

Altered eotaxin-1 and interleukin-34 levels in obsessive-compulsive disorder: a case-control observational study in Bangladesh

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ABSTRACT

Objectives: Obsessive-compulsive disorder (OCD) is a prevalent mental health condition that impacts daily life. It is thought to be associated with genetic, biological, and structural brain changes, serotonergic abnormalities, altered neuromodulation, and environmental factors. Limited observational studies have examined cytokines in Bangladeshi patients with OCD. This study aimed to assess the levels of eotaxin-1 and interleukin (IL)-34 in individuals with this disorder.

Methods: This case-control observational study included 58 patients with OCD and 30 healthy controls (HCs) matched for age, sex, and body mass index. The severity of OCD was assessed using the Yale-Brown obsessive-compulsive scale (Y-BOCS). Psychiatrists evaluated participants according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. Serum levels of eotaxin-1 and IL-34 were measured using enzyme-linked immunosorbent assay kits.

Results: Patients with OCD exhibited significantly higher serum eotaxin-1 levels (121.13 ± 7.84 pg/mL) than HCs (85.52 ± 9.42 pg/mL). Conversely, IL-34 levels were considerably lower in patients than in HCs (119.02 ± 14.53 pg/mL vs. 179.96 ± 27.88 pg/mL). The Cohen d values for eotaxin-1 and IL-34 were 0.55 and -0.48, respectively. Among patients with OCD, a significant positive correlation was found between serum eotaxin-1 level and Y-BOCS score, along with a negative correlation between serum eotaxin-1 and IL-34 levels.

Conclusion: The findings suggest that altered eotaxin-1 and IL-34 levels may be associated with OCD. These chemokines and cytokines could serve as primary tools for assessing the risk of OCD, warranting further clinical investigation. This could potentially support more extensive research and the development of diagnostic and therapeutic strategies targeting these pathways.

Keywords: Chemokine CCL-11; Eotaxin-1; Interleukin-34; Mental disorders; Obsessive-compulsive disorder

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Introduction

Obsessive-compulsive disorder (OCD) is characterized by recurring obsessions—repetitive, peculiar, and intrusive thoughts or images related to various issues—and compulsions, which are repetitive mental acts or rituals typically performed to reduce the anxiety associated with obsessions and to provide temporary relief [1–3]. These obsessions and compulsions can lead to functional impairment, ultimately affecting the quality of life of individuals with OCD [4]. OCD typically emerges early in life, from childhood to early adulthood, and the severity of symptoms can fluctuate over time [5,6]. The global prevalence of OCD is estimated to be between 1.5% and 3% across all age groups, affecting individuals regardless of age, sex, or socioeconomic background [7]. The National Mental Health Survey of Bangladesh reported that 0.7% of Bangladeshi adults had an OCD diagnosis in 2018–2019 [8]. The World Health Organization ranks OCD as the fourth most common mental disorder and among the top 10 leading causes of disability worldwide [9]. Without proper diagnosis and treatment, OCD can become chronic, leading to prolonged disability and an increased health burden [10]. Furthermore, OCD can exacerbate economic strain by reducing productivity and frequently requiring medical treatment, counseling, and medication, thereby imposing a greater financial burden on society [11,12].

In recent years, the pathogenesis of OCD has been researched across various dimensions. Nevertheless, its complete pathogenesis remains elusive due to the complex interplay of genetic, biological, and environmental factors [13,14]. Evidence suggests that neuroinflammation, marked by increased levels of proinflammatory cytokines and immune dysregulation, may play a role in the development and progression of OCD [15]. Elevated immune markers have been observed in some patients with OCD, indicating a potential link between peripheral inflammation and inflammation of the brain [15]. This immune dysregulation may impact brain circuits implicated in OCD, such as the orbitofrontal cortex, cortico-striato-thalamo-cortical loop, and anterior cingulate cortex, as well as the caudate nucleus and thalamus. These regions are involved in decision-making, impulse control, habit formation, and cognitive processing [16]. Neuroimaging studies have revealed structural and functional abnormalities in these brain areas among individuals with OCD [17,18]. Furthermore, alterations in the levels of neurotransmitters, including serotonin, dopamine, and glutamate, have been implicated in the pathophysiology of this condition [19].

