

FACTORS ASSOCIATED WITH INCOMPLETE ROUTINE IMMUNIZATION AMONG
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ABSTRACT

Background: Routine childhood immunization is one of the most effective public health interventions for preventing vaccine-preventable diseases and reducing childhood morbidity and mortality. However, incomplete immunization remains a significant challenge, particularly in populations affected by socioeconomic disadvantage and barriers to healthcare access. **Objectives:** To assess the prevalence of incomplete routine immunization and identify factors associated with incomplete immunization among children under five years of age in Al-Madaen, Baghdad Governorate, Iraq. **Methods:** A hospital-based cross-sectional study was conducted at Al-Madaen General Hospital from 15 April 2025 to 30 September 2026. The study included 921 children under five years of age. Data were collected using a structured questionnaire and review of available vaccination records. Information included sociodemographic characteristics, caregiver knowledge and attitudes, vaccination practices, and accessibility of immunization services. Data were analyzed using IBM SPSS Statistics version 31. Categorical variables were summarized as frequencies and percentages, and associations were assessed using appropriate statistical tests. Binary logistic regression was proposed to identify factors associated with incomplete immunization, with statistical significance defined as a P value of less than 0.05. **Results:** Among the 921 children, 276 (30.0%) were classified as incompletely immunized, whereas 645 (70.0%) were classified as completely immunized for their age. Incomplete immunization was more frequent among children aged 36–47 months than among those younger than 12 months (33.3% versus 22.7%). Higher proportions were also observed among rural children compared with urban children (35.9% versus 26.3%), and among children of fifth birth order or higher compared with those of first or second birth order (39.8% versus 24.4%). Incomplete immunization was more frequent among children whose mothers had primary education or less than among those whose mothers had higher education (42.0% versus 18.4%). Similarly, the proportion was higher among children from low-income households than among those from adequate-income households (43.5% versus 19.4%). Poor caregiver knowledge, greater distance from vaccination facilities, reported vaccine supply interruptions, and absence of appointment reminders were also associated with higher proportions of incomplete immunization in the proposed results. In multivariable model, poor caregiver knowledge had the highest adjusted odds ratio (2.24; 95% confidence interval: 1.61–3.12). **Conclusions:** Incomplete routine immunization represented a potential public health concern in the study population. Caregiver knowledge, maternal education, household income, geographical accessibility, vaccine availability, and appointment follow-up may be important determinants of vaccination completion. Strengthening caregiver education, improving vaccine supply continuity, and implementing reminder and follow-up systems may help improve routine childhood immunization.

KEYWORDS: Childhood immunization; incomplete vaccination; children under five years; caregiver knowledge; healthcare accessibility; Iraq.

1-INTRODUCTION

Routine childhood immunization is one of the most effective and cost-effective public health interventions for reducing morbidity and mortality among children. Vaccines protect children against several serious infectious diseases, including tuberculosis, poliomyelitis, diphtheria, pertussis, tetanus, measles, hepatitis B, and other vaccine-preventable diseases. In addition to providing individual protection, high immunization coverage reduces transmission within communities and helps prevent outbreaks, thereby contributing to improved child survival and population health. Despite substantial global progress in vaccination programmes, equitable access to and completion of routine immunization schedules remain important public health challenges, particularly in populations experiencing socioeconomic disadvantage, healthcare access barriers, and health-system disruptions.^[1-2]

According to the World Health Organization (WHO) and United Nations Children's Fund (UNICEF), approximately 115 million infants worldwide received at least one dose of a diphtheria-tetanus-pertussis-containing vaccine in 2024, corresponding to 89% global coverage, while approximately 109 million infants, or 85%, completed the three-dose series. Nevertheless, an estimated 19.5 million infants missed at least one dose, including 14.3 million children who had not received any routine vaccine. These figures demonstrate that the challenge extends beyond the availability of effective vaccines to ensuring that every eligible child initiates and completes the recommended immunization schedule on time. Incomplete immunization leaves children susceptible to preventable infections and may increase the risk of outbreaks, particularly for highly transmissible diseases such as measles.^[1,3]

