Activity-based cost analysis of laboratory tests in clinical chemistry

Declerck, Baptist; Swaak, Mathijs; Martin, Manuella; Kesteloot, Katrien

Published in:
Clinical Chemistry and Laboratory Medicine

DOI:
10.1515/cclm-2020-1849
10.1515/cclm-2020-1849

Publication date:
2021

Baptist Declerck*, Mathijs Swaak, Manuella Martin and Katrien Kesteloot

Activity-based cost analysis of laboratory tests in clinical chemistry

https://doi.org/10.1515/cclm-2020-1849
Received December 21, 2020; accepted April 14, 2021;
published online April 23, 2021

Abstract

Ojectives: Since health care budgets are limited and must be allocated efficiently, there is an economic pressure to reduce the costs of health care interventions. This study aims to investigate the cost of testing within a Clinical Chemistry laboratory.

Methods: This study was conducted in the Clinical Chemistry laboratory of the University Hospital UZ Brussel, Belgium, in which 156 tests were included and an average cost per test was calculated for the year 2018. Activity-based costing (ABC) was applied, using a top-down perspective. Costs were first allocated to different activity centers and subsequently to different tests. Number of tests, parameters, analyzers and time estimates were used as activity cost drivers.

Results: The blood glucose test on the point-of-care testing (POCT) analyzer Accu Chek Inform II had the lowest unit cost (€0.92). The determination of methanol, ethanol and isopropanol on the GC-FID (7820A) is the test with the highest unit cost (€129.42). In terms of average cost per test per activity center, core laboratory (€3.37) scored lowest, followed consecutively by POCT (€3.49), diabetes (€22.09), toxicology (€31.52), metabolic disorder (€41.53) and cystic fibrosis (€86.02). The cost per test was mainly determined by staff (57%), costs of support services (23%) and reagents (14%).

Conclusions: High-volume and automated tests have lower unit costs, as is the case with the core laboratory. ABC provides the ability to identify high average cost tests that can benefit from optimizations, such as focusing on automation or outsourcing low-volume tests that can benefit from economies of scale.

Keywords: activity-based costing; clinical chemistry; costs; cost per test; laboratory tests.

Introduction

In healthcare, 70–80% of clinical decisions require one or more laboratory investigations [1, 2]. In the Belgian health care system, most of these tests are reimbursed by the public (compulsory) health insurance. Since 1998, the finance system for Clinical Biology changed from a full fee-for-service (FFS) system to a mixed system (FFS + lump sum payments) to avoid overconsumption of tests and to control the growth rate of expenses. The bulk of funding is currently arranged through lump-sum payments, related to the number of hospital admissions and stay days (for in-hospital patients) and the number of lab test prescriptions (for ambulatory patients). On top the lump-sum payment, all tests are reimbursed by means of a relatively low fee-per-test, set at 25% of the initial full reimbursement rate per test. The underlying economic rationale is a combination of a low fee-per-test to cover the marginal costs of each test, combined with lump sum payments, based on the total patient volume in the hospital (to cover the fixed costs). This combination induces few to no incentives for prescribing too many tests, while still covering the marginal costs of the extra tests being ordered. Due to the increasing economic pressure in health care, it is important to keep the cost per test as low as possible – besides avoiding unnecessary testing (which is not in the scope of our study). In order to achieve this goal, it is also important to map out the cost per test in advance. Current literature includes only a limited number of cost analyses in clinical laboratories. Recent studies mainly use activity-based costing as cost allocation method [1, 3–5]. This method is based on the principles described by Cooper and Kaplan

Baptist Declerck and Mathijs Swaak contributed equally to this work.

***Corresponding author: Baptist Declerck**, Department of Laboratory Medicine, Vrije Universiteit Brussel (VUB), Universitair Ziekenhuis Brussel, Laarbeeklaan 101, 1090 Brussels, Belgium,
E-mail: baptistdeclerck@outlook.com
Mathijs Swaak, Department of Clinical Pharmacy, Vrije Universiteit Brussel (VUB), Universitair Ziekenhuis Brussel (UZ Brussel), Brussels, Belgium
Manuella Martin, Department of Laboratory Medicine, Vrije Universiteit Brussel (VUB), Universitair Ziekenhuis Brussel (UZ Brussel), Brussels, Belgium
Katrien Kesteloot, University Hospitals Leuven, Leuven, Belgium; and Faculty of Medicine (Leuven Institute for Health Care Policy), KU Leuven, Leuven, Belgium

and can be seen as a more accurate method than traditional full costing because of the more precise allocation of indirect costs [6].

