

# Role of N-formyl-met-leu-phe (FPR1) Receptor in Immune System Response to Vaginal Infections Associated with Spontaneous Pregnancy Loss

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## Abstract

**Background:** The immune system's ability to identify and react to microbial infections is crucial for sustaining pregnancy. The formyl peptide receptor (FPR1), which interacts with fMLP, is crucial for identifying bacterial presence and initiating immune responses. **Aim:** This study seeks to examine the relationship between the N-formyl-met-leu-phe receptor and bacterial infections in women experiencing spontaneous abortions. **Materials and Methods:** One hundred women aged 17 to 50 with a history of sexual assault participated. We employed two vaginal swabs. They were initially cultivated. The Vitek2 method was employed subsequent to the identification of isolates by biochemical assays. The second swab was utilised to assess for vaginosis employing Amsel criteria. Serum fMLP concentrations were quantified by ELISA. **Results:** Substantial correlations were identified between the frequency of abortion and variables including pregnancy-related and chronic illnesses, as well as educational attainment. fMLP receptor levels exhibited a strong correlation with Gram-positive bacteria and normal flora ( $P = 0.041$ ), but not with Gram-negative bacteria or fungal diseases. No significant correlation was found between fMLP receptor levels and the presence of clue cells ( $P = 0.261$ ) or the number of abortions ( $P = 0.629$ ), indicating a minimal direct influence of receptor levels on pregnancy loss. More targeted results suggest that FPR1 plays a role in early pregnancy stability and term labour, with alterations in expression potentially leading to complications. **Conclusion:** The correlation between fMLP receptor levels and normal vaginal flora indicates a possible biomarker for vaginal health. FPR1 may have a role in early pregnancy stability and term labour, with alterations in expression potentially leading to problems.

**Keywords:** FPR1 Receptor, fMLP receptor, Vaginitis, Spontaneous Pregnancy Loss.

## INTRODUCTION

Spontaneous abortion (SAB) is a prevalent and significant complication of pregnancy, occurring in roughly 10–15% of all acknowledged pregnancies. Recurrent pregnancy loss (RPL) is characterised by the termination of two or more pregnancies before to 20 weeks of gestation. Contributing factors may originate from either foetal or parental sources, with infections recognised as a causative agent. Recent research indicate that immunogenetic variables, which improperly stimulate the immune system, may contribute to recurrent pregnancy loss (RPL).<sup>[1]</sup> Vaginitis, a prevalent infectious aetiology of spontaneous abortion, entails inflammation of the vagina resulting from the disturbance of the normal vaginal flora. Infections that stimulate endometrial immune cells may

elicit an amplified maternal immunological response to trophoblastic invasion, potentially leading to early pregnancy loss in people with recurrent miscarriages. Autoimmune illnesses exhibit a significant correlation with recurrent abortion.<sup>[2]</sup>

Numerous bacteria commence protein synthesis with N-formyl methionine, which serves as a signal for evaluating neutrophil activation.<sup>[3]</sup> N-formyl-methionyl-leucyl-phenylalanine (fMLP) is a formylated tripeptide recognised

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for its chemotactic characteristics. The engagement of fMLP with formyl peptide receptor 1 (FPR1) is pivotal to the investigation of neutrophil G-protein signalling pathways.<sup>[4]</sup> Recent data indicates that FPR1 is involved in the modulation of myometrial contractions, highlighting its significance in reproductive physiology.

The concurrent engagement of fMLP/FPR1 in immune response and myometrial contraction may facilitate the diagnosis and treatment of infection-associated reproductive disorders, including premature labour.

## SUBJECTS AND METHODS

### Patients

From September 2024 to January 2025, 100 women aged 17 to 50 engaged in women's consulting and lounge services at Kirkuk Teaching Hospital. The medical history of each participant was meticulously recorded, emphasising the count of abortions. Additionally, significant attention was directed towards previous instances of vaginitis symptoms, the timing of spontaneous abortion (SA), the presence of comorbidities, and conditions such as toxoplasmosis, as well as parasitic and viral infections. It was further confirmed that no antibiotics had been supplied.