Immune dysregulation, characterized by altered chemokine and cytokine levels, may play a role in the pathophysiology

HIGHLIGHTS

- The role of cytokines in obsessive-compulsive disorder (OCD) remains unclear, with few observational studies exploring eotaxin-1 and interleukin (IL)-34 levels in patients with OCD.
- The present study observed altered levels of eotaxin-1 and IL-34 in patients with OCD relative to healthy controls.
- Among these patients, we noticed a significant positive correlation between serum eotaxin-1 levels and OCD symptoms and a negative correlation between serum eotaxin-1 and IL-34 levels.
- The findings indicate that altered levels of eotaxin-1 and IL-34 could be utilized in the diagnosis and treatment of OCD.

of OCD. Eotaxin-1, a chemokine involved in the selective recruitment of eosinophils to sites of inflammation, has been found to exhibit altered levels in the pathogenesis of OCD. This change is attributed to immune dysregulation and subsequent neuroinflammation [20,21]. Factors such as aging, reduced neurogenesis, neurodegeneration, and immune dysregulation may contribute to the pathophysiology of OCD through altered levels of eotaxin-1 [22,23]. Research has shown an increased level of eotaxin-1 in patients with OCD compared to healthy controls (HCs), although the difference was not statistically significant [24]. While the precise mechanisms are not fully understood, immunomodulation and resulting neuroinflammation are prevalent in OCD. Consequently, the level of eotaxin-1 is elevated due to the selective recruitment of eosinophils to the inflammatory sites of the brain [25].

Interleukin (IL)-34 is a cytokine with a multifaceted role in both proinflammatory and anti-inflammatory processes. It is implicated in the differentiation, survival, and function of macrophages. IL-34 promotes the activation of macrophages and microglia, contributing to the immune response through increased secretion of inflammatory mediators such as tumor necrosis factor alpha, IL-6, and IL-1 β [26,27]. This positions IL-34 as a key player in autoimmune diseases and neuroinflammatory disorders. Conversely, IL-34 can also display anti-inflammatory effects by inducing regulatory macrophages and boosting the production of IL-10, a cytokine known for its anti-inflammatory properties [28]. Although IL-34 has been associated with cognitive impairment in vascular dementia and Alzheimer's disease and is crucial in modulating the immune system by influencing various

signaling pathways, its direct relationship with OCD has not been established [29]. Nevertheless, several studies have suggested a potential link between IL-34 and OCD, given its role in neuroprotection and the activation of different immune system target cells [30–34].

The current absence of specific assessment techniques for diagnosing and monitoring OCD necessitates heavy reliance on clinical assessments, which can be biased and variable. Consequently, the development of robust diagnostic methods that incorporate biomarkers could facilitate the early detection and diagnostic precision of OCD [35,36]. Potential biomarkers, such as serum markers, genetic markers, and neuroimaging findings, could also assist in differentiating OCD from other psychiatric disorders. These biomarkers may provide valuable insights into the neurobiological mechanisms underlying OCD, ultimately leading to more effective therapies through the creation of targeted treatment plans [37].

Recently, several studies have aimed to identify potential biomarkers for OCD. The discussions above suggest a possible association between eotaxin-1 and IL-34 with OCD. However, research on these biomarkers in relation to OCD remains inconclusive. Therefore, this study was designed to evaluate and compare the serum levels of eotaxin-1 and IL-34 in patients with OCD and HCs. The goal is to explore their viability as early risk assessment tools and to understand their role in the pathophysiology of OCD.

