

IMPACT OF DELAYED IMMUNIZATION ON CHILD MORBIDITY: CHALLENGES FOR PAEDIATRIC NURSING PRACTICE

Rajwinder Kaur^{1*}, Minakshi Rana², Pooja Taank³

^{1*} Assistant Professor, University College of Nursing, Faridkot, Punjab (*Corresponding Author)

² Assistant Professor, Swakar College of Nursing, Sarkaghat, Mandi, Himachal Pradesh

³ Assistant Professor, JIET College of Nursing, Jodhpur, Rajasthan

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Abstract

Delayed and incomplete immunization remains a significant contributor to increased child morbidity, particularly in low and middle income settings where healthcare access, parental awareness, and follow up systems are limited. Failure to adhere to recommended vaccination schedules exposes children to preventable infectious diseases such as Measles, Diphtheria, and Pertussis, leading to higher rates of hospitalization, complications, and mortality. Pediatric nursing practice plays a critical role in addressing these gaps through education, early identification of missed doses, and implementation of reminder and tracking systems. Nurses act as frontline healthcare providers who can influence parental attitudes, improve health literacy, and ensure continuity of care through community engagement and follow up interventions. However, challenges such as workload burden, inadequate training in immunization counseling, and lack of structured monitoring systems limit the effectiveness of nursing interventions. Addressing these barriers requires strengthening nursing competencies, integrating digital health solutions, and promoting family centered care approaches. Enhancing the role of pediatric nurses in immunization programs can significantly reduce disease burden and improve child health outcomes by ensuring timely and complete vaccination coverage.

Keywords: Immunization Delay, Child Morbidity, Pediatric Nursing, Vaccine Compliance, Preventable Diseases, Community Health, Follow Up Care.

Introduction

Immunization is recognized as one of the most cost-effective and impactful public health interventions, preventing approximately 4.4 million deaths annually among children worldwide (World Health Organization et al., 2025). Over the past decades, vaccination programs have significantly reduced the burden of infectious diseases such as measles, polio, and diphtheria, contributing to improved child survival rates globally (Greenwood et al., 2020). Despite these achievements, global immunization coverage has plateaued in recent years, with only modest improvements observed in vaccine uptake (World Health Organization et al., 2024). Recent global estimates indicate that around 89% of infants receive at least one dose of a diphtheria–tetanus–pertussis vaccine, while only 85% complete the full schedule, reflecting gaps in adherence (UNICEF et al., 2023). Alarming, nearly 20 million children miss at least one essential vaccine dose annually, leaving a significant proportion vulnerable to preventable diseases (Gavi Alliance et al., 2022). Among these, approximately 14.3 million children are classified as zero-dose children, meaning they have not received any routine immunization (World Health Organization et al., 2022). Delayed immunization further complicates this scenario, as children who receive vaccines later than recommended remain unprotected during critical developmental periods (Smith et al., 2020). This delay increases the risk of infection, particularly for highly contagious diseases such as measles,

which can rapidly exploit immunity gaps within populations (Cutts et al., 2019). Globally, outbreaks of vaccine-preventable diseases have been linked to declining or delayed vaccination coverage, emphasizing the importance of timely immunization (Patel et al., 2020). For instance, millions of children remain under-protected against measles, contributing to frequent outbreaks across multiple regions (Zhou et al., 2019). The situation is particularly concerning in low- and middle-income countries, where healthcare infrastructure challenges, socioeconomic barriers, and limited awareness contribute to delays in vaccination schedules (Restrepo-Méndez et al., 2016). In such settings, fragile health systems and disruptions further exacerbate the problem, leading to widening gaps in immunization coverage (Orenstein et al., 2017). Even in higher-income countries, misinformation and vaccine hesitancy have emerged as significant barriers to timely immunization (Larson et al., 2018). The COVID-19 pandemic also played a critical role in disrupting routine immunization services, resulting in millions of missed or delayed vaccinations worldwide (World Health Organization et al., 2020). Post-pandemic recovery efforts have attempted to address these gaps, yet progress remains uneven across regions and populations (PAHO et al., 2025).

Delayed immunization not only increases individual susceptibility but also undermines herd immunity, thereby facilitating the resurgence of controlled diseases (Dubé et al., 2021). This creates a dual burden on healthcare systems, as they must manage both preventable disease outbreaks and routine health services simultaneously (Lassi et al., 2021). Children who experience delayed vaccination are more likely to suffer from severe disease outcomes, including hospitalization, complications, and long-term health consequences (Nelson et al., 2020). Furthermore, early delays in vaccination schedules often predict incomplete immunization later in childhood, creating a cumulative risk effect (Brown et al., 2018). Socioeconomic determinants such as parental education, income level, and geographic accessibility play a crucial role in influencing immunization timeliness (Serhan et al., 2025). Parental perceptions, including fear of adverse effects and lack of awareness about vaccination schedules, further contribute to delays (MacDonald et al., 2019). Healthcare system-related factors, including inadequate follow-up mechanisms and missed opportunities during clinical visits, also significantly affect timely vaccine delivery (Qin et al., 2025). Missed opportunities for vaccination occur when eligible children interact with healthcare services but do not receive the required vaccines, contributing to delays (Pons-Salote et al., 2024). Addressing these gaps requires a comprehensive approach involving healthcare providers, policymakers, and community stakeholders (André et al., 2018). In this context, paediatric nurses play a vital role in ensuring timely immunization through education, advocacy, and follow-up care (World Health Organization et al., 2022). They are often the first point of contact for caregivers and are responsible for counselling, administering vaccines, and maintaining immunization records (CDC et al., 2022). However, paediatric nursing practice faces numerous challenges, including high workload, limited resources, and communication barriers with caregivers (UNICEF et al., 2021). These challenges can hinder effective implementation of immunization programs and contribute to delays in vaccine administration (Ministry of Health and Family Welfare India et al., 2023). Emerging digital health technologies, such as electronic immunization registries and reminder systems, offer promising solutions to improve vaccination timeliness (World Health Organization et al., 2022). Nevertheless, the successful integration of these technologies requires adequate training, infrastructure, and policy support (Gavi Alliance et al., 2023). Given the critical importance of timely immunization in preventing child morbidity, there is an urgent need to strengthen nursing strategies and healthcare systems (Global Burden of Disease Study et al., 2021). This study aims to explore the impact of delayed immunization on child morbidity and identify challenges faced by paediatric nurses in clinical practice (Orenstein et al., 2017). It also seeks to provide evidence-based recommendations to improve immunization adherence and reduce preventable disease burden among children (Greenwood et al., 2020). This figure 1 illustrates the proportion of fully immunized children, partially immunized children, and zero-dose children worldwide, highlighting persistent gaps in vaccination coverage across different regions. Immunization is widely recognized as one of the most cost-effective public health interventions, preventing an estimated 3–5 million deaths annually. Despite significant progress in global vaccination programs, delayed and incomplete immunization schedules continue to pose a serious threat to child health. Delayed immunization extends the period during which children remain

vulnerable to vaccine-preventable diseases such as measles, diphtheria, and pertussis. Globally, millions of children fail to receive vaccines on time, with a substantial proportion classified as “zero-dose” children. This issue is particularly prevalent in low- and middle-income countries, where healthcare access, awareness, and follow-up systems remain inadequate.