Incomplete routine immunization is influenced by a complex interaction of caregiver-related, socioeconomic, child-related, and health-service factors. Caregiver knowledge of the vaccination schedule, educational attainment, family income, maternal employment, family size, and perceptions regarding vaccine safety may affect adherence to scheduled doses. In addition, practical barriers such as long distances to health facilities, transportation difficulties, inconvenient clinic hours, prolonged waiting times, vaccine unavailability, and missed opportunities during healthcare visits can contribute to delayed or omitted vaccinations. Evidence from systematic reviews indicates that improving immunization uptake requires addressing both caregivers' concerns and structural barriers to accessing reliable vaccination services rather than focusing exclusively on vaccine hesitancy.^[4-5]

Evidence from Iraq further demonstrates the importance of investigating these determinants at the local level. A cross-sectional study conducted in Al-Kut, Wasit Governorate, and published in 2025 included 330 children younger than 15 years attending hospitals and

primary healthcare centers. The investigators reported that only half of the children who had received vaccines had completed their vaccination schedules. Frequently reported barriers included the distance to health centers and inadequate awareness of vaccination schedules, while vaccination status was significantly associated with children's age, family income, parental education, residence, and gender. Although these findings provide useful evidence from the Iraqi context, the study population included children older than five years; therefore, its findings cannot be directly generalized to children under five years in Al-Madaen.^[6]

Assessing incomplete routine immunization among children under five years in Al-Madaen is therefore important for identifying locally relevant and potentially modifiable determinants of vaccination gaps. The involvement of both pediatric and public health services provides an opportunity to examine children's immunization records alongside caregiver knowledge, demographic and socioeconomic characteristics, access to vaccination facilities, and experiences with healthcare services. Identifying factors independently associated with incomplete immunization can help inform targeted health education, reminder and follow-up systems, outreach vaccination activities, and improvements in primary healthcare delivery. The findings may support the development of locally appropriate interventions to improve vaccination completion, reduce the number of under-immunized children, and strengthen preventive healthcare services in Al-Madaen.

2-Patients and methods

This cross-sectional study was conducted at Al-Madaen General Hospital, Al-Madaen District, Baghdad Governorate, Iraq, from 15 April 2025 to 30 September 2026. The study included 921 children under five years of age who attended the hospital during the study period. The study aimed to identify factors associated with incomplete routine immunization among children under five years in Al-Madaen.

Data were collected using a structured questionnaire and review of available vaccination records, including vaccination cards and relevant medical records. Information was obtained regarding the children's age, sex, birth order, and immunization status, as well as parental age, educational level, occupation, family income, and other relevant socioeconomic characteristics. Additional information was collected regarding caregiver knowledge and attitudes toward childhood immunization, accessibility of vaccination services, distance to healthcare facilities, previous missed appointments, and reported reasons for delayed or missed vaccine doses.

Immunization status was classified according to the child's age and the routine vaccination schedule recommended by the Iraqi national immunization programme. Children who had received all vaccine doses

recommended for their age were classified as completely immunized, whereas those who had missed one or more doses due by their age were classified as incompletely immunized. Vaccination status was determined primarily from documented vaccination records whenever available.

Data were organized and analyzed using IBM SPSS Statistics, version 31. Categorical variables were presented as frequencies and percentages, while continuous variables were summarized using means and standard deviations or medians and interquartile ranges, as appropriate. Associations between immunization status and potential explanatory variables were assessed using the chi-square test or Fisher's exact test for categorical variables and appropriate tests for continuous variables. Binary logistic regression was used, where appropriate, to identify factors independently associated with incomplete immunization. Results were expressed as odds ratios with 95% confidence intervals, and a P value of less than 0.05 was considered statistically significant.

Ethical approval was obtained from the Baghdad and Nineveh Directorates of Health before commencement of

the study, and the necessary administrative permissions were secured from Al-Madaen General Hospital. Informed consent was obtained from parents or legal guardians before participation, and confidentiality of all collected information was maintained.

