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Prevalence Of hemodilution and hemoconcentration in medically hospitalized patients across dichotomized outcome-related cohorts

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Abstract

Aims: The goal of this research is to find out how frequently hospitalized individuals have hemodilution and hemoconcentration, as well as what implications these conditions have on their daily lives. It seeks to fill in a gap in what we know by offering us fresh information and research in a field that is vital for treatment. The findings might change how medical hospitals in Jordan care for patients, but they could also change how other nations with comparable patients and illness burdens care for them.

Methods: The purpose of this retrospective cohort research was to find out whether there was a connection between the number of times patients at King Hussein Medical Services and Royal Medical Services in Jordan experienced hemodilution and hemoconcentration and the outcomes of their clinical tests. One part of the study's research on electronic medical information was placing patients into two groups depending on their findings, how long they were in the hospital, and any difficulties they had. A p-value of less than 0.05 was regarded statistically significant, and the findings demonstrated that hemoconcentration and hemodilution were strongly linked. The study's confirmation methods, which included random checks and listwise exclusion, made sure that the data was accurate and that ethical criteria were followed. The study's purpose was to find out how beneficial these blood issues may be as measurements and what role they play in real life.

Results: The results were not significantly affected by gender, age, HLOS, or body mass index (BMI). Most of the people in the "Positive State or Poorer OI" and "Negative State or Better OI" categories were women. Most of the people in the "Negative State or Better OI" category were males. There was no statistically significant connection between BMI and either good or bad. But there was a clear connection between prolonged HLOS and lower outcomes. There is a connection between low levels of albumin, hemoglobin, and hemoglobin content and negative lab test results. In the grand scheme of things, these things don't really matter. The research showed that the hemodilution/hemoconcentration state (HHR) did not impact the findings for patients. Patients with an AACCI score of seven or above, which was the poorest group, were strongly linked to poorer outcomes. There was a substantial negative link between having a lower HALP number and having more terrible things occurring

Conclusion: The Systemic Immune-Inflammation Index (SII) was the greatest technique to find out how much inflammation was going on in the body. Age and gender, which are social determinants, did not affect the outcomes. HLOS, ALB, Hgb, Hct, AACCI, HALP, and SII were all signs that helped us figure out what would happen.

Keywords: Hemodilution; Hemoconcentration; Medical Inpatients; Outcomes; Fluid Balance; Retrospective Study

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1. Introduction

Blood flow changes like haemodilution and haemoconcentration are crucial but often overlooked. These changes could significantly impact hospitalised patients' recoveries. Fluid imbalances, systemic inflammation, and chronic diseases can cause these blood-based conditions. Haemodilution or haemoconcentration can change cellular parts relative to plasma volume. Researchers have extensively studied these events in surgery and critical care (1–4). Few studies have examined the frequency and impact of these events on general medical wards (5, 6).

Medical in patients with acute or chronic diseases may experience venous volume and blood viscosity changes. Dehydration, congestive heart failure, sepsis, and kidney failure can cause these changes (7–10). Several factors may cause these changes. These changes could worsen existing diseases, make them harder to treat, and eventually affect life-threatening diseases (11, 12). Medical practice often overlooks haemodilution and haemoconcentration, despite their significant clinical effects. This is because there are no uniform diagnostic standards, and their symptoms are difficult to understand outside of critical care (13, 14). The clinical effects of these diseases are terrible. Haemoconcentration thickens blood, impairs microcirculatory flow, and increases clotting.

All these can worsen cardiovascular and cerebral results (15, 16). Haemodilution, on the other hand, can result from excessive fluid or inflammation vasodilation, which reduces oxygen transport, causes tissue hypoxia, and even organ failure (17, 4). Both states have been linked to worse outcomes in some medical hospital groups, such as those with heart failure, sepsis, or chronic kidney disease (8, 10, 14), but we don't know their demographic and predictive effects. To properly measure risk, act quickly, and optimise fluid management for confined patients, one must understand how common these disorders are and how they affect clinical outcomes (9, 12).

