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The Role of School-Based Vaccination Programs in Improving Coverage

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Abstract The analysis revealed that school-based vaccination programs can significantly enhance vaccine coverage. Educational interventions, reminders, provider-directed interventions, financial incentives, and multilevel interventions were found to improve vaccination rates among children and adolescents. Additionally, school-based programs were effective in delivering vaccines such as the influenza vaccine and the HPV vaccine, achieving high coverage rates and reducing illness incidence. School-based vaccination programs are a viable and effective strategy for increasing vaccination coverage among school-aged children and adolescents. These programs benefit from the structured school environment, which facilitates the organization and delivery of vaccines. Future efforts should focus on optimizing these programs by addressing logistical challenges and ensuring stakeholder engagement to maximize their impact on public health. The study aimed to evaluate the role of school-based vaccination programs in improving vaccination coverage among school-aged children and adolescents and analyze various interventions and their effectiveness to identify key factors that contribute to higher vaccination rates within the school setting.

Keywords School-based vaccination; Immunization coverage; Public health intervention; Stakeholder engagement; Vaccination programs

1 Introduction

Vaccination is one of the most effective public health interventions for preventing infectious diseases and reducing associated morbidity and mortality. Immunization programs have historically focused on infants and young children, achieving significant reductions in global infant and child mortality rates (Das et al., 2016). However, despite these successes, vaccination coverage remains suboptimal in many regions, leading to the persistence of vaccine-preventable diseases (Jacob et al., 2016; Vann et al., 2018; Mcfadden and Seale, 2020). The complexity of immunization schedules and the increasing demands on primary care providers further complicate efforts to achieve optimal vaccination rates (Vann et al., 2018).

School-based vaccination programs have emerged as a promising strategy to improve immunization coverage among school-aged children and adolescents. These programs leverage the school setting to reach a large population efficiently, ensuring that vaccines are administered in a controlled and accessible environment (King et al., 2006; Pan et al., 2017; Feldstein et al., 2020). Evidence suggests that school-based vaccination can significantly reduce the incidence of diseases such as influenza, with high vaccination coverage and matched vaccines leading to fewer outbreaks (Pan et al., 2017). Additionally, school-based programs have been shown to increase vaccination rates and reduce influenza-like illness (ILI) among students and their household members (Lau et al., 2019). Despite these benefits, the impact of school-based clinics and policy interventions on overall vaccination coverage remains uncertain, highlighting the need for further research (Siddiqui et al., 2022).

The purpose of this study was to evaluate the role of school-based vaccination programs in improving vaccination coverage among school-aged children and adolescents, synthesize existing evidence on the effectiveness of these programs, identify key factors for their success, and provide recommendations for optimizing their implementation. By examining a variety of interventions, including educational initiatives, reminders, and policy changes, this study hopes to provide a comprehensive picture of how school-based vaccination programs can improve public health outcomes. These findings will inform policymakers, educators, and health care providers on

best practices to increase immunization rates and reduce the burden of vaccine-preventable diseases in school Settings.

2 Historical Context of School-Based Vaccination Programs

2.1 Early implementation and evolution

School-based vaccination programs have a long history, with their roots tracing back to the early 20th century when schools were first recognized as effective venues for mass immunization efforts. The initial focus was on diseases such as smallpox and diphtheria, which posed significant public health threats at the time. Over the decades, the scope of these programs has expanded to include a variety of vaccines aimed at preventing diseases like measles, mumps, rubella, and more recently, human papillomavirus (HPV) and meningococcal infections (Paul and Fabio, 2014; Perman et al., 2017; Tiley et al., 2020).

2.2 Key milestones and policy developments

Several key milestones have marked the evolution of school-based vaccination programs. In the 1970s, the introduction of mandatory vaccination policies for school entry in the United States significantly increased vaccination coverage and reduced the incidence of vaccine-preventable diseases (Greyson et al., 2019). The implementation of the HPV vaccination program in schools in the early 2000s represented another significant milestone, with countries like Australia and the United Kingdom achieving high coverage rates through these initiatives (Skinner and Robbins, 2010; Paul and Fabio, 2014; Muhamad et al., 2018). Policy developments have also played a crucial role, with many countries adopting laws that require vaccination records to be checked upon school entry, thereby ensuring higher compliance and coverage rates (Greyson et al., 2019; Zuo et al., 2020).

