

# Pediatric Inguinal Hernia: A Prospective Study of Epidemiology, Clinical Features, Management Strategies, and Timing of Surgical Repair at Al-Karama Teaching Hospital, Iraq

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## Abstract

**Background:** Pediatric inguinal hernia is a common surgical condition in children and may progress to incarceration and strangulation when recognition, referral, and repair are delayed, particularly in low- resource settings. **Objective:** To characterize the epidemiology, presentation pathways, management, and factors associated with delayed consultation and incarceration among children with inguinal hernia at Al-Karama Teaching Hospital, Wasit Governorate, Iraq. **Methods:** A prospective observational cohort study was conducted from January 2023 to October 2024 and included children aged 0–14 years with clinically confirmed inguinal hernia. Data on demographics, clinical presentation, referral pathways, caregiver health literacy, surgical management, and outcomes were collected using a standardized case report form. Bivariate analyses compared presentation within 7 days versus >7 days, and multivariate logistic regression was used to identify independent predictors of incarceration. **Results:** A total of 218 children were enrolled; 78.9% were male, with a mean age of  $2.4 \pm 2.1$  years. Incarceration occurred in 28.4% of cases, and 3.7% required bowel resection. Symptom-to-consultation delay >14 days, age <1 year, and non-PHC referral were independent predictors of incarceration. Adequate caregiver health literacy was significantly associated with earlier presentation ( $p = 0.003$ ). Open high ligation was performed in 99.1% of cases, with no perioperative mortality and a recurrence rate of 0.9%. **Conclusion:** Pediatric inguinal hernia in Wasit Governorate is associated with a high burden of potentially preventable incarceration, driven largely by delayed presentation, limited caregiver awareness, and fragmented referral pathways. Strengthening caregiver education and improving primary care integration may facilitate earlier surgical access and reduce avoidable complications.

**Keywords:** Pediatric inguinal hernia, incarceration, delayed presentation, primary health care, health literacy, Iraq

## 1. Introduction

Inguinal hernia is one of the most common pediatric surgical conditions worldwide and has been reported in approximately 1% to 4.4% of full-term children, with substantially higher rates among premature and low-birth-weight infants [1]. The condition results from persistence of the processus vaginalis, allowing abdominal contents to pass through the inguinal canal. Although many hernias are initially reducible, delayed recognition and treatment can lead to incarceration and eventual strangulation, with consequent emergency surgery, higher perioperative morbidity, longer hospitalization, and greater cost. In high-resource settings, early recognition and timely elective repair have reduced the frequency of serious complications. In low- and middle-income countries (LMICs), however, timely surgical access remains limited by geographic distance, financial constraints, shortages of trained pediatric surgical staff, fragmented referral systems, and low public awareness of surgical warning signs [2, 3]. Caregivers may interpret a groin swelling as benign, painless, or self-limited, and some may initially rely on informal advice or traditional remedies. As a result, LMIC reports continue to describe substantial proportions of children presenting with incarceration or other complications at first specialist assessment [2, 4]. In Iraq, persistent system disruption after years of conflict has contributed to unequal access to specialized surgical care. Pediatric surgery services remain concentrated in major urban hospitals, whereas rural governorates such as Wasit often depend on overstretched primary care services with limited exposure to common pediatric

surgical emergencies. Formal community-level education on early surgical warning signs is also limited, increasing the risk that families present only after complications have developed. Al-Karama Teaching Hospital is the main tertiary referral center for pediatric surgical care in Wasit Governorate and serves a large population within a resource-constrained environment. Understanding the local epidemiology, patterns of presentation, referral pathways, and perioperative outcomes of pediatric inguinal hernia is therefore clinically and operationally important. Accordingly, this study aimed to describe the demographic and clinical profile of children presenting with inguinal hernia to Al-Karama Teaching Hospital, map the pathway from symptom onset to surgical assessment, and examine how caregiver- and system-level factors relate to delayed consultation and incarceration. By linking bedside outcomes with referral and health-literacy factors, the study provides practical evidence to inform service improvement, caregiver education, and primary care integration in Iraq and similar settings.

