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Original Article

Correlation Between Granulocyte Counts (Neutrophils, Eosinophils, Basophils) and IgG/IgM *Salmonella typhi* Test Result in Suspected Typhoid Fever Patient

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ABSTRACT

Typhoid fever is a systemic infectious disease that remains prevalent in Indonesia, particularly in areas with poor sanitation. It's primarily caused by *Salmonella typhi*, which is transmitted through contaminated food or water. The diagnosis of typhoid fever can be supported by several laboratory examinations that are expected to provide rapid, accurate, and specific results. The purpose of this study was to determine the correlation between granulocyte counts (neutrophils, eosinophils, and basophils) and IgG/IgM *Salmonella typhi* test results in patients with suspected typhoid fever to support diagnosis. This study employed an analytic observational design with a cross-sectional approach. The samples comprised 32 patients suspected of typhoid fever, recruited from Ultramedica Clinic, Tulungagung, using purposive sampling based on predetermined inclusion criteria. Granulocyte cell counts (neutrophils, eosinophils, and basophils) were examined using a hematology analyzer, while IgG/IgM *Salmonella typhi* testing was performed using an immunochromatographic method. Statistical analysis was conducted using the Spearman correlation test. The results revealed a significant positive correlation between neutrophil count and IgM test results ($p = 0.000 < 0.05$; $r = 0.712$). However, eosinophil and basophil counts showed no significant correlation with IgM results ($p > 0.05$). Furthermore, no correlation was found between any granulocyte type and IgG *Salmonella typhi* results ($p > 0.05$). These findings indicate that increased neutrophil levels are associated with positive IgM results, whereas eosinophil and basophil counts are not related to IgM response. In addition, the absence of correlation between all granulocyte types and IgG results indicates that granulocyte counts are not associated with the late-phase immune response.

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INTRODUCTION

Typhoid fever is a systemic infectious disease caused by *Salmonella typhi* and remains a significant public health problem in developing countries, including Indonesia[1,2]. The World

Health Organization (WHO) estimates that 11–21 million cases of typhoid fever occur annually worldwide[3]. In Indonesia, the prevalence ranges from 350 to 810 cases per 100,000 population, with a relatively high mortality rate[2,4]. Therefore, rapid and accurate diagnostic methods are essential for effective disease management and control.

A complete blood count (CBC) is commonly used as an initial laboratory examination to support the diagnosis of typhoid fever[5]. A complete blood count is recommended because it is associated with changes in hematological parameters in typhoid fever[6]. Relevant hematological parameters include total and differential leukocyte counts. White blood cells are the body's primary defense against infection and disease[7]. Types of leukocytes include granulocytes (neutrophils, eosinophils, basophils) and agranulocytes (monocytes, lymphocytes), which play a crucial role in fighting pathogens. Granulocytes reach the site of infection more quickly to perform their functions than agranulocytes[8].

In addition, diagnosis can be supported by serological tests such as Widal and Typhidot. The Typhidot test detects IgG and IgM antibodies against the outer membrane proteins of *Salmonella typhi*[2]. That test has higher sensitivity and specificity than the Widal test[9]. The Typhidot test demonstrated a sensitivity of 90–92% and a specificity of 89–90%, whereas the Widal test showed a sensitivity of 70–75% and a specificity of 83–85%[10].

Previous studies investigating the relationship between hematological parameters and serological test results in typhoid fever have shown inconsistent findings. Fitriani and Aliviameita (2024) reported a decrease in neutrophil count associated with high Widal titers, whereas Haryanti, Nugroho, and Faizal (2025) found an increased neutrophil count correlated with positive IgM *Salmonella typhi* results. These discrepancies indicate the need for further research on the correlation between leukocyte subtypes, particularly granulocytes (neutrophils, eosinophils, and basophils), and IgG/IgM *Salmonella typhi* test results[11,12].

