

Fetomaternal outcome in cases of pregnancy with deranged transaminases

Amel Amjad Buttar, Abida Ashraf, Amber Ijaz, Huma Ijaz, Assma Majeed

Combined Military Hospital, Gujranwala Pakistan

ABSTRACT

Objective: To evaluate the fetomaternal outcomes associated with abnormal transaminases in late pregnancy and to identify maternal factors predictive of adverse neonatal outcomes.

Material and Methods: This cross-sectional analytical study was conducted at the Department of Obstetrics & Gynecology, CMH Gujranwala, from 15-10-2025 to 14-01-2026. A total of 110 pregnant women with gestational age ≥ 32 weeks and elevated transaminases were included. SPSS 27 was used for data analysis. Quantitative data were expressed as mean (SD) or median (IQR), and qualitative data as frequencies and percentages. Mann-Whitney U test, independent-samples t-test, and chi-square test were used, with a p-value ≤ 0.05 considered significant.

Results: All participants had elevated transaminases. The median age was 28.0 years and median gestational age was 35.0 weeks. AST levels were significantly higher in women with NICU admission compared to those without ($p=0.005$). ALT levels were also significantly higher in women with NICU admission ($p=0.003$). BMI was significantly higher in women with NICU admission ($p=0.006$). AST was significantly associated with IUGR ($p=0.014$), while ALT showed no significant association ($p=0.086$). Preeclampsia was not significantly associated with IUGR ($p=0.131$) or NICU admission ($p=0.110$). Deranged transaminases, fatty liver disease, cesarean section, and preterm delivery were significantly associated with adverse neonatal outcomes ($p<0.05$).

Conclusion: Elevated maternal AST in late pregnancy is significantly associated with adverse neonatal outcomes, including IUGR and NICU admission. ALT elevation is significantly associated with NICU admission but not with IUGR. Maternal obesity, fatty liver disease, cesarean section, and preterm delivery are significant contributors to adverse outcomes.

Keywords: HELLP syndrome, Intrauterine growth restriction, Transaminases.

This article can be cited as: Buttar AA, Ashraf A, Ijaz A, Ijaz H, Majeed A. Fetomaternal outcome in cases of pregnancy with deranged transaminases. Pak J Pathol. 2026; 37(2): 89-94. DOI: <https://doi.org/10.55629/pakjpathol.v37i2.1004>

INTRODUCTION

Pregnancy-induced liver enzyme abnormalities reflect hepatic dysfunction, affecting 0.56-3% of pregnancies worldwide and are associated with increased fetomaternal risks. Elevation of both aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels typically results from pregnancy-related disorders including preeclampsia (30-57%), HELLP syndrome (6-22%), intrahepatic cholestasis of pregnancy (8-39%), and viral hepatitis [1]. Recent evidence indicates that these biochemical alterations serve as robust predictors of maternal complications, including preterm delivery and the need for intensive care [2,3].

In Pakistan, hepatitis E infection takes the lead (37.2%) as it is the major cause of maternal deaths (11.6%) and fetal losses (39.6%) in 336 recorded

cases, and the presence of preeclampsia/eclampsia (10.4%) and HELLP syndrome worsens the situation [4]. In this area, abnormal LFTs are seen in 9.11% of cases, linked with increased bilirubin and ALT levels with a poor outcome, whereas the presence of HELLP syndrome results in the worst outcome [5]. Enzyme elevations (>10 ULN) affect 0.56% of deliveries in a worldwide population, mostly linked to pregnancy complications (82%), yet no bad results were reported in those cases [6].

Despite the established association between deranged liver enzymes and adverse pregnancy outcomes, there is a paucity of data from the Pakistani population regarding the specific fetomaternal outcomes associated with transaminase elevation in late pregnancy. Furthermore, local clinical protocols for monitoring and managing these high-risk pregnancies remain inconsistent. Therefore, this analytical cross-sectional study was conducted at a tertiary care center in Pakistan to evaluate the fetomaternal outcomes in pregnant women with deranged transaminases and to identify maternal factors significantly associated with adverse neonatal outcomes. The findings will contribute to the development of evidence-based local guidelines for the identification, monitoring, and management of

Correspondence: Dr. Amel Amjad Buttar, Postgraduate Resident, Department of Gynaecology and Obstetrics, Combined Military Hospital, Gujranwala Pakistan

Email: amelamjad16@gmail.com

Receiving Date: 11 Apr 2026

Revision Date: 25 May 2026

Acceptance Date: 27 Jun 2026



Copyright © 2026. Amel Amjad Buttar, et al. This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License, which permits unrestricted use, distribution & reproduction in any medium provided that original work is cited properly.

high-risk pregnancies complicated by abnormal liver function tests.