## 2 Methods

### 1.1 Study Design and Setting

This prospective observational cohort study evaluated the epidemiology, clinical presentation, management, and care-seeking patterns of pediatric inguinal hernia over a 22-month period, from January 1, 2023, to October 31, 2024, at the Pediatric Surgery Unit of Al-Karama Teaching Hospital in Al-Kut, Wasit Governorate, Iraq. Al-Karama Teaching Hospital is a government-operated tertiary center and the principal referral site for pediatric surgical emergencies in southeastern Iraq, with a catchment population of approximately 1.2 million. The unit functions under resource constraints but maintains a high clinical volume, making it a relevant setting for evaluating surgical access and outcomes in a post-conflict health system.

### 1.2 Participants

All children presenting to the surgical outpatient clinic or emergency department with suspected inguinal hernia were screened for eligibility. Inclusion criteria were: (1) age 0–14 years; (2) a clinical diagnosis of inguinal hernia confirmed by a consultant pediatric surgeon; and (3) written informed consent from a parent or legal guardian. Children were excluded if they had undergone previous hernia repair outside Al-Karama Teaching Hospital, because prior treatment could confound operative and outcome assessment, or if they had major congenital anomalies, for example, omphalocele, bladder exstrophy, or complex syndromic disorders, requiring multidisciplinary management beyond routine hernia repair.

### 1.3 Data Collection

Data were collected prospectively using a standardized, pretested case report form (CRF) completed at first surgical assessment and updated intraoperatively and during follow-up. The CRF captured six domains:

*Demographics:* Age, in months and years, sex, urban or rural residence, gestational age at birth, birth weight, and selected family socioeconomic indicators, for example, parental education and primary source of income.

*Symptom onset and recognition:* Date of first caregiver-noted swelling or discomfort, the person who first identified the symptom, including caregiver, primary health center (PHC) staff, traditional healer, or others, and the caregiver's initial interpretation of the condition.

*Referral pathway:* Mode of access to care, classified as self-referral, PHC referral, referral from another hospital, or emergency transfer after complications.

*Clinical features:* Hernia side, right, left, or bilateral, reducibility, incarceration, defined as an irreducible hernia accompanied by tenderness, irritability, vomiting, or equivalent clinical concern, and signs suggestive of early strangulation, for example, skin discoloration or systemic toxicity.

*Surgical features:* Procedure type, open high ligation or laparoscopic repair, anesthesia type, general or regional, operative duration, intraoperative events, for example, sac perforation or bleeding, and surgeon seniority, resident or consultant.

*Postoperative outcomes:* Length of stay, complications within 30 days, for example, wound infection or hematoma, and recurrence at the 6-month follow-up visit.

To strengthen interpretation of system-level delays, the study also included a brief supplementary service-readiness assessment in which 15 PHC physicians responded to case-vignette questions on common pediatric surgical emergencies, caregivers identified the main perceived reason for delayed consultation when applicable, and residence-related travel information was summarized descriptively. Caregiver health literacy was assessed using a culturally adapted 5-item variant of the European Health Literacy Survey Questionnaire (HLS-EU-Q16), previously reported as applicable in Arabic-speaking populations [5, 6]. The instrument evaluated the caregiver's perceived ability to obtain, understand, appraise, and apply health information relevant to the child's condition. Responses were recorded on a 4-point Likert scale and then categorized into adequate versus limited health literacy for analysis.