This study aimed to determine the correlation between granulocyte counts (neutrophils, eosinophils, and basophils) and IgG/IgM *Salmonella typhi* test results in patients suspected of typhoid fever as a diagnostic support.

METHODS

This observational study employed a cross-sectional design and was conducted at the Ultramedica Clinical Laboratory in Tulungagung from January to March 2026. The variables investigated included neutrophil, eosinophil, and basophil counts, IgG/IgM *Salmonella typhi* test results, and suspected typhoid fever patients. The study population consisted of all patients with suspected typhoid fever who underwent a complete blood count and IgG/IgM *S. typhi* rapid testing during the study period. Samples were selected using purposive sampling based on the following inclusion criteria: patients diagnosed by a physician with suspected typhoid fever, presenting with

fever >38°C for more than 3 days, accompanied by symptoms such as headache, abdominal pain, nausea or vomiting, and loss of appetite. Patients with infectious diseases such as HIV/AIDS or hepatitis, and chronic diseases such as cancer, were excluded from the study. A total of 32 participants were included, as determined using the Fisher Z Transformation formula.

The study procedure began with the collection of 3 mL of venous blood into K3EDTA and non-anticoagulant tubes. Complete blood count analysis was performed using a hematology analyzer. Prior to analysis, EDTA samples were homogenized using a figure-eight mixing motion and then aspirated into the analyzer according to the manufacturer's instructions[13]. Serum was obtained by centrifugation at 3000 rpm for 10 minutes and used for the IgG/IgM *S. typhi* rapid test kit orient gene. One drop of serum was added to the sample well marked "S," followed by one drop of buffer solution, according to the kit instructions (orient gene). The reaction was allowed to develop and was read within 10–15 minutes. The rapid test result was considered positive when a red line appeared in the IgG and/or IgM area, whereas a negative result was indicated by the appearance of a red line only in the control (C) area[14]. The hematological and serological results were subsequently recorded and analyzed to determine the correlation between granulocyte counts and serological findings.

Data analysis was performed using SPSS software. Correlation analysis was performed using Spearman's rank correlation coefficient because the granulocyte count was measured on a ratio scale, whereas the IgG/IgM test results were measured on an ordinal scale. The correlation coefficient was interpreted as follows: very weak (0.00–0.199), weak (0.20–0.399), moderate (0.40–0.599), strong (0.60–0.799), and very strong (0.80–1.00). Rapid test results for IgG and IgM were coded as 1 (positive) and 0 (negative) for statistical analysis. Interpretation of the test results, including IgM positive, IgG positive, IgG/IgM positive, and IgG/IgM negative.

RESULTS

The results of the granulocyte (neutrophil, eosinophil, basophil) examination are expressed as percentages (%) and compared with normal reference values. Furthermore, testing for *Salmonella typhi* infection is performed using an IgG/IgM immunochromatographic test. The test result is considered positive if a red line appears in the IgM and/or IgG test zones, indicating the presence of antibodies against *Salmonella typhi*, while the result is considered negative if a red line appears only in the control zone without a line in the test zone[14].

Table 1 Characteristics of Respondents by Gender and Age.

No.	Characteristics	Category	Frequency	Percentage (%)
1.	Gender	Male	19	59.4
		Female	13	40.6
2.	Age (Years)	< 5 (Infants and Toddlers)	2	6.2
		5 – 9 (Children)	4	12.5
		10 – 18 (Teenager)	3	9.4
		19 – 59 (Adults)	20	62.5
		> 59 (Elderly)	3	9.4
	Total		32	100%

The results show that of the 32 suspected typhoid fever cases at the Ultramedica Clinic in Tulungagung, 19 were male and 13 were female, with the sex difference relatively small. Then, the majority of patients with suspected typhoid fever were in the adult age group (19–59 years), totaling 20 patients, while the fewest were in the infant and toddler age group (<5 years), totaling 2 patients.

