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Anemia Severity and Its Differential Impact on Healthcare Utilization, Treatment Intensity, and Economic Burden in Women with Iron Deficiency Anemia

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Research Article

Keywords: Iron deficiency anemia, Anemia severity, Healthcare utilization, Cost analysis, Economic burden, Women

Posted Date: May 19th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9520784/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Iron deficiency anemia (IDA) is a highly prevalent condition, particularly among women, and is associated with substantial clinical and healthcare burden. However, the relationship between anemia severity and healthcare utilization, and economic burden remains insufficiently characterized in large real-world populations. This study aimed to evaluate the association between anemia severity and healthcare utilization, treatment patterns, and economic burdens in a large cohort of female patients with IDA.

Methods

This retrospective study included female patients diagnosed with IDA between October 1, 2021, and December 31, 2025. A total of 28,978 patients were screened, and 5,624 patients meeting inclusion and exclusion criteria were analyzed. Anemia severity was classified according to World Health Organization criteria. Healthcare utilization parameters, treatment modalities, and total healthcare costs were evaluated.

Results

The mean age of the study population was 38.96 ± 11.00 years. Among patients, 52.9% had mild anemia, 43.5% moderate anemia, and 3.7% severe anemia. Healthcare utilization increased significantly with anemia severity, with higher inpatient admission rates, inpatient service use, and iron deficiency–related hospitalizations observed in more severe cases (all $p < 0.001$). Treatment intensity also increased with severity, as reflected by higher use of oral iron therapy, intravenous iron therapy, and blood transfusion (all $p < 0.001$). In contrast, total healthcare costs did not differ significantly across anemia severity groups when evaluated in both local currency and USD ($p = 0.355$)

Conclusion

Anemia severity in female patients with IDA is associated with increased healthcare utilization and treatment intensity. These findings suggest a complex relationship between disease severity and economic burden. Early diagnosis and appropriate management of IDA may help reduce healthcare burden and improve patient outcomes.

Introduction

Iron deficiency (ID) and iron deficiency anemia (IDA) are among the most prevalent nutritional disorders worldwide, affecting more than 1.2 billion individuals and representing a major global public health

challenge [1, 2]. Iron deficiency encompasses a spectrum ranging from depleted iron stores without anemia to overt anemia with significant hematological and systemic consequences. Despite advances in diagnostic approaches and treatment strategies, ID and IDA continue to impose a substantial burden on individuals and healthcare systems worldwide.

Women are disproportionately affected by iron deficiency due to physiological, reproductive, and social factors. In particular, women of reproductive age are at increased risk because of menstrual blood loss, pregnancy, and lactation-related iron demands [3, 4]. Heavy menstrual bleeding represents one of the most common causes of iron deficiency in this population and is often underrecognized or normalized, leading to delayed diagnosis and treatment [5, 6]. Moreover, disparities in access to healthcare and nutritional resources further exacerbate the burden of iron deficiency, particularly in vulnerable populations.

The clinical consequences of iron deficiency extend beyond hematological abnormalities. Iron plays a critical role in cellular metabolism, oxygen transport, and enzymatic processes, and its deficiency may result in fatigue, impaired cognitive function, reduced exercise capacity, and decreased work productivity [7, 8]. In addition, iron deficiency has been associated with adverse reproductive outcomes, including complications during pregnancy and potential long-term neurocognitive effects in offspring [9]. Importantly, even in the absence of anemia, iron deficiency alone may lead to clinically significant symptoms and reduced quality of life.

From a pathophysiological perspective, iron homeostasis is tightly regulated by mechanisms involving intestinal absorption, systemic transport, and storage, with hepcidin playing a central role in iron metabolism [1]. Disruptions in these regulatory pathways, whether due to increased demand, chronic blood loss, impaired absorption, or inflammation, contribute to the development and progression of iron deficiency. Accurate diagnosis can be challenging, particularly in the presence of inflammatory conditions, where conventional biomarkers such as ferritin may be influenced by acute-phase responses [10].

