

Efficacy of Oral Zinc Therapy in Reducing Serum Bilirubin in Neonatal Jaundice in Term Neonates Undergoing Phototherapy: A Case-Control Study

Deepak Gurjar¹, Gopi Kishan Sharma², Piyush Kumar Gupta³

¹MD Paediatrics Resident; Government Medical College and Associated Group of Hospitals, Kota, Rajasthan, India.

²Associate Professor, Department of Pediatrics, Government Medical College and Associated Group of Hospitals, Kota, Rajasthan, India. Email: dr.gopikishan.sharma6162@gmail.com

³Professor, Department of Community Medicine, Geetanjali Institute of Medical Sciences, Jaipur, Rajasthan.

Abstract

Background: Neonatal hyperbilirubinemia is among the commonest conditions requiring neonatal intensive care admission and phototherapy. Prolonged phototherapy increases hospitalization and healthcare burden, prompting interest in adjunctive therapies such as oral zinc, which reduces enterohepatic circulation of bilirubin.

Objective: To assess the efficacy of oral zinc therapy in reducing serum bilirubin in term neonates with jaundice undergoing phototherapy, and its effect on duration of phototherapy and hospital stay.

Methods: This case-control study was conducted in the Department of Pediatrics, Government Medical College, Kota, Rajasthan, over one year and one month. A hundred term neonates (37–41 weeks) with indirect hyperbilirubinemia requiring phototherapy were enrolled and divided equally into two groups: Group A (oral zinc sulfate 5 mg/day plus phototherapy) and Group B (phototherapy alone). Serial total and indirect serum bilirubin were measured at baseline, 24, 48 and 72 hours. Duration of phototherapy, hospital stay, NICU stay and adverse effects were recorded and compared using Student's t-test, chi-square test, ANOVA and Pearson correlation.

Results: Baseline demographic and clinical parameters were comparable between groups. Serum bilirubin reduction was significantly greater in the zinc group at 24, 48 and 72 hours ($p < 0.001$). Mean duration of phototherapy was significantly shorter in the zinc group (51.0 ± 5.22 vs 70.3 ± 5.27 hours, $p < 0.001$), as were hospital stay (3.10 ± 0.76 vs 4.18 ± 0.69 days) and NICU stay (2.94 ± 0.71 vs 3.70 ± 0.61 days). Fewer neonates in the zinc group required extended phototherapy (20.0% vs 68.0%, $p < 0.001$). Adverse effects were mild and comparable between groups, and overall clinical improvement was superior in the zinc group.

Conclusion: Oral zinc supplementation, when added to standard phototherapy, significantly accelerates bilirubin clearance, shortens the duration of phototherapy and hospitalization, and is well tolerated in term neonates with indirect hyperbilirubinemia.

Keywords: Neonatal jaundice; Oral zinc; Phototherapy; Hyperbilirubinemia; Serum bilirubin; Term neonates.

Introduction

Neonatal jaundice is a common clinical condition observed during the early neonatal period, characterized by yellow discoloration of the skin and sclera due to elevated serum bilirubin levels, arising from physiological immaturity of hepatic conjugation mechanisms and increased breakdown of foetal erythrocytes after birth [1].

In most cases jaundice is benign and self-limiting; however, excessive accumulation of unconjugated bilirubin may cross the immature blood–brain barrier and cause bilirubin-induced neurological dysfunction, with the potential for long-term neurodevelopmental impairment, making timely diagnosis and management essential [2].

Phototherapy remains the standard treatment for neonatal hyperbilirubinemia, converting unconjugated bilirubin into water-soluble photo-isomers that can be excreted without hepatic conjugation; several adjunctive therapies have nonetheless been explored to enhance bilirubin reduction and shorten treatment duration [3]. Among these, zinc has attracted attention for its ability to bind unconjugated bilirubin in the intestinal lumen and reduce enterohepatic circulation, thereby potentially accelerating bilirubin clearance [4].

Neonatal jaundice is broadly classified as physiological or pathological depending on the timing of onset, rate of bilirubin rise and associated clinical factors, with pathological jaundice presenting earlier or persisting longer and being associated with hemolysis, infection or metabolic disorders [5]. Management strategies focus primarily on reducing serum bilirubin and preventing toxicity; oral zinc supplementation has been explored as an adjunct that may limit intestinal reabsorption of bilirubin and improve its elimination [6,7].

