REVIEW ARTICLE

Reviewing the Pillars of Immunization: Essential Vaccines and Their Public Health Benefits

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ABSTRACT

Vaccination has lowered, across the globe, morbidity and mortality from infectious diseases. It is considered one of the basic principles of preventive health measures. The World Health Organization's Expanded Programme on Immunization defined vaccinations that are required and their tremendous benefits to public health, which are discussed in this review article. These involve the vaccinations taken against most communicable diseases, such as COVID-19, polio, measles, rubella, pneumococcal diseases, rotavirus, human papillomavirus, tuberculosis, *Haemophilus influenzae* type B, diphtheria, pertussis, and tetanus.

The article points out that quite a number of vaccinations have been proven effective and safe and if administered, could prevent serious disease, disability, and death. For example, vaccination against measles has been rated to be vital in the containment of outbreaks within nonimmune populations, while the DTP vaccine is paramount in decreasing the cases of pertussis, tetanus, and diphtheria. The effect of vaccination can be exemplified by the dramatic decrease in the occurrence of serious bacterial contagion in children since the introduction of conjugate vaccines against Hib and pneumococcus.

Notwithstanding these successes, there are persistent obstacles, such as vaccine hesitancy, misinformation, and inequities in access to vaccines, all heightened by the COVID-19 pandemic. The article discusses the global impact of vaccination efforts under siege and appeals for further public health efforts toward the attainment of these goals.

Keywords: Immunization, Vaccines, Public health, Disease prevention, Global health.

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INTRODUCTION

Since vaccination has become one of the oldest and most economical methods of protecting kids from disease, it is a key component of public health policy. Over the past century, vaccines have completely eradicated smallpox and significantly decreased the morbidity and death rates from several infectious illnesses. In fact, immunizations currently avert between 3.5 and 5 million losses every year from diseases including measles, tetanus, diphtheria, and pertussis, according to WHO estimates.[1-5]

This review article's objective is to offer a far-reaching overview of the major vaccines that the WHO's Enhanced Programmes on Immunization, or EPI for short, suggests, along with the benefits they offer for general public health. The EPI was established in 1974 with the purpose of ensuring that each kid, irrespective of location or social and financial status, has a vaccine supply that can save their lives. Originally focusing on six childhood diseases (tuberculosis, diphtheria, tetanus, pertussis, polio, and measles), the program has since been broadened to propose 13 vaccinations for regular vaccinations: BCG, COVID-19, diphtheria, human papillomavirus (HPV), hepatitis B (HepB), pertussis, tetanus, *Haemophilus influenzae* type B (Hib), polio, measles, rubella, pneumococcal disease (PNC), and rotavirus (Rota) (for adults).[2-5]

Immunization has huge benefits to public health. Vaccines protect by allowing the immune response to identify and resist infection without ever actually causing illness. That builds herd immunity, slowing infectious diseases' spread in populations while also protecting those that are vaccinated. The most effective health programs, according to the WHO, are vaccination and immunization, which have the potential to save millions of lives every year.[1-5]

Notwithstanding these EPI achievements, challenges remain. Global health services were stretched by the COVID-19 pandemic, which reduced the immunization rate. In 2023, there were wide gaps in access to vaccines; 14.5 million children did not receive any vaccinations. The WHO vaccination Agenda 2030 sets out a shared vision and strategy at the global level

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to overcome the above-mentioned hurdles to ensure that all individuals everywhere reap the life-saving advantages of vaccines.[1,5]

The Expanded Programme on Immunization (EPI)

The broadened region of worldwide vaccination was established in 1974 with the goal of providing each kid with vaccines that can save their lives. Over the course of the last forty years, EPI has grown to cover older children, teens, and adults, as well as new vaccinations. Vaccinations are now widely available worldwide and are regarded as one of the most adequate, safest, and most efficient public health interventions for avoiding disease and extending life.

