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Breaking the guidelines: how financial unawareness fuels guideline deviations and inefficient DVT diagnostics

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Abstract

Objectives: To examine factors impacting diagnostic evaluation of suspected deep vein thrombosis (DVT) by analyzing the test ordering patterns and provider decision-making within a universal health coverage system in Hungary.

Methods: We analyzed test orders for suspected DVT between 2007 and 2020, and the financial framework influencing diagnostic practices. An anonymous survey was also conducted among Emergency Department physicians to explore factors influencing diagnostic decision-making.

Results: A total of 6,821 patients were identified. From 2008 to 2013, the most common diagnostic approach combined D-dimer and duplex ultrasound tests (64.5 %), followed by sole ultrasound (20.5 %) and sole D-dimer (15 %) testing. A marked shift occurred from 2014 onward, with sole ultrasound rising to 88 % of cases by 2018–2020, while combined testing and sole D-dimer orders decreased to 7.9 and 4 %, respectively. In survey results, time efficiency emerged as a key factor for bypassing D-dimer testing, cited by 75 % of physicians. 45 % believed D-dimer costs were comparable to or higher than duplex ultrasound. Financial analysis revealed that the outdated performance points system misrepresented actual costs, resulting in duplex ultrasound being significantly underfunded, which impacts the Radiology Department. This discrepancy contributes to higher national level expenses, driven by the increased reliance on ultrasound.

Conclusions: We found diagnostic practices deviating from international diagnostic guidelines, with an increase in duplex ultrasound over D-dimer. This shift, allowed by an outdated financing structure, increases overall costs for the healthcare system. Revising financial frameworks to reflect true costs is essential for sustainable operations in universal health coverage systems.

Keywords: diagnostics; efficiency; healthcare cost; decision-making

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Introduction

Monitoring of diagnostic efficiency

Low-value care (LVC), offering minimal to no benefit to the patients while incurring excess costs, is a global challenge and is estimated to cost the US healthcare system between 76 and 102 billion USD yearly [1]. Overuse of tests is a common form of LVC [2] and can be driven by financial incentives, medico-legal concerns, and availability/turn-around time. The de-implementation of LVC is essential to reducing resource waste and thus indirectly improving patient and population health [3]. Clinical guidelines, algorithms, evidence-based recommendations, and indices [4] that quantify and monitor hospital-level LVC can optimize patient care.

Diagnostic considerations for deep vein thrombosis

The current study examines the diagnostic evaluation for suspected deep vein thrombaosis (DVT) to analyze diagnostic considerations of healthcare providers (HCPs). DVT represents a critical medical concern due to the risk of progressing to pulmonary embolism. DVT is a relatively frequent provisional diagnosis, and data indicate a rising incidence of DVT cases [5, 6]. Current guidelines advocate that suspected DVT evaluations should include a pretest probability assessment, with the Wells score being the most widely used tool [7, 8]. In the low probability group, D-dimer is the suggested initial test; if normal (<500 ng/mL), no further testing is necessary. However, elevated D-dimer levels prompt the performance of duplex ultrasound of the affected lower extremity [7]. The high probability group is recommended to undergo immediate ultrasound examination without prior D-dimer testing [7]. In the moderate probability group, diverse clinical perspectives exist regarding initiating D-dimer testing or directly proceeding to ultrasound examination [7].

Healthcare and hospital financial models

Healthcare financing varies globally; however most industrialized countries operate some form of publicly funded healthcare with universal coverage. In Hungary, healthcare predominantly operates under a national health insurance model, wherein most hospitals are state-funded, and patients are nationally insured and receive healthcare services free of charge at the point of use. The National Health Insurance Fund of Hungary (Hungarian abbreviation: NEAK) reimburses hospitals based on procedures performed. A "performance unit" score is assigned to each procedure (e.g., diagnostic tests). Reimbursement is based on a flat conversion rate of the performance units. This Fund aims to promote cost-efficient operations by allocating a monthly allowed budget of "performance units". Exceeding allocated budgets leads to unreimbursed services, encouraging providers to prioritize lower-cost diagnostics.

