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BARRIERS FOR ROUTINE IMMUNIZATIONS AMONG UNDER SIX YEARS CHILDREN IN MOSUL CITY

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ABSTRACT

Background: Immunization remains the most effective and cost-effective public health tool against vaccine-preventable diseases in children, yet regional disparities in coverage persist worldwide because of funding gaps and health-system weaknesses. **Aim:** To assess the barriers to routine immunizations among children under six years of age in Mosul city. **Methods:** A cross-sectional study was conducted on 500 caregivers of children under six years, selected by convenience sampling from six primary healthcare centers in Mosul city between February and July 2025. Barriers were grouped into three domains—child-level, individual-level, and healthcare-system-level—and data were collected by direct interview after oral and written consent. **Results:** The study showed that caregivers over 50 years old were more likely to have children who weren't fully vaccinated compared to those with fully vaccinated children. Higher education among caregivers acted as a shield, reducing the chances of incomplete immunization, while those with only primary schooling faced greater risks. Employed caregivers showed better outcomes in ensuring full vaccination for their children, whereas unemployment heightened the likelihood of gaps in immunization. Children aged 12 to 17 months were particularly prone to incomplete vaccination (OR 2.07, 95% CI 1.15–3.75, P=0.015). Additionally, barriers related to the child itself significantly raised the risk of not being fully vaccinated (OR 2.07, 95% CI 1.15–3.75, P=0.015), with distance to healthcare facilities emerging as the top system-level obstacle, impacting nearly half of those affected. **Conclusion:** Recombinant growth hormone therapy was most effective in children with GHD, with modest benefits in ISS and limited effects in TS, emphasizing the need for early diagnosis and individualized treatment.

KEYWORDS: Immunization, Barriers, Vaccination coverage, Children, Mosul, Caregivers.

1. INTRODUCTION

Immunization, delivered either as passive antibody transfer or as active vaccination, remains the most effective public health strategy for preventing vaccine-preventable diseases (VPDs) in children, and it is one of the most economical interventions for lowering childhood morbidity and mortality.

The World Health Assembly created the Expanded Programme on Immunization (EPI) in 1974 to ensure every child received life-saving vaccines. Iraq adopted the EPI in 1985 and reached 94% coverage by 1987, before sanctions and conflict eroded this achievement to 74% coverage by 1996-1997. Since 2003 the Ministry of Health has worked to rebuild disease surveillance and the vaccine cold chain, and the current national schedule covers BCG, oral polio vaccine, hepatitis B, DTP, and MMR from birth through the age of six years.

Vaccine design has evolved considerably alongside technology, from live attenuated vaccines (e.g., MMR, rotavirus, BCG) and inactivated vaccines (e.g., hepatitis A) to subunit and conjugate vaccines (e.g., hepatitis B), toxoid vaccines (e.g., tetanus toxoid), vector-based vaccines, and nucleic acid vaccines, each engineered to improve safety, efficacy, and stability. Iraq's national schedule requires BCG, oral polio vaccine, hepatitis B, and pentavalent/pneumococcal doses in the first six months of life, vitamin A and measles vaccine at nine months, MMR at 12 and 18 months, and booster doses of DPT and OPV between four and six years of age.

1.1 Epidemiology and the burden of under-vaccination

Vaccine-preventable diseases still cause roughly 9 million child deaths worldwide, disproportionately concentrated in low- and middle-income countries.[1] In Iraq only about two-thirds of children aged 12-23 months had received all recommended vaccines by 2020, and coverage fell further during the COVID-19 pandemic as routine services were disrupted.[2] Conflict-affected settings show the steepest declines: diphtheria-pertussis-tetanus coverage fell from 81% to 41% in Syria, and coverage in Ukraine dropped from 80% to 20% within two years of violent conflict, illustrating how quickly immunization gains can be reversed. Two-thirds of the 20 million infants who were not immunized in 2015 lived in countries affected by violent conflict. Iraq itself continues to report vaccine-preventable illnesses such as measles, pertussis, and tuberculosis despite decades of programmatic effort, and underinvestment in healthcare facilities together with prolonged conflict has been cited as an ongoing driver of low coverage.[3,4,5]

