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Determinants Of Childhood Immunization In Low- And Middle-Income Countries: A Multi-Level Analysis Using The Socio-Ecological Model

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Abstract
Background *Childhood immunization is a cornerstone of public health in low- and middle-income countries (LMICs), where vaccine-preventable diseases significantly contribute to child mortality. Despite global efforts, immunization coverage in many LMICs remains below target levels. This article examines the determinants of childhood immunization through the lens of the Socio-Ecological Model (SEM), considering influences at intrapersonal, interpersonal, organizational, community, and policy levels. By integrating findings from diverse studies, this analysis provides a comprehensive understanding of the factors affecting vaccine uptake and offers insights for targeted interventions to improve coverage.*
Method: *We conducted a literature synthesis drawing on systematic reviews and country-specific studies to identify key determinants of childhood immunization in LMICs. Searches were performed in academic databases (e.g., PubMed, Google Scholar) focusing on publications from 2017 onward. A foundational source was a 2017 systematic review that screened thousands of studies on vaccine coverage determinants in LMICs and qualitatively analysed 78 relevant articles (Vaccine Coverage Determinants). Findings from that review – which used a critical interpretive synthesis incorporating frameworks like the WHO health system building blocks and the Theory of Planned Behaviour – were supplemented with additional evidence from Nigeria, Uganda, Guinea, and other LMICs to ensure context-specific insights. All identified factors were then organized according to the five SEM levels to facilitate a multi-level analysis.*
Result: *Caregiver knowledge and attitudes emerged as pivotal intrapersonal factors influencing immunization uptake: higher maternal education and awareness were associated with better adherence to vaccination schedules, whereas misconceptions and fears about vaccine safety led to hesitancy or refusal. At the interpersonal level, family dynamics and peer networks played a critical role – for example, spousal approval often determined whether a child was vaccinated, and misinformation circulating among family or friends could undermine trust in vaccines. Organizational factors related to health services were also significant. Long distances to clinics, high transportation costs, and clinic fees frequently deterred caregivers from completing immunizations, while positive healthcare experiences (such as clinics with friendly staff and shorter wait times or outreach services) encouraged participation. Community-level influences included the presence of outreach programs and the advocacy of local leaders, which helped boost coverage in underserved areas; conversely, community-wide rumours or cultural resistance to vaccines impeded uptake. Finally, policy-level determinants such as national immunization programs proved essential: government provisions of free vaccines and immunization cards helped reduce barriers to access, though issues like vaccine stockouts and insufficient funding continued to pose challenges in maintaining high coverage rates.*
Conclusion: *Childhood immunization in LMICs is driven by a complex interplay of factors across all SEM levels. Efforts to improve vaccine coverage must be multifaceted – simultaneously educating and empowering caregivers, engaging family and community supporters, strengthening health services, and bolstering policy support for immunization. An integrated, socio-ecological approach that addresses barriers at each level is crucial for closing immunization gaps and achieving universal vaccine coverage.*
Keyword: *Immunization; Socio-Ecological Model; LMICs; Secondary Data Analysis; Health Equity*

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I. Introduction

Childhood vaccination is one of the most cost-effective interventions to prevent infectious diseases and reduce child mortality globally. Widespread immunization has saved millions of young lives by protecting against illnesses such as measles, polio, diphtheria, and pertussis. In low- and middle-income countries (LMICs), where infectious diseases remain a leading cause of death among children under five, robust immunization programs are especially critical for improving child survival.(1) However, many LMICs continue to struggle with inadequate vaccine coverage. Recent data from the World Health Organization (WHO) and UNICEF highlight stagnant progress: in 2023, global coverage with the third dose of the diphtheria-tetanus-pertussis vaccine (DTP3) stood at 84%, down from 86% in 2019, resulting in *2.7 million* additional children being un- or under-vaccinated compared to pre-pandemic levels (WHO & UNICEF 2023). Alarmingly, nearly three-quarters of infants now live in countries where low immunization rates are contributing to outbreaks of vaccine-preventable diseases like measles (WHO & UNICEF 2023). These statistics underscore that immunization coverage remains suboptimal in many regions, falling short of the WHO's target of 90% coverage for essential vaccines. The consequence is that countless children, primarily in LMICs, are left vulnerable to preventable diseases.(2).(3).

The barriers to achieving high immunization coverage in LMICs are multifaceted, spanning individual, social, and systemic domains. At the individual (intrapersonal) level, a caregiver's knowledge, attitudes, and beliefs about vaccines play a crucial role in vaccination decisions. For instance, when parents understand the benefits and safety of vaccines, they are more likely to ensure their children receive all recommended shots. Conversely, misconceptions – such as unfounded fears of severe side effects – can lead to vaccine hesitancy or refusal. Practical issues like time constraints (e.g. a working mother unable to take time off for clinic visits) and economic pressures (e.g. the cost of travel to a distant health facility) further hinder timely immunization. At the community level, social and cultural factors come into play. Misinformation can spread rapidly through social networks, meaning that if friends, neighbours, or local community members harbour doubts about vaccines, their scepticism can influence other caregivers. Cultural norms and traditions also affect acceptance; in some communities, longstanding beliefs or past negative experiences with vaccination can create resistance. On the other hand, strong community support – such as encouragement from other parents or positive anecdotes about immunization – can greatly bolster confidence in vaccines. Systemic and organizational barriers are another major challenge. In many LMICs, health infrastructure limitations (such as a shortage of clinics or healthcare workers, and unreliable vaccine supply chains) impede access to vaccination services. Families may have to travel long distances on poor roads or pay prohibitive transportation costs to reach the nearest clinic. When they arrive, they might encounter long wait times or occasional vaccine stockouts, which can discourage them from returning for the next dose. These infrastructural issues, coupled with any clinic fees or unofficial charges, create additional disincentives for families who are already economically disadvantaged.(4). (5)