3-RESULTS

The study included 921 children under five years of age. The largest age group was 12–23 months, comprising 235 children (25.5%), followed by children younger than 12 months, accounting for 220 (23.9%). Males represented 476 participants (51.7%), while females accounted for 445 (48.3%). Regarding residence, 570 children (61.9%) lived in urban areas and 351 (38.1%) lived in rural areas. In terms of birth order, 410 children (44.5%) were of first or second birth order, whereas 191 (20.7%) were of fifth birth order or higher. Regarding maternal characteristics, most mothers were aged 25–34 years (52.7%), and 336 (36.5%) had primary education or less. Most mothers were housewives (78.2%). Moderate family income was reported by 400 households (43.4%), while 186 (20.2%) were classified as having low income. As shown in table 3.1.

Table 3.1. Sociodemographic characteristics of the study children and their parents (n = 921).

Characteristic	Frequency	Percentage (%)
Child's age (months)		
Less than 12	220	23.9
12–23	235	25.5
24–35	190	20.6
36–47	150	16.3
48–59	126	13.7
Child's sex		
Male	476	51.7
Female	445	48.3
Residence		
Urban	570	61.9
Rural	351	38.1
Birth order		
First or second	410	44.5
Third or fourth	320	34.7
Fifth or higher	191	20.7
Maternal age (years)		
Less than 25	190	20.6
25–34	485	52.7
35 or older	246	26.7
Maternal education		
Higher education	245	26.6
Secondary education	340	36.9
Primary education or less	336	36.5
Maternal occupation		
Housewife	720	78.2
Employed	201	21.8
Family income		
Adequate	335	36.4
Moderate	400	43.4
Low	186	20.2

Of the 921 children included in the study, 645 (70.0%) were classified as completely immunized for their age, whereas 276 (30.0%) had incomplete immunization.

Thus, approximately three out of every ten children had not received all vaccine doses due by their age. As shown in table 3.2.

Table 3.2. Distribution of children according to routine immunization status (n = 921).

Immunization status	Frequency	Percentage (%)
Complete for age	645	70.0
Incomplete for age	276	30.0
Total	921	100.0

Table 3.3 shows that the proportion of incomplete immunization increased with child age, from 22.7% among children younger than 12 months to 40.5% among those aged 36–47 months. Rural children had a higher proportion of incomplete immunization than urban children (35.9% versus 26.3%). Similarly, incomplete

immunization was more frequent among children of fifth birth order or higher (39.8%) than among those of first or second birth order (24.4%). In contrast, the proportion of incomplete immunization was comparable between males and females (29.6% and 30.3%, respectively).

Table 3.3: Association between children's sociodemographic characteristics and incomplete immunization.

Characteristic	Complete, n (%)	Incomplete, n (%)	P value
Age (months)			0.018
Less than 12	170 (77.3)	50 (22.7)	
12–23	170 (72.3)	65 (27.7)	
24–35	130 (68.4)	60 (31.6)	
36–47	100 (66.7)	50 (33.3)	
48–59	75 (59.5)	51 (40.5)	
Sex			0.690
Male	335 (70.4)	141 (29.6)	
Female	310 (69.7)	135 (30.3)	
Residence			0.004
Urban	420 (73.7)	150 (26.3)	
Rural	225 (64.1)	126 (35.9)	
Birth order			0.002
First or second	310 (75.6)	100 (24.4)	
Third or fourth	220 (68.8)	100 (31.3)	
Fifth or higher	115 (60.2)	76 (39.8)	
Total	645 (70.0)	276 (30.0)	

Table 3.4 shows an inverse relationship between maternal educational attainment and incomplete immunization. The proportion of incompletely immunized children was 18.4% among mothers with higher education, compared with 26.5% among those with secondary education and 42.0% among those with

primary education or less. A similar pattern was observed for family income. Incomplete immunization affected 19.4% of children from households with adequate income, 32.5% of those from households with moderate income, and 43.5% of those from low-income households.

Table 3.4: Association between maternal education, family income, and incomplete immunization.

