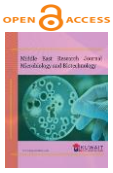

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Haemagglutination Patterns of Enteropathogenic *Escherichia coli* of Cancer and Noncancer Patients

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Abstract: ***Background*:** The haemagglutination has been used for detection of many infectious diseases as a cheep tool for identification compared to other sophisticated techniques such as serology, biochemical and phage typing. Because of bacterial pili, the agglutination of erythrocytes with bacteria has been demonstrated to be facilitated. ***Materials and Methods***: 400 patients were included and they were 200 patients with cancer diseases and 200 patients complaining of other illnesses. Swabs were taken from faeces and inoculated on MacConkey agar for isolation and identification of *Escherichia coli*. Haemagglutination typing between *E.coli* serotypes and erythrocytes of different human blood groups was carried out with and without mannose and the patterns were concluded. ***Results*:** Among cancer patients, blood group A represented the most prevalent blood type, accounting for 36% of the total cancer population, followed closely by blood group O (34.5%). Blood group B constituted 23.5%, whereas blood group AB showed the lowest prevalence at only 6%. This pattern suggests a possible predominance of blood groups A and O among cancer-associated individuals. Blood group A cancer patients under mannose-positive conditions showed the greatest overall agglutination intensity, with multiple positive interactions against serotypes 026, 055, 086, 0119, 0127, 0126, 0114, and 0142 (Table 2). This finding may indicate enhanced susceptibility of blood group a erythrocyte antigens to bacterial attachment in cancer-associated physiological conditions. Overall, the findings suggest that ABO blood group antigens significantly influenced *E. coli* haemagglutination behavior and cancer-associated blood samples demonstrated enhanced bacterial interaction patterns. ***Conclusions*:** He present study revealed that cancer patients were mostly of blood group A. It was also noticed that o125 and 0128 serotypes of *E.coli* agglutinated with blood groups O and B but the serotype o124 did not show any sort of haemagglutination with different blood groups. It was concluded that most serotypes were group A agglutinating bacterial strains with frequency exceeded 70%. Table 2 shows that most of serotypes reacted to A,B and O positively as far as cancer patients were concerned particularly group A but no haemagglutination was seen with blood group type AB. A significant Chi-square result ($p < 0.05$) would indicate that blood group distribution differs significantly between cancer and non-cancer populations. These results support the hypothesis that erythrocyte surface carbohydrate structures, disease-associated physiological changes, and bacterial adhesin diversity collectively contribute to host–pathogen interaction dynamics.

Keywords: Cancer, Patients, *E. coli*, EPEC, Blood Groups, Haemagglutination.

Research Paper

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INTRODUCTION

Nine identified pathovars of Escherichia coli strains isolated from humans can cause diarrheagenic and extraintestinal diseases [1-4]. Seven of these pathotypes are enteric pathogenic *E. coli,* including Enteropathogenic *E. coli* (EPEC), enterohaemorrhagic *E. coli* (EHEC), enterotoxigenic *E. coli* (ETEC), enteroinvasive *E. coli* (EIEC), enteroaggregative *E. coli*(EAEC), diffusely adherent *E. coli* (DAEC), and a recently discovered pathotype, edherent-Invasive *E. coli* (AIEC) [5-8]. These particular pathotypes are mainly responsible for triggering diarrhea and various intestinal

disorders. For instance, enterohemorrhagic *E. coli* (EHEC) pathotypes pose significant public health concerns as they are known foodborne pathogens and have been linked to fatal outbreaks in both developed and developing countries [9-12]. These pathotypes cause diseases by expressing genes that encode virulence factors, and recent studies have emphasized their potential impact on a range of disorders [13-18]. It was found that Gram-negative bacteria particularly *E. coli* are associated with many infectious diseases attacking cancer patients like bacteraemia [19], who concluded that 13.8% of patients with cancer of bladder were suffered from urinary tract infection due to incidence of *E.coli*. It was postulated by many investigators that there is a relationship between natural selection and blood group types. They found a relation between ABO and duodenal ulcer, carcinoma of stomach and diabetes mellitus [20-24]. The haemagglutination has been used for detection of many infectious diseases as a cheep tool for identification compared to other sophisticated techniques such as serology, biochemical and phage typing [25-30]. Because of bacterial pili, the agglutination of erythrocytes with bacteria has been demonstrated to be facilitated. The usage of sugars such as mannose for inhibition of hemagglutination with certain bacterial strains giving d differential patterns of haemagglutination for different types of bacteria depending on types of pili. It was shown that type-I was very common causing mannose-sensitive haemagglutination (MSHA) as discovered by Duguid *et al*., [32]. Generally, there are two main types of direct haemagglutination which are mannose-sensitive which utilized for identification of type-I-fimbriae (MSHA) and mannose-resistant haemagglutination (MRHA) which was commonly used for epidemiological studies. This is because that most of the virulent pathogens possess fimbriae of MRHA [33]. It was found a relation between O,K and H bacterial antigens and fimbrial antigen of isolates causing urinary tract infection [34,35,36] of *E. coli* causing this disease. It was also demonstrated that there is a difference between haemagglutination patterns occurred with human RBCs and that of animals like cattle, chicken, guinea pig and rabbit due to different fimbriae [8-37].