Management of iron deficiency and IDA primarily involves iron replacement therapy, either oral or intravenous, depending on the severity of deficiency, underlying etiology, and patient tolerance [2, 11]. Oral iron therapy remains the first-line treatment in most cases; however, gastrointestinal side effects and poor adherence may limit its effectiveness. Intravenous iron has emerged as an effective alternative, particularly in patients with severe anemia, malabsorption, or intolerance to oral formulations, offering more rapid correction of iron stores [12, 7]. In severe cases, blood transfusion may be required as a life-saving intervention, although it is generally reserved for specific clinical indications.

Beyond its clinical implications, IDA is increasingly recognized as a condition with substantial healthcare and economic consequences. Patients with IDA often require repeated healthcare visits, frequent laboratory testing, and ongoing treatment, which collectively contribute to increased healthcare utilization and costs. However, despite the high prevalence of the condition, the relationship between

anemia severity and healthcare resource utilization remains insufficiently characterized, particularly in large real-world datasets.

Taken together, although IDA is a highly prevalent and clinically significant condition, important gaps remain in understanding how disease severity influences healthcare utilization, treatment patterns, and economic burden. Therefore, the aim of this study was to evaluate the association between anemia severity and healthcare utilization, treatment patterns, and economic burden in a large real-world cohort of female patients with IDA.

Materials and Methods

Study Population

This retrospective study was conducted using data from female patients who were admitted to Gebze Medical Park Hospital between October 1, 2021, and December 31, 2025. A total of 28,978 female patients with a diagnosis of IDA were initially identified. Among these, 5,624 patients who met the inclusion and exclusion criteria were included in the final analysis.

Inclusion and Exclusion Criteria

Female patients aged 18 years and older who had at least one recorded diagnosis of IDA were eligible for inclusion. Patients with conditions that could substantially influence healthcare costs, including malignancy, chronic kidney disease, and pregnancy, were excluded to minimize potential bias. In addition, patients who underwent surgical procedures were excluded, as surgery-related blood loss and subsequent complications could contribute to secondary IDA and confound cost analyses. Patients with missing laboratory data were also excluded from the study.

Classification of Iron Deficiency Anemia

To evaluate the impact of anemia severity on healthcare costs, patients were categorized based on anemia severity. The index date was defined as the first clinical encounter during which IDA was diagnosed and laboratory measurements of hemoglobin and ferritin were available within the same visit.

Anemia severity was classified according to World Health Organization criteria, with hemoglobin levels of 11–11.9 g/dL defined as mild anemia, 8–10.9 g/dL as moderate anemia, and < 8 g/dL as severe anemia. As only patients with iron deficiency anemia were included, non-anemic individuals (hemoglobin ≥ 12 g/dL) were not part of the analysis.

Cost Analysis

To comprehensively assess the economic burden, total healthcare costs were calculated by including all visit-related expenditures rather than limiting the analysis to iron deficiency-specific costs. All costs were converted into United States dollars (USD) using the current exchange rate to ensure comparability. It should be noted that prescription-related medication costs incurred outside the hospital were not included in the monetary calculations. Therefore, the reported cost estimates may not fully reflect the total economic burden.

Despite the applied exclusion criteria, residual confounding due to unmeasured clinical factors that may increase healthcare costs cannot be entirely ruled out.

In addition to monetary outcomes, healthcare utilization parameters were analyzed, including the total number of inpatient admissions for any reason, the presence of iron deficiency-related hospitalizations, administration of blood transfusions during hospitalization, and iron treatment modalities. Iron deficiency–related visits were defined as visits with a recorded diagnosis of iron deficiency or iron deficiency anemia.

Data Completeness

As this study relied on retrospectively collected electronic health record data, certain variables may not have been consistently documented for all patients. Therefore, missing data may be attributable to incomplete data entry or variability in clinical documentation practices rather than the true absence of a clinical condition. No data imputation methods were applied, and all analyses were performed using available-case data.

Variable Grouping Strategy

Continuous variables were dichotomized into low and high groups based on predefined thresholds. Total Visit Count was grouped as ≤ 10 and > 10 based on the median. Iron Deficiency Related Visit Count was categorized as ≤ 2 and > 2 according to the median value. Total Inpatient Admission Count was classified as ≤ 1 and > 1 admissions. Similarly, Iron Deficiency Related Inpatient Admission Count was grouped as ≤ 1 and > 1 admissions.

