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Impact of a computerized intervention to optimize laboratory tests ordering: one-year follow-up in a geriatric unit

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Abstract

Objectives: Approximately 30 % of laboratory tests are ordered inappropriately, substantially impacting patient care, costs, and carbon footprint of laboratories. Predefined laboratory test panels are a pragmatic and routinely used tool in laboratories, where tests are bundled for efficiency to diagnose or monitor specific conditions. The aim of the present study is to evaluate the impact of optimizing predefined laboratory test panels on the amount of laboratory tests ordered in a geriatric unit.

Methods: Geriatricians and laboratory medicine specialists revised existing test-ordering panels to fit current testing guidelines and Belgian reimbursement regulations. The number of tests requested and quality of care outcomes (length of stay, readmission rates, mortality, transfusion events) were monitored and compared for the one-year periods before and after the panel revision. Economic impact was calculated considering costs of manpower, reagents and consumables required for each test. The carbon footprint was estimated using monetary ratios.

Results: Prescription of tests included in ordering panels dropped from 48,502 before the computerized intervention to 38,912 afterward (a 30 %-fold change normalized by blood sampling per period), with no adverse impact on quality of care. Those 9,590 spared laboratory tests correspond to a saving of €7,974 and a reduction of 2,042 kg CO_2 equivalent emissions for the laboratory. Regarding tests excluded from the computerized ordering panels, reductions ranged from 30 % for white blood cell differential to 78 % for activated partial thromboplastin time tests.

Conclusions: Reshaping predefined laboratory test panels in collaboration with geriatricians represents an effective strategy to tackle test overprescription in laboratory medicine in a geriatric unit.

Keywords: APTT; demand management; geriatric medicine; inappropriateness; laboratory medicine; testing

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Introduction

Over the past two decades, there has been growing awareness regarding inappropriate use of medical resources, particularly clinical laboratory testing [1, 2]. A seminal meta-analysis showed that approximately 30 % of ordered laboratory tests may be inappropriate, although being context dependent [2]. More recent data suggests that overuse could be as high as 70 % for specific tests (namely: potassium, lactate dehydrogenase, aspartate aminotransferase, activated partial thromboplastin time (APTT), and prothrombin time (PT)/International Normalized Ratio (INR)) [1].

Overuse of laboratory testing adversely affects patients as it may lead to incidental findings, resulting in unnecessary diagnostic workups and psychological burden. Overuse also favors excessive blood sampling, increasing the risk of hospital-acquired anemia and subsequent need for transfusion, particularly in specific contexts such as geriatric and intensive care units [3]. Furthermore, overuse of laboratory testing substantially increases costs and contributes to the carbon footprint of laboratories. The Lancet has called climate change “the biggest global health threat of the century” [4], yet, paradoxically, the healthcare sector is a major contributor to greenhouse gas emissions. Indeed, depending on the country of reference, healthcare is responsible for 3–10 % of total national greenhouse gas emissions [5], with laboratory medicine representing up to 10 % of healthcare sector’s total environmental impact [6].

In this context, numerous interventions designed to promote appropriate test ordering have been developed and can be broadly categorized into several strategy types. The most encountered in the literature are: audit and feedback-, guidance-, gatekeeping-, and computerized provider order entry (CPOE)-based strategies [7, 8]. Across categories, most of the published interventions have demonstrated positive results with the greatest impact observed for multifaceted interventions [7, 8], i.e., the use of more than one strategy during intervention. However, data regarding the context of geriatric units is lacking.

In the specific setting of a geriatric unit, the present study implemented a CPOE-based intervention aimed at optimizing computerized test-ordering panels to reduce inappropriate laboratory testing.

Materials and methods

Setting

The present study was conducted in the 26-bed geriatric unit at the academic center CHU UCL Namur, Belgium.

Intervention and timepoints of the study

OmniPro (Zorgi, Brussels, Belgium) is the CPOE used in the institution to order laboratory tests. In this CPOE, physicians can order predefined laboratory test panels, each consisting of a group of tests related to the diagnosis or monitoring of a specific condition. Geriatricians and specialists in laboratory medicine met to revise the eight ordering panels available for the geriatric unit. The intervention pursued two main objectives. First, to ensure that all eight test-ordering panels complied with current clinical guidance and national reimbursement regulations. Second, to promote the appropriate use of these panels in clinical practice. Changes in the ordering panels were implemented over the course of a single day, delineating the period of reference (PoR), defined as the one-year period preceding the intervention, from the period of interest (PoI), the one-year period immediately following the intervention (Figure 1).

Laboratory tests monitoring

All tests included in the six commonly used geriatric panels (hereafter, “tests of interest”) that were ordered by physicians working within the geriatric unit during PoR and PoI were monitored. These physicians were either geriatric residents completing six-month rotations in the department, or board-certified geriatricians hired under long-term contracts.