Once, the EPI was designed to protect children resistant to six diseases preventable by immunization: measles, polio, pertussis, tetanus, and TB. Currently, it recommends 13 vaccinations for routine immunization: PNC, polio, measles, rubella, tetanus, pertussis, diphtheria, and *H. influenzae* type B are among the diseases that could be caused by Bacillus Calmette-Guérin (BCG).

Reducing the incidence of morbidity and mortality from most infectious diseases is the testimony of the performance of EPI. World Health Organization estimates that vaccination now prevents 3.5-5 million unnecessary deaths every year from measles, tetanus, diphtheria, and pertussis. The elimination of smallpox and the nearly complete annihilation of polio are the two most notable achievements of EPI.

Offsetting these successes, there are challenges. With pandemic gains in vaccination coverage slipping, 14.5 million children in 2023 will not have received any vaccinations. The EPI has continued to integrate with many other initiatives in public health towards the prevention of infectious diseases for better health of people around the world. Table 1 shows the overview of EPI vaccines.

Essential Vaccines and Their Public Health Benefits:

Bacillus calmette-guérin (BCG)

The bacillus Calmette-Guérin vaccine is a very significant vaccination to counter tuberculosis. It gets mainly administered to infants in countries where the disease is considerably prevalent. Developed in the early 1900s, this vaccination has been shown to be very effective in preventing serious forms of TB, especially among small children. Research has shown that BCG prevents or reduces serious sequelae like tuberculosis meningitis and miliary tuberculosis, which are dangerous to neonates' and infants' lives.[6]

However, evidence has been obtained from studies carried out to show the extreme variation in the effectiveness of BCG from 0 to 80% in preventing pulmonary tuberculosis in adults, depending on both environmental and regional factors. Many variables had to be considered responsible for this diversity in efficiency, among them being genetic variation in populations, exposure to other infections, and the specific vaccination strains used in different geographic regions[7, 8]. Though BCG vaccination does not prevent initial infection from TB, it is considered a very important vaccine in preventing the development of active illness, especially in susceptible groups.[6,9]

BCG should be taken as a part of national vaccination campaigns in countries where TB is endemic because it may provide some protection to those at the highest risk of infection. WHO suggests that the current control policy should include BCG vaccination as an integral part because, despite all of its limitations, BCG remains the one and only vaccine used in prevention against tuberculosis and has been administered to millions of children worldwide, indicating its importance in the programs of public health administered worldwide.[7,10] Research on new vaccines that are highly potent against pulmonary tuberculosis, especially in adults, must be continued since the prevalence of tuberculosis remains at a high rate globally.[9,10]

Diphtheria, tetanus, and pertussis (DTP)

The DTP vaccine is an essential immunization that guards against pertussis, tetanus, and diphtheria—three serious bacterial illnesses. The pathogen *C. diphtheriae* causes the deadly respiratory disease diphtheria, which can have life-threatening side effects such as coronary artery disease, paralysis, and breathing difficulties. Tetanus is an infection, probably fatal, triggered by an obligate anaerobic bacterium

Table 1: Overview of EPI vaccines

S. No.	*Vaccine*	*Disease targeted*	*Age of administration*	*Efficacy rate (%)*	*Global coverage (%)*
1	BCG	Tuberculosis	At birth	70-80	90
2	DTP	Diphtheria, tetanus, pertussis	2, 4, 6 months	85-95	86
3	Hib	Hib disease	2, 4, 6 months	95	75
4	HepB	Hepatitis B	At birth,1, 6 months	95	85
5	Polio	Poliomyelitis	2, 4, 6 months	99	85
6	Measles	Measles	9 months, 12 months	93-95	85
7	Rubella	Rubella	12 months	95	80
8	PCV	Pneumococcal disease	2, 4, 6 months	90	50
9	Rota	Rotavirus	2, 4 months	85	60
10	HPV	Human papillomavirus	11-12 years	90	50
11	COVID-19	COVID-19	Varies	70-95	70

called *Clostridium tetani*. It leads to severe, often deadly muscular spasms, which terminate with respiratory paralysis. Pertussis, or whooping cough, is a very infectious respiratory disease produced by *Bordetella pertussis*. The common feature of pertussis illness is bouts of violent coughing. Pertussis can also give rise to severe problems, such as pneumonia, brain damage, and even death in young children.