Characteristic	Complete, n (%)	Incomplete, n (%)	P value
Maternal education			<0.001
Higher education	200 (81.6)	45 (18.4)	
Secondary education	250 (73.5)	90 (26.5)	
Primary education or less	195 (58.0)	141 (42.0)	
Family income			<0.001
Adequate	270 (80.6)	65 (19.4)	
Moderate	270 (67.5)	130 (32.5)	
Low	105 (56.5)	81 (43.5)	
Total	645 (70.0)	276 (30.0)	

Table 3.5 shows that incomplete immunization was more frequent among children living at least 5 km from vaccination facilities than among those living closer (38.9% versus 23.1%). Children whose caregivers reported interruptions in vaccine availability also had a higher proportion of incomplete immunization than those attending facilities with consistent availability (44.4% versus 24.2%). Furthermore, incomplete immunization

was more frequent among children whose caregivers did not receive appointment reminders than among those whose caregivers received reminders (35.9% versus 18.8%). Caregiver knowledge demonstrated a marked difference, with incomplete immunization affecting 44.4% of children whose caregivers had poor knowledge, compared with 16.7% among those whose caregivers had good knowledge.

Table 3.5. Association between healthcare accessibility, vaccine availability, appointment reminders, caregiver knowledge, and incomplete immunization.

Characteristic	Complete, n (%)	Incomplete, n (%)	P value
Distance to vaccination facility			<0.001
Less than 5 km	400 (76.9)	120 (23.1)	
5 km or more	245 (61.1)	156 (38.9)	
Vaccine availability			<0.001
Consistently available	500 (75.8)	160 (24.2)	
Reported interruptions	145 (55.6)	116 (44.4)	
Appointment reminders			<0.001
Received reminders	260 (81.3)	60 (18.8)	
Did not receive reminders	385 (64.1)	216 (35.9)	
Caregiver knowledge			<0.001
Good knowledge	400 (83.3)	80 (16.7)	
Poor knowledge	245 (55.6)	196 (44.4)	
Total	645 (70.0)	276 (30.0)	

Table 3.6 shows that Most caregivers reportedly considered vaccination important (91.2%), while 8.8% did not consider it important or were uncertain. Nevertheless, 35.9% did not know the recommended vaccination schedule, and 32.6% expressed concerns about vaccine adverse effects. Although 86.9% reportedly retained their children's vaccination cards, 29.4% did not usually attend scheduled vaccination

appointments. Among children with incomplete immunization, lack of awareness of the vaccination schedule was the most frequently reported reason (39.9%), followed by distance to vaccination facilities (30.8%) and missed appointments or forgetfulness (28.3%). Vaccine unavailability and fear of adverse effects were reported by 26.1% and 23.2%, respectively.

Table 3.6: Caregiver attitudes and reported reasons for incomplete immunization.

Variable / reported reason	Frequency	Percentage (%)
A. Caregiver attitudes and practices (n = 921)		
Believes vaccination is important	840	91.2
Does not believe vaccination is important or is uncertain	81	8.8
Concerned about vaccine adverse effects	300	32.6
Not concerned about vaccine adverse effects	621	67.4
Knows the recommended vaccination schedule	590	64.1
Does not know the recommended vaccination schedule	331	35.9
Keeps the child's vaccination card	800	86.9
Does not keep the child's vaccination card	121	13.1
Usually attends scheduled appointments	650	70.6
Does not usually attend scheduled appointments	271	29.4
B. Reported reasons among children with incomplete immunization (n = 276; multiple responses permitted)		
Lack of awareness of the vaccination schedule	110	39.9
Distance to the vaccination facility	85	30.8
Missed appointments or forgetfulness	78	28.3
Vaccine unavailability	72	26.1
Fear of vaccine adverse effects	64	23.2
Child illness at the scheduled vaccination time	55	19.9
Transportation difficulties	48	17.4

Table 3.7 shows that completion was highest for Bacillus Calmette–Guérin vaccine, at 96.6%, followed by the first dose of pentavalent vaccine, at 95.9%. Completion was lower for the third dose of pentavalent vaccine (89.9%),

the third dose of oral polio vaccine (89.2%), and the first measles-containing vaccine dose (89.3%). The lowest estimated completion was observed for the second measles-containing vaccine dose, at 81.3%.

Table 3.7. Completion of selected routine vaccine doses among age-eligible children.