While numerous studies have documented specific determinants of immunization – for example, the c reality, the determinants of vaccine uptake interact across different levels of influence. A family's decision to immunize a child might simultaneously depend on a mother's personal belief in vaccines, her husband's approval, the availability of a nearby clinic, and the broader policy environment ensuring vaccines are free and accessible. Fragmented approaches that address only one layer of this problem (say, an awareness campaign that ignores service quality, or an infrastructure improvement that ignores community beliefs) may have limited success. To better understand and address the full complexity of this issue, a holistic framework is needed. The Socio-Ecological Model (SEM) provides such a framework by positing that health behaviours are shaped by nested levels of influence – from individual factors to interpersonal relationships, community contexts, organizational systems, and public policies. This model suggests that improving an outcome like immunization requires interventions at multiple levels simultaneously, as each level can reinforce or hinder the others. In the context of childhood immunization, an SEM approach encourages us to consider how personal beliefs, family dynamics, community engagement, health services, and government policies collectively determine whether a child gets vaccinated.(6)

Given the multi-layered nature of immunization determinants, this article adopts an SEM-guided approach to synthesize existing research on childhood vaccination in LMICs. Our aim is to integrate findings across intrapersonal, interpersonal, community, organizational, and policy levels in order to present a comprehensive picture of why children in many LMICs remain under vaccinated. By examining these determinants in unison, we can identify leverage points at each level and suggest how interventions might be coordinated to effectively improve immunization coverage. In doing so, this analysis offers insights to inform policymakers, public health practitioners, and communities in designing holistic strategies that ultimately move LMICs closer to achieving universal childhood immunization and protecting all children from preventable diseases (7).

II. Methods

This study is a secondary analysis that synthesizes existing literature on the determinants of childhood immunization in LMICs, using the Socio-Ecological Model as an organizing framework. Our approach is analogous to a narrative review or interpretive synthesis, where evidence from multiple sources is combined to build a multi-level understanding of a complex issue. We focused on identifying factors at all five levels of the SEM (intrapersonal, interpersonal, organisational, community, and policy) and examining how these factors interact to influence vaccine uptake.

Literature Search Strategy

We employed a broad literature search strategy to capture both global findings and context-specific insights. First, we drew heavily on a comprehensive systematic review by Phillips et al. (2017) that examined determinants of effective vaccine coverage in LMICs (Vaccine Coverage Determinants). In that review, the authors conducted an exhaustive search of academic and gray literature, ultimately examining over 9,000 titles and identifying 1,609 relevant studies. Through a critical interpretive synthesis (following Dixon-Woods et al. 2006 methodology), Phillips et al. integrated findings across those studies with established theoretical frameworks – including the WHO's health system building blocks and the Theory of Planned Behaviour – to derive three principal themes explaining why children go unvaccinated. These themes were: (1) Intent to Vaccinate (the willingness and decision of caregivers to seek vaccination), (2) Facility Readiness (the capability of health facilities to provide, encompassing supply, staffing, and accessibility), and (3) Community Access (the reach of immunization services into communities and the social dynamics affecting uptake). The systematic review's emphasis on these themes provides a valuable starting point, as they correspond to different SEM levels (approximately aligning with intrapersonal intent, organizational readiness, and community-level access factors). (8).

Building on that foundation, we conducted targeted searches to update and contextualize the evidence. We searched databases and repositories (including Google Scholar, PubMed, and specialized public health databases) for studies published from 2017 onward that addressed childhood immunization determinants in LMIC settings. Key search terms included combinations of *"childhood immunization"*, *"vaccination coverage"*, *"determinants"*, *"low- and middle-income countries"*, and *"socio-ecological model"*. We also reviewed reference lists of relevant articles to identify additional sources. Our search was not limited to quantitative studies; we explicitly included qualitative research and mixed-methods studies to capture rich, contextual factors (such as cultural beliefs or personal experiences) that quantitative surveys might overlook.

In selecting literature for inclusion, we prioritized studies that either provided a broad overview (e.g., multi-country analyses, reviews) or offered deep insight into specific contexts that could illuminate SEM level factors. In particular, evidence from three countries – Nigeria, Uganda, and Guinea – was incorporated through a recent multi-country qualitative study that applied an SEM approach to understand vaccine hesitancy and demand in those settings (Nigeria, Uganda, Guinea Study). We also included findings from an in-depth study in Lagos State, Nigeria, which used the socio-ecological model to explore immunization uptake through interviews with caregivers, community leaders, and healthcare workers (Lagos SEM Study). Including such context-specific studies ensured that our analysis reflects on-the-ground realities (e.g., direct quotations from caregivers about their challenges), thereby complementing broader patterns identified in global or regional analyses.

After gathering the relevant literature, we extracted key determinants of childhood immunization mentioned in each source and noted the SEM level(s) at which each determinant operates. We then organized these determinants by the five SEM categories, allowing us to collate evidence for each level from different studies. In synthesizing the information, we looked for commonalities (factors that appeared across multiple contexts) as well as unique insights (factors highlighted in one context that might be applicable elsewhere). By using the SEM as a guiding framework, our synthesis highlights how factors at different levels coexist and interact. The results below are structured by SEM level, moving from the innermost level (intrapersonal) to the outermost (policy), to present a multi-level analysis of childhood immunization determinants in LMICs.