MATERIALS AND METHODS

Patients

This study was carried out in hospital of atomic medicine, Al-Khansaa Hospital and general hospital of Mosul city, Iraq. 400 patients were included and they were 200 patients with cancer diseases and 200 patients complaining of other illnesses. The acceptance for participation in the present study was taken from all the participants whose native language is Arabic. They were not mentally retarded and they were completely healthy considering hearing and speaking.

Sampling

Swabs were taken from faeces. Swabs were rinsed with sterile nutrient broth as a transport media. 200 samples of cancer patients and 200 swabs were from noncancer patients [16-38].

Isolation

All samples were inoculated on MacConkey agar (Oxoid). Inoculated plates were incubated at 37 ^{0}C for 24 hours [38, 39].

Identification of Escherichia coli

The purified isolates of suspected *E.coli* were conventionally identified following methods of workers [40, 41].

Haemagglutination Typing

Type A human blood was drawn from volunteers and placed into a tube containing 1.0 ml of 3.8% citric acid in distilled water per 9.0 ml of blood. Blood was diluted 1:4 with phosphate-buffered saline to test for HA and 1:4 with 1% mannose in phosphate buffered saline to test for MRHA. The same procedure was used for blood freshly drawn from guinea pigs and for bovine, adult chicken, and African Green monkey erythrocytes obtained from Flow Laboratories, Inc., McLean, Va. HA tests were performed by slide agglutination as follows. Bacterial cells from CFA agar cultures (see above) were picked up with a sterile wooden toothpick and mixed with a drop of the appropriate species of blood (approximately 20 g/l) on a glass slide at room temperature. After observation for HA for about 1 min, the slides showing less than maximum HA were placed on the surface of ice and observed for a least 2 min, with intermittent mixing by rotation of the slide. Results were recorded at 4+ when the HA reaction was instantaneous and complete, involving all the erythrocytes. Lesser degrees of HA were recorded as 3+, 2+, 1+, or negative [11]. HA was denoted as resistant (MRHA) if the same degree of HA occurred with and without mannose and as sensitive (MSHA) if HA was prevented or grossly reduced by the presence of mannose. For consistency each test strain was tested first with erythrocytes in phosphate-buffered saline in the following order: human, bovine, chicken, monkey, guinea pig. If positive for HA, the test was repeated with the appropriate species of erythrocytes in phosphate-buffered saline plus mannose. There was only one circumstance, which occurred infrequently, in which an HA pattern could not be obtained; a few rough (untypable) isolates of *E. coli* were found to produce MRHA with every species of erythrocyte tested, but this HA was not typical and therefore, was easily recognized [42].

Statistical Analyses

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM

Corp., Armonk, NY, USA). Descriptive statistics such as means, standard deviations, and frequency distributions were computed to summarize the data. A paired sample t test correlation coefficient (R) and coefficient of determination (R2) were calculated [28-44].

RESULTS

Blood Group Typing

The distribution analysis of ABO blood groups among cancer and non-cancer patients in Nineveh, Iraq revealed noticeable variations in blood group prevalence according to disease status and gender composition. A total of 400 individuals were included in the study, comprising 200 cancer patients and 200 non-cancer controls (Table 1). Among cancer patients, blood group A represented the most prevalent blood type, accounting for 36% of the total cancer population, followed closely by blood group O (34.5%). Blood group B constituted 23.5%, whereas blood group AB showed the lowest prevalence at only 6%. This pattern suggests a possible predominance of blood groups A and O among cancer-associated individuals. Gender distribution among cancer patients demonstrated clear male predominance, where males represented 61% of all cancer cases compared with 39% for females. Male cancer patients showed the highest frequencies within blood groups a (36.1%) and B (29.5%), whereas female cancer patients demonstrated relatively greater representation in blood group O (42.3%). Blood group AB remained the least common in both genders. Within the non-cancer group, blood groups A and O each represented 34% of the population, while blood group B accounted for 25% and AB for 7%. Unlike cancer patients, the non-cancer group exhibited a comparatively balanced distribution between blood groups A and O. The non-cancer group also showed a smaller male predominance than the cancer group, with males accounting for 54.5% and females 45.5%. Among non-cancer males, blood group O demonstrated the highest frequency (39.4%), whereas among females, blood group B was most prevalent (34.1%). Comparative analysis between cancer and non-cancer populations indicates that blood group A was slightly more common among cancer patients (36%) than controls (34%); blood group O showed nearly similar prevalence in both groups; blood group B appeared slightly reduced among cancer patients compared with controls; blood group AB remained consistently the least frequent blood group across all study categories. These observations may suggest a potential association between specific ABO blood groups and cancer susceptibility, particularly for blood group A. However, statistical confirmation requires inferential testing such as Chi-square analysis. Chi-square testing is the most appropriate statistical method for this dataset because all variables are categorical. A significant Chi-square result ($p < 0.05$) would indicate that blood group distribution differs significantly between cancer and non-cancer populations. Additionally, Cramér's V analysis would help determine the strength of association between blood group and cancer status. The grouped bar plot further demonstrated that cancer-associated males exhibited elevated frequencies in blood groups A and B; female cancer patients showed stronger predominance of blood group O; blood group AB consistently exhibited minimal representation, suggesting weak association with either disease condition. Overall, the data indicate that ABO blood group distribution may be associated with cancer occurrence and gender-related variability in the studied Iraqi population. The predominance of blood groups A and O among cancer patients suggests these blood groups may have greater biological interaction with cancer-related mechanisms, whereas blood group AB appears to have minimal contribution to disease prevalence (Figure 1).