Neonatal jaundice remains a significant contributor to neonatal morbidity worldwide and a leading cause of neonatal hospitalization, particularly in developing countries where delayed recognition and variability in access to standardized treatment facilities remain concerns [8,9]. Recent systematic reviews have highlighted ongoing efforts to explore adjunct therapeutic approaches, including zinc supplementation, to improve treatment outcomes and reduce the overall disease burden [10].

Despite the wide acceptance of phototherapy, its effectiveness may vary with baseline bilirubin concentration, gestational maturity and individual metabolic variation, and some neonates require prolonged therapy that increases hospitalization and resource utilization. Consistent evidence supporting the routine use of adjunctive pharmacological agents such as zinc remains limited, and variability in treatment protocols underscores the need for further research to clarify the role of such supportive interventions [11,12].

Given this background, the present study was undertaken to assess the efficacy of oral zinc therapy in reducing serum bilirubin among term neonates with jaundice undergoing phototherapy, and to determine its effect on the duration of phototherapy and hospital stay.

Materials And Methods

Study design and setting: This was a case-control study conducted in the Department of Pediatrics, Government Medical College and associated group of hospitals over a period of one year and one month (1 March 2025 to 31 March 2026), after approval from the Institutional Ethics Committee and Research Review Board.

Study population: Term neonates (37–41 weeks gestation) admitted with neonatal jaundice undergoing phototherapy were included. Neonates having Direct hyperbilirubinemia; systemic illness or severe sepsis; severe respiratory disease or oral intolerance; major congenital malformations; early discharge, discontinuation of therapy or loss to follow-up; jaundice of less than 24 hours or more than 7 days duration and refusal for consent were excluded from the study.

The sample size was calculated using the formula $N = 2SD^2(Z\alpha/2 + Z\beta)^2/d^2$, using a standard deviation of 2.854 and an effect size of 1.74 from a previous study [1], at 95% confidence and 80% power. The calculated size of 84 was rounded to 100 (50 per group) to increase precision.

Eligible neonates were enrolled after obtaining informed written parental consent and were randomly divided into two groups of 50 each. Group A (zinc group) received oral zinc supplementation (5 mg/day, once daily, in suspension form) along with standard phototherapy for five days or until bilirubin normalized; Group B (control group) received phototherapy alone. Phototherapy units were of standard specification and calibrated identically for both groups. Breast milk and spoon feeds were given on demand as per NICU protocol. Medication was discontinued, and supportive treatment given, if adverse effects such as vomiting, abdominal distension, diarrhoea, skin rash or irritation occurred.

A structured proforma was used to record baseline characteristics (gestational age, birth weight, total serum bilirubin), serial bilirubin levels, duration of phototherapy, and adverse events. Neonates were assessed twice daily. Serum total and indirect bilirubin were measured at baseline and at 24, 48 and 72 hours after initiation of intervention, and thereafter as required. Phototherapy was discontinued once bilirubin fell below the phototherapy range as per guideline [13].

Outcomes: The primary outcome was reduction in serum bilirubin at 24, 48 and 72 hours. Secondary outcomes were duration of phototherapy, length of hospital and NICU stay and incidence of adverse effects.

Statistical analysis: Data were entered in Microsoft Excel and analysed using SPSS software. Continuous variables were compared using Student's independent-samples t-test and one-way ANOVA; categorical variables were compared using the chi-square test; Pearson's correlation was used to assess association between continuous variables. A p-value ≤ 0.05 was considered statistically significant.

Results

A total of 116 term neonates with neonatal jaundice requiring phototherapy were screened, of whom 16 were excluded as per the eligibility criteria. The remaining 100 eligible neonates were enrolled and divided equally into the zinc group (n=50) and the control group (n=50).

Baseline demographic and clinical characteristics, including gender distribution, gestational age, birth weight, Age at onset of jaundice, mode of delivery, gravida status and feeding pattern were comparable between both groups, (Table 1)

Table 1. Distribution and baseline demographic characteristics of the study population (N=100)