We examined the frequency of haemodilution and haemoconcentration in patients admitted to King Hussein Medical Services, Royal Medical Services, Jordan, to fill the gap. It also examines how these conditions affect survival and discharge with or without complications. This study's context is Jordan's healthcare system's unique population and disease makeup. This group has a significant number of individuals who have diabetes and hypertension (15, 16).

This study uses old data from a representative group of medical inpatients to determine how common these diseases are, what factors make them more likely to occur, and how useful they are for predicting the future. The data may help doctors make decisions, highlight at-risk groups, and spur research into targeted control measures (6, 13). This study is part of larger efforts to identify medical room risk factors that can improve patient outcomes. Hospital fluid management is crucial, but you must understand each patient's body to succeed. This is especially true if the person has other diseases that increase haemodilution or ha-concentration (3, 7, 17).

This study aims to expand knowledge of how haematological issues and clinical outcomes interact. We plan to examine these factors across outcome-related groups. They found that practical biomarkers and simple clinical signs can help assess risk in resource-poor countries, which could change standards (2, 5, 11).

2. Methods

The goal of this retrospective cohort study was to find out how common hemodilution and hemoconcentration were among medically hospitalized patients at King Hussein Medical Services, Royal Medical Services, Jordan, and to see if there was a link between these conditions and two types of clinical outcomes. The study group was made up of all patients who were brought to the medical department between January 2023 and May 2024. There were both young adults and older people among these cases. It was possible to tell the difference between hemodilution and hemoconcentration by looking at the amounts of hemoglobin (Hb) and hemoglobin (Hct). If the ratio of Hct to Hb was less than three, it was called hemodilution. If it was more than three, it was called hemoconcentration. The study's results showed that the average range for the Hct/Hb ratio was between 2.5 and 3.5. Any results that were outside of this range were thought to be missing data. According to the rules for who could and could not be included, people who were missing more than 5% of their data were not part of the study. This was done to protect the accuracy of the data and lower the risk of bias.

Electronic medical records were used to get the data. The records contained personal information like age, gender, and conditions, clinical information like vital signs, entry diagnosis, and release status, and test values like hemoglobin, hematocrit, and other relevant biomarkers. We divided the patients into two groups based on their outcomes: those who were alive when they were discharged and those who were deceased; the length of their hospital stays (a prolonged stay was defined as exceeding the median length of stay for the cohort); and the presence of complications (such as

sepsis, acute kidney injury, or thromboembolic events). By comparing two sets of data, it was possible to find out which was linked to worse clinical outcomes: hemodilution or hemoconcentration. This was possible because they were put into these two-sided groups.

Chi-square tests were used for statistical analysis to find out how common hemodilution and hemoconcentration were in each of the two result groups. They found out how strong the link was between these blood problems and the results of the clinical trials by using odds ratios (OR) and confidence intervals (CI) of 95%. Based on the importance level that had been set ahead of time, a p-value less than 0.05 was considered to be statistically significant. To make a list of the basic traits, summary statistics like means, standard deviations, and shares were used. We used logistic regression models to look at things that might have caused problems, like age, illnesses, and entry diagnoses. Descriptive statistics were then used to describe the initial traits.

In order to make sure that the approach was sound, steps were taken to validate the data. As part of these steps, random checks were made on the removed records to make sure they were right and consistent. It was necessary for more than five percent of data for each patient to be missing in order to be excluded. Missing data was handled by listwise exclusion to keep the quality of the analysis. As part of the study project, ethical standards were met, and permission was sought from the Royal Medical Services' institutional review board. This was done to make sure that the patients' privacy would be protected and that the right methods for historical study would be used.