Table 1: Distribution of blood groups among cancer and noncancer patients in Nineva, Iraq

Source	Blood group	Gender				Total	
		Males		Females			
		No.	%	No.	%	No.	%
Leukemic patients	A	44	36.1	28	35.1	72	36
	B	36	29.5	11	14.1	47	23.5
	AB	6	4.9	6	7.6	12	6
	O	36	29.5	33	42.3	69	34.5
	Total	122	61	78	39	200	100
Non-cancer patients	A	38	34.7	30	32.7	68	34
	B	19	17.4	31	34.1	50	25
	AB	9	8.2	5	5.5	14	7
	O	43	39.4	25	27.5	68	34
	Total	109	54.5	91	45.5	200	100
Overall		231	57.8	169	42.2	400	100

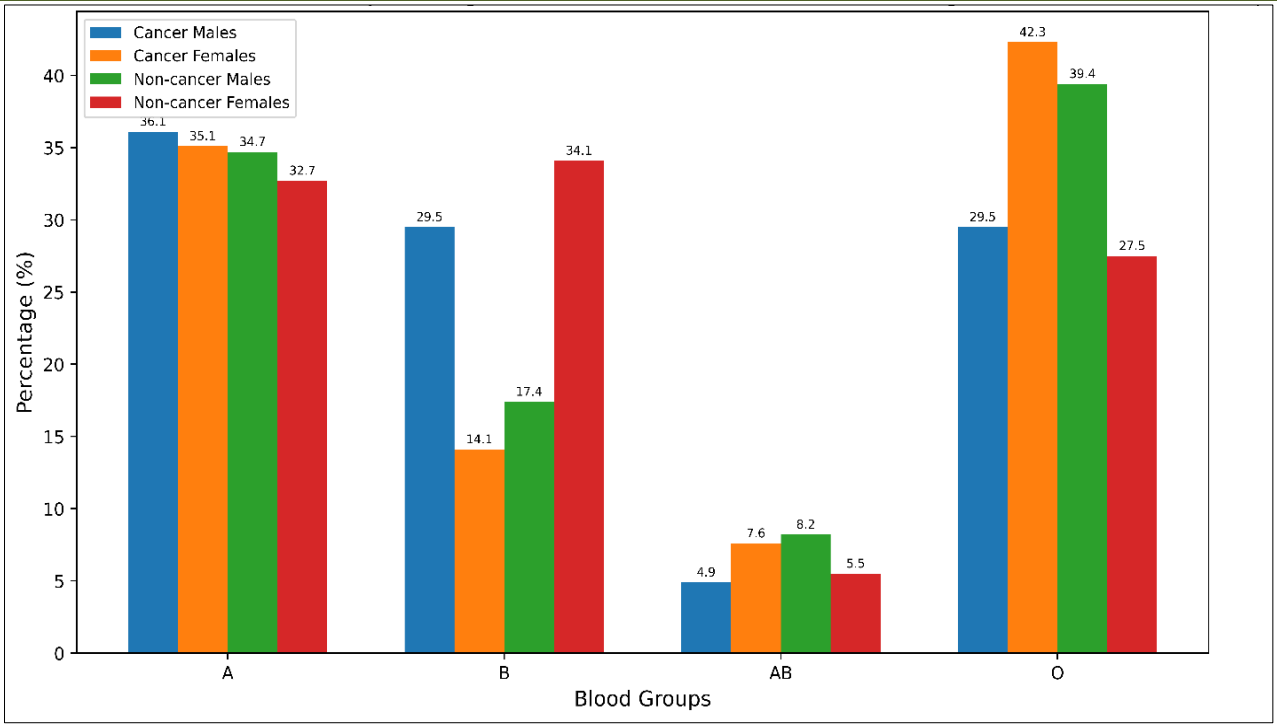

Figure 1: Distribution of ABO blood groups among cancer and non-cancer patients according to gender in Nineveh, Iraq