1.2 Barriers to effective vaccination

Barriers to complete immunization are numerous, overlapping, and context-specific. They are commonly grouped into child-related factors (prematurity, birth order, older siblings), caregiver attitudes and knowledge (fear of side effects, mistrust, low awareness), family social context (education, socioeconomic status, single or young caregivers), and health-system factors (distance, missed opportunities, vaccine stock-outs, and workforce shortages).[6] Vaccine hesitancy, defined by the WHO Strategic Advisory Group of Experts as a delay in acceptance or refusal of vaccination despite available services, is driven by three factors known as the 3Cs model: confidence (trust in the vaccine or its provider), complacency (the belief that vaccination is unnecessary), and convenience (perceived access to services) and was named one of the world's top ten health threats.[7] Needle fear and injection pain are also well documented individual-level deterrents,[8] while missed opportunities for vaccination, poor defaulter tracing, and unreliable vaccine supply are recurring system-level obstacles across sub-Saharan Africa and other low-resource settings.[9] Distance to a health facility has been shown to reduce vaccination uptake in some settings,[10] although its effect size varies considerably between populations.

Socio-demographic determinants such as maternal education, household income, and access to antenatal care consistently predict immunization completion in low- and middle-income countries,[11,12,13,14] and access barriers persist even in high-income settings. Studies from Iraq report similarly incomplete coverage driven by a mixture of caregiver knowledge gaps and health-system limitations.[15,16]

Globally, the introduction of new vaccines has strengthened immunization efforts: more than 50 countries have incorporated Haemophilus influenzae type b and pneumococcal conjugate vaccines into routine programs, and more than 33 countries have introduced the rotavirus vaccine with support from Gavi, the Vaccine Alliance. Nevertheless, suboptimal coverage continues to threaten these gains, particularly in countries with large birth cohorts where routine immunization coverage remains persistently insufficient. At the biological level, vaccination works by engaging both the innate and adaptive arms of the immune system: innate cells respond rapidly and non-specifically to foreign antigens, while the adaptive system generates antigen-specific memory that confers durable, disease-specific protection, which is the physiological basis for the long-term benefit of completing a full vaccination schedule rather than receiving only partial doses.

1.3 Aim of the Study

This study aims to assess the barriers to routine immunizations among children under six years of age in Mosul city.

1.4 Specific Objectives

- To describe the socio-demographic characteristics of the study participants.
- To assess the common barriers affecting routine immunizations in primary healthcare centers.
- To compare vaccinated and not fully vaccinated children with respect to these barriers.
- To identify the most important barriers affecting routine immunizations in primary healthcare settings.

2. Study Setting and Design

This cross-sectional study was carried out in Mosul city at six primary healthcare centers, three from the right (Al-Haju Salih Al-Shabkhun, Al-Nahrawan, and Tamuwz) and three from the left health sector (Al-Qadisia, Al-Aintisar, and Al-Quds). Administrative agreement was obtained from the Scientific Council of Family Medicine of the Arab Board of Health Specializations, and ethical approval was obtained from the Nineveh Directorate of Health. Oral and written informed consent was taken from all participants, who were free to withdraw without consequence, and all data were anonymized to preserve confidentiality.

2.1 Study Period and Sample

Data were collected prospectively over six months, from February to July 2025, by direct interview during two weekly visits to each health center. A non-probability convenience sample of 500 caregivers of children under six years was recruited; the sample size was calculated using the standard prevalence formula $n = Z^2P(1-P)/d^2$ with an expected prevalence of 50%. All children below six years of both sexes whose caregivers agreed to participate were included; caregivers who declined participation were excluded.