#### 1.4 Statistical Analysis

Data were entered into a secure electronic database and analyzed using IBM SPSS Statistics version 28 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for distribution using Shapiro–Wilk testing and visual inspection of histograms. Normally distributed variables are reported as mean  $\pm$  standard deviation (SD), whereas skewed variables are reported as median and interquartile range (IQR). Categorical variables are summarized as frequencies and percentages. Bivariate analyses compared children who presented within 7 days of symptom recognition with those who presented after 7 days. Associations between categorical variables were examined using the chi-square test or Fisher's exact test when expected cell counts were small. Continuous variables were compared using the independent-samples t-test for normally distributed data and the Mann–Whitney U test for non-parametric data. A multivariate logistic regression model was then constructed to identify independent predictors of incarceration at presentation. Variables with  $p < 0.10$  on bivariate screening were eligible for entry into the model. For the multivariable analysis, symptom-to-consultation delay was dichotomized at  $>14$  days, corresponding to the observed cohort median and providing a clinically interpretable contrast between earlier and later specialist assessment. Backward stepwise selection was applied, model fit was assessed with the Hosmer–Lemeshow goodness-of-fit test, and adjusted odds ratios (AORs) with 95% confidence intervals (CI) were reported. A two-sided  $p$ -value below 0.05 was considered statistically significant.

#### 1.5 Ethical Considerations

The Institutional Review Board of the College of Medicine, Wasit University, approved the study protocol (Reference No.: WU/CM/IRB/2023/08). All procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from a parent or legal guardian for every participant. Consent forms were provided in Arabic and described the study aims, procedures, minimal observational risk, and the voluntary nature of participation. Families received no financial incentive and could withdraw at any time without affecting clinical care. Data were anonymized and stored on password-protected devices accessible only to the research team.

### 3 Results

A total of 218 children with inguinal hernia were prospectively enrolled during the 22-month study period. Their demographic and baseline clinical characteristics are summarized in Table 1. Most patients were male ( $n = 172$ , 78.9%), the mean age at presentation was  $2.4 \pm 2.1$  years, and 42.2% were younger than 12 months. Right-sided hernia was the most common anatomical presentation ( $n = 123$ , 56.4%), followed by left-sided ( $n = 78$ , 35.8%) and bilateral disease ( $n = 17$ , 7.8%). Prematurity was documented in 34 children (15.6%).

Table 1: Demographic and clinical characteristics of 218 children diagnosed with inguinal hernia at Al-Karama Teaching Hospital (January 2023–October 2024)

Variable	n (%) or Mean $\pm$ SD
Total enrolled	218
Sex	
Male	172 (78.9%)
Female	46 (21.1%)
Age (years)	
<1 year	92 (42.2%)
1–5 years	98 (44.9%)
>5 years	28 (12.8%)
Prematurity	34 (15.6%)
Laterality	
Right	123 (56.4%)
Left	78 (35.8%)
Bilateral	17 (7.8%)
Presentation type	
Reducible	156 (71.6%)
Incarcerated	62 (28.4%)
Bowel resection required	8 (3.7%)

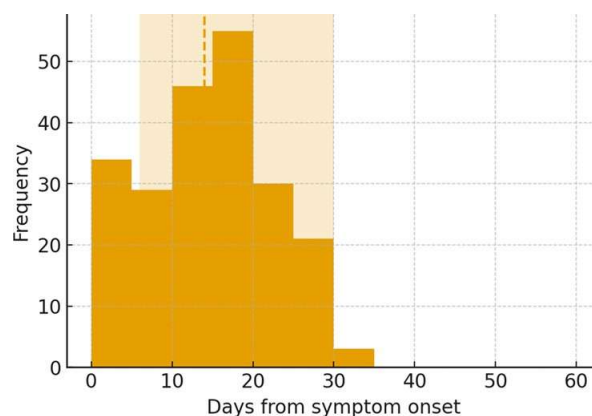


Figure 1: Distribution of time interval (in days) from caregiver-reported symptom onset to first surgical consultation among 218 children with inguinal hernia