Data Preprocessing

Data preprocessing and preparation were conducted using Wanalyzer v3.0 (WisdomEra Corp., Istanbul, Turkey), a python-based analytical environment integrating scientific computing libraries (https://analyzer.wisdomera.io, accessed on 03 April 2026). The platform is directly integrated with hospital information systems and laboratory information systems, enabling secure extraction, structured transformation, and standardized processing of routinely collected clinical data. The platform was used for data cleaning, normalization, transformation, feature structuring, and dataset harmonization prior to

analysis. Data preprocessing procedures were applied according to data characteristics and variable types. These platforms are routinely used in institutional data analytics workflows.

Statistical Analysis

All statistical procedures were carried out with Wistats v3.0 (WisdomEra Corp., Istanbul, Turkey), a Python-based analytical platform integrating SciPy, scikit-learn, and statsmodels libraries (https://wistats.wisdomera.io, accessed on 03 April 2026).

Data distribution was assessed using skewness and kurtosis values, along with the Shapiro–Wilk test. Based on distribution characteristics, continuous variables were compared using the independent samples t-test or Mann–Whitney U test, as appropriate. For comparisons involving more than two groups, one-way ANOVA or the Kruskal–Wallis test was used. Categorical variables were analyzed using the Chi-square test or Fisher's exact test. A two-sided p value of < 0.05 was considered statistically significant.

Results

Study Population

A total of 28,978 female patients with IDA were initially identified. After applying the inclusion and exclusion criteria, 5,624 patients were included in the final analysis. The detailed patient selection process is presented in Fig. 1.

Baseline Characteristics

The baseline clinical, laboratory, and healthcare utilization characteristics of the study population are summarized in Table 1. The mean age of the patients was 38.96 ± 11.00 years. Among the study population, 52.9% had mild anemia, 43.5% moderate anemia, and 3.7% severe anemia. The mean hemoglobin level was 10.68 ± 1.16 g/dL, and the mean ferritin level was 18.52 ± 57.66 ng/mL.

Table 1
Baseline Clinical, Laboratory, and Healthcare Utilization Characteristics of the Study Population

Variables	**cases**
	Mean ± SD, N (%)
Number of cases	5,624 (100%)
Age (years)	38.96 ± 11.00
Anemia Severity	
mild	2973 (52.8%)
moderate	2444 (43.4%)
severe	207 (3.8%)
Hemoglobin (g/dL)	10.68 ± 1.16
Ferritin (ng/mL)	18.52 ± 57.66
Total Visit Count	12.18 ± 10.47
Total Visit Count Group	
high (> 10)	2508 (44.6%)
low (< = 10)	3116 (55.4%)
Iron Deficiency Related Visit Count	2.42 ± 2.25
Iron Deficiency Related Visit Count Group	
high (> 2)	1717 (30.5%)
low (< = 2)	3907 (69.5%)
Amount (USD)	578.50 ± 618.45
Total Inpatient Admission Count	0.19 ± 0.59
Total Inpatient Admission Count Group	
high (> 1)	190 (3.4%)
low (< = 1)	5434 (96.6%)
Total Inpatient Service Count	2.64 ± 16.69
Iron Deficiency Related Inpatient Admission Count	0.06 ± 0.33
Iron Deficiency Related Inpatient Admission Count Group	
high (> 1)	61 (1.1%)

Variables	cases Mean ± SD, N (%)
low (< = 1)	5563 (98.9%)
Oral Iron Treatment Given	
no	3705 (65.9%)
yes	1919 (34.1%)
Intravenous Iron Given	
no	5173 (92.0%)
yes	451 (8.0%)
Blood Transfusion	
no	5558 (98.8%)
yes	66 (1.2%)

The mean total visit count was 12.18 ± 10.47, and 44.6% of patients had more than 10 visits. The mean iron deficiency–related visit count was 2.42 ± 2.25.

In terms of healthcare utilization, the mean total inpatient admission count was 0.19 ± 0.59, and 3.4% of patients had more than one hospitalization. The mean total inpatient service count was 2.64 ± 16.69. Iron deficiency–related inpatient admissions were relatively rare (mean 0.06 ± 0.33).

Regarding treatment, 34.1% of patients received oral iron therapy, while 8.0% received intravenous iron. Blood transfusion was administered in 1.2% of patients.