### Collection of Samples

Two vaginal swabs were collected from each subject using sterile Dacron swabs and promptly processed. The initial swab was cultured on Blood, MacConkey, and Chocolate agar, followed by incubation at 37°C for 24 hours for bacterial isolation. The isolates were characterised by biochemical assays, and the diagnosis was validated utilising the Vitek2 system. The second swab was utilised for Amsel's criterion, with clue cells discovered by wet mount and Gramme staining techniques. Three millilitres of venous blood were extracted to get serum, which was then transferred into Eppendorf tubes and preserved at -20°C until utilised for quantifying FPR1 levels by an ELISA technique. The FPR1 concentration was quantified using an enzyme-linked immunosorbent test (ELISA) kit (Manufacturer: BT Laboratory, Catalogue No: E7066Hu). The assay's limit of detection (LOD) was 0.21 ng/mL, with intra- and inter-assay coefficients of variation (CV%) of less than 8% and 10%, respectively.

### Patient's Consent Statement

This study did not require explicit consent from women, as the data was gathered exclusively for educational reasons, and the identities of the participants were never revealed at any time. The researchers maintained the anonymity and integrity of all data gathered until the study's conclusions were published.

### Ethical Consideration

This investigation was conducted in accordance with the guidelines set forth by the Helsinki Statement and sanctioned by the Institutional Review Committee of Northern Technical University, Technical College Kirkuk, in collaboration with the Local Ethics Committee

approved by a research committee at the Kirkuk Health Directorate (No. 701, on 10 Sept. 2024). The approval of the Iraqi Ministry of Health was secured for data collection. Prior to sample collection, all participants in the present investigation were informed and provided verbal consent to partake in this research.

### Inclusion Criteria

Female exhibiting indications of vaginal infection (abnormal discharge, odour, itching); female with recurrent spontaneous abortions.

### Exclusion Criteria

Unmarried individuals, both female and male, Expectant mothers, Women without a history of abortion, Women utilising anti-inflammatory or immunosuppressive medications, Women diagnosed with cancer.

### Anonymity and Confidentiality

All participants' information was maintained in strict confidentiality during the research process.

### Academic Research Purpose

This study aimed to examine the immunological pathways linked to spontaneous pregnancy loss, emphasising the significance of FPR1 in detecting vaginal microbiota.

### Limitations of the Study

Constraints encompass a restricted sample size and absence of longitudinal follow-up, potentially impacting the generalisability of the results.

### Statistical Analysis

The data were analysed via Minitab Program System Version 17. ANOVA and Chi-square testing were utilised. Means were analysed using Duncan's Multiple Range test at a significance threshold of 0.05.

## RESULTS

### Demographic Characteristics

This cross-sectional study encompassed 100 women having a history of spontaneous or recurrent abortion. Among these, 49 had undergone a singular spontaneous abortion, whereas 51 reported two or more losses. The ages of participants varied from 17 to 50 years, with a mean age of 30.05 years. For subgroup analysis, individuals were classified by age into three categories: Group A ( $\leq 25$  years), Group B (26–35 years), and Group C ( $\geq 36$  years), representing different reproductive phases. Subgrouping was additionally determined by infection type (Gram-positive bacteria, Gram-negative bacteria, or fungi) and the frequency of abortion. A notable correlation was identified between age categories and fMLP receptor levels ( $\chi^2 = 9.652$ ,  $p = 0.040$ ). Moreover, fMLP concentrations exhibited a strong correlation with the occurrence of Gram-positive bacterial infections, normal flora, and age group. Significantly, 20 of the 23 women who underwent a recent abortion exhibited reduced fMLP levels.

The analysis indicates substantial correlations between the incidence of abortions and variables including pregnancy-related ailments, chronic illnesses, and educational attainment, with no notable correlations

observed concerning age. These findings highlight the necessity of addressing maternal health and socioeconomic variables to decrease abortion rates. As indicated in Table 1.

