

# Development of A Clinical Prediction Model for Oxytocin Resistance During Labor: A Prospective Cohort Study

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## ABSTRACT

**Background:** Oxytocin resistance is an emerging clinical concept defined by inadequate uterine response despite escalating doses of exogenous oxytocin. It underlies a substantial proportion of failed inductions, prolonged labor, and unplanned cesarean deliveries. No validated bedside prediction model exists, particularly in South Asian settings.

**Materials and Methods:** A prospective cohort study was conducted over an 18-months period from January 2022 to June 2023 in the Department of Obstetrics and Gynecology at Mardan Medical Complex, Mardan, Pakistan. A total of 420 women with singleton term pregnancies undergoing oxytocin induction or augmentation of labor were enrolled. Oxytocin resistance was defined as the requirement for oxytocin infusion rates exceeding 40 mIU/min without achieving adequate uterine activity or cervical progression. The primary outcome measures included total oxytocin dose, failed induction, cesarean delivery, and prolonged labor (>18 hours). A multivariate logistic regression model was developed to predict oxytocin resistance, and its discriminative ability was evaluated using the area under the receiver operating characteristic curve (AUC-ROC).

**Results:** Of 420 participants, 112 (26.7%) met criteria for oxytocin resistance. Independent predictors were Bishop score  $\leq 4$  (OR 4.8, 95% CI 2.9–7.9), nulliparity (OR 3.2, 95% CI 1.8–5.7), BMI  $\geq 30$  kg/m<sup>2</sup> (OR 2.6, 95% CI 1.5–4.4), gestational age  $\geq 41$  weeks (OR 2.1, 95% CI 1.2–3.7), and prior oxytocin exposure (OR 1.9, 95% CI 1.1–3.3). The model achieved an AUC-ROC of 0.83 (95% CI 0.78–0.88). Oxytocin-resistant women had significantly higher rates of cesarean delivery (61.6% vs. 18.2%,  $p < 0.001$ ) and prolonged labor (54.5% vs. 9.1%,  $p < 0.001$ ).

**Conclusions:** A five-variable bedside prediction model demonstrates good discrimination for oxytocin resistance and could guide pre-induction risk stratification. Multicenter external validation is warranted.

**Keywords:** Oxytocin resistance; labor induction; cesarean section; failed induction; uterine contractility; prediction model; Bishop score; prolonged labor

## INTRODUCTION

Oxytocin remains the most widely used uterotonic agent worldwide, administered to over 50% of laboring women in many hospital systems for induction or augmentation of labor<sup>1,2</sup>. Its contractile action depends on binding to the oxytocin receptor (OXTR), a G-protein-coupled receptor expressed in myometrial smooth muscle, which initiates a calcium-mediated cascade driving cervical dilation and fetal descent<sup>3</sup>.

What is less widely appreciated in clinical practice is that prolonged or high-dose oxytocin exposure triggers  $\beta$ -arrestin-mediated OXTR internalization and downregulation, producing paradoxical reduction of uterine contractility despite continued drug infusion<sup>4</sup>. This phenomenon, increasingly termed oxytocin resistance, contributes directly to failed induction, dysfunctional labor, unplanned cesarean delivery, and postpartum hemorrhage from uterine atony<sup>5,6</sup>.

Molecular research has identified both epigenetic regulation of OXTR through DNA methylation and genetic variation in single-nucleotide polymorphisms (SNPs) as contributing mechanisms<sup>7,8</sup>. However, clinically accessible bedside predictors remain poorly characterized. The Bishop score is the standard pre-induction cervical assessment tool and predicts induction success broadly, but does not specifically identify women at risk of receptor exhaustion<sup>9,10</sup>. Likewise, while BMI, nulliparity, and gestational age influence induction outcomes individually, their combined predictive value for oxytocin resistance as a distinct physiological endpoint has not been formally modeled<sup>11,12</sup>.