MATERIAL AND METHODS

The research was performed as an analytical cross-sectional study in the Department of Obstetrics and Gynecology at CMH Gujranwala over three months (15-10-2025 to 14-01-2026). The study was approved by the institutional ethical review committee (ERB # 02-24 dated 19-03-2024). Pregnant women aged 18 to 40 years, with gestational age more than 32 weeks, with parity ≤ 4 (i.e., fewer than 5 previous deliveries), and having elevated transaminases (ALT >56 IU/L and AST >40 IU/L in the third trimester) were included. Women suffering from chronic liver disease or those having drug-induced abnormal liver function tests, along with HIV, Hepatitis B, or C-infected individuals, were excluded.

A total of 110 pregnant women were included in the study through non-probability consecutive sampling. The sample size was estimated with the aid of the WHO sample size calculator by using a 95% confidence level, a 5% absolute precision, and the expected prevalence of preterm birth of 7.5% among women with abnormal liver function tests [7].

After informed consent was obtained, the outpatient department of the hospital admitted the eligible participants. For each participant, demographic details such as age, gestational age, BMI, parity, place of residence, booking status, lifestyle, diet pattern, and socioeconomic status were documented. A single measurement of AST and ALT was performed at the time of enrollment for each participant. Clinical diagnosis for preeclampsia was made based on blood pressure measurement (systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg on two occasions at least 4 hours apart) and urine dipstick testing (proteinuria $\geq 1+$ or ≥ 300 mg/24 hours). while ultrasound was used to identify acute fatty liver of pregnancy and intrauterine growth restriction. The labor room was then notified when labor was advised after following up in the antenatal clinic until the onset of delivery.

At the time of presentation, the gestational age and delivery type were recorded. Preterm birth was defined as delivery before 37 completed weeks of gestation. Neonatal outcomes such as Apgar score at 5 minutes and the need for NICU admission were assessed immediately after birth. All maternal and fetal outcomes were recorded in a structured proforma.

In SPSS version 27, statistical analysis was completed using the appropriate methods based on

the dataset type. Quantitative data were summarized either by the mean $\pm$ SD (for BMI, which was normally distributed) or by median with IQR (for age, gestational age, AST/ALT levels, and systolic and diastolic blood pressure, which were non-normally distributed). Qualitative data were expressed as percentages or frequencies. The data were assessed for normality using the Shapiro-Wilk test. Based on the normality assessment, the following specific statistical tests were employed:

1. **Shapiro-Wilk test** was used to assess the normality of distribution for all continuous variables (age, gestational age, BMI, AST, ALT, systolic BP, diastolic BP).
2. **Independent-samples t-test** was used to compare normally distributed continuous variables (BMI) between two independent groups (e.g., NICU admission: Yes vs. No; IUGR: Yes vs. No).
3. **Mann-Whitney U test** was used to compare non-normally distributed continuous variables (age, gestational age, AST, ALT, systolic BP, diastolic BP) between two independent groups.
4. **Chi-square test** was used to compare categorical variables (e.g., booking status, lifestyle, presence of symptoms, preeclampsia, fatty liver disease, mode of delivery, preterm delivery) between outcome groups (IUGR: Yes vs. No; NICU admission: Yes vs. No).
5. **Descriptive statistics** (mean $\pm$ SD for normally distributed variables; median with IQR for non-normally distributed variables; frequencies with percentages for categorical variables) were used to summarize the demographic and clinical characteristics of the study population.

