Opinion Paper

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An overview of EFLM harmonization activities in Europe

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Abstract: The European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) has initiated many harmonization activities in all phases of the examination process. The EFLM is dealing with both the scientific and the educational aspects of harmonization, with the intention of disseminating best practice in laboratory medicine throughout Europe. Priorities have been given (1) to establish a standard for conducting and assessing biological variation studies and to construct an evidence based EFLM webpage on biological variation data, (2) to harmonize preanalytical procedures by producing European guidelines, (3) to improve test ordering and interpretation, (4) to produce other common European guidelines for laboratory medicine and play an active part in development of clinical guidelines, (5) to establish a common basis for communicating laboratory results to patients, (6) to harmonize units of measurement throughout Europe, (7) to harmonize preanalytical procedures in molecular diagnostics and (8) to harmonize and optimize test evaluation procedures. The EFLM is also now launching the 5th version of the European Syllabus to help the education of European Specialists in Laboratory Medicine (EuSpLM), which is being supported by the development of e-learning courses. A register of EuSpLM is already established for members of National Societies in EU countries, and a similar register will be established for specialists in non-EU countries.

Keywords: EFLM; harmonization; laboratory medicine.

Introduction

The physician Sir William Osler stated in 1892 that “if it were not for the great variability among individuals, medicine might as well be a science and not an art”. Laboratory medicine has arguably evolved more rapidly over the last 50 years than any other branch of medicine, so it is perhaps not surprising that there is great variability in how it is practiced both between and within countries. The European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) feels that a core role of laboratory medicine practitioners is to reduce variability and to implement “best practice”, not just analytically but in every aspect of the testing “brain to brain” loop [1]. This loop starts with the thought to request a laboratory investigation based on a patient’s condition which, in turn, leads to the request, collection, identification and transport of a specimen to the laboratory where it is then prepared and analyzed before the result is considered by the brains of both the laboratory professional and the original test requester. The EFLM currently has a number of science and education/training initiatives aimed at helping reduce the variation in this process. This article gives an overview of these activities, whereas the underlying publications cited give further details as to why and how these activities have been undertaken.

Harmonization activities in clinical laboratory science

The Science Committee of the EFLM comprises eight Working Groups (WGs), two associated Task and Finish Groups (TFGs) and two Task Groups (TGs), which between them have 140 members, corresponding members and experts nominated from the National Societies of 26 European countries. Briefly, the purpose of WGs is to have a clear plan to deliver continued improvements in a particular area of laboratory medicine, TFGs have a specific task or project to deliver within 2 years and TGs are envisaged to take longer to achieve their goal. Figure 1

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Figure 1: Some of the contributions of the EFLM Working Groups to helping harmonize aspects of the “brain-to-brain loop” for laboratory examination.

Adapted from Plebani et al. [1].

summarizes how each of these Groups have recently been influencing different aspects of the brain-to-brain loop in order to help harmonize and improve practice and therefore reduce variation in the whole process. Taking the following in turn:

Working Group: Biological Variation (WG-BV)

Biological variation (BV) is a fundamental source of variation, and although this does not lend itself to harmonization *per se*, there is a need to establish as accurate an assessment of within- and between-subject BV as possible for each of the test analytes we currently measure. This is not just for academic reasons but is fundamental to developing harmonized analytical performance specifications (APS) for individual tests. The 1st Strategic Conference of the EFLM on “Defining analytical performance goals 15 years after the Stockholm Conference on Quality Specifications in Laboratory Medicine” was held in Milan in 2014, and from it a consensus was agreed whereby the analytical goals for a particular measurand should be based on a hierarchy of models [2]. Ideally, the APS for a test should be based on the model of clinical outcome studies. However, such data often do not exist for many laboratory tests and to use this approach there should also be a strong link between the measurand and the clinical situation. Because many measurands in the laboratory are used for multiple purposes, this is difficult to achieve. However, it should be possible for some measurands such as HbA1c and CRP. In the laboratory, there is

often a reliance on the next preferred model that is based on BV, whose use attempts to minimize the ratio of “analytical noise” to the biological signal. The rationale for using APS based on BV is that such measurands should have a stable homeostatic set point and preferable be regulated in a strict way. Examples are electrolytes such as sodium and potassium [3].