**Table 1: Differences in the Number of Abortions According to Demographic Data of Patient Groups.**

Variable	Number of Abortions				Chi Square (P-Value)	
	1	2	3	≥ 4		
Age	25≥	22	14	2	2	* Chi-Square = 9.02 P-Value = 0.172
	26 - 35	21	10	5	2	
	36≤	6	9	3	4	
Disease during pregnancy	Hypertension	3	3	0	1	** Chi-Square = 39.815 P-Value = 0.004
	Hypotension	3	2	2	0	
	Blood coagulation	1	1	3	0	
	Anemia	0	0	2	0	
	No	42	27	3	7	
Chronic disease	Hypertension	4	3	1	0	* Chi-Square = 4.976 P-Value = 0.049
	Hypotension	2	0	0	0	
	Blood coagulation	0	0	0	0	
	Anemia	0	1	0	0	
	No	43	29	9	8	
Residency	Urban	37	20	5	8	* Chi-Square = 7.429 P-Value = 0.051
	Rural	12	13	5	0	
	No	18	7	1	3	
Education level	Primary	13	12	5	0	** Chi-Square = 18.006 P-Value = 0.015
	Secondary	4	6	4	1	
	High	14	8	0	4	

**Estimation of fMLP Receptor Level**

Table 2 demonstrates a statistically significant correlation between formyl peptide receptor (fMLP receptor) concentrations and several demographic and health-

related characteristics in women experiencing spontaneous abortion (SA). The chi-square tests reveal substantial correlations with age, weight, chronic illness, residency, and educational attainment.

**Table 2: Differences in fMLP Receptor Concentration According to Demographic Data of Cases.**

Demographic Variable	fMLP Receptor Concentration				Chi Square (P-Value)	
	1	2	3	≥ 4		
Age	25≥	22	17	2	2	* Chi-Square = 9.652 P-Value = 0.040
	26 - 35	21	10	5	2	
	36≤	6	9	3	4	
Weight	40 - 60	11	11	5	3	* Chi-Square = 6.656 P-Value = 0.035
	61 - 80	29	20	4	3	
	81 - 100	9	2	1	2	
Chronic disease	Hypertension	4	3	1	0	* Chi-Square = 4.976 P-Value = 0.049
	Hypotension	2	0	0	0	
	Blood coagulation	0	0	0	0	
	Anemia	0	1	0	0	
	No	43	29	9	8	
Residency	Urban	37	20	5	8	* Chi-Square = 7.429 P-Value = 0.051
	Rural	12	13	5	0	
	No	18	7	1	3	
Education level	Primary	13	12	5	0	** Chi-Square = 18.006 P-Value = 0.015
	Secondary	4	6	4	1	
	High	14	8	0	4	

Among 100 high vaginal swabs (HVS) analysed, a statistically significant correlation was observed between fMLP receptor concentrations and the presence of Gram-positive bacteria and normal flora (Chi-Square = 11.311, P-Value = 0.041).

No significant relationships were detected with Gram-negative bacteria or fungal illnesses. This indicates that the expression of fMLP receptors fluctuates based on the type of microorganism present. As seen in Table 3.

**Table 3: Differences in fMLP Receptor Concentration According to the Type of Bacterial Isolates.**

Microorganisms	fMLP Receptor Concentration								Total	
	1.5 – 3 ng/ml		3 – 6 ng/ml		6 – 12 ng/ml		12 – 24 ng/ml		NO.	%
	NO.	%	NO.	%	NO.	%	NO.	%		
Gram-positive Bacteria									69	81.1

**Table 3: Differences in fMLP Receptor Concentration According to the Type of Bacterial Isolates.**

Microorganisms	fMLP Receptor Concentration									
	1.5 – 3 ng/ml		3 – 6 ng/ml		6 – 12 ng/ml		12 – 24 ng/ml		Total	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
<i>S. aureus</i>	0	0	2	2.3	0	0	0	0	2	2.3
<i>S. haemolyticus</i>	0	0	4	4.7	2	2.3	1	1.2	7	8.2
<i>S. lugdunensis</i>	0	0	1	1.2	1	1.2	0	0	2	2.3
<i>S. agalactiae</i>	0	0	0	0	1	1.2	0	0	1	1.2
<i>E. faecalis</i>	0	0	0	0	2	2.3	0	0	2	2.3
<i>S. epidermidis</i>	0	0	9	10.5	9	10.5	0	0	18	21.1
( <i>Micrococcus, C. diphtheroid, Lactobacillus spp.</i> )	2	2.3	16	18.8	15	17.6	4	4.7	37	43.5
* Chi-Square = 11.311, P-Value = 0.041										
Gram-negative Bacteria									8	9.4
<i>E. coli</i>	0	0	5	5.9	0	0	0	0	5	5.9
<i>Klebsiella spp.</i>	0	0	2	2.3	1	1.2	0	0	3	3.5
ns, Chi-Square = 1.905 P-Value = 0.424										
Fungal Infection									8	9.4
<i>C. albicans</i>	0	0	6	7	2	2.3	0	0	8	9.4
ns, Chi-Square = 1.679 P-Value = 0.511										

Clue cell examined by direct wet mount and gram stain Figure 1.