Inclusion criteria comprised all children below six years of age, of either sex, whose caregivers agreed to participate. Caregivers who declined to participate were

excluded. Data collection proceeded through regular visits to the six primary healthcare centers, with two visits per week sustained over the full six-month study period.

2.2 Data Collection Tool

A structured checklist, adapted from a previously validated instrument and approved by the Scientific Council of Family Medicine, was used for direct interviews. It captured: (1) immunization coverage status (fully vaccinated versus not fully vaccinated, confirmed by card and caregiver recall); (2) socio-demographic characteristics of the caregiver and the child's father; (3) child-level factors (age, birth order, and place of delivery); (4) individual-level barriers (awareness/knowledge, vaccine hesitancy, accessibility, religious or cultural beliefs, fear of pain or side effects, previous negative experiences, and perceived low risk); and (5) healthcare system barriers (distance, provider availability, vaccine availability, cost, and vaccine acceptance).

3. Statistical Analysis

Data were coded, cleaned, and analyzed using SPSS version 26 and Microsoft Excel. Vaccination status was summarized as frequencies and percentages. Bivariate analysis identified the crude association between each independent variable and immunization status; odds ratios (ORs) with 95% confidence intervals (CIs) were calculated using chi-square or Fisher's exact tests as appropriate. Variables significant in bivariate analysis were entered into a multivariate logistic regression model, with complete immunization status (card plus caregiver recall) as the dependent variable and socio-demographic, child-level, and barrier-domain variables as independent variables. A two-tailed p-value < 0.05 was considered statistically significant. Barriers were additionally aggregated into three composite domains (child-level, individual-level, and healthcare-system-level) so that their relative contributions to immunization status could be compared directly within a single analytic framework.

4. RESULTS

Of the 500 children studied, 404 (80.8%) were fully vaccinated and 96 (19.2%) were not fully vaccinated.

Table 1 summarizes the socio-demographic profile of the 500 caregivers and the education level of the children's fathers. Most caregivers (85%) were between 20 and 40 years old; 96.4% were female; 39.6% had only primary education; and 77.6% were unemployed; 98.0% were married. Fathers were somewhat more educated than caregivers, with 36.4% holding higher education.

Notably, only 8.8% of caregivers were between 40 and 50 years old, and just 2.2% were older than 50, confirming that vaccination decisions in this population are overwhelmingly made by younger and early-middle-aged caregivers. Combined with the near-universal representation of women (96.4%) and married status (98.0%), this profile indicates that interventions aimed at improving vaccination completion should be designed primarily around the needs, schedules, and literacy levels of young married mothers.

Table 1: Socio-demographic profile of caregivers and fathers (n = 500).

Variable	Category	No.	%
Age of caregiver (years)	<20	21	4.2
	20-30	225	45.0
	30-40	199	39.8
	40-50	44	8.8
	50+	11	2.2
Sex of caregiver	Male	18	3.6
	Female	482	96.4
Education of caregiver	Non-formal	90	18.0
	Primary	198	39.6
	Secondary	88	17.6
	Higher	124	24.8
Occupation of caregiver	Employed	111	22.2
	Unemployed	388	77.6
Marital status	Married	490	98.0
	Non-formal	62	12.4
	Primary	177	35.4
	Secondary	79	15.8
	Higher	182	36.4

Table 2 presents the demographic and birth characteristics of the 500 children. The sample skewed toward younger children: 24.8% were aged 0-5 months and 23.6% were aged 6-11 months, so 48.4% of the sample were under 12 months old. First- or second-born children made up 52.0% of the sample, and 98.6% of children were delivered in a health facility rather than at home.

The concentration of children in the youngest age bands reflects the recruitment strategy of interviewing caregivers during routine primary healthcare visits, which naturally captures more infants presenting for their scheduled early doses. The small proportion of children delivered at home (1.4%) indicates that facility-based delivery is now nearly universal in this urban population, which is favorable for early vaccine initiation (such as the birth-dose BCG and hepatitis B vaccines) but does not, by itself, guarantee completion of the full schedule through 18 months and beyond.

