**Letter to the Editor**

Luigi Devis, Emilie Catry, Régis Debois, Isabelle Michaux, Patrick M. Honore, Eric Pinck, Frédéric Foret, François Mullier* and Mélanie Closset

# A simple gatekeeping intervention improves the appropriateness of blood urea nitrogen testing

https://doi.org/10.1515/cclm-2024-0937
Received July 20, 2024; accepted September 18, 2024;
published online September 25, 2024

**Keywords:** demand management; inappropriate; laboratory tests; prescription; sustainability; urea

To the Editor,

Evidence suggests that laboratory resources are being inappropriately used [1, 2], resulting in avoidable costs for the healthcare system. Inappropriate testing can harm patients by causing hospital-acquired (iatrogenic) anemia and increasing the risk for transfusion, infections, missed or delayed diagnosis, additional unnecessary interventions, and incidental findings. Overuse of testing can also cause discomfort and stress for patients while creating additional workload for staff, increasing costs, and having an environmental impact [3]. In this context, numerous interventions have been published aiming to improve the appropriateness of laboratory testing, including gatekeeping interventions [4].

Effective March 1st, 2023, a new Belgian regulation stipulates that patients with an estimated glomerular filtration rate (eGFR) greater than 30 mL/min/1.73 $m^2$ will not be reimbursed for blood urea nitrogen (BUN) analysis, and that the cost of tests will be charged on clinical laboratories. This retrospective before-and-after study at the CHU UCL Namur, a Belgian three-centered 936-bed academic hospital (see Supplementary Material), examines the impacts of the aforementioned regulatory changes on clinicians' prescribing patterns for BUN testing. This analysis is achieved by monitoring pre- and post-intervention test volumes, encompassing both ordered and performed tests. Additionally, cost estimates are carried out for both periods to assess the financial impact of such intervention.

The study was split into four periods (P1 to P4) delineated by three successive events (Figure 1A; Supplementary Material). Briefly, P1 is the pre-intervention period and P4 is the post-intervention period (both 3 months). P2 is the period between the implementation of the new Belgian regulation and the decision of the central laboratory to implement the gatekeeping intervention. Multiple informative emails were sent to all clinicians of the three centers before the second event effectively took effect. P3 refers to the period between the implementation of the intervention and the decision to allow BUN tests ordered in ICU patients meeting a specific list of indications (see below).

The primary outcome was BUN testing. Tests were divided into three distinct categories. Tests requested in the right indication were recorded as "standard"; this category encompasses all tests in P1 and P2 (gatekeeping intervention off), as well as tests in patients with eGFR <30 in P3 and P4 (gatekeeping intervention on). In P3 and P4, tests ordered in patients with eGFR >30 but explicitly requested by clinicians were recorded as "mandatory". Finally, in P4, a list of allowed

***Corresponding author: Prof. François Mullier**, Department of Laboratory Medicine, CHU UCL Namur site Godinne, UCLouvain, Avenue Docteur G. Therasse 1, 5530 Yvoir, Belgium; Namur Thrombosis & Hemostasis Center (NTHC), Namur Research Institute for Life Sciences (NARILIS), University of Namur, CHU UCL Namur, Namur, Belgium; Institute of Experimental and Clinical Research (IREC), UCLouvain, Yvoir, Belgium; Institute of Experimental and Clinical Research (IREC), UCLouvain, Yvoir, Belgium; and Namur Laboratory Appropriateness and Sustainability Team (LAST), CHU UCL Namur, UCLouvain, 5530 Yvoir, Belgium,
E-mail: francois.mullier@chuuclnamur.uclouvain.be
**Luigi Devis and Mélanie Closset,** Department of Laboratory Medicine, CHU UCL Namur Site Godinne, UCLouvain, Yvoir, Belgium; and Namur Laboratory Appropriateness and Sustainability Team (LAST), CHU UCL Namur, UCLouvain, Yvoir, Belgium. https://orcid.org/0000-0003-4576-0057 (L. Devis)
**Emilie Catry,** Department of Laboratory Medicine, CHU UCL Namur Site Godinne, UCLouvain, Yvoir, Belgium; Institute of Experimental and Clinical Research (IREC), UCLouvain, Yvoir, Belgium; and Namur Laboratory Appropriateness and Sustainability Team (LAST), CHU UCL Namur, UCLouvain, Yvoir, Belgium
**Régis Debois,** Department of Laboratory Medicine, CHU UCL Namur Site Sainte-Elisabeth, UCLouvain, Namur, Belgium
**Isabelle Michaux and Patrick M. Honore,** Department of Intensive Care, CHU UCL Namur Site Godinne, UCLouvain, Yvoir, Belgium
**Eric Pinck,** Department of Intensive Care, CHU UCL Namur Site Sainte-Elisabeth, UCLouvain, Namur, Belgium
**Frédéric Foret,** Department of Intensive Care, CHU UCL Namur Site Dinant, UCLouvain, Dinant, Belgium