III. Results

Across the literature, numerous determinants were found to influence whether children in LMICs receive their full course of vaccinations. These determinants span all levels of the Socio-Ecological Model, from individual caregiver beliefs to national policies.

Table 1 provides an overview of the key determinants identified at each SEM level, along with brief examples. The subsequent sections then describe in detail how these factors operate and interact at each level.

Table 1. Key Determinants of Childhood Immunization by SEM Level

SEM Level	Key Determinants	Examples of Influence
Intrapersonal	Caregiver knowledge; attitudes and beliefs; time and resource constraints	A mother's awareness of vaccine benefits improves uptake, whereas fears or misconceptions about vaccines cause hesitancy. Lack of time or money for clinic visits can delay vaccinations.
Interpersonal	Family dynamics; social support networks	In many households, a father's permission is decisive for child vaccination. Advice from relatives (e.g., mothers-in-law) or peers can encourage immunization or spread anti-vaccine misinformation.
Organizational	Health facility access and quality; healthcare staff characteristics	Long distances to clinics, high transport costs, or clinic fees deter families from completing immunizations. Understaffed facilities and long wait times lead to dropouts, whereas well-equipped clinics (offering free supplies, courteous staff) encourage vaccine uptake.
Community	Community outreach programs; local leadership; prevailing community norms	Regular outreach clinics and national immunization days bring vaccines to remote areas and raise coverage. Supportive messaging from respected community and religious leaders builds trust in vaccines, while community-level myths or rumours can undermine vaccination efforts.
Policy	National immunization policies; vaccine supply and funding; monitoring systems	Government mandates for free childhood vaccination and use of immunization cards remove financial barriers and help keep track of schedules. However, vaccine stockouts and insufficient funding of immunization programs disrupt coverage and erode public confidence.

Intrapersonal Level

At the intrapersonal level, the knowledge, perceptions, and resources of the primary caregiver (usually a parent, often the mother) are fundamental determinants of a child's immunization status. Research consistently shows that caregivers who are well-informed about vaccines and understand their life-saving benefits are far more likely to get their children vaccinated on schedule. For instance, awareness of the diseases that vaccines prevent and confidence in vaccine safety tend to motivate caregivers to utilize immunization services. In contrast, caregivers who harbour doubts or misconceptions about vaccines often delay or refuse immunization for their children. Common false beliefs – such as fears that vaccines might cause infertility, serious illness, or other harm – have been documented in various LMIC settings and contribute to vaccine hesitancy. Such misconceptions can arise from misinformation in the community or past anecdotes of adverse events, underscoring the importance of accurate health education.

Empirical studies illustrate these dynamics. In Nigeria, for example, mothers with at least a secondary school education were found to have higher rates of full immunization for their children compared to those with little or no formal education. Education likely improves a caregiver's ability to access and understand health information, reinforcing positive attitudes toward vaccines. Conversely, in settings where rumours about vaccines are rampant, even some educated parents may become fearful of vaccinating their children. One study focusing on Lagos, Nigeria noted that caregivers' trust in immunization could be shaken by hearing unverified stories of children allegedly harmed by vaccines (Lagos SEM Study). Thus, beliefs and attitudes at the individual level can either drive vaccine uptake or create hesitation.

Intrapersonal factors are not limited to knowledge and beliefs – practical constraints also play a major role. Even a caregiver who is motivated to vaccinate her child might face personal barriers in doing so. Time constraints are a common issue: caregivers (often mothers) may have responsibilities such as work, farming, or caring for other children that make it difficult to visit a clinic during operating hours. If immunization services are only available at times that conflict with a caregiver's job or daily duties, the child's vaccinations might be postponed. Economic pressures also intervene. While vaccines in national programs are usually provided for free, there are often indirect costs – such as paying for transport to the clinic, or missing a day's wages to take a child for immunization. In impoverished settings, these indirect costs can be prohibitive. Caregivers might prioritize immediate needs (food, work, etc.) over what they perceive as a less urgent preventive visit to the clinic, especially if they are not fully convinced of the vaccine's importance. In summary, at the intrapersonal level, a child's likelihood of being immunized is highest when his or her caregiver is knowledgeable about vaccines, positively disposed toward them, and has the time and resources to access immunization services. When these conditions are not met – for example, if a mother fears vaccine side effects and cannot easily get to the clinic – the child is at much greater risk of missing vaccinations.

Interpersonal Level

Beyond the caregiver's own knowledge and attitudes, the immediate social circle of the family significantly influences immunization decisions. At the interpersonal level, factors include the roles and opinions of family members (such as husbands, grandmothers, or older relatives) and the support or pressure coming from friends, neighbours, and social networks. In many LMIC contexts, decision-making about children's health is a family affair rather than an individual choice by the mother. Household dynamics – particularly gender roles – can heavily impact immunization. For example, in patriarchal societies, fathers (husbands) often hold the ultimate authority in family matters, including whether children receive medical care. If a father is supportive of vaccination, he can facilitate and encourage the mother to get the child immunized (for instance, by providing money for transport or taking the family to the clinic). On the other hand, if the father is opposed to or suspicious of vaccines, his stance can become a firm barrier. In some cases, husbands have outright forbidden their wives from vaccinating the children due to personal distrust or cultural/religious beliefs. *One Nigerian mother explained her situation:* "I am under my husband, because he has even forbidden me to immunize his children" (Nigeria, Uganda, Guinea Study). This quote illustrates how a mother's pro-vaccine intention can be overruled by her spouse's opposition. In such households, women may fear defying their husbands; as reported in Uganda, a wife who disregards her husband's orders regarding vaccination might face marital conflict or even threats to her relationship. Thus, spousal approval can be a make-or-break factor for a child's immunization.