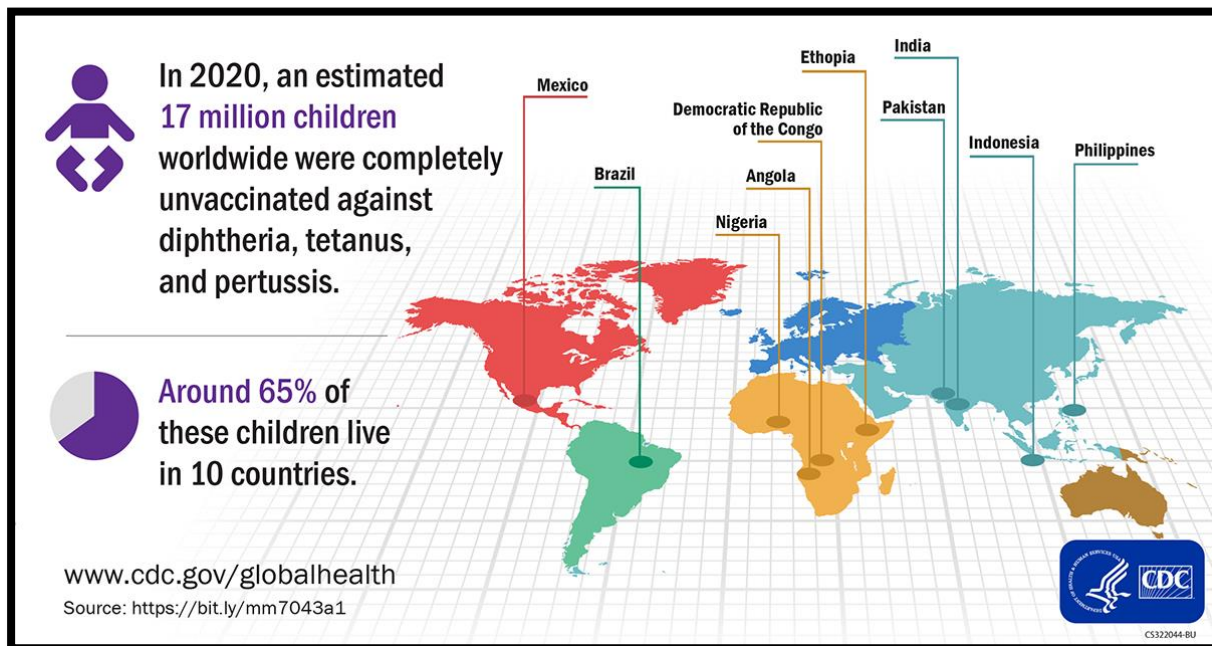


Figure 1: Global Immunization Coverage and Gaps

Problem Statement

Incomplete and delayed immunization schedules remain a persistent public health concern that continues to expose children to preventable diseases and associated complications (World Health Organization et al., 2024). Despite the availability of structured national and global immunization programs, a significant proportion of children fail to receive vaccines within the recommended time frame, thereby increasing their vulnerability to infectious diseases (UNICEF et al., 2023). Delayed immunization extends the period during which children remain susceptible to pathogens, particularly in early childhood when immunity is still developing (Smith et al., 2020). Evidence suggests that even short delays in vaccination can substantially increase the risk of outbreaks of highly contagious diseases such as measles and pertussis (Cutts et al., 2019). Globally, millions of children either miss or delay essential vaccines each year, highlighting gaps not only in coverage but also in timeliness of immunization (Gavi Alliance et al., 2022). These delays contribute significantly to increased child morbidity, hospitalization rates, and, in severe cases, mortality (Nelson et al., 2020). The burden is disproportionately higher in low- and middle-income countries, where healthcare systems often struggle with inadequate infrastructure, workforce shortages, and limited accessibility (Restrepo-Méndez et al., 2016). In such contexts, barriers such as poverty, geographic isolation, and low parental education further hinder timely vaccine uptake (Serhan et al., 2025). Additionally, parental misconceptions, fear of adverse events, and vaccine hesitancy continue to play a critical role in delaying immunization schedules (MacDonald et al., 2019).

Healthcare system-related challenges, including vaccine stock-outs, poor record-keeping, and lack of reminder or recall systems, further exacerbate the problem (World Health Organization et al., 2022). Missed opportunities for vaccination during healthcare visits remain a major contributor to delays, as eligible children often leave health facilities without receiving due vaccines (Pons-Salote et al., 2024). Studies indicate that early delays in vaccination are strong predictors of incomplete immunization later in childhood, thereby compounding the risk over time (Brown et al., 2018). Furthermore, disruptions such as the COVID-19 pandemic have significantly affected routine immunization services, leading to widespread delays and backlogs in vaccination schedules (World Health Organization et al., 2020). Although recovery efforts have been initiated, the restoration of timely immunization remains uneven across regions (PAHO et al., 2025). The consequences of delayed

immunization extend beyond individual health, as they undermine herd immunity and increase the likelihood of disease outbreaks within communities (Dubé et al., 2021). This creates an additional burden on healthcare systems, which must simultaneously manage preventable disease outbreaks and routine healthcare services (Lassi et al., 2021). Paediatric nurses, who are central to immunization delivery, face numerous challenges in addressing these delays, including high patient loads, limited resources, and difficulties in maintaining follow-up with caregivers (UNICEF et al., 2021). Their role in educating parents, administering vaccines, and ensuring adherence to schedules is critical, yet often constrained by systemic inefficiencies (Ministry of Health and Family Welfare India et al., 2023). Moreover, inadequate integration of digital health technologies and tracking systems limits the ability to monitor and improve vaccination timeliness effectively (Gavi Alliance et al., 2023). Addressing delayed immunization therefore requires a multifaceted approach that includes strengthening healthcare systems, improving caregiver awareness, and enhancing the role of paediatric nursing practice (André et al., 2018). Given the significant impact of delayed immunization on child morbidity and public health outcomes, there is an urgent need to develop and implement effective nursing strategies aimed at ensuring timely vaccination and reducing preventable disease burden among children (Global Burden of Disease Study et al., 2021). This figure 2 compares the standard immunization timeline with commonly observed delayed vaccination patterns, illustrating the increased vulnerability period for children. Incomplete and delayed immunization schedules continue to expose children to preventable diseases, largely due to lack of awareness, inadequate follow-up, and systemic healthcare barriers. These delays significantly increase morbidity risks and undermine national immunization programs. The problem is further compounded by missed opportunities during healthcare visits, where eligible children are not vaccinated. This highlights the urgent need for structured paediatric nursing interventions to ensure adherence to immunization schedules.

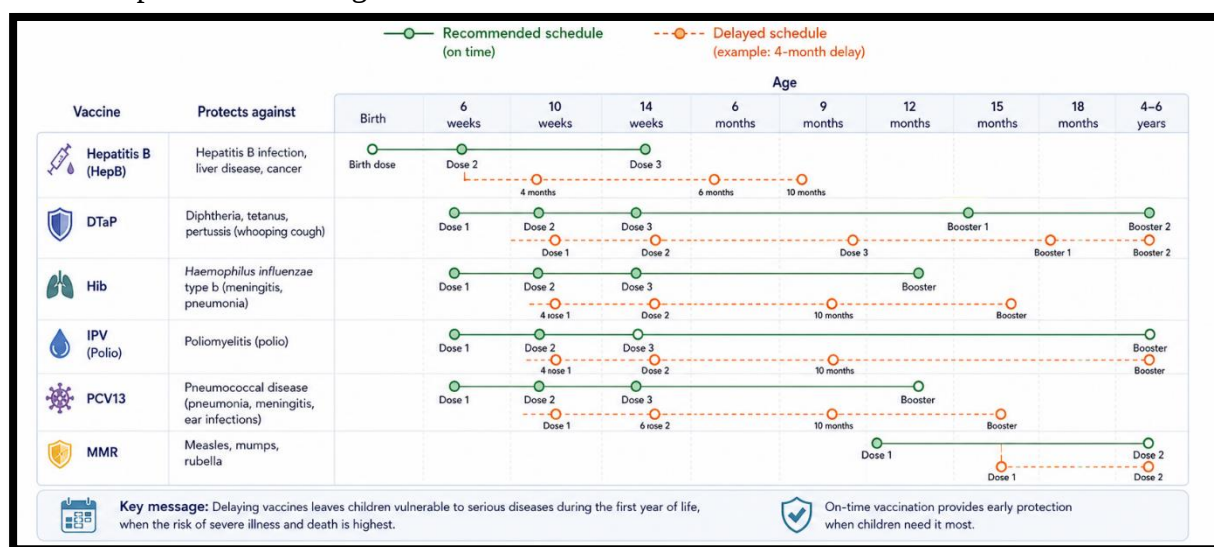


Figure 2: Timeline of Recommended vs Delayed Immunization Schedule

Epidemiology of Delayed Immunization

Delayed immunization is a widespread global public health issue affecting both developed and developing countries, with significant implications for child health outcomes (World Health Organization et al., 2024). Although overall vaccination coverage has improved over the years, the timeliness of vaccine administration remains a critical but often overlooked indicator of immunization program effectiveness (Smith et al., 2020). Globally, it is estimated that approximately 20 million children each year fail to receive at least one essential vaccine dose, and a substantial proportion of these children experience delays in receiving scheduled vaccinations (UNICEF et al., 2023). Among them, around 14.3 million are categorized as zero-dose children, reflecting profound inequities in access to healthcare services and immunization programs (Gavi Alliance et al., 2022). The epidemiology of delayed immunization reveals marked disparities across regions, with the highest prevalence observed in low- and middle-income countries, particularly in South Asia and Sub-Saharan Africa (Restrepo-Méndez et al., 2016). In these regions, structural challenges such as