Table 2. Results of Granulocyte Counts (Neutrophils, Eosinophils, Basophils) in Patients with Suspected Typhoid Fever at the Ultramedica Clinic in Tulungagung

No	Parameter	Range	Frequency	Percentage	n
1	Neutrophils	Low < 50%	0	0 %	32
		Normal 50-70%	24	75 %	
		High > 70%	8	25 %	
2	Eosinophils	Low < 2%	4	12,5 %	32
		Normal 2-4%	19	59,4 %	
		High > 4%	9	28.1 %	
3	Basophils	Normal 0-1%	32	100%	32
		High > 1%	0	0%	

The analysis results showed that the majority of patients had normal neutrophil levels (75%, or 24 patients), while 25% (8 patients) had elevated levels. Regarding eosinophils, 59.4% (19 patients) were within the normal range, 12.5% (4 patients) were below normal, and 28.1% (9 patients) were above normal. All patients (100%) had basophil levels within the normal range.

Table 3. Results of Salmonella typhi IgG/IgM Testing in Patients with Suspected Typhoid Fever at the Ultramedica Clinic in Tulungagung

No.	IgG/IgM	Frequency	Percentage (%)
1.	IgM Positive	12	37.5
2.	IgG/IgM Positive	4	12.5
3.	IgG Positive	4	12.5
4.	IgG/IgM Negative	12	37.5
	Total	32	100

The results of the Salmonella typhi IgG/IgM test showed that 37.5% (12 patients) were IgM-positive, 12.5% (4 patients) were IgG/IgM-positive, 12.5% (4 patients) were IgG-positive, and 37.5% (12 patients) were negative for both antibodies.

Since the data on granulocyte counts (neutrophils, eosinophils, basophils) are ratio-scaled and the Salmonella typhi IgG/IgM is ordinal, the correlation analysis was performed using the Spearman rank test.

Table 4. Results of Spearman's Rank Correlation Test

Variabel	Sig. Value	Correlation Coefficient
Neutrophils - IgM	0.000	0.712
Neutrophils - IgG	0.753	-0.055
Eosinophils - IgM	0.408	- 0.151
Eosinophils - IgG	0.069	- 0.326
Basophils - IgM	0.168	-0.250
Basophils - IgG	0.431	-0.144

Table 4 shows the results of the Spearman rank correlation test between neutrophil count and *Salmonella typhi* IgG/IgM test results. Neutrophils and IgM showed a significant positive correlation ($p = 0.000$; $r = 0.712$), indicating that an increase in neutrophil count tends to be followed by an increase in IgM. In contrast, the correlation between neutrophil count and IgG was not significant ($p = 0.753$; $r = -0.055$).

In the correlation test between eosinophil count and *Salmonella typhi* IgM, a p-value of 0.408 ($p > 0.05$) and a correlation coefficient of -0.151 were obtained, indicating no significant correlation. Similarly, basophils showed no significant correlation with IgM ($p = 0.168$; $r = -0.250$) or IgG against S. typhi ($p = 0.431$; $r = -0.144$). All of these relationships were negative, with correlation strengths ranging from very weak to weak.

DISCUSSION

Based on a study of 32 patients with suspected typhoid fever at the Ultramedica Clinic in Tulungagung, the number of male patients was slightly higher than that of female patients. These findings are consistent with the study by Situmorang and Apriani (2022), which also found a predominance of male patients[15]. The difference in numbers between the two genders is relatively small, indicating that both genders face an equal risk of exposure to *Salmonella typhi* infection. The incidence of typhoid fever is more influenced by environmental factors, personal hygiene, consumption of contaminated food or beverages, and poor sanitation conditions[16]. Regarding the age characteristics of respondents, the study found that the adult age group (19–59 years) had the highest number of cases. Adults are at a higher risk of exposure *to Salmonella typhi* due to their greater outdoor activity. This finding is also consistent with the study by Situmorang and Apriani (2022)[15]. Conversely, infants and toddlers had the fewest cases, likely due to stricter parental supervision of their diets and limited exposure to high-risk environments.