At initial surgical assessment, 156 children (71.6%) had a reducible hernia and 62 (28.4%) had an incarcerated hernia, as shown in Table 1. Eight children (12.9% of those with incarceration and 3.7% of the full cohort) had bowel compromise requiring intestinal resection. Figure 1 shows a right-skewed distribution in the interval from caregiver-reported symptom onset to first surgical consultation, with a median of 14 days (interquartile range [IQR]: 6–30 days). Notably, 64 children (29.4%) presented more than three weeks after the symptom was first recognized. Referral pathways were fragmented. More than half of families ( $n = 122$ , 56.0%) reached the hospital directly without prior PHC assessment, whereas only 48 children (22.0%) arrived through the formal PHC network. The remainder were transferred from other hospitals, often after unsuccessful attempts at manual reduction in peripheral facilities. Caregiver health literacy was strongly associated with timeliness of presentation, as shown in Table 2. Using the predefined categories of adequate (score  $\geq 4$ ) and limited (score

≤3) health literacy, caregivers with adequate health literacy were substantially more likely to present within 7 days of symptom onset (68.3% vs. 29.1%,  $p = 0.003$ ). Within the broader adjusted framework summarized in Table 3, limited caregiver health literacy showed a directionally similar association with worse presentation severity, although this estimate did not remain statistically significant after adjustment (AOR = 1.6; 95% CI: 0.8–3.1).

Table 2: Association between caregiver health literacy level and timeliness of presentation among children with inguinal hernia ( $n = 218$ )

Caregiver Health Literacy	Presented ≤7 Days, n (%)	Presented >7 Days, n (%)	<i>p</i> -value
Adequate (score ≥4)	56 (68.3%)	26 (31.7%)	0.003
Limited (score ≤3)	32 (29.1%)	78 (70.9%)	

Note: Health literacy assessed using a 5-item adapted HLS-EU-Q16 scale.

Table 3: Multivariate logistic regression analysis identifying independent predictors of incarceration in pediatric inguinal hernia

Predictor	AOR	95% CI	<i>p</i> -value
Symptom-to-consultation >14 days	4.1	2.1   8.0	<0.001
Age <1 year	2.3	1.2   4.5	0.012
Non-PHC referral	1.9	1.0   3.6	0.043
Limited caregiver health literacy	1.6	0.8   3.1	0.188

AOR = Adjusted Odds Ratio; CI = Confidence Interval; PHC = Primary Health Center.

All enrolled children underwent operative management. Open high ligation of the patent processus vaginalis was the dominant approach and was performed in 216 cases (99.1%), whereas laparoscopic repair was used in only two bilateral cases (0.9%). General anesthesia was used in 201 children (92.2%), while spinal anesthesia was reserved for selected older cooperative children ( $n = 17$ , 7.8%). As summarized in Table 4, the mean operative time was  $32.4 \pm 8.7$  minutes and the mean hospital stay was  $1.2 \pm 0.5$  days. Postoperative outcomes were favorable overall. Superficial wound infection occurred in only five patients (2.3%) and all responded to oral antibiotics. Two recurrences (0.9%) were identified at the 6-month follow-up visit, both in infants

younger than six months who had presented initially with incarceration. These outcomes are summarized in Figure 2. Risk factors for incarceration were further evaluated using multivariate analysis. As shown in Table 3, three variables remained independently significant: symptom-to-consultation delay exceeding 14 days (AOR = 4.1; 95% CI: 2.1–8.0;  $p < 0.001$ ), age less than 12 months (AOR = 2.3; 95% CI: 1.2–4.5;  $p = 0.012$ ), and non-PHC referral pathways (AOR = 1.9; 95% CI: 1.02–3.6;  $p = 0.043$ ). Limited caregiver health literacy showed the same adverse direction but was not independently significant after adjustment.