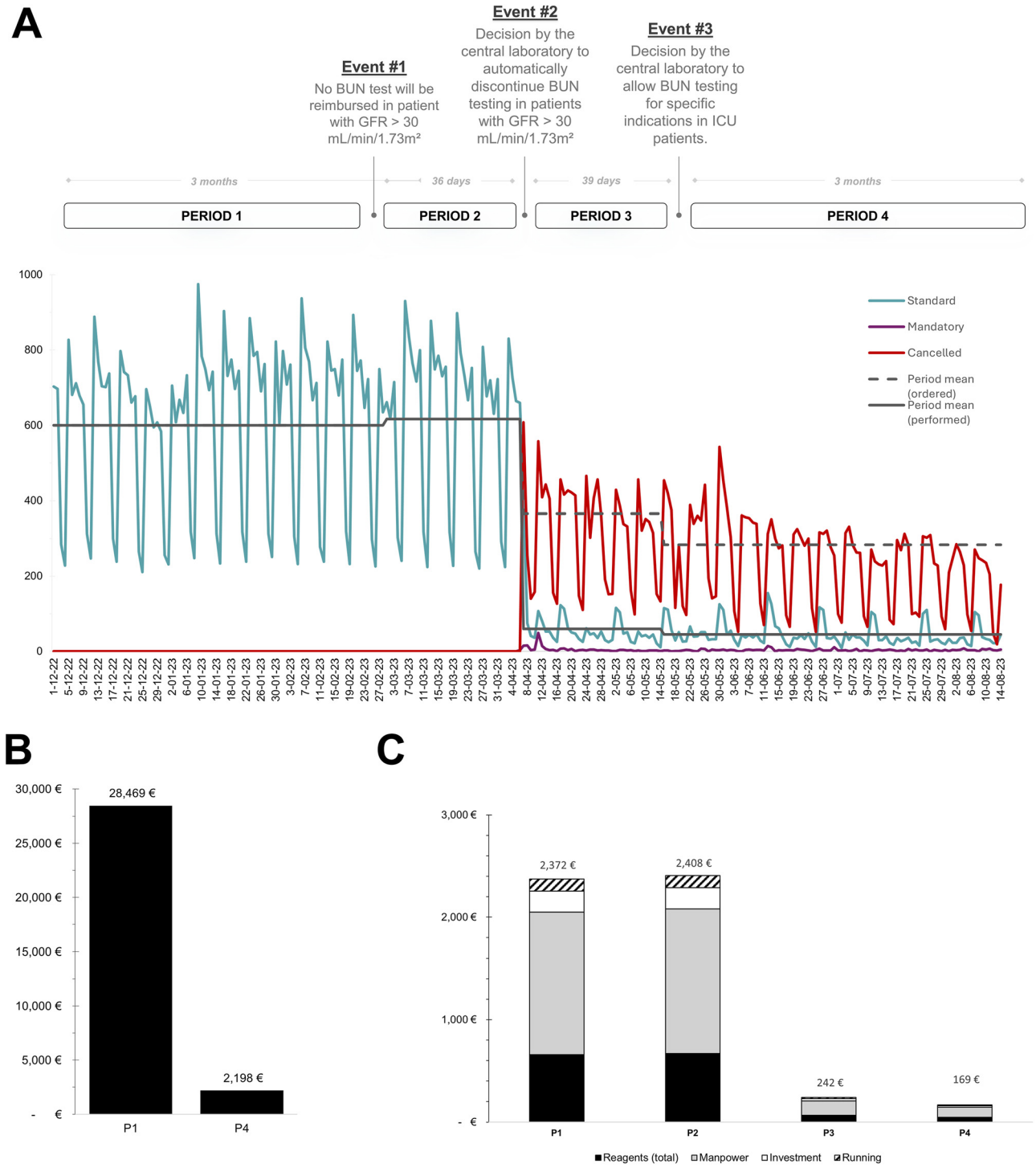


**Figure 1:** Evolution of BUN testing and cost estimates during study periods. (A) Intervention timeline and evolution of BUN tests ordered and performed per day. Three events delineates the four study periods (P1 to P4). "Standard tests" represent tests prescribed in a routine manner; in P1 and P2, they correspond to all tests ordered; in P3 and P4, they correspond to the tests prescribed in the appropriate indication (eGFR<30 min/mL/1.73 $m^2$). "Mandatory tests" are tests performed in patients with eGFR>30 min/mL/1.73 $m^2$ but explicitly requested by clinicians along with a justification, after the implementation of the gatekeeping intervention by the central laboratory (P3 and P4). Note that during P4, the "mandatory tests" category as well include tests requested by ICU clinicians that are part of the closed list of authorized tests. "Cancelled tests" represent tests requested by clinicians that do not match the intended indications and have therefore not been performed by the central laboratory. (B) Total estimated costs for pre-intervention period (P1) and post-intervention period (P4). (C) Detailed cost estimates per week for each period. The costs include direct costs of reagents, as well as manpower, investment in the automated line, and energy consumption costs (see Supplementary Material). The total cost estimates per week for each period are given above each bar.