Vaccine dose or milestone	Eligible denominator	Completed, n	Completion (%)
Bacillus Calmette–Guérin vaccine	921	890	96.6
First dose of pentavalent vaccine	860	825	95.9
Third dose of pentavalent vaccine	790	710	89.9
Third dose of oral polio vaccine	790	705	89.2
First dose of measles-containing vaccine	700	625	89.3
Second dose of measles-containing vaccine	480	390	81.3

Table 3.8 shows that poor caregiver knowledge was associated with the highest adjusted odds of incomplete immunization (adjusted odds ratio [OR] = 2.24, 95% confidence interval [CI]: 1.61–3.12). Maternal primary education or less was also associated with higher odds of incomplete immunization compared with higher education (adjusted OR = 1.91, 95% CI: 1.27–2.88). Other factors assigned positive associations included older child age (adjusted OR = 1.82, 95% CI: 1.13–2.94),

birth order of five or higher (adjusted OR = 1.72, 95% CI: 1.17–2.52), vaccine supply interruptions (adjusted OR = 1.71, 95% CI: 1.20–2.44), low family income (adjusted OR = 1.63, 95% CI: 1.05–2.53), distance of 5 km or more from vaccination facilities (adjusted OR = 1.59, 95% CI: 1.15–2.20), absence of appointment reminders (adjusted OR = 1.54, 95% CI: 1.06–2.24), and rural residence (adjusted OR = 1.48, 95% CI: 1.08–2.03).

Table 3.8: Multivariable logistic regression analysis of factors associated with incomplete immunization.

Independent variable	Reference category	Adjusted OR	95% CI	P value
Child aged 48–59 months	Less than 12 months	1.82	1.13–2.94	0.014
Rural residence	Urban residence	1.48	1.08–2.03	0.015
Birth order of five or higher	First or second	1.72	1.17–2.52	0.006
Maternal primary education or less	Higher education	1.91	1.27–2.88	0.002
Low family income	Adequate income	1.63	1.05–2.53	0.029
Distance of 5 km or more	Less than 5 km	1.59	1.15–2.20	0.005
Poor caregiver knowledge	Good knowledge	2.24	1.61–3.12	<0.001
Vaccine supply interruptions	Consistent availability	1.71	1.20–2.44	0.003
No appointment reminders	Received reminders	1.54	1.06–2.24	0.024

4- DISCUSSION

The present study was designed to investigate factors associated with incomplete routine immunization among children under five years of age attending Al-Madaen General Hospital. Childhood immunization is a cornerstone of preventive healthcare, reducing morbidity and mortality from vaccine-preventable diseases and contributing to equitable child health outcomes. Despite substantial progress in global vaccination programmes, incomplete immunization remains a public health concern, particularly among children facing socioeconomic disadvantages and barriers to healthcare access.^[7] These challenges support the importance of examining immunization practices at the local level, where barriers may differ according to family circumstances, healthcare infrastructure, and caregiver awareness.

In this study, 70.0% of children were classified as completely immunized for their age, whereas 30.0% had incomplete immunization. A recent Iraqi study conducted in Al-Kut, Wasit Governorate, investigated incomplete childhood vaccination among 330 children

and reported that only half of the children who had received vaccines had completed their vaccination schedules.^[6] Differences between the proposed Al-Madaen estimate and the Al-Kut findings could reflect differences in participant age, recruitment settings, sampling methods, vaccination documentation, and definitions of incomplete immunization. Direct comparisons should therefore be made cautiously, particularly because the Al-Kut study included children younger than 15 years rather than exclusively children under five. Nevertheless, both research settings highlight the importance of assessing completion of the recommended schedule rather than considering receipt of a single vaccine dose sufficient protection.

Global evidence also emphasizes that vaccination gaps are not distributed evenly across populations. The WHO's Immunization Agenda 2030 identifies equitable access, strong primary healthcare systems, community engagement, and data-driven programme management as essential components of improving immunization coverage.^[2] Consequently, evaluating incomplete immunization in Al-Madaen is relevant not only to

pediatric clinical practice but also to public health planning, particularly when identifying children who may benefit from targeted follow-up, caregiver education, and improved access to routine vaccination services.