Granulocyte examination results show that most patients with suspected typhoid fever have neutrophil counts within the normal range, while some have above-normal neutrophil counts. An increased neutrophil count (neutrophilia) in the blood is common in patients with typhoid fever as an immune response to *Salmonella typhi* infection[17]. Eosinophil counts showed variation, ranging from below normal to normal to elevated. An increase in eosinophil count (eosinophilia) is likely influenced by other factors such as allergic reactions or atopic diseases[15]. Meanwhile, all patients had basophil counts within the normal range, indicating that *Salmonella typhi* infection does not cause significant changes in this parameter. This finding is consistent with the study by Situmorang and Apriani (2022), which reported normal basophil levels in all patients with suspected typhoid fever[15].

Testing for *Salmonella typhi* IgG and IgM revealed variations in the immune response among patients with suspected typhoid fever. A total of 12 patients tested positive for IgM, 4 tested positive for IgG, 4 tested positive for both IgM and IgG, and 12 tested negative for both antibodies. Patients suspected of having typhoid fever who tested positive for IgM alone indicated that the *Salmonella typhi* infection was in its early phase[18]. IgM is the first antibody produced by the immune system in response to an infection, and during an acute infection, this antibody typically appears on the third or fourth day of fever[2,19]. A positive IgG result alone indicated an advanced phase of infection or prior exposure, given that IgG is produced more slowly and can persist in the body for a long time[20,21]. Meanwhile, a simultaneous positive result for both IgM and IgG indicates a transitional phase from acute infection to the later phase, when the body begins to develop immunity against the infection[14]. A negative result for both antibodies may be due to an infection that is still in a very early phase, so that antibodies have not yet formed.

The results of the Spearman's rank correlation test showed a significant correlation between neutrophil count and *Salmonella typhi* IgM (p=0.000; r=0.712), indicating a strong positive correlation. These findings suggest that an increase in neutrophil count is followed by a positive IgM result. Neutrophils are a major component of the innate immune system and serve as the first line of defense against bacterial infections. Neutrophil activation is the body's initial response to eliminate pathogens before the adaptive immune system kicks in[22]. IgM is produced as an initial response to the O antigen (LPS), which possesses endotoxin properties[20]. Therefore, the increase in neutrophil count in the early phase of infection will coincide with IgM production as part of the specific immune response, resulting in a positive correlation between the two. These findings are consistent with a study by Haryanti (2025) at Emanuel Hospital in Banjarnegara, which demonstrated a significant association between neutrophil count and *Salmonella typhi* IgM levels[12]. Conversely, no significant correlation was found between eosinophils and IgM (p=0.408; r=-0.151) or between basophils and IgM (p=0.168; r=-0.250). This indicates that these two types of granulocytes do not play a direct role in IgM production during acute typhoid infection. Eosinophil activation is commonly associated with allergic reactions, whereas basophil activation may occur in various conditions, including inflammation, allergic reactions, leukemia, and hemolytic anemia[15,23].

Analysis of *Salmonella typhi* IgG also showed no significant correlation with neutrophils (p=0.753; r=-0.055), eosinophils (p=0.069; r=-0.326), or basophils (p=0.431; r=-0.144). The absence of such a relationship is likely due to differences in the mechanisms and timing of responses between the innate and adaptive immune systems. Granulocytes (neutrophils, eosinophils, and basophils) are components of the innate immune system that serve as the first line of defense against pathogens, with neutrophils acting as the primary phagocytes in bacterial infections[24]. In contrast, IgG antibodies are part of the adaptive immune system, which develops several days to weeks after antigen exposure[22]. IgG is typically produced several weeks after the initial infection and can persist in the body for a prolonged period, even for years[25]. This difference in response timing may cause granulocyte counts, which reflect acute immune responses, to not always correspond with IgG levels resulting from previous antigen exposure, which may persist for a longer period[26]. Therefore, no significant correlation was observed between granulocyte counts and IgG levels in patients suspected of having typhoid fever.