The aim of this study was to develop a cost allocation model for a wide range of tests within Clinical Chemistry, i.e. not only for the majority of automated tests but also for more rare and more labor-intensive tests, given the university nature of the study setting. With this model, we hope to provide more insight into the cost-determining factors per test and to allow comparison between tests.

Materials and methods

The study was conducted in the Clinical Chemistry laboratory of the University Hospital UZ Brussel, Belgium. UZ Brussel is a 721-bed university-affiliated, general and tertiary care teaching hospital, servicing 25,000 inpatients and 400,000 outpatients each year. The Clinical Chemistry laboratory, the laboratory of Microbiology and the laboratory of Hematology together form the laboratory of Clinical Biology. Clinical Chemistry is the largest subdiscipline of the Clinical Biology, laboratory, responsible for 48% of total costs and 65% of the reimbursed tests. A total 156 different tests were included in this study and an average cost per test was calculated for the year 2018. Tests historically belonging to the Radioimmunology department (hormonology, tumor markers, and allergens) were excluded for practical reasons (separate cost centers and personnel planning system). The Clinical Chemistry department is divided into six activity centers: Core laboratory with the bulk of automated tests, POCT (Point-of-care testing; blood gas analysis, capillary blood glucose, 3-hydroxybutyrate in blood, urine dipstick test), diabetes (autoantibodies, proinsulin), toxicology (drugs in urine and blood, heavy metals in blood,…), metabolic disorders (organic acids in urine and CSF (cerebrospinal fluid), amino acids in blood, urine and CSF, catecholamines in urine, hemoglobin chromatography, vitamin A and E,…) and cystic fibrosis (sweat test). Activity-based costing (ABC) was applied, using a top-down perspective to allocate total costs, in order not to underestimate the cost per test.

A first part of the study consisted of the retrospective collection of cost data. First of all, all tests of the Clinical Chemistry laboratory were mapped, using the lab guide and the Hospital Information System of UZ Brussel. Subsequently, for each parameter, the used equipment, reagents, controls, standards and materials with any associated article references were extracted from the SOPS (Standard Operating Procedures). In order to be able to link costs to the aforementioned products, the finance department provided the 2018 P&L (profit & loss account) for cost center 51,000 Clinical Chemistry and cost center 52,000 General Laboratory.

The next step consisted of allocating the costs to the different activities and subsequently to the tests. Virtually all costs of cost center 51,000 Clinical Chemistry were allocated (salaried personnel, depreciation [including software, equipment, etc.], medical costs [including reagents], maintenance costs [including maintenance contracts for medical equipment]). A small part (3.8%) of the total costs was excluded from the cost allocation process, because no solid, acceptable activity cost drivers could be identified. Examples of the latter are cleaning products, medical gasses, collection material,… (these costs are added as a 3.8% mark up to the unit cost, at the end of the ABC-allocation exercise). Data on the cost center 52,000 General Laboratory were required to allocate personnel costs of the staff doing the night shifts. Costs of support services (= overhead costs) of the department of Laboratory Medicine (e.g. depreciation of laboratory building, financing of support services, etc.) were allocated partially to the Clinical Chemistry laboratory according to the internal allocation keys of the hospital (e.g. m^2, fte), and subsequently allocated over the different tests, based on the numbers of tests. Some costs were directly attributable to the final product (e.g. reagents for a test), while other were attributed, based on various allocation keys (e.g. equipment used for different tests). In addition to the cost data, other data were required, such as the number of tests performed in 2018 from the LIS (Laboratory Information System).