Haemagglutination

The haemagglutination heatmap demonstrated substantial variability in the interaction patterns between ABO blood groups and different *Escherichia coli* serotypes under mannose-positive and mannose-negative conditions. Distinct agglutination profiles were observed among cancer patients, non-cancer patients, and control groups, indicating that both disease status and blood group antigens may influence bacterial adhesion behavior. Among the examined serotypes, serotype O142 exhibited the highest and most persistent agglutination activity across nearly all blood groups and experimental conditions, including mannose-positive and mannose-negative environments. This suggests that O142 may possess strong mannose-resistant adhesins capable of binding erythrocyte surface receptors independently of mannose inhibition mechanisms. Blood group A cancer patients under mannose-positive conditions showed the greatest overall agglutination intensity, with multiple positive interactions against serotypes 026, 055, 086, 0119, 0127, 0126, 0114, and 0142 (Table 2). This finding may indicate enhanced susceptibility of blood group A erythrocyte antigens to bacterial attachment in cancer-associated physiological conditions. In contrast, mannose-negative conditions markedly reduced agglutination frequencies in most groups, demonstrating the inhibitory effect of mannose-sensitive fimbrial adhesins. The reduction of positive reactions after mannose removal suggests that several *E. coli* serotypes rely predominantly on mannose-dependent adhesion pathways. Blood group B non-cancer patients displayed moderate agglutination activity, particularly against serotypes 026, 086, 0126, 0128, 0114, and 0142, whereas blood group O groups exhibited selective interaction patterns with stronger responses toward serotypes 055, 086, 0119, and 0127. Control groups generally demonstrated fewer positive agglutination reactions compared with cancer-associated groups, suggesting that cancer-related physiological or immunological alterations may enhance bacterial binding affinity to erythrocyte surface antigens. The binary heatmap also revealed clustering tendencies among serotypes. Certain serotypes demonstrated similar adhesion behaviors across multiple blood groups, indicating potential similarity in fimbrial or adhesin structures. Particularly, serotypes 086 and 0142 consistently showed broader interaction spectra than other serotypes. Overall, the findings suggest that ABO blood group antigens significantly influenced *E. coli* haemagglutination behavior and cancer-associated blood samples demonstrated enhanced bacterial interaction patterns. Mannose strongly modulated bacterial adhesion mechanisms. Specific *E. coli* serotypes possess probable mannose-resistant adhesion properties, especially serotype O142 (Figure 2). These results support the hypothesis that erythrocyte surface carbohydrate structures, disease-associated physiological changes, and bacterial adhesin diversity collectively contribute to host–pathogen interaction dynamics.

Table 2: Haemagglutination of cancer and noncancer patients blood groups with different serotypes of *Escherichia coli* in presence and absence of mannose

Blood group	Source	Mannose	*Escherichia coli* serotypes										
A	Leukemic patients	Mannose +	026	055	086	0119	0127	0125	0126	0128	0114	0124	0142
			+	+	+	+	+	-	+	-	+	-	+
		Mannose-	+	-	+	-	-		-		-		+
	Control	Mannose+	-	-	+	-	+	-	-	-	+	-	+
		Mannose-			+		-				-		+
B	Noncancer patients	Mannose+	+	-	+	-	-	-	+	+	+	-	+
		Mannose-	+		-				-	-	+		-
	Control	Mannose+	+	-	+	+	-	-	-	+	-	-	+
		Mannose-	-		-	-				-			+
O	Cancer patients	Mannose+	-	+	+	+	+	-	+	-	-	-	+
		Mannose-		-	-	-	+						+
	Control	Mannose+	-	-	+	+	-	+	-	-	+	-	+
		Mannose-				-		-		-			+