Laboratory tests appearing exclusively in the two deleted COVID-19-related panels were not monitored. Using our laboratory information system (GLIMS version 10, CliniSys MIPS, Ghent, Belgium), the number of tests of interest as well as the number of blood samplings for PoR and PoI were extracted. The normalization of test counts by the number of blood sampling events was used to account for care unit activity, using blood sampling frequency as a proxy measure.

Costs estimates

Costs estimates were calculated by summing the costs of (i) tests reagent, (ii) consumables, and (iii) manpower. (i) Reagent costs were estimated by dividing the purchase price of each reagent kit by the total number of reactions performed per kit, including sample, internal quality control, and calibration reactions. (ii) Consumables costs were calculated by dividing the annual price of consumables to operate a single analyzer within the automated testing line by the total number of analyses performed by that analyzer

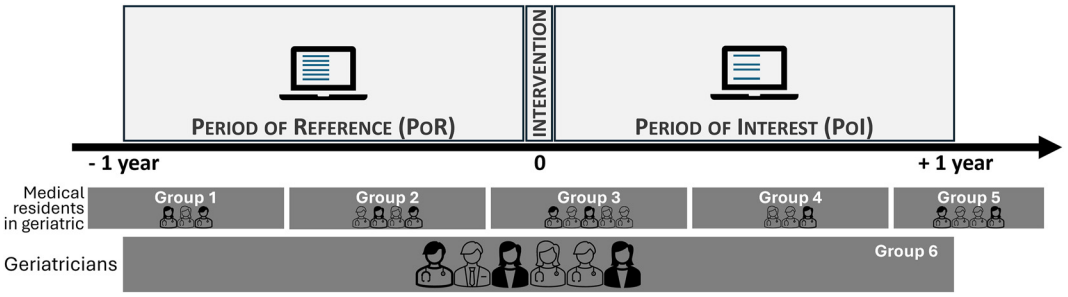

Figure 1: Timeline and settings of the study intervention. Groups 1 through 5 represent the different groups of geriatric residents during the study period. The figure illustrates the distribution of residents and highlights two key points: (1) the residents present in the PoR period differ from those in the PoI period, (2) with the exception of group 3, which covers both PoR and PoI. Group 6 represents geriatricians and did not vary throughout the study period. PoR, period of reference; PoI, period of interest.

over the same year. The cost estimates did not include financial depreciation or maintenance costs of the automated line, as these instruments are also used for other tests. (iii) Manpower costs per test were estimated by multiplying the hourly wage of a medical laboratory technician by the annual operational time of the analyzer (weekly operating hours × 52 weeks), and dividing this value by the total number of tests performed on the analyzer during the corresponding year.

CO_2 equivalent measurement

The monetary ratio, as calculated by the French Environment and Energy Management Agency (Agence de la transition écologique, ADEME) and available in the Base Empreinte® database, represents the mass of CO_2 equivalent (eCO_2) per kilo-euro spent within a specific sector of activity [9]. For our analysis, we used the most recent (2023) available data to assess the environmental impact of test consumables (plastics: 312 kg eCO_2/k€ spent), test reagents (chemical products: 603 kg eCO_2/k€ spent), and labour (specialized scientifical and technical services: 110 kg eCO_2/k€ spent).

Quality of care outcomes

To account for potential changes in quality of care, several clinical outcomes were monitored across the PoR and PoI: length of stay, re-admission rate, in-hospital mortality, and red blood cell (RBC) transfusion events. All clinical outcomes were retrieved using the institution's electronic healthcare record system. Length of stay was calculated as the median and interquartile range (IQR) of days for all patients hospitalized in the geriatric unit. Re-admission rate was defined as the percentage of patients readmitted within 10 days following discharge, relative to all patients admitted during each study period. In-hospital mortality was defined as the percentage of deaths among all patients admitted to the geriatric unit during each study period. Finally, RBC transfusion events represent the number of patients that have experienced at least one RBC transfusion during each study period.

Statistical analysis

Quality of care outcomes monitoring

Continuous variables (length of stay) were summarized as median (IQR), and categorical variables (re-admission, in-hospital mortality rate, transfusion events) as percentage (%). Comparisons between groups were performed using the Wilcoxon rank-sum test for continuous variables and chi-squared test for categorical variables. Statistical significance was defined as a two-tailed p-value <0.05.

Tests ordering monitoring

Negative binomial distribution was selected due to evidence of overdispersion in the count data, as indicated by variance exceeding the mean and supported by model diagnostics. For each statistical analysis performed, the logarithm of the number of blood samplings was included as an offset to model tests rates per blood sampling; rate ratios with 95 % confidence intervals (CI) were derived from the fitted model. All the statistical analyses were conducted using the software R, version 4.5.2.

Impact of periods on laboratory tests of interest ordering
To assess the overall change in laboratory tests rates between the PoR and the PoI, we fitted a mixed-effects negative binomial regression model with a log link. The number of

laboratory tests was modeled as the dependent variable, with periods (PoI vs. PoR) as a fixed effect. To account for clustering, random intercepts were included for physician and test type.