inadequate healthcare infrastructure, shortage of trained healthcare workers, and limited availability of vaccines contribute significantly to delays in immunization schedules (Orenstein et al., 2017). Socioeconomic factors, including poverty, low maternal education, and rural residence, further exacerbate these disparities, leading to uneven distribution of vaccination services (Serhan et al., 2025). Studies have shown that children born to mothers with lower educational attainment are more likely to experience delayed or incomplete immunization compared to those with educated caregivers (Brown et al., 2018). In addition, urban–rural differences play a crucial role, with children in rural and remote areas facing greater barriers to accessing timely vaccination services (Lassi et al., 2021). The epidemiological pattern of delayed immunization is also influenced by cultural beliefs, parental attitudes, and vaccine hesitancy, which vary across populations and geographic regions (MacDonald et al., 2019). In high-income countries, although access to vaccines is generally adequate, delays are often associated with parental choice, misinformation, and concerns regarding vaccine safety (Larson et al., 2018). Furthermore, missed opportunities for vaccination during healthcare visits contribute significantly to delayed immunization globally, as many children who interact with healthcare systems do not receive eligible vaccines (Pons-Salote et al., 2024). The COVID-19 pandemic has had a profound impact on the epidemiology of delayed immunization, disrupting routine vaccination services and leading to significant declines in vaccine coverage worldwide (World Health Organization et al., 2020). As a result, millions of children missed or delayed their scheduled vaccinations, increasing the risk of outbreaks of vaccine-preventable diseases (PAHO et al., 2025). Epidemiological data indicate that delays in early childhood vaccination are strongly associated with subsequent delays or non-completion of the immunization schedule, thereby compounding the risk of disease over time (Nelson et al., 2020). This cumulative effect highlights the importance of ensuring timely administration of vaccines at each stage of the immunization schedule (Cutts et al., 2019). Additionally, variations in national immunization policies, healthcare delivery systems, and surveillance mechanisms contribute to differences in the epidemiology of delayed immunization across countries (André et al., 2018). In many settings, inadequate monitoring and reporting systems limit the ability to accurately assess vaccination timeliness and identify high-risk populations (World Health Organization et al., 2022). Emerging digital health technologies, including electronic immunization registries, have shown potential in improving data collection and tracking vaccination schedules, thereby enhancing epidemiological surveillance (Gavi Alliance et al., 2023). Despite these advancements, significant gaps remain in the availability and quality of data on immunization timeliness, particularly in resource-limited settings (Global Burden of Disease Study et al., 2021). Overall, the epidemiology of delayed immunization underscores the complex interplay of socioeconomic, cultural, and healthcare system factors that influence vaccination timeliness, highlighting the need for targeted interventions to address these disparities and improve child health outcomes worldwide (Greenwood et al., 2020). This figure 3 presents global disparities in immunization timeliness, showing higher prevalence of delays in South Asia and Sub-Saharan Africa. Delayed immunization is a global concern affecting both developed and developing nations. While overall vaccination coverage may appear adequate, timeliness remains a neglected indicator. Studies indicate that a significant proportion of children receive vaccines later than recommended, increasing their susceptibility to infections.

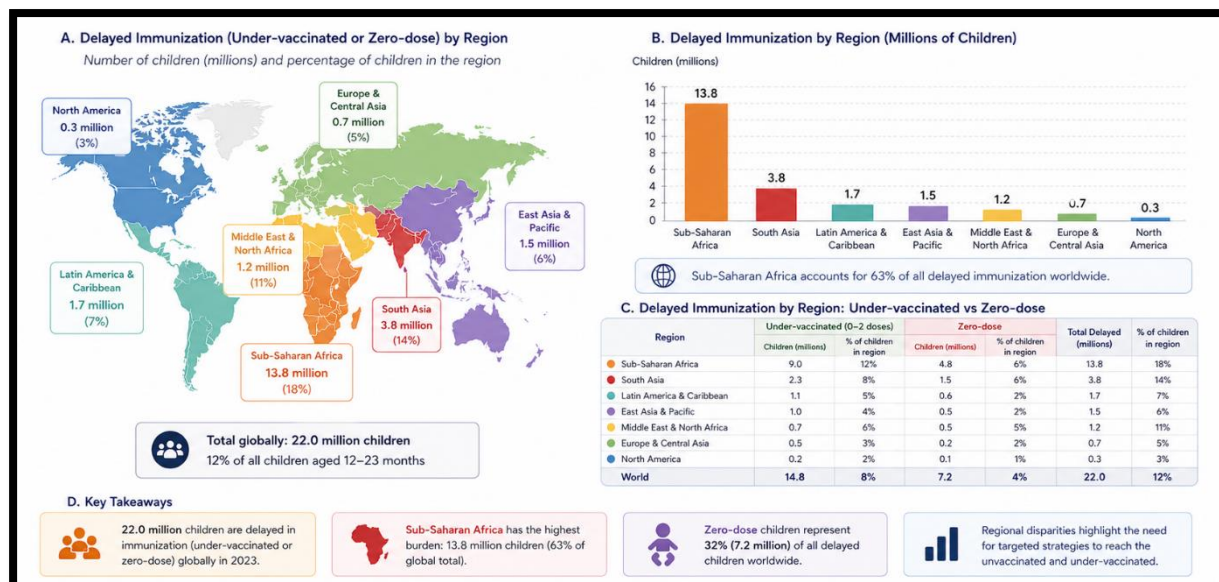


Figure 3: Regional Distribution of Delayed Immunization

The table 1 summarizes key global immunization indicators, highlighting both coverage levels and critical gaps in vaccination services. While a high proportion of children receive initial vaccines, as reflected by DTP1 coverage, a noticeable decline in subsequent doses indicates challenges in follow-up and continuity of care. The presence of a large number of zero-dose children and those missing at least one vaccine underscores inequalities in access to healthcare services. Additionally, measles vaccine coverage remaining below the herd immunity threshold increases the risk of disease outbreaks.

Table 1: Global Immunization Indicators

Indicator	Estimate	Description	Public Health Implication
Zero-dose children	14.3 million	Children who have not received any routine vaccines	High risk of severe infections and mortality, indicates extreme inequity in healthcare access
Children missing at least one vaccine	~20 million	Children who start but do not complete immunization schedules	Increased susceptibility to vaccine-preventable diseases and incomplete immunity
DTP1 coverage	89%	Children receiving the first dose of diphtheria–tetanus–pertussis vaccine	Reflects initial access to immunization services
DTP3 coverage	85%	Children completing three doses of DTP vaccine	Indicator of health system performance and continuity of care
Dropout rate (DTP1–DTP3)	~4%	Percentage of children who do not complete the DTP series	Indicates gaps in follow-up and service utilization
Measles vaccine (MCV1) coverage	84%	Coverage of first dose of measles-containing vaccine	Below threshold required for herd immunity (~95%)
Measles vaccine (MCV2) coverage	~74%	Coverage of second dose of measles vaccine	Reflects challenges in completing immunization schedules