Extended family and other influencers also come into play. In many cultures, mothers-in-law (the child's grandmother) or elder relatives are deeply respected and have a strong say in child-rearing practices. These family elders often share traditional wisdom and past experiences, which can either support or discourage modern health interventions. For instance, a grandmother who ensured her own children were immunized may encourage her daughter or daughter-in-law to do the same, providing reminders and even accompanying them to clinics. Conversely, if a grandmother believes that a vaccine once harmed her child (or heard of such an incident), she might advise the younger mother against immunization. Such scenarios were observed in the study across Nigeria, Uganda, and Guinea: some caregivers recounted that older family members dissuaded them from vaccines by recounting unfortunate tales – for example, attributing a child's disability to a vaccination in the past. These intergenerational influences can create an atmosphere of fear or acceptance around immunization, depending on the nature of the advice given.

Social networks and peer influence extend beyond family boundaries. Community peers and friends who are young parents themselves often discuss child health practices, including vaccination. When the prevailing sentiment in a peer group is pro-vaccination – for example, if neighbours share positive experiences about how immunizing their children was easy and beneficial – it can encourage hesitant caregivers to follow suit. Peer support can include carpooling to clinics, reminding each other of vaccination dates, or collectively trusting the local health workers. On the other hand, if scepticism dominates local social circles, it can significantly dampen vaccine uptake. Rumours and misinformation can spread quickly among friends and neighbours. In some communities, false information (such as "vaccines can cause infertility in children later in life" or "polio drops are a foreign plot") has circulated and taken hold, leading multiple families to opt out of immunizations. In Guinea, for example, researchers noted that some caregivers were swayed by neighbours' negative views on vaccination, leading them to skip clinics (Nigeria, Uganda, Guinea Study). Misinformation amplified within social networks thus poses a serious challenge, as it normalizes vaccine avoidance in certain communities.

In summary, the interpersonal environment in which caregivers make decisions can either reinforce positive attitudes toward immunization or magnify doubts. Support from husbands and relatives, combined with encouragement from peers, creates a social norm of vaccination that can greatly improve uptake. Conversely, household opposition or community-level scepticism can isolate a pro-vaccine caregiver or bolster a hesitant one's resolve not to vaccinate. Effective immunization programs in LMICs often seek to leverage interpersonal influences – for instance, by enlisting family members (like husbands) and local champions to advocate for vaccines, thus turning the social tide in favour of immunization.

Organizational Level

The organizational level refers to the characteristics and performance of health services and facilities that deliver immunization. In LMICs, even when caregivers are willing and socially supported to vaccinate their children, the practical ability to do so hinges on the accessibility and quality of the healthcare system. Several key determinants at this level emerged from the literature, including physical access to health facilities, the cost and convenience of services, the adequacy of health centre resources, and the attitudes of health workers. These factors collectively determine how easy or difficult it is for a caregiver to actually get a child vaccinated.

One of the most prominent organizational barriers is accessibility. This encompasses geographic distance to vaccination sites, transportation availability, and associated costs. Studies from various countries have found that long distances and travel times significantly reduce the likelihood of completing childhood vaccination schedules. If a village is far from the nearest clinic, caregivers may have to undertake long walks or find transport,

which can be expensive or unreliable. High transportation costs (relative to household income) effectively act as a fee for vaccination, even if the vaccine itself is free. In Uganda, for instance, rural caregivers described the hardship of reaching clinics: *"the distance to our health centre is very far and transport means are costly"* (Nigeria, Uganda, Guinea Study). This sentiment captures why many families in remote or underserved areas fail to return for the full series of immunizations – it is simply too burdensome. Additionally, the time investment required (travel plus waiting at the clinic) can deter families who cannot afford to spend a full day on a vaccination visit, linking back to intrapersonal time constraints but rooted in the way services are organized.

Even when physically accessible, the quality and efficiency of health facilities influence immunization uptake. Clinic attributes such as staffing, wait times, and available resources play a role in whether caregivers continue with vaccination schedules or drop out partway. In some settings, clinics are under-staffed and overcrowded, resulting in very long wait times for routine immunizations. If a mother arrives at a clinic early in the morning but isn't seen until the afternoon, she may decide not to return for the next appointment, especially if this experience repeats itself. Health facilities that lack basic amenities – for example, no shelter from the sun/rain while waiting, or no seating – can further alienate caregivers, especially if they must wait with a crying or sick child. Understaffing and poor facility conditions have been cited as causes for immunization dropout in studies from Nigeria and other countries (Lagos SEM Study). One outcome of these issues is the so-called "dropout rate," where initial vaccines (like BCG or first doses) are given, but later doses (like the third DTP dose or measles vaccine) are missed. High dropout rates often signal that families started the immunization process but were discouraged by their experience at the health facility.