Materials and Methods

Study Population

This observational case-control study was conducted between July 1, 2023, and December 31, 2023. It included 58 individuals diagnosed with OCD according to the International Classification of Diseases code of F42 for OCD, with F42.1 indicating predominantly compulsive acts, F42.2 denoting mixed obsessional thoughts and acts, and F42.9 representing unspecified OCD. Additionally, 30 HCs were included in the study. To ensure statistical power, the odds ratio, alpha risk, and exposed controls were considered. The patients with OCD were recruited from a tertiary care teaching hospital in Dhaka, Bangladesh, while the HCs were sourced from various areas within Dhaka. All participants underwent diagnosis and evaluation by experienced psychiatrists at the hospital. The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, and the Yale-Brown obsessive-compulsive scale (Y-BOCS) were utilized to diagnose OCD and assess symptom severity, respectively. A comprehensive matching process was employed to ensure consistency in age, sex, and sociodemographic

variables between groups. Sociodemographic and clinical data were collected from both patient and HC groups using standardized questionnaires. All participants were between 18 and 60 years old. Exclusion criteria encompassed cognitive impairment, other comorbid psychiatric disorders such as anxiety and depression, severe medical conditions including any acute medical or physical condition, history of kidney or liver failure, concomitant psychosis, and prior use of antipsychotic drugs. Furthermore, individuals who were receiving medications, supplements, or blood transfusions that could influence the blood levels of the target biomarkers were also excluded from the study.

Sample Collection

A 5-mL blood sample was drawn from the cephalic vein of each participant. The samples were left to clot in Falcon tubes at room temperature for 1 hour. Subsequently, the tubes containing the clotted blood were centrifuged at 3,000 rpm for approximately 15 minutes at room temperature to separate the serum. The serum was then carefully transferred to Eppendorf tubes and refrigerated at -80°C to ensure optimal preservation.

Measurement of Serum Eotaxin-1 and IL-34

Commercially available enzyme-linked immunosorbent assay (ELISA) kits from Boster Bio were used to measure the serum levels of eotaxin-1 and IL-34. The serum concentrations of eotaxin-1 and IL-34 were determined following the manufacturer's instructions for the ELISA kit (Picokine; Boster Bio) [38,39]. The manufacturer provided intra-assay coefficients of variation, which were 5% for eotaxin-1 and 5.7% for IL-34. To maintain consistency and minimize potential bias, all experiments were performed by the same researchers, who were blinded to the potential outcomes.

Yale-Brown Obsessive-Compulsive Scale

The Y-BOCS is a widely utilized clinical instrument for evaluating the severity of symptoms in OCD, covering 2 primary domains: obsessions and compulsions. Each domain is scored on a scale ranging from 0 to 4. Obsessions are rated based on factors such as the time spent on intrusive thoughts, the degree to which these obsessions interfere with daily life, the distress they cause, efforts to resist them, and the individual's control over them. Similarly, compulsions are evaluated based on the time dedicated to repetitive behaviors, the level of interference with daily activities, the anxiety experienced when compulsions are resisted, attempts to resist them, and the degree of control. The overall Y-BOCS score categorizes OCD severity into 4 distinct levels: scores of 8–15 indicate mild OCD, 16–23 moderate,

24–31 severe, and 32–40 extremely severe. This essential tool is instrumental in the diagnosis and monitoring of OCD [40,41]. A study conducted with a Bangladeshi cohort found that the Bengali version of the dimensional Y-BOCS demonstrates excellent internal consistency and good to excellent interrater reliability [42]. To gather clinical and sociodemographic data, the local language and English versions of the Y-BOCS, along with all questionnaires, were employed.

