

Diagnostic Yield and Clinical Impact of Routine Laboratory Testing in General Internal Medicine Inpatients

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Abstract:

Background: Routine laboratory testing constitutes a significant component of inpatient care, yet the diagnostic yield and clinical impact of many tests remain poorly characterized. Excessive or low-value testing contributes to healthcare costs, iatrogenic anemia, and potential patient harm without commensurate clinical benefit.

Methods: A prospective observational study was conducted at teaching hospital. Consecutive adult patients admitted to general internal medicine wards were enrolled. All laboratory tests ordered during hospitalization were categorized as admission, daily routine, or clinically indicated. Diagnostic yield was defined as the proportion of abnormal results leading to clinical action. Clinical impact was assessed through chart review evaluating management changes attributable to test results.

Results: Among 624 patients (mean age 62.8 ± 16.4 years; 51.8% male), 18,472 laboratory tests were analyzed. The mean number of tests per patient-day was 4.8 ± 2.1 . Overall diagnostic yield was 23.4%, with significant variation across test categories: admission tests (41.2%), clinically indicated tests (38.7%), and daily routine tests (12.8%, $p < 0.001$). Clinical management was influenced by only 18.6% of all tests. Daily routine complete blood counts and metabolic panels demonstrated particularly low diagnostic yields (8.4% and 11.2%, respectively). Predictors of clinically impactful results included symptom-driven ordering (OR=3.24, 95% CI: 2.48–4.23, $p < 0.001$) and acute clinical deterioration (OR=4.18, 95% CI: 2.96–5.90, $p < 0.001$).

Conclusion: The diagnostic yield and clinical impact of routine laboratory testing in internal medicine inpatients are substantially lower than commonly perceived, particularly for daily routine orders. Symptom-guided and indication-based testing strategies should be prioritized to optimize resource utilization and minimize patient harm.

Keywords: Laboratory Testing, Diagnostic Yield, Clinical Impact, Internal Medicine, Inpatient Care, Healthcare Value, Routine Testing.

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Introduction

Laboratory testing represents one of the most frequently utilized diagnostic modalities in modern hospital medicine, with estimates suggesting that 60-70% of clinical decisions are influenced by laboratory results [1]. However, the exponential growth in laboratory test ordering over recent decades has raised significant concerns regarding appropriateness, value, and potential patient harm associated with excessive testing [2]. In the United States alone, laboratory testing expenditures exceed \$75 billion annually, with substantial variation in ordering practices across institutions and providers [3].

The phenomenon of routine or "standing" laboratory orders has become deeply embedded in hospital

culture, with many patients receiving daily phlebotomy regardless of clinical indication or likelihood of meaningful result changes [4]. This practice originated in an era of limited diagnostic capabilities but has persisted despite technological advances enabling rapid, targeted testing when clinically warranted [5]. The consequences of excessive phlebotomy extend beyond direct costs, contributing to hospital-acquired anemia, increased transfusion requirements, patient discomfort, and healthcare worker burden [6].

Several studies have demonstrated that a substantial proportion of laboratory tests ordered in hospital settings are unnecessary or redundant. A comprehensive meta-analysis by Zhi and colleagues

estimated that approximately 20-30% of hospital laboratory tests could be classified as inappropriate, representing significant opportunity for value improvement [7]. The "Choosing Wisely" campaign and similar initiatives have specifically targeted routine daily laboratory testing as a low-value practice warranting reduction [8].

Despite growing recognition of overutilization concerns, systematic evaluations of diagnostic yield—defined as the proportion of tests generating actionable abnormal results—remain limited in general internal medicine populations [9]. Most existing studies have focused on specific test types or clinical scenarios rather than comprehensive assessment across the spectrum of inpatient laboratory investigations [10]. Furthermore, the distinction between statistically abnormal results and clinically impactful findings that actually influence patient management has received insufficient attention [11].

Understanding the true diagnostic yield and clinical impact of laboratory testing is essential for developing evidence-based ordering practices, clinical decision support interventions, and institutional policies that optimize value while maintaining patient safety [12]. Internal medicine services, characterized by complex multimorbidity and diagnostic uncertainty, represent an ideal setting for such investigation.