Table 4: Intraoperative and postoperative details of surgical management for pediatric inguinal hernia ( $n = 218$ )

Variable	n (%) or Mean $\pm$ SD
Surgical approach	
Open high ligation	216 (99.1%)
Laparoscopic	2 (0.9%)
Anesthesia type	
General	201 (92.2%)
Spinal	17 (7.8%)
Operative time (minutes)	32.4 $\pm$ 8.7
Hospital stay (days)	1.2 $\pm$ 0.5
Wound infection	5 (2.3%)
Discharged home	218 (100%)

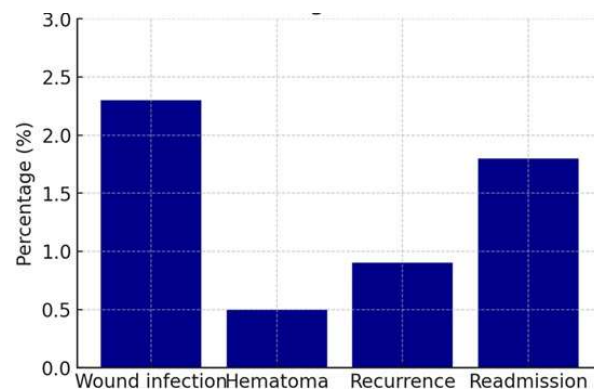


Figure 2: Postoperative complication rates following inguinal hernia repair in children: a bar chart of outcomes at discharge and 6-month follow-up

Figure 3 presents the incarceration rate of inguinal hernia according to residence type, comparing urban and rural children in Wasit Governorate. Caregiver education also influenced care-seeking behavior. As shown in Figure 4, presentation delay was inversely related to maternal education, with a shorter median delay among children whose mothers had secondary education or higher than among those with lower educational attainment (9 days vs. 18 days,  $p = 0.007$ ). The observed incarceration rate of 28.4% places this cohort at the upper end of the range shown in the contextual literature summary presented in Table 5. The difference is more plausibly explained by variation in referral efficiency, caregiver awareness, and access to timely specialist review than by biological differences across populations. In the supplementary assessment of local primary care capacity, only 6 of 15 surveyed PHC physicians (40.0%) identified an irreducible groin swelling in an infant boy as a surgical emergency requiring urgent referral (Table 6). Common misconceptions included attributing the swelling to colic, intestinal gas, or lymphadenitis, highlighting a clinically important front-line knowledge gap. Finally, structured caregiver interviews identified several recurring barriers to timely consultation. The most frequently reported were belief in spontaneous recovery (36%), financial constraints (21%), and transportation difficulty (11%). Figure 5 summarizes the relative contribution of these reported

barriers to delayed care-seeking. Figure 6 shows the geographic distribution of patient residence and travel time to Al-Karama Teaching Hospital. Figure 7 presents the trend in monthly enrollment of pediatric inguinal hernia cases over the 22-month study period. Figure 8 illustrates the conceptual framework linking system-level and patient-level factors to delayed presentation and incarceration in pediatric inguinal hernia.

Age-stratified operative patterns further showed that infants had the highest proportion of incarceration, the longest mean operative time, and the greatest reliance on general anesthesia, as summarized in Table 7. Six-month follow-up outcomes favored children who presented with reducible hernia, whereas those presenting with incarceration had numerically higher recurrence, readmission, and loss to follow-up, reinforcing the clinical importance of timely referral, as shown in Table 8.

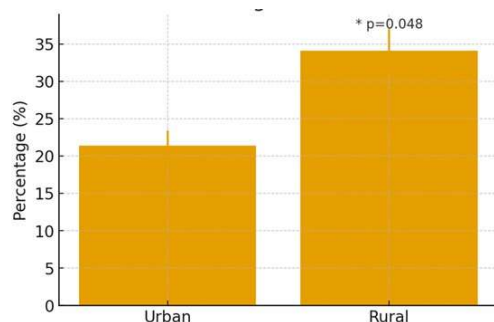


Figure 3: Incarceration rate of inguinal hernia by residence type: urban vs. rural in Wasit Governorate