Impact of the intervention on laboratory tests of interest ordering

To examine whether changes in tests rates between the PoR and the PoI differ according to tests status within panels (maintained vs. excluded), we fitted a mixed-effects negative binomial regression model with a log link. The number of laboratory tests was modeled as the dependent variable, with period, status, and their interaction included as fixed effects. To account for clustering, random intercepts were included for physician and test type.

Impact of the intervention on the ordering of each laboratory test

To evaluate whether temporal changes in analysis rates differed according to test type, we fitted a generalized linear mixed-effects model using a negative binomial distribution (nbinom2 parameterization) with a log link. The number of tests was modeled as the dependent variable, with period (PoI vs. PoR), test type, and their interaction included as fixed effects. To account for clustering of observations within physicians, a random intercept was specified for physicians.

In addition, as represented in Figure 1, some physicians contributed data for only one of the two periods (PoR or PoI) while others contributed for both periods. Thus, we used R package glmmTMB [10] which allows mixed-effects approaches that appropriately accommodate such unbalanced and partially crossed data structures without requiring complete repeated measures, as estimation is based on maximum likelihood using all available observations.

Results

Changes in ordering panels and rationale

The rationale for the reshaping of ordering panels was based on consultation with the geriatricians and a thorough review of the literature guidelines as presented in Table 1.

Accordingly, the following modifications in the ordering panels were implemented (Figure 2):

- Two of the eight panels (both related to COVID-19 pandemic) were removed altogether;
- Aspartate transaminase, direct bilirubin, serum protein electrophoresis, APTT, PT/INR, and WBC differential were removed from the “admission” panel;
- Chloride, APTT, and PT/INR were removed from the “Hospitalization: follow-up” panel;
- Albumin, chloride, APTT, and PT/INR were removed from the “Hospitalization: full follow-up” panel; “IV nutrition: risk of refeeding syndrome”, “IV nutrition: weekly follow-up”, and “work-related accident” panels were unchanged.

Impact of the CPOE intervention on the number of tests ordered

The geriatric unit ordered 48,502 absolute number of tests of interest (for 4,902 blood samplings) before the CPOE intervention (PoR) against 38,912 absolute number of tests of interest (for 5,651 blood samplings) after the intervention (PoI) (Figure 3), representing a significant 30 % reduction of tests per blood samplings (p-value<0.001; CI=23–36 %), on average, across physicians. Focusing specifically on tests of interest *excluded* from the computerized ordering panels (Figure 2, red squares), the impact on relative number of tests was higher with a significant reduction of 61 % (p-value<0.001; CI=52–68 %). This reduction ranged from 30.1 % (p-value=0.077, CI=7.7–47.0 %) for WBC differential to 77.4 % (p-value<0.001; CI=74.9–79.5 %) for APTT and 77.6 % (p-value<0.001; CI=75.2–79.8 %) for direct bilirubin tests, highlighting a substantial impact of the intervention (Figure 4A, left, “excluded”). In contrast, tests of interest maintained throughout the six CPOE panels (Figure 2, yellow squares) underwent a mean decrease of 19 % (p-value<0.001; CI=10–26 %). Orderings of five from the maintained tests (namely, anti-HBc and anti-HBs antibodies, HBs antigen, Hepatitis C antibody, and blood glucose) increased in PoI as compared to PoR. However, for the first four tests, the absolute number of tests per year was low (<60 tests ordered over the course of the two-year study period).

Impact of the intervention on laboratory medicine department expenditures

The total cost of laboratory tests of interest ordered by the geriatric unit amounted to €30,834.89 during the PoR and €22,861.01 during the PoI, representing a 26 % reduction in expenditure (Figure 3). Since the calculated cost for each test of interest depends on the absolute number of this test ordered during the study (Figure 4B), this 26 % decrease in costs was primarily attributable to the tests targeted by the intervention.

Table 1: Rationale for the reshaping of ordering panels.

Laboratory test	Rationale	Reference
Activated partial thromboplastin time and prothrombin time/international normalized ratio	No precise guidelines specifically addressing the appropriate use of hemostasis tests in geriatric units exist. However, a recent guidance has summarized the appropriate use of hemostasis tests including APTT and PT/INR in the acute care setting.	[11]
WBC differential	There is no indication for systematically determining white blood cell (WBC) differential in the absence of abnormalities in hemoglobin, platelet count, and WBC count.	[12]
Aspartate transaminase	Aspartate transaminase is highly correlated to alanine transaminase, the latter being more specific.	[13]
Direct and total bilirubin	There is little clinical value in testing direct bilirubin when total bilirubin levels are normal. For these two parameters, the implementation of reflex tests has therefore made it possible to remove them from the panels.	[14]
Chloride	Measuring chloride levels may be clinically useful in the specific context of a nephrological checkup or when assessing the anion gap. However, in routine practice, chloride levels typically correlate to sodium levels, making it a redundant test.	[15]
Albumin	Albumin has a half-life of approximately 20 days, making it a slow-changing marker. If albumin is included in the admission workup and there are no underlying conditions likely to affect it, routine follow-up testing does not seem appropriate. A minimum retest interval has not been implemented, but the removal of the follow-up panel is part of this approach.	[16]
Serum protein electrophoresis	Serum protein electrophoresis should only be ordered if there are clinical or biological findings suggestive of monoclonal gammopathy or as part of the follow-up of a confirmed case of monoclonal gammopathy.	[17, 18]