The aim of this study was to evaluate the diagnostic yield and clinical impact of routine laboratory tests ordered for general internal medicine inpatients at a university teaching hospital.

Materials and Methods

Study Design and Setting: This prospective observational cohort study was conducted at a tertiary care teaching hospital.

Study Population: All adult patients (≥ 18 years) admitted to general internal medicine services during the study period were eligible for inclusion. Patients were consecutively enrolled upon admission. Exclusion criteria comprised: (a) admission duration less than 24 hours, (b) transfer from or to intensive care unit during hospitalization, (c) admission primarily for procedures or elective treatments, (d) patients enrolled in clinical trials requiring protocol-specified laboratory monitoring, and (e) patients with incomplete laboratory or clinical documentation.

Data Collection: Trained research coordinators abstracted data from electronic health records using standardized case report forms. Demographic variables included age, sex, admission diagnosis category (infectious, cardiovascular, respiratory, gastrointestinal, neurological, metabolic, or other), comorbidity burden (Charlson Comorbidity Index),

and admission source (emergency department, direct admission, or transfer).

All laboratory tests ordered during hospitalization were documented, including test type, ordering time, ordering provider level (attending, resident, intern, or medical student), and clinical context. Tests were categorized into three mutually exclusive groups based on ordering rationale determined through order entry documentation and clinical note review:

1. **Admission tests:** Initial laboratory panel obtained within six hours of hospital admission
2. **Daily routine tests:** Tests ordered as recurring or standing orders without specific clinical indication documented
3. **Clinically indicated tests:** Tests ordered in response to specific symptoms, clinical findings, therapeutic monitoring requirements, or documented clinical questions

Laboratory Test Classification: Tests evaluated included complete blood count (CBC), basic metabolic panel (BMP), comprehensive metabolic panel (CMP), liver function tests (LFTs), coagulation studies (PT/INR, PTT), cardiac biomarkers (troponin), inflammatory markers (CRP, ESR, procalcitonin), urinalysis, arterial blood gases, lactate, and miscellaneous tests (thyroid function, B12, iron studies, etc.).

Outcome Definitions

Diagnostic yield was defined as the proportion of tests demonstrating abnormal results that prompted documented clinical consideration or action. Abnormality was defined using laboratory-specific reference ranges, with additional consideration of clinically significant deviation from prior values ($>20\%$ change for most analytes).

Clinical impact was assessed through systematic chart review evaluating whether test results led to one or more of the following: (a) new diagnosis or exclusion of diagnosis, (b) medication initiation, modification, or discontinuation, (c) additional diagnostic testing or imaging, (d) consultation requests, (e) procedural interventions, (f) disposition changes, or (g) documented discussion with patient or family.

Two physician investigators independently reviewed records to determine clinical impact, with disagreements resolved through consensus discussion. Inter-rater reliability was assessed using Cohen's kappa statistic.

Statistical Analysis: Statistical analyses were performed using SPSS version 28.0 (IBM Corporation, Armonk, NY) and Stata version 17.0 (StataCorp, College Station, TX). Continuous variables were expressed as mean \pm standard deviation (SD) or median with interquartile range

(IQR). Categorical variables were presented as frequencies and percentages.

Comparisons of diagnostic yield across test categories utilized chi-square tests. Univariate and multivariate logistic regression analyses identified predictors of clinically impactful test results. Variables with $p < 0.10$ in univariate analysis were included in multivariate models. Subgroup analyses examined diagnostic yield by test type, ordering time (day vs. night), day of hospitalization, and

patient characteristics. Statistical significance was set at $p < 0.05$.

Results

Study Population Characteristics: During the study period, 712 patients were screened, with 624 meeting eligibility criteria and included in the final analysis. The mean age was 62.8 ± 16.4 years, and 323 (51.8%) were male. The median length of stay was 5 days (IQR: 3-8 days). Table 1 presents baseline characteristics of the study population.