The major part of this cost allocation exercise involved estimating the time component to allocate the personnel costs to each test. Given the wide range of tests in the Clinical Chemistry laboratory, it was decided not to perform a time measurement for every single test. A more pragmatic approach was chosen; the time expressed as full-time equivalents was allocated on the basis of the staffing, according to the 2018 framework report, and allocated to the different workstations within the Clinical Chemistry laboratory. Various activity centers were examined separately: common staff for the entire laboratory, triage (sorting of samples), core laboratory, POCT, diabetes, toxicology, metabolic disorders and cystic fibrosis. Time estimates were made with the help of the personnel in charge of the floor. Specific time measurements were performed only for tests where time estimation was difficult. This was the case for blood gas measurements performed in the laboratory, as these are carried out in between the sorting of samples (10 time measurements were taken by different medical laboratory technologists on different days). Functions other than medical laboratory technologist, also involved in the lab process, are more difficult to assign directly to tests. These could be subdivided over the different activity centers and were subsequently allocated over the number of tests.

Microsoft Excel software was used to collect and process the data. To be able to process the costs in spreadsheets, all unique tests were mapped on the basis of sequence numbers. To determine the cost per unique test three levels are used as described in Figure 1 (applicable to all costs, except costs of support services and personnel costs): the analyzer level (e.g. Vitros 4600), the parameter level (e.g. glucose on the Vitros 4600) and the test level (e.g. glucose in urine on the Vitros 4600). On the analyzer level the first question asked about the costs was if they were present on only one analyzer. If so, the costs can be allocated to all parameters that are evaluated using said analyzer. If not, a second question helps to define the structure of the allocation key: are the devices of a different type? When multiple analyzers are of the same type some costs can be easily distributed, for example the GC–MS Agilent 5975 and GC–MS Agilent 5977 share a maintenance contract. The expenditures on maintenance are in this case allotted evenly between both analyzers. If the analyzers are of different types, the costs are first assigned to each analyzer, based on the volume of tests per analyzer. On the parameter level, a cost can be present on only one parameter, e.g. a unique liquid control for C-reactive protein (CRP) on the Vitros 4600. This cost can then be further distributed among the unique tests within a parameter based on the volume of analyses per unique test. If there is only one test within the parameter, all costs are directly attributed to the unique test. While costs for multiple parameters evaluated on the same analyzer, e.g. common costs of liquid control on the Vitros 4600 for glucose (urine), proteins

(CSF), ethanol (blood plasma) and ammonia (blood plasma), can be either made with or without respect to the volume of analyses. If costs are made without respect to the volume of analyses, the costs are distributed evenly over all parameters, e.g. software for a specific analyzer. In some cases expenses are related to the volume of analyses for practical reasons, which are distributed among the parameters (e.g. Liquicheck Urine Control, which is used for 15 different parameters), based on the volume of analyses within a parameter divided by the total volume of analyses affected by the costs. On the test level, there can be a last allocation of costs based on the volume of tests per unique test within a parameter.

Results

The total cost per test for the Clinical Chemistry laboratory for the year 2018 is made up of various cost types, as shown in Figure 2. The cost per test was mainly determined by staff costs (57.4%), costs of support services (22.7%) and reagents (13.7%). In addition, the costs of the analyzers represents 4.6% of the total costs. These consist of maintenance contracts and depreciation of analyzers and associated software. Less pronounced cost types include costs of control material (1.1%), analyzer associated material (0.3%), test specific material and standards (both 0.1%). Costs of analyzer-associated material includes costs for material directly attributable to an analyzer (e.g. Micro Sample Cups for the Cobas e411 analyzer) and depreciation of material that is used for the analyzers (e.g. columns for chromatography, computers,…). Costs of test specific material consists of material directly assignable to an individual test (e.g. Spin Column and Receiver Tube for the determination of amino acids on the Biochrom 30+ Amino Acid Analyzer).

The test volume for the year 2018 amounted to 2,847,679 tests in total, split up among the activity centers as follows: core laboratory (2,499,807, 87.78%), POCT (263,520, 9.25%), diabetes (28,141, 0.99%), toxicology (21,561, 0.76%), metabolic disorders (34,120, 1.20%) and cystic fibrosis (530, 0.02%). For the year 2018 the total costs