CONCLUSION

Based on the study results, the majority of patients with suspected typhoid fever had neutrophil counts within the normal range, although some showed counts above normal. Eosinophil counts varied from decreased to normal to elevated, with normal values

predominating, and all patients had basophil counts within the normal range. The results of the *Salmonella typhi* IgG/IgM test showed that the proportions of positive and negative IgM results were relatively balanced, whereas IgG results were predominantly negative, with only a small proportion of patients showing positive results.

Correlation analysis revealed a strong and significant positive relationship between neutrophil counts and *Salmonella typhi* IgM test results, indicating that increased neutrophils are associated with the immune response during the acute phase of infection. In contrast, eosinophil and basophil counts did not show a significant correlation with IgM results. Furthermore, no significant correlation was found among all granulocyte types (neutrophils, eosinophils, and basophils) and *Salmonella typhi* IgG results; thus, granulocyte counts are not associated with the late-phase immune response in patients with suspected typhoid fever.

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AUTHOR CONTRIBUTIONS

All authors contributed to the conceptualization and design of the study, data collection, data analysis and interpretation, and the preparation and revision of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding the publication of this article.

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REFERENCES

1. Zaffar S, Sadiqa A. Emergence of Azithromycin-resistant Salmonella Typhi in Southeast Asia: A systematic review. *Pakistan J Med Sci*. 2025;41(7):2101–2109. doi:10.12669/pjms.41.7.12194
2. Idrus HH. *Buku demam tifoid Hasta 2020*. Research Gate; 2020.