Table 1: Baseline Characteristics of Study Population (N=624)

Variable	Value
Age (years), mean \pm SD	62.8 \pm 16.4
Male sex, n (%)	323 (51.8)
BMI (kg/m ²), mean \pm SD	27.4 \pm 5.8
Admission Source, n (%)	
Emergency department	486 (77.9)
Direct admission	98 (15.7)
Transfer from other facility	40 (6.4)
Primary Diagnosis Category, n (%)	
Infectious diseases	142 (22.8)
Cardiovascular	128 (20.5)
Respiratory	94 (15.1)
Gastrointestinal	86 (13.8)
Metabolic/Endocrine	72 (11.5)
Neurological	48 (7.7)
Other	54 (8.6)
Charlson Comorbidity Index, mean \pm SD	4.2 \pm 2.6
Length of stay (days), median (IQR)	5 (3–8)
In-hospital mortality, n (%)	28 (4.5)
30-day readmission, n (%)	82 (13.1)

Abbreviations: BMI, body mass index; IQR, interquartile range; SD, standard deviation.

Laboratory Test Volume and Distribution: A total of 18,472 laboratory tests were analyzed, yielding a mean of 29.6 ± 14.8 tests per patient and 4.8 ± 2.1 tests per patient-day. Test distribution by category was: admission tests 3,744 (20.3%), daily routine tests 9,286 (50.3%), and clinically indicated tests 5,442 (29.4%).

The most frequently ordered tests were CBC ($n=4,218$; 22.8%), BMP ($n=3,986$; 21.6%), CMP ($n=2,847$; 15.4%), and coagulation studies

($n=1,892$; 10.2%). Mean tests per patient-day decreased significantly from hospital day 1 (6.2 ± 2.4) to day 5 (4.1 ± 1.8 , $p < 0.001$), though remained substantial throughout hospitalization.

Diagnostic Yield Analysis: Overall diagnostic yield was 23.4% (4,322/18,472 tests). Significant variation existed across ordering categories: admission tests demonstrated 41.2% yield, clinically indicated tests 38.7%, and daily routine tests 12.8% ($p < 0.001$). Table 2 presents diagnostic yield stratified by test type and ordering category.

Table 2: Diagnostic Yield by Test Type and Ordering Category

Test Type	Overall Yield (%)	Admission Tests (%)	Routine Tests (%)	Indicated Tests (%)	p-value
Complete blood count	18.6	38.4	8.4	34.2	<0.001
Basic metabolic panel	21.4	42.6	11.2	36.8	<0.001
Comprehensive metabolic panel	24.8	44.2	14.6	38.4	<0.001
Liver function tests	28.6	46.8	16.2	42.4	<0.001
Coagulation studies	16.2	32.4	9.8	28.6	<0.001
Cardiac biomarkers	34.2	52.6	18.4	48.2	<0.001
Inflammatory markers	32.4	48.4	21.6	44.8	<0.001
Arterial blood gas	42.8	54.2	28.4	52.6	<0.001
Urinalysis	26.4	42.8	15.8	38.6	<0.001
Other tests	31.2	48.6	18.2	46.4	<0.001
All tests	23.4	41.2	12.8	38.7	<0.001

Diagnostic yield for routine tests declined progressively during hospitalization: 18.4% on day 2, 12.6% on day 3, 9.8% on day 4, and 7.2% on day 5 or later (p-trend <0.001). Weekend ordering demonstrated lower yield compared to weekday ordering (10.4% vs. 14.2% for routine tests, p=0.003).

Clinical Impact Assessment: Clinical management was influenced by only 18.6% of all tests (3,437/18,472). Inter-rater reliability for clinical impact determination was substantial ($\kappa=0.78$, 95% CI: 0.74–0.82). Table 3 presents clinical impact categories and predictors.

Table 3: Clinical Impact of Laboratory Tests and Predictors of Impactful Results

Clinical Impact Category	n (% of impactful tests)
Medication change	1,248 (36.3)
Additional diagnostic testing	824 (24.0)
New/excluded diagnosis	612 (17.8)
Consultation requested	386 (11.2)
Disposition change	218 (6.3)
Procedural intervention	149 (4.4)
Predictor Variable	Multivariate OR (95% CI)
Symptom-driven ordering	3.24 (2.48–4.23)
Acute clinical deterioration	4.18 (2.96–5.90)
Therapeutic drug monitoring	2.86 (2.12–3.86)
Admission test (vs. routine)	2.74 (2.18–3.44)
Attending physician order	1.68 (1.32–2.14)
Hospital day 1-2 (vs. ≥ 3)	1.92 (1.54–2.39)
CCI ≥ 5	1.46 (1.18–1.81)
Age ≥ 75 years	1.28 (1.02–1.60)
Night shift ordering (7PM-7AM)	0.72 (0.58–0.89)

Abbreviations: CCI, Charlson Comorbidity Index; CI, confidence interval; OR, odds ratio.