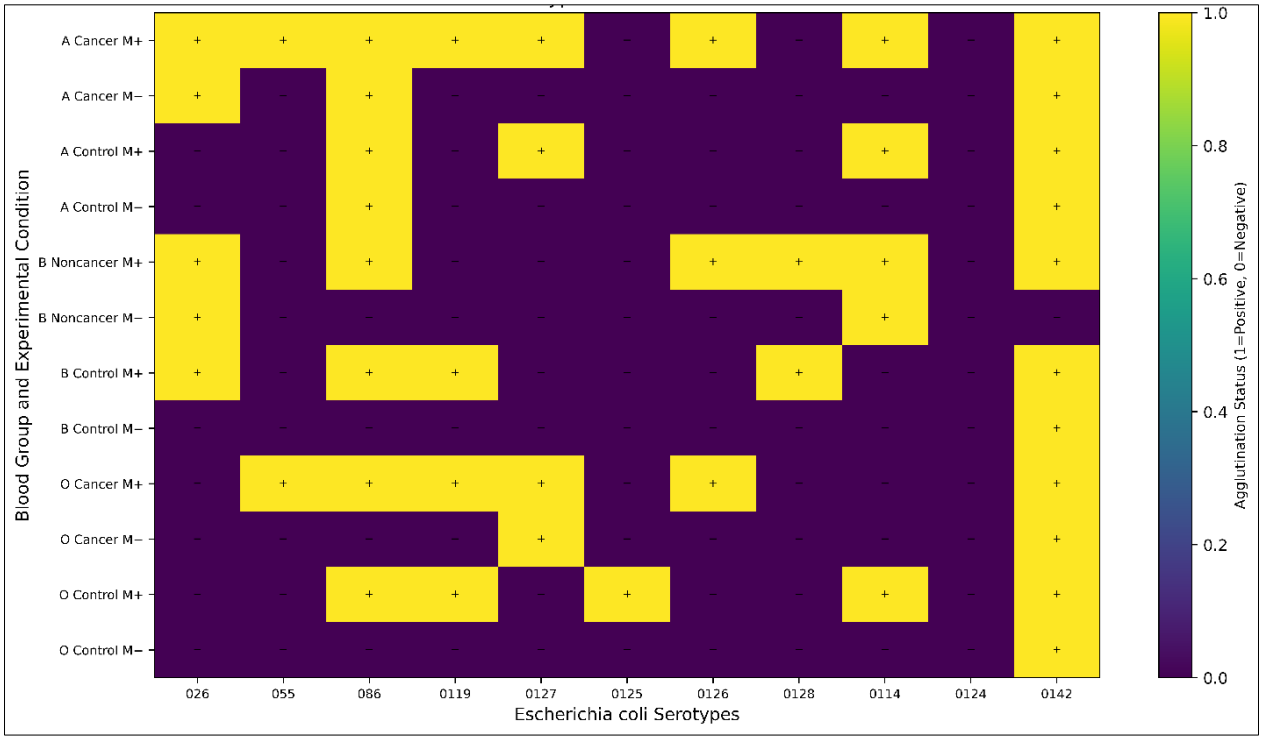

Figure 2: Heatmap visualization of haemagglutination patterns between ABO blood groups and *Escherichia coli* serotypes in the presence and absence of mannose

DISCUSSION

The present study revealed that cancer patients were mostly of blood group A (Table 1). On the other hand, the haemagglutination patterns of human erythrocytes with enteropathogenic Escherichia coli (EPEC) showed a variable differences with respect to different serotypes of EPEC (Table 2). It was demonstrated that o86 and 0142 serotypes agglutinated with all blood group types of cancer and noncancer patients in the presence and absence of mannose sugar. It was also noticed that o125 and 0128 serotypes agglutinated with blood groups O and B but the serotype o124 did not show any sort of haemagglutination with different blood groups. However, it was concluded that most serotypes were group A agglutinating bacterial strains with frequency exceeded 70%. Table 2 shows that most of serotypes reacted to A, B and O positively as far as cancer patients were concerned particularly group A but no haemagglutination was seen with blood group type AB. Moreover, haemagglutination was more common among blood groups of cancer patients compared to blood types of noncancer patients. This conclusion might explained as due to morphological

changes occurred and increasing membrane receptors responsible for reaction with bacteria as far as blood types of cancer patients were concerned which were probably different from those of noncancer patients erythrocytes. Furthermore, the present study revealed a specific presence and distribution of agglutination patterns in absence of mannose (mannose-sensitive haemagglutination(MSHA) as type-1-fimbriae was concern which was most common even among nonpathogenic E.coli [45, 46]. The other type which was mannose-resistant haemagglutination (HRHA) which was considered by Evans *et al*., [42-49] has no significant value because the serotypes specific for this patter are virulence carrier causing various infections. Moreover, colonization factor antigens (CFA) were also considered as able to haemagglutinate in presence of mannose sugar (MRHA). It was also demonstrated that CFA were specifically reacted with host membrane receptors [42-50]. However, there are two types of CFA, CFA/I which agglutinates with erythrocytes of human, cattle and poultry and the other type CFA/II was able to agglutinate with erythrocytes of cattle and poultry only [8-52], who found two types of haemagglutination which were mannose-sensitive and mannose-resistant. In addition, Al-Jebouri and Al-Rahaley concluded a unique pattern of negative haemagglutination for all blood group types with 16 frequency among 44 serotypes of EPEC *E.coli* whereas the second was seen with blood group A only with 17 frequency [8]. Furthermore, the cross- reactions were postulated by Orskov and Orskov [33-55], who noticed a strong cross-reaction occurred between serotype 086 of EPEC *E.coli* and blood group B which almost to the present findings (Table 2). It was suggested by Evans *et al*., [42-58], that haemagglutination should be carried out at the same time with EPEC serotyping to identify the most distributed variant causing diarrhoea for children. However, the purpose of the present utilization of CFA/I and CFA/II was to assess of application of these patterns for preparation of vaccines specific for *E.coli* strains causing gastrointestinal infections.

CONCLUSIONS

He present study revealed that cancer patients were mostly of blood group A. It was also noticed that o125 and 0128 serotypes of EPEC *E.coli* agglutinated with blood groups O and B but the serotype o124 did not show any sort of haemagglutination with different blood groups. It was concluded that most serotypes were group A agglutinating bacterial strains with frequency exceeded 70%. Table 2 shows that most of serotypes reacted to A,B and O positively as far as cancer patients were concerned particularly group A but no haemagglutination was seen with blood group type AB. A significant Chi-square result ($p < 0.05$) would indicate that blood group distribution differs significantly between cancer and non-cancer populations. These results support the hypothesis that erythrocyte surface carbohydrate structures, disease-associated physiological changes, and bacterial adhesin diversity collectively contribute to host–pathogen interaction dynamics.

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Statement of Ethics

All the procedures involving human participation were conducted in strict accordance with ethical standards of Institutional Research Committee, Department of Scientific Research, Mosul University as well as the 1964 Helsinki Declaration and its subsequent amendments or equivalent ethical norms.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest Statement: The author declares that he has no conflicts of interest, financial or otherwise.

