
Educational status	☐ Illiterate ☐ Below Primary ☐ Primary ☐ S.S.C ☐ H.S.C ☐ Others:	☐ Illiterate ☐ Below Primary ☐ Primary ☐ S.S.C ☐ H.S.C ☐ Others:
Occupational status	☐ Unemployed ☐ Day labor ☐ Rickshaw puller ☐ Garments worker ☐ Shop-keeper ☐ Others……	☐ Unemployed/Housewife ☐ Garments worker ☐ House maid ☐ Day labor ☐ Business/job holder ☐ Others……

07. In case of non-working parents, earning member of the family: _____

08. Monthly family income (Tk.): ☐ <5000 ☐ 5000~<10000 ☐ 10000~15000 ☐ >15000

09. Birth order of the child: _____ out of _____ (total children of parents)

10. Primary caregiver of child: ☐ Father ☐ Mother ☐ Others: _____

11. Does caregiver know about vaccination? ☐ Yes ☐ No

If yes, then source of information: ☐ Radio ☐ Television ☐ Health care provider ☐ Announcements (Miking) by Govt./NGO etc. ☐ Educational institute ☐ Relatives ☐ Neighbours ☐ Others: _____

12. Status of vaccination card (Reception and Possession):

☐ Received & have it ☐ Received but do not have it now ☐ Never received