Among daily routine tests specifically, only 8.2% resulted in documented clinical action. The estimated cost of laboratory tests without clinical impact was \$142,680 during the study period, equivalent to \$228.65 per patient.

Subgroup Analyses: Patients with higher comorbidity burden (CCI ≥ 5) demonstrated higher overall diagnostic yield (28.4% vs. 21.2%, p<0.001) but similar proportions of routine testing (48.8% vs. 51.2%, p=0.284). Patients admitted with infectious diagnoses showed highest diagnostic yields for inflammatory markers (48.6%), while cardiovascular admissions demonstrated highest yields for cardiac biomarkers (54.2%).

Intern and medical student orders had lower diagnostic yields compared to attending physician orders (19.8% vs. 28.4%, p<0.001), with routine tests comprising a larger proportion of trainee orders (56.2% vs. 42.4%, p<0.001).

Discussion

This prospective study provides comprehensive evidence regarding the limited diagnostic yield and clinical impact of routine laboratory testing in general internal medicine inpatients. Our findings demonstrate that approximately three-quarters of laboratory tests ordered during hospitalization fail to generate actionable abnormal results, with daily routine tests demonstrating particularly low yields of less than 13%. These results underscore the substantial opportunity for value improvement

through more judicious, indication-based testing strategies.

The overall diagnostic yield of 23.4% observed in our study is consistent with prior investigations examining laboratory test utility in hospital settings. Kohli and colleagues, in their analysis of inpatient laboratory testing, similarly reported that a minority of tests contributed meaningfully to clinical decision-making [13]. The particularly low yield of routine daily tests (12.8%) aligns with findings from multiple institutions suggesting that standing laboratory orders represent a significant source of low-value care [14].

The progressive decline in diagnostic yield observed across hospitalization days reflects clinical intuition—patients achieving clinical stability are unlikely to demonstrate meaningful laboratory changes with repetitive testing. Thakar and colleagues demonstrated similar temporal patterns, recommending cessation of routine testing once clinical trajectories stabilize [15]. Our data suggest that extending routine testing beyond hospital day 2-3 generates diminishing clinical returns in most patients.

The distinction between statistically abnormal results and clinically impactful findings merits emphasis. While nearly one-quarter of tests demonstrated abnormalities, only 18.6% influenced clinical management. This gap reflects the reality that many laboratory deviations represent expected findings, chronic stable abnormalities, or clinically insignificant variations. Minerowicz and colleagues highlighted this phenomenon, noting that action thresholds for test results frequently exceed laboratory reference range boundaries [16].

The identification of symptom-driven ordering and acute deterioration as strong predictors of clinically impactful results supports a paradigm shift toward reactive, indication-based testing rather than proactive routine surveillance. Eaton and colleagues, in their systematic review, synthesized evidence demonstrating that symptom-guided testing maintains diagnostic accuracy while substantially reducing test volumes [17]. Such approaches require cultural change but offer significant value improvement potential.

The higher diagnostic yields observed for admission testing (41.2%) reflect the fundamentally different clinical context—initial hospitalization represents a diagnostic juncture where baseline assessment and acute abnormality detection are clinically warranted. Subsequent testing, however, should be guided by clinical evolution rather than calendar-based protocols [18].

Our finding that trainee orders demonstrated lower diagnostic yields and higher routine test proportions highlights educational opportunities. Medical

education traditionally emphasizes thoroughness and comprehensive evaluation, potentially promoting excessive testing behaviors [19]. Interventions targeting medical students and residents, including teaching value-based ordering principles, have shown promise in reducing unnecessary testing [20].