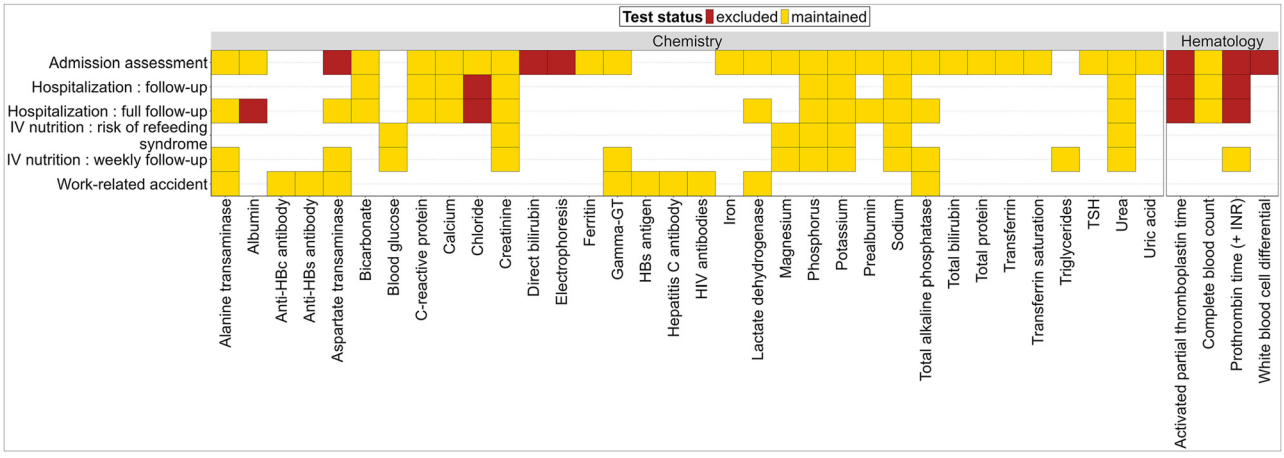

Figure 2: Evolution of CPOE panels available in the geriatric unit before and after intervention. Each row represents a predefined ordering panel. The columns represent the laboratory tests included in each panel. Red squares indicate tests excluded from the panels after revision with the geriatric unit (intervention), while yellow squares indicate tests maintained in the panels after revision with the geriatric unit. IV, intravenous; HB, hepatitis B; Gamma-GT, gamma-glutamyl transferase; HIV, human immunodeficiency virus; TSH, thyroid-stimulating hormone; INR, International Normalized Ratio.

Impact of the intervention on the carbon footprint of the laboratory medicine department

Using the monetary ratios, the total carbon footprint of tests ordered by the geriatric unit during the PoR was 9.4 tons of eCO_2. After intervention, the carbon footprint decreased to 7.4 tons of eCO_2, representing a 22 % reduction (Figure 3). As anticipated, this reduction was more pronounced for the tests excluded from the CPOE system panels (Figure 4, Panel C).

Impact of the intervention on quality-of-care outcomes

Overall quality-of-care outcomes were monitored throughout the study period (Table 2). Median length of stay