Comparison According to Anemia Severity

Comparisons of clinical, laboratory, and healthcare utilization outcomes according to anemia severity are presented in Table 2. Patients with more severe anemia were significantly older ($p < 0.001$). Hemoglobin and ferritin levels decreased progressively with increasing anemia severity ($p < 0.001$ for both).

Table 2
Comparison of Clinical, Laboratory, and Healthcare Utilization Outcomes According to Anemia Severity

Variables	mild	moderate	severe	p
	Mean ± SD, N (%)	Mean ± SD, N (%)	Mean ± SD, N (%)	
Number of cases	2973 (52.8%)	2444 (43.4%)	207 (3.8%)	
Age (years)	38.13 ± 10.67	39.82 ± 11.21	40.68 ± 12.15	**< 0.001**
Hemoglobin (g/dL)	11.51 ± 0.29	9.97 ± 0.76	7.16 ± 0.74	**< 0.001**
Ferritin (ng/mL)	20.27 ± 35.58	17.09 ± 77.47	10.30 ± 34.54	**< 0.001**
Total Visit Count	12.38 ± 10.72	11.99 ± 10.22	11.44 ± 9.73	0.388
Total Visit Count Group				0.502
high (> 10)	1343 (45.2%)	1079 (44.1%)	86 (41.5%)	
low (< = 10)	1630 (54.8%)	1365 (55.9%)	121 (58.5%)	
Iron Deficiency Related Visit Count	2.14 ± 1.99	2.65 ± 2.41	3.57 ± 2.93	**< 0.001**
Iron Deficiency Related Visit Count Group				**< 0.001**
high (> 2)	748 (25.2%)	861 (35.2%)	108 (52.2%)	
low (< = 2)	2225 (74.8%)	1583 (64.8%)	99 (47.8%)	
Amount (USD)	572.17 ± 582.62	582.38 ± 660.15	623.62 ± 609.95	0.355
Total Inpatient Admission Count	0.16 ± 0.51	0.21 ± 0.65	0.37 ± 0.75	**< 0.001**
Total Inpatient Admission Count Group				**< 0.001**
high (> 1)	72 (2.4%)	105 (4.3%)	13 (6.3%)	
low (< = 1)	2901 (97.6%)	2339 (95.7%)	194 (93.7%)	
Total Inpatient Service Count	1.93 ± 10.51	3.19 ± 21.73	6.35 ± 19.71	**< 0.001**
Iron Deficiency Related Inpatient Admission Count	0.03 ± 0.25	0.07 ± 0.37	0.29 ± 0.69	**< 0.001**

Variables	mild Mean ± SD, N (%)	moderate Mean ± SD, N (%)	severe Mean ± SD, N (%)	p
Iron Deficiency Related Inpatient Admission Count Group				**< 0.001**
high (> 1)	9 (0.3%)	40 (1.6%)	12 (5.8%)	
low (< = 1)	2964 (99.7%)	2404 (98.4%)	195 (94.2%)	
Oral Iron Treatment Given				**< 0.001**
no	2101 (70.7%)	1485 (60.8%)	119 (57.5%)	
yes	872 (29.3%)	959 (39.2%)	88 (42.5%)	
Intravenous Iron Given				**< 0.001**
no	2855 (96.0%)	2171 (88.8%)	147 (71.0%)	
yes	118 (4.0%)	273 (11.2%)	60 (29.0%)	
Blood Transfusion				**< 0.001**
no	2965 (99.7%)	2416 (98.9%)	177 (85.5%)	
yes	8 (0.3%)	28 (1.1%)	30 (14.5%)	
Blood Transfusion Count	0.01 ± 0.19	0.04 ± 0.53	0.40 ± 1.06	**< 0.001**

Total visit count did not differ significantly between groups (p = 0.388). Iron deficiency–related visit count increased significantly with anemia severity (p < 0.001), indicating a higher burden of disease in more severe cases.

Healthcare utilization was notably higher in patients with more severe anemia. Total inpatient admission count, inpatient service count, and iron deficiency–related inpatient admission count all increased significantly across severity groups (all p < 0.001), as illustrated in Fig. 2.

Similarly, the proportion of patients receiving treatment increased with anemia severity. The use of oral iron therapy, intravenous iron therapy, and blood transfusion was significantly higher in patients with more severe anemia (all p < 0.001).