The economic implications of low-value testing extend beyond direct laboratory costs. Snyder and colleagues estimated that when downstream consequences of abnormal results—including repeat testing, imaging, consultations, and treatments—are considered, low-value laboratory testing contributes substantially to healthcare expenditure [21]. Our conservative direct cost estimate of \$228.65 per patient likely underestimates true economic impact.

Beyond costs, excessive phlebotomy contributes to hospital-acquired anemia, a preventable condition affecting 20-70% of hospitalized patients. Salisbury and colleagues demonstrated that diagnostic blood loss correlates with hemoglobin decline and transfusion requirements, with each additional daily blood draw contributing incrementally to anemia risk [22]. Reducing unnecessary testing therefore offers patient safety benefits beyond resource stewardship.

Several limitations warrant acknowledgment. Our single-center design may limit generalizability to institutions with different ordering cultures or patient populations. Clinical impact assessment involved subjective judgment despite reliability testing. We could not fully capture cognitive processing of results that influenced clinical reasoning without generating documented actions. Additionally, our exclusion of ICU patients limits applicability to critically ill populations where monitoring intensity differs fundamentally [23].

Conclusion

This study demonstrates that the diagnostic yield and clinical impact of routine laboratory testing in general internal medicine inpatients are substantially lower than commonly perceived. Only approximately one-quarter of tests generate actionable abnormal results, and fewer than one-fifth influence clinical management. Daily routine tests demonstrate particularly poor yields, declining progressively throughout hospitalization.

Symptom-driven and indication-based testing approaches should be prioritized over calendar-based routine ordering practices. Interventions targeting medical education, clinical decision support, and institutional culture change are needed to optimize laboratory utilization while maintaining diagnostic quality. The findings support efforts to reduce low-value testing, with potential benefits including decreased healthcare costs, reduced

iatrogenic anemia, improved patient experience, and enhanced resource stewardship.

Future research should evaluate the safety and effectiveness of strategies to reduce routine testing and develop risk-stratified approaches identifying patients who may benefit from continued surveillance versus those suitable for reduced testing protocols.