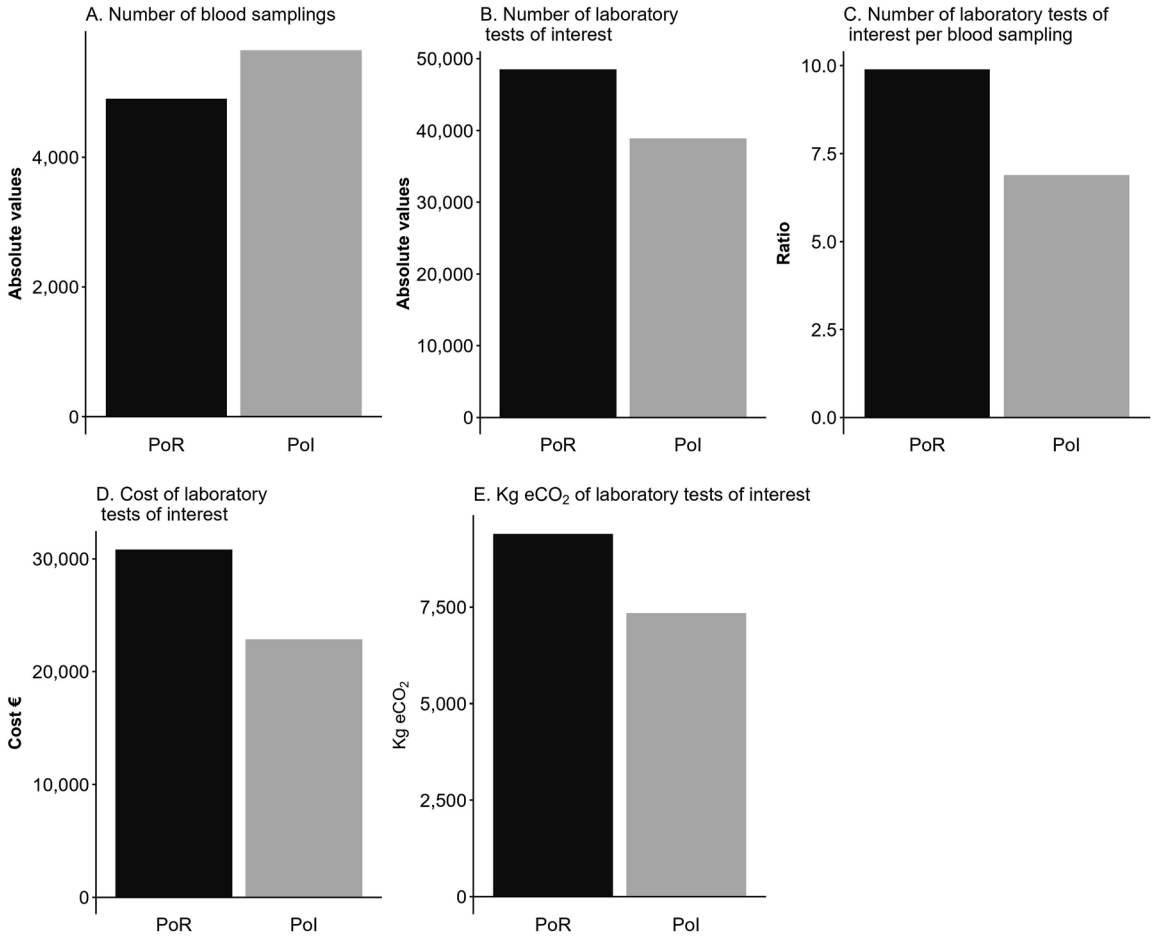

Figure 3: Overall impact of the CPOE intervention for period of reference (black) and period of interest (light gray). (A) Raw number of blood samplings performed per period. (B) Raw number of tests of interest per period. (C) Ratio of raw number of tests of interest per blood sampling. (D) Total calculated costs of tests of interest per period. (E) CO2 equivalent emissions (kg eCO_2) estimated for the tests of interest per period. PoR, period of reference; PoI, period of interest.

was significantly reduced from 16 days (IQR, 11–24) during the PoR to 14 days (IQR, 10–21.75) during the PoI. In-hospital mortality rate (p-value=0.27), readmission rate (p-value=0.33) and RBC transfusion rate (p-value=0.36) in the unit were not statistically different between the two periods. Altogether, this reveals no negative impact of the intervention on quality of care.

Discussion

In this study, we assessed the impact of revising CPOE ordering panels in a 26-bed geriatric unit. In consultation with clinicians, we removed two of the eight CPOE panels available for the unit, as well as several standalone tests in three other panels.

One year after intervention, we observed an absolute reduction of 20 % (relative reduction: 30 %) in the total number of tests of interest, consistent with overuse rates reported in the literature [2]. When restricting the analysis to tests of interest that were excluded from the CPOE panels, the absolute reduction reached 52 % (relative reduction: 61 %), indicating a substantial effect of the intervention. We estimate that this reduction in tests ordering prevented up to 9,590 unnecessary laboratory tests over one year, corresponding to a cost saving of €7,974 for the laboratory and a reduction of 2,042 kg eCO_2 emissions.

Interestingly, a reduction of 11 % of tests of interest that were maintained within the CPOE panels was observed. This finding suggests a shift in ordering behavior extending beyond the tests directly targeted by the intervention. Such broader effect may reflect increased awareness within the geriatric unit regarding laboratory appropriateness and more