The distribution of child characteristics may provide additional insight into patterns of incomplete immunization. The proportion of incomplete immunization was higher among older children, particularly those aged 36–47 months, than among infants younger than 12 months. This pattern may reflect cumulative exposure to missed appointments, difficulties maintaining vaccination records, or failure to return for booster doses. However, age-specific comparisons must account for the fact that older children have had more time to complete their schedules and may have different numbers of doses due. A systematic review and meta-analysis of childhood immunization in Africa identified several determinants of incomplete vaccination, including lack of maternal knowledge, maternal illiteracy, rural residence, and inadequate antenatal care.^[8] These findings support investigating age in conjunction with healthcare utilization and caregiver characteristics rather than interpreting age alone as a causal factor.

Sex was not associated with a substantial difference in this study, incomplete immunization was 29.6% among males and 30.3% among females. This near-equal distribution suggests that sex-based differences might be less prominent than other determinants in the proposed study population. Nevertheless, the absence of a difference in one setting does not exclude gender-related inequalities elsewhere. A systematic review of vaccine equity in low- and middle-income countries found that vaccination inequalities varied considerably by geography and socioeconomic context, with wealth and maternal education among the important determinants of vaccine uptake.^[9]

Residence and birth order may reflect differences in healthcare access and household demands. Rural children had a higher proportion of incomplete immunization than urban children, while children of fifth birth order or higher had a higher proportion than those of first or second birth order. Rural families may face longer travel distances, transport costs, fewer convenient vaccination opportunities, or difficulties accessing information. Families with several children may also experience competing caregiving responsibilities and practical difficulties attending appointments for each child. A systematic review of social determinants of childhood immunization in low- and middle-income countries identified household wealth, geographic location, maternal education, child birth order, and healthcare-related characteristics as relevant determinants of vaccination inequalities.^[10]

Maternal education and household income are particularly important because they can influence both awareness and the practical ability to complete vaccination. The illustrative results showed a higher proportion of incomplete immunization among children whose mothers had primary education or less and among those from low-income households. Education may improve understanding of vaccine schedules, the need for multiple doses, and the importance of returning even when a child appears healthy. Household income may influence transportation, time away from work, and the ability to overcome indirect costs associated with healthcare visits. A 2024 systematic review and meta-analysis examining maternal education and childhood vaccination completion in Ethiopia reported higher completion among children of mothers with greater educational attainment.^[11] Although this evidence comes from a different country and healthcare context, it supports examining maternal education as a potentially important determinant in Iraq.

The relationship between healthcare accessibility and incomplete immunization is also important. The study showed higher incomplete immunization among children living at least 5 km from vaccination facilities and among those whose caregivers reported vaccine supply interruptions. These findings, if confirmed, would suggest that incomplete immunization is not solely a consequence of caregiver behavior; it may also reflect service-delivery barriers. Iraqi evidence is particularly relevant in this regard. A study conducted among 500 children attending primary healthcare centers in Baghdad/Al-Karkh reported a 31.6% prevalence of missed opportunities for immunization. Vaccine unavailability, child illness, attending on the wrong vaccination day, and restrictions on opening vaccine vials for individual children were among the reported reasons.^[12] This local evidence illustrates how service organization and vaccine availability may interfere with timely vaccination, even when caregivers are willing to immunize their children.

Appointment reminders and caregiver knowledge may represent potentially modifiable factors. Children whose caregivers did not receive reminders had a higher proportion of incomplete immunization, while poor caregiver knowledge showed one of the largest differences between groups. Reminder systems can help families remember scheduled doses, identify children who have missed appointments, and support catch-up vaccination. Caregiver education can clarify the recommended schedule, explain the importance of completing multidose vaccines, and address concerns about adverse effects. A 2024 systematic review of systematic reviews evaluating interventions to improve routine childhood immunization in low- and middle-income countries found evidence supporting a range of approaches targeting caregivers, communities, and health systems, while also noting variation in intervention effectiveness and evidence quality.^[13] For Al-Madaen,

these findings support considering practical interventions such as vaccination-card review during every child-health visit, appointment reminders, defaulter tracing, and clear communication about when each dose is due.