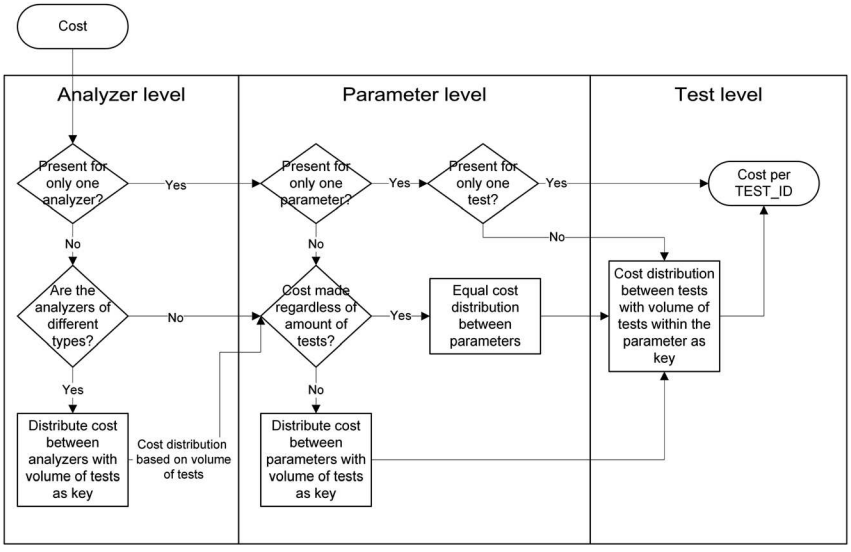

Figure 1: Flowchart about the allocation of costs over analyzer, parameter and test level.

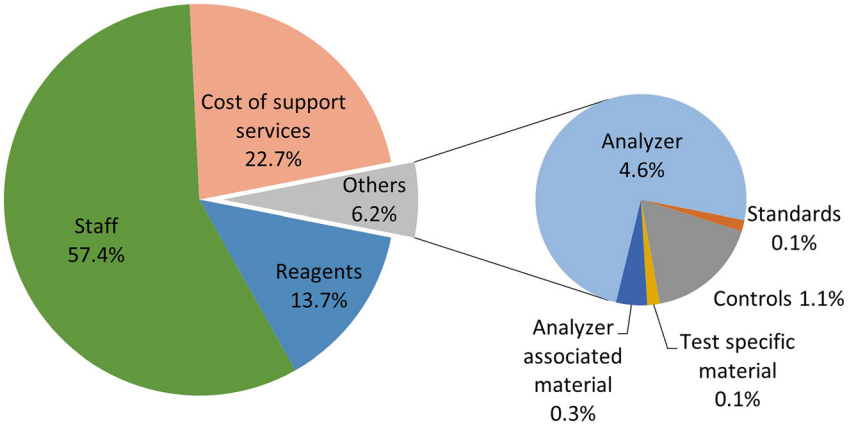

Figure 2: Overall cost per test ratio.

amounted to €6,735,568, which was divided among the different activity centers as follows: core laboratory (€4,431,304, 65.79%), POCT (€457,260, 6.79%), diabetes (€657,618, 9.76%), toxicology (€501,481, 7.44%), metabolic disorders (€642,316, 9.54%) and cystic fibrosis (€45,589, 0.68%). Figure 3 shows the average cost per test across the different activity centers within the Clinical Chemistry laboratory. A noticeably lower cost was obtained for the core laboratory (€3.37) and POCT (€3.49). These two activity centers have a lower share of personnel costs compared to the other activity centers, as illustrated in Figure 4. The determination of creatinine in blood on the Vitros 4600 is the most requested test in the core laboratory (n=147,499, year 2018) with an average cost of €1.58 per test (or €1.04 per test excluding overhead costs). The glucose in blood test on the POCT analyzer Accu Chek Inform II had the lowest average cost per test of all activity centers (€0.92 or €0.38 excluding overhead costs) and is also the most requested test (n=185,800, year 2018) of all activity centers. The other activity centers have a higher average cost per test: diabetes (€22.09), toxicology (€31.52), metabolic disorder (€41.53) and cystic fibrosis (€86.02). These activity centers have higher shares of personnel costs, which are more pronounced for diabetes and cystic fibrosis (both 97%). The activity centers toxicology and metabolic disorders have high analyzer costs of 21 and 13% respectively of their total costs compared to an average of 5% for all activity centers combined. The test with the highest cost of all tests, belonging to toxicology, is the determination of alcohols (methanol, ethanol and isopropanol) on the GC-FID (7820A) (avg. €129.42), of which 75% are equipment costs. The determination of alcohols is the only test performed on this device and it is not often requested (n=90, year 2018).