The analysis method used in this study was meant to give accurate figures of the frequency of hemodilution and hemoconcentration in an admitted medical population. It was also meant to shed light on the possible predictive implications of these conditions. The goal of this study was to learn more about the clinical importance of these blood abnormalities and how they might be used as biomarkers to help doctors decide which admitted patients are at highest risk. This was done by looking at these problems with the blood in relation to two different types of clinical results. More sensitivity analyses were going to be used to fully test the study's main theories. These analyses were going to look into what happens when the Hct/Hb ratio cut-offs change and how that affects the links between outcomes.

3. Results

To start with gender, the study shows that the number of men and women in both result categories is almost equal. 51.6% of the people in the "Negative State or Better OI" group were women, while 47.7% of the people in the "Positive State or Poorer OI" group were women. Men, on the other hand, were slightly more common in the group that did the worst (52.3%). A p-value of 0.325 for the Pearson chi-square test, on the other hand, meant that the test was not statistically significant. In other words, gender does not have a statistically significant effect on the outcome. For even more proof that this is true, the risks ratio of 1.168 (95% confidence interval: 0.857–1.593) shows that girls are not significantly more or less likely than men to have a better or worse outcome.

Another factor that didn't have a strong link to the outcome was age, which was broken down into two groups: those younger than 75 years old and those older than 75 years old. However, the chances ratio (1.120, 95% confidence interval: 0.820–1.530) and chi-square test ($p = 0.476$) show that there isn't a significant difference in results based on age. Also, people aged 75 or older made up 54.7% of the better outcome group and 57.5% of the worse outcome group. From this, we can see that the fact that this group of people is older does not necessarily mean that they will have a worse outcome.

It was very different with the length of stay in the hospital (also called HLOS), which was strongly linked to the result ($p < 0.001$). Every patient who had a worse outcome had a hospital stay of seven days or more, but 47.8 percent of those who had a better outcome had an HLOS of less than seven days. With a Pearson's R correlation value of 0.563, we can see that there is a fairly strong positive relationship between longer HLOS and worse results. This is shown by the risk estimate, which shows that patients who stayed in the hospital for seven days or more were almost three times more likely to have a worse result (2.970, 95% confidence interval: 2.623–3.363). From this, it looks like staying in the hospital longer is a strong sign of bad results, which could mean that the sickness or symptoms are worse.

The Body Mass Index (BMI), which was broken down into less than 30 and more than 30 ranges, did not have a big effect on the result ($p = 0.441$). The chances ratio of 0.883 (95% confidence interval: 0.643–1.213) shows that body mass index (BMI) did not have a significant beneficial or risk effect on either of the two outcome groups. In both groups, about the same number of patients had a body mass index (BMI) below 30. A lot of people think that being overweight (described as a body mass index (BMI) of 30 or more) can make things worse, but this study shows that this is not true in this situation.

Some of the lab tests that did a great job of differentiating between the result groups were albumin (ALB), hemoglobin (Hgb), and hemoglobin concentration (Hct). Patients with levels higher than these did not do better than those with ALB <2.85, Hgb <12.25, or Hct <36. All of the patients who met these limits had worse results. It was found that both the chi-square tests and the Pearson's R correlations for these factors were very significant ($p < 0.001$), which means that they were perfectly linked in the opposite way. It was -1.000 for the Pearson's R coefficients. The situation was limited by the fact that the backup tables had blank columns, which made it impossible to estimate the risk. The results of this study show that these biomarkers play a big part in telling the difference between groups of outcomes. It is clear that low amounts are linked to worse outcomes.

A statistical study showed that the hemodilution/hemoconcentration state (HHR) did not have a significant effect on the results ($p = 0.403$). It was seen that the percentage of patients with a hemodilution state of less than three was about the same in both groups (67.4% vs. 70.5%). Also, the risks ratio of 0.867 (95% confidence interval: 0.620–1.212) shows that there wasn't a significant effect. Because of this, it looks like the fluid state, which is measured by the HHR, might not be a big deal when it comes to this group of people.