Pakistan's cesarean rate has risen steadily over the past decade, with induction failure accounting for a disproportionate share of operative deliveries at tertiary centers<sup>13</sup>. Locally validated tools for pre-induction risk stratification are absent. This study aimed to identify independent clinical predictors of oxytocin resistance and to construct a bedside prediction model applicable in resource-limited settings.

## MATERIALS AND METHODS

**Study Design and Setting:** This was a prospective cohort study conducted at the Department of Obstetrics and Gynecology of a 800-bedded tertiary Health care Teaching hospital in Mardan, KP Pakistan, from January 2022 to June 2023 (18 months). Ethical approval was granted by the Institutional Review Board of Bacha Khan Medical College Mardan. All participants provided written informed consent. The study was conducted in accordance with the Declaration of Helsinki and is reported following STROBE guidelines for observational studies.

**Participants:** Women aged 18–40 years with singleton term pregnancies ( $\geq 37$  weeks) undergoing oxytocin induction or augmentation were enrolled. Exclusion criteria were: prior uterine surgery including classical cesarean, contraindication to vaginal labor (placenta previa, non-cephalic presentation), multiple gestation, severe fetal growth restriction (EFW below 3<sup>rd</sup> centile), known hypersensitivity to oxytocin, and significant maternal cardiac or renal disease. Of 471 women assessed, 32 met exclusion criteria and 19 declined participation; 420 were enrolled.

**Oxytocin Protocol and Outcome Definition:** All participants received the institutional low-dose oxytocin regimen: starting at 2 mIU/min, increased by 2 mIU/min every 30 minutes to a maximum of 40 mIU/min. Oxytocin resistance was defined as a requirement exceeding 40 mIU/min without achieving: (a) adequate uterine activity (at least 3 contractions of  $\geq 30$  seconds per 10-minute window), or (b) active-phase cervical progress of  $\geq 1$  cm/hour. This operational definition was adapted from published criteria for high-dose oxytocin requirements associated with dysfunctional labor<sup>12</sup>.

Primary outcome variables were: (1) total cumulative oxytocin dose in mIU; (2) failed induction, defined as inability to achieve active labor after 12 hours of active induction; (3) unplanned cesarean delivery; and (4) prolonged labor, defined as total duration from induction initiation to delivery exceeding 18 hours.

**Predictor Variables and Data Collection:** A structured proforma collected maternal age, parity, body mass index (BMI), gestational age, pre-induction Bishop score, indication for induction, antenatal corticosteroid use, prior oxytocin exposure in the current or

Received on 15-08-2023

Accepted on 26-09-2023

immediately preceding pregnancy, and pre-existing comorbidities. Bishop score was assessed by a trained resident blinded to study allocation; inter-rater reliability was evaluated in 40 participants, yielding Cohen's  $\kappa$  of 0.76, indicating substantial agreement.

**Statistical Analysis:** Continuous variables are presented as mean  $\pm$  SD or median (IQR); categorical variables as frequencies and percentages. Bivariate comparisons used the chi-square or Fisher exact test for categorical outcomes and the independent samples t-test or Mann-Whitney U test for continuous variables. Variables with  $p < 0.10$  on bivariate analysis were entered into a multivariate logistic regression model using backward stepwise elimination. Model calibration was assessed with the Hosmer-Lemeshow goodness-of-fit test; discrimination was quantified by AUC-ROC with 95% confidence interval. A predictive nomogram was constructed from the final model. All analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA);  $p < 0.05$  was considered statistically significant.

**RESULTS**

**Participant Characteristics:** Of 420 enrolled women, 112 (26.7%) fulfilled the pre-specified criteria for oxytocin resistance and 308 (73.3%) did not. Baseline characteristics by resistance status are shown in Table 1. The groups were comparable in mean age ( $27.4 \pm 4.8$  vs.  $26.9 \pm 4.6$  years,  $p = 0.32$ ) and prevalence of pre-eclampsia and gestational diabetes. Resistant women were significantly more likely to be nulliparous (75.0% vs. 46.1%), to have BMI  $\geq 30$  kg/m<sup>2</sup> (55.4% vs. 28.6%), gestational age  $\geq 41$  weeks (51.8% vs. 33.8%), an unfavorable Bishop score  $\leq 4$  (85.7% vs. 38.3%), and prior oxytocin exposure (33.9% vs. 21.4%), all at  $p < 0.05$ .