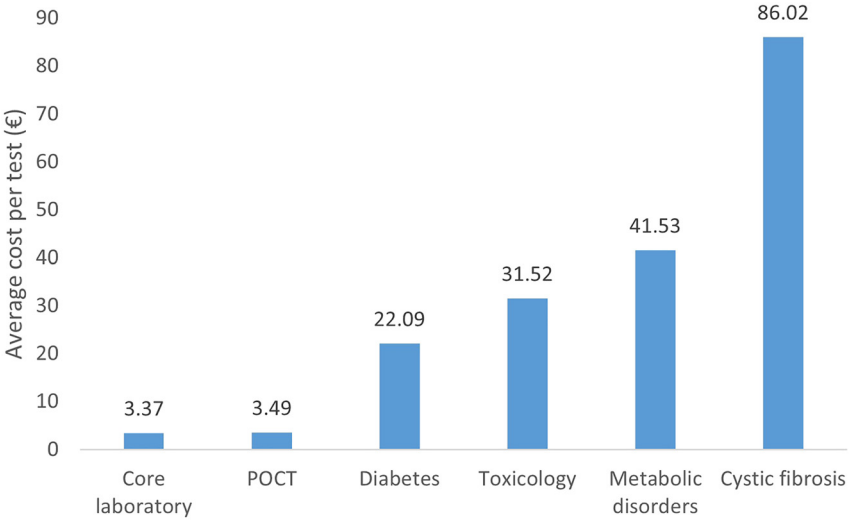

Figure 3: Average cost per test across the different activity centers within clinical chemistry.

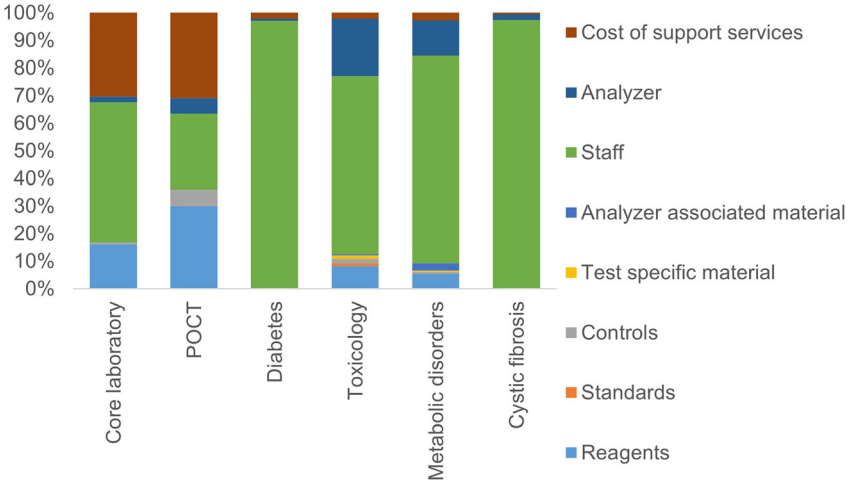

Figure 4: Ratio of cost per test across the various activity centers within clinical chemistry.

Discussion

The results of this study point out that the cost of a test was mainly determined by staff costs (57%), costs of support services (23%) and reagents (14%). A cross sectional study of Mouseli et al., applying ABC in 34 private laboratories, showed consumables (37%) and personnel (36%) represented an equally large share in total costs [4]. The remarkably higher share of personnel costs (57%) in our study is probably due to the difference in study setting (private laboratory vs. university laboratory). The lab of a tertiary care hospital does not only perform high volumes of routine (and automated) tests but also a substantial amount of high volume very specialized test, that are much less automated and require specific expertise, both for performing and interpreting these tests. All of this implies that staff costs are relatively higher in a university lab than in a private lab, performing relatively more routine tests. Additionally, specifically for our lab, the automatic analyzers are quite old (low replacement value – cf. infra) which implies that these costs are, accidently, relatively low. Consequently, all other things being equal, this raises the relative share of staffing in total costs.