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REFERENCES

1. Donnenberg MS. Pathogenic strategies of enteric bacteria. Nature. 2000;406(6797):768-74. doi: 10.1038/35021212. PMID: 10963606.
2. Ho YS. Comments on "Mapping the scientific research on non-point source pollution: a bibliometric analysis" by Yang et al. (2017). Environmental Science and Pollutry Research International. 2018;25(30):30737-30738. doi: 10.1007/s11356-017-0381-8. Epub 2017 Oct 7. PMID: 28986728.
3. Al-Jebouri MM, Al-Ani IA, Al-Jumaily S. The effect of the war of the American and the affiliated forces against Iraq on the distribution and elevation of cancer diseases in Mosul. Consequences of Depleted Uranium used by U.S. and British forces in the 1991 Gulf War Hotel Al-Rashid, Baghdad, Iraq, December 2-3, 1998.
4. Al-Jebouri MM, Anton BG. *Escherichia Coli* Type-I Isolated From Mid-Fingers As Indicator A New Of Potential Microbial Health Hazards Associated With Food Handler Employees. World Journal of Pharmacy and Pharmaceutical Sciences.2026; 15(2), 1147–1164.
5. Herzog K , Debertolis L , Kastelic J. P , Schmicke M , Ulbrich S E , Bollwein H. et al. Effects of intravenous infusion of E. coli lipopolysaccharide in early pregnant cows. Reproduction. 2019;157(1): 65–76. doi: 10.1530/REP-18-0174

6. Boisen N, Østerlund MT, Joensen KG, Santiago AE, Mandomando I, Cravioto A, et al. Redefining enteroaggregative Escherichia coli (EAEC): Genomic characterization of epidemiological EAEC strains. PLoS Negl Tropical Diseases.2020; 14(9): e0008613. https://doi.org/10.1371/journal.pntd.0008613
7. Al-Jebouri MM."Clinical Immunology and Allergy". 1st 2dn. Peramerd Publishing Company, Sulaymania, Iraq, 2024,514 p., ISBN:978-9922-9227-7-5,(in Arabic).
8. Al-Jebouri MM, Al-Rahaley IM. An assessment of antibiotic resistance and resistotyping of *Escherichia coli* from stools of infants. Journal of Chemotherapy. 1991;3:119-121.
9. Kaper J, Nataro J, Mobley H. Pathogenic *Escherichia coli*. Natural Review of Microbiology.*2004;* **2**: 123–140. https://doi.org/10.1038/nrmicro818
10. Ahmad O M, Rukh S, Dos Santos Pereira S, et al, A Comprehensive Review of the Role of Virulence Factors in Enteropathogenic *Escherichia coli*-Induced Intestinal Injury. Cureus.2025; 17(5): e83475. DOI 10.7759/cureus.83475
11. Foster M A, Iqbal J, Zhang C, McHenry R, Cleveland B E, Romero-Herazo Y. et al. Enteropathogenic and enteroaggregative *E. coli* in stools of children with acute gastroenteritis in Davidson County, Tennessee. Diagnostic Microbiology and Infectious diseases.2015; 83: 319–324. doi: 10.1016/j.diagmicrobio.2015.07.016
12. Al-Jebouri MM, Mahmood BY. Prevalence of different types of microorganisms and levels of complement C5a in patients with acute-phase wound infections. Open Journal of Pathology.2019;9:02-19.
13. Al-Jebouri MM, Hasen AH. Vitamin D3 variation between children and adults with reference to renal stone, environment and urinary tract infections. Open Journal of Urology. 2012; 2(3):119-126
14. Jangid H , Kumar D , Kumar G , Kumar R , Mamidi N. An Emerging Foodborne Pathogen Spotlight: A Bibliometric Analysis and Scholarly Review of *Escherichia coli* O157 Research. Antibiotics (Basel). 2024;13(1), 60. doi: 10.3390/antibiotics13010060
15. Palmela C, Chevarin C, Xu Z, Torres J, Sevrin G, Hirten R, et al. Adherent-invasive *Escherichia coli* in inflammatory bowel disease. Gut.2018; 67, 574–587. doi: 10.1136/gutjnl-2017-314903
16. Desvaux M., Dalmasso, G., Beyrouthy, R., Barnich, N., Delmas, J., Bonnet, R., et al. 2020). Pathogenicity factors of genomic islands in intestinal and extraintestinal *Escherichia coli*. Frontier of Microbiology. 2020;11:. 2065. doi: 10.3389/fmicb.2020.02065
17. Al-Jebouri M M, Al-Faham Y M N. Synergistic effect of laser irradiation and photosensitizers on *Pseudomonas aeruginosa* isolated from the wound. World Journal of Pharmacy and Pharmaceutical Sciences.2025;14(11): 502-517.
18. Al-Jebouri MM, Al-Jebouri OAH. Prevalence, Incidence, and Associated Risk Factors of Urolithiasis Among Population of Salah-Aldeen Province In Iraq. World Journal of Pharmaceutical Research.2026; 15(5), 817–832.
19. Rozen D E, Lenski R E. Long-Term Experimental Evolution in *Escherichia coli*. VIII. Dynamics of a Balanced Polymorphism". The American Naturalist.2000; 155 (1): 24–35. Bibcode:2000ANat..155...24R. doi:10.1086/303299.
20. Check JH, O'Neill EA, O'Neill KE, Fuscaldo KE. Effect of anti-B antiserum on the phagocytosis of *Escherichia coli*. Infection and Immunity. 1972;6(1):95-6. doi: 10.1128/iai.6.1.95-96.1972. PMID: 4564154; PMCID: PMC422496.
21. Martins FH, Guth B E , Piazza M. Leão S C , Ludovico A , Ludovico M S, et al. Diversity of Shiga toxin-producing *Escherichia coli* in sheep flocks of Paraná State, southern Brazil. Veterinary Microbiology.2015; 175(1): 150–6. doi: 10.1016/ j.vetmic.2014.11.003
22. Messerer M, Fischerv Wv, v SchubertvvS. Investigation of horizontal gene transfer of pathogenicity islands in *Escherichia coli* using next-generation sequencing. PLoS One.2017; 12: e0179880. doi: 10.1371/journal.pone.0179880
23. Al-Jebouri MM, Al-Jebouri OAH. Urinary Metabolic Profile and Stone Composition, Location and Recurrence in Kidney Stone Formers of the Salah-Aldeen Province, Iraq. Middle East Research Journal of Microbiology and Biotechnology., 2026 ; 6(1): 1-9.
24. Al-Jebouri MM, Al-Jebouri OAH. Antibiotic Resistance Patterns of Bacteria Isolated from Patients with Urolithiasis in Tikrit City, Iraq. World Journal of Pharmacy and Pharmaceutical Sciences.2026; 15(5): 296-312.
25. Crichton PB, Old DC. Characterization of *Escherichia coli* strains from non-term urinary tract infection by combined typing techniques. The Journal of Urology.1983;192(1):160-162.
26. Palmela, C, Chevarin C, Xu Z, Torres J., Sevrin G, Hirten R, et al. (2018). Adherent-invasive *Escherichia coli* in inflammatory bowel disease. Gut.2018; 67, 574–587. doi: 10.1136/gutjnl-2017-314903
27. Paramita R I, Nelwan E J, Fadilah F, Renesteen E, Puspandari N, Erlina L., et al. Genome-based characterization of *Escherichia coli* causing bloodstream infection through next-generation sequencing. PLoS One.2020; 15(12), e0244358. doi: 10.1371/journal.pone.0244358
28. Al-Jebouri MM, Kaki MM. Mathematical Considerations for the Infectious Infertility of Male in Iraq. World Journal of Public Health. 2025; 10(4):