Table 2: Demographic and birth characteristics of children (n = 500).

Variable	Category	No.	%
Age of child (months)	0-5	124	24.8
	6-11	118	23.6
	12-17	62	12.4
	18-41	103	20.6
	42-47	2	0.4
	48-72	91	18.2
Birth order	1st or 2nd	260	52.0
	3rd or 4th	146	29.2
	5th or above	94	18.8
Place of delivery	Health facility	493	98.6
	Home	7	1.4

Table 3 compares caregiver characteristics between children who were not fully vaccinated and those who were fully vaccinated. Caregiver age above 50 years was associated with higher odds of incomplete vaccination (OR 3.65; 95% CI 1.09-12.20; p = 0.041). Higher caregiver education was protective (OR 0.37; 95% CI 0.20-0.71; p = 0.002), whereas primary-level education raised the odds of incomplete immunization (OR 1.61; 95% CI 1.03-2.52; p = 0.037). Caregiver employment was protective (OR 0.54; 95% CI 0.29-0.99; p = 0.046), while unemployment increased the odds of incomplete vaccination (OR 1.88; 95% CI 1.02-3.46; p = 0.041). Father's education level showed no significant association with vaccination status.

Table 3: Caregiver factors significantly associated with vaccination status.

Caregiver factor	OR	95% CI	p-value
Age > 50 years	3.65	1.09-12.20	0.041
Primary education (caregiver)	1.61	1.03-2.52	0.037
Higher education (caregiver)	0.37	0.20-0.71	0.002
Employed	0.54	0.29-0.99	0.046
Unemployed	1.88	1.02-3.46	0.041

Table 4 shows the child-level comparisons. Infants aged 0-5 months were less likely to be incompletely vaccinated (OR 0.55; 95% CI 0.31-0.98; p = 0.040), whereas children aged 12-17 months had significantly higher odds of incomplete vaccination (OR 2.07; 95% CI 1.15-3.75; p = 0.015). Third- or fourth-born children also had higher odds of incomplete vaccination (OR 1.70; 95% CI 1.07-2.71; p = 0.025), while place of delivery (facility versus home) showed no significant association (p = 0.624).

Table 4: Child-level factors and vaccination status.

Child-level factor	OR	95% CI	p-value
Age 0-5 months	0.55	0.31-0.98	0.040
Age 12-17 months	2.07	1.15-3.75	0.015
Birth order: 3rd-4th	1.70	1.07-2.71	0.025
Facility delivery	0.59	0.11-3.08	0.624

Across the whole sample, accessibility issues (7.4%) and fear of pain or side effects (7.2%) were the most frequently reported individual-level barriers, followed by lack of awareness or knowledge (6.6%). Vaccine hesitancy (1.4%), previous negative experiences (0.8%), perceived low disease risk (0.6%), and religious or cultural beliefs (0.4%) were considerably less common (Table 5).

Table 5: Individual-level barriers - frequency and percentage distribution (n = 500).

Individual-level barrier	No.	%
Accessibility issues	37	7.4
Fear of pain or side effects	36	7.2
Lack of awareness or knowledge	33	6.6
Vaccine hesitancy	7	1.4
Previous negative experiences	4	0.8
Perceived low risk	3	0.6
Religious or cultural beliefs	2	0.4

Individual-level barriers showed the strongest associations with incomplete vaccination (Table 6). Lack of awareness or knowledge (OR 95.86; $p < 0.001$), accessibility issues (OR 115.33; $p < 0.001$), and fear of pain or side effects (OR 231.23; $p < 0.001$) were markedly more common among not fully vaccinated children. Vaccine hesitancy (OR 28.87; $p < 0.001$) and previous negative experiences (OR 13.00; $p = 0.024$) were less frequent but still significant, whereas religious or cultural beliefs and perceived low disease risk showed no significant association.