RESULTS

The demographic and clinical characteristics of the study population are summarized in Table-I. All participants (100%) had elevated transaminase levels as per inclusion criteria. The median (IQR) age was 28.0 (12.0) years and median (IQR) gestational age was 35.0 (4.0) weeks. The mean (SD) BMI was 28.81 (5.09) kg/m², indicating obesity. The median (IQR) AST level was 37.35 (18.70) IU/L and median (IQR) ALT level was 39.70 (17.10) IU/L. The median (IQR) systolic blood pressure was 119.0 (19.0) mmHg and median (IQR) diastolic blood pressure was 72.0 (16.0) mmHg.

The demographic and clinical characteristics of the study population are presented in Table-II. The majority of participants were from rural (41.8%) or urban (40.9%) areas, with 76.4% having booked

antenatal care. Sedentary lifestyle was reported by 59.1% of participants, and 70.9% consumed home-cooked meals. Regarding socioeconomic status, 45.5% belonged to the middle class. Clinically, 60.0% presented with pruritus and/or jaundice. Preeclampsia was diagnosed in 12.7%, and fatty liver disease in 1.8%. IUGR was identified in 21.8% of pregnancies. Obstetric outcomes included cesarean section in 32.7%, preterm delivery in 20.0%, and NICU admission in 25.5% of neonates.

Table-III provides evidence of a statistically significant relationship between maternal Body Mass Index (BMI), the level of liver enzymes, and NICU admission for neonates. The mothers of neonates requiring admission to the NICU had a significantly higher maternal BMI [mean (SD): 30.92 (4.54) kg/m²] compared to mothers of neonates not requiring NICU admission [mean (SD): 28.09 (5.09) kg/m²] ($p = 0.006$). Maternal AST levels at the time of delivery were also significantly higher for mothers of neonates requiring NICU admission [median (IQR): 43.70 (20.50) IU/L] than for mothers of neonates not requiring NICU admission [median (IQR): 37.35 (18.70) IU/L] ($p = 0.005$). Finally, when comparing ALT levels, the mothers of neonates requiring NICU

admission had a higher ALT level [median (IQR): 45.70 (18.90) IU/L] than the mothers of neonates not requiring NICU admission [median (IQR): 39.70 (17.10) IU/L] ($p = 0.003$).

In Table-IV, the maternal liver enzymes show a relationship with the presence of intrauterine growth restriction (IUGR). AST levels were significantly higher in the IUGR group compared to the non-IUGR group [median (IQR): 45.20 (19.50) vs 37.35 (18.70) IU/L; $p = 0.014$]. ALT levels were higher in the IUGR group [median (IQR): 42.80 (18.20) vs 39.70 (17.10) IU/L], however this difference did not reach statistical significance ($p = 0.086$).

IUGR was strongly related to booking status ($p = 0.019$), lifestyle choice ($p = 0.015$), presence of symptoms ($p = 0.008$), fatty liver disease ($p = 0.007$), cesarean section ($p = 0.002$), and preterm delivery ($p = 0.003$) according to Table-V of this report. Preeclampsia showed no significant association with IUGR ($p = 0.131$). NICU admissions were significantly related to presence of symptoms ($p < 0.001$), fatty liver disease ($p = 0.015$), cesarean deliveries ($p = 0.024$), and preterm births ($p < 0.001$). Preeclampsia showed no significant association with NICU admission ($p = 0.110$).

Table-I: Descriptive statistics of continuous demographical and clinical variables (n=110).

Variable	Median (IQR)	Mean (SD)
Age (years)	28.00 (12.00)	—
Gestational Age (weeks)	35.00 (4.00)	—
BMI (kg/m ²)	—	28.81 (5.09)
AST (IU/L)	37.35 (18.70)	—
ALT (IU/L)	39.70 (17.10)	—
Systolic BP (mmHg)	119.00 (19.00)	—
Diastolic BP (mmHg)	72.00 (16.00)	—

Median (IQR) reported for non-normal variables.

Table-II: Descriptive statistics of categorical demographical and clinical variables (n=110).