indications for patients with eGFR >30 hospitalized in the intensive care unit (ICU) was developed in collaboration with ICU clinicians (i.e., renal failure, blood volume assessment, dialysis, toxicity, tumor lysis syndrome, pre-eclampsia, suspected upper gastrointestinal bleeding, severe catabolism and/or severe malnutrition [5–9]). When a BUN test was ordered, a prompt appeared in the computerized physician order entry system asking the ICU clinician to select the indication for which the BUN test was requested. Tests falling into this category were recorded as "allowed".

The cost estimates of BUN testing was monitored as secondary outcome. Costs were calculated by adding the cost of tests reagents and calibration reagents, the manpower cost, the investment cost, and the running (energy) cost for the automated line (see Supplementary Material). C-reactive protein was used as a control to monitor any major, unexpected variation in the average number of tests performed.

Results are shown in Table 1 and Figure 1. While there was no statistically significant difference between P1 and P2 (p=0.35) and between P3 and P4 (p=0.08), there was a decrease of 90 and 92 % in tests performed, from P1 to P3 (p<0.001), and from P1 to P4 (p<0.001), respectively. Nonetheless, in gatekeeping interventions, the number of tests performed may only reflect the mechanical decrease resulting from the automatic cancellation of inappropriate tests. Therefore, it may not accurately reflect clinicians' prescribing behavior. To address this issue, we also monitored the number of tests that were *ordered* but not performed (i.e., "standard" tests for P1 and P2; "standard", "mandatory" and "allowed" tests in P3 and P4). A significant change in prescribing behavior was observed after the gatekeeping intervention, with a 39 % decrease (p<0.001) between P1 and P3 and a 53 % decrease (p<0.001) between P1 and P4. This change in prescribing persisted for at least 3 months following the intervention. No statistically significant difference was noted in C-reactive protein (CRP) tests performed during the four periods (Table 1), and there were no significant differences in the proportion of tests performed in the three centers during each period (data not shown). Standard indicators of quality of care and patient tsafety [10] are monitored daily in the ICU of our centers. No change was observed in the post-intervention period compared to the pre-intervention period (data not shown). Overall, there was a decrease in total costs from €28,469 in P1 to €2,198 in P4 (Figure 1B). This represents €26,271 for the 3 months monitored (post-intervention), i.e. savings of €2,203 per week. The main costs associated with BUN were the manpower (salaries) and the direct costs of reagents and calibration assays (Figure 1C). Taking the 53 % decrease in BUN tests *ordered* by clinicians, we estimated a post-intervention cost savings of €15,088 due to the change in behavior induced by the gatekeeping intervention, i.e. €1,257 per week. If the reduction observed in P4 were extended over a full year, for BUN tests alone, this would represent savings of €114,572 in total costs.

Notably, few clinicians ordered "mandatory" tests. This suggests that clinicians did not ask the central laboratory to perform an unnecessary BUN test. Furthermore, there was no increase in the proportion of critical BUN values from P3 and P4 (data not shown). This could suggest that the excess of ordered tests in P1 (as compared to P4) did not significantly influence patient management and can therefore be considered of doubtful value.

**Table 1:** Mean number of BUN tests per day, and differences from baseline, during intervention periods.

| Period | Total tests ordered | | Total tests performed | | Standard tests | Mandatory tests | Cancelled tests | Control (CRP) | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean number per day ± SD | Difference from P1, % | Mean number per day ± SD | Difference from P1, % | Mean number per day ± SD | Mean number per day ± SD | Mean number per day ± SD | Mean number per day ± SD | % of difference from P1 (p-Value) |
| P1 | 600±224 | N/A | 600±224 | N/A | 600±226 | N/A | N/A | 568±209 | N/A |
| P2 | 617±227 | +3 % (p=0.35) | 617±227 | +3 % (p=0.35) | 617±230 | N/A | N/A | 589±215 | +4 % (p=0.31) |
| P3 | 366±172 | −39 % (p<0.001) | 60±62 | −90 % (p<0.001) | 55±60 | 5±8 | 306±136 | 535±219 | −6% (p=0.21) |
| P4 | 283±137 | −53 % (p<0.001) | 45±31 | −92 % (p<0.001) | 42±31 | 3±2 | 237±115 | 611±253 | +8 % (p=0.11) |