2.3 Expansion and adaptation across different regions

The success of school-based vaccination programs in high-income countries has led to their adaptation and expansion in various regions worldwide. For instance, Malaysia's school-based HPV vaccination program, launched in 2010, achieved high coverage rates through a well-coordinated, multi-sectoral approach (Muhamad et al., 2018). Similarly, in China, the implementation of a vaccination record check program at school entry has significantly increased coverage rates for multiple vaccines and reduced the incidence of diseases like measles (Zuo et al., 2020). These programs have demonstrated that with proper planning and execution, school-based vaccination can be an effective strategy in diverse settings (Cawley et al., 2010; Perman et al., 2017; Tiley et al., 2020).

3 Effectiveness of School-Based Vaccination Programs

3.1 Impact on vaccination coverage rates

School-based vaccination programs have demonstrated a significant impact on increasing vaccination coverage rates among children and adolescents. A meta-analysis revealed that educational interventions, reminders, provider-directed interventions, financial incentives, and multilevel interventions can improve vaccination coverage by varying degrees, with financial incentives showing the highest increase at 67% (Siddiqui et al., 2022). Additionally, a systematic review highlighted that school-located vaccination programs are feasible and effective, particularly when strategies such as incentives, education, and reminders are employed (Cawley et al., 2010). In Hong Kong, a school outreach vaccination program significantly improved influenza vaccination rates among primary school students, achieving a coverage rate of 69.2% compared to 34.3% in control schools (Lau et al., 2019). Furthermore, a review of HPV vaccine delivery strategies found that school-based programs achieved high vaccination coverage rates in 9 to 13-year-old girls across different geographic locations (Paul and Fabio, 2014).

3.2 Reduction in vaccine-preventable diseases

The implementation of school-based vaccination programs has also been associated with a reduction in vaccine-preventable diseases. For instance, a study on school-based influenza vaccination found that households with children attending intervention schools had significantly fewer influenza-like symptoms compared to control-school households (King et al., 2006). Similarly, the Hong Kong school outreach vaccination program reported a significant reduction in influenza-like illness (ILI) rates among vaccinated students, with an ILI rate of

7.7% compared to 14.1% among non-vaccinated students (Lau et al., 2019). Additionally, a systematic review of adolescent immunization programs indicated that strategies to improve HPV vaccine coverage resulted in a significant decrease in the prevalence of HPV and genital warts (Das et al., 2016).

3.3 Cost-effectiveness of school-based programs

The cost-effectiveness of school-based vaccination programs has been a subject of interest in several studies. A systematic review emphasized the need for prospective, well-controlled trials to establish the cost-effectiveness of specific vaccination strategies in school settings (Cawley et al., 2010). In Africa, a comparison of school-based and supplemental vaccination strategies found that while both approaches achieved high vaccination coverage, school-based vaccinations were generally more expensive than supplemental immunization activities (Haddison et al., 2017). However, the review also noted that school-based programs did not negatively affect routine immunization services, suggesting that they can be a sustainable option for increasing vaccination coverage (Haddison et al., 2017). Additionally, the role of school nurses in vaccination programs has been highlighted as a cost-effective strategy to increase immunization rates, as their involvement has been shown to positively impact vaccination adherence (Guarinoni and Dignani, 2021).

4 Case Studies and Examples of Successful Programs

4.1 High-income countries

4.1.1 United States: successes and challenges

In the United States, school-based vaccination programs have been instrumental in increasing vaccination coverage among children and adolescents. Mandated vaccination for school attendance has shown a positive impact on vaccination rates, although the implementation of these mandates has faced challenges, particularly with the human papillomavirus (HPV) vaccine, which has been controversial (Greyson et al., 2019). Organizational factors such as program leadership, communication with parents, and the role of school nurses have been identified as critical to the success of these programs (Perman et al., 2017). Despite these challenges, educational interventions and reminders have been effective in improving vaccination uptake (Siddiqui et al., 2022).

4.1.2 United Kingdom: program implementation and outcomes

The United Kingdom has successfully implemented school-based vaccination programs, particularly for the HPV vaccine. The UK's approach has been characterized by strong government support and effective communication strategies, which have led to high vaccination coverage rates (Hardt et al., 2016). The use of grade-based eligibility criteria has also facilitated the implementation of these programs in school settings (Paul and Fabio, 2014). The success of the UK's program highlights the importance of tailored, culturally-appropriate approaches and robust organizational structures (Perman et al., 2017).

4.1.3 Australia: effective strategies and results

Australia's National HPV Vaccination Program, which began in 2007 for females and in 2013 for males, has achieved substantial reductions in the prevalence of HPV and genital warts among young Australians (Skinner et al., 2015). The program's success can be attributed to a combination of educational interventions, decisional support tools, and logistical strategies such as in-school mop-up vaccination and consent form return strategies (Skinner et al., 2015). Australia's long history of school-based vaccination programs and high coverage rates underscore the effectiveness of these strategies (Skinner et al., 2015; Hardt et al., 2016).