In contrast, total healthcare costs did not differ significantly across anemia severity groups when evaluated in both TRY and USD (p = 0.355 for both), despite a clear increase in healthcare utilization and treatment intensity across severity groups, as shown in Fig. 3.

Discussion

In this large real-world study including 5,624 female patients with IDA, we investigated the relationship between anemia severity and healthcare utilization, treatment patterns, and economic burden. The main findings of our study can be summarized as follows: (i) healthcare utilization increased significantly with increasing anemia severity, (ii) treatment intensity, including intravenous iron therapy and blood transfusion, was markedly higher in more severe anemia, and (iii) total healthcare costs did not differ significantly across severity groups.

Our findings demonstrate that patients with more severe anemia had significantly higher healthcare utilization, including increased inpatient admissions, inpatient service use, and iron deficiency–related hospitalizations (all $p < 0.001$). This observation is consistent with previous studies showing that anemia is associated with increased healthcare resource utilization. In a study conducted in patients with inflammatory bowel disease, anemia severity was directly associated with higher hospitalization rates, longer length of stay, and increased healthcare utilization [13]. Similarly, earlier evidence has shown that anemia in hospitalized women is associated with substantially higher transfusion rates and longer hospital stays, reflecting increased disease burden [14]. These findings support the concept that anemia severity may serve as a surrogate marker of clinical complexity and healthcare demand.

In parallel with increased healthcare utilization, we observed a significant rise in treatment intensity with increasing anemia severity. The proportion of patients receiving intravenous iron therapy and blood transfusion increased markedly in the severe anemia group (both $p < 0.001$). This is in line with current clinical practice, where more aggressive treatment strategies are required in patients with advanced anemia. Intravenous iron therapy has been shown to provide more rapid correction of hemoglobin levels and reduce the need for transfusion in selected patient populations [15].

Despite the clear increase in healthcare utilization and treatment intensity, total healthcare costs did not differ significantly across anemia severity groups in our study ($p = 0.355$). This finding is noteworthy and may initially appear counterintuitive. However, similar observations have been reported in previous studies, where treatment of anemia was associated with increased healthcare utilization without a proportional increase in total costs [13]. One possible explanation is that cost components may be distributed across multiple healthcare services, and certain high-cost interventions may be relatively infrequent. In addition, cost structures may vary depending on healthcare systems, reimbursement models, and the distribution of outpatient versus inpatient care. Importantly, our cost analysis did not include prescription-related medication costs outside the hospital, which may have contributed to an underestimation of the true economic burden. This may explain why the observed increase in healthcare utilization was not reflected in total measured healthcare costs.

From a broader perspective, IDA represents a substantial societal and economic burden, particularly among women. A population-based study conducted in Switzerland demonstrated that iron deficiency is associated with considerable direct medical costs and productivity losses, highlighting the broader economic implications of the condition [16]. In addition, iron deficiency has been shown to negatively

impact quality of life, physical functioning, and mental well-being, further reinforcing its clinical and socioeconomic importance [17].

Our study has several important strengths. First, it includes a large real-world cohort of female patients, providing robust statistical power and generalizability within similar healthcare settings. Second, the integration of clinical, laboratory, healthcare utilization, and cost data allows for a comprehensive evaluation of the burden of IDA. Third, the use of standardized data preprocessing and analytical platforms enhances data consistency and reproducibility.

However, several limitations should be acknowledged. First, the retrospective design may introduce selection bias and limits causal inference. Second, although major confounding conditions were excluded, residual confounding due to unmeasured clinical variables cannot be completely ruled out. Third, prescription-related medication costs outside the hospital were not included in the cost analysis, which may have led to an underestimation of the true economic burden. Fourth, variability in clinical documentation and missing data inherent to electronic health records may have influenced certain analyses. In addition, the exclusion of conditions such as pregnancy and surgical cases may have led to an underestimation of real-world healthcare costs.

Future studies should aim to evaluate longitudinal outcomes, including the impact of treatment optimization on healthcare utilization and costs. In addition, prospective studies incorporating detailed cost components, including outpatient medication costs and indirect costs such as productivity loss, would provide a more comprehensive assessment of the economic burden.

Conclusions

In conclusion, anemia severity in female patients with IDA is strongly associated with increased healthcare utilization and treatment intensity. These findings highlight the importance of early diagnosis and effective management of IDA to reduce healthcare burden and improve patient outcomes.