Objectives

At the Department of Laboratory Medicine of the University of Debrecen Clinical Center (UDCC), a decline in the D-dimer test orders for suspected DVT has been observed over the past decade. Given the prominent role of D-dimer in DVT diagnosis, our objective was to explore the diagnostic practices for suspected deep vein thrombosis at the Emergency Department of the UDCC and compare that to gold-standard guidelines. Rather than proposing new guidelines, we aimed to assess factors contributing to deviation from existing recommendations.

Subjects and methods

Data sources

We used hospital-level data from the University of Debrecen Clinical Center. The clinical data warehouse was accessed via Microsoft Azure Databricks PaaS (Platform as a Service), a cloud-based solution for processing, storing, sharing, analyzing, and modeling datasets. We used Spark SQL queries and rule-based text processing techniques to generate data for subsequent statistical analysis.

Defining and finding DVT-suspect cases in medical records

We tried various filter queries to identify all patients who presented with suspected DVT at the ED. It was not possible to identify cases where test results were negative using discharge codes because discharge codes do not include diagnoses that were ruled out during the visit. To capture all patients with suspected DVT, we analyzed the presenting complaints, past medical history, physical examination results, and discharge summary in free text format. We found that medical phrases and discharge language were relatively consistent, which aided patient identification with classic data mining library of regular expressions (regex).

Our final filters included admission date (January 1, 2007–December 31, 2020), department code, the presence of the Hungarian terms for "DVT" or "deep vein thrombosis" in the discharge summary in combination with the phrases: "was ruled out", "was proved", "was confirmed" or "was excluded". The chosen expression reflects terminology commonly used in everyday clinical practice. We excluded those cases where neither D-dimer nor lower extremity duplex ultrasound test results were available despite being mentioned in the discharge summary.

Information on the identified patient records, including admission date, chief complaints, medical status, D-dimer results, lower extremity duplex ultrasound results, and discharge summary, were exported for all cases. We curated the exported cases by thoroughly reviewing chief complaints and discharge summaries, ensuring the relevance of all included cases for the study.

The extracted case numbers matched clinical expectations. The good sensitivity of patient identification is further supported by literature data indicating an annual incidence of 1–2 deep vein thrombosis (DVT) cases per 1,000 population [9, 10]. Given the 200,000–250,000 population in the ED catchment area, the annual DVT count was expected to range from 200 to 500. Our method identified 2–5 times this number, which is reasonable considering that a portion of patients initially suspected of having DVT were ultimately not diagnosed with the condition. The specificity of patient identification was considered 100 %, due to highly targeted filters.

Reimbursement rates

All diagnostic tests are assigned performance points by the NEAK, which we retrieved from the official NEAK website [11, 12]. NEAK determines the reimbursement valuation of the performance points [13]. Reimbursement based on NEAK's valuation, may not reflect actual costs incurred by the hospital. Hungarian Forint (HUF) was converted to US Dollar (USD) at the average exchange rate of 308 HUF/USD based on the average conversion rate between January 1, 2020, and December 31, 2020 [14].

Survey

We conducted an anonymous survey among the current healthcare providers to explore factors influencing their diagnostic decision-making. All physicians, including residents and specialists, had the opportunity to fill out the survey during their daytime shifts, voluntarily. Of the 20 attending specialists and 17 resident physicians employed at the Emergency Department of the University of Debrecen, 12 (60 %) specialists and 7 (41 %) residents participated. 40 % of the responders were resident physicians, 60 % were specialists. 35 % of the responders had specializations in emergency medicine; the rest had other specializations or did not have any (i.e., resident physicians). Responders' years of experience in emergency care are shown in Figure 1.

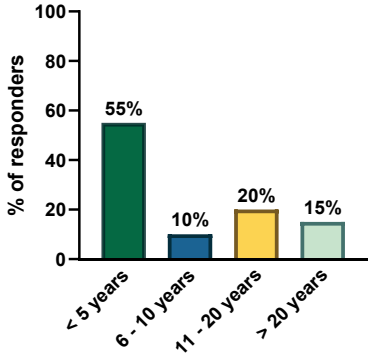

Figure 1: Responders' years of experience in emergency care.

Statistical analysis

Anonymized data from health records were exported in.csv and further analyzed in Microsoft Excel (Microsoft) and GraphPad Prism version 10.2 (GraphPad Software). The data were tested for normal distribution with the D'Agostino & Pearson test. Those that passed the normality test were further examined with the Pearson correlation test. For those that were non-Gaussian, a non-parametric Spearman correlation test was performed. All of these were done using GraphPad Prism.