Parameter	Variable	Zinc group (n=50)	Control group (n=50)	p-value
Gender	Male, n (%)	33 (66.0)	34 (68.0)	0.832
	Female, n (%)	17 (34.0)	16 (32.0)	
Gestational age (weeks),	Mean±SD	38.75±1.01	38.75±1.02	0.992
Birth weight (kg)	Mean±SD	2.89±0.35	2.88±0.36	0.960
Age at onset of jaundice (hours)	Mean±SD	39.06±7.55	39.76±7.36	0.640
Mode of delivery	LSCS, n (%)	27 (54%)	26 (52%)	0.841
	NVD (%)	23 (46%)	24 (48%)	
Gravida status	Primigravida, n (%)	20 (40.0)	19 (38.0)	0.838
	Multigravida, n (%)	30 (60.0)	31 (62.0)	
Feeding status	Formula feeding, n (%)	14 (28.0)	15 (30.0)	0.0917
	Mixed feeding, n (%)	17 (34.0)	18 (36.0)	

Serial assessment showed a progressive decline in bilirubin levels in both groups, with a significantly greater decline in the zinc group at all post-intervention intervals (Table 2).

Table 2. Serial total and indirect serum bilirubin levels between study groups (mg/dL, Mean±SD)

Time interval	Zinc group (n=50)	Control group (n=50)	p-value
Total bilirubin – Before intervention	17.22±1.52	17.30±1.52	0.723
Total bilirubin – 24 hours	15.09±1.15	15.90±1.34	<0.001
Total bilirubin – 48 hours	11.53±0.94	13.40±1.19	<0.001
Total bilirubin – 72 hours	8.29±0.73	10.30±1.04	<0.001
Indirect bilirubin – Before intervention	16.47±1.36	16.57±1.36	0.714
Indirect bilirubin – 24 hours	14.34±0.99	15.18±1.19	<0.001
Indirect bilirubin – 48 hours	10.85±0.82	12.64±1.07	<0.001
Indirect bilirubin – 72 hours	7.73±0.63	9.68±0.92	<0.001

The absolute reduction in serum bilirubin at each interval was significantly higher in the zinc group (Table 3).

Table 3. Reduction in serum bilirubin between study groups at different time intervals (mg/dL, Mean±SD)

Interval	Zinc group (n=50)	Control group (n=50)	p-value
Reduction at 24 hours	2.13±0.38	1.39±0.18	<0.001
Reduction at 48 hours	5.69±0.59	3.96±0.33	<0.001
Reduction at 72 hours	8.93±0.80	7.02±0.48	<0.001

Duration of phototherapy, hospital stay and NICU stay were significantly shorter in the zinc group, and fewer neonates in this group required extended phototherapy (Table 4).

Table 4. Duration of phototherapy, hospital stay, NICU stay and requirement of extended phototherapy between study groups

Parameter	Zinc group (n=50)	Control group (n=50)	p-value
Duration of phototherapy (hours), Mean±SD	51.0±5.22	70.3±5.27	<0.001
Hospital stay (days), Mean±SD	3.10±0.76	4.18±0.69	<0.001
NICU stay (days), Mean±SD	2.94±0.71	3.70±0.61	<0.001

Extended phototherapy required, n (%)	10 (20.0)	34 (68.0)	<0.001
---------------------------------------	-----------	-----------	--------

Adverse effects were infrequent in both groups and did not differ significantly (Table 5).

Table 5. Adverse effects associated with therapy among study groups (N=100)

Adverse effect	Zinc group (n=50)	Control group (n=50)	p-value
Vomiting, n (%)	3 (6.0)	2 (4.0)	0.646
Diarrhoea, n (%)	3 (6.0)	2 (4.0)	0.646
Skin rash, n (%)	1 (2.0)	1 (2.0)	1.000
Excessive cry, n (%)	2 (4.0)	4 (8.0)	0.400
Irritability, n (%)	2 (4.0)	4 (8.0)	0.400

All neonates in both groups recovered; however, overall clinical improvement was significantly better in the zinc group, with a higher proportion showing excellent improvement and none graded as fair (Table 6).

Table 6. Final clinical outcome and overall clinical improvement between study groups (N=100)

Outcome	Zinc group (n=50)	Control group (n=50)	p-value
Recovered, n (%)	50 (100.0)	50 (100.0)	1.000
Excellent improvement, n (%)	15 (30.0)	0 (0.0)	<0.001
Good improvement, n (%)	35 (70.0)	34 (68.0)	
Fair improvement, n (%)	0 (0.0)	16 (32.0)	

Baseline total serum bilirubin correlated strongly with clinical severity of jaundice, neonates with severe jaundice showing substantially higher baseline levels than those with moderate jaundice (19.2 ± 0.44 vs 16.3 ± 0.65 mg/dL, $p < 0.001$).