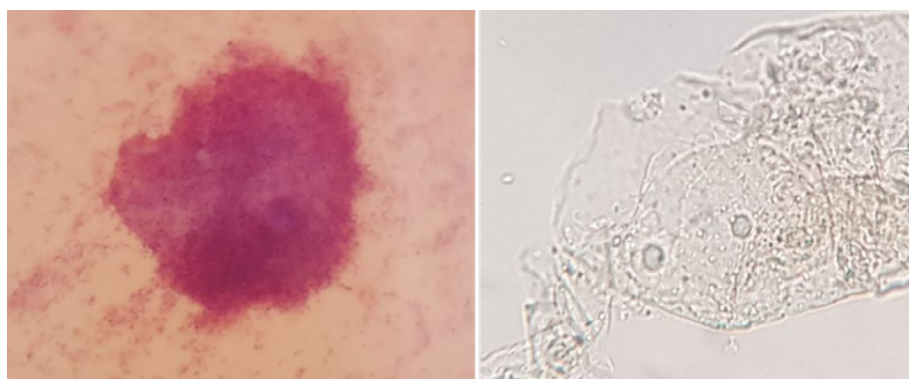


Figure 1: Clue Cell by Gram Staining and wet Mount Direct Examination.

The findings demonstrate that fMLP receptor concentration did not correlate with the presence of clue cells. The average concentration of Group 1 is 7.781 ng/ml. Group

2 is absent; the measurement is 6.881 ng/ml. The P-value is 0.261, as depicted in Figure 2.

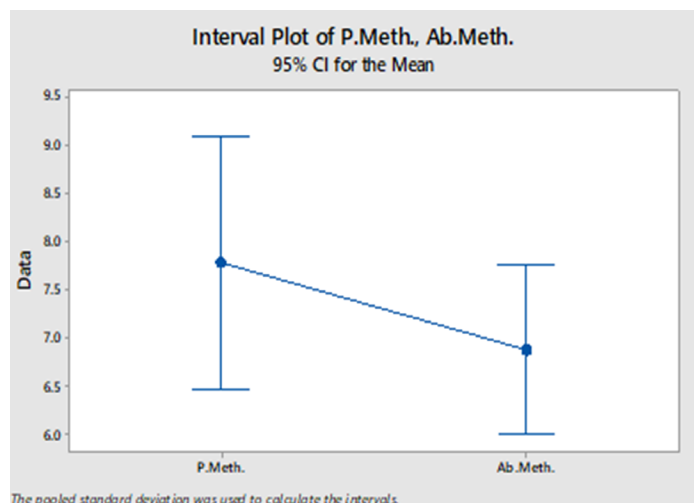


Figure 2: fMLP Receptor Concentration with Clue Cell Appearance. The Mean Level of (Group1 present) is 7.781ng/ml. (Group 2 absent) 6.881 ng/ml. The P-value 0.261.

The findings indicate that fMLP receptor concentration did not affect the frequency of recurrent abortion. The average concentration of Group N1 1-2 is 7.324 ng/ml.

Group N2 3-4: 1.088 ng/ml. Group N3  $\geq 5$ : 6.433 ng/ml. The P-value is 0.629, as illustrated in Figure 3.