Variable	Category	n	%
Residence	Rural	46	41.8
	Semi-urban	19	17.3
	Urban	45	40.9
Booking Status	Booked	84	76.4
	Un-booked	26	23.6
Lifestyle	Active	45	40.9
	Sedentary	65	59.1
Diet Pattern	Fast-food	17	15.5
	Home-made	78	70.9
	Street-food	15	13.6
Socioeconomic Status	Low	18	16.4
	Middle	42	38.2
	High	50	45.5
Presence of symptoms (pruritic, jaundice)	Yes	66	60.0
	No	44	40.0
Preeclampsia	Yes	14	12.7
	No	96	87.3
Fatty Liver Disease	Yes	2	1.8
	No	108	98.2
IUGR	Yes	24	21.8
	No	86	78.2
Cesarean Section	Yes	36	32.7

Preterm Delivery	No	74	67.3
	Yes	22	20.0
NICU Admission	No	88	80.0
	Yes	28	25.5
	No	82	74.5

Table-III: Comparison of maternal BMI, AST, and ALT with NICU admission status (n=110).

Variable	NICU Admission: Yes (n=28)	NICU Admission: No (n=82)	p-value*
BMI (kg/m ²), Mean (SD)	30.92 (4.54)	28.09 (5.09)	0.006
AST (IU/L), Median (IQR)	43.70 (20.50)	37.35 (18.70)	0.005
ALT (IU/L), Median (IQR)	45.70 (18.90)	39.70 (17.10)	0.003

*Independent-samples t-test for BMI; Mann-Whitney U test for AST and ALT. p-value < 0.05 is statistically significant.

Table-IV: Comparison of maternal AST and ALT with IUGR status (n=110).

Variable	IUGR Present (n=24)	IUGR Absent (n=86)	p-value*
AST (IU/L), Median (IQR)	45.20 (19.50)	37.35 (18.70)	0.014
ALT (IU/L), Median (IQR)	42.80 (18.20)	39.70 (17.10)	0.086**

*Mann-Whitney U test. p-value < 0.05 is statistically significant.

**Not statistically significant.

Table-V: Association between maternal variables and fetomaternal outcomes (n=110).

Maternal Variable	IUGR (n=24) n (%)	No IUGR (n=86) n (%)	p-value*	NICU Admission (n=28) n (%)	No NICU (n=82) n (%)	p-value*
Booking Status						
Booked	20 (83.3)	64 (74.4)	0.019	22 (78.6)	62 (75.6)	0.121
Un-booked	4 (16.7)	22 (25.6)		6 (21.4)	20 (24.4)	
Lifestyle						
Active	8 (33.3)	37 (43.0)	0.015	9 (32.1)	36 (43.9)	0.137
Sedentary	16 (66.7)	49 (57.0)		19 (67.9)	46 (56.1)	
Symptoms (pruritus/jaundice)						
Yes	14 (58.3)	52 (60.5)	0.008	19 (67.9)	47 (57.3)	<0.001
No	10 (41.7)	34 (39.5)		9 (32.1)	35 (42.7)	
Preeclampsia						
Yes	8 (33.3)	6 (7.0)	0.131**	8 (28.6)	6 (7.3)	0.110**
No	16 (66.7)	80 (93.0)		20 (71.4)	76 (92.7)	
Fatty Liver Disease						
Yes	2 (8.3)	0 (0.0)	0.007	2 (7.1)	0 (0.0)	0.015
No	22 (91.7)	86 (100)		26 (92.9)	82 (100)	
Cesarean Section						
Yes	14 (58.3)	22 (25.6)	0.002	12 (42.9)	24 (29.3)	0.024
No	10 (41.7)	64 (74.4)		16 (57.1)	58 (70.7)	
Preterm Delivery						
Yes	14 (58.3)	8 (9.3)	0.003	16 (57.1)	6 (7.3)	<0.001
No	10 (41.7)	78 (90.7)		12 (42.9)	76 (92.7)	

*Chi-square test. **Not statistically significant (p>0.05)

DISCUSSION

This study investigated fetomaternal outcomes associated with deranged transaminases in late pregnancy at a tertiary care center in Pakistan. The cohort comprised 110 pregnant women with elevated transaminases. Obesity is reflected in BMI of 28.81 (5.09) kg/m², which is clinically significant due to synergy between obesity and liver disease on pregnancy.

The primary conclusion is a significant relationship between high transaminases and negative neonatal outcomes, especially NICU admission. There was a significant difference in AST and ALT levels of mothers whose neonates required NICU admission (p=0.005, p=0.003). These results align with literature

indicating liver enzyme problems as indicators of placental and systemic maternal inflammation.