The core laboratory and POCT activity centers have the lowest average cost per test due to low personnel costs and high test volumes. The share of the costs of these activity centers to the total laboratory costs is lower than the share of volume of tests to the total laboratory volume. For example, the core laboratory is responsible for 88% of the total volume of tests and only 66% of the total costs. These findings of relatively low unit costs for high-volume tests are in the line with Barletta et al. showing that a decrease in cost per test, due to an increase in test volumes, attained statistical significance for quantities of up to about 1,100,000 tests per year [1]. The core laboratory includes highly automated tests, whereby high volumes of tests can be carried out at a relatively lower cost. Although the core laboratory's share of personnel costs (51%) is low compared to most other activity centers within our hospital, it still represents a relatively high part of the total costs for this sector. This could be explained by the fact that the automatic analyzers are relatively old in the study period, which corresponds to low analyzer costs (i.e. low depreciation) – and hence low 'other' costs, which, all other things being equal, augments the share of the other cost components. Currently, the core laboratory is in the middle of a full automation project and we expect this to reduce personnel costs in future and simultaneously to increase equipment costs. Obviously, this will reduce the share of staffing costs while augmenting the share of 'other' costs. The relatively low cost per test in POCT should be interpreted with caution, as neither the personnel costs nor the space for carrying out these tests in the nursing wards have been included (since our study focused on the "within lab" total costs). The relatively high costs of support services in both activity centers can be explained by the decision to allocate these overhead costs on the basis of the total number of tests performed. The other activity centers have a higher average cost per test because they are more labor intensive, given their higher share of personnel costs, which was especially the case for diabetes and cystic fibrosis. The highest average cost for cystic fibrosis can be explained by the very high personnel costs per test, because, in addition to performing the sweat test, the sampling is also carried out by laboratory personnel. Moreover, sweat tests are not often requested (n=530, year 2018), but personnel must always be available for every single test. Noticeably higher analyzer costs were seen for the toxicology and metabolic disorders activity centers, which can be explained by the fact that they use high-tech chromatographic equipment.

Our study is quite unique because current literature only includes a limited number of costing studies in clinical laboratories. A top-down approach was used in order to avoid underestimation of the true cost per test. The study setting is also unique because of the university lab setting, which means that more rare and labor-intensive tests were also included. A drawback of this study is the fact that we used mainly time-estimates to calculate the staff time and only few real time measurements, as is suggested by time-driven activity-based costing (TDABC) [7–11]. The use of TDABC seemed less practical to us because of the diverse range of laboratory tests within Clinical Chemistry that were included in this study – and hence the extensive time measurements that would have been required. Another limitation of this study was that we only focused on the total cost to the laboratory. All costs relating to lab activities elsewhere in the hospital were excluded. This implies that the actual cost of performing POCT tests is underestimated, since the costs of these activities within the nursing wards was not included in the analysis. The use of ABC within a clinical laboratory can support various policy decisions, such as outsourcing low-volume tests to benefit from economies of scale. Although we are a tertiary hospital, this is only medium-sized in Belgium. As a result, some infrequently ordered tests are outsourced to (larger) general and other university hospital laboratories. Possible examples of tests with a high cost and a low volume are lidocaine in blood on Acquity UPLC-PDA 2 (avg. €96.21, n=5 for the year 2018)

and thiocyanate in blood on the spectrophotometer Shimadzu UV-1650PC (avg. €94.19, n=4 for the year 2018). Both tests are among the 10 most expensive tests identified in this study. In addition, such rare tests also require training costs to keep the staff familiar with the tests. In the Belgian healthcare system, where clinical networks of hospitals are being formed, our study offers opportunities to clinical laboratories to identify tests, based on costing data, that could benefit from centralization. Obviously, decisions about (de)centralizing tests should never be based on costing data only. Also the impact on the quality of the tests as well as the quality of care should be incorporated. For lab tests, an important quality parameter is TAT (turnaround time), which should not be ignored. Hence decisions about outsourcing or centralizing tests should always be made in collaboration with clinicians [12, 13]. Besides identifying tests that can benefit from economies of scale, it is also relevant to analyze the work processes for tests with a high average cost, for instance organic acids on GC–MS Aligent 5975 (avg. €93.8, n=1,198 for the year 2018). Since the cost of this test consists mainly of personnel costs (92%), it seems worthwhile to search for an alternative method that is less labor intensive to reduce costs. Another application could be to compare the unit cost per test with its reimbursement fee, in order to suggest optimizations in the reimbursement system. The cost-effectiveness of the various tests was also beyond the scope of this study. Because staff allocation to different work stations was used to allocate staff costs to different types of tests, no potential efficiency improvements by changing the staff allocation between platforms could be identified from our study. Future research, based on actual time estimates, could be used to initiate future cost reductions within the laboratory by optimizing the staff allocation across platforms.