Results

To evaluate the D-dimer and lower extremity duplex ultrasound test orders for patients with suspected DVT, we identified 6,821 cases from the UDCC medical database (2007–2020) using filtering criteria. Patient volume increased annually, ranging from 67 to 921 cases, and it was attributed to the evolving "single-admission-site" pathways within the clinical center. Demographics, including the patient population served, the age distribution of the patients and the rate of D-dimer positivity were constant, based on the Spearman correlation test.

We revealed significant trends in test ordering patterns within the examined period (Figure 2). From 2008 to 2013, the combined D-dimer and ultrasound assessments were most common (64.5 %), followed by sole ultrasound (20.5 %) and sole D-dimer orders (15 %). However, beginning in 2014, a shift in ordering habits became apparent, sole ultrasound evaluations increased, reaching an average of 88 % of cases by 2018–2020, with combined D-dimer and ultrasound tests comprising 7.9 % of cases and sole D-dimer orders at 4 %. Further curation of the data showed that in 57 % of D-dimer orders, other conditions (e.g., suspected pulmonary embolism) also influenced the decision. Adjusting for pure DVT-suspect cases, the order rates shifted to 94.5 % ultrasound, 3.3 % combined, and 1.7 % sole D-dimer orders. The trends in test ordering showed statistical significance over the whole studied period, with a strong correlation after 2012. The rate of sole ultrasound ordering exhibited a strong positive correlation between 2012 and 2020 ($r=0.93$, $p<0.001$). Conversely, the downward trend in combined D-dimer and ultrasound

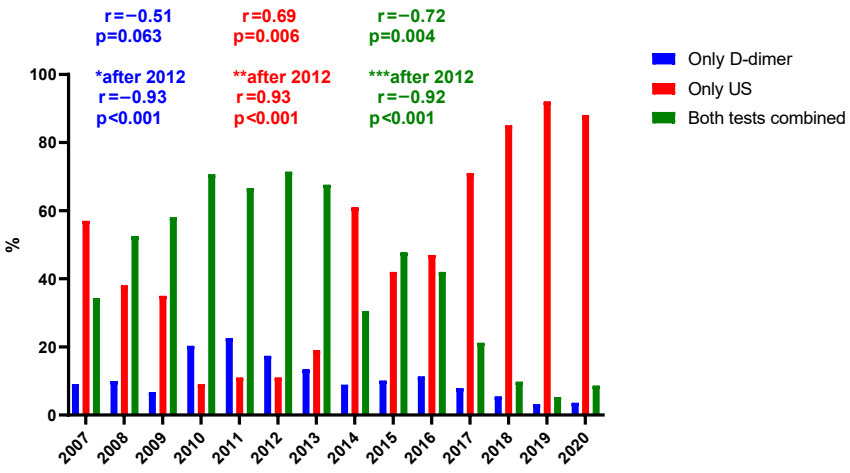

Figure 2: Notable trends in the rate of D-dimer, duplex ultrasound, and combined-test evaluations for patients with suspected DVT at the emergency department of UDCC between 2007 and 2020. Whereas D-dimer orders constituted an essential method in the diagnostic workout of DVT until 2016, sole ultrasound evaluation became by far the most common by 2020. D-dimer, laboratory test for D-dimer; US, lower extremity duplex ultrasound.

test rates showed a strong negative correlation over the same period (r=−0.92, p<0.001).

Despite this evolution in practice, no relevant changes in clinical guidelines or technological advancements were identified. The study cohort exhibited a consistent likelihood of DVT, with a stable incidence of positive D-dimer results (29.2 %).

To assess the predictive values of D-dimer tests, we used the cases with combined diagnostic testing. Ultrasound findings served as the gold standard reference for diagnostic comparison. D-dimer levels were considered negative if <0.5 mg FEU/L, resulting in 923 cases identified as negative. The negative predictive value (NPV) for acute DVT among these was 99.46 % (5 false negative cases). NPV for all cases of acute DVT, subacute DVT, or thrombosis in superficial veins was 96.86 % (31 false negative cases) and 95.56 % for post-thrombotic conditions (41 false negative cases).