Statistical Methods

IBM SPSS ver. 25.0 (IBM Corp.) and Microsoft Excel (Microsoft Corp.) were utilized for data processing and statistical analysis. The independent samples t-test and the chi-square test were employed to differentiate between groups and evaluate the relationships between variables. The Cohen *d* was calculated to determine the effect sizes for significant findings. Spearman correlation analysis was conducted to explore the associations among various study parameters in patients with OCD, with Bonferroni adjustments applied to correct for multiple comparisons. Box plot graphs were employed to visually represent the results. Descriptive analysis was used to outline the sociodemographic profiles of the participants, and results were presented as mean $\pm$ standard error of the mean. Receiver operating characteristic (ROC) curve analysis was performed to quantify the diagnostic accuracy of the altered serum parameters. A 2-tailed *p*-value less than 0.05 was considered to indicate statistical significance.

Ethics Statement

The Research Ethics Committee (REC) of the University of Asia Pacific (UAP) approved the study protocol (UAP/REC/2023/207). Informed written consent was obtained from all participants prior to data collection. Written informed consent was also secured for the publication of these anonymous study results. The investigations were conducted in accordance with the principles outlined in the Helsinki Declaration.

Results

Participants and Descriptive Data

The characteristics of the study population are detailed in Table 1. Regarding age distribution, the most common age range for both patients and HCs was 18 to 25 years, with 65.5% of patients and 50.0% of HCs falling within this category ($p=0.112$). When considering marital status, patients had a slightly higher percentage of unmarried patients compared to HCs (patients with OCD, 53.4%; HCs, 50.0%; $p=0.759$). In

Table 1. Characteristics of the study population

Parameter	Patients with OCD (<i>n</i> = 58)	Healthy controls (<i>n</i> = 30)	<i>p</i>
Age (y)	25.57 $\pm$ 0.78	27.70 $\pm$ 1.01	0.112
18–25	38 (65.5)	15 (50.0)	
26–35	15 (25.9)	11 (36.7)	
36–45	5 (8.6)	4 (13.3)	
Sex			0.653
Male	30 (51.7)	14 (46.7)	
Female	28 (48.3)	16 (53.3)	
BMI (kg/m ²)	22.56 $\pm$ 0.32	23.47 $\pm$ 0.46	0.130
Below 18.5 (CED)	1 (1.7)	1 (3.3)	
18.5–25.0 (normal)	47 (81.0)	23 (76.7)	
Above 25.0 (obese)	10 (17.2)	6 (20.0)	
Marital status			0.759
Married	27 (46.6)	15 (50.0)	
Unmarried	31 (53.4)	15 (50.0)	
Education level			0.428
Illiterate	3 (5.2)	0 (0)	
Primary	10 (17.2)	4 (13.3)	
Secondary	24 (41.4)	11 (36.7)	
Graduate and above	21 (36.2)	15 (50.0)	
Occupation			0.156
Business	9 (15.5)	4 (13.3)	
Service	8 (13.8)	8 (26.7)	
Housewife	15 (25.9)	7 (23.3)	
Student	17 (29.3)	8 (26.7)	
Unemployed	9 (15.5)	3 (10.0)	
Economic status			0.971
High	5 (8.6)	3 (10.0)	
Medium	36 (62.1)	18 (60.0)	
Low	17 (29.3)	9 (30.0)	
Area of residence			0.785
Rural	23 (39.7)	11 (36.7)	
Urban	35 (60.3)	19 (63.3)	
Smoking history			0.968
Non-smoker	54 (93.1)	28 (93.3)	
Smoker	4 (6.9)	2 (6.7)	
Family history of OCD			0.004
Yes	12 (20.7)	0 (0)	
No	46 (79.3)	30 (100.0)	

Data are presented as mean $\pm$ standard deviation or *n* (%).

OCD, obsessive-compulsive disorder; BMI, body mass index; CED, chronic energy deficiency.

and IL-34 between patients with OCD and HCs. Serum eotaxin-1 levels were significantly higher in the OCD group than in HCs, with a significant positive correlation observed between eotaxin-1 level and the severity of OCD. Conversely, serum IL-34 levels were significantly lower in patients, but these levels did not correlate significantly with OCD severity. Additionally, a significant negative correlation was found between eotaxin-1 and IL-34 levels. ROC analysis suggests

terms of education, the largest proportion of both patients and HCs had reached the secondary level (patients with OCD, 41.4%; HCs, 36.7%; $p=0.428$), and the most common occupation was student. Participants predominantly lived in urban areas (patients with OCD, 60.3%; HCs, 63.3%; $p=0.785$). Finally, 20.69% of the patients had a previous history of OCD.