Discussion

This case-control study evaluated the effect of oral zinc supplementation, given alongside standard phototherapy, on the reduction of serum bilirubin and related clinical outcomes in term neonates with indirect hyperbilirubinemia. Both groups were well matched at baseline, with comparable neonatal age at admission, gestational age, birth weight, age at onset of jaundice and baseline bilirubin levels (all $p > 0.05$), supporting the validity of intergroup comparison. Equal allocation between intervention and control arms and comparable baseline characteristics have similarly been reported in earlier zinc-supplementation trials, including those by Mandlecha et al [1], Ibrahim Eldesoky et al [2], El-Araby et al [4] and Nikouei et al [14], underscoring the importance of balanced study design when assessing adjunctive therapies for neonatal jaundice.

Males predominated among the enrolled neonates (67.0%), consistent with the male preponderance reported in previous studies on neonatal hyperbilirubinemia, including those by Goodarzi et al [15], Baiomi et al [16] and Boskabadi et al [17], although gender showed no significant association with treatment allocation or outcome in the present or prior studies.

The principal finding of this study was a significantly greater and more rapid decline in both total and indirect serum bilirubin in the oral zinc group compared with the phototherapy-alone group at 24, 48 and 72 hours ($p < 0.001$ at all intervals), with a correspondingly greater absolute reduction at each time point. This is consistent with several previous studies. Mandlecha et al [1] reported significantly lower bilirubin levels in the zinc group at serial intervals compared with placebo; Ibrahim Eldesoky et al [2] similarly observed greater bilirubin reduction with zinc supplementation at 12 and 24 hours and at discharge. Nikouei et al [14] found a substantially greater bilirubin decline at 24 hours in the zinc group compared with placebo, and de Oliveira et al [10], in an updated meta-analysis, reported significant mean differences favouring zinc supplementation at 24, 48 and 72 hours. ElRaggal et al [9] and Hamed et al [7] also reported greater bilirubin reduction with high-dose zinc and zinc-salt supplementation respectively, and Ghadirzadeh et al [18], in a meta-analysis, concluded that zinc supplementation was associated with reduced bilirubin levels, particularly among term neonates. In contrast, El-Araby et al [4] and Alam et al [19] did not find a statistically significant difference in bilirubin reduction between zinc-treated and control groups, illustrating

heterogeneity in the published literature; nonetheless, the consistent and progressive decline observed across all three post-intervention intervals in the present study supports a genuine adjunctive benefit of oral zinc in enhancing bilirubin clearance during phototherapy.

Consistent with this enhanced biochemical response, neonates receiving oral zinc required a significantly shorter duration of phototherapy (51.0 ± 5.22 vs 70.3 ± 5.27 hours, $p < 0.001$), had a markedly lower requirement for extended phototherapy (20.0% vs 68.0%, $p < 0.001$), and had significantly shorter hospital and NICU stay. Similar reductions in phototherapy duration with zinc supplementation have been reported by Mandlecha et al [1], Nikouei et al [14], Ibrahim Eldesoky et al [2] and ElRaggal et al [9], while Hamed et al [7] also reported shorter hospitalization with zinc administration. Shoris et al [20] emphasized the clinical value of strategies that shorten phototherapy exposure given the potential for phototherapy-related adverse effects, further supporting the relevance of the reduction in treatment duration observed here. As with the bilirubin outcomes, El-Araby et al [4] and Alam et al [19] did not observe a significant reduction in phototherapy duration with zinc, reflecting variability in reported outcomes across settings and dosing protocols.

A significant inverse correlation was observed between the magnitude of bilirubin reduction at 72 hours and duration of phototherapy (Pearson's $r = -0.486$, $p < 0.001$), indicating that neonates with greater early bilirubin clearance required a shorter overall duration of treatment. This reinforces the clinical utility of monitoring early treatment response as a predictor of subsequent phototherapy requirement.

Adverse effects, including vomiting, diarrhoea, skin rash, excessive cry and irritability, were infrequent and did not differ significantly between groups, indicating that oral zinc supplementation was well tolerated. This safety profile is consistent with the findings of Mandlecha et al [1], Ibrahim Eldesoky et al [2], El-Araby et al [4], ElRaggal et al [9] and the meta-analysis by Ghadirzadeh et al [18], all of which reported no significant excess of adverse events with zinc supplementation. Baiomi et al [16] and Goodarzi et al [15], however, cautioned that phototherapy itself may raise serum zinc levels and that additional supplementation could theoretically predispose to zinc excess, although overt clinical toxicity was not demonstrated in either their studies or the present one; this highlights an area warranting biochemical monitoring in future research.