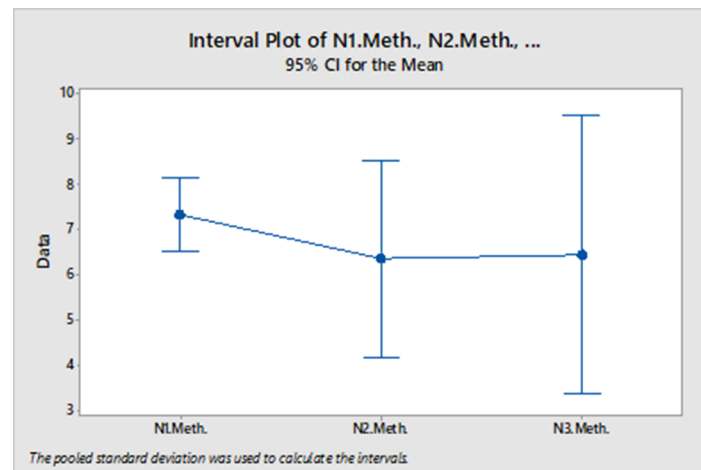


Figure 3: fMLP receptor Concentration with Abortion Number. The Mean Level of (Group N1 1-2) is 7.324 ng/ml. (Group N2 3-4) 1.088 ng/ml. (Group N3  $\geq 5$ ) 6.433 ng/ml. The P-value 0.629.

However, a focused analysis of the 23 recent occurrences of spontaneous abortion revealed that 20 of the 23 women exhibited low FPR1 levels (1–9 ng/ml).

## DISCUSSION

No substantial correlation was identified between age demographics and the incidence of abortions. The findings indicated that the mean age of patients is 30.05 years, which is consistent with a local study that determined a patient age range of 18 to 44 years, indicating a mean age of 29.8 years.

A notable correlation was identified between pregnancy-related conditions (such as hypertension, hypotension, blood coagulation problems, and anaemia) and the incidence of abortions. Complications in maternal health during pregnancy are recognised to elevate the chance of negative pregnancy outcomes, including miscarriages.

A notable correlation was identified between the existence of chronic conditions and the frequency of abortions. Chronic health issues might negatively impact pregnancy outcomes, resulting in increased abortion rates.

Although the p-value slightly exceeds the traditional significance level, a trend indicates that resident status may affect abortion rates. Urban inhabitants exhibited varying abortion rates in contrast to rural inhabitants, likely attributable to disparities in healthcare accessibility and socioeconomic conditions. Urban settings frequently subject humans to elevated concentrations of contaminants and stressors.<sup>[5]</sup>

A notable correlation exists between educational attainment and the incidence of abortions. Women with reduced educational qualifications demonstrated increased abortion rates, in accordance with a Chinese study<sup>[6]</sup>.

A chi-square statistic of 9.652 and a p-value of 0.040 indicate a significant correlation between age groups

and fMLP receptor concentrations. This suggests that age-related variables may affect immunological responses during pregnancy, thus impacting SA risk. The chi-square test yielded a score of 6.656 ( $p = 0.035$ ), showing a strong correlation between weight categories and fMLP receptor levels.

A chi-square statistic of 4.976 and a p-value of 0.049 signify a significant correlation between hypertension and fMLP receptor concentrations. Hypertension correlates with an increased risk of SA, perhaps due to its effects on the vascular and immunological systems. This receptor is present in vascular tissues. The activation of FPR-1 in arteries is essential for the temporal reorganisation of actin, resulting in a rapid induction of actin polymerisation. The activation of FPR-1 may operate as a catalyst for vascular remodelling via actin polymerisation, resulting in hypertension.<sup>[7]</sup>

The chi-square test produced a result of 7.429 ( $p = 0.051$ ), indicating a marginally significant correlation between urban/rural residency and fMLP receptor levels. Differences in immunological responses may be affected by environmental and lifestyle variations in different regions.

A chi-square statistic of 18.006 and a p-value of 0.015 signify a substantial association between educational attainment and fMLP receptor concentrations.

The notable correlation between elevated fMLP receptor levels and Gram-positive bacteria, including elements of the typical flora, indicates that these microorganisms may enhance fMLP receptor expression. This overexpression may improve the host's capacity to identify and react to these bacteria, preserving mucosal immunity and homeostasis. Formyl peptide receptors (FPRs), including FPR1 and FPR2, are recognised for their functions in detecting bacterial peptides and facilitating immune responses. Their

expression can be affected by multiple circumstances, including the existence of commensal bacteria, which may assist in modulating immune responses to sustain tolerance and avert severe inflammation.<sup>[8]</sup>

A study discovers certain formyl peptides from Gram-positive bacteria that serve as effective chemoattractants for neutrophils through FPRs. The results highlight the significance of FPRs in identifying bacterial infections and facilitating immune cell recruitment.<sup>[9]</sup>