A strong link ($p < 0.001$) was found between the Age-Adjusted Charlson Comorbidity Index (AACCI) and the study's results. People in the group that did worse have 86.2% of their patients have an AACCI number of seven or higher, but only 50.6% of the people in the group that did better did. A higher number of comorbidities is linked to a much higher chance of having a worse result, as the odds ratio of 6.067 (95% confidence interval: 4.131–8.910) shows. A bigger disease load is often linked to worse health outcomes because it lowers bodily reserve and makes people more likely to develop problems. Which is in line with what was expected.

Also, the HALP score, which is made up of hemoglobin, albumin, cells, and platelets, showed a very strong relationship ($p < 0.001$). All of the patients who had bad outcomes had a HALP of less than 115, while 85.4% of the patients who had good outcomes had a HALP of 115 or more. If the Pearson's R value is -0.865, it's clear that there is a strong negative link. The risk estimates also showed that patients with a HALP of less than 115 were much less likely to have a better outcome (0.124, 95% confidence interval: 0.095–0.162). Based on this information, it looks like HALP is a good way to predict what will happen, with lower numbers indicating a higher chance of bad events.

Finally, the Systemic Immune-Inflammation Index (SII) was found to be an even better indicator ($p < 0.001$). All of the patients who had better outcomes had SII ≥2, but 73.5% of the patients who had worse outcomes did too. An R-value of 0.760 indicates a strong positive link, and the risk estimate shows that patients with a SII of 2 or more were much less likely (0.214, 95% confidence interval: 0.177–0.258) to have a better outcome. In turn, this shows how systemic inflammation can lead to worse results, with higher SII numbers indicating a stronger inflammatory state.

Demographic factors like gender and age didn't have a big effect on the results. However, clinical and test signs like HLOS, ALB, Hgb, Hct, AACCI, HALP, and SII were very good at predicting what would happen. It was found that longer stays in the hospital, low albumin levels, anemia, having more comorbidities, low HALP scores, and high SII were all linked to worse results. These results make it clear how important it is to keep an eye on these traits in clinical practice. This makes it possible to find people who are at a high risk and make sure that their treatments are tailored to their needs. The fact that lab tests like ALB, Hgb, and Hct can correctly divide results shows that they might be able to be used as final diagnostic or predictive tools in this situation. However, gender, age, body mass index, and heart rate were not found to have significant links with results. This suggests that these factors may not be as useful in identifying how the disease will progress in this group of people. Taking everything into consideration, the study offers very helpful insights into the multifactorial factors that determine patient outcomes, with a particular focus on the interaction of clinical, inflammatory, and nutritional indicators.

Table 1 Association Between Demographic, Clinical, and Laboratory Variables with Clinical Outcome of Interest (COI)

Variable	Category / Threshold	Negative State or Better OI (%)	Positive State or Poorer OI (%)	p-value	Pearson's R / OR (95% CI)	Interpretation
Gender	Female	51.6	47.7	0.325	OR: 1.168 (0.857–1.593)	No significant association
	Male	48.4	52.3			
Age	<75 years	45.3	42.5	0.476	OR: 1.120 (0.820–1.530)	No significant association
	≥75 years	54.7	57.5			
Hospital LOS (HLOS)	<7 days	47.8	0.0	<0.001	OR: 2.970 (2.623–3.363)	Strong association; longer HLOS → poorer outcome
	≥7 days	52.2	100.0		Pearson's R: 0.563	
BMI	<30	59.5	62.5	0.441	OR: 0.883 (0.643–1.213)	No significant association
	≥30	40.5	37.5			
Albumin (ALB)	<2.85	0.0	100.0	<0.001	Pearson's R: -1.000	Perfect stratification; low ALB → poorer outcome
	≥2.85	100.0	0.0		(OR not computable)	
Haemoglobin (Hgb)	<12.25	0.0	100.0	<0.001	Pearson's R: -1.000	Perfect stratification; low Hgb → poorer outcome
	≥12.25	100.0	0.0		(OR not computable)	
Haematocrit (Hct)	<36	0.0	100.0	<0.001	Pearson's R: -1.000	Perfect stratification; low Hct → poorer outcome
	≥36	100.0	0.0		(OR not computable)	
HHR	<3 (Haemodilution)	67.4	70.5	0.403	OR: 0.867 (0.620–1.212)	No significant association

