Evaluating the Effectiveness and Coverage of Vaccination Programs in Reducing the Incidence of Paediatric Infectious Diseases

Abstract:

Background: Vaccination programs have been integral to controlling infectious diseases, particularly in pediatric populations. Routine immunizations target numerous vaccine-preventable diseases, significantly reducing morbidity and mortality. However, despite the proven success of these interventions, gaps in vaccine coverage persist in various populations. This issue remains particularly relevant as new vaccines are introduced to tackle emerging diseases, making the assessment of vaccine effectiveness and coverage essential for improving public health outcomes.

Literature Review: Numerous studies have demonstrated the impact of vaccines in preventing pediatric infectious diseases. Routine childhood vaccinations in the United States have resulted in dramatic reductions in diseases such as measles, polio, and rubella, with some diseases showing a near 100% decrease in incidence. For instance, research in South Korea confirmed the effectiveness of pneumococcal vaccines against diseases like pneumonia and acute otitis media, while studies from Ethiopia highlighted low vaccination coverage due to factors such as maternal healthcare access and parental education. Meanwhile, the introduction of the 4CMenB vaccine in South Australia showed sustained effectiveness against serogroup B meningococcal disease. However, disparities in vaccination rates, as observed in U.S. adult populations, demonstrate that despite healthcare accessibility, missed opportunities and racial/ethnic inequalities continue to hinder optimal vaccine coverage.

Conclusion: The review highlights that while vaccines have dramatically reduced the burden of pediatric infectious diseases, maintaining and improving coverage is crucial. Factors such as healthcare access, education, and vaccine awareness play pivotal roles in ensuring high vaccination rates. Addressing these gaps, especially in low-coverage regions and among marginalized populations, is essential to maximize the public health benefits of vaccination programs. Continued evaluation of vaccination effectiveness and coverage will aid in refining immunization strategies and preventing future outbreaks.

Keywords: Vaccine, vaccine coverage, Immunization, Pediatric infectious diseases

Introduction

Immunization is one of the most effective and cost-efficient strategies for disease prevention. Its successes include the global eradication of smallpox, the control of poliomyelitis with the goal of eradication, and the elimination of measles and rubella in the ~~(1)~~United States (1). However, In ~~the~~ 2015 the increase in measles cases serves as a reminder that measles continues to be imported into the U.S~~(2)~~. The incidence of most other vaccine-preventable diseases, with the exception of tetanus and pertussis, has decreased by 99% or more compared to annual morbidity rates prior to vaccine development(2).

Comment [AHE1]: Repetition of refrence

A report by the US Preventive Services Task Force highlighted childhood immunization as one of only three preventive services to receive a perfect score of 10~~(3)~~. This ranking was based on both the clinical burden that vaccines can prevent and their cost-effectiveness to society(3). Vaccinating children has significantly lowered the rates of illness, death, and disability from diseases that can be prevented ~~by vaccines~~. In the United States, around 21 million hospitalizations, 732,000 deaths, and 322 million cases of the disease were avoided from 1994 to 2013(4). Among illnesses targeted by vaccines suggested before 1980, three—measles, polio, and rubella—have accomplished removal status as defined by the World Health Organization, and one—smallpox—has been eliminated(5).Tetanus and Diphtheria have seen a significant drop in cases due to regular immunization and are now well managed(6). On the other hand, while the rates of mumps and pertussis have decreased compared to before vaccines were available, they still tend to vary with occasional outbreaks since the introduction of vaccination(7). The overall health burden of diseases targeted by the childhood immunization scheme from 1980 to 2015, such as invasive pneumococcal disease, varicella, hepatitis B, Hemophilus influenzae type b, and hepatitis A, has decreased by more than 80% in countries including USA, Australia and ~~Ethopia~~Ethiopia.~~.~~ There have also been noticeable reductions in related diseases that weren't specifically targeted, such as acute otitis media caused by Streptococcus pneumoniae(8). After 2015, the routine immunization schedule for children in

various countries who are 10 years old or younger included more pathogens, like rotavirus and additional pneumococcal serotypes(9).The aim of this literature review is to evaluate the effectiveness and coverage of Vaccination Programs in Reducing the Incidence of Pediatric Infectious Diseases in various countries.