Cost calculation at the UDCC

We calculated the reimbursements based on the performance points and the reimbursement rates defined by NEAK. Lower extremity venous duplex ultrasound was associated with 1,296 points, and the D-dimer laboratory test was associated with 3,543 points in 2020 [11, 12, 15].

We observed that the performance points allocated for the duplex ultrasound and D-dimer remained unchanged throughout the examined period between 2007 and 2020 (Figure 3). To ascertain whether these assignments were outliers or reflective of the standard practice of stagnant performance point levels, we checked other commonly requested diagnostic procedures. We found that performance point levels were virtually always constant, suggesting that performance points assigned to the diagnostic tests do not change.

However, reimbursement valuation of performance points increased gradually over time in a stepped method, from 0.44 USD cents/point in January 2007 by 45 % to 0.64 USD cents/point in January 2020 (Figures 3 and 4) [13].

As the cumulative inflation rate during this period was comparable to this, 54.45 % [16], we used the latest reimbursement values to compare the costs of diagnostic tests to private healthcare costs. We collected the current prices (as of 2024) of diagnostic tests in a private setting (Figure 4), as the pricing history of private services is not publicly available. Via online searches, we collected costs from 19 private facilities for D-dimer diagnostic tests and from 39 sites for lower extremity duplex ultrasound. In the private setting, the costs of the examined diagnostic tests exhibited notable disparities. Costs of D-dimer tests in private healthcare in Hungary were similar to the state reimbursement rates (24.59 USD compared to 22.67 USD); however, the price of the duplex ultrasound was nearly 10 times higher in the private setting compared to the state reimbursement value, with an average of 74 USD vs. 8.29 USD.

To compare Hungarian pricing ratios, we also collected pricing and reimbursement data from the USA. Medicare reimbursement was 10.52 USD for a D-dimer and 195.87 USD for a lower extremity duplex ultrasound. Prices in a private setting were slightly higher but proportional; the average price of a D-dimer test at 174 healthcare sites was reported to be 27 USD [17], while the unilateral lower extremity duplex ultrasound averaged 238 USD [18] at 146 sites across the country. While ultrasound assessments were significantly more expensive than D-dimer tests in the U.S. Medicare and private and in the Hungarian private setting, the Hungarian state reimbursement scheme is striking: ultrasound examination prices constituted one-third that of a D-dimer test reimbursed by the state, altogether approximately 30 times less than that observed in the USA.

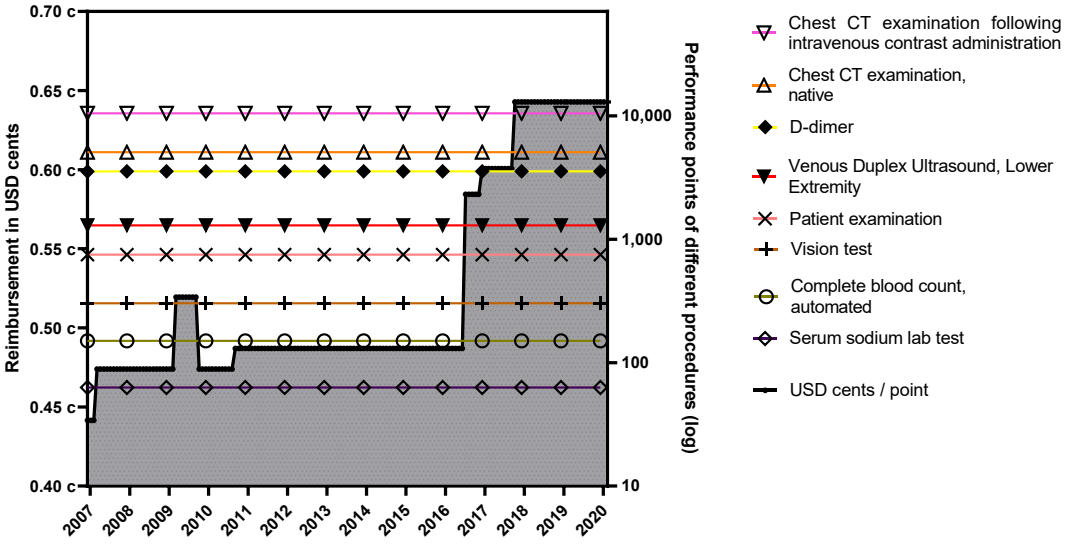

Figure 3: Reimbursement rates and performance points assigned to selected diagnostic tests by NEAK. Performance points remained constant between 2007 and 2020 for all the diagnostic tests. There was one universal reimbursement rate for all diagnostic tests, and that increased over time between 2007 and 2020. (Shading under USD cents/points only serves better visibility of that particular function). NEAK, National Health Insurance Fund of Hungary; USD, United States Dollar.