Research indicates that intestinal epithelial cells exposed to *Lactobacillus* phosphorylate and activate formyl peptide receptors (FPRs), which are associated with the response elicited by fMLP. This activation triggers downstream signalling pathways, including the generation of reactive oxygen species (ROS), which are crucial for preserving mucosal homeostasis and barrier integrity.<sup>[10]</sup>

Although no statistically significant correlation exists, Gram-negative bacteria such as *E. coli* and *Klebsiella* spp. are recognised for their interaction with fMLP receptors. These bacteria secrete formylated peptides that can stimulate FPRs, resulting in neutrophil chemotaxis and activation. Nevertheless, certain Gram-negative bacteria have developed strategies to circumvent immune recognition, including the alteration of their lipopolysaccharides or the secretion of substances that diminish receptor expression. This immunological evasion may elucidate the noted absence of a substantial correlation in the data.<sup>[11]</sup>

The data indicate no substantial correlation between fMLP receptor levels and fungal infections. Fungi, including *Candida* spp., possess distinct pathogen-associated molecular patterns relative to bacteria and may exhibit limited interaction with fMLP receptors. Fungal recognition frequently entails additional pattern recognition receptors such as dectin-1 and toll-like receptors. Consequently, the function of fMLP receptors in fungal infections may be constrained, consistent with the absence of a notable correlation seen. Fungal recognition mostly entails pattern recognition receptors (PRRs) distinct from formyl peptide receptors (FPRs).<sup>[12]</sup> The concentration of fMLP receptors did not correlate with the presence of clue cells. The mean concentration of Group 1 present is 7.781 ng/ml, while Group 2 absent is 6.881 ng/ml. The P-value is 0.261. Consequently, its engagement with the host immune system seems to be facilitated via other receptors and pathways. A recent study demonstrated that *Gardnerella vaginalis* activates matrix metalloproteinases via TLR-2, resulting in epithelial barrier failure.<sup>[13]</sup>

In 23 recent occurrences of spontaneous abortion, 20 women exhibited low FPR1 levels (1–9 ng/ml), indicating that diminished receptor expression may contribute to early pregnancy loss. This contrasts with another study that identified substantial amounts of FPR1 in the myometrium during labour, when its activation enhances contractions. These findings indicate that FPR1 may serve dual functions: regulating the immune system and preserving tissue integrity during early pregnancy, and facilitating myometrial contraction at term. Consequently, alterations in its expression

may result in complications during gestation.

Annexin A1 (AnxA1) facilitates embryo implantation by enhancing trophoblast adhesion and elevating the expression of implantation-associated markers (Muc-1, claudin-1, ZO-1) in uterine epithelial cells via the activation of FPR1 and FPR2. This occurs via ERK1/2 signalling and the assembly of F-actin polymers, independent of IL-6. FPR2 facilitates the release of VEGF by AnxA1, promoting angiogenesis. The diminished levels of FPR1 observed in spontaneous abortion cases may result from deficiencies in activating this pathway, indicating insufficient epithelial remodelling and implantation support, potentially leading to early pregnancy loss. The existence of a healthy vaginal environment markedly diminishes the likelihood of miscarriage attributable to bacterial infections.

## CONCLUSION

The correlation between fMLP receptor levels and normal vaginal flora indicates a possible biomarker for vaginal health. FPR1 may have a role in early pregnancy stability and term labour, with alterations in expression potentially resulting in difficulties.

## Financial Support and Sponsorship

Nil.

## Conflicts of Interest

There are no conflicts of interest.

## Plain Language Summary

This study explores how the fMLP receptor might be linked to recurrent pregnancy loss in women. We found that its level affected by the vaginal health and different infections, understanding this could help doctors develop new methods to enhance reproductive immunity. And FPR1 may contribute to early pregnancy stability and term labor, with changes in expression possibly resulting in complications.

## Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

## REFERENCES

1. Tyagi P, Alharthi NS. Evaluation of Pro-inflammatory Cytokine Level in Cases of Idiopathic Recurrent Spontaneous Miscarriage in Saudi Arabia. *Biomedical and Biotechnology Research Journal (BBRJ)*. 2020; 4(3): 225-31. doi: [https://doi.org/10.4103/bbrj.bbrj\\_71\\_20](https://doi.org/10.4103/bbrj.bbrj_71_20).
2. Aziz MJ, Ali AA, Hameed MF. Prevalence of anticardiolipin antibody IgM and IgG in women with recurrent abortions in Kirkuk city. *NTU Journal of Pure Sciences*. 2023; 2(4): 23-26. doi: <https://doi.org/10.56286/ntujps.v2i4>.
3. Napolitano F, Montuori N. The N-formyl peptide receptors: much more than chemoattractant receptors. Relevance in health and disease. *Front Immunol*. 2025; 16: 1568629. doi: <https://doi.org/10.3389/fimmu.2025.1568629>.

4. Dahlgren C, Lind S, Mårtensson J, et al. G protein coupled pattern recognition receptors expressed in neutrophils: Recognition, activation/modulation, signaling and receptor regulated functions. *Immunol Rev.* 2023; 314(1): 69-92. doi: <https://doi.org/10.1111/imr.13151>.
5. Sonu HS, Das SK, Tony R, Binu VS. Risk and protective factors of miscarriage: Evidence from a nationally representative sample of women in India. *J Family Med Prim Care.* 2024; 13(9): 3879-86. doi: [https://doi.org/10.4103/jfmpe.jfmpe\\_329\\_24](https://doi.org/10.4103/jfmpe.jfmpe_329_24).
6. Li C, Gao J, Liu J. Repeat abortion and associated factors among women seeking abortion services in northwestern China: a cross-sectional study. *BMC Public Health.* 2021; 21(1): 1626. doi: <https://doi.org/10.1186/s12889-021-11653-4>.
7. Wenceslau CF, McCarthy CG, Szasz T, Calmasini FB, Mamenko M, Webb RC. Formyl peptide receptor-1 activation exerts a critical role for the dynamic plasticity of arteries via actin polymerization. *Pharmacol Res.* 2019; 141: 276-90. doi: <https://doi.org/10.1016/j.phrs.2019.01.015>.
8. Danne C, Skerniskyte J, Marteyn B, Sokol H. Neutrophils: from IBD to the gut microbiota. *Nat Rev Gastroenterol Hepatol.* 2024; 21(3): 184-97. doi: <https://doi.org/10.1038/s41575-023-00871-3>.
9. Krepel SA, Wang JM. Chemotactic Ligands that Activate G-Protein-Coupled Formylpeptide Receptors. *Int J Mol Sci.* 2019; 20(14): 3426. doi: <https://doi.org/10.3390/ijms20143426>.
10. Dumas A, Knaus UG. Raising the 'Good' Oxidants for Immune Protection. *Front Immunol.* 2021; 12: 698042. doi: <https://doi.org/10.3389/fimmu.2021.698042>.
11. Scharf P, Sandri S, Rizzetto F, et al. GPCRs overexpression and impaired fMLP-induced functions in neutrophils from chronic kidney disease patients. *Front Immunol.* 2024; 15: 1387566. doi: <https://doi.org/10.3389/fimmu.2024.1387566>.
12. Li D, Wu M. Pattern recognition receptors in health and diseases. *Signal Transduct Target Ther.* 2021; 6(1): 291. doi: <https://doi.org/10.1038/s41392-021-00687-0>.
13. Gerson KD, Anton L, Ferguson B, Ravel J, Burris HH, Elovitz MA. *Gardnerella vaginalis* induces matrix metalloproteinases in the cervicovaginal epithelium through TLR-2 activation. *J Reprod Immunol.* 2022; 152: 103648. doi: <https://doi.org/10.1016/j.jri.2022.103648>.

Abbreviation	Definition
fMLP	N-Formylmethionyl-leucyl-phenylalanine
FPRs	Formyl-peptide receptors
BV	Bacterial vaginosis
SA	Spontaneous abortion
RPL	Recurrent pregnancy losses
ELISA	Enzyme-linked immunosorbent assay
ENOVA	Analysis of Variance
ROS	reactive oxygen species
TLR-2	Toll-like Receptor 2
AnxA1	Annexin A1
ERK1/2	Extracellular Signal-Regulated Kinases 1 and 2
IL6	Interleukin 6
VEGF	Vascular Endothelial Growth Factor