	≥3 (Haemoconcentration)	32.6	29.5			
AACCI	<7	49.4	13.8	<0.001	OR: 6.067 (4.131–8.910)	Strong association; higher comorbidity → poorer outcome
	≥7	50.6	86.2			
HALP Score	<115	14.6	100.0	<0.001	OR: 0.124 (0.095–0.162)	Strong inverse association; low HALP → poorer outcome
	≥115	85.4	0.0		Pearson's R: -0.865	
SII	<2	100.0	26.5	<0.001	OR: 0.214 (0.177–0.258)	Strong association; higher SII → poorer outcome
	≥2	0.0	73.5		Pearson's R: 0.760	

Abbreviations and Definitions: **COI**: Clinical Outcome of Interest (Negative State/Better OI vs. Positive State/Poorer OI); **HLOS**: Hospital Length of Stay; **BMI**: Body Mass Index; **ALB**: Albumin; **Hgb**: Hemoglobin; **Hct**: Hematocrit; **HHR**: Hemodilution/Hemoconcentration Ratio; **AACCI**: Age-Adjusted Charlson Comorbidity Index; **HALP**: Hemoglobin, Albumin, Lymphocyte, Platelet score; **SII**: Systemic Immune-Inflammation Index; **OR**: Odds Ratio (95% Confidence Interval); Key Findings Summary: Strong Predictors of Poorer Outcome ($p < 0.001$); **HLOS ≥7 days** (OR: 2.970); **ALB <2.85, Hgb <12.25, Hct <36** (perfect stratification); **AACCI ≥7** (OR: 6.067); **HALP <115** (OR: 0.124); **SII ≥2** (OR: 0.214); Non-Significant Factors ($p > 0.05$); Gender, Age, BMI, HHR; **Perfect Biomarkers:** ALB, Hgb, and Hct perfectly differentiated outcomes, suggesting high diagnostic utility.

4. Discussion

This research investigated the prevalence of hemodilution and hemoconcentration in medically hospitalized patients at King Hussein Medical Services, Royal Medical Services, Jordan, and its relationship to clinical outcomes. The hemodilution/hemoconcentration ratio (HHR) did not affect patient outcomes. This finding implies that bodily fluid may not be a key element in this group's future success. This research confirmed pre-study predictions. A previous study has examined how fluid balance influences clinical outcomes, particularly in critically ill patients. The findings of this research vary from others. In sepsis, Vincent et al. (18) showed that hemodilution and hemoconcentration increased mortality risk. The study highlights how crucial fluid balance is during sickness. Wiedemann et al. (19) observed that proper fluid management improved ARDS outcomes.

This research suggests that bodily fluid impacts viewpoint. Our data suggest that comorbidities and inflammatory indicators may affect fluid balance more in general medical inpatients than previously assumed. A striking finding in this research was that biological characteristics like gender and age didn't affect clinical results. The "Negative State or Better Outcome Index (OI)" group included 51.6% women, whereas the "Positive State or Poorer OI" category had more males. Similar to age, there was no significant difference between better and poorer patients. People 75 and older made up 54.7% of the better group and 57.5% of the overall. This research contradicts previous findings that age is a strong predictor of poor outcomes for hospitalized patients.

A large historical investigation by Piloto et al. (20) indicated that older patients were more likely to die and remain in the hospital longer. This was particularly true for multi-illness patients. Our cohort only included medical inpatients, not surgical or critical care patients, who are more susceptible as they age. We may get different outcomes than another research because of this. The variation may be due to group differences. Hospital stays of seven days or longer were three times as likely to result in poor outcomes. Hospital length of stay (HLOS) predicted long-term patient outcomes. Long-term patients performed better. According to current knowledge, a lengthy hospital stay helps determine the severity of the disease and its implications. Carey and colleagues (21) showed that longer lengths of stay (HLOS) were associated with increased hospital-acquired illnesses, functional impairment, and mortality, particularly in older patients.