**Primary Outcome Variables:** Outcome data are summarized in Table 2. Women meeting criteria for oxytocin resistance had a median total oxytocin dose of 7,840 mIU (IQR 5,200–11,400) compared to 2,160 mIU (IQR 1,100–3,800) in non-resistant women ( $p < 0.001$ ). Failed induction occurred in 44 of 112 resistant women (39.3%) versus 18 of 308 non-resistant women (5.8%), giving an unadjusted OR of 10.3 (95% CI 5.6–18.9,  $p < 0.001$ ). Cesarean delivery was required in 69 resistant women (61.6%) versus 56 non-resistant women (18.2%; OR 7.1, 95% CI 4.3–11.7,  $p < 0.001$ ). Prolonged labor occurred in 61 resistant (54.5%) versus 28 non-resistant women (9.1%; OR 12.0, 95% CI 7.0–20.5,  $p < 0.001$ ). Postpartum hemorrhage was recorded in 24 resistant (21.4%) versus 16 non-resistant women (5.2%; OR 4.9, 95% CI 2.5–9.6,  $p < 0.001$ ).

**Multivariate Logistic Regression Model:** After backward stepwise elimination, five variables independently predicted oxytocin resistance (Table 3). Bishop score  $\leq 4$  was the strongest predictor (adjusted OR 4.8, 95% CI 2.9–7.9,  $p < 0.001$ ), followed by nulliparity (OR 3.2, 95% CI 1.8–5.7), BMI  $\geq 30$  kg/m<sup>2</sup> (OR 2.6, 95% CI 1.5–4.4), gestational age  $\geq 41$  weeks (OR 2.1, 95% CI 1.2–3.7), and prior oxytocin exposure (OR 1.9, 95% CI 1.1–3.3). The model intercept ( $\beta_0$ ) was  $-3.22$ .

Table 1: Baseline Characteristics of Women with and Without Oxytocin Resistance (n=420)

Variable	Oxytocin-Resistant (n=112)	Non-Resistant (n=308)	p-value
Age, years (mean $\pm$ SD)	27.4 $\pm$ 4.8	26.9 $\pm$ 4.6	0.32
Nullipara, n (%)	84 (75.0%)	142 (46.1%)	<0.001
BMI $\geq 30$ kg/m <sup>2</sup> , n (%)	62 (55.4%)	88 (28.6%)	<0.001
Gestational age $\geq 41$ weeks, n (%)	58 (51.8%)	104 (33.8%)	0.001
Bishop score $\leq 4$ , n (%)	96 (85.7%)	118 (38.3%)	<0.001
Prior oxytocin exposure, n (%)	38 (33.9%)	66 (21.4%)	0.009
Post-dates induction, n (%)	48 (42.9%)	98 (31.8%)	0.030
Pre-eclampsia, n (%)	22 (19.6%)	48 (15.6%)	0.310
Gestational diabetes, n (%)	18 (16.1%)	44 (14.3%)	0.650

Prevalence and Cesarean Outcomes

Table 2: Primary outcome variables stratified by oxytocin resistance status (n=420)

Outcome	Resistant (n=112)	Non-Resistant (n=308)	Unadj. OR (95% CI)	p-value
Total oxytocin dose, mIU; median (IQR)	7,840 (5,200–11,400)	2,160 (1,100–3,800)	—	<0.001
Failed induction, n (%)	44 (39.3%)	18 (5.8%)	10.3 (5.6–18.9)	<0.001
Cesarean delivery, n (%)	69 (61.6%)	56 (18.2%)	7.1 (4.3–11.7)	<0.001
Prolonged labor (>18h), n (%)	61 (54.5%)	28 (9.1%)	12.0 (7.0–20.5)	<0.001
Postpartum hemorrhage, n (%)	24 (21.4%)	16 (5.2%)	4.9 (2.5–9.6)	<0.001