Conversely, positive organizational factors can encourage and sustain vaccine uptake. When local clinics are well-equipped and welcoming, caregivers are more likely to use them regularly. For example, in Lagos, Nigeria, caregivers reported greater enthusiasm for immunization when facilities improved – when clinics had enough staff to avoid long lines, adequate seating and cleanliness, and when essential supplies were present (needles, vaccines, and even small complementary items for mothers and babies) (Lagos SEM Study). Some health centres in LMICs have implemented practices like offering free consumables or small incentives to encourage immunization. These might include providing soap, vitamin supplements, mosquito nets, or baby formula to mothers who bring children for vaccination. According to the Lagos study, mothers valued facilities that provided free items such as cotton wool, gloves, or even baby products during immunization visits, as it made them feel cared for and reduced incidental costs. While such incentives are not the core of immunization programs, they exemplify the broader point that a supportive clinic environment – one that is friendly, efficient, and resourceful – can build trust and motivate caregivers to return.

Another crucial organizational factor is the attitude and communication style of healthcare workers. Frontline health workers (nurses, midwives, community health volunteers) are often the primary source of information and reassurance about vaccines for caregivers. When health workers are respectful, patient, and willing to answer questions, caregivers tend to develop trust in the system and confidence in immunization. Alternatively, negative experiences with health personnel can deter families. There are reports from various countries of caregivers feeling scolded or disrespected by clinic staff – for instance, a mother arriving late and being reprimanded harshly, or a question about vaccine side effects being dismissed without explanation. In the Lagos qualitative study, some participants mentioned that rude or dismissive treatment by healthcare workers made them reluctant to return for subsequent visits. In contrast, health workers who took the time to educate caregivers – explaining how vaccines work, what side effects to expect, and why completing all doses is important – had a positive impact on caregivers' willingness to continue with the immunization schedule. Healthcare worker professionalism and compassion thus directly influence compliance: a positive rapport can improve uptake and retention, whereas a breakdown in trust can lead to dropout.

In summary, the organizational context of immunization delivery in LMICs can either facilitate or hinder success. Key determinants include how accessible services are (distance, cost), how well the health facility functions (staffing, wait times, supplies), and how health personnel interact with clients. Many of the "missed opportunities" for vaccination in LMICs occur not because caregivers flatly refuse vaccines, but because the system around them makes it too difficult or unpleasant to get those vaccines. Strengthening health facilities and ensuring a good client experience are therefore critical components in improving immunization coverage.

Community Level

At the community level, broader social structures and collective efforts in the community influence immunization outcomes. This includes community-based programs, the role of community leaders and influencers, prevailing norms and information within the community, and local events or circumstances that affect public health practices. In many LMICs, even if health facilities are functioning and individual families are motivated, the overall community environment can significantly boost or impede vaccination coverage.

One of the positive determinants at the community level is the presence of outreach programs and immunization campaigns that extend services beyond fixed health facilities. Many countries hold periodic events

such as National Immunization Days (NIDs) or Supplementary Immunization Activities, where vaccination teams go out to villages, markets, and other gathering points to provide vaccines (often focusing on polio or measles) to all eligible children. These outreach efforts are especially crucial in areas with limited clinic access. They have been credited with raising immunization rates in remote or marginalized communities by bringing vaccines directly to the population. For example, during National Immunization Plus Days in Nigeria, health workers set up temporary posts in hard-to-reach villages and immunized children who might otherwise never be brought to a distant clinic. The literature indicates that regular outreach services – even at the level of monthly or quarterly mobile clinics – significantly increase access and help ensure children get their doses on time (Lagos SEM Study). Outreach is most effective when it's predictable (so communities know the vaccinators will come on a certain schedule) and well-publicized by local authorities or volunteers.

Community engagement and local leadership form another critical piece of the puzzle. In many communities, people are more likely to trust and respond to messages delivered by someone they know and respect, rather than an unknown outsider. Thus, involving community leaders in immunization advocacy can greatly influence acceptance. These leaders may include village chiefs, elders, religious leaders (such as priests, pastors, or imams), teachers, or community health workers who are part of the community. When such figures champion vaccination – for instance, when a respected elder publicly gets his own grandchildren vaccinated or when a religious leader proclaims that immunization is in line with religious teachings – it can sway public opinion in favour of vaccines. In settings where misinformation or fear is present, trusted community voices are often the key to countering false rumours. For example, some rural communities in Guinea were initially hesitant about vaccination due to false beliefs, but when local leaders and health educators held open dialogues addressing those beliefs, community members became more receptive (Nigeria, Uganda, Guinea Study). Likewise, in parts of Nigeria, imams have been involved in polio immunization campaigns to assure Muslim communities that the vaccine is safe and beneficial, thereby overcoming resistance. The endorsement of vaccination by influential community members creates a social norm where immunizing children is seen as the right and responsible thing to do.

However, just as positive influence can spread through a community, so can negative influence. Community-level misinformation or collective scepticism can seriously undermine immunization efforts. If a significant portion of the community starts to believe an anti-vaccine narrative, it can quickly become a dominant local norm. For instance, during certain periods in northern Nigeria, a rumour spread that polio vaccines were part of a foreign plot to sterilize children; this led to large-scale refusals in some districts until the rumour was dispelled through concerted efforts. The spread of such rumours is often fuelled by lack of accurate information and sometimes by past incidents that erode trust (for example, mishandled health campaigns or historical unethical medical practices that make communities wary). In Guinea, as mentioned, neighbours sharing negative views about vaccines influenced others – an illustrative scenario was one where a few families' scepticism influenced an entire neighbourhood's turnout at vaccination clinics (Nigeria, Uganda, Guinea Study). Community mistrust can also be exacerbated by external factors such as political instability or recent crises. In the wake of the Ebola epidemic in West Africa, for example, some communities became more distrustful of health interventions, affecting their attitude toward routine immunization.