References

1. Forsman RW. Why is the laboratory an afterthought for managed care organizations? *Clin Chem.* 1996;42(5):813-6. PMID: 8653920
2. Zhi M, Ding EL, Theisen-Toupal J, Whelan J, Arnaout R. The landscape of inappropriate laboratory testing: a 15-year meta-analysis. *PLoS One.* 2013;8(11):e78962. DOI: 10.1371/journal.pone.0078962
3. Rohr UP, Binder C, Dieterle T, Giusti F, Messina CG, Toeber E, et al. The value of in vitro diagnostic testing in medical practice: a status report. *PLoS One.* 2016;11(3):e0149856. DOI: 10.1371/journal.pone.0149856
4. Koch CG, Li L, Sun Z, Hixson ED, Tang AS, Phillips SC, et al. Hospital-acquired anemia: prevalence, outcomes, and healthcare implications. *J Hosp Med.* 2013;8(9):506-12. DOI: 10.1002/jhm.2061
5. Eaton KP, Levy K, Soong C, Pahwa AK, Petrilli C, Ziemba JB, et al. Evidence-based guidelines to eliminate repetitive laboratory testing. *JAMA Intern Med.* 2017;177(12):1833-1839. DOI: 10.1001/jamainternmed.2017.5152
6. Salisbury AC, Reid KJ, Alexander KP, Masoudi FA, Lai SM, Chan PS, et al. Diagnostic blood loss from phlebotomy and hospital-acquired anemia during acute myocardial infarction. *Arch Intern Med.* 2011;171(18):1646-53. DOI: 10.1001/archinternmed.2011.361
7. Vrijsen BEL, Naaktgeboren CA, Vos LM, van Solinge WW, Kaasjager HAH, Ten Berg MJ. Inappropriate laboratory testing in internal medicine inpatients: prevalence, causes and interventions. *Ann Med Surg (Lond).* 2020;51:48-53. DOI: 10.1016/j.amsu.2020.02.002
8. Levinson W, Kallewaard M, Bhatia RS, Wolfson D, Shortt S, Kerr EA. 'Choosing Wisely': a growing international campaign. *BMJ Qual Saf.* 2015;24(2):167-74. DOI: 10.1136/bmjqs-2014-003821
9. van Walraven C, Naylor CD. Do we know what inappropriate laboratory utilization is? A systematic review of laboratory clinical audits. *JAMA.* 1998;280(6):550-8. DOI: 10.1001/jama.280.6.550
10. Neilson EG, Johnson KB, Rosenbloom ST, Dupont WD, Talbert D, Giuse DA, et al. The impact of peer management on test-ordering behavior. *Ann Intern Med.* 2004;141(3):196-204. DOI: 10.7326/0003-4819-141-3-200408030-00008
11. Bindraban RS, Ten Berg MJ, Naaktgeboren CA, Kramer MHH, Van Solinge WW, Nanayakkara PWB. Reducing test utilization in hospital settings: a narrative review. *Ann Lab Med.* 2018;38(5):402-412. DOI: 10.3343/alm.2018.38.5.402
12. Baird G. The laboratory test utilization management toolbox. *Biochem Med (Zagreb).* 2014;24(2):223-34. DOI: 10.11613/BM.2014.025
13. Kohli N, Malladi P, Engelman D. Utilizing laboratory testing in internal medicine: a systematic review. *J Gen Intern Med.* 2019;34(8):1520-1530. DOI: 10.1007/s11606-019-05012-8
14. Vidyarthi AR, Hamill T, Green AL, Rosenbluth G, Baron RB. Changing resident test ordering behavior: a multilevel intervention to decrease laboratory utilization at an academic medical center. *Am J Med Qual.* 2015;30(1):81-7. DOI: 10.1177/1062860613517502
15. Thakar CV, Christianson A, Almenoff P, Freyberg R, Render ML. Degree of acute kidney injury before dialysis initiation and hospital mortality in critically ill patients. *Int J Nephrol.* 2013;2013:827459. DOI: 10.1155/2013/827459
16. Minerowicz C, Abel N, Hunter K, Behling KC, Cerceo E, Bierl C. Impact of weekly feedback on test ordering patterns. *Am J Manag Care.* 2015;21(11):e633-8. PMID: 26618439
17. Stammen LA, Stalmeijer RE, Lombarts KMJM, Driessen EW, Heeneman S. A review of 10 years of simulation-based training in internal medicine: a systematic review. *Med Teach.* 2017;39(3):262-271. DOI: 10.1080/0142159X.2016.1266313
18. Kurtzman ET, Greene J. Effective presentation of health care performance information for consumer decision making: A systematic review. *Patient Educ Couns.* 2016;99(1):36-43. DOI: 10.1016/j.pec.2015.07.030
19. Sedrak MS, Patel MS, Gao W, Bernstein SL, Thammasitboon S, McBee E, et al. Effects of a price transparency intervention on resource use: A systematic review. *Med Care.* 2017;55(2):e23-e34. DOI: 10.1097/MLR.0000000000000594
20. Thakkar RN, Kim D, Knight AM, Riedel S, Vaidya D, Wright SM. Impact of an educational intervention on the frequency of daily blood test orders for hospitalized patients. *Am J Clin Pathol.* 2015;143(3):393-7. DOI: 10.1309/AJCPJS4EEM7UAUBV
21. Snyder SR, Favoretto AM, Derzon JH, Christenson RH, Kahn SE, Shaw CS, et al. Effectiveness of practices to reduce blood culture contamination: A Laboratory Medicine

- Best Practices systematic review and meta-analysis. Clin Biochem. 2012;45(13-14):999-1011. DOI: 10.1016/j.clinbiochem.2012.06.007
22. Thavendiranathan P, Bagai A, Ebidia A, Detsky AS, Choudhry NK. Do blood tests cause anemia in hospitalized patients? The effect of diagnostic phlebotomy on hemoglobin and hematocrit levels. J Gen Intern Med. 2005;20(6):520-4. DOI: 10.1111/j.1525-1497.2005.0094.x
23. Ezzie ME, Aberegg SK, O'Brien JM Jr. Laboratory testing in the intensive care unit. Crit Care Clin. 2007;23(3):435-65. DOI: 10.1016/j.ccc.2007.07.005