Causes of Delayed Immunization

Delayed immunization is a multifactorial issue arising from the complex interaction of parental, socioeconomic, and healthcare system-related factors that collectively influence vaccination timeliness (World Health Organization et al., 2024). Parental factors play a crucial role, as lack of awareness regarding immunization schedules, misconceptions about vaccine safety, and fear of adverse effects often lead to postponement or avoidance of vaccination (MacDonald et al., 2019). Vaccine hesitancy, driven by misinformation and distrust in healthcare systems, has emerged as a significant contributor to delayed immunization even in regions with adequate vaccine availability (Larson et al., 2018). In many cases, parents may not perceive the immediate risk of vaccine-preventable diseases, resulting in complacency toward timely vaccination (Dubé et al., 2021). Additionally, low levels of maternal education have been consistently associated with delays in immunization, as caregivers may lack the knowledge necessary to adhere to recommended vaccination schedules (Restrepo-Méndez et al., 2016). Socioeconomic factors further compound these challenges, with poverty, unstable living conditions, and lack of transportation limiting access to healthcare services (Serhan et al., 2025). Children residing in rural or geographically isolated areas often face significant barriers in reaching vaccination centres, leading to missed or delayed doses (Lassi et al., 2021). Cultural beliefs and traditional practices may also influence immunization behaviour, particularly in communities where alternative health practices are preferred over modern medicine (André et al., 2018). Healthcare system-related factors represent another major category of causes, including inadequate infrastructure, shortages of trained healthcare personnel, and inconsistent vaccine supply chains that can disrupt immunization services (Orenstein et al., 2017). Vaccine stock-outs and limited clinic hours may prevent caregivers from accessing services at convenient times, contributing to delays (World Health Organization et al., 2022). Furthermore, poor record-keeping and lack of effective reminder or recall systems hinder the ability to track and follow up with children who miss scheduled vaccinations (Gavi Alliance et al., 2023). Missed opportunities for vaccination during healthcare visits are also a critical factor, as children who interact with health services for other reasons often do not receive due vaccines due to oversight or lack of screening (Pons-Salote et al., 2024). Communication barriers between healthcare providers and caregivers can further impede timely immunization, particularly when health information is not conveyed in a culturally appropriate or understandable manner (UNICEF et al., 2021). In addition, systemic issues such as fragmented healthcare delivery systems and lack of coordination between public and private sectors contribute to inefficiencies in immunization programs (Ministry of Health and Family Welfare India et al., 2023). External factors such as public health emergencies, natural disasters, and pandemics have also been shown to disrupt routine immunization services, leading to widespread delays (World Health Organization et al., 2020). The COVID-19 pandemic, for instance, significantly impacted healthcare utilization, with lockdowns and fear of infection preventing caregivers from seeking vaccination services (PAHO et al., 2025). Behavioural factors, including forgetfulness and competing priorities among caregivers, also contribute to delays, particularly in busy or resource-constrained households (Brown et al., 2018). Additionally, early delays in vaccination schedules often lead to subsequent delays or incomplete immunization, creating a cumulative effect that increases vulnerability to disease (Nelson et al., 2020). Addressing the causes of delayed immunization therefore requires a comprehensive understanding of these interrelated factors and the implementation of targeted interventions at multiple levels, including community education, healthcare system strengthening, and policy support (Greenwood et al., 2020). Given the critical role of paediatric nurses in immunization delivery, addressing these challenges is essential to ensure timely vaccination and improve child health outcomes (Global Burden of Disease Study et al., 2021). This figure 4 categorizes causes into parental, healthcare system, and socioeconomic factors. Delayed immunization results from a complex interplay of multiple factors: Parental factors include lack of awareness, fear of adverse effects, and cultural misconceptions. Healthcare system-related factors involve inadequate infrastructure, vaccine stock-outs, and lack of reminder systems. Socioeconomic barriers such as poverty, low maternal education, and geographic inaccessibility further contribute to delays. These determinants often overlap, creating compounded barriers that prevent timely vaccination.

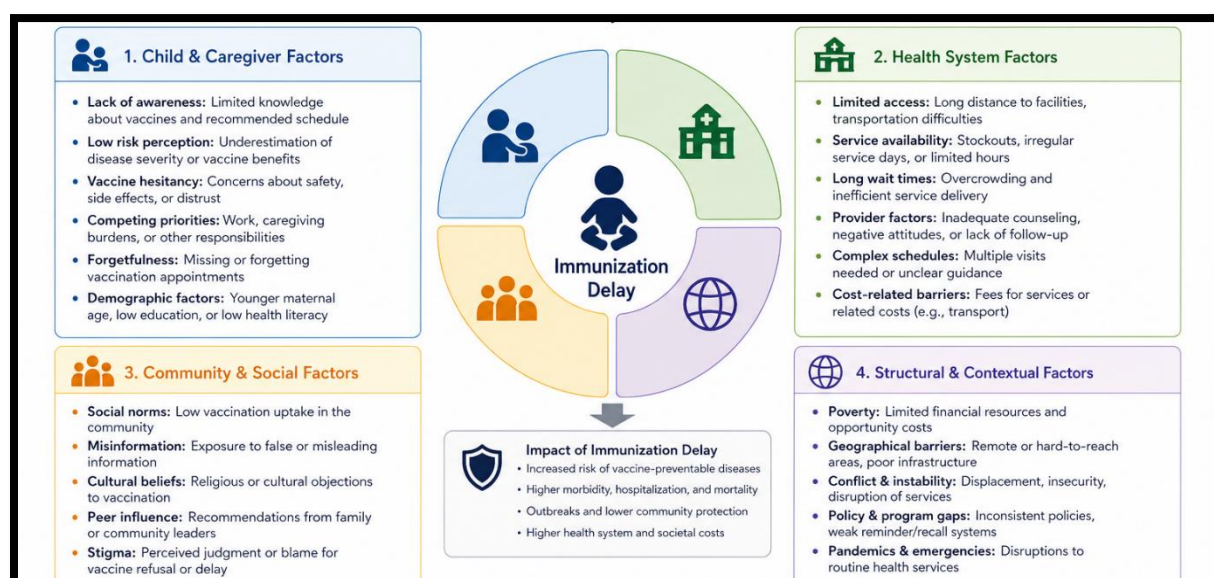


Figure 4: Determinants of Immunization Delay

Impact on Child Morbidity

Delayed immunization has a profound and measurable impact on child morbidity, significantly increasing the risk, severity, and spread of vaccine-preventable diseases among vulnerable populations (World Health Organization et al., 2024). When children do not receive vaccines according to the recommended schedule, they remain unprotected during critical periods of immune development, thereby increasing their susceptibility to infections such as measles, pertussis, pneumonia, and rotavirus (Nelson et al., 2020). This prolonged window of vulnerability facilitates the transmission of infectious agents, particularly in densely populated or resource-limited settings where disease exposure is high (Cutts et al., 2019). Epidemiological evidence suggests that delayed vaccination is strongly associated with increased incidence of vaccine-preventable diseases, contributing to higher morbidity rates among under-five children (Patel et al., 2020). In addition to increased disease incidence, delayed immunization often results in more severe clinical manifestations, as children lack the necessary immune protection to effectively combat infections (Greenwood et al., 2020). Consequently, affected children are more likely to require hospitalization, experience complications, and suffer from long-term health consequences, including impaired growth and developmental delays (Lassi et al., 2021). Delayed immunization also contributes to the persistence and resurgence of diseases that have otherwise been controlled or nearly eliminated, thereby undermining global public health achievements (Orenstein et al., 2017). For example, gaps in measles vaccination coverage have been linked to recurrent outbreaks in multiple regions, demonstrating the direct relationship between immunization delays and disease transmission (Zhou et al., 2019). Furthermore, delayed vaccination weakens herd immunity, reducing the overall level of population protection and increasing the likelihood of outbreaks within communities (Dubé et al., 2021). This not only affects unvaccinated children but also places immunocompromised individuals and those unable to receive vaccines at greater risk (André et al., 2018).

The burden of morbidity associated with delayed immunization is particularly pronounced in low- and middle-income countries, where healthcare systems may already be strained and less equipped to manage outbreaks of preventable diseases (Restrepo-Méndez et al., 2016). In such settings, increased morbidity leads to greater healthcare utilization, higher economic costs, and additional strain on limited medical resources (Ozawa et al., 2019). Delayed immunization has also been linked to increased mortality rates, particularly in cases of severe infections such as measles and pneumonia, which remain leading causes of death among young children in many regions (World Health Organization et al., 2022). Moreover, the cumulative effect of repeated delays or missed vaccinations can result in incomplete immunization, further amplifying the risk of morbidity over time (Brown et al., 2018). Studies have demonstrated that children who experience delays in early vaccine doses are more likely to miss subsequent vaccinations, creating a cycle of vulnerability that persists throughout

childhood (Smith et al., 2020). Behavioural and systemic factors contributing to delays, such as missed opportunities for vaccination and inadequate follow-up, further exacerbate this issue by preventing timely correction of immunization gaps (Pons-Salote et al., 2024). The impact of delayed immunization extends beyond physical health, as frequent illness and hospitalization can negatively affect a child's cognitive development, educational attainment, and overall quality of life (UNICEF et al., 2021). Additionally, families and communities bear the indirect burden of increased healthcare costs, loss of productivity, and emotional stress associated with managing preventable illnesses (Serhan et al., 2025). The COVID-19 pandemic further highlighted the consequences of disrupted immunization services, with significant increases in missed and delayed vaccinations leading to heightened risk of disease outbreaks (World Health Organization et al., 2020). Recovery efforts have emphasized the importance of restoring routine immunization services, yet gaps in timeliness continue to pose challenges for healthcare systems worldwide (PAHO et al., 2025). Addressing the impact of delayed immunization on child morbidity therefore requires a comprehensive approach that includes strengthening immunization programs, improving caregiver awareness, and enhancing healthcare delivery systems (Gavi Alliance et al., 2023). Paediatric nurses play a crucial role in mitigating these effects by ensuring timely vaccine administration, educating caregivers, and identifying children at risk of delayed immunization (Global Burden of Disease Study et al., 2021). Ultimately, reducing delays in immunization is essential to minimizing child morbidity, preventing disease outbreaks, and achieving global health targets related to child survival and well-being (World Health Organization et al., 2024). This figure 5 demonstrates how increasing delay duration correlates with higher risk of infection and complications. Delayed immunization significantly increases the risk of vaccine-preventable diseases. Children who do not receive vaccines on time remain unprotected during critical developmental periods, making them highly susceptible to infections. This leads to increased incidence of diseases such as measles, pneumonia, and pertussis, resulting in higher hospitalization rates and long-term complications. In severe cases, delayed immunization can contribute to mortality.