Clinical Profile and Laboratory Findings

The mean ages of the patient group and the HC group were 25.57 ± 0.78 years and 27.70 ± 1.01 years, respectively ($p=0.112$). The mean body mass indices for the patient and HC groups were 22.56 ± 0.32 kg/m² and 23.47 ± 0.46 kg/m², respectively ($p=0.107$).

Serum levels of eotaxin-1 were higher in patients (121.13 ± 7.84 pg/mL) than in HCs (85.52 ± 9.42 pg/mL), a statistically significant difference ($p=0.007$) with a Cohen *d* effect size of 0.55. In contrast, serum levels of IL-34 were considerably lower in patients (119.02 ± 14.53 pg/mL) compared to HCs (179.96 ± 27.88 pg/mL), with this difference also displaying statistical significance ($p=0.035$) and a Cohen *d* effect size of -0.48 . [Figure 1](#) compares serum eotaxin-1 and IL-34 levels between patients with OCD and HCs.

Correlation Analysis

The Spearman correlations among various parameters are presented in [Table 2](#). We observed a significant positive correlation between serum eotaxin-1 level and the Y-BOCS score in patients with OCD ($r=0.287$, $p=0.029$). Conversely, we found a negative correlation between serum IL-34 levels and Y-BOCS scores in these patients ($r=-0.018$, $p=0.894$), although this finding was not statistically significant. Additionally, a significant negative correlation was observed

between serum eotaxin-1 and IL-34 levels ($r=-0.273$, $p=0.038$).

ROC Curve Analysis

The results of the ROC curve analysis for serum eotaxin-1 and IL-34 levels are presented in [Table 3](#) and illustrated in [Figure 2](#). According to the analysis, the cut-off values for serum eotaxin-1 and IL-34 levels were determined to be 83.04 pg/mL and 175.62 pg/mL, respectively. The sensitivity for serum eotaxin-1 was found to be 72.4%, with a specificity of 76.3%. For serum IL-34, the sensitivity was 73.3%, and the specificity was 77.2%. The area under the curve for serum eotaxin-1 was 0.717, and for IL-34, it was 0.719 ($p < 0.001$ for both).

Discussion

In the present study, we compared serum levels of eotaxin-1

Table 2. Spearman correlation analysis of research parameters in patients with OCD

Correlation parameter	<i>r</i>	<i>p</i> ^{a)}
Age and Y-BOCS score	-0.059	0.660
Age and eotaxin-1	0.154	0.250
Age and IL-34	0.024	0.860
BMI and Y-BOCS score	0.102	0.447
BMI and eotaxin-1	-0.094	0.482
BMI and IL-34	-0.141	0.290
Eotaxin-1 and Y-BOCS score	0.287	0.029
IL-34 and Y-BOCS score	-0.018	0.894
Eotaxin-1 and IL-34	-0.273	0.038

OCD, obsessive-compulsive disorder; Y-BOCS, Yale-Brown obsessive-compulsive scale; IL, interleukin; BMI, body mass index.

^{a)} Bonferroni-corrected *p*-values.