3. Eric M Bin, Netongo PM, Kamdem SD, et al. Stress-mediating inflammatory cytokine profiling reveals unique patterns in malaria and typhoid fever patients. *PLoS One*. 2025;20(2 February):1–17. doi:10.1371/journal.pone.0306585
4. Tobing JF. Demam Tifoid. *Ikraith-Humaniora*. 2024;8(2):463–470. doi:10.37817/ikraith-humaniora.v8i2
5. Widat Z, Jumadewi A, Hadijah S. Gambaran Jumlah Leukosit Pada Penderita Demam Tifoid. *Heal J Inov Ris Ilmu Kesehat J Inov Ris Ilmu Kesehat*. 2022;1(3):142–147. doi:10.51878/healthy.v1i3.1461
6. Baye A, Bayih A, Tessafa M, Wordofa M, Planet JAT, 2023 U. Hematological Profiles in Adult patients with Typhoid Fever: A comparative Cross-Sectional Study. *The Planet*. 2024;7(2):2–7. doi:dx.doi.org
7. Loddo A, Putzu L. On the Effectiveness of Leukocytes Classification Methods in a Real Application Scenario. *AI*. 2021;2(3):394–412. doi:10.3390/ai2030025
8. Aliviameita A, Puspitasari. *Buku Ajar Hematologi*. UMSIDA Press; 2019.
9. Yemeli Piankeu AD, Fodouop SPC, Noubom M, Gomseu Djoumsie EB, Ful Kuh G, Gatsing D. Epidemiology and Performances of Typhidot Immunoassay and Widal Slide Agglutination in the Diagnosis of Typhoid Fever in Febrile Patients in Bafoussam City, Cameroon: A Cross-Sectional Comparative Study. *Can J Infect Dis Med Microbiol*. 2024;2024. doi:10.1155/2024/6635067
10. Singh R, Singh G. A comparative evaluation of Typhidot and Widal tests for the detection of agglutinins against typhoid and paratyphoid bacilli in patients' sera. *MGM J Med Sci*. 2021;8(3):222–226. doi:10.4103/mgmj.mgmj_57_21
11. Fitriani D, Aliviameita A. Hubungan Titer Widal dengan Jumlah Leukosit , Limfosit dan Neutrofil pada Pasien Demam Tifoid. *Usmida Prepr Serv*. Published online 2024:1–5. doi:10.21070/ups.5086
12. Haryanti A, Nugroho YE, Faizal IA. Correlation between Neutrophil Counts and Salmonella IgM in Typhoid Fever Patients at Emanuel Hospital, Banjarnegara. *J Indones Med Lab Sci*. 2025;6(2):104–111. doi:10.53699/joimedlabs.v5i2.235 Citation
13. Bere DS, Sudrajat A. Gambaran Kadar Hemoglobin pada Pasien Demam Berdarah Dengue di Rumah Sakit Al-Ihsan Bandung. *Prepotif J Kesehat Masy*. 2024;8(3):4749–4755. doi:10.31004/prepotif.v8i3.33500
14. Prasetyaningsih Y, Nadifah F, Arisandi D, et al. Identifikasi Immunoglobulin Miu (IgM) Immunoglobulin Gamma (IgG) Anti Salmonella Pada Serum Pasien Demam tifoid di Puskesmas Godean II, Sleman, Yogyakarta. *Gema Kesehat*. 2020;12(2):79–87. doi:10.47539/gk.v12i2.134
15. Situmorang R, Apriani. Gambaran Jenis Leukosit pada Penderita Suspek Demam Tifoid. *J Sehat Indones*. 2022;4(02):64–69. doi:10.36418/jsi.v4i01.36
16. Anggraeni R, Soleha TU, Himayani R, Farmasi PS, Kedokteran F, Lampung U. Faktor - Faktor yang Berpengaruh Terhadap Kejadian Demam Tifoid di Indonesia. *J Ris Ilmu Kesehat Umum*. 2025;3(3):207–216. doi:10.57213/jrikuf.v3i3.781
17. Zerlinda N, Woelansari ED, Anggraini AD. Association of Immunoglobulin Immunoglobulin M Typhoid Expression with Neutrophil-Lymphocyte Ratio in Patients at Haji Hospital , Surabaya. *Int J Adv Heal Sci Technol*. 2023;3(4):229–234. doi:10.35882/ijahst.v3i4.289
18. Haritsa KB, Sangeeta P. Systematic Review of Rapid Typhoid Diagnostic Kits. *J Sci Soc*. 2024;51(2):165–176. doi:10.4103/jss.jss
19. Darwin E, Elvira D, Elfi EF. *Imunologi dan Infeksi*. Andalas University Press; 2021.
20. Novarina AKV. *Peran Imunitas pada Infeksi Salmonella Typhi*. C.V Athra Samudra; 2020.
21. Najib MA, Mohd K, Mustaffa F, et al. Performance of Immunodiagnostic Tests for Typhoid Fever : A Systematic Review and Meta-Analysis. *Pathogens*. 2021;10(9):1–14. doi:10.3390/pathogens10091184
22. Abbas AK, Lichtman AH, Pillai S. *Cellular and Molecular Immunology*. Elseiver; 2022.
23. Nurhayati B, Astuti D, Maharani EA, Nugraha G, Gunawan LS, Ujiani S. *Hematologi*. Kementerian Kesehatan Republik Indonesia; 2022.
24. Murphy K, Weaver C. *Janeway's Immunobiology*. Garland Science, Taylor & Francis Group, LLC; 2017.
25. Brilianto SS, Mulyanto A, Sulistiyowati R, Rahaju M. Perbandingan Hasil Pemeriksaan Demam Tifoid Menggunakan Metode Widal Slide Dan Metode Rapid Test IgG IgM Di RSUD Dr R Goeteng Taroenadibrata. *Ulil Albab J Ilm Multidisiplin*. 2024;3(10):132–139. doi:10.56799/jim.v3i10.5228
26. Teunis PFM, Seidman JC, Tamrakar D, et al. Seroresponse to repeated infections with Salmonella enterica Typhi and Paratyphi A. *Epidemics*. 2026;54(100874):1–43. doi:10.1016/j.epidem.2025.100874.Seroresponse