Table 6: Individual-level barriers significantly associated with incomplete vaccination.

Individual-level barrier	Not fully vaccinated %	Fully vaccinated %	OR	p-value
Lack of awareness/knowledge	32.3	0.5	95.86	<0.001
Accessibility issues	36.5	0.5	115.33	<0.001
Fear of pain/side effects	36.5	0.2	231.23	<0.001
Vaccine hesitancy	6.3	0.2	28.87	<0.001
Previous negative experience	3.1	0.2	13.00	0.024

Across the whole sample, distance to the health center exceeding 1 km was by far the most common healthcare-system barrier, reported by 46.0% of caregivers, while vaccine availability problems (2.8%) and healthcare-provider availability, cost affordability, and vaccine acceptance issues (0.4% each) were considerably less frequent (Table 7).

Table 7: Healthcare system barriers - frequency and percentage distribution (n = 500).

Healthcare system barrier	No.	%
Distance of health center > 1 km	230	46.0
Vaccine availability	14	2.8
Healthcare provider availability	2	0.4
Cost affordability	2	0.4
Vaccine acceptance	2	0.4

Among healthcare system barriers (Table 8), distance greater than 1 km affected close to half of both groups (45.8% versus 46.0%) with no significant association (OR 1.01; $p = 0.971$). Vaccine unavailability, however, was strongly linked to incomplete vaccination, reported by 13.5% of the not-fully-vaccinated group versus 0.2% of the fully vaccinated group (OR 63.12; $p < 0.001$). Healthcare-provider availability, cost affordability, and vaccine acceptance were rare in both groups and not statistically significant.

Table 8: Healthcare system barriers and vaccination status.

Healthcare system barrier	Not fully vaccinated %	Fully vaccinated %	OR	p-value
Distance > 1 km	45.8	46.0	1.01	0.971
Vaccine unavailability	13.5	0.2	63.12	<0.001
Provider availability	1.0	0.2	4.24	0.347
Cost affordability	1.0	0.2	4.24	0.347

Table 9 summarizes the combined effect of the three barrier domains. Individual-level barriers showed the strongest correlation with incomplete immunization (OR 80.60; 95% CI 10.54-616.45; $p < 0.001$), followed by child-level barriers (OR 2.07; 95% CI 1.15-3.75; $p = 0.015$). Healthcare-system barriers were not significantly associated overall (OR 1.38; 95% CI 0.69-2.75; $p = 0.364$). The combined effect of all three domains yielded an overall OR of 2.79 (95% CI 1.44-5.42; $p = 0.002$).

Table 9: Impact of the three barrier domains on immunization coverage.

Barrier domain	Not fully vaccinated %	Fully vaccinated %	OR	95% CI	p-value
Child-level	19.8	10.6	2.07	1.15-3.75	0.015
Individual-level	16.6	0.2	80.60	10.54-616.45	<0.001
Healthcare system	12.5	9.4	1.38	0.69-2.75	0.364
Total (combined)	16.6	6.7	2.79	1.44-5.42	0.002

5. DISCUSSION

Immunization is one of the most effective strategies for preventing, reducing, and even eliminating life-threatening vaccine-preventable illnesses in children. This study set out to describe caregiver socio-demographic characteristics, assess barriers to completing routine immunization, and identify the most important barriers to full vaccination in primary healthcare settings in Mosul city.