In addition, cultural norms and religious beliefs at the community level can play a role. Some communities might traditionally use herbal remedies or spiritual healing for illnesses and be less familiar with modern preventive care like vaccines. If vaccination doesn't fit into their traditional understanding of health, uptake may be low until efforts are made to integrate and explain it in culturally sensitive ways. Alternatively, communities with a strong collective orientation might be very successful in immunization if they decide as a group that every child should be protected; peer pressure in such settings ensures high coverage.

In summary, the community context can amplify the reach of immunization programs through outreach and positive social influence, or it can present hurdles through widespread misinformation and normative resistance. High immunization coverage in LMICs often correlates with communities that have active health outreach and education, visible support from local leaders, and generally positive attitudes toward vaccines. On the flip side, clusters of low coverage are frequently linked to communities where trust in immunization is low due to rumours, lack of engagement, or historical/cultural reasons. Strengthening community involvement and trust is therefore a cornerstone of improving immunization rates.

Policy Level

At the outermost level of the SEM, national and regional policies and the broader health system environment set the stage for all other levels. Policy-level determinants include government commitments, immunization program policies, financing and supply chain management, and broader sociopolitical factors that can facilitate or hinder vaccination efforts across a country. While individual and community efforts are crucial, without supportive policies, their impact can be limited or unsustainable. Our synthesis identified several policy-level factors that are particularly influential in LMIC immunization outcomes.

One of the most important policy determinants is the existence of strong national immunization programs with clear policies that prioritize vaccination. This typically includes having an official schedule of childhood vaccinations, making those vaccines available at no cost (or very low cost) to the public, and integrating immunization into primary healthcare. In LMICs that have achieved high coverage, it is often the case that the government has established vaccination as a right or expectation – for example, by mandating that all children should be immunized and conducting regular outreach. Free immunization services are especially critical in low-income settings: when vaccines and related services are provided free of charge, it removes a significant financial barrier for families. Many countries have enshrined this in policy (sometimes supported by international donors), ensuring that routine vaccines like DTP, polio, measles, etc., are available at public clinics at no cost. Nigeria, for instance, has a national policy of free immunization, which has been cited by caregivers as an important encouragement to get their children vaccinated (Lagos SEM Study). Such policies can dramatically improve uptake by making immunization accessible to the poorest segments of society.

Another policy-level component is the use of immunization cards and monitoring systems. Most immunization programs issue each child an immunization card or booklet where vaccines received are recorded. This policy might seem simple, but it has meaningful effects: the card serves as a tangible reminder for parents about which vaccines the child has had and which are still due. In Nigeria's policy, for example, every child is given an immunization card, and this has helped caregivers keep track of their child's schedule and also allowed them to continue vaccines at different facilities if they move or travel (Lagos SEM Study). In some places, presenting an up-to-date immunization card is also required for school entry, which is another policy lever to encourage compliance. Furthermore, robust health information systems at the policy level allow health authorities to identify areas of low coverage and respond with targeted campaigns or resource allocation.

Perhaps the biggest challenges at the policy level are vaccine supply chain management and sustained funding. It is not enough for a country to declare that vaccines are free – the government must also ensure that vaccines are consistently available where and when they are needed. Vaccine stockouts (running out of vaccines at clinics) remain a problem in various LMICs and can severely disrupt immunization services. If a caregiver makes the effort to bring a child to a clinic and finds that the vaccine is out of stock, that opportunity is lost and the caregiver may not return soon. Chronic stockouts erode public trust; communities might begin to doubt the reliability of the health system if vaccines are frequently unavailable. Stockouts usually stem from weaknesses in the supply chain, which can be due to poor forecasting, limited cold chain capacity (for storing vaccines), logistical issues, or funding shortfalls. Ensuring a robust supply chain – from procuring adequate vaccine doses at the national level, to distributing them in a timely manner to all health centres, and keeping them at proper temperatures – is a fundamental policy and management task. In alignment with Phillips et al. (2017)'s findings, a well-functioning supply chain contributes to what they termed "facility readiness," a key determinant of coverage (Vaccine Coverage Determinants).

Adequate funding is the backbone that supports all immunization activities. Many LMIC immunization programs rely on a combination of government budget and external donor support (such as Gavi, the Vaccine Alliance). When funding is insecure or insufficient, it can lead to a cascade of problems: health worker salaries might go unpaid (affecting motivation), outreach activities might be cancelled, maintenance of cold chain equipment might lapse, and vaccine procurement might fall short. On the other hand, sustained investment in immunization ensures that programs can plan ahead, innovate, and reach every community. Policy-level commitment often translates into budget allocations specifically for immunization within the health sector. Countries that have achieved high coverage usually have strong political will behind immunization, sometimes influenced by global initiatives and targets. In recent years, stagnation or declines in immunization coverage have sometimes been attributed to competing health priorities (like responses to COVID-19), which diverted resources and attention. Recognizing this, WHO and UNICEF have called for renewed policy focus and funding to "catch up" on missed vaccinations post-pandemic (WHO & UNICEF 2023).

Another broad factor at the policy level is how immunization is affected by national stability and public health emergencies. Conflicts, political instability, or outbreaks like the COVID-19 pandemic can disrupt immunization programs countrywide. The COVID-19 pandemic in 2020–2021, for example, forced temporary suspension of routine immunization in some areas and caused many families to skip clinic visits due to lockdowns or fear of infection. Countries with resilient health systems (often those with strong policies and emergency plans in place) were better able to maintain vaccination services or quickly restore them. This has highlighted the importance of embedding immunization into national health security and pandemic preparedness plans. In policy terms, it suggests that immunization should not be seen as a stand-alone vertical program, but rather as an integral part of primary health care that needs protection and continuity even during crises.