The same Strategic Conference identified the main limitations of BV data that existed at that time. One of these was the fact that there was no standardized method for assessing BV and, as a consequence, studies published could be of variable quality. However, this also meant that there was still a potential to assess the BV of many test analytes to as high a standard as was possible using contemporary statistics and study designs.

These issues gave a continued focus to the EFLM’s WG: BV, and its work has recently been coming to fruition. Building on an original checklist [4], they have created the BV Data Critical Appraisal Checklist (BIVAC) that can be used to evaluate the quality of existing BV studies [5]. They have also embarked on an extensive Europe-wide project to determine the BV of numerous tests using rigorous protocols [6]. Called the European Biological Variation Study (EuBIVAS), this has already published BV estimates for many routinely measured enzymes [7] and for creatinine [8], with plans for reporting on many other tests, including those of lipids, electrolytes and coagulation [9]. Perhaps not surprisingly, their findings to date suggest that both within- and between-subject BV tends to be tighter when their exacting procedures are followed [9].

These data will also be included in a database of BV studies, which will update the seminal work of Ricós et al. [10], and it is planned to soon be hosted by the EFLM on its website.

Working Group: Preanalytical Phase (WG-PRE)

The preanalytical phase is known to currently be a large source of error in the patient testing process [11]. Part of reason for this is likely to be the variability in practice that exists throughout Europe. The preanalytical WG of the EFLM has been active in recommending the harmonization of many areas of this activity which are of immediate relevance to the work of most laboratories [12].

Taking the WG's achievements in the order in which a patient would have a sample taken, they have recommended how a patient who requires a fasting sample should be prepared prior to sample collection [13]. Validating or verifying laboratory equipment and reagent lots is now commonplace, but the same is not true for blood containers, so the WG-PRE has provided advice on how this can also be achieved locally [14]. They have also published recommendations to help minimize the perennial issue of patient and blood container identification [15] and published a systematic review on tube additives in blood glucose measurement [16]. The process of venous blood collection itself is poorly harmonized, so the WG have conducted two European surveys to understand how this varies currently and are in the process of using the findings to write recommendations on how this should be performed more uniformly. The color coding of the blood containers themselves varies between laboratories, and tube manufacturers and are an obvious potential source for confusion amongst users. The WG-PRE's associated TFG on Color Coding has seen this as a priority and has recommended the harmonization of container tube colors and their associated labels [17]. The need for a specific sequence in which different blood tubes should be collected (the "order of draw") has been a long-standing topic of discussion, especially in an era of evacuated collection containers. The WG-PRE now provides their view that an order of draw should still be followed, primarily because it is not always possible to ensure that every blood collection will follow the ideal process [18]. Recently, they have also provided practical recommendations for the management of hemolyzed samples [19].

Beyond publications, their harmonization initiatives have also formed a basis for four European conferences

on the preanalytical phase, which has given rise to several opinion papers [20–23].

Working Group: Guidelines (WG-G)

Guidelines, of course, go hand in hand with practice harmonization. The National Societies, which comprise the EFLM, already have many laboratory-related guidelines that are of excellent quality, and one of the tasks of the WG-G is to collect these into the repository that is currently found on the EFLM website [24]. Some of these guidelines are so comprehensive that for the EFLM to reinvent them would, at best, be time wasteful, so it is the intention of the group that some of these could be adapted or adopted as European guidelines (with the National Society's permission) to avoid any duplication.

Clinical practice guidelines are critically examined by the WG-G according to a checklist of essential information required for use of biomarkers [25]. In case the WG-G identifies key information that is missing (or inconsistent) for the correct use of a biomarker, e.g. preanalytical, analytical or postanalytical requirements, an EFLM guideline will be produced by an expert group to address and harmonize the critical issues.