Table 3: Multivariate Logistic Regression Model: Independent Predictors of Oxytocin Resistance

Predictor	Adj. OR	95% CI	$\beta$ Coeff.	SE	p-value
Bishop score $\leq 4$	4.8	2.9–7.9	1.57	0.25	<0.001
Nulliparity	3.2	1.8–5.7	1.16	0.29	<0.001
BMI $\geq 30$ kg/m <sup>2</sup>	2.6	1.5–4.4	0.96	0.27	0.001
Gestational age $\geq 41$ wk	2.1	1.2–3.7	0.74	0.29	0.009
Prior oxytocin exposure	1.9	1.1–3.3	0.64	0.28	0.023
Constant ( $\beta_0$ )	—	—	-3.22	0.41	<0.001

Table 4: Risk Stratification using the Clinical Prediction Score

Score	Risk Category	Predicted Probability	Recommended Action
0–1	Low	<10%	Standard induction protocol
2–3	Intermediate	10–45%	Enhanced monitoring; consider cervical ripening first
4–5	High	>57%	MDT review; counsel on operative delivery risk; alternative uterotonics

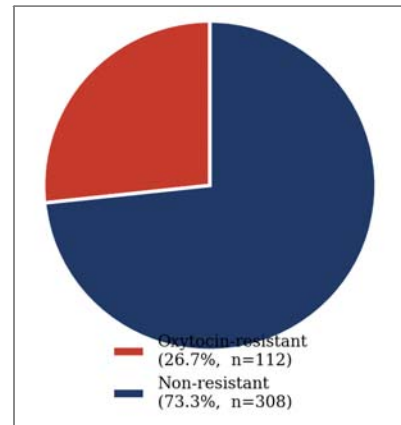


Figure 1: Prevalence of Oxytocin Resistance (n=420)

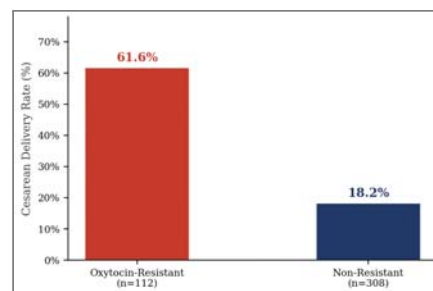


Figure 2: Cesarean Delivery Rate by Resistance Status (OR 7.1, 95% CI 4.3–11.7,  $p < 0.001$ )

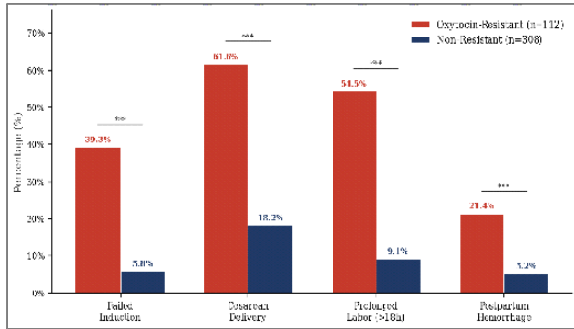


Figure 3: Comparison of Primary Outcomes between Oxytocin-Resistant and Non-Resistant Groups (%). All Between-Group Differences Significant at  $p < 0.001$ .

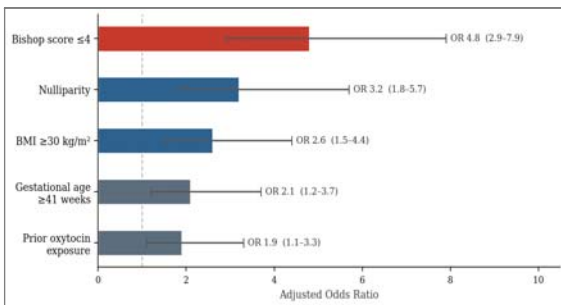


Figure 4: Adjusted odds ratios for independent predictors of oxytocin resistance (multivariate logistic regression). Error bars = 95% CI.