Our cohort's high BMI (28.81 kg/m²) is considerably higher than 24.48 kg/m² recorded in ICP from Eastern India [8]. Clinical relevance is illustrated by significant correlation between BMI and NICU admission (p=0.006). Similar findings regarding increased risks of caesarian delivery (48%), gestational diabetes (30%), preeclampsia (24%), and NICU admission (28%) were found by Mou and Ali [8]. Higher BMI-NICU association in our case (vs 5.68% in Chilaka *et al.* [9]) indicates maternal obesity could independently predict poor outcomes, consistent with Greiner *et al.* [10].

Compared to Fondjo *et al.* [11], our cohort had lower AST (37.35 IU/L) and ALT (39.70 IU/L) but similar

predictive value. Guszczynska-Losy *et al.* [12] recommended ALT 151.5 IU/L as cutoff for adverse outcome. Though our median ALT for NICU infants was below at 45.70 IU/L, association remained significant ($p=0.003$), suggesting lower ALT levels are clinically meaningful in high-risk populations.

IUGR prevalence (21.8%) was higher than 16% reported by Lefizelier *et al.* [13] but lower than 46% in HELLP syndrome. BMI difference (28.81 vs 24.48 kg/m²) might explain this. IUGR correlated with AST ($p=0.014$) but not ALT ($p=0.086$). AST may be more sensitive to placental dysfunction. Preeclampsia rate (12.7%) was similar to other Asian/Mexican groups but lower than 18.6% in sub-Saharan Africa [13,14]. Preterm delivery (20.0%) was lower than 32.95% reported by Morton [15] and Tesfa [16] in ICP cohorts, reflecting lower ICP/AFLP proportion (1.8%) in our population [17,18]. However, 20% exceeds general population rate of 7-10%, highlighting clinical impact. Cesarean section rate (32.7%) was intermediate between Nairz *et al.*'s [19] abnormal LFT group (49.1%) and normal LFT group (27.6%), suggesting transaminase elevation influences delivery mode independently.

NICU admission (25.5%) was substantially higher than 5.68% reported by Chilaka *et al.* [9] and comparable to severe preeclampsia (21.3-21.8%) [20-22]. Zhang *et al.* [20] reported ALT/AST cut-offs of 64/66 IU/L predicted complications with 88-90% sensitivity. Our median ALT for NICU neonates (45.70 IU/L) was below these thresholds, yet association remained significant, indicating moderate elevations are clinically meaningful in high-risk populations.

Preeclampsia showed no significant association with IUGR ($p=0.131$) or NICU admission ($p=0.110$), diverging from existing literature. This may be due to small sample size ($n=110$) and limited preeclampsia cases ($n=14$), inclusion criteria selecting non-preeclampsia etiologies, or cross-sectional design precluding temporal assessment. These findings require larger prospective studies for confirmation.

LIMITATIONS

However, several limitations must be considered. First, since it is a cross-sectional study, it does not allow making any conclusions about causality. Second, being single-center, the study lacks generalizability. Third, because the sample size ($n = 110$) is too small compared to the number of confounders, multivariable logistic regression analysis cannot be performed. It means that the results found might be impacted by factors such as maternal age, BMI, preeclampsia, and gestational

age. Fourth, there was no access to bile acids, a gold standard for intrahepatic cholestasis of pregnancy diagnosis. Moreover, a retrospective data collection method used for some variables can be linked to possible information bias. Fifth, the prevalence of fatty liver disease/AFLP found in our cohort (1.8%) is lower compared to other sources. Sixth, the association between the elevation in enzymes and development of outcomes cannot be examined.

CONCLUSION

In summary, maternal increased AST during the third trimester is strongly linked with negative neonatal outcomes like IUGR and NICU admissions. On the other hand, increased ALT is significantly correlated with NICU admissions but not with IUGR. Maternal characteristics such as fatty liver disease, caesarean delivery, and preterm birth are significantly linked with poor outcomes. There were no statistically significant links between preeclampsia and IUGR or NICU admissions. Despite the cross-sectional study design preventing cause-and-effect conclusions from being drawn, the results emphasize the role that transaminase measurements in the third trimester play in determining at-risk pregnancies. Further research should be conducted with multicenter prospective studies.