449-458. https://doi.org/10.11648/j.wjph.20251004.12
29. Al-Jebouri MM, Mdish SA. Tracing of antibiotic-resistant bacteria isolated from semen of Iraqi males with primary infertility. Open Journal of Urology.2019;9(1):19-29
30. Al-Jebouri MM, Jasim HH. The relationship between periodontal disease and predisposing factors. Tikrit Journal of Dental Sciences.2016;4(1):68-80. S.
31. Grund S, Stolpe H, Adhesion of Salmonella typhimurium var. copenhagen in the intestines of pigeons, International Journal of Food Microbiology.1992;15(3-4): 299-306. https://doi.org/10.1016/0168-1605(92)90062-8
32. Lee JB, Kim SK, Yoon JW. Pathophysiology of enteropathogenic *Escherichia coli* during a host infection. Journal of Veterinary Sciences. 2022; 23(2):e28. doi: 10.4142/jvs.21160. Epub 2022 Jan 27. PMID: 35187883; PMCID: PMC8977535.
33. Orskov F, Orskov I. Sertyping of *Escherichia coli*. Methods in Microbiology. 1984;14:44-112.
34. Al-Jebouri MM,Mohamed AA. A study on infertility of males infected with *Mycoplasma hominis* with reference to sperm morphology. Open Journal of Pathology. 2020;11(1):7-21.
35. Al-Jebouri M.M, Kaki MNM. Application of Matrices Modelling for Infectious Diseases of Humans. Open Journal of Applied Sciences; 2025;15: 2733-2758. https://doi.org/10.4236/ojapps.2025.159184
36. Sultan HI, Al-Jebouri MM. Pulmonary tuberculosis in Al-Zab district. Tikrit Medical Journal. 2010;16(1):37-41
37. Al-Jebouri MM. Medical Bacteriology. 1st edn. Mosul University Press, Mosul,Iraq.1990,388p. (Arabic).
38. Al-Jebouri MM, Al-Bayati HS. A Study On The Possible Sources Of Hospital-Acquired Pathogens Leading To Caesarean Wound Infection In Tikrit Teaching Hospital, Iraq. World Journal of Pharmacy and Pharmaceutical Sciences.2025; 14(12), 1460–1479.
39. Al-Jebouri MM, Dheyaa DS. A assessment of immunological parameters associated with typhoid fever among displaced Iraqi patients. World Journal of Pharmacy and Pharmaceutical Sciences.2025; 14(11), 487–501. https://doi.org/10.4236/ojpathology. 2025.154015
40. Al-Jebouri,M M ,Sharif,A Y and Abdulla, B A.(1988) The prevalence of antibiotic resistance among three nosocomial pathogens isolated from the maternity hospital in Ninveh.Iraqi Medical Journal,Vol.37,97-101.
41. 41.Al-Jebouri MM, Mdish SA. Tracing of Sortoli-cell-only syndrome and other histopathological abnormalities in Iraqi males with primary infertility of azoospermia. Open Journal of Pathology. 2019;9(1):10-17.
42. Evans DJ Jr, Evans DG, DuPont HL. Hemagglutination patterns of enterotoxigenic and enteropathogenic *Escherichia coli* determined with human, bovine, chicken, and guinea pig erythrocytes in the presence and absence of mannose. Infect and Immunity. 1979; 23(2):336-46. doi: 10.1128/iai.23.2.336-346.1979.
43. Al-Jebouri MM, Kaki MM. Dynamics and Phase Portraits of the SEIQR Model. Annals of Public Health and Epidemiology. 2025; 3(2):1-8.
44. Al-Jebouri MM, Kaki MM, Mutlek T. Quantitative assessment of wound healing of mice treated with combinations of laser irradiations and antibiotics via experimental mathematical modelling. 2026; 15(2): 1165-1177.
45. Thorn A. the role of enteropathogenic *E.coli* in infantile diarrhoea. Doctoral dissertation. University of Lund,1983.
46. Al-Jebouri MM, Al-Shakarjy. The effect of low-power laser combined with providine-iodine photosensitizer on elastase production of *Pseudomonas aeruginosa* isolated from wounds. Journal of Applied Medical Sciences.2013;2(2):63-67. http://dx.doi.org/10.4236/oju.2012.23021
47. Al-Jebouri MM, Al-Dobony HM. Incidence of antibiotic-resistant bacteria in urine from healthy secondary school girls in Mosul. Iraqi Medical Journal.1985;33:97-107.
48. Al-Jebouri MM, Madish SA. The role of sex hormones in the formation of renal stones with reference to urinary tract infections of Iraqi patients. World Journal of Pharmacy and Pharmaceutical Sciences. 2014;3(4):352-365.
49. Al-Jebouri MM, Al-Alwani HR. Angiotensin I-converting enzyme gene polymorphism in patients with chronic renal failure. World Journal of Pharmaceutical Research. 2014;4:1-11.
50. Al-Jebouri MM, Al-Jebouri OAH. Urinary Metabolic Profile and Stone Composition, Location and Recurrence in Kidney Stone Formers of the Salah-Aldeen Province, Iraq. Middle East Research Journal of Microbiology and Biotechnology., 2026 ; 6(1): 1-9.
51. Al-Jebouri MM, Al-Bayati HS. Effect of Disinfectants Exposure on the Susceptibility of Antibiotics, Disinfectants, Heavy Metals and Biochemical Profile *for Staphylococcus aureus* Isolated from Caesarean Wounds" Middle East Research Journal of Microbiology and Biotechnology. 2026 ; 6(1): 22-34.
52. Al-Jebouri MM, Al-Bayati. The degree of association between antibiotic resistance among population of *Staphylococcus aureus* of caesarean wounds. Annals of Public Health & Epidemiology. 2025;3(1):1-10.
53. Mare A D, Ciurea C N, Man A, Tudor B, Moldovan V, Decean L, Toma F. Enteropathogenic *Escherichia coli*—A Summary of