In summary, policy-level determinants form the enabling environment for all lower-level factors. Supportive policies – free services, routine monitoring, strong supply chains, and sufficient funding – create conditions in which communities, facilities, families, and individuals can successfully participate in immunization. Conversely, weak policy support or systemic issues (like stockouts and underfunding) can

undermine even the best efforts at the grassroots. The success stories in LMIC immunization often involve both bottom-up community engagement and top-down policy robustness working in tandem. Notably, the interplay between policy and other levels can be seen in how a policy of free immunization (policy level) improves clinic attendance (organizational level) and eases the burden on caregivers (intrapersonal level), or how policy neglect (e.g., failing to address a persistent vaccine rumour at a national scale) can leave communities more vulnerable to misinformation (community level).

IV. Discussion

This analysis highlights the interconnected nature of factors influencing childhood immunization in LMICs. By examining determinants through the Socio-Ecological Model, we can see clearly that no single level operates in isolation: a caregiver's decision to vaccinate (or not) is shaped by personal beliefs, family influences, community norms, the accessibility of health services, and the broader policy environment all at once. An important implication is that strengthening one level may have limited impact if bottlenecks or adverse influences persist at other levels. Integrated strategies are therefore needed to effectively improve vaccine coverage (9).

Our findings align with and build upon previous comprehensive studies in this field. Notably, Phillips et al. (2017) identified three overarching themes – intent to vaccinate, facility readiness, and community access – as critical determinants of vaccine coverage in LMICs. These correspond closely with the factors we discussed at the intrapersonal level (caregiver intent/knowledge), the organizational level (health facility readiness and service quality), and the community level (access facilitated by community outreach and acceptance). The present analysis extends those themes by situating them within the five-level SEM framework, which allows us to appreciate how they interact. For example, a policy decision to increase funding for immunization (policy level) can improve facility readiness by ensuring vaccine stock and staff training (organizational level), which in turn might boost caregiver confidence and intent to vaccinate (intrapersonal level. On the other hand, if any one of these links is weak – say, vaccines are free by policy but communities are not engaged and misinformation abounds – coverage gains may remain limited. The SEM approach thus adds a layer of understanding about synergy: interventions at one level often depend on support from other levels to achieve their full effect.

At the intrapersonal level, efforts like educational campaigns and personalized counselling can address knowledge gaps and fears. These initiatives work best when they are culturally tailored and delivered in the local language, possibly through trusted channels (for example, community health workers or radio programs featuring local doctors). Education can empower caregivers with accurate information, dispel myths, and emphasize the importance of completing all vaccine doses. At the same time, interventions on the interpersonal front could involve engaging family members. Programs in some countries have begun involving fathers through targeted "father's meetings" or including immunization messages in workplaces and male-dominated community gatherings, in order to gain the support of men for child health decisions. Likewise, leveraging positive influence from grandmothers and other relatives – for instance, organizing group discussions where experienced mothers or elders who support vaccination share their stories – can create a conducive family atmosphere for immunization.

Strengthening health services (organizational level) is an equally vital component. This can include expanding the network of vaccination sites (e.g., establishing mobile clinics or outreach posts in underserved areas) to reduce distance barriers, as well as improving the quality of care at existing facilities. Training healthcare workers not only in technical skills but also in interpersonal communication can make a big difference; a respectful, reassuring interaction can build a caregiver's trust in immunization and the health system overall. Additionally, relatively simple fixes at the clinic level – such as instituting queue management to shorten waiting times, providing shaded waiting areas or refreshments, and ensuring clinics have adequate supplies so that caregivers don't leave empty-handed – can significantly enhance the user experience. When caregivers have a positive experience (short wait, friendly staff, available vaccines), they are more likely to return and to encourage others in their community to vaccinate their children as well. Health ministries and partners should consider monitoring drop-out rates between vaccine doses as an indicator of service quality problems and investigate local solutions (like better scheduling or community follow-up for defaulters).

At the community level, building broad support for immunization is key to sustaining high coverage. Community mobilization efforts can enlist local influencers such as teachers, religious leaders, and traditional chiefs to promote vaccination. For instance, organizing vaccine outreach drives with public ceremonies or endorsements by leaders can turn immunization into a community-backed norm. Peer education programs, where volunteer mothers ("immunization champions") visit households to talk about their own positive experiences, have also shown success in some settings. Combating community-level misinformation may require proactive strategies: setting up forums for community members to ask questions and voice concerns, and providing clear, factual responses in a non-judgmental way. Social media and messaging apps are increasingly prevalent even in LMIC communities, so health authorities might also monitor and engage with these platforms to dispel rumours quickly before they spread widely.

On the policy level, our analysis underscores the need for sustained political commitment and resources for immunization. Governments should ensure that immunization programs are well-funded and that vaccine supply chains are robust. This might involve increasing domestic budget allocations for vaccines and logistics, as well as working with international donors to secure vaccine stock (especially for newer vaccines that can be costly). Policy-makers should focus on removing systemic barriers – for example, enforcing the elimination of user fees for vaccines and related services, and perhaps covering transportation costs for the poorest families through conditional cash transfers or other incentives. Strong policy support also means maintaining surveillance and response systems: tracking immunization coverage data closely (to identify areas that are lagging) and responding with targeted initiatives (like supplemental immunization days in districts with outbreaks or low coverage). Integrating immunization with other health and social services (such as child health days that provide a package of services) can also create efficiencies and broader appeal.