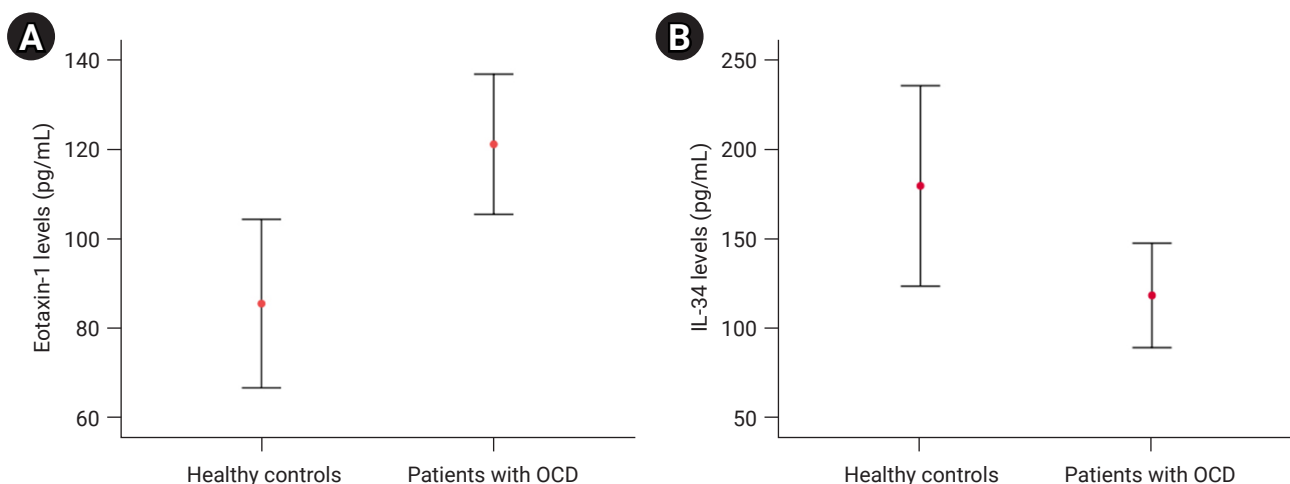


Figure 1. Comparison of serum eotaxin-1 (A) and interleukin (IL)-34 (B) levels between patients with obsessive-compulsive disorder (OCD) and healthy controls.

Table 3. Receiver operating characteristic curve analysis of serum eotaxin-1 and IL-34 levels

Parameter	Cut-off value (pg/mL)	Sensitivity (%)	Specificity (%)	AUC	95% CI	<i>p</i>
Eotaxin-1	83.04	72.4	76.3	0.717	0.598–0.836	<0.001
IL-34	175.62	73.3	77.2	0.719	0.612–0.826	<0.001

IL, interleukin; AUC, area under the curve; CI, confidence interval.