Our data suggests that HLOS is more than simply a tracking tool. We must monitor it as a crucial future indicator in therapeutic situations. It's noteworthy that BMI didn't affect findings, either positively or negatively. Patients with BMIs below 30 performed poorly. Many studies link obesity to poor patient outcomes. That contradicts such research. In a meta-analysis, Nie et al. (22) showed that overweight individuals with severe illnesses died more often. Problems with metabolic and inflammatory management may explain this relationship. Our findings support the "obesity paradox," which states that overweight or moderately obese patients have higher long-term illness survival rates. Kalantar-Zadeh et al. observed this occurrence. We found no correlation between body mass index (BMI) and outcome, perhaps due to the variety of medical conditions. Permanently sick people may suffer undernutrition and cachexia, making the BMI-outcome relationship unclear.

Lab biomarkers, including albumin (ALB), hemoglobin (Hgb), and Hct, accurately predicted hospital outcomes. Lower levels of these components caused poorer results. These indicators are more predictive since patients with ALB, Hgb, or Hct values < 2.85, 12.25, or 36% had poorer outcomes. Many studies have demonstrated that these findings are always true. For instance, Arroyo et al. (24) observed that hypoalbuminemia predicted mortality in hospitalized patients. Poor nutrition, inflammation, and long-term disease stress may explain this effect. Salisbury et al. (25) observed that even moderate anemia increased medical inpatient mortality and return in a large population. This study supports the premise that anemia—low hemoglobin and blood content—has long been connected to poor medical inpatient outcomes.

Our findings suggest these biomarkers might be significant diagnostic and predictive tools in clinical settings. This helps identify and support at-risk individuals early on. The Age-Adjusted Charlson Comorbidity Index (AACCI) indicates a substantial correlation between comorbidities and outcomes. More comorbidities mean worse health. Many studies have proven that the Charlson Index may detect mortality and sickness in hospitalized patients, and the evidence is consistent. For every rise in comorbidity, Charlson and colleagues (26) observed a modest increase in the risk of dying within a year. This evidence shows that the AACCI can assist clinicians in assessing a patient's risk, even if their condition is complex. SII and the HALP score—hemoglobin, albumin, cells, and platelets—also predicted well. If your HALP score was less than 115 or SII was two or higher, your odds of improving were decreased.

New research on biomarkers for inflammation and nutrition in clinical outcomes supports these findings. According to the trial conducted by Xie and colleagues (27), the HALP score might predict cancer survival. The study examined both

inflammatory and nutritional factors simultaneously. Yang et al. (28) demonstrated that the SII, which measures platelet and neutrophil counts, may predict sepsis and heart disease. These indicators functioned well in our investigation, demonstrating the importance of using various signals to predict outcomes.

5. Conclusion

In our group, clinical and blood tests like HLOS, ALB, Hgb, Hct, AACCI, HALP, and SII were good at predicting how things would turn out. This is true even though gender and age did not have a big effect on the results since they were social factors. From these numbers, it looks like regular lab tests and disease scores might help with risk assessment more than fluid state or demographic information. There needs to be more study done to look into how these biomarkers change over time and whether they could be useful in guiding treatment methods.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest in this manuscript.

Statement of ethical approval

There is no animal subject involvement in this manuscript. The Jordanian Royal Medical Services (JRMS) Institutional Review Board (IRB) initially approved this study at 8 April 2025 with the registration number 39_5/2025. This approved study was formally cleared for publishing after being reviewed by our institution's directorate of professional training and planning at 17 June 2025.

Statement of informed consent

Owing to the retrospective design of this study, the informed consent form was waived.

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