Comment [AHE2]: Aim wording as it is the title. Aim should be more elaborative and clearly understood

Literature Review

Real-world data shows that vaccination programs have been highly effective in reducing the incidence of pediatric infectious diseases. High vaccination coverage for diseases like measles, mumps, rubella, hepatitis A, hepatitis B, varicella, and invasive pneumococcal disease (IPD) has resulted in significant declines in cases globally. For instance, countries with comprehensive immunization programs report over 90% reductions in vaccine-preventable diseases such as Hib and IPD. The introduction of combination vaccines and sustained coverage rates above 85% have further contributed to herd immunity, preventing outbreaks and protecting vulnerable populations such as infants and immunocompromised children. Consequently, the public health burden of these diseases has been drastically reduced, improving child survival rates and preventing long-term complications.

In 2019, routine childhood immunizations in the United States included vaccines for 14 diseases that can be prevented in children under 10. This study looked at how these vaccines~~ations~~ affect public health by calculating disease incidence both with and without the universally advised children's vaccines(10). Routine immunization has really helped lower the rates of all the diseases we focus on, with reductions from 17% for influenza to a complete 100% for diseases like Haemophilus influenzae type b, diphtheria, rubella measles, polio, mumps, and rubella. In 2019, with a U.S. population of 328 million, these reductions meant that more than 24 million cases of vaccine-preventable diseases were avoided. The highest incidence rates during the vaccine era were seen for influenza, which was 13,412 cases per 100,000, and for acute otitis media related to Streptococcus pneumoniae, which was 2,756 cases per 100,000. The study found that regular childhood vaccinations led to significant and lasting decreases in the rates of all the diseases they aimed to prevent in the U.S. Keeping up and enhancing vaccination rates is really important for maintaining these low levels of diseases that can be prevented by vaccines.

A study was conducted to evaluate child immunization coverage and to identify factors related to full vaccination among kids aged 12–23 months in Mizan Aman town in ~~Ethopia~~Ethiopia(11). The study used a community-based cross-sectional survey approach and collected data using a checked structured questionnaire. This research interviewed a total of 322 caretakers and mothers. Based on vaccination cards and the memories of caretakers and mothers, 295 (91.6%) of the kids got at least one dose of a vaccine. Out of the children, 27 (8.4%) had no vaccinations at all, 159 (49.4%) had some vaccinations, and 136 (42.2%) were fully vaccinated. Factors like the education levels of dads and moms, where the baby is born, how often mothers use healthcare services, and what mothers and caregivers know about vaccines and diseases that can be prevented by vaccines were all linked to whether a child gets fully immunized. The results showed that the level of child immunization coverage in the area we looked at was low. The town health office and other important groups should really step up their efforts to make the expanded immunization program better in this area.

Pneumococcal conjugate vaccinations

Pneumococcal conjugate vaccinations were evaluated for their efficiency in treating acute otitis media, pneumococcal illness, pneumococcal pneumonia, and pneumoniain children in Korea, a country with high immunization coverage(12). The goal of the study was to determine whether or not these vaccines are effective in treating these conditions. The limited number of people who had not been immunized posed a hurdle when attempting to evaluate the efficacy of the vaccine (12).For the purpose of conducting this retrospective study, children who were born between the years 2013 and 2015 were identified from the national population register. Records of vaccinations obtained from the National Immunization Program and medical information obtained from the National Health Insurance System were coordinated in order to establish the study cohort. The effectiveness of the vaccine was evaluated and compared between the original cohort and the group that was matched based on their propensity scores.There was a total of 990,224 youngsters on the list, and 98 percent of them had received vaccinations. Vaccinated individuals had a greater incidence of ACP, PP, and AOM in the initial cohort than those who had not received vaccinations. It was discovered that the vaccine was effective against both pneumococcal pneumonia and acute otitis media. This was determined after considering a number of characteristics, including age, comorbidities, gender, and the consumption of

healthcare services. In the group that was matched based on their propensity scores, the Vaccine was found to be effective against AOM.

BCG vaccine

The BCG vaccine has consistently demonstrated high efficacy against miliary tuberculosis and childhood tuberculous meningitis while its effectiveness against adult pulmonary tuberculosis and other mycobacterial diseases has been more variable(13). In 2006, approximately 100.5 million BCG vaccinations administered to infants were estimated to have prevented 29,729 cases of tuberculous meningitis in children during their first five years of life, equating to one case averted for every 3,435 vaccinations. Additionally, 11,486 cases of military tuberculosis were prevented, with one case averted for every 9,314 vaccinations. The greatest number of cases prevented occurred in regions such as the western Pacific region (15%), sub-Saharan Africa (27%), and South East Asia (46%), where the risk of tuberculosis infection and vaccine coverage are highest. With a cost of US$2–3 per dose, BCG vaccination was calculated to cost US$206 per healthy life year gained, making it a highly cost-effective intervention. As a result, BCG vaccination remains an essential strategy in high-incidence countries, complementing the chemotherapy of active tuberculosis.