Abbreviations

IDA
Iron deficiency anemia
USD
United States dollar
TRY
Turkish lira

Declarations

Ethics approval and consent to participate

The research was conducted in compliance with the principles of the Declaration of Helsinki. Ethical clearance was obtained from the Ethics Committee of Istanbul Kent University prior to data analysis. The study was reviewed at the committee meeting held on January 20, 2026 and was approved (Protocol No: 2026-03).

This study utilized a retrospective design based on previously collected clinical records. Prior to analysis, all patient data were irreversibly anonymized. In view of the retrospective framework and the absence of identifiable personal information, the institutional ethics committee granted a waiver of informed consent.

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and/or analysed during the current study are available in the Dataset Sharing Platform of Istinye University repository, [https://dataset.istinye.edu.tr/dataset?did=94]

Competing interests

The authors declare no conflicts of interest.

Funding

No external funding was received.

Authors' contributions

Conceptualization: N.A., Z.A; Methodology: N.A., Z.A; Investigation: N.A.; Resources: N.A.; Data Curation: N.A.; Writing – Original Draft Preparation: N.A.; Writing – Review & Editing: N.A., Z:A; Supervision: N.A., Z.A; Formal Analysis: N.A.

Acknowledgments

The authors would like to thank the Artificial Intelligence Research and Application Center of Istinye University (https://yzaum.istinye.edu.tr/, accessed on 03 April 2026) for providing technical support during manuscript preparation, including assistance with data validation processes and pre-submission similarity evaluation. The authors also acknowledge the Ditako Data Analytics Team (https://ditako.com, accessed on 03 April 2026) for their valuable contributions to the statistical analyses and methodological support provided for this study.