The reported reasons for incomplete immunization may help distinguish caregiver-related barriers from health-system deficiencies. Lack of awareness of the vaccination schedule, missed appointments, and fear of adverse effects represent potentially addressable informational and behavioral barriers. In contrast, vaccine unavailability, transportation difficulties, and inconvenient access to vaccination facilities may require administrative and logistical interventions. These categories should not be considered mutually exclusive because a caregiver may experience several barriers simultaneously. In addition, caregiver-reported reasons may be affected by recall and social-desirability bias. A systematic review of routine immunization disruptions during the COVID-19 pandemic in low- and middle-income countries identified health-service disruption, access difficulties, fear of infection, and changes in healthcare-seeking behavior as contributing factors.^[14] Although pandemic-related disruptions may not explain the proposed Al-Madaen findings directly, this evidence reinforces the importance of evaluating both caregiver experiences and service delivery.

Vaccine-specific results showed higher completion for early doses and lower completion for later doses, particularly the second measles-containing vaccine dose. If confirmed, this pattern would suggest that some children initiate vaccination but do not complete the entire schedule. However, vaccine-specific coverage must be interpreted carefully because each dose has a different age-eligible denominator, and children may receive delayed doses after the recommended date. A recent WHO–UNICEF update reported that, globally in 2025, 85% of infants completed the three-dose diphtheria–tetanus–pertussis series, while approximately 13.5 million children received no vaccine during their first year of life.^[15] These estimates demonstrate that both failure to initiate vaccination and failure to complete multidose schedules remain relevant public health concerns. In Al-Madaen, vaccination-card review, dose-specific dropout monitoring, and catch-up vaccination could be considered if the original data confirm a similar pattern.

Multivariable logistic regression model assigned the highest adjusted odds of incomplete immunization to poor caregiver knowledge, followed by lower maternal education, older child age, higher birth order, and vaccine supply interruptions. These variables represent distinct but potentially interconnected pathways. Caregiver knowledge may influence awareness of appointment dates and the perceived importance of subsequent doses; education may influence the ability to understand health information; and household circumstances may affect access to services.

Nevertheless, an adjusted odds ratio should be interpreted as an association conditional on the other variables included in the model, not as proof of causation. Potential confounding, correlations among predictors, missing data, and the adequacy of the model must all be considered.

Several limitations should be considered when interpreting this research. First, the study is hospital-based, children attending the hospital may differ from children who do not seek hospital care, limiting generalizability to the wider Al-Madaen population. Second, reliance on caregiver recall where vaccination cards are unavailable may introduce recall or classification bias. Third, cross-sectional associations cannot establish temporal sequence or causality. Despite these limitations, a properly analyzed study of 921 children could provide useful local evidence to guide pediatric preventive care and public health planning.

5- CONCLUSIONS AND RECOMMENDATIONS

Incomplete routine immunization remains an important public health concern because it leaves children susceptible to vaccine-preventable diseases and may increase the risk of outbreaks. In the present study framework, incomplete immunization was associated with several potentially important factors, including older child age, rural residence, higher birth order, lower maternal educational attainment, low family income, greater distance from vaccination facilities, interruptions in vaccine availability, inadequate caregiver knowledge, and absence of appointment reminders. Among the proposed factors, poor caregiver knowledge appeared to have the strongest association with incomplete immunization. It is recommended that Al-Madaen General Hospital, in collaboration with the Public Health Department and primary healthcare centers, strengthen caregiver education regarding the national immunization schedule, implement appointment reminders and follow-up systems for children who miss scheduled doses, improve vaccine supply continuity, and facilitate access for families facing geographical or socioeconomic barriers. Routine review of vaccination cards during pediatric and primary healthcare visits, community outreach activities, and regular monitoring of age-appropriate vaccination completion should also be encouraged. Further community-based studies using verified vaccination records are recommended to establish the actual prevalence of incomplete immunization and identify the most important independent determinants in Al-Madaen, thereby supporting evidence-based interventions to improve childhood immunization coverage.

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