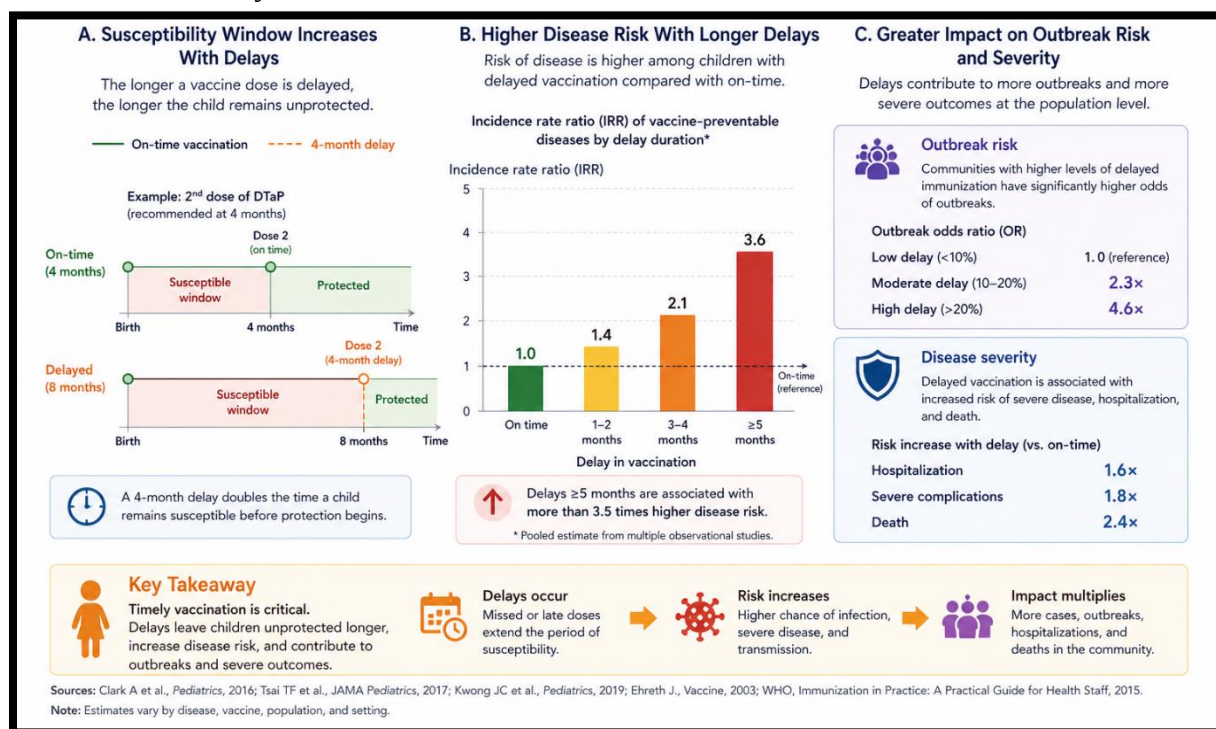


Figure 5: Relationship Between Delayed Immunization and Disease Risk
Missed Opportunities for Vaccination (MOV)

Missed opportunities for vaccination (MOV) represent a significant and preventable contributor to delayed immunization, occurring when children who are eligible for vaccination interact with healthcare services but do not receive the vaccines, they are due (World Health Organization et al., 2022). MOV is widely recognized as a systemic failure within healthcare delivery, reflecting gaps in

provider practices, service organization, and immunization policies (Brown et al., 2018). Studies have shown that a substantial proportion of children visiting healthcare facilities for routine check-ups, illness, or other services leave without receiving recommended vaccines, thereby contributing to delays and incomplete immunization (Pons-Salote et al., 2024). This issue is particularly prevalent in low- and middle-income countries, where healthcare systems often lack standardized protocols for assessing vaccination status during every patient encounter (Restrepo-Méndez et al., 2016). One of the primary causes of MOV is the failure of healthcare providers to routinely check immunization records or to screen children for vaccine eligibility during clinical visits (Orenstein et al., 2017). In many cases, healthcare workers may focus solely on the presenting illness and overlook the opportunity to administer due vaccines, especially when immunization is not the primary reason for the visit (Lassi et al., 2021).

Additionally, misconceptions among healthcare providers regarding contraindications to vaccination can result in unnecessary deferral of vaccines, further contributing to missed opportunities (MacDonald et al., 2019). Health system constraints, such as high patient load, limited staffing, and inadequate training, also play a critical role in the occurrence of MOV, as overburdened healthcare workers may not have sufficient time to assess vaccination needs comprehensively (UNICEF et al., 2021). Poor documentation and lack of integrated immunization records further hinder the identification of children who are due for vaccination, leading to missed opportunities during subsequent visits (Gavi Alliance et al., 2023). In addition, inconsistent vaccine availability and stock-outs can prevent healthcare providers from administering vaccines even when children are present and eligible (World Health Organization et al., 2024). Behavioural factors on the part of caregivers, such as lack of awareness about the importance of vaccination during illness or uncertainty regarding vaccine schedules, may also contribute to MOV (Serhan et al., 2025). Cultural beliefs and misconceptions about vaccinating sick children can lead caregivers to decline vaccination during healthcare visits, thereby increasing the likelihood of missed opportunities (Dubé et al., 2021). The consequences of MOV are significant, as they directly contribute to delays in immunization and increase the risk of vaccine-preventable diseases among children (Nelson et al., 2020). Repeated missed opportunities can lead to cumulative delays, resulting in incomplete immunization and prolonged susceptibility to infections (Smith et al., 2020). Furthermore, MOV undermines the efficiency and effectiveness of immunization programs, as resources are not optimally utilized to deliver vaccines during available healthcare encounters (André et al., 2018). The COVID-19 pandemic further exacerbated the problem of MOV, as disruptions in routine healthcare services and reduced healthcare-seeking behaviour limited opportunities for vaccination (World Health Organization et al., 2020). Efforts to address MOV have emphasized the importance of implementing systematic screening protocols, integrating immunization services into all healthcare visits, and training healthcare providers to recognize and utilize every opportunity for vaccination (World Health Organization et al., 2022). Digital health technologies, such as electronic immunization registries and reminder systems, have shown promise in reducing MOV by improving tracking and follow-up of vaccination status (Gavi Alliance et al., 2023). Paediatric nurses play a critical role in minimizing missed opportunities by actively assessing vaccination status, educating caregivers, and ensuring that eligible children receive vaccines during every healthcare interaction (Global Burden of Disease Study et al., 2021). Addressing MOV is therefore essential for improving immunization timeliness, reducing delays, and ultimately decreasing child morbidity associated with vaccine-preventable diseases (Greenwood et al., 2020). This figure 6 illustrates how children visiting healthcare facilities often leave without receiving eligible vaccines. Missed opportunities for vaccination occur when children interact with healthcare services but fail to receive due vaccines. This is a major contributor to delayed immunization.