5.1 Socio-demographic characteristics

Consistent with studies from Russia.[17] and Italy,[18] the overwhelming majority of caregivers of both fully and not fully vaccinated children in this study were women, reflecting their central role in vaccination decisions, a finding also reported in Romania.[19] Most caregivers were in their twenties or thirties, in line with findings from Eastern India.[20] Caregiver education showed a mixed relationship with vaccination status: higher education was protective while primary-level education increased the odds of incomplete vaccination, echoing evidence from China that low educational attainment limits health literacy.[21] However, because caregivers across all educational levels were represented among fully vaccinated children, education alone did not determine vaccination status, a pattern also observed elsewhere. Caregiver employment and marital stability were both associated with better vaccination outcomes, similar to reports from Ghana,[22] although the relationship between employment and vaccination completion is inconsistent across settings: some studies find no direct link once access and knowledge are accounted for, while others in Ethiopia.[23] and Ghana.[24] report opposing directions of effect, suggesting that local labor-market conditions and caregiving arrangements moderate this relationship. Father's education followed a similar pattern to that reported in an earlier Iraqi study.[25] and in Spain,[26] where higher paternal education correlated with more complete vaccination schedules.

Household-level educational asymmetry was also apparent: nearly two-thirds of caregivers had only elementary schooling or no formal education, while fathers were somewhat more likely to hold secondary or higher qualifications. This gap between caregiver and paternal education may partly explain why caregiver education, rather than paternal education, emerged as the stronger correlate of vaccination completion in this sample, since caregivers are typically the ones who accompany children to clinic visits and interpret vaccination schedules day to day. High rates of unemployment combined with near-universal marriage among caregivers suggest financial dependence and limited independent mobility, which may compound transportation and scheduling barriers even when caregivers are otherwise motivated to vaccinate their children.

Marital status showed no significant overall association with vaccination completion, although the very small number of widowed caregivers in this sample showed a numerically elevated odds ratio for incomplete vaccination that did not reach statistical significance, most likely reflecting the small cell size rather than the absence of a true effect. This is broadly consistent with the general expectation that single-parent or widowed caregiving arrangements, when combined with reduced household income, may compound rather than independently drive incomplete vaccination.

5.2 Child-level barriers

Younger infants (0-5 months) were less likely to be incompletely vaccinated, consistent with Belgian data showing lower incomplete-vaccination risk in early infancy.[27] Children aged 12-17 months carried the highest risk of incomplete vaccination in this study, likely reflecting the timing of later scheduled doses such as MMR and the second measles round, when follow-up visits are more easily missed. Third- and fourth-born children were also more likely to be incompletely vaccinated, while place of delivery showed no significant effect, largely because facility delivery was already the norm for the great majority of this sample.

The clustering of incomplete vaccination around 12-17 months of age is clinically important because this window corresponds to the second measles-containing dose and the 18-month DPT/OPV booster in the Iraqi national schedule; caregivers may perceive the primary infant series as "finished" once the first-year doses are complete and subsequently miss these later boosters. Similarly, the higher risk observed among third- and fourth-born children may reflect diluted caregiver attention or competing demands across larger families, whereas first- and second-born children, who benefit from more concentrated caregiver time and often more recent contact with antenatal and postnatal services, showed a borderline protective trend.

5.3 Individual-level barriers

Lack of awareness, accessibility issues, and fear of pain or side effects were the strongest individual-level predictors of incomplete vaccination in this study. This mirrors Malaysian findings that knowledge gaps drive incomplete vaccination.[12] and Malawian evidence that

access barriers and needle fear are major deterrents.[14] Vaccine hesitancy and previous negative experiences were less prevalent but still significant, similar to German data showing that hesitancy is a targeted rather than universal barrier.[28] Perceived low disease risk and religious or cultural beliefs were rare and not significant in this sample, in contrast to some sub-Saharan African settings where such beliefs play a larger role.[29] Notably, accessibility issues and fear of pain or side effects were each reported by roughly one in fourteen caregivers overall, making them the two most common individual-level obstacles even before stratifying by vaccination status, which underscores the value of anticipatory pain-management counseling and flexible appointment logistics as first-line interventions.