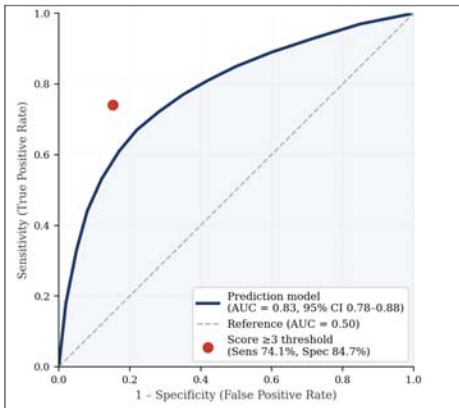


Figure 5: Receiver Operating Characteristic (ROC) curve of the clinical prediction model. AUC = 0.83 (95% CI 0.78–0.88). Red dot marks the score  $\geq 3$  threshold (Sensitivity 74.1%, Specificity 84.7%).

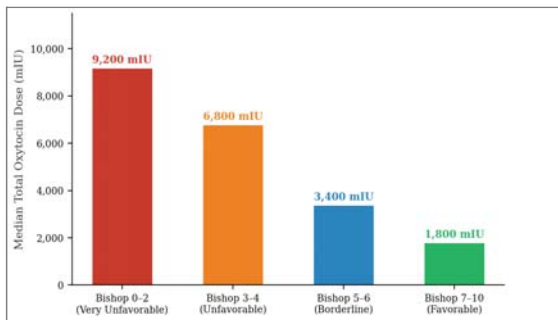


Figure 6: Median total oxytocin dose (mIU) by pre-induction Bishop score category. Higher Bishop score associated with markedly lower oxytocin requirement ( $p < 0.001$ ).

The AUC-ROC was 0.83 (95% CI 0.78–0.88), indicating good discrimination. The Hosmer-Lemeshow test confirmed adequate model calibration ( $\chi^2=7.2$ ,  $df=8$ ,  $p=0.51$ ).

**Clinical Prediction Score (Bedside Tool):** Assign 1 point for each predictor present: Bishop score  $\leq 4$  | Nulliparity | BMI  $\geq 30$  kg/m<sup>2</sup> | GA  $\geq 41$  weeks | Prior oxytocin exposure

**Risk Stratification:** Score 0–1 = Low (<10%) | Score 2–3 = Intermediate (10–45%) | Score 4–5 = High (>57%)

**At score  $\geq 3$ :** Sensitivity 74.1%, Specificity 84.7%, PPV 63.8%, NPV 90.0%

## DISCUSSION

This prospective study offers, to our knowledge, the first bedside clinical prediction model targeting oxytocin resistance as a defined physiological endpoint in a South Asian population. Five readily available clinical variables Bishop score, parity, BMI, gestational age, and prior oxytocin exposure collectively achieved an AUC-ROC of 0.83, placing the model within the range described as good discrimination for obstetric prediction tools.

The strongest predictor was an unfavorable Bishop score of  $\leq 4$  (adjusted OR 4.8). This aligns with the established literature linking cervical immaturity to prolonged induction and failed vaginal delivery<sup>9,15</sup>. Beyond mechanical cervical unreadiness, an unfavorable Bishop score may also reflect inadequate myometrial OXTR upregulation, since cervical maturation and receptor expression are partly co-regulated by prostaglandin and estrogen gradients in late pregnancy<sup>16</sup>.

Nulliparity was the second strongest independent predictor (OR 3.2). Parous women demonstrate lower oxytocin requirements and shorter induction-to-delivery intervals across multiple studies,<sup>11,17</sup> possibly because multiparity is associated with greater baseline OXTR density and a more permissive myometrial environment.