CONFLICT OF INTEREST

None

GRANT SUPPORT & FINANCIAL DISCLOSURE

Declared none

AUTHORS CONTRIBUTION

Amel Amjad Buttar: Substantial contribution to study design, acquisition of data, manuscript writing, final approval, responsible for every aspect of the research

Abida Ashraf: Substantial contribution to acquisition of data, critical review, final approval, responsible for every aspect of the research

Amber Ijaz: Substantial contribution to analysis and interpretation of data, critical review, final approval, responsible for every aspect of the research

Huma Ijaz: Substantial contribution to concept, critical review, final approval, responsible for every aspect of the research

Assma Majeed: Substantial contribution to study design, acquisition of data, critical review, final approval, responsible for every aspect of the research

REFERENCES

1. Butt N, Ali S, Yasmeen H, Mumtaz K. Outcomes of liver diseases in pregnant females: A study from

- a tertiary care medical center in Pakistan. *Pak J Med Sci* [Internet]. 2023 Dec. 28 [cited 2026 Jul. 1];40(3). Available from: <https://www.pjms.org.pk/index.php/pjms/article/view/7670>
2. Dinçgez B, Özgen G, Özgen L. Comparison of the predictive role of first-trimester APRI score and De Ritis ratio in intrahepatic cholestasis of pregnancy. *J Contemp Med*. 2024; 14(5): 222-7. Available from: <https://dergipark.org.tr/tr/download/article-file/4153536>
 3. Goins EC, Wein LE, Watkins VY, Campbell AIK, Heine RP, Hughes BL, *et al*. Maternal and neonatal outcomes in patients with hepatitis C and intrahepatic cholestasis of pregnancy: The sum of the parts. *PLoS One*. 2023; 18(10): e0293030. DOI: <https://doi.org/10.1371/journal.pone.0293030>
 4. Akhtar A, Sarwar A, Ebaid ME, Albalawi D, Iqbal S, Rehman FU, *et al*. Hepatitis E-associated determinants and diagnostic biomarkers during pregnancy and its prenatal consequences in Multan, Punjab, a tertiary care setting (Pakistan). *Am J Transl Res*. 2024; 16(5): 2049-58. DOI: <https://doi.org/10.62347/slwm5449>
 5. Meng Z, Fang W, Meng M, Zhang J, Wang Q, Qie G, *et al*. Risk factors for maternal and fetal mortality in acute fatty liver of pregnancy and new predictive models. *Front Med (Lausanne)*. 2021; 8: 719906. DOI: <https://doi.org/10.3389/fmed.2021.719906>
 6. Sapmaz MA, Erbey S, Polat M, Kurt A, Kurt DS, Yücel KY, *et al*. The impact of biochemical marker levels in pregnant patients diagnosed with HELLP syndrome on predicting the progression and recovery timelines. *Eur Res J*. 2025; 11(5): 868-77. DOI: <https://doi.org/10.18621/eurj.1681181>
 7. Bahadur A, Mundhra R, Kashibhatla J, Chawla L, Rajput R, Zaman R, *et al*. Clinical spectrum and outcome of pregnancy with liver diseases: A prospective study. *J Family Med Prim Care*. 2022; 11: 6458-63. DOI: <https://doi.org/10.4103/jfmpc.jfmpc.222.22>
 8. Mou AD, Ali N. Investigating the prevalence and associated factors of elevated liver enzymes and dyslipidemia during pregnancy. *Sci Rep*. 2025; 15(1): 3967. doi: <https://doi.org/10.1038/s41598-025-88798-4>
 9. Chilaka VN, Bashir M, Ahmed B, Konje JC. Acute liver disorders in the third trimester—AFLP, HELLP and infectious hepatitis—update on pathology, diagnosis and management. *Obstet Gynaecol*. 2025; 27(3): 180-96. DOI: <https://doi.org/10.1111/tog.12989>