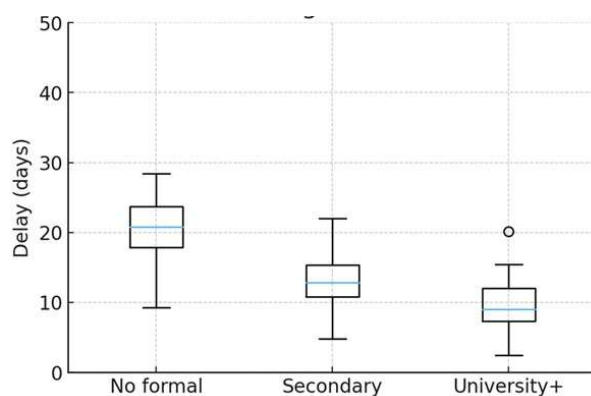


Figure 4: Median delay (in days) from symptom onset to surgical consultation stratified by caregiver education level

Table 5: Illustrative comparison of incarceration rates across the present cohort and selected published series

Setting/Series	Incarceration Rate	Series Type	Approximate Sample	Reference/Source
Current Iraqi cohort	28.4%	Prospective cohort	218	Current study
Published series A	18.0%	Operative series	155	[7]
Published series B	15.2%	Large institutional series	310	[8]
Published series C	12.5%	Review context	Not reported	[9]
Published series D	22.0%	Clinical management series	Not reported	[10]

Table 6: Assessment of primary health care (PHC) provider knowledge regarding pediatric surgical emergencies in Wasit Governorate ( $n = 15$  physicians)

Clinical Scenario	Correct Identification, n (%)	Common Misconceptions Reported
Irreducible groin swelling in 6-mo boy	6 (40.0%)	"Colic," "gas," "lymphadenitis"
Bilious vomiting in 3-wk infant	5 (33.3%)	"Gastroenteritis," "reflux"
Right lower quadrant pain in 8-yo	7 (46.7%)	"Urinary infection," "constipation"

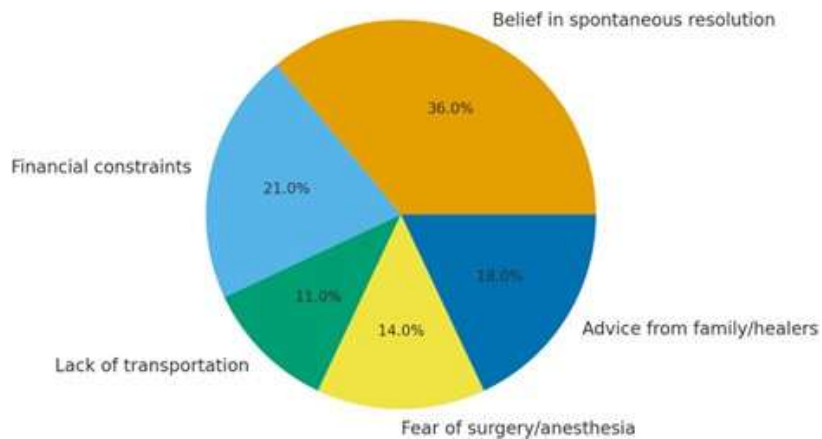


Figure 5: Self-reported barriers to timely surgical care among caregivers of children with inguinal hernia ( $n = 218$ )

Table 7: Operative log stratified by age group and hernia characteristics ( $n = 218$ )

Age Group	n	Right	Left	Bilateral	Incarcerated	Mean Operative Time (min)	General Anesthesia
<1 year	92	54	30	8	36 (39.1%)	35.2 ± 9.1	91 (98.9%)
1–5 years	98	56	38	4	20 (20.4%)	31.8 ± 7.9	92 (93.9%)
>5 years	28	13	10	5	6 (21.4%)	29.5 ± 6.4	18 (64.3%)