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Figures

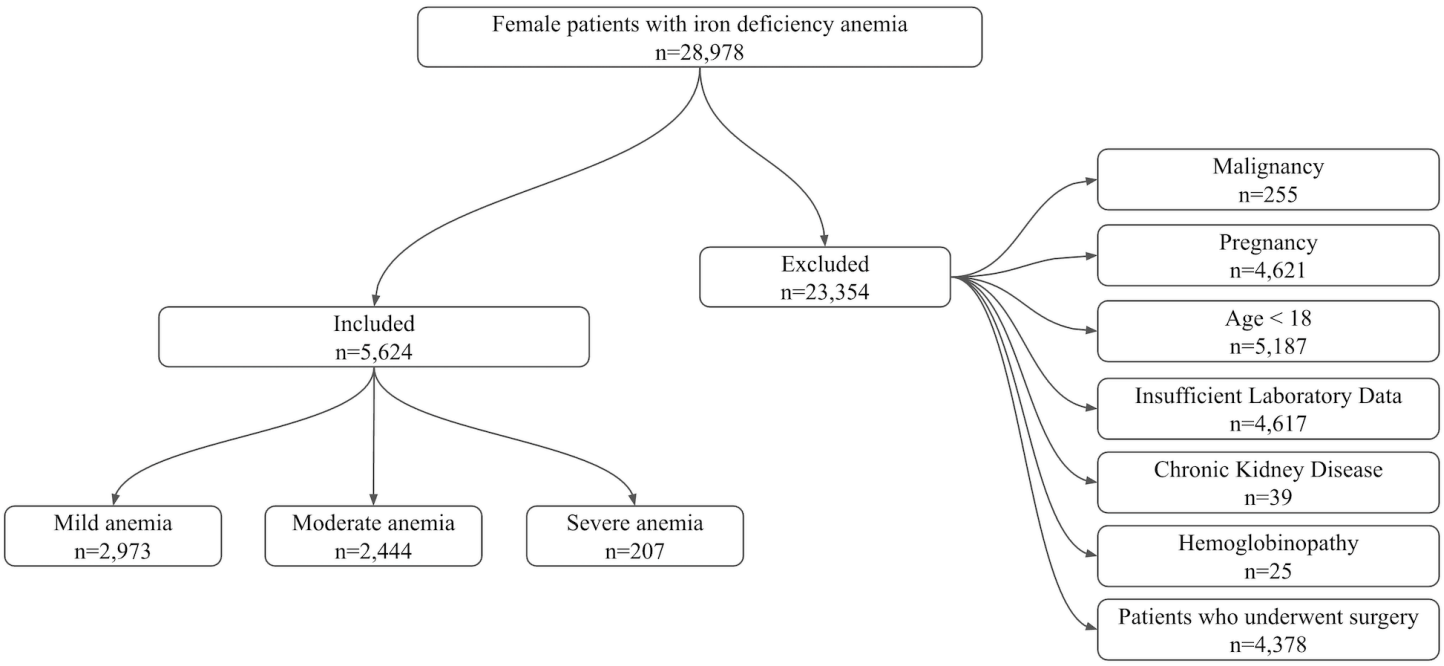


Figure 1

Flow diagram of patient selection and anemia severity classification.

A total of 28,978 female patients with iron deficiency anemia were initially identified. After applying the inclusion and exclusion criteria, 5,624 patients were included in the final analysis. Patients were excluded due to malignancy (n = 255), pregnancy (n = 4,621), age <18 years (n = 5,187), insufficient laboratory data (n = 4,617), chronic kidney disease (n = 39), hemoglobinopathy (n = 25), and history of surgery (n = 4,378). The final study population was categorized according to anemia severity as mild anemia (n = 2,973), moderate anemia (n = 2,444), and severe anemia (n = 207). Patients may have met more than one exclusion criterion.