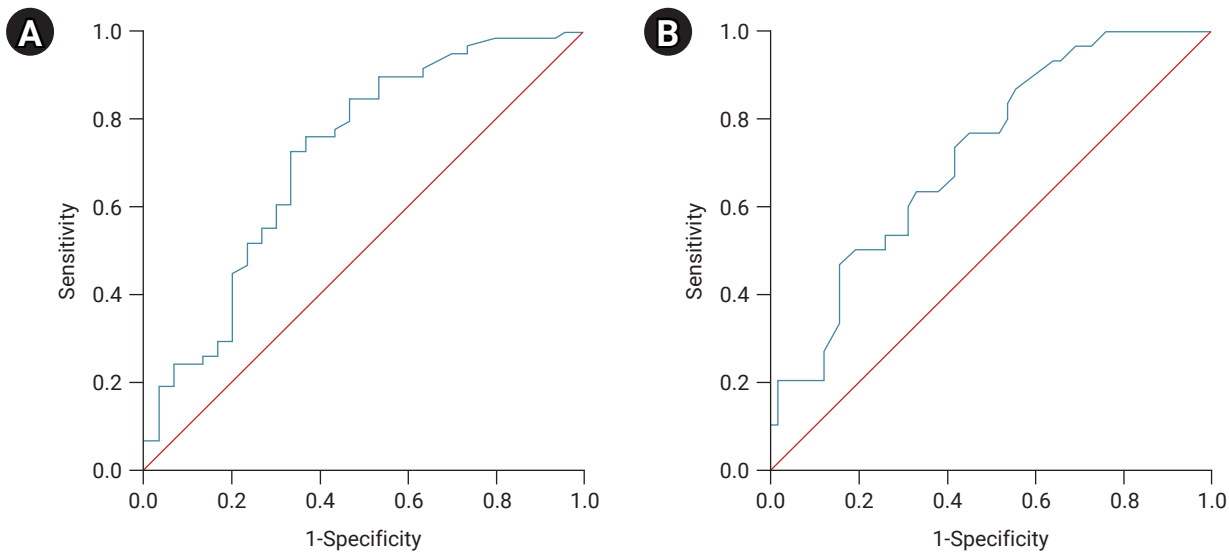


Figure 2. Receiver operating characteristic curves of serum eotaxin-1 levels (A) and serum interleukin 34 levels (B) among the study population.

that both eotaxin-1 and IL-34 exhibit good sensitivity and specificity for distinguishing between patients with OCD and HCs. The study also included no significant differences in sociodemographic and biophysical evaluations between the OCD patients and HCs, suggesting that these factors did not significantly influence the laboratory findings.

Consistent with the findings of this study, previous research has also reported elevated levels of eotaxin-1 in patients with OCD compared to HCs; however, the increase observed in the earlier study was not statistically significant [24]. Studies have suggested that eotaxin-1 plays a critical role in the recruitment of eosinophils to sites of inflammation, which is believed to be a key component of OCD pathophysiology [24,43]. As a chemoattractant, eotaxin-1 binds to the CCR3 receptor on eosinophils, directing them to sites of inflammation where they release inflammatory mediators that contribute to central inflammation [44]. Eotaxin-1 has also been associated with aging, decreased neurogenesis, and neurodegeneration, affecting neural progenitor cells and microglia, which could potentially lead to cognitive impairments associated with OCD [24,45]. Additionally, studies have highlighted the effects of aging, reduced neurogenesis, and mitochondrial dysregulation on OCD [46,47].

Although the current study found statistically significant decreases in serum IL-34 levels, previous research did not establish a direct correlation between IL-34 and OCD. Instead, it reported that IL-34 was involved in inflammation and immune responses. IL-34 acts as a ligand for the colony-stimulating factor 1 receptor, playing a crucial role in the survival, proliferation, and differentiation of macrophages and microglia, which are thought to contribute to the pathophysiological circumstances of OCD [25,32,33]. By promoting microglial activation, IL-34 contributes to the inflammatory response within the central nervous system (CNS) [26]. IL-34 is also found to play a vital role in exerting anti-inflammatory effects by altering leukocyte adhesion and transendothelial migration, and by reducing the secretion of proinflammatory cytokines [48,49]. Additionally, IL-34 has been shown to restore blood-brain barrier integrity by upregulating tight junction proteins, which are often downregulated by proinflammatory cytokines. Thus, decreased IL-34 levels are associated with increased proinflammatory cytokines in the CNS, leading to neuroinflammation, which is involved in the pathogenesis of OCD [50]. In OCD, ongoing neuroinflammation and consequent oxidative stress lead to a predominance of proinflammatory cytokines, further

rationalizing the decreased levels of IL-34 due to its anti-inflammatory nature [16,43,51,52].

The current lack of reliable quantitative diagnostic methods and established biomarkers for mental disorders, such as OCD, is notable [53–56]. Research into these biomarkers can markedly improve our understanding of OCD by illuminating the roles of immunomodulation, neuroinflammation, neurodegeneration, and oxidative stress in the development and persistence of the condition. Overall, investigating eotaxin-1 and IL-34 as potential biomarkers for OCD may improve diagnostic precision, advance new treatment options, and enrich our understanding of the mechanisms underlying this disorder.