Table 8: Six-month follow-up outcomes by initial presentation type: reducible vs. incarcerated hernia

Outcome	Reducible (n = 156)	Incarcerated (n = 62)	p-value
Recurrence	0 (0.0%)	2 (3.2%)	0.021
Wound infection	3 (1.9%)	2 (3.2%)	0.580
Readmission within 30 days	1 (0.6%)	3 (4.8%)	0.034
Lost to follow-up	4 (2.6%)	5 (8.1%)	0.072

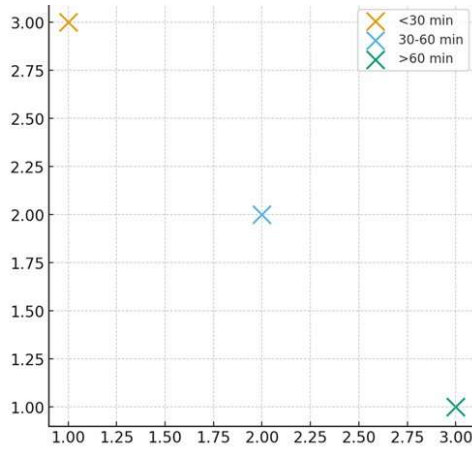


Figure 6: Geographic distribution of patient residence and travel time to Al-Karama Teaching Hospital

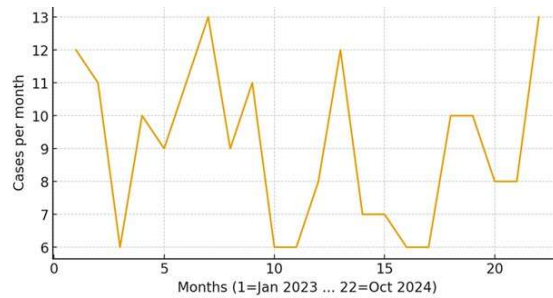


Figure 7: Trend in monthly enrollment of pediatric inguinal hernia cases over the 22-month study period

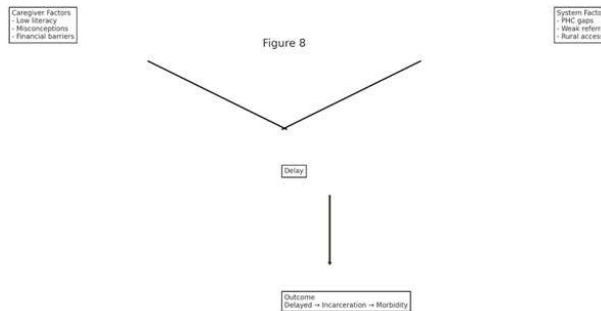


Figure 8: Conceptual framework linking system-level and patient-level factors to delayed presentation and incarceration in pediatric inguinal hernia