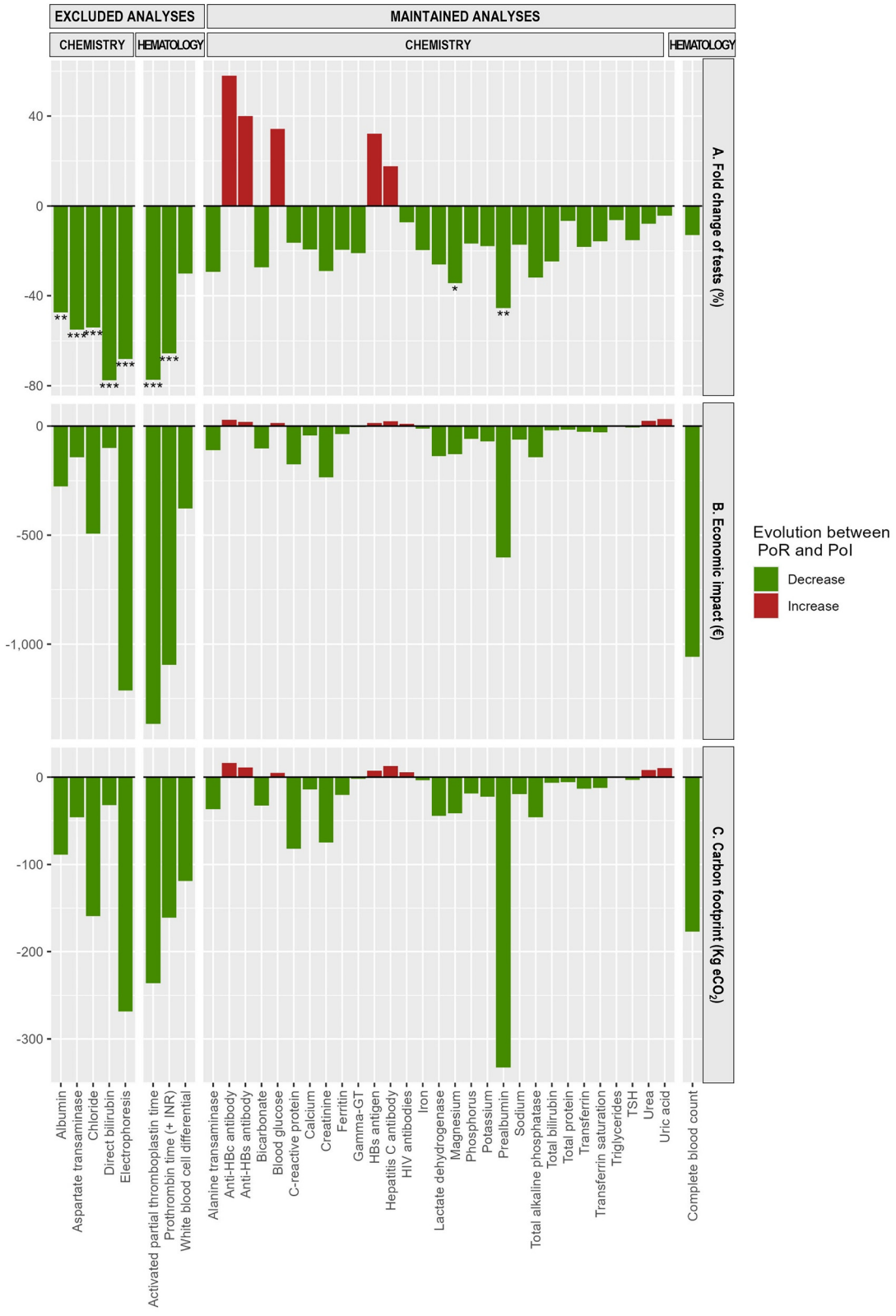

Figure 4: Evolution of the relative number (A), costs (B), and carbon footprint (C) for each test present in ordering panels between period of reference (PoR) and period of interest (PoI) in the geriatric unit. The X axis corresponds to the tests of interest for the geriatric unit, separated between tests excluded from at least one ordering panel (left) and tests maintained in the ordering panels after intervention. The y-axis shows the difference between PoR and PoI for (A) the fold change of tests normalized by blood sampling, (B) total costs, and (C) the CO2 equivalent emissions (kg eCO2) for each test. The green bars represent a decrease, while the red bars represent an increase in the evolution between PoR and PoI. HB, hepatitis B; Gamma-GT, gamma-glutamyl transferase; HIV, human immunodeficiency virus; TSH, thyroid stimulating hormone; INR, International Normalized Ratio; PoR, period of reference; PoI, period of interest. p-Value: < 0.001: ***; < 0.01: **; < 0.05: *

Table 2: Overall quality-of-care outcomes monitored throughout the study period.

	PoR	PoI	p-Value
Number of admissions	489	514	
Length of stay, days, median (IQR)	16 (11–24)	14 (10–21.75)	<0.001
In-hospital mortality	10.22 %	12.65 %	0.27
Re-admission within 10 days	7.57 %	5.84 %	0.33
RBC transfusion events	13.4 %	11.2 %	0.36

sustainable medical practices. It might also suggest that this intervention also had an indirect educational effect, known as the spillover' effect, i.e. the positive or negative effect on other related behaviors if change occurred [19]. The revision of ordering panels was carried out through close collaboration between geriatricians and laboratory specialists, a key methodological aspect that helped establish an ongoing dialogue between stakeholders. At our academic institution, this approach is reinforced by recurring educational sessions on laboratory appropriateness for incoming medical residents.