Conclusions

The development of a cost allocation model for the Clinical Chemistry laboratory resulted in improved insights into the cost structure of tests. These insights could offer opportunities to reduce the cost per test, for example by focusing on personnel costs, which forms the highest share of costs. Although the specific results may differ between laboratories and may depend on the allocation keys used, we believe that the insights from our analysis may be insightful for other laboratories too. This study confirms that high-volume and automated tests have lower unit costs, as is the case for tests of the core laboratory. Overall, less common, low-volume tests have a higher average costs due to a lower degree of automation and associated higher personnel costs, which was the case for example for the cystic fibrosis and diabetes activity centers. Activity-based costing gives the opportunity to identify tests with a high average cost, which could benefit from optimizations. This can be achieved by various policy decisions, such as focusing on automation or outsourcing low-volume tests that can benefit from economies of scale.

Acknowledgments: This study was part of a thesis in Master of Health Care Management and Policy at the KU Leuven University. We thank the management of UZ Brussel for allowing this study to be carried out and all those involved at UZ Brussel who participated in this study.
Research funding: None declared.
Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.
Competing interests: Authors state no conflict of interest.
Informed consent: Not applicable.
Ethical approval: Not applicable.

References

1. Barletta G, Zaninotto M, Faggian D, Plebani M. Shop for quality or quantity? Volumes and costs in clinical laboratories. Clin Chem Lab Med 2013;51:295–301.
2. Plebani M, Lippi G. Is laboratory medicine a dying profession? Blessed are those who have not seen and yet have believed. Clin Biochem 2010;43:939–41.
3. Su BG, Chen SF, Yeh SH, Shih PW, Lin CC. Cost evaluation of clinical laboratory in Taiwan's National Health System by using activity-based costing. Clin Chem Lab Med 2016;54: 1753–8.
4. Mouseli A, Barouni M, Amiresmaili M, Mirab Samiee S, Vali L. Cost-price estimation of clinical laboratory services based on activity-based costing: a case study from a developing country. Electron Phys 2017;9:4077–83.
5. Adane K, Abiy Z, Desta K. The revenue generated from clinical chemistry and hematology laboratory services as determined using activity-based costing (ABC) model. Cost Eff Resour Alloc 2015;13:1–7.
6. Cooper R, Kaplan R. Activity-based systems: measuring the costs of resource usage. Account Horiz 1992;6:1–13.
7. Kaplan RS, Anderson SR. Time-driven activity-based costing. Harv Bus Rev 2003;82:131–8.

8. Kaplan RS, Porter ME. How to solve the cost crisis in health care understanding the value of health care. Harv Bus Rev 2011;89:47–64.
9. Keel G, Savage C, Rafiq M, Mazzocato P. Time-driven activity-based costing in health care: a systematic review of the literature. Health Pol 2017;121:755–63.
10. Kaplan AL, Agarwal N, Setlur NP, Tan HJ, Niedzwiecki D, McLaughlin N, et al. Measuring the cost of care in benign prostatic hyperplasia using time-driven activity-based costing (TDABC). Healthcare 2015;3:43–8.
11. DiGioia AM, Greenhouse PK, Giarrusso ML, Kress JM. Determining the true cost to deliver total hip and knee arthroplasty over the full cycle of care: preparing for bundling and reference-based pricing. J Arthroplasty 2016;31:1–6.
12. Plebani M. Quality and future of clinical laboratories: the Vico's whole cyclical theory of the recurring cycles. Clin Chem Lab Med 2018;56:901–8.
13. Plebani M. Clinical laboratory: bigger is not always better. Diagnosis 2018;5:41–6.