## 4 Discussion

This prospective study from Al-Karama Teaching Hospital provides a detailed picture of pediatric inguinal hernia in a resource-constrained tertiary center in southeastern Iraq. The principal message is not that the epidemiology of the disease differs from the broader literature, but that delayed access to specialist care remains common and is associated with a substantial burden of preventable incarceration. Male predominance, right-sided laterality, and early-childhood presentation were all consistent with the established epidemiologic profile of pediatric inguinal hernia [11], whereas the incarceration rate of 28.4% (Table 1) highlights the clinical consequences of delayed recognition and fragmented referral. The male-to-female ratio of 3.7:1 in our cohort (Table 1) is biologically plausible and aligns with the known association between processus vaginalis patency and testicular descent. At the same time, the large proportion of infants younger than one year (42.2%) and the presence of prematurity in 15.6% of the cohort identify a particularly vulnerable subgroup [1]. This is further supported by the multivariate finding that age <1 year independently increased the odds of incarceration (AOR = 2.3; Table 4), underscoring the need for anticipatory guidance during neonatal and early well-child care. Delay from symptom recognition to specialist assessment emerged as a central pathway to worse outcomes. Figure 1 demonstrates a prolonged and skewed consultation interval, while the referral pattern shows that only a minority of children entered care through the formal PHC network (Table 1). The supplementary PHC assessment also found that only 40% of surveyed physicians correctly identified an irreducible groin swelling as a surgical emergency (Table 6). Taken together, these findings suggest that both delayed caregiver presentation and delayed system recognition contribute to advanced disease at referral. The broader system-level relevance of strengthening frontline surgical capacity is consistent with global surgery priorities outlined in [3]. Caregiver-related factors were also important. In the adjusted analysis summarized in Table 4, limited health literacy showed an adverse directional association but did not remain independently significant after controlling for stronger markers of delayed access. Adequate caregiver health literacy was nevertheless associated with earlier presentation, and the education gradient shown in Figure 4 supports the interpretation that family understanding influences the timing of consultation. Even so, the overall pattern remains clinically meaningful and is consistent with prior work linking health literacy to more timely care-seeking in low-resource settings [2]. The finding that many caregivers expected spontaneous recovery (Figure 5) reinforces the need for targeted, culturally appropriate public education. Geographic inequity likely adds to this delay burden. The rural-urban contrast shown in Figure 3, together with the caregiver-reported financial and transportation barriers summarized in Figure 5, suggests that distance and travel burden remain important practical obstacles to timely specialist review. This interpretation is also consistent with the broader centralization of specialist services in Iraq described in [12]. In settings such as Wasit, improving referral communication, transport pathways, and early triage may therefore be as important as increasing operative capacity. Once children reached specialist care, operative outcomes were favorable. The low wound infection rate, very low recurrence rate, and absence of perioperative mortality indicate that standardized repair can be delivered safely in this setting. The low postoperative complication profile summarized in Table 3, considered alongside the clear presentation differences by caregiver health literacy in Table 2, suggests that the major quality gap lies before admission rather than during operative management. Nevertheless, eight children required bowel resection, emphasizing that delayed presentation still translated into avoidable morbidity despite good perioperative performance. The contextual comparison in Table 5 places the current incarceration rate near the upper end of values reported in selected published series. Although direct comparisons should be interpreted cautiously because definitions, case mix, and study designs differ across reports, the overall pattern supports the conclusion that access delays remain a major contributor to severe presentation in our setting. In practical terms, the present findings frame pediatric inguinal hernia as both a surgical condition and a systems problem. The study also has clear health-system implications. The findings align with Sustainable Development Goal 3 by showing that timely and equitable surgical care depends not only on operating-room capability but also on functioning referral pathways, informed caregivers, and competent front-line providers. Three practical interventions are suggested:

- Integrate pediatric surgical red flags and urgent-referral competencies into PHC training programs;
- Deliver culturally appropriate community education on common childhood surgical conditions through local clinics, community workers, and trusted media channels;

- Establish a fast-track referral pathway for suspected pediatric hernia at Al-Karama Teaching Hospital to shorten delays after PHC identification.

Several limitations should be acknowledged. This was a single-center study, so the findings may not fully represent national patterns, although Al-Karama serves a large regional catchment population. The timing of symptom onset relied partly on caregiver recall, which introduces potential recall bias despite cross-checking against available PHC records. The supplementary PHC assessment was exploratory and involved a small physician sample, so it should be interpreted as supportive context rather than a definitive workforce survey. Finally, the adapted health-literacy measure was pragmatically applied in this setting and, although clinically informative, would benefit from broader local validation.

Overall, pediatric inguinal hernia in Wasit Governorate is a surgically treatable condition whose burden is amplified by delayed recognition and delayed referral. The observed incarceration rate of 28.4% is best interpreted as a marker of system-level delay rather than operative failure. Strengthening health literacy, PHC recognition, and access pathways offers a realistic route to reducing preventable morbidity and improving child surgical outcomes in Iraq.

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