The association between BMI  $\geq 30$  kg/m<sup>2</sup> and resistance (OR 2.6) reflects several converging mechanisms. Adipose tissue aromatase activity alters estrogen-progesterone ratios that modulate OXTR expression; simultaneously, increased volume of distribution in obese women may reduce effective oxytocin plasma concentrations<sup>12,18</sup>. These findings reinforce calls for pharmacokinetic-guided dosing or weight-adjusted protocols in this population<sup>19</sup>.

Post-term pregnancy ( $\geq 41$  weeks) independently predicted resistance (OR 2.1). Prolonged intrauterine exposure to endogenous oxytocin before induction may lead to partial receptor downregulation, a mechanism supported by DNA methylation studies of the OXTR gene showing epigenetic silencing with prolonged oxytocin stimulus<sup>7</sup>.

Prior oxytocin exposure was the smallest but still significant predictor (OR 1.9). Women with a previous induction or augmentation attempt may carry patterns of receptor resensitization failure an area explored in ex vivo myometrial studies showing variable and incomplete OXTR resensitization timelines after oxytocin washout<sup>4</sup>.

The clinical impact of oxytocin resistance in our cohort was substantial. Cesarean rate reached 61.6% in resistant women against 18.2% in non-resistant women (OR 7.1), and prolonged labor exceeded 18 hours in over half the resistant group. Postpartum hemorrhage was four times more frequent in the resistant group (21.4% vs. 5.2%), consistent with receptor desensitization extending into the third stage of labor<sup>5,6</sup>.

Our model differs from existing induction prediction tools in its mechanistic focus<sup>14,20-23</sup>. Rather than predicting mode of delivery as a composite endpoint, it targets the specific physiological failure of oxytocin-receptor coupling. Its five binary variables can be assembled from any pre-induction assessment without additional investigations, making it immediately applicable in under-resourced settings where Bishop scoring is already routine<sup>24,25</sup>.

Limitations include the single-center design and the use of an operational rather than molecular definition of resistance. Direct

quantification of OXTR density or downstream signaling markers was outside the study scope. Internal rather than external validation was performed, and the reported AUC should be interpreted cautiously pending multicenter confirmation. Additionally, this study did not systematically assess time from last endogenous oxytocin stimulation to induction initiation, which may modulate receptor resensitization.

## CONCLUSIONS

A five-variable bedside prediction model incorporating pre-induction Bishop score, parity, BMI, gestational age, and prior oxytocin exposure identifies women at high risk of oxytocin resistance before it becomes clinically manifest, with good discriminative performance (AUC-ROC 0.83) and adequate calibration. In practical terms, a score of  $\geq 3$  at pre-induction assessment should prompt enhanced monitoring, earlier escalation to alternative uterotonic strategies, and realistic patient counseling about the risk of operative delivery. External validation in larger multicenter cohorts is the necessary next step.

**Acknowledgments:** The authors thank the nursing and midwifery staff of the Labour Ward, Mardan Medical Complex Mardan, for assistance with data collection, and all women who consented to participate.

### Authors' Contributions

**Hemasa Gul:** conceived and designed the study.

**Huma Gul:** performed data collection and patient recruitment.

**Naila:** performed all statistical analyses.

**Fatima Rehman:** supervised clinical protocols and reviewed obstetric definitions. All authors critically revised the manuscript for intellectual content and approved the final version for submission.

**Source of Funding:** No external funding was received. The study was conducted using departmental resources of Bacha Khan Medical College and Mardan Medical Complex Mardan.

**Conflict of Interest:** The authors declare no conflicts of interest relevant to this publication.

**AI and Technology Disclosure:** Artificial intelligence tools were used solely to assist with language editing and readability improvement. All scientific interpretation, data analysis, statistical modeling, and conclusions are entirely the responsibility of the authors. AI was not used to interpret results or draw scientific conclusions.