"Standard tests" represent tests prescribed in a routine manner. In P1 and P2, they correspond to all the tests prescribed. In P3 and P4, they correspond to the tests prescribed in the appropriate indication (eGFR<30 min/mL/1.73 $m^2$). "Mandatory tests" are tests performed in patients with eGFR>30 min/mL/1.73 $m^2$ but explicitly requested by clinicians along with a justification, after the implementation of the gatekeeping intervention by the central laboratory (P3 and P4). Note that during P4, the "Mandatory tests" category as well include tests requested by ICU clinicians that are part of the closed list of authorized tests. "Cancelled tests" represent tests requested by clinicians that do not match the intended indications and have therefore not been performed by the central laboratory. BUN, blood urea nitrogen; CRP, C-reactive protein; N/A, not applicable; SD, standard deviation.

This study has several limitations that should be noted. First, it is a retrospective before-and-after study. Second, a single-strategy intervention was evaluated. To confirm the outcomes of our study on BUN testing, further research would be required with multifaceted interventions assessed in a prospective manner, ideally in multiple centers. Third, cost estimates might be underestimated because we did not take into account the costs of the consequences of the inappropriate ordering of BUN tests (e.g., additional unnecessary tests or interventions).

Evidence suggests that laboratory resources are being inappropriately used, resulting in avoidable costs for the healthcare system. Given the urgent need to provide high quality care at a lower cost, and an increased attention to the ethical and environmental responsibilities of healthcare [3], reducing unnecessary laboratory tests has become crucial. To reduce these unnecessary costs, public insurers may consider reducing the number of inappropriately performed tests, as has been done in Belgium with BUN. Although an effective type of intervention, gatekeeping interventions are scarce in the published literature [4]. This may be due to the fact that the implementation of a gatekeeping intervention may have a negative impact on long-term relationships with clinicians. It is important to acknowledge this shortcoming when implementing such interventions. Using a gatekeeping strategy, in conjunction with education or other strategies, in a multifaceted intervention, is recommended for achieving the greatest and most sustained reduction in the ordering of inappropriate laboratory tests [4].

In conclusion, the implementation of a simple gatekeeping intervention for BUN tests (no test in patients with an eGFR >30 mL/min/1.73 $m^2$) resulted in a 92 % reduction in tests *performed* and a 53 % reduction in tests *ordered* with no evident change in quality of care. These results suggest that gatekeeping interventions are effective not only to decrease the number of inappropriate tests but also in changing clinicians' prescribing behavior. Therefore, if used appropriately, gatekeeping interventions could prove an effective tool for reducing inappropriate ordering of other tests in the future.

**Research ethics:** Not applicable.

**Informed consent:** All data were extracted in an anonymous manner. Only quantitative data (number of tests 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 have 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 interests:** The authors state no conflict of interest.

**Research funding:** None declared.

**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:e78962.
3. 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. Accepted in J Appl Lab Med. https://doi.org/10.1093/jalm/jfae087.
4. Devis L, Catry E, Honore PM, Mansour A, Lippi G, Mullier F, et al. Interventions to improve appropriateness of laboratory testing in the intensive care unit: a narrative review. Ann Intensive Care 2024;14:9.
5. Rifai N, Chiu RWK, Young I, Burnham C-AD, Wittwer C. Tietz textbook of laboratory medicine, 7th ed. Amsterdam: Elsevier Health; 2022: 1584 p.
6. Lilly CM, Irwin RS, Boyle WA, Kelly WF. Irwin and Rippe's intensive care medicine, 9th ed. Philadelphia, PA: Wolters Kluwer Health; 2023:2400 p.
7. Buckenmayer A, Siebler N, Haas CS. Evaluation of simple diagnostic parameters in acute kidney injury in hospitalized patients-diagnostic recommendations for non-nephrologists. Intern Emerg Med 2023;18:1769–76.
8. Dimitriadis E, Rolnik DL, Zhou W, Estrada-Gutierrez G, Koga K, Francisco RPV, et al. Pre-eclampsia. Nat Rev Dis Primers 2023;9:8.
9. Liu H, Li Y, Liu C, Liu Z, Chen K. Diagnosis value of the blood urea nitrogen-to-creatinine ratio in determining the need for intervention of acute upper gastrointestinal bleeding. Dig Dis 2024;42:285–91.
10. Al-Dorzi HM, Arabi YM. Quality indicators in adult critical care medicine. Glob J Qual Saf Healthc 2024;7:75–84.

**Supplementary Material:** This article contains supplementary material (https://doi.org/10.1515/cclm-2024-0937).