Five tests of interest retained in the CPOE panels (namely, anti-HBc and anti-HBs antibodies, HBs antigen, Hepatitis C antibody, and blood glucose) showed an increase in ordering. However, four of these tests were infrequently ordered (fewer than 60 tests over two years; 474 tests for blood glucose), resulting in minimal absolute increases in test volume, associated costs, and carbon footprint over the study period.

Eight standalone tests were excluded from panels: 3 hemostasis tests and 5 biochemical tests. A recent guidance has summarized the appropriate use of hemostasis tests including APTT and PT/INR in the acute care setting [11]. The indications for ordering APTT and PT/INR differ, suggesting that APTT and PT/INR should not be bundled to avoid automatic ordering of the 2 assays. Moreover, APTT and PT/INR testing are not recommended in liver disease nor to estimate direct oral anticoagulant levels [11]. There is no indication for systematically determining WBC differential in the absence of abnormalities in hemoglobin, platelet count, and WBC count. Laboratories may implement reflex testing depending on hemoglobin level, platelet count, and WBC count and/or flags [12].

For biochemical tests, the panels were adapted considering clinical relevance and three additional criteria: redundant duplication, reflex testing, and minimal interval retest. Aspartate transaminase falls into the first and second categories. Aspartate transaminase is highly correlated to alanine transaminase, which is more specific. It seems more appropriate to order an aspartate transaminase test only when alanine transaminase levels are abnormal [13]. Direct bilirubin also belongs to the second category: there is little clinical value in testing direct bilirubin when total bilirubin levels are normal. For these two parameters, the implementation of reflex tests has therefore made it possible to remove them from the panels [14]. Measuring chloride levels may be clinically useful in the specific context of a nephrological checkup or when assessing the anion gap. However, in routine practice, chloride levels typically correlate to sodium levels, making it a redundant test [15]. Albumin has a half-life of approximately 20 days, making it a slow-changing marker [16]. If albumin is included in the admission workup and there are no underlying conditions likely to affect it, it does not seem appropriate to include it in the routine follow-up testing. A minimum retest interval has not been implemented, but the removal of the follow-up panel is part of this approach. Serum protein electrophoresis should only be ordered if there are clinical or biological findings suggestive of monoclonal gammopathy or as part of the follow-up of a confirmed case of monoclonal gammopathy [17, 18]. Depending on the clinical context, physicians always have the option of ordering additional tests that are not part of a specific panel.

The strategy of reshaping CPOE ordering panels presents several advantages. First, it is relatively easy to implement. Second, it reduces friction for the ordering physicians, as the panels are predesigned according to commonly encountered clinical presentations or routine orders (e.g., admission assessment). In other words, physicians do not need to order each test individually but instead select the appropriate clinical scenario, thereby saving not only unnecessary testing, but also time and attention. Third, the panels were optimized in collaboration with the ordering physicians, which likely promotes adherence and supports long-term collaboration. Finally, unlike many published CPOE-based interventions, we deliberately avoided the use of electronic alerts. Indeed, although being effective initially, alerts are known to provoke "alert fatigue", ultimately leading physicians to disregard them [20, 21].

This study presents some limitations. The reduction in the prescription of PT/INR and APTT, the only screening tests performed on citrate tubes, led to the elimination of citrate tube collection and thus to a reduction not only in plastics consumption but also in the volume of blood collected. Unfortunately, it was not possible to calculate the exact volume of blood spared through the reduction in citrate tube use, as we were unable to monitor the use of predefined computerized prescription panels.

Moreover, the scope of the cost and carbon footprint calculation was strictly limited to sample processing in the laboratory, deliberately ignoring the costs associated with sample collection or administrative processing.

Furthermore, although the amount of savings achieved seems rather modest, it is important to bear in mind that the study was not only conducted in a small 26-bed unit but also focused on a few low-cost measures. Therefore, our cost savings estimation may be substantially underestimated. There are several methods for assessing the carbon footprint of an activity, including the physical ratio, which is based on the amount of plastic consumed, and the monetary ratio, which is based on the expenditure associated with the activity. In this study, we chose to use the monetary ratio to gain a broader view of the carbon footprint of testing rather than focusing on plastic consumption only.

Conclusions

In a 26-bed geriatric unit, removing two outdated ordering panels and reshaping three others led to a sustained 61 % decrease in inappropriate laboratory tests. This intervention avoided over one year, roughly 10,000 unnecessary tests, yielded €8,000 in savings, and prevented 2 tons of eCO_2 emissions. Importantly, these gains were achieved with no changes in transfusion rate, in-hospital length of stay, mortality, or re-admission rate across study periods. Restructuring CPOE ordering panels therefore represents an effective and safe strategy to address inappropriate use of laboratory tests ordering.