Overall clinical improvement was significantly better in the oral zinc group, with 30.0% of neonates showing excellent improvement compared with none in the control group, and no neonate in the zinc group graded as having only fair improvement. This pattern of superior clinical response parallels the findings of Mandlecha et al [1], Ibrahim Eldesoky et al [2], Nikouei et al [14], Hamed et al [7] and de Oliveira et al [10], although, as noted, not all published trials — notably those of El-Araby et al [4] and Alam et al [19] — have demonstrated additional clinical benefit from zinc supplementation.

Baseline total serum bilirubin correlated strongly with clinical severity of jaundice, neonates with severe jaundice showing substantially higher baseline levels than those with moderate jaundice (19.2 ± 0.44 vs 16.3 ± 0.65 mg/dL, $p < 0.001$), consistent with the recognized role of baseline bilirubin concentration as a determinant of disease severity and treatment need, as emphasized in the Standard Treatment Guidelines of the Indian Academy of Pediatrics [13]. Taken together, these findings support the hypothesis that oral zinc, administered as an adjunct to phototherapy, meaningfully accelerates bilirubin clearance and improves treatment-related outcomes in term neonates with indirect hyperbilirubinemia, without an appreciable increase in short-term adverse effects.

This study was conducted at a single tertiary-care teaching hospital with a relatively modest sample size, which may limit generalizability. Only term neonates with indirect hyperbilirubinemia were included; preterm neonates, infants with hemolytic or conjugated hyperbilirubinemia, and those with major congenital anomalies were excluded, limiting applicability to these subgroups. Serum zinc levels were not measured before or after supplementation, precluding assessment of baseline zinc status or biochemical correlation with bilirubin reduction, and neonates were not followed up after discharge, so delayed adverse effects, rebound hyperbilirubinemia and neurodevelopmental outcomes could not be evaluated.

Conclusion

Oral zinc supplementation, when administered as an adjunct to standard phototherapy, significantly enhances the reduction of total and indirect serum bilirubin at 24, 48 and 72 hours, shortens the duration of phototherapy and the need for its extension, and reduces hospital and NICU stay in term neonates with indirect hyperbilirubinemia, without a significant increase in adverse effects, indicating that it is both effective and well tolerated over the short term.

Larger multicentric randomized controlled trials involving diverse neonatal populations, including preterm and low-birth-weight infants, are recommended to validate the efficacy and safety of oral zinc supplementation across varying severities of hyperbilirubinemia.