the Literature. Gastroenterology Insights. 2021; *12*: 28-40. https://doi.org/10.3390/gastroent12010004

54. Al-Jebouri MM, Ahmed ER. Estimation of Selected Immunological Parameters and their Interactions among Ramadan Fasting Displaced Iraqi. Annals of Public Health & Epidemiology.2025;3(2):1-7.
55. Al-Jebouri MM, Kaki MNM. Euler Iterative Method for Solving Seirv Model Equations for Human Infectious Diseases. World Journal of Pharmacy and Pharmaceutical Sciences.2926; 15(4): 672–685.
56. Al-Jebouri MM, Kaki MNM. Application of Iteration Methods of Linear and Non-Linear Differential Equations for Infectious Diseases Of Humans. World Journal of Pharmacy and Pharmaceutical Sciences.2026; 15(4):935–959.
57. Al-Jebouri MM, Al-Jebouri AM, Ali AZ, Ali ZZ, Salih AK, Mohammed HA, Sheet SF, et al. A Distribution Comparison of ABO and Rh Blood Group Types and Chronic Diseases with Aging. Middle East Research Journal of Microbiology and Biotechnology. 2026; 6(1): 41-49.
58. Al-Jebouri MM, Al-Bayati HS. Incidence of surgical site infection following caesarean section and its associated factors in a Tikrit Teaching Hospital, Iraq. Journal of Current Medical Research Opinion.2025; 08(8): 4426- 4437.