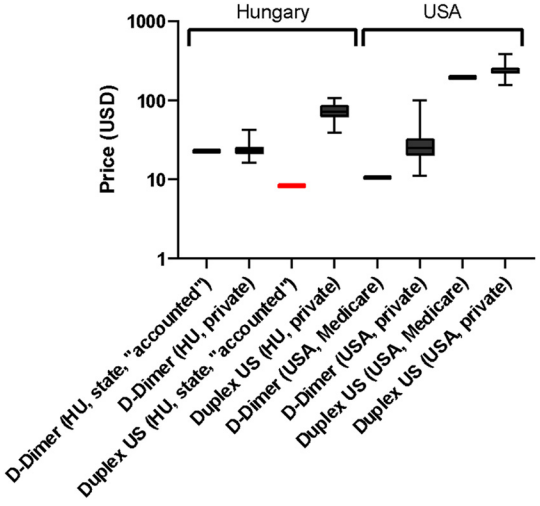

Figure 4: Real and "accounted" costs of D-dimer and duplex ultrasound tests in the United States and Hungary. The remarkably low Hungarian state reimbursement value for the duplex ultrasound is in red. HU, Hungary; US, Lower extremity duplex ultrasound; USA, United States of America; USD, United States Dollar.

Calculation of actual costs of diagnostic tests

Upon comparing the state-funded reimbursement rates for duplex ultrasound to prices in private settings in Hungary in the USA, they appeared outdated and did not accurately reflect the actual costs. We actual costs for this labor-intensive diagnostic test at the UDCC, performed by radiologists with administrative support. Publicly available data on salaries [19–22], accessory pricing from online price comparison platforms [23, 24], energy prices from the service provider's official price list [25] and equipment depreciation with maintenance intervals and replacement periods based on manufacturers' recommendations and previous research studies [26–29] were used. We used an average examination time of 14–15 min, factoring in preparation and breaks [30].

We modeled three cost scenarios: best-case, worst-case, and the average (Table 1). Expenses included wages, accessories, energy consumption, and depreciation. In the best-case scenario, lower wages (junior physicians) and prices were used with a shorter examination duration, reduced accessory usage, and an extended device lifecycle. In the worst-case scenario, higher wages and prices were used with long examination duration, increased accessory consumption, and a shorter device lifecycle.

Actual costs ranged between 11.24 USD and 44.51 USD, averaging 25.16 USD. The primary cost driver was wages, led by radiologists (7.2 USD to 33 USD per test), assistants (2.1 USD to 5.8 USD per test), followed by hospital attendants' wages for helping with the moving and transportation of the patient, at 1.4 USD to 3.3 USD. Wages accounted for approximately 96 % of all expenses.

Accessories contributed ~3.3 % (e.g., gel, gloves, paper), and depreciation of equipment added 0.81–1.47 %. Negligible factors like energy costs and minor furniture depreciation were excluded.

Table 1: Detailed costs of the lower extremity duplex ultrasound examination at the UDCC.