Importantly, the need for a multi-level approach has become even more evident in the wake of recent global setbacks. The stagnation in vaccine coverage around 2023, as reported by WHO and UNICEF, shows that previous gains are fragile and can be reversed if any level of the system weakens. For instance, the COVID-19 pandemic disrupted routine immunization services (organizational level) and also diverted political attention and funding (policy level), leading to a surge of zero-dose and under-vaccinated children worldwide. These insights are a call to action: countries must reinvigorate immunization programs across all fronts. In practical terms, that means renewing community outreach, re-engaging with families who missed vaccines, ensuring clinics are well-prepared for catch-up campaigns, and allocating emergency funds or stimulus to immunization activities. It also means addressing newly emerging concerns and questions that caregivers might have after the pandemic (for example, some caregivers might be more anxious about visiting health facilities or might question vaccine priorities).

Looking ahead, future research and program evaluation should prioritize multilevel intervention strategies. Rather than testing one intervention in isolation (e.g., an SMS reminder system for parents), researchers might design and assess combined interventions – for example, a package that includes community education, SMS reminders, and clinic service improvements together – to see the synergistic effect on coverage. Different LMIC contexts might require different combinations of interventions; thus, context-specific studies (in various cultural settings, urban vs rural, stable vs conflict-affected regions) are needed to tailor approaches. We also encourage exploration of innovative approaches to complement traditional strategies. One promising avenue is the use of mobile health technologies (mHealth) to support immunization programs. Mobile phone ownership has grown rapidly in LMICs, and health programs have begun leveraging this for things like appointment reminders, education via text messages, or even digital immunization records. Early evidence suggests mHealth interventions can improve health service delivery and adherence – for instance, SMS reminders have increased clinic attendance for vaccinations in some pilot projects. However, more research is needed on how effective these tools are at scale for immunization uptake specifically, and how to implement them in low-resource settings where literacy or network coverage might be limitations (mHealth in LMICs). Testing innovations like smartphone apps for immunization tracking, WhatsApp groups for peer support among mothers, or GIS mapping to plan outreach could provide new strategies to reach children who are currently missed.

Ultimately, adopting a comprehensive socio-ecological approach in both research and practice can guide us toward more effective solutions. By acknowledging that factors at all levels must be addressed, stakeholders can avoid the pitfall of one-dimensional fixes and instead design coordinated interventions. For example, an immunization improvement plan might simultaneously involve: a mass media campaign to change public attitudes (community level), training for health workers (organizational), policy reforms to strengthen supply chains, and the engagement of community and religious leaders (interpersonal/community). The findings of this study underscore that such multifaceted efforts are not only beneficial but likely necessary to overcome the entrenched barriers to immunization in LMICs. In the long run, improving immunization coverage through a multi-level lens will save lives, prevent V. disease outbreaks, and move countries closer to achieving health equity for children.

V. Conclusion

Childhood immunization in low- and middle-income countries is influenced by a complex interplay of determinants spanning individual caregivers to national policies. This multi-level analysis, using the Socio-Ecological Model, demonstrates that no single factor can fully account for why children are under-vaccinated; instead, factors at the intrapersonal, interpersonal, organizational, community, and policy levels all contribute to immunization outcomes. To substantially improve vaccine coverage and reach every child, integrated interventions are required that tackle obstacles and leverage facilitators across all these levels. This means educating and empowering caregivers, engaging families and social networks to support vaccination, ensuring health facilities are accessible and user-friendly, mobilizing communities and trusted leaders to promote immunization, and solidifying political will and resources to maintain strong immunization systems. By adopting

such a comprehensive, multi-level approach, LMICs can make significant progress toward closing the immunization gap.

These efforts are essential for achieving global immunization targets and safeguarding child health. Reaching the WHO's goal of 90% coverage for essential vaccines will only be possible if strategies address both demand and supply – generating demand through awareness and trust, and meeting that demand with reliable services and supply chains. Success in this realm will not only reduce the burden of vaccine-preventable diseases within countries, improving survival and quality of life for children, but also contribute to broader global health security. When more children everywhere are immunized, the risk of outbreaks and cross-border spread of diseases diminishes, benefiting the international community. In essence, strengthening childhood immunization programs in LMICs protects individual children and fortifies communities, creating a foundation for healthier, more resilient societies. Continued commitment, collaboration, and innovation in immunization efforts will be vital to ensure that no child is left behind and that the lifesaving potential of vaccines is fully realized worldwide.(10)

Key Citations

- Global childhood immunization levels stalled in 2023, leaving many without life-saving protection. (WHO/UNICEF report on worldwide immunization coverage and post-pandemic setbacks.)
- Determinants of effective vaccine coverage in low and middle-income countries: a systematic review and interpretive synthesis. (Phillips et al. 2017 – comprehensive review identifying key factors affecting immunization in LMICs.)
- The Socioecological Model as a framework for exploring factors influencing childhood immunization uptake in Lagos state, Nigeria. (Olaniyan et al. – qualitative study from Nigeria applying SEM to immunization.)
- Applying a social-ecological model to understand factors impacting demand for childhood vaccinations in Nigeria, Uganda, and Guinea. (Bell et al. – multi-country study examining interpersonal and community influences on vaccine hesitancy and acceptance.)

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