Conflict of Interest: Nil

Funding: Nil

References

1. Mandlecha TH, Mundada SM, Gire PK, Reddy N, Khaire P, Joshi T, Pawar S. Effect of oral zinc supplementation on serum bilirubin levels in term neonates with hyperbilirubinemia undergoing phototherapy: a double-blind randomized controlled trial. *Indian Pediatrics*. 2023 Dec;60(12):991-5.
2. Ibrahim Eldesoky ME, El-Samannody MI, Elghannam MZ, Elmazahy MM. Effect of zinc supplementation on serum bilirubin level in term neonates undergoing phototherapy. *International Journal of Medical Arts*. 2020 Oct 1;2(4):736-40.
3. Beiranvand S, Hosseinabadi R, Firouzi M, Almasian M, Anbari K. Impact of Combined Oral Zinc Sulfate and Phototherapy on Serum Bilirubin Levels in the Term Neonates with Jaundice. *Iranian Journal of Neonatology*. 2018 Jun 1;9(3).
4. El-Araby HA, Sallam HS, Elsaheed HH, Hussein MH, Abdel Aziz SA. Concomitant oral zinc sulfate and phototherapy versus phototherapy alone in treatment of neonatal indirect hyperbilirubinemia: a randomized clinical trial study. *Annals of Neonatology*. 2024 Jul 1;6(2):18-35.
5. Almarhoon FM, Aljarwan RM, Alzahrani SA, Alotaibi HF, Alshehri AM, Alabdely MH, Alqasim GS, Alhodibi MH. Is Zinc Supplementation Effective in Reducing Neonatal Jaundice? A Systematic Review and Meta-analysis of Randomised Controlled Trials. *Journal of Advanced Trends in Medical Research*. 2024 Jul 1;1(3):961-73.
6. Sharma D, Farahbakhsh N, Sharma P, Shastri S. Role of oral zinc supplementation for reduction of neonatal hyperbilirubinemia: a systematic review of current evidence. *The Journal of Maternal-Fetal & Neonatal Medicine*. 2017 Aug 18;30(16):1953-62.
7. Hamed AM, Ismael AH, Ragab MS. Comparison between oral zinc and agar with phototherapy in the treatment of neonatal jaundice: A prospective clinical trial study. *Annals of Neonatology Journal*. 2022 Jul 1;4(2):204-16.
8. Mosayebi Z, Rahmani M, Ardakani SB, Sheikh M, Shariat M, Rezaeizadeh G. Evaluation of serum zinc levels in hyperbilirubinemic neonates before and after phototherapy. *Iranian Journal of Pediatrics*. 2016 Mar 17;26(3):e4146.
9. ElRaggal NM, Ali HR, Farid YA. Effect of Oral Zinc Sulfate Therapy on the Management of Neonatal Non-Hemolytic Unconjugated Hyperbilirubinemia: A Randomized Control Trial. *Iranian Journal of Neonatology*. 2022 Jul 1;13(3).
10. de Oliveira HM, Gallo Ruelas M, Barbosa LM, Diaz CA, Wegner GR, Wegner BF, da Cruz AV. Zinc sulfate on neonatal hyperbilirubinemia: an updated systematic review and meta-analysis. *European Journal of Pediatrics*. 2024 Dec 13;184(1):79.
11. Yadav A, Sivagnanaganesan S, Meena J, Shamim MA, Yadav J, Kumar J. Zinc Supplementation in Neonatal Hyperbilirubinemia: An Updated Systematic Review and Meta-Analysis of Randomized Controlled Trials. *The Journal of Perinatal & Neonatal Nursing*. 2025 Sep 8:10-97.
12. Hartadi PA, Kinasih KV, Haryasa WS. How do Different Management Strategies (Standard Phototherapy, Intensive Phototherapy, and Pharmacological Interventions) to Neonatal Jaundice?: A Systematic Review. *The International Journal of Medical Science and Health Research*. 2025 Nov 29;20(1):1-39.
13. Standard Treatment Guidelines 2022. Indian Academy of Pediatrics (IAP). Available at: <https://iapindia.org/pdf/Ch-079-Neonatal-Jaundice.pdf> (accessed 16 July 2024).
14. Nikouei M, Cheraghi M, Mansouri M, Hemmatpour S, Moradi Y. The effect of oral zinc sulfate supplementation on hospitalized infants with hyperbilirubinemia: a double-blind randomized clinical trial. *European Journal of Pediatrics*. 2024 Nov;183(11):4649-58.
15. Goodarzi R, Saadat SH, Janbozorgi F, Darban B. Zinc level alternation after phototherapy in neonates with hyperbilirubinemia. *Journal of Parathyroid Disease*. 2023 Jan 4;11(1):e11193.
16. Baiomi AM, Hassan KH, Beshir MA, Mahmoud MH. Effect of phototherapy on serum zinc level in neonatal jaundice. *The Egyptian Journal of Hospital Medicine*. 2020 Oct 1;81(3):1614-20.

17. Boskabadi H, Maamouri G, Zakerihamidi M, Vatanchi AM, Sokhtanloo M, Mousavi MS, Ghahremani S, Bagheri F. Comparison of hyperbilirubinemia incidence between the newborns of zinc-taking and non-zinc-taking mothers during the third trimester of pregnancy. *Caspian Journal of Internal Medicine*. 2021;12(4):521.
18. Ghadirzadeh B, Afshar M, Afraie M, Moradveisi B, Moradi Y. Efficacy of zinc sulfate supplementation in managing neonatal hyperbilirubinemia: a meta-analysis. *The Journal of Maternal-Fetal & Neonatal Medicine*. 2025 Dec 31;38(1):2528696.
19. Alam MS, Khan UU, Singh M, Raza H. Effectiveness of oral zinc sulphate in reducing the serum bilirubin level in neonates having unconjugated hyperbilirubinemia. *Medical Forum Monthly*. 2021;32(5).
20. Shoris I, Gover A, Toropine A, Iofe A, Zoabi-Safadi R, Tsuprun S, Riskin A. "Light" on phototherapy—complications and strategies for shortening its duration, a review of the literature. *Children*. 2023 Oct 17;10(10):1699.