Research ethics: Not applicable.
Informed consent: All data were extracted in an anonymous manner. Only quantitative data (number of tests and blood samplings performed over a given period), and not qualitative data, were extracted for this study.
Author contributions: All authors were involved in the design of the study, the extraction of data, and the analysis of the results. LD was responsible for the initial draft and the figures. All authors made substantial contributions to the manuscript through the editing and improvement of the text. All authors approved the final manuscript. All authors accepted responsibility for the entire content of this manuscript and approved its submission.
Use of Large Language Models, AI and Machine Learning Tools: None declared.
Conflict of interest: The authors state no conflict of interest.
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Data availability: The raw data can be obtained on request from the corresponding author.

References

1. Cadamuro J, Gaksch M, Wiedemann H, Lippi G, von Meyer A, Pertersmann A, et al. Are laboratory tests always needed? Frequency and causes of laboratory overuse in a hospital setting. Clin Biochem 2018;54:85–91.
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. https://doi.org/10.1371/journal.pone.0078962.
3. Borst A, Choorapoikayil S, Stuhlmann S, Zacharowski K, Meybohm P. Advances in the understanding and management of hospital-acquired anemia. Curr Opin Anaesthesiol 2026;39:401–8.
4. Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R, et al. Managing the health effects of climate change. Lancet and University College London Institute for Global Health Commission. Lancet 2009;373: 1693–733.
5. Devis L, Closset M, Degosserie J, Lessire S, Modrie P, Gruson D, et al. Revisiting the environmental impact of inappropriate clinical laboratory testing: a comprehensive overview of sustainability, economic, and quality of care outcomes. J Appl Lab Med 2025;10: 113–29.
6. Malik A, Lenzen M, McAlister S, McGain F. The carbon footprint of Australian health care. Lancet Planet Health 2018;2:e27–35.
7. Kobewka DM, Ronksley PE, McKay JA, Forster AJ, Van Walraven C. Influence of educational, audit and feedback, system based, and incentive and penalty interventions to reduce laboratory test utilization: a systematic review. Clin Chem Lab Med 2015;53:157–83.
8. 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;38:402–12.
9. ADEME. Base Empreinte® – ratios monétaires [Online]. https://base-empreinte.ademe.fr [Accessed 2 Apr 2026].
10. Brooks ME, Kristensen K, Van Benthem KJ, Magnusson A, Berg CW, Nielsen A, et al. glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. R J 2017; 9:378–400.
11. Devis L, Arachchillage DJ, Hardy M, Mansour A, Catry E, Closset M, et al. Guidance-based appropriateness of hemostasis testing in the acute setting. Hamostaseologie 2025;45:24–48.
12. Cornet E, Mullier F, Despas N, Jacqmin H, Geara C, Boubaya M, et al. Evaluation and optimization of the extended information process unit (E-IPU) validation module integrating the sysmex flag systems and the recommendations of the French-speaking cellular hematology group (GFHC). Scand J Clin Lab Invest 2016;76:465–71.
13. Xu Q, Higgins T, Cembrowski GS. Limiting the testing of AST: a diagnostically nonspecific enzyme. Am J Clin Pathol 2015;144: 423–6.
14. Panteghini M, Dolci A, Birindelli S, Szoke D, Aloisio E, Caruso S. Pursuing appropriateness of laboratory tests: a 15-year experience in an academic medical institution. Clin Chem Lab Med 2022;60:1706–18.
15. Morrison G. Serum chloride. In: Walker H, Hall W, Hurst J, editors. Clinical Methods: The History, Physical, and Laboratory. Boston: Butterworths; 1990.
16. Gounden V, Vashisht R, Jialal I. Hypoalbuminemia. Treasure Island (FL): StatPearls Publishing; 2023.

17. Beaune G, Oris C, Boizot HT, Annette-Reisch M, Pecquet M, Schmitt F, et al. Help sheets for ordonnance in biochemistry: proposal. Ann Biol Clin (Paris) 2023;81:61–85.
18. Choosing Wisely [Online]. https://choosingwiselycanada.org/recommendation/medical-biochemistry/ [Accessed 2 Apr 2026]. Choosing Wisely Canada.
19. Atkins L, Francis J, Islam R, O'Connor D, Patey A, Ivers N, et al. A guide to using the theoretical domains framework of behaviour change to investigate implementation problems. Implement Sci 2017;12. https://doi.org/10.1186/s13012-017-0605-9.
20. Lo HG, Matheny ME, Seger DL, Bates DW, Gandhi TK. Impact of non-interruptive medication laboratory monitoring alerts in ambulatory care. J Am Med Inform Assoc 2009;16:66–71.
21. Baysari MT, Tariq A, Day RO, Westbrook JI. Alert override as a habitual behavior - a new perspective on a persistent problem. J Am Med Inform Assoc 2017;24:409–12.