These diseases have seen their prevalence drop radically worldwide due to a great extent to the development of the DTP vaccination. Cases of pertussis and diphtheria that have been reported have been drastically cut down through immunization efforts, thereby improving public health outcomes. Indeed, based on the World Health Organization, the World Health Organization, during the course of its functioning, has reported that, since the vaccine's introduction, the incidence of diphtheria has fallen by more than 90% worldwide.[11] Likewise, through the wide use of the DTP vaccine, pertussis morbidity and death rates have precipitously declined.[12]

Despite these successes, outbreaks of the diseases diphtheria, tetanus, and pertussis can occur. In light of this, vaccination rates can be drastically reduced in certain areas because of hesitancy from vaccination, misinformation, and access issues, and as a consequence, resurgence has been witnessed for a number of vaccine-preventable diseases.[13] Public health campaigns repetitively hammer home the message about how imperative keeping up vaccination rates really is to protecting susceptible groups of people, most notably young children and those medically incapable of being vaccinated.

H. influenzae type B (Hib)

H. influenzae type B is one of the key causes of life-threatening invasive infections in kids, with meningitis leading the pack. The burden of this disease has been reduced immensely worldwide by the introduction of the Hib vaccination. WHO recommends that all countries introduce the Hib vaccine into routine infant immunization programs.[14]

Hib vaccinations come in liquid or lyophilized forms and are administered singly or combined with other antigens such as DPT and/or hepatitis B. They have also been highly effective and cost-effective in developed and developing country settings. As of June 2011, 170 countries worldwide include the Hib vaccine in their national vaccination programs.

Besides protecting the vaccinated individual, the Hib vaccine lowers nasopharyngeal colonization of this bacterium and thus reduces the incidence of the Hib disease by providing herd immunity. In most countries where vaccination has been implemented, especially industrially developed ones and those with growing economies where the uptake of vaccination is modest to low, the disease has largely been eradicated.[14]

But such Hib vaccination is effective; it is a manner whereby a significant number, especially in poor resource countries, lack total immunity to Hib or have minimally protected Hib immune system. Efforts in trying to make it possible to reduce the burden of illness from Hib infections in the future will take priority.[15]

Hepatitis B (HepB)

Hepatitis B is a serious viral illness, and it majorly affects the organ liver, able to cause cirrhosis, liver cancer, and chronic liver disease. Hepatitis B virus is obtained through the exposure of blood, semen, or any body fluid from an infected person. Early childhood immunization shall be quite essential in preventing mother-to-child transmission because a newborn baby from a woman's body carrying the virus is at considerable risk of picking up the infection at the time of delivery.[16]

The hepatitis B vaccination is one safe and effective way to prevent HBV infection. According to WHO recommendations, the first dose of HepB vaccination should be given to every newborn infant no later than 24 hours after birth, with subsequent doses at 4 weeks and 6 months.[16,17] This triple-dose schedule provides long-lasting protection against the pathogen.[18]

There has been a significant decline in the global burden of chronic hepatitis B infection since the universal newborn immunization programs were launched. For example, in the United States, acute hepatitis B incidence has decreased by more than 90% since the recommendation for routine newborn hepatitis B vaccination was enacted in 1991.[19]

The hepatitis B vaccine is one of the safest and most successful vaccinations available today. There's no proof to show any link between the 1 billion times administered vaccine worldwide with any cause of autism, multiple sclerosis, SIDS, and any other neurological disorder.[18]