4.2 Low- and middle-income countries

4.2.1 India: challenges and successes

In India, school-based vaccination programs face significant challenges, including logistical issues and varying levels of parental knowledge about the importance of vaccinations (Lukusa et al., 2018). However, educational interventions targeting parents and community-based education campaigns have shown promise in improving vaccination coverage (Figure 1) (Lukusa et al., 2018). These interventions have led to substantial improvements in childhood vaccination rates, demonstrating the potential for school-based programs to overcome barriers in low- and middle-income countries (Lukusa et al., 2018).

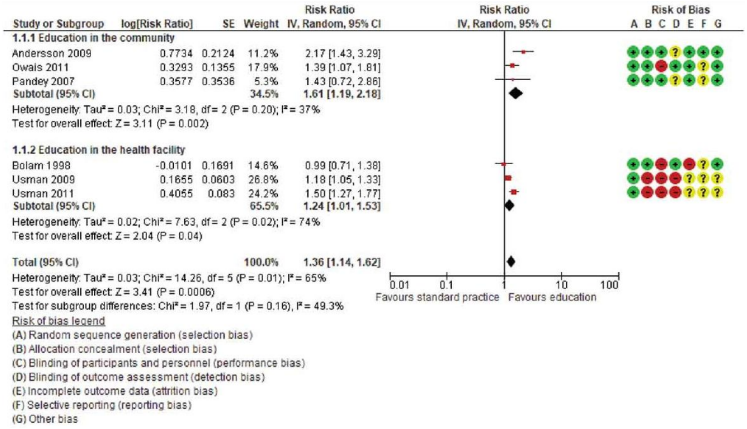

Figure 1 The effect of caregiver education on uptake of any vaccine among children (Adopted from Lukusa et al., 2018)

Image caption: Three studies assessed the effects of educating caregivers in communities, outside of health facilities. Two of these studies reported DTP3 coverage and the third reported coverage with at least one childhood vaccine. The investigators reported DTP3 coverage of 72% (129/179) in the intervention group and 52% (92/178) in the control group. Pooling the data from the studies shows that community-based education improves childhood vaccination coverage (three trials, 2 339 participants: RR 1.61, 95% CI 1.19 to 2.18, I2 = 37%) (Adopted from Lukusa et al., 2018)

4.2.2 Kenya: implementation and outcomes

Kenya has implemented school-based vaccination programs with a focus on increasing HPV vaccination coverage among adolescent girls. The use of community-based education and structured group discussions has been effective in improving vaccine uptake (Lukusa et al., 2018). Despite challenges such as limited resources and logistical constraints, these programs have achieved significant increases in vaccination coverage, highlighting the importance of community involvement and education (Lukusa et al., 2018).

4.2.3 Brazil: program effectiveness and challenges

Brazil's school-based vaccination programs have faced challenges related to local service infrastructures and varying levels of vaccine coverage across different regions (Hardt et al., 2016). However, the implementation of vaccination requirements in schools and national permissive recommendations have contributed to improved immunization uptake (Das et al., 2016). The success of these programs underscores the need for strong support from government and healthcare organizations, as well as tailored approaches to address local challenges (Hardt et al., 2016; Das et al., 2016).

4.3 Lessons learned and best practices

The case studies from both high-income and low- and middle-income countries provide valuable insights into the factors that contribute to the success of school-based vaccination programs. Effective program leadership, clear communication strategies, and the involvement of school nurses are critical to the success of school-based vaccination programs (Hardt et al., 2016; Perman et al., 2017). Providing education to students, parents, and the community about the importance of vaccinations can significantly improve vaccination uptake (Skinner et al., 2015; Lukusa et al., 2018; Siddiqui et al., 2022). Implementing logistical strategies such as in-school mop-up vaccination, consent form return strategies, and grade-based eligibility criteria can facilitate the smooth operation of vaccination programs (Paul and Fabio, 2014; Skinner et al., 2015). Strong support from government and healthcare organizations is essential for the successful implementation of vaccination programs, particularly in low- and middle-income countries (Hardt et al., 2016; Das et al., 2016). By incorporating these best practices, school-based vaccination programs can achieve higher coverage rates and contribute to the overall improvement of public health outcomes.