## REFERENCES

- Daly D, Minnie KCS, Bignaut A, Blix E, Vika Nilsen AB, Dencker A, et al. How much synthetic oxytocin is infused during labour? A review and analysis of regimens used in 12 countries. *PLoS One* [Internet]. 2020;15(7):e0227941. Available from: <http://dx.doi.org/10.1371/journal.pone.0227941>
- Dasanayake DLW, Goonewardene M. Use of oxytocin for induction of labour. *Sri Lanka J ObstetGynaecol* [Internet]. 2021;42(4):137. Available from: <http://dx.doi.org/10.4038/sljog.v42i4.7959>
- Wray S, Arrowsmith S. Uterine excitability and ion channels and their changes with gestation and hormonal environment. *Annu Rev Physiol* [Internet]. 2021;83(1):331–57. Available from: <http://dx.doi.org/10.1146/annurev-physiol-032420-035509>
- Jurek B, Neumann ID. The oxytocin receptor: From intracellular signaling to behavior. *Physiol Rev* [Internet]. 2018;98(3):1805–908. Available from: <http://dx.doi.org/10.1152/physrev.00031.2017>
- Phaneuf S, Liñares R, Tambyraja B, Mackenzie RL, López Bernal A. Loss of myometrial oxytocin receptors during oxytocin-induced and oxytocin-augmented labour is associated with reduced uterine responsiveness. Findings summarized and discussed in contemporary reviews of oxytocin resistance and uterine atony. *Int J ObstetAnesth* [Internet]. 2021;48. Available from: <http://dx.doi.org/10.1016/j.ijoa.2021.103207>
- Bischoff K, Nothacker M, Lehane C, Lang B, Meerpohl J, Schmucker C. Lack of controlled studies investigating the risk of postpartum haemorrhage in cesarean delivery after prior use of oxytocin: a scoping review. *BMC Pregnancy Childbirth* [Internet]. 2017;17(1):399. Available from: <http://dx.doi.org/10.1186/s12884-017-1584-1>
- Danoff JS, Wroblewski KL, Graves AJ, Quinn GC, Perkeybile AM, Kenkel WM, et al. Genetic, epigenetic, and environmental factors controlling oxytocin receptor gene expression. *Clin Epigenetics* [Internet]. 2021;13(1):23. Available from: <http://dx.doi.org/10.1186/s13148-021-01017-5>
- Tops S, Habel U, Radke S. Genetic and epigenetic regulatory mechanisms of the oxytocin receptor gene (OXTR) and the (clinical) implications for social behavior. *Horm Behav* [Internet]. 2019;108:84–93. Available from: <http://dx.doi.org/10.1016/j.yhbeh.2018.03.002>
- Teixeira C, Lunet N, Rodrigues T, Barros H. The Bishop Score as a determinant of labour induction success: a systematic review and meta-analysis. *Arch GynecolObstet* [Internet]. 2012;286(3):739–53. Available from: <http://dx.doi.org/10.1007/s00404-012-2341-3>
- Vital M, Grange J, Le Thuaut A, Dimet J, Ducarme G. Predictive factors for successful cervical ripening using a double-balloon catheter after previous cesarean delivery. *Int J GynaecolObstet* [Internet]. 2018;142(3):288–94. Available from: <http://dx.doi.org/10.1002/ijgo.12566>
- Ivars J, Garabedian C, Devos P, Therby D, Carlier S, Deruelle P, et al. Simplified Bishop score including parity predicts successful induction of labor. *Eur J ObstetGynecolReprod Biol* [Internet]. 2016;203:309–14. Available from: <http://dx.doi.org/10.1016/j.ejogrb.2016.06.007>
- Ellis JA, Brown CM, Barger B, Carlson NS. Influence of maternal obesity on labor induction: A systematic review and meta-analysis. *J Midwifery Womens Health* [Internet]. 2019;64(1):55–67. Available from: <http://dx.doi.org/10.1111/jmwh.12935>