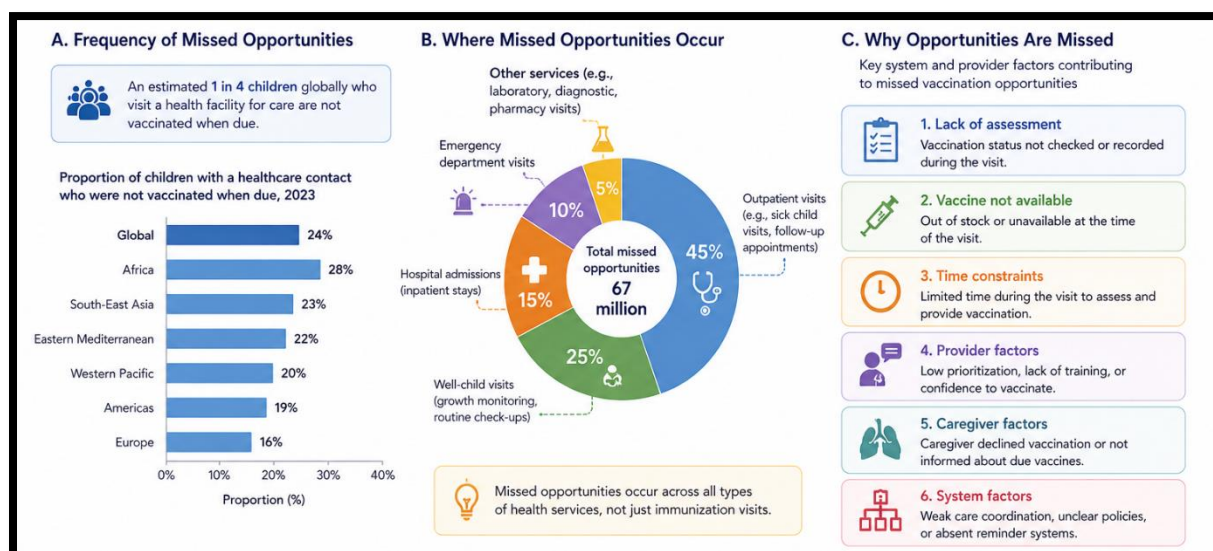


Figure 6: Missed Opportunities in Healthcare Settings

The table 2 outlines the major types of missed opportunities for vaccination, emphasizing how failures at multiple levels of the healthcare system contribute to delayed immunization. These missed opportunities often occur even when children have contact with healthcare services, indicating inefficiencies in service delivery rather than lack of access alone. Factors such as inadequate screening, provider-related errors, and false contraindications highlight gaps in healthcare worker training and practices. System-level issues like vaccine stock-outs and poor integration of services further limit the effectiveness of immunization programs. Additionally, caregiver-related factors such as refusal or lack of awareness also play a role in missed opportunities.

Table 2: Types of Missed Opportunities

Type	Description	Example	Public Health Implication
Health facility visit without vaccination	Child visits a healthcare facility but does not receive due vaccines	Child comes for fever treatment but vaccination status is not checked	Leads to delayed immunization despite healthcare contact
Lack of screening	Immunization status is not assessed during visit	No review of vaccination card during consultation	Missed chance to identify due or overdue vaccines
Provider-related missed opportunity	Healthcare worker fails to recommend or administer vaccines	Nurse assumes mild illness is a contraindication	Reduces vaccination uptake due to provider error
False contraindications	Vaccines withheld due to incorrect beliefs about eligibility	Vaccination postponed due to minor cold or fever	Unnecessary delays in immunization schedule
Vaccine stock-outs	Vaccines unavailable at health facility	Child asked to return later due to shortage	Interrupts continuity of immunization
Caregiver refusal at visit	Parent declines vaccination despite availability	Fear of side effects leads to refusal	Contributes to incomplete immunization
Poor documentation	Incomplete or missing immunization records	Lost vaccination card prevents decision-making	Increases risk of missed or repeated doses
Limited-service integration	Immunization not linked with other health services	No vaccination offered during nutrition visits	Reduces opportunities for vaccine delivery

Challenges for Paediatric Nursing Practice

Paediatric nursing practice plays a central role in ensuring timely immunization, however, nurses face numerous challenges that hinder effective vaccine delivery and contribute to delays in immunization schedules (World Health Organization et al., 2024). One of the primary challenges is the high workload and staffing shortages in healthcare settings, particularly in low- and middle-income countries, where nurses are often responsible for managing large patient populations with limited resources (UNICEF et al., 2021). This increased workload reduces the time available for thorough assessment of immunization status, caregiver counselling, and follow-up, thereby increasing the likelihood of missed or delayed vaccinations (Lassi et al., 2021). In addition, inadequate training and continuing education on immunization practices can limit nurses' ability to effectively address vaccine hesitancy and misinformation among caregivers (MacDonald et al., 2019). Communication barriers also present a significant challenge, as differences in language, literacy levels, and cultural beliefs can hinder effective interaction between nurses and caregivers, leading to misunderstandings about vaccination schedules and safety (Dubé et al., 2021). Paediatric nurses must often address concerns related to vaccine side effects and misconceptions, which require strong communication skills and evidence-based knowledge (Larson et al., 2018). Another critical challenge is poor documentation and record-keeping systems, which make it difficult to track vaccination histories and identify children who are due for immunization (Gavi Alliance et al., 2023). In many healthcare settings, reliance on paper-based records increases the risk of errors, loss of information, and inability to maintain accurate immunization data (World Health Organization et al., 2022). This lack of reliable data hampers effective follow-up and contributes to delays in vaccine administration (Brown et al., 2018). Limited access to digital health technologies further restricts the ability of nurses to implement reminder and recall systems that could improve immunization timeliness (Global Burden of Disease Study et al., 2021). Healthcare system constraints, including vaccine stock-outs, inadequate infrastructure, and inconsistent service availability, also pose significant barriers for paediatric nurses attempting to deliver timely immunization services (Orenstein et al., 2017). In such situations, nurses may be unable to administer vaccines even when children are present and eligible, leading to missed opportunities and delays (Pons-Salote et al., 2024). Additionally, the lack of coordination between different levels of healthcare services, including public and private sectors, creates fragmentation in immunization delivery and complicates follow-up efforts (Ministry of Health and Family Welfare India et al., 2023). Socioeconomic factors affecting caregivers, such as poverty, lack of transportation, and competing priorities, further challenge nurses in ensuring adherence to vaccination schedules (Serhan et al., 2025). Paediatric nurses often encounter difficulties in maintaining consistent follow-up with families who may have limited access to healthcare facilities or irregular healthcare-seeking behaviour (Restrepo-Méndez et al., 2016). The COVID-19 pandemic introduced additional challenges by disrupting routine healthcare services, increasing workload, and heightening concerns about infection risk, which affected both healthcare providers and caregivers (World Health Organization et al., 2020). These disruptions resulted in delays in immunization services and increased the burden on nurses to recover missed vaccinations (PAHO et al., 2025). Emotional and psychological stress among healthcare workers, including burnout and fatigue, further impacts the quality of care provided by paediatric nurses (Nelson et al., 2020). Despite these challenges, paediatric nurses remain essential to the success of immunization programs, as they are responsible for vaccine administration, caregiver education, and monitoring of adverse events (André et al., 2018). Addressing the challenges faced by paediatric nurses requires strengthening healthcare systems, improving training and resources, and implementing supportive policies that enable nurses to perform their roles effectively (Greenwood et al., 2020). Enhancing communication strategies, integrating digital health solutions, and ensuring adequate staffing are critical steps toward overcoming these barriers and improving immunization outcomes (Gavi Alliance et al., 2023). Ultimately, empowering paediatric nurses is key to reducing delays in immunization and improving child health outcomes on a global scale (World Health Organization et al., 2024). This figure 7 outlines the multifaceted responsibilities of paediatric nurses in vaccination programs. Paediatric nurses play a crucial role in ensuring timely immunization but face several challenges. These include communication barriers

with caregivers, high workload, limited resources, and inadequate documentation systems. Nurses are often responsible for educating parents, administering vaccines, maintaining records, and ensuring follow-up, making their role central to immunization success.