5 Challenges and Limitations

5.1 Logistical challenges

School-based vaccination programs face significant logistical challenges that can hinder their effectiveness. One major issue is the coordination required between schools and health services to ensure smooth delivery of

vaccines. This includes scheduling vaccination days, managing vaccine storage and transportation, and ensuring that there are enough trained personnel to administer the vaccines (Cawley et al., 2010; Perman et al., 2017; Siddiqui et al., 2022). Additionally, the physical setup of schools may not always be conducive to running vaccination clinics, which can lead to delays and inefficiencies (Robbins et al., 2010). The need for extensive planning and communication between various stakeholders is crucial to address these logistical hurdles (Perman et al., 2017; Tiley et al., 2020).

5.2 Legal and ethical considerations

Legal and ethical considerations also pose challenges to school-based vaccination programs. Obtaining informed consent from parents or guardians is a critical aspect that can be complicated by language barriers, literacy levels, and varying levels of trust in the healthcare system (Robbins et al., 2011; Lind et al., 2014). There are also ethical concerns related to the autonomy of older children and adolescents, who may have differing opinions from their parents regarding vaccination (Humiston and Rosenthal, 2005; Lind et al., 2014). Ensuring that all legal requirements are met while respecting the rights and preferences of both parents and children is a delicate balance that must be maintained (Carpenter et al., 2007; Robbins et al., 2011).

5.3 Socio-cultural factors

Socio-cultural factors significantly influence the success of school-based vaccination programs. Cultural beliefs and misconceptions about vaccines can lead to resistance and lower uptake rates (Carpenter et al., 2007; Lind et al., 2014; Paul and Fabio, 2014). For instance, some communities may have specific concerns about the safety and necessity of vaccines, which can be exacerbated by misinformation (Lind et al., 2014; Paul and Fabio, 2014). Additionally, socio-economic disparities can affect access to vaccination programs, with schools in lower-income areas often facing more significant challenges in achieving high coverage rates (Carpenter et al., 2007). Addressing these socio-cultural barriers requires targeted education and outreach efforts to build trust and acceptance within diverse communities (Carpenter et al., 2007; Lind et al., 2014; Paul and Fabio, 2014).

6 Strategies and Suggestions for Improvement

6.1 Enhancing program reach and accessibility

To improve the reach and accessibility of school-based vaccination programs, several strategies can be implemented. Firstly, educational interventions targeting both parents and students can significantly increase vaccination coverage. Studies have shown that vaccination education can increase overall vaccination coverage by 19% (Siddiqui et al., 2022). Additionally, simplifying the consent process and ensuring that consent forms are easily accessible and understandable can lead to higher return rates and increased participation (Robbins et al., 2011). Offering vaccinations at no cost to families and providing multiple vaccination options, such as intramuscular and intranasal vaccines, can also enhance accessibility and acceptance (Cawley et al., 2010).

6.2 Strengthening partnerships and collaborations

Strengthening partnerships between schools, healthcare providers, and public health organizations is crucial for the success of school-based vaccination programs. Effective communication and collaboration among these stakeholders can facilitate the organization and delivery of vaccination services. For instance, involving school nurses, teachers, and parents in the planning and implementation process can ensure that all parties are well-informed and supportive of the program (Robbins et al., 2011). Additionally, leveraging existing health system infrastructure and resources can enhance the efficiency and reach of vaccination efforts (Paul and Fabio, 2014). Collaborative efforts can also help address logistical challenges and ensure that vaccination programs are well-coordinated and effectively managed (Perman et al., 2017).

6.3 Continuous monitoring and evaluation

Continuous monitoring and evaluation of school-based vaccination programs are essential to identify areas for improvement and ensure the effectiveness of the interventions. Regularly collecting and analyzing data on vaccination coverage, consent form return rates, and reasons for non-vaccination can provide valuable insights into the program's performance (Robbins et al., 2011). Implementing robust evaluation frameworks that consider

organizational factors, such as leadership, communication, and workforce capacity, can help identify best practices and areas needing attention (Perman et al., 2017). Additionally, conducting prospective, well-controlled trials to assess the cost-effectiveness of specific vaccination strategies can inform future program design and policy decisions (Cawley et al., 2010).

By implementing these strategies and continuously evaluating their impact, school-based vaccination programs can be optimized to improve vaccination coverage and protect the health of school-aged children and adolescents.