- National Institute of Population Studies. *Pakistan Maternal Mortality Survey 2019–20*. Islamabad: Ministry of Health; 2021. Available from: <https://nips.org.pk>
- Danilack VA, Hutcheon JA, Triche EW. Development and validation of a risk prediction model for cesarean delivery after labor induction. *J Womens Health (Larchmt)* [Internet]. 2020;29(5):656–69. Available from: <http://dx.doi.org/10.1089/jwh.2019.782>
- Kolkman DGE, Verhoeven CJM, Brinkhorst SJ, van der Post JAM, Pajkrt E, Opmeer BC, et al. The Bishop score as a predictor of labor induction success: a systematic review. *Am J Perinatol* [Internet]. 2013;30(8):625–30. Available from: <http://dx.doi.org/10.1055/s-0032-1331024>
- Uvnäs-Moberg K, Gross MM, Agius A, Downe S, Calleja-Agius J. Are there epigenetic oxytocin-mediated effects on the mother and infant during physiological childbirth? *Int J Mol Sci* [Internet]. 2020;21(24):E9503. Available from: <http://dx.doi.org/10.3390/ijms21249503>
- Ellis JA, Brown CM, Barger B, Carlson NS. Influence of maternal obesity on labor induction: A systematic review and meta-analysis. *J Midwifery Womens Health* [Internet]. 2019;64(1):55–67. Available from: <http://dx.doi.org/10.1111/jmwh.12935>
- Banner H, Souza D. Towards an evidence-based approach to optimize the success of labour induction. *Best Pract Res Clin ObstetGynaecol* [Internet]. 2021;77:129–43. Available from: <http://dx.doi.org/10.1016/j.bpobgyn.2021.06.001>
- Govind N. Prophylactic oxytocin for the third stage of labour to prevent postpartum haemorrhage: A Cochrane review summary. *Int J Nurs Stud* [Internet]. 2021;121(103712):103712. Available from: <http://dx.doi.org/10.1016/j.ijnurstu.2020.103712>
- Jochum F, Ray L, Blanc-Petitjean C, Langer P, Meyer B, Severac N. Externally validated score to predict cesarean delivery after labor induction with cervical ripening. *ObstetGynecol* [Internet]. 2019;134(8):502–10. Available from: <http://dx.doi.org/10.1097/AOG.0000000000003405>
- Kamel RA, Negm SM, Youssef A, Elgazzar A, Koch M, Wex J. Predicting cesarean delivery for failure to progress as an outcome of labor induction in term singleton pregnancy. *Am J ObstetGynecol* [Internet]. 2021;224(6). Available from: <http://dx.doi.org/10.1016/j.ajog.2021.01.010>
- Carlson N, Ellis J, Page K, Dunn Amore A, Phillippi J. Review of evidence-based methods for successful labor induction. *J Midwifery Womens Health* [Internet]. 2021;66(4):459–69. Available from: <http://dx.doi.org/10.1111/jmwh.13238>
- Vannucci S, Torricelli M, Bocchi C, Severi FM, Di Tommaso M, Petraglia F. Fetal middle cerebral artery Doppler in late-term pregnancy: a predicting factor for failed induction of labor. *J Matern Fetal Neonatal Med* [Internet]. 2017;31(20):1–7. Available from: <http://dx.doi.org/10.1080/14767058.2017.1355900>
- Grobman WA, Rice MM, Reddy UM, Tita ATN, Silver RM, Mallett G, et al. Labor induction versus expectant management in low-risk nulliparous women. *N Engl J Med* [Internet]. 2018;379(6):513–23. Available from: <http://dx.doi.org/10.1056/NEJMoa1800566>
- Deo RC. Machine learning in medicine. *Circulation* [Internet]. 2015;132(20):1920–30. Available from: <http://dx.doi.org/10.1161/CIRCULATIONAHA.115.001593>

**This article may be cited as:** Gul H., Gul H., Rehman F., Naila, Development of A Clinical Prediction Model for Oxytocin Resistance During Labor: A Prospective Cohort Study. *Pak J Med Health Sci*, 2023; 17(10): 460–463.