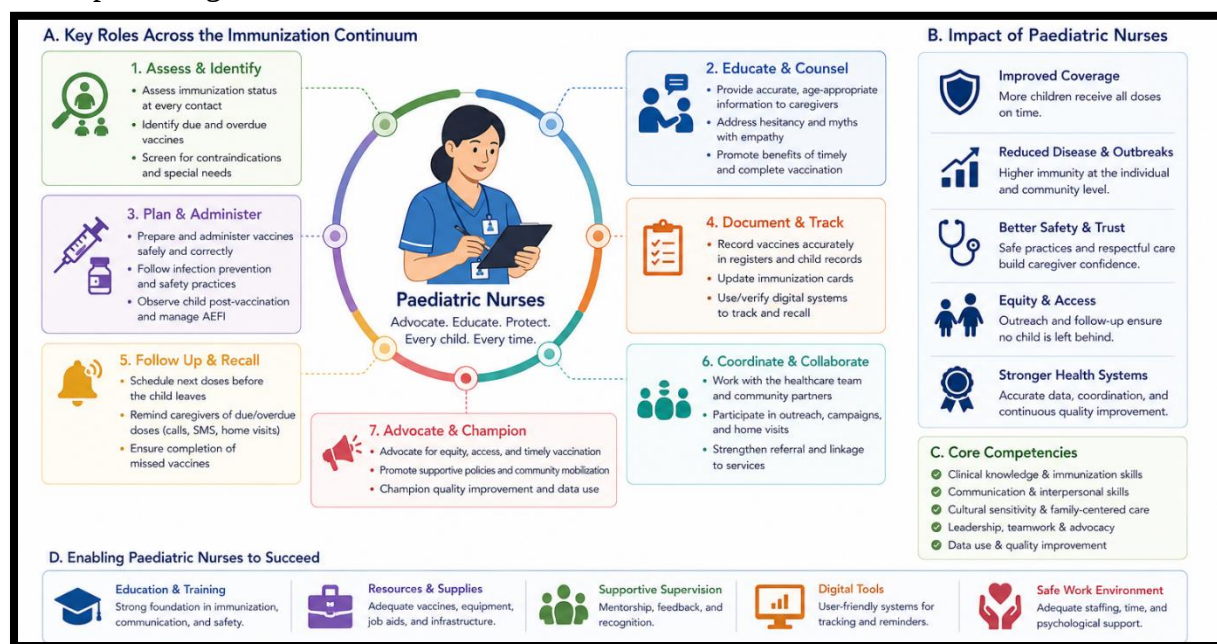


Figure 7: Role of Paediatric Nurses in Immunization

Nursing Strategies for Improvement

Effective nursing strategies are essential to address delayed immunization and improve adherence to vaccination schedules, as paediatric nurses play a central role in immunization delivery and caregiver engagement (World Health Organization et al., 2024). One of the most important strategies involves strengthening caregiver education through targeted health communication, where nurses provide clear, evidence-based information about the importance of timely vaccination, vaccine safety, and the risks associated with delays (MacDonald et al., 2019). Educational interventions have been shown to significantly reduce vaccine hesitancy and improve parental compliance with immunization schedules (Dubé et al., 2021). In addition, the use of culturally sensitive communication approaches helps address misconceptions and build trust between healthcare providers and communities (Larson et al., 2018). Implementing reminder and recall systems is another highly effective strategy, as these systems notify caregivers about upcoming or missed vaccinations, thereby improving adherence and reducing delays (Gavi Alliance et al., 2023). Mobile health technologies, including SMS reminders and smartphone applications, have demonstrated success in enhancing immunization coverage, particularly in resource-limited settings (World Health Organization et al., 2022). Paediatric nurses can also conduct active follow-up through home visits or community outreach programs to ensure that children who miss scheduled vaccinations are promptly identified and vaccinated (UNICEF et al., 2021).

Strengthening documentation and record-keeping systems is equally important, as accurate and accessible immunization records enable nurses to track vaccination status and plan timely interventions (Brown et al., 2018). The adoption of electronic immunization registries has been shown to improve data accuracy, facilitate monitoring, and support decision-making in immunization programs (Global Burden of Disease Study et al., 2021). Integrating immunization services into routine healthcare visits is another effective strategy to reduce missed opportunities for vaccination, ensuring that every contact with the healthcare system is utilized to deliver vaccines (Pons-Salote et al., 2024). Training and capacity building of paediatric nurses are critical components of improving immunization practices, as ongoing education enhances knowledge, skills, and confidence in vaccine administration and communication (Lassi et al., 2021). Supportive supervision and mentoring programs further strengthen nursing performance and ensure adherence to immunization guidelines (Orenstein et al., 2017). Addressing healthcare system barriers, such as vaccine stock-outs and inadequate infrastructure, is also essential to enable nurses to deliver services effectively (World

Health Organization et al., 2022). Policy-level interventions, including the integration of immunization programs with primary healthcare services and school-based vaccination initiatives, can enhance accessibility and coverage (Ministry of Health and Family Welfare India et al., 2023). Community engagement strategies, such as collaboration with local leaders and community health workers, play a vital role in promoting vaccination acceptance and improving outreach to underserved populations (Serhan et al., 2025). The use of digital health tools, including telehealth platforms, provides additional opportunities for caregiver counselling and follow-up, particularly in remote or hard-to-reach areas (Gavi Alliance et al., 2023). Monitoring and evaluation of immunization programs are crucial to identify gaps, assess progress, and implement corrective measures, ensuring continuous improvement in vaccination timeliness (André et al., 2018). Paediatric nurses can contribute to these efforts by maintaining accurate records, reporting data, and participating in quality improvement initiatives (Greenwood et al., 2020). Furthermore, addressing behavioural factors such as forgetfulness and competing priorities among caregivers requires flexible service delivery models, including extended clinic hours and outreach services (Nelson et al., 2020). The recovery of immunization services following disruptions such as the COVID-19 pandemic also necessitates targeted catch-up campaigns and intensified outreach efforts (PAHO et al., 2025). Ultimately, a comprehensive approach that combines education, technology, system strengthening, and community engagement is essential to improve immunization timeliness and reduce delays (World Health Organization et al., 2024). Empowering paediatric nurses with the necessary resources, training, and support is critical to the success of these strategies and to achieving improved child health outcomes globally (Global Burden of Disease Study et al., 2021). This figure 8 presents a structured model of nursing interventions including education, reminders, and follow-up systems.

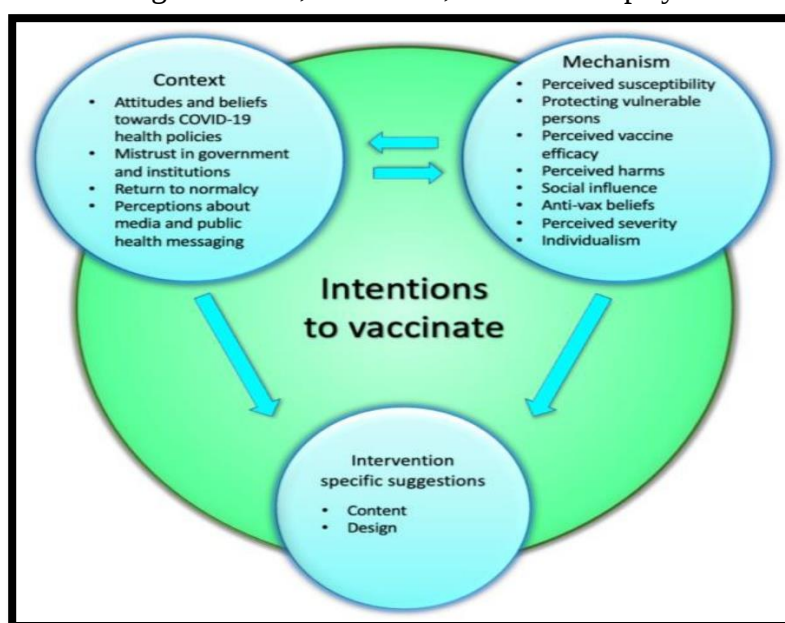


Figure 8: Nursing Intervention Framework for Timely Immunization

The table 3 highlights the role of technological interventions in improving immunization timeliness and reducing delays in vaccine delivery. Tools such as SMS reminders and electronic reminder-recall systems have proven effective in enhancing caregiver adherence by providing timely notifications about vaccination schedules. Digital records and cloud-based systems improve the accuracy and accessibility of immunization data, enabling healthcare providers to track vaccination status and ensure continuity of care. Telehealth and mobile health applications further enhance accessibility by allowing remote counselling and empowering caregivers with real-time information. Additionally, advanced tools such as data analytics systems and GIS mapping support healthcare planning by identifying coverage gaps and high-risk populations, thereby enabling targeted interventions.