Comment [AHE3]: Complete form

Vaccination program

A vaccination program with the four-component serogroup B meningococcal vaccine started in South Australia on October 1, 2018, targeting children aged 0–3 years and infants(14). It was then extended on February 1, 2019, to include senior school students in years 10 and 11, as well as young adults aged 17–20 years. The purpose of this study was to assess how effective the vaccine is and what its effects are on gonorrhea and serogroup B meningococcal disease two years after the program started. The 4CMenB vaccine has demonstrated lasting effectiveness against serogroup B meningococcal disease two years after being introduced in adolescents and infants, and it shows moderate effectiveness against gonorrhea in adolescents. The strong effectiveness against serogroup B meningococcal disease is probably due to the substantial vaccine coverage in the intended age groups and a favorable match between the circulating serogroup B strains and the 4CMenB vaccine in South Australia. Also, the physical distancing measures related to COVID-19 might have led to even more decreases in cases of serogroup B meningococcal disease in the program's second year.Invasive meningococcal disease (IMD),

caused by Neisseria meningitidis, leads to significant morbidity and mortality worldwide. A systematic review assessed the effectiveness of meningococcal vaccines in preventing IMD and reducing N. meningitidis pharyngeal carriage(15).Meningococcal conjugate C, ACWY (A, C, W, and Y serogroups), and outer membrane vesicle (OMV) vaccines were shown to effectively reduce IMD. A small number of studies indicated that monovalent C conjugate vaccines reduce N. meningitidis pharyngeal carriage. However, there is no evidence of carriage reduction with multivalent MenACWY, OMV, or recombinant MenB vaccines, which has important implications for immunization strategies.The research showed that the PCV program has a direct effect on ACP, PP, and AOM. Using a propensity score-matched cohort turned out to be a really effective way to assess vaccine effectiveness in countries that have really high vaccination rates.

According to data from the National Health Interview Survey in the United States, a significant number of adults are still not protected against diseases that could be prevented by vaccines(16). The vaccination coverage for age-appropriate composite measures was low in all adult age groups. Even though the overall vaccination rates for adults stayed low, there were some small improvements in coverage for hepatitis B among adults aged 19 and older, as well as healthcare workers in the same age group. Additionally, there were gains in HPV vaccination for males aged 19 to 26 and Hispanic females in that age range. Still, there has been no improvement in coverage for other vaccines and groups with Advisory Committee on Immunization Practices (ACIP) recommendations since 2017(16).. Even though there have been rises in HPV vaccination rates for males and Hispanic females aged 19–26 years, around 50% of females and 70% of males in this age group are still not vaccinated. There are still differences in vaccination rates among different racial and ethnic groups for the vaccines that are usually recommended for adults. Even though things like health insurance coverage, having a consistent healthcare provider, and seeing a doctor at least once in the past year were linked to higher vaccination rates, these factors by themselves didn't ensure the best adult vaccination coverage. The results show that there were missed chances for vaccination.

Comment [AHE4]: Add some tables, figures to clearly represent your idea

Conclusion

In conclusion, vaccination programs have played a pivotal role in reducing the global burden of pediatric infectious diseases, significantly curbing morbidity and mortality. The literature

consistently demonstrates the effectiveness of routine childhood immunizations in preventing diseases such as measles, polio, rubella, and pneumococcal infections. However, despite these successes, disparities in vaccination coverage remain a pressing issue, particularly in low-resource settings and among certain demographic groups. Factors such as healthcare access, parental education, and socioeconomic status significantly influence immunization rates. The data also suggest that while healthcare access and regular physician visits are associated with higher vaccination rates, these factors alone do not guarantee optimal coverage, indicating that missed opportunities for immunization persist. Moving forward, addressing these disparities through targeted public health interventions, education campaigns, and enhanced healthcare accessibility is critical to ensuring the sustained success of vaccination programs. Continued monitoring of vaccine effectiveness and coverage will be essential in preventing the resurgence of vaccine-preventable diseases and safeguarding public health.

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