Polio

Being such a contagious virus, polio leads to irreparable paralysis or even death. The most often infected group is that of children below the age of five years. The poliovirus can pose serious consequences in children and even lifelong impairment. Among the most vital facets of the international campaign to eliminate the disease has been the development of the polio vaccine. Since the Global Polio Eradication Initiative was launched in 1988, more than 20 million children have been saved from paralysis due to polio, and the cases of polio have reduced by more than 99%.[20] By 2023, only two countries host endemic wild poliovirus transmission: Afghanistan and Pakistan. There has been immense progress in this fight, but there still exist barriers to be battled through—vaccination hesitancy and, in some places, access problems that have been exacerbated by violence.[21] GPEI strongly advocates for maintaining high vaccination rates and active surveillance to stop outbreaks of both naturally occurring and vaccine-derived poliovirus. Prognostications warn that, in a decade, without eradication, the world may face up to 200,000 new cases annually, after which further vaccination would be imperative to avoid this consequence. A reappearance of the virus may mean a worldwide health disaster.[22] Indeed, worldwide efforts to get every last child vaccinated are part of the enduring commitment to eradicate polio.

Measles

Measles is a highly dangerous virus, resulting in many cases of blindness, encephalitis, and pneumonia. Measles presents

a severe public health concern because it easily spreads by coughing, sneezing, and direct physical contact, especially within an unvaccinated population. Before the introduction of the measles vaccine in 1963, the disease was suspected to be the cause of 2.6 million deaths per year worldwide.[23]

The measles vaccine has been a tremendous factor in minimizing the spread of this disease across the world. It is estimated that between 2000 and 2022, 57 million deaths from measles have been averted because the countries, the World Health Organization, and other international partners have hastened vaccination campaigns. By the time they turned one year old in 2023, 83% of children had already been given their first dose of the measles vaccination. The percentage cover, however, is below the 86% that was achieved in 2019.[23]

Even where a safe and affordable vaccine exists—measles—with low immunization rates, epidemics still happen. In 2023, 22 million children missed the required first dose of the measles vaccination alone, far from the 19.3 million children in 2019.[23] As a result of such immunization gaps, many children are at risk of catching the disease with complications that can be life-threatening or fatal. The long-term effects of measles include blindness, brain damage, and weakening of the immune system, which makes the kids more susceptible to other infectious illnesses.[24]

To avert outbreaks of measles and support regional goals of elimination, strengthening of primary health care vaccination programs with intensified efforts to vaccinate every child with two doses of the vaccine is required. Robust surveillance programs need to identify and close immunity gaps, particularly in areas where, due to the COVID-19 pandemic, delivery of vaccines has been delayed and rates of vaccination plummeted worldwide.[23]

Rubella

German measles, also known as rubella, is a viral illness that may create a little bit of joint discomfort and a red, itchy rash. The symptoms of rubella are usually mild in most children, but the virus can be quite harmful if you acquire it while you are pregnant. Suppose rubella virus is transmitted during the first trimester. In that case, an unborn child may develop congenital rubella syndrome (CRS) with serious birth abnormalities, including heart defects, losses of hearing, and issues with development.

The rubella vaccine is given together with the measles and mumps vaccinations as part of the MMR immunization course to reduce these risks. The MMR vaccination provides long-term protection against most diseases and is reasonably efficient. Even with proper immunization, campaigns may result in outbreaks occurring in areas where the coverage of rubella immunization is low. In 2022 alone, an approximate number of 17,865 rubella cases occurred in 78 countries. This is an underlining fact that immunization efforts are far from over, and ladies at childbearing age must be vaccinated to prevent CRS and save future generations from the hazardous effects of infection with rubella.[25-27]

Pneumococcal disease (PCV)