Expenditure	Minimum	Average	Maximum
Radiologist's wage per examination, USD[a]	7.2	18	33
Assistant's wage per examination, USD[a]	2.1	3.8	5.8
Hospital attendant's wage per examination, USD[a]	1.4	2.3	3.3
Cost of gel per examination, USD[a]	0.091	0.211	0.370
Cost of exam table paper per examination, USD[a]	0.146	0.313	0.519
Cost of gloves per examination, USD[a]	0.097	0.231	0.409
Cost of paper towels per examination, USD[a]	0.036	0.088	0.162
Energy cost of computers per examination, USD[a]	0.005	0.020	0.049
Energy cost of screens per examination, USD[a]	0.001	0.002	0.006
Energy cost of ultrasound machine per examination, USD[a]	0.011	0.039	0.089
Energy cost of lighting per examination, USD[a]	0.000	0.002	0.007
Maintenance cost of ultrasound machine per examination, USD[a]	0.01	0.03	0.09
Depreciation of ultrasound machine per examination, USD[a]	0.05	0.13	0.35
Depreciation of ultrasound probe per examination, USD[a]	0.035	0.085	0.206
Subtotals, USD[a]			
Wages combined, USD[a]	10.76	24.01	42.24
Accessories combined, USD[a]	0.37	0.84	1.46
Energy combined, USD[a]	0.02	0.06	0.15
Maintenance and depreciation combined, USD[a]	0.09	0.25	0.65
Total, USD[a]	11.24	25.16	44.51

[a]USD, United States Dollar.

Study among ED healthcare providers

We surveyed Emergency Department healthcare providers to explore factors influencing their diagnostic decision-making. When evaluating suspected deep vein thrombosis, 75 % of respondents reported ordering Duplex ultrasound as their initial test, 15 % ordered both tests concurrently, and 10 % preferred starting with a D-dimer test.

Time efficiency was cited by 75 % of physicians at least once as a key reason for not prioritizing D-dimer testing (Figure 5), despite 60 % reporting similar turnaround times for D-dimer and ultrasound (Figure 6). This preference appears tied to the belief that starting with ultrasound avoids additional tests after a positive D-dimer. All attending specialists (100 %) strongly agreed, and all residents (100 %) agreed or strongly agreed that elevated D-dimer levels can have multiple underlying causes.

Cost considerations were directly mentioned by only 10 % of respondents, though 45 % believed D-dimer costs were comparable to or higher than duplex ultrasound (58 % among specialists) (Figure 7). Additionally, just 15 % (3 respondents) cited "workplace requirements" as a factor influencing their decisions, and management confirmed that no official policy mandates ultrasound use. These findings suggest that the local diagnostic practices have evolved into informal customs that some providers feel obligated to follow.

Discussion

This study investigated diagnostic practices and clinical reasoning within a universal health coverage system, focusing on DVT diagnostics in a state-owned ED.

International guidelines suggest using the Wells score to guide D-dimer and duplex ultrasound use based on pretest probability. Despite a stable patient distribution across DVT probability levels, we revealed a decline in D-dimer orders, with duplex ultrasound becoming the preferred diagnostic method.

From 2014, sole ultrasound evaluations rose to 88 % of cases, while sole D-dimer and combined D-dimer/ultrasound orders accounted for 4 and 7 %, respectively. A survey revealed that 75 % of ED physicians prioritize time efficiency by bypassing D-dimer testing to avoid follow-up diagnostics. Additionally, 66 % believed D-dimer costs were comparable to or higher than duplex ultrasound.

The performance points and reimbursement rates are the only cost markers for HCPs. Duplex ultrasound has lower performance points than D-dimer, suggesting it is cheaper. From the cost-effectiveness perspective, an increased order number of the duplex ultrasound with a reduced number of D-dimer tests is advantageous for the ED's monthly performance point budget. The clinical reasoning favoring duplex ultrasound is understandable given its perceived advantages – "*cheaper, better, and saves time*" – despite deviating from international recommendations as the Wells-score approach.

However, our cost analysis revealed that the true direct cost of a duplex ultrasound, and it is significantly underfunded by the NEAK. The reason of the underfunding may be that the performance points of the tests were unchanged between 2007 and 2020, conserving outdated cost proportions. The actual cost factors of the diagnostic tests evolve over time, leading to disparities between current costs and the initial rates. If HR remuneration rises faster than the