7 Future Directions

7.1 Research gaps and areas for future study

Despite the growing body of literature on school-based vaccination programs, several research gaps remain. One significant gap is the lack of theory-informed research to guide the implementation of these programs. Most studies are descriptive and do not utilize robust theoretical frameworks to understand the organizational factors influencing program delivery (Perman et al., 2017). Additionally, there is a need for more prospective, well-controlled trials to establish the cost-effectiveness of specific vaccination strategies (Cawley et al., 2010). Research should also focus on standardizing methods to estimate vaccine coverage to facilitate better program evaluation (Paul and Fabio, 2014). Furthermore, the impact of school-based clinics and policy and legislation on overall vaccination coverage remains uncertain and warrants further investigation (Siddiqui et al., 2022).

7.2 Technological innovations

Technological advancements offer promising avenues to enhance the effectiveness of school-based vaccination programs. For instance, web-based educational programs have shown potential in increasing vaccination coverage among adolescents by improving their knowledge and reducing vaccine hesitancy (Esposito et al., 2018). Integrating digital tools for consent management and communication with parents and students could streamline the vaccination process and address logistical challenges (Cawley et al., 2010; Perman et al., 2017). Additionally, leveraging social media platforms for accurate information dissemination and countering misinformation could play a crucial role in improving vaccine uptake (Delany-Moretlwe et al., 2018).

7.3 Policy recommendations for sustainable programs

To ensure the sustainability of school-based vaccination programs, several policy recommendations can be made. First, programs should be designed to optimize service delivery efficiency, such as integrating vaccination with other adolescent health services (Rosen et al., 2023). Policymakers should also consider the economic sustainability of these programs, particularly in regions with high proportions of Vaccines for Children (VFC) eligible children. Subsidies or increased reimbursement rates for Medicaid could enhance program viability (Tran et al., 2016). Furthermore, strong partnerships between government ministries, schools, and healthcare providers are essential for successful program implementation and sustainability (Delany-Moretlwe et al., 2018). Finally, streamlined consent processes and proactive commodity procurement and security measures are critical to maintaining high vaccination coverage and program effectiveness (Delany-Moretlwe et al., 2018; Rosen et al., 2023).

By addressing these research gaps, leveraging technological innovations, and implementing sustainable policy recommendations, school-based vaccination programs can significantly improve vaccination coverage and contribute to better public health outcomes.

8 Concluding Remarks

School-based vaccination programs have demonstrated significant potential in improving vaccination coverage among children and adolescents. Various studies have highlighted the effectiveness of different strategies and interventions. These have been shown to increase vaccination coverage by 19% and 15%, respectively. Offering financial incentives can significantly boost vaccination rates, with an increase of up to 67%. Provider-directed interventions have also been effective, increasing coverage by 13%. High coverage rates were achieved in school-based HPV vaccination programs, particularly when grade-based eligibility criteria were used. School-located influenza vaccination programs have been effective in increasing coverage and reducing absenteeism. Successful implementation of school-based vaccination programs often involves ensuring that all

stakeholders are well-informed and involved in the process. Effective delivery of school-based vaccination programs depends on factors such as leadership, communication, and logistical planning. The adoption of school-based vaccination programs has increased globally, with many countries reporting the delivery of vaccines in school settings. School outreach vaccination programs have significantly improved influenza vaccination rates and reduced influenza-like illness among students.

The findings from these studies have several important implications for public health practice. School-based vaccination programs can significantly enhance vaccination coverage, particularly for vaccines targeting school-aged children. These programs are a cost-effective method of delivering vaccines to a large population in a short period. By increasing vaccination rates, school-based programs can reduce the burden of vaccine-preventable diseases and associated absenteeism. Implementing policies that mandate vaccination for school attendance can be an effective strategy to increase coverage. Ensuring that all stakeholders, including parents, teachers, and healthcare providers, are involved and informed is crucial for the success of these programs. The global adoption of school-based vaccination programs indicates their feasibility and effectiveness across different settings and populations.

Looking ahead, there are several areas that require further research and development. More research is needed to standardize methods for estimating vaccine coverage to ensure accurate evaluation of programs, prospective, well-controlled trials to determine the cost-effectiveness of specific vaccination strategies. Studies using population-wide coverage data and considering joint interventions, confounding factors, and context are also necessary to better understand the impact of vaccination mandates. Further controlled studies to identify best practices for implementing school-based vaccination programmes in various Settings. Understanding the organizational factors that affect the implementation of vaccination programs can help design and implement better programs. More data is needed to assess the global prevalence of checking vaccination status in schools and to identify factors that promote optimal implementation.

In conclusion, school-based vaccination programs hold great promise for improving vaccination coverage and reducing the burden of vaccine-preventable diseases. Continued research and careful implementation of these programs can further enhance their effectiveness and impact on public health.

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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