The present study has several notable strengths. It represents the first investigation to examine eotaxin-1 and IL-34 levels among patients with OCD within a homogeneous population, achieved through stringent application of exclusion criteria. Globally, only a limited number of studies have explored these chemokines and cytokines in individuals with OCD, with inconclusive results. This research utilized ROC analysis, which demonstrated good sensitivity and specificity, indicating that the altered parameters have diagnostic accuracy for differentiating patients from healthy individuals. As such, this study offers new insights to the existing body of knowledge in the field. Additionally, the study specifically selected patients who had not been exposed to medication, ensuring that the biomarker levels were not influenced by pharmaceutical interventions. This approach supports the generalizability and reliability of the research findings.

The current research also has certain limitations that should be acknowledged. First, as with any cross-sectional study that employs random sampling, the findings may exhibit some degree of variability. The limited sample size and the inclusion of individuals with a history of smoking could introduce confounding factors that affect the analysis of biomarkers. Additionally, this study did not account for variables such as diet, physical activity, and sleep patterns. The correlation coefficients between variables were moderate, indicating that the observed relationships should be interpreted with caution. Therefore, the findings of this research should be considered preliminary. To improve the robustness of the results, further investigations are necessary. These should explore a broader range of cytokines and involve a larger and more homogeneous population, taking into account any potential confounding factors associated with OCD.

The results of this study suggest that eotaxin-1 and IL-34 may be valuable as diagnostic biomarkers for OCD. By measuring the levels of these biomarkers, clinicians may gain key insights into the processes of immunomodulation, neuroinflammation, neurodegeneration, and oxidative stress

that are associated with OCD. Incorporating eotaxin-1 and IL-34 into the evaluation process, such as in interventional studies, could improve clinical decision-making and facilitate the delivery of more personalized and targeted treatments for patients with OCD.

The present findings highlight the relationship between serum eotaxin-1 and IL-34 levels and the pathophysiology and progression of OCD. A thorough understanding of the disease's pathogenesis, including the relevant immune and inflammatory markers, is essential for effective patient management. Based on the results of this study, we recommend the following: (1) the use of serum eotaxin-1 and IL-34 levels as risk assessment tools for evaluating patients with OCD; (2) the recognition of the significance of eotaxin-1 and IL-34 through ROC analysis; (3) the development of targeted therapeutic interventions that address alterations in cytokines and chemokines in patients with OCD; and (4) the provision of dietary recommendations that may be beneficial in managing OCD symptoms.

Conclusion

Altered levels of eotaxin-1 and IL-34 in patients with OCD may be linked to the condition. The significant increase in eotaxin-1 and decrease in IL-34 observed in this study suggest that these cytokines play a role in OCD. By providing new insights into this psychiatric disorder, the findings could lead to the development of practical and reliable diagnostic tools. Identifying these specific biomarkers in OCD could increase diagnostic precision, enable targeted treatments, and ultimately improve patient outcomes. These results not only contribute to the growing body of knowledge about OCD but also highlight the importance of further research to validate these findings and discover new information that could lead to more effective diagnostic and therapeutic strategies for this challenging disorder.

Notes

Ethics Approval

The Research Ethics Committee (REC) of the University of Asia Pacific (UAP) has approved the study protocol (UAP/REC/2023/207). Informed written consent was obtained from all participants prior to data collection. Additionally, we secured written informed consent for the publication of these anonymous study results. The investigations were conducted in accordance with the principles outlined in the Helsinki Declaration.

Conflicts of Interest

The authors have no conflicts of interest to declare.

Funding

None.

Availability of Data

The datasets used and/or analyzed during the present study are available from the corresponding author upon reasonable request.

Authors' Contributions

Conceptualization: SIH, RS, MRI; Data curation: SIH, RS; Formal analysis: SIH, SMAI; Funding acquisition: MRI; Investigation: MRI, SIH; Methodology: MRI; Project administration: MRI; Supervision: MRI; Validation: MAB; Visualization: MMASQ; Writing—original draft: SIH, RS; Writing—review & editing: all authors. All authors read and approved the final manuscript.

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