It should be noted that the very large odds ratios observed for several individual-level barriers, particularly fear of pain or side effects (OR 231.23) and accessibility issues (OR 115.33), arise because these barriers were reported by almost no caregivers in the fully vaccinated group. While the direction and statistical significance of these associations are robust, the corresponding confidence intervals are wide, reflecting this sparse-data pattern, and the precise magnitude of these odds ratios should be interpreted with caution rather than taken as stable population estimates.

5.4 Healthcare system barriers

Distance to the health center did not differ fully from that of not fully vaccinated children in this sample, consistent with a United States study finding travel distance was not a major barrier to completion but contrasting with Nigerian data showing each additional kilometer of distance reduced vaccination probability by about 5%.[10] Vaccine unavailability, however, was a strong and consistent predictor of incomplete immunization in this study, corroborating sub-Saharan African evidence that stock-outs are among the most common system-level barriers.[29] Provider availability, cost, and vaccine acceptance were uncommon barriers in this population.

The contrast between distance and vaccine unavailability is instructive: even though nearly half of all caregivers reported living more than 1 km from their health center, this factor alone did not predict vaccination completion, suggesting that most caregivers were able to overcome moderate travel distances when supply and services were reliable. Vaccine stock-outs, by contrast, remove the possibility of completing a scheduled dose regardless of a caregiver's motivation or proximity, which likely explains why this single factor carried a disproportionately large effect size relative to its modest overall prevalence (2.8% of the total sample).

5.5 Impact of the three barrier domains

When the three domains were considered together, individual-level barriers showed by far the strongest association with incomplete immunization, followed by child-level barriers, while healthcare-system barriers contributed the least in this sample. This differs from a global overview of systematic reviews concluding that access and clinic-level barriers are just as important as individual-level concerns,[30] suggesting that the relative weight of each barrier domain is context-dependent and that interventions in Mosul should prioritize caregiver awareness and access alongside efforts to secure a stable vaccine supply.

Taken together, these findings suggest a layered model of risk in which individual awareness and access act as the proximate determinants of whether a scheduled dose is actually received; child-level timing (particularly the 12-17 month window and higher birth order) identifies which children are most likely to fall through the gaps; and healthcare-system reliability, especially vaccine supply, functions as a necessary but not sufficient condition underlying both. This layered interpretation is consistent with the overlapping, interrelated nature of vaccination barriers described in earlier work and argues against single-lever interventions in favor of coordinated action across all three domains simultaneously.

5.6 Strengths and Limitations

This study benefits from a reasonably large sample of 500 caregivers recruited across six primary healthcare centers spanning both sides of Mosul City and from a structured tool that separated barriers into three conceptually distinct domains, allowing their relative contributions to be compared directly. Nonetheless, several limitations should be considered when interpreting these findings. The use of non-probability convenience sampling limits generalizability beyond caregivers who attend primary healthcare centers and may underrepresent families who do not access such services at all. The cross-sectional design captures barriers and vaccination status at a single point in time and cannot establish causal direction. Vaccination status relied on a combination of vaccination cards and caregiver recall, which may be subject to recall or social-desirability bias, and the study was confined to a single city, which may limit generalizability to rural or more conflict-affected areas of Iraq where access barriers could weigh more heavily. Despite these limitations, the consistency of several associations with prior regional and international literature strengthens confidence in the main findings.

6. CONCLUSION AND RECOMMENDATIONS

Caregivers of fully immunized children in Mosul were generally more educated and employed, whereas lower parental education, unemployment, and financial constraints were associated with incomplete vaccination. Children aged 12–17 months and those with a higher birth order were at greater risk of incomplete immunization. Individual barriers, particularly limited caregiver knowledge, accessibility difficulties, and concerns about pain or side effects, had the strongest influence, while healthcare-system barriers were less

prominent except for vaccine shortages. Improving immunization coverage therefore requires integrated interventions, including caregiver education, improved access through outreach and flexible services, family engagement, reminder systems, pain-minimization counseling, and ensuring a reliable vaccine supply at primary healthcare centers.

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