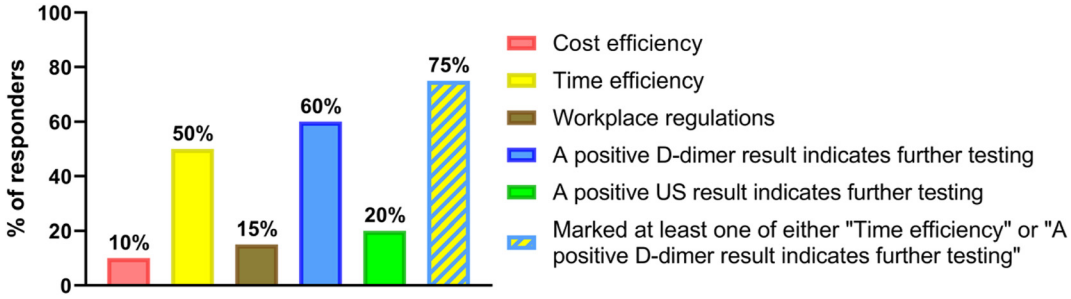

Figure 5: Responses to the survey question "what influences your preferred diagnostic approach in suspected DVT?"

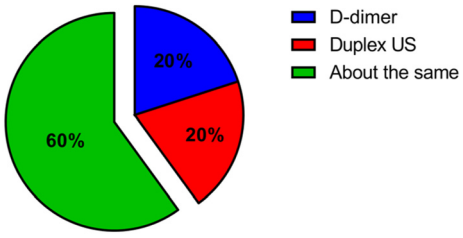

Figure 6: Responses to the survey question "which test results do you get sooner (within shorter turnaround time)?"

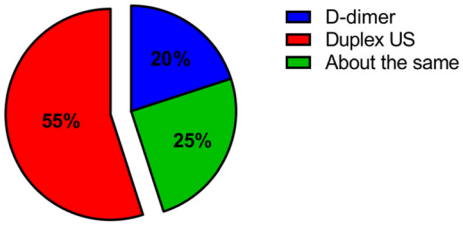

Figure 7: Responses to the survey question "which test costs more money to your department?"

material costs, labor-intensive tests will face underfunding. This phenomenon likely underlies the peculiar ratios observed between duplex ultrasound examination and the D-dimer test. The underfunding of the ultrasound examination will fall on the side of the Radiology Department and the Clinical Center as a whole.

We did not aim to analyze the clinical impact of bypassing D-dimer for ultrasound. The sensitivity of the duplex ultrasound is comparable to D-dimer, with superior specificity [31, 32]. Additionally, it identifies post-thrombotic stages or non-thrombotic findings, aiding diagnostic clarity in non-DVT cases. Without objective data on diagnostic turnaround times, potential benefits as earlier diagnoses remain unexplored. This study does not challenge existing guidelines but highlights the costs of deviating from a widely accepted, efficient standard in quality healthcare.

The excessive use of duplex ultrasound testing worsens underfunding for the Radiology Department and Clinical Center. Addressing this would require intervention at the Clinical Center level. Financially, recommending D-dimer in the ED could balance costs, but this only addresses one issue. Similar underfunding likely affects other diagnostic tests and clinical decisions.

Overutilization of seemingly inexpensive, but in reality expensive tests inflates hospital debts requiring state compensation [33]. A sustainable solution would be a true cost-based funding system, with regular assessment to monitor spending, addressing discrepancies and promoting long-term efficiency.

This study underscores the complex cost dynamics in healthcare, focusing on the labor-intensive tests, primarily due to personnel wages. Cost efficiency requires prudent cost management, accurate cost tracking, and sharing accurate cost information with healthcare providers as final optimization occurs locally.

Research ethics: The study was approved by the University of Debrecen Central Ethics Committee (DE RKEB/IKEB 6658-2023, January 10, 2023.) and was carried out in compliance with local legislation and institutional regulations. Since only anonymized patient data was utilized and individual identities were not disclosed, written informed consent from participants or their legal guardians/next of kin was not deemed necessary. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Informed consent: Not applicable.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission. Jozsef Kiraly: Data Curation, Formal analysis, Investigation, Writing – Original Draft; Andras Berzi; Miklos Emri: Data Curation; Eniko Sebestyen and Dora Ujvarosy: Writing – Review & Editing; Rob El-Kareh, Harjit Pal Bhattoa, Janos Kappelmayer, Kristen E. Miller: Conceptualization, Writing – Review & Editing; Gabor Toth: Conceptualization, Methodology, Resources,

Writing – Original Draft. All authors contributed to the article and approved the submitted version.

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Data availability: The raw data supporting the conclusions of this article will be made available by the authors, with restrictions to the availability of medical data.

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