Table 3: Technological Interventions

Technology	Benefit	Application	Public Health Implication
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SMS reminders	Improves adherence	Automated messages to caregivers for upcoming or missed vaccinations	Reduces missed appointments and enhances timely vaccine uptake
Digital records	Enhances tracking	Electronic immunization registries for maintaining vaccination history	Improves accuracy, continuity of care, and follow-up
Telehealth	Remote counselling	Virtual consultations for caregiver education and guidance	Increases accessibility and reduces misinformation
Mobile health apps	Real-time monitoring	Apps for tracking vaccination schedules and alerts	Empowers caregivers and supports self-management
Data analytics systems	Identifies gaps	Analysis of immunization data for coverage and delay trends	Supports targeted interventions and policy decisions
Electronic reminder-recall systems	Strengthens follow-up	Automated alerts for healthcare providers and caregivers	Minimizes dropout rates in immunization schedules
Cloud-based health systems	Data accessibility	Centralized storage of immunization records	Enables coordination across healthcare facilities
GIS mapping tools	Geographic tracking	Identifies underserved and high-risk areas	Improves outreach and resource allocation

Conclusion

Delayed immunization remains a major contributor to child morbidity globally, as it prolongs the period during which children are vulnerable to vaccine-preventable diseases and increases the likelihood of infection, complications, and hospitalization. In many settings, delays are not simply the result of a single factor but arise from a complex interaction of socioeconomic barriers, healthcare system inefficiencies, and gaps in caregiver awareness. These delays can weaken herd immunity, allowing outbreaks of diseases such as measles and pertussis to re-emerge even in populations where vaccines are available. Furthermore, children who miss or delay early doses are more likely to fall behind on subsequent vaccinations, creating a cumulative effect that significantly increases health risks over time. This not only affects individual child health outcomes but also places additional strain on healthcare systems, particularly in resource-limited regions where the burden of infectious diseases is already high. Addressing this issue requires a coordinated and multi-level approach involving healthcare systems, communities, and especially paediatric nurses, who play a pivotal role in immunization delivery. Strengthening nursing practices through continuous education, effective communication, and culturally sensitive counselling can help improve caregiver awareness and reduce vaccine hesitancy. In addition, implementing robust follow-up mechanisms such as reminder systems, home visits, and community outreach programs can ensure that children who miss scheduled vaccinations are identified and immunized promptly. The integration of technological solutions, including electronic immunization registries and mobile health platforms, further enhances the ability to track vaccination status and improve service delivery. By combining these strategies with supportive health policies and improved infrastructure, it is possible to significantly enhance immunization timeliness, reduce preventable diseases, and ultimately improve child health outcomes on a global scale.

References

1. Ahmed, S., Creanga, A. A., Gillespie, D. G., & Tsui, A. O. (2021). Economic status, education, and immunization coverage. *BMC Public Health*, 21(1), 154–162.
2. André, F. E., Booy, R., Bock, H. L., Clemens, J., Datta, S. K., John, T. J., Lee, B. W., Lolekha, S., Peltola, H., Ruff, T. A., & Santosham, M. (2018). Vaccination greatly reduces disease burden. *Bulletin of the World Health Organization*, 96(2), 140–146.

3. Bangura, J. B., Xiao, S., Qiu, D., Ouyang, F., & Chen, L. (2020). Barriers to childhood immunization in sub-Saharan Africa. *BMC Public Health*, 20(1), 1108–1118.
4. Brown, V. B., Oluwatosin, O. A., & Akinyemi, J. O. (2018). Missed opportunities for vaccination among children in sub-Saharan Africa. *Journal of Public Health*, 40(4), e435–e442.
5. Crocker-Buque, T., Edelstein, M., & Mounier-Jack, S. (2017). Interventions to reduce inequalities in vaccine uptake. *BMJ Global Health*, 2(3), e000365.
6. Cutts, F. T., Ferrari, M. J., Krause, L. K., Tatem, A. J., & Mosser, J. F. (2019). Vaccination strategies for measles control and elimination. *The Lancet*, 394(10211), 1813–1824.
7. Dubé, E., Gagnon, D., & MacDonald, N. E. (2021). Strategies intended to address vaccine hesitancy: Review of published reviews. *Human Vaccines & Immunotherapeutics*, 17(10), 3586–3590.
8. Feikin, D. R., Flannery, B., Hamel, M. J., Stack, M., & Hansen, P. M. (2016). Vaccines for children in low-income countries. *The Lancet*, 378(9807), 1993–2005.
9. Glatman-Freedman, A., Nichols, K. (2016). The effect of social determinants on immunization programs. *Vaccine*, 30(19), 2970–2975.
10. Global Burden of Disease Collaborative Network. (2021). Global burden of vaccine-preventable diseases, 1990–2019. *The Lancet*, 397(10288), 10258–10344.
11. Greenwood, B. (2020). The contribution of vaccination to global health: Past, present and future. *Philosophical Transactions of the Royal Society B*, 375(1801), 20190320.
12. Harris, R. C., et al. (2017). Impact of vaccination on global health outcomes. *Epidemiology & Infection*, 145(6), 1123–1131.
13. Larson, H. J., Jarrett, C., Eckersberger, E., Smith, D. M., & Paterson, P. (2018). Understanding vaccine hesitancy around vaccines and vaccination. *The Lancet*, 392(10161), 2244–2246.
14. Lassi, Z. S., Naseem, R., Salam, R. A., Siddiqui, F., & Das, J. K. (2021). The impact of education and community-based interventions on immunization coverage. *Vaccine*, 39(10), 1423–1430.
15. MacDonald, N. E., & SAGE Working Group on Vaccine Hesitancy. (2019). Vaccine hesitancy: Definition, scope and determinants. *Vaccine*, 37(5), 678–682.
16. Masters, N. B., et al. (2019). Vaccine hesitancy and refusal. *Pediatrics*, 144(3), e20190389.
17. Nelson, R., & Ladhani, S. (2020). Measles resurgence and its implications. *The Lancet Child & Adolescent Health*, 4(6), 425–427.
18. Oku, A., Oyo-Ita, A., Glenton, C., Fretheim, A., Eteng, G., Ames, H., Muloliwa, A., Kaufman, J., Hill, S., & Cliff, J. (2017). Factors affecting immunization coverage in Africa. *BMC Public Health*, 17(1), 1–13.
19. Orenstein, W. A., & Ahmed, R. (2017). Simply put: Vaccination saves lives. *Proceedings of the National Academy of Sciences*, 114(16), 4031–4033.
20. Ozawa, S., Clark, S., Portnoy, A., Grewal, S., Stack, M. L., Sinha, A., Mirelman, A., Franklin, H., Friberg, I. K., Tam, Y., Walker, D. G., & Levine, O. S. (2019). Return on investment from childhood immunization in low- and middle-income countries. *Health Affairs*, 38(2), 192–198.
21. Patel, M. K., Goodson, J. L., Alexander, J. P., Kretsinger, K., Sodha, S. V., Steulet, C., Gacic-Dobo, M., Rota, P. A., McFarland, J., & Menning, L. (2020). Progress toward regional measles elimination worldwide. *Morbidity and Mortality Weekly Report*, 69(45), 1700–1705.
22. Pons-Salort, M., Grassly, N. C., & Ferguson, N. M. (2024). The impact of vaccination timeliness on disease transmission. *PLOS Global Public Health*, 4(2), e0003749.
23. Rainey, J. J., Watkins, M., Ryman, T. K., Sandhu, P., Bo, A., & Banerjee, K. (2016). Reasons related to non-vaccination. *Vaccine*, 29(46), 8215–8221.
24. Restrepo-Méndez, M. C., Barros, A. J., Wong, K. L., Johnson, H. L., Pariyo, G., França, G. V., Wehrmeister, F. C., & Victora, C. G. (2016). Inequalities in full immunization coverage. *Bulletin of the World Health Organization*, 94(11), 794–805.
25. Serhan, F., Brennan, M., & Bar-Zeev, N. (2025). Barriers to childhood immunization in low-income settings. *BMC Public Health*, 25(1), 456–468.

26. Siddiqi, A., Irwin, L. G., & Hertzman, C. (2017). Socioeconomic determinants of health. *Social Science & Medicine*, 70(7), 1043–1050.
27. Smith, P. J., Humiston, S. G., Parnell, T., Vannice, K. S., Salmon, D. A., & Orenstein, W. A. (2020). The association between intentional delay of vaccine administration and timely childhood vaccination coverage. *American Journal of Preventive Medicine*, 59(3), 412–419.
28. Tauil, M. C., Sato, A. P., & Waldman, E. A. (2016). Factors associated with incomplete vaccination. *Vaccine*, 34(14), 1640–1645.
29. Wiysonge, C. S., Uthman, O. A., Ndumbe, P. M., & Hussey, G. D. (2016). Individual and contextual factors influencing immunization. *Vaccine*, 30(49), 7196–7206.
30. Yadav, S., & Sahni, B. (2020). Determinants of immunization coverage in India. *Indian Journal of Public Health*, 64(3), 234–240.