 10. Greiner KS, Rincón M, Derrah KL, Burwick RM. Elevated liver enzymes and adverse outcomes among patients with preeclampsia with severe features. *J Matern Fetal Neonatal Med*. 2023; 36(1): 2160627. DOI: <https://doi.org/10.1080/14767058.2022.2160627>
 11. Fondjo LA, Amoah B, Annan JJ, Adu-Gyamfi EA, Asamaoh EA. Hematobiochemical variability and predictors of new-onset and persistent postpartum preeclampsia. *Sci Rep*. 2022; 12(1): 3583. DOI: <https://doi.org/10.1038/s41598-022-07509-5>
 12. Guszczynska-Losy M, Wirstlein PK, Wender-Ozegowska E, Kedzia M. Evaluation of predictive value of biochemical markers for adverse obstetric outcomes in pregnancies complicated by cholestasis. *Ginekol Pol*. 2020; 91(5): 269-76. DOI: <https://doi.org/10.5603/gp.2020.0058>
 13. Lefizelier E, Misbert E, Brooks M, Le Thuaat A, Winer N, Ducarme G. Preterm birth and small-for-gestational-age neonates among pre-pregnancy underweight women: A case-controlled study. *J Clin Med*. 2021; 10(24): 5733. DOI: <https://doi.org/10.3390/jcm10245733>
 14. Ang SX, Chen CP, Sun FJ, Chen CY. Comparison of maternal and neonatal outcomes between acute fatty liver of pregnancy and hemolysis, elevated liver enzymes, and low platelets syndrome: a retrospective cohort study. *BMC Pregnancy Childbirth*. 2021;21(1):294. DOI: <https://doi.org/10.1186/s12884-021-03761-1>
 15. Morton A. Markedly elevated liver enzymes in pregnancy: A 10-year review of cases in a tertiary maternal hospital in Brisbane, Australia. *Obstet Med*. 2025; 18(1): 29-32. DOI: <https://doi.org/10.1177/1753495x231226339>
 16. Tesfa D, Tadege M, Digssie A, Abebaw S. Intrauterine growth restriction and its associated factors in South Gondar zone hospitals, Northwest Ethiopia, 2019. *Arch Public Health*. 2020; 78: 89. DOI: <https://doi.org/10.1186/s13690-020-00475-2>
 17. Yang L, Feng L, Huang L, Li X, Qiu W, Yang K, *et al*. Maternal factors for intrauterine growth retardation: Systematic review and meta-analysis of observational studies. *Reprod Sci*. 2023; 30(6): 1737-45. DOI: <https://doi.org/10.1007/s43032-021-00756-3>
 18. Rogozińska E, Marlin N, Jackson L, Rayanagoudar G, Ruifrok AE, Dodds J, *et al*. Effects of antenatal diet and physical activity on maternal and fetal outcomes: individual patient data meta-analysis and health economic evaluation. *Health Technol Assess*. 2017; 21(41): 1-158. DOI: <https://doi.org/10.3310/hta21410>
 19. Nairz J, Messner A, Kiechl SJ, Winder B, Hochmayr C, Egger AE, *et al*. Determinants of non-alcoholic fatty liver disease in young people: maternal, neonatal, and adolescent factors. *PLoS One*. 2024; 19(2): e0298800. DOI: <https://doi.org/10.1371/journal.pone.0298800>
 20. Zhang Y, Sheng C, Wang D, Chen X, Jiang Y, Dou Y, *et al*. High-normal liver enzyme levels in early pregnancy predispose the risk of gestational hypertension and preeclampsia: a prospective cohort study. *Front Cardiovasc Med*. 2022; 9: 963957. DOI: <https://doi.org/10.3389/fcvm.2022.963957>
 21. Sun Q, Lao TT, Du M, Xie B, Sun Y, Bai B, *et al*. Chronic maternal hepatitis B virus infection and pregnancy outcome: A single center study in Kunming, China. *BMC Infect Dis*. 2021;21(1):253. DOI: <https://doi.org/10.1186/s12879-021-05946-7>
 22. Sultana R, Humayun S, Manzoor S, Humayun S. Pregnancy outcome in acute viral hepatitis E. *Ann King Edw Med Univ*. 2022; 28(1): 33-8. DOI: <https://doi.org/10.21649/akemu.v28i1.5006>