Streptococcus pneumoniae is a bacterium causing pneumococcal disease, which includes sepsis, meningitis, and pneumonia. Due to the introduction of the pneumococcal conjugate vaccination, there has been a reduction in the incidence of invasive pneumococcal disease in children. Diseases caused by the serotypes that the vaccination covers decreased dramatically after the implementation of PCV. Not all serotypes of S. However, the vaccination itself protects only from pneumoniae, so other people may still be susceptible to the illness. Moreover, the antibiotic-resistant forms of this very bacterium never cease to appear, thus further hindering the treatment options and posing a real danger to public health. Continuous surveillance and vaccination campaigns are needed to keep the situation with pneumococcal illness under control and prevent outbreaks, especially in groups of people where it is particularly susceptible, such as young children and the elderly.[28,29]

Rotavirus (Rota)

Around the globe, rotavirus is the major cause of severe diarrhea and dehydration among children in the first years of life. In countries with high coverage rates, the rotavirus vaccine has been shown to drastically reduce the cases of serious rotavirus gastroenteritis and related hospitalizations, which was a great success for public health. Research shows that more than 90% of the severe cases of rotavirus diarrhea can be prevented using this rotavirus vaccination in areas where the child mortality rate is less. However, its efficiency is relatively low in countries with high child mortality since it can prevent only 35 to 58% of severe cases.

More than 100 nations have integrated rotavirus vaccinations into their vaccination regimen since the World Health Organization's recommendation in 2009, such significantly reducing hospital admissions due to rotavirus. However, challenges still remain, as not all the circulating virus strains are covered by the vaccine, and new antibiotic-resistant viruses are continuously emerging. Further reduction in the burden of rotavirus illness worldwide would entail continuous promotion of vaccination coverage and monitoring of vaccine effectiveness.[30-32]

Human papillomavirus (HPV)

One family includes the human papillomavirus, which causes several malignancies: oropharyngeal, anal, and cervical cancers. Adolescents are vaccinated counter to the types of HPV that cause cancer most frequently to prevent infection. Several real-world studies and clinical trials have demonstrated that, among populations immunized with the HPV vaccination, precancerous cervical lesions are less common.

Specifically, administered before the onset of sexual activity, the vaccine has been shown to prevent as high as 97% of cervical cancers, reflecting the importance of very early immunization. Although vaccination is effective, it doesn't provide immunization against all serotypes of HPV. Hence,

continuous monitoring is necessary in order to identify changes in strains causing resistance to the shot. Raising vaccination rates can dramatically lower the number of cancer cases linked to HPV; indeed, it is estimated that a global immunization program could decrease by up to 90% the burden of cervical cancer. Therefore, to ensure public health and prevent cancer, there is a need to increase HPV vaccination among adolescents.[33,34]

Challenges and future directions

Although vaccinations have been quite impressive at avoiding infectious illnesses, there are a number of problems:

- Maintaining high vaccination coverage in the face of vaccine hesitancy and misinformation
- Keeping infectious illnesses at bay for the increasing number of elderly people
- Preventing infectious illnesses from affecting the increasing number of elderly persons.
- Ensuring equitable access to vaccines globally

These were problems to which WHO responded with a global campaign under the name Vaccination Agenda for 2030, aka IA2030, which serves only for a future vision in which all people everywhere fully benefit from vaccines for well-being and optimal health realized through the motivation and coordination of the efforts of local, national, regional, and global stakeholders.[35-37]

CONCLUSION

According to the overview, immunization is among the health interventions that very effectively avoid infectious diseases and reduce mortality rates. Undeniably, the vaccines on the WHO-recommended EPI schedule are very safe and efficient, cost-effective; it is evidence that they fairly reduce the burden of diseases like rotavirus, HPV, COVID-19, Hepatitis B, polio, measles, rubella, and tuberculosis. Even with the huge successes of vaccination campaigns, continuous hurdles, vaccine hesitancy, and inequitable access to vaccination in many major parts of the world continue to threaten high immunization rates. These issues were once again at the forefront of the COVID-19 pandemic and present an argument for continued investment and collaboration toward strong vaccination programs in the wake of future health emergencies.

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