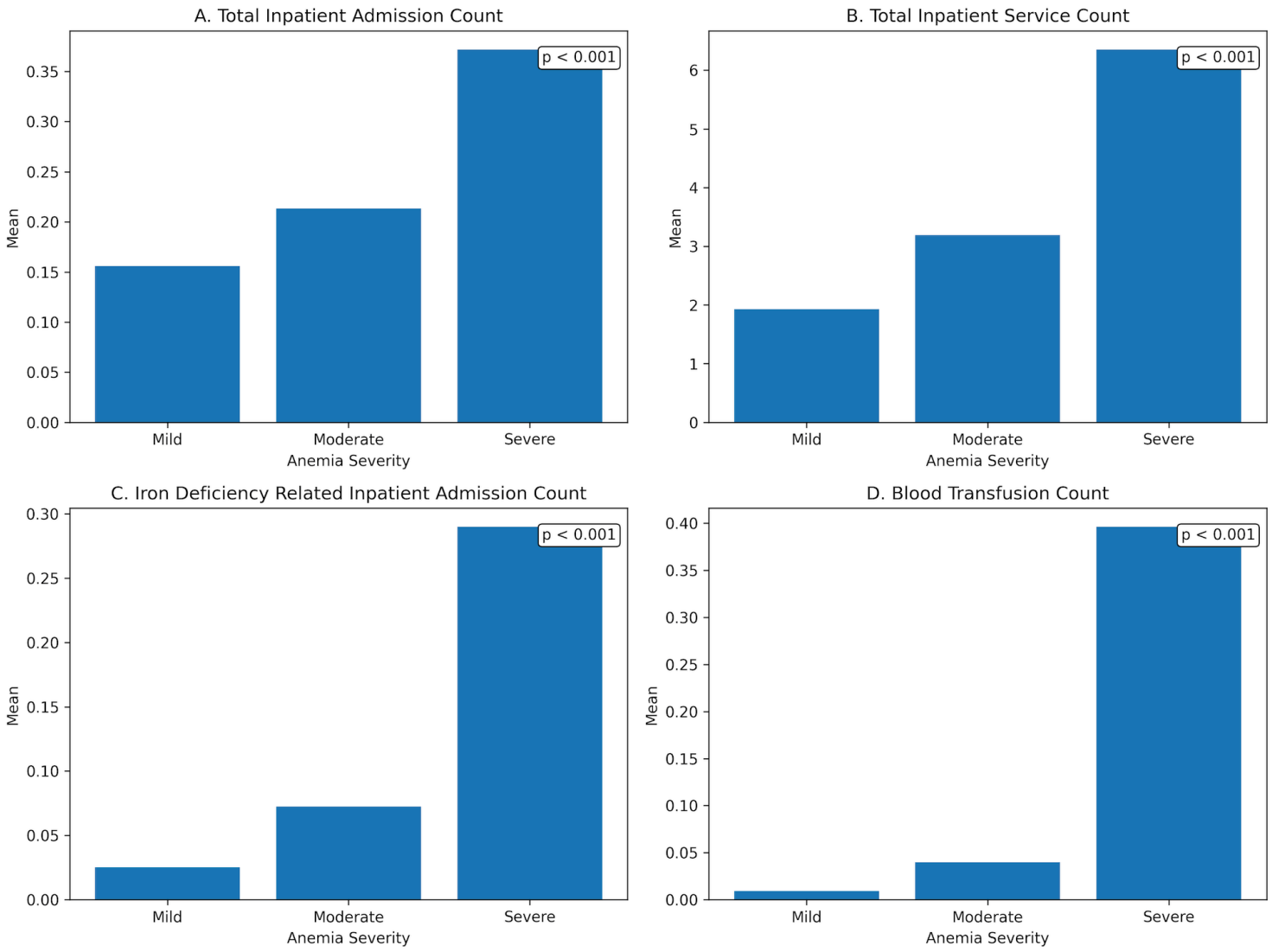


Figure 2

Healthcare utilization according to anemia severity.

Panel A shows the mean total inpatient admission count, Panel B the mean total inpatient service count, Panel C the mean iron deficiency–related inpatient admission count, and Panel D the mean blood transfusion count across mild, moderate, and severe anemia groups. All healthcare utilization parameters increased significantly with increasing anemia severity (all $p < 0.001$).

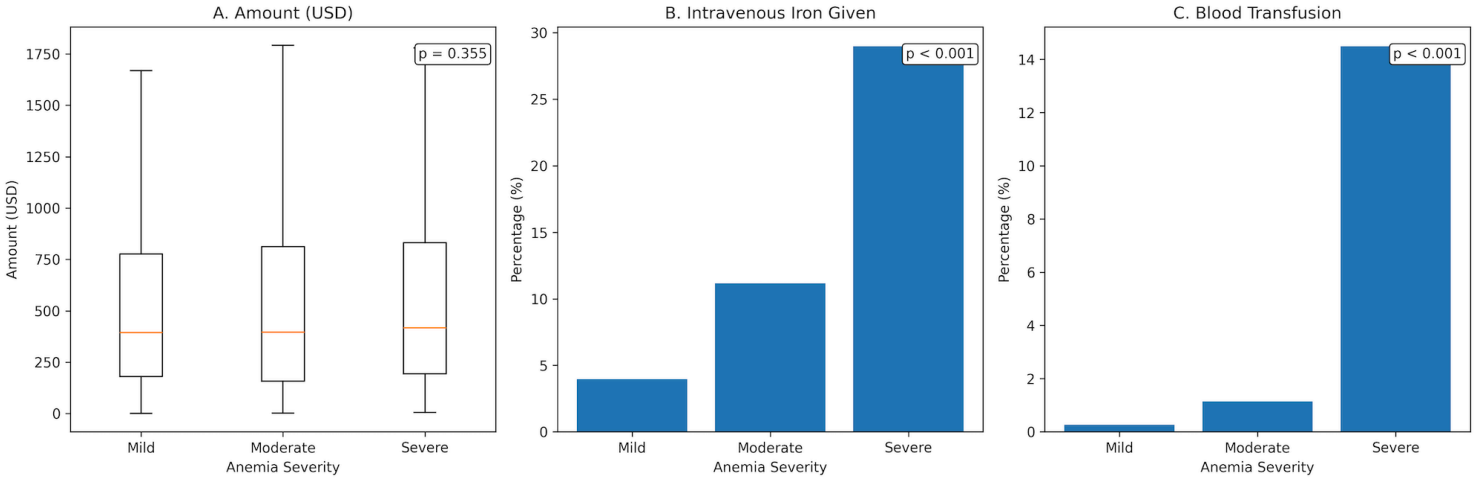


Figure 3

Cost and treatment intensity according to anemia severity.

Panel A shows the distribution of healthcare costs in USD across anemia severity groups. Panel B shows the proportion of patients receiving intravenous iron therapy, and Panel C shows the proportion of patients receiving blood transfusion. The use of intravenous iron therapy and blood transfusion increased significantly with increasing anemia severity (both $p < 0.001$), whereas overall healthcare costs did not differ significantly between groups ($p = 0.355$).