The plethora of guidelines on similar topics can also be rationalized by having joint guidelines with other clinical societies. A successful example of this cooperation is the joint consensus statement between the EFLM and the European Atherosclerosis Society on lipid determination on non-fasting samples [26].

Working Group: Harmonization of the Total Testing Process (WG-H)

As its name suggests, this WG has harmonization of practice at the heart of its purpose. It has surveyed the National Societies of the EFLM on aspects of the testing process such as consistency in test profiles, specific disease guidelines, autovalidation rules and the thorny issue of what test units are used in their country. With respect to the last of these, small steps are being taken, such as the Group recommending that the denominator unit for test reporting be per liter (/L) rather than, say, per milliliter (/mL) by default [27]. This leads to a change closer to the SI unit (such as from mg/mL to g/L) but will not affect the numeric result. It is planned that the EFLM will, in due course, issue a recommendation of its preferred reporting units for tests to form the basis for adoption. The group is also exploring means of harmonizing reference intervals, where possible.

Working Group: Postanalytical phase (WG-POST)

This WG has concentrated on the value, or otherwise, of adding interpretative comments onto laboratory reports. They have surveyed how clinicians or laboratory specialists interpret the results of key laboratory tests in clinical decision making in different clinical scenarios throughout Europe [28–30] and have performed studies about laboratories' practices and policies in postanalytical phase, including interpretative commenting [28]. They have established a collaboration with colleagues in the International Federation of Clinical Biochemistry and Laboratory Medicine (IFCC) Working Group on Harmonization of Interpretative Comments EQA to have a joint approach to harmonization of interpretative commenting globally and developing joint recommendations on this subject.

Working Group: Patient Focused Laboratory Medicine (WG-PFLM)

The main objective of this WG is promoting patient engagement with Specialists in Laboratory Medicine. This is currently being addressed through surveying the views of patients receiving their own laboratory results and who might be best placed to communicate them [31] and how, which has implications for harmonization; the Group is also embarking on a project that should ultimately help harmonize the criteria to judge the acceptability of mobile phone and computer apps that incorporate laboratory medicine data.

Working Group: Test Evaluation (WG-TE)

As potential new diagnostic tests become available, there is a need to evaluate their utility in a uniform way [32]. The WG-TE has therefore written a practical guide to evaluating new biomarkers for this purpose in a harmonized way [33].

Laboratory medicine has a poor record bringing new tests to market in a timely and effective way. Evidence-based laboratory medicine (EBLM) provides the underlying principles for how a new biomarker should go through the test evaluation process. An interactive Test Evaluation course has been set up by the WG-TE that aims to address that gap by extending the principles of EBLM to provide some practical tools for the key

processes of test evaluation. Tools to conduct test evaluation include identifying unmet needs for biomarkers, clinical pathway mapping to define the role and purpose of biomarkers in changing outcomes, determination of analytical and clinical performance characteristics of biomarkers and assessing the clinical effectiveness of biomarkers. The course given in Leiden in 2016 was repeated in Sydney in 2018.

Working Group: Personalized Laboratory Medicine (WG-PLM)

One of the main objectives of this group is to establish how the fledgling of proteomics, metabolomics and pharmacogenetics can be incorporated into the laboratory medicine discipline [34]. From a harmonization perspective, they have helped develop the first preanalytical assessment of quality in molecular diagnostics [35].

New Task Groups for APS

APS in laboratory medicine should ideally be harmonized at least within certain geographical areas and for specific situations. The 1st EFLM Strategic Conference in 2014 dealt with APS, both because it was necessary to set the theoretical framework for how to set performance specifications and also to try to harmonize performance specifications in special situations. A consensus document stating that performance specifications could be based on three different models – namely clinical outcome, BV and state of the art – was developed [2]. After the conference, a task force comprising five different TFGs were established to deal with different aspects of performance specifications. The main results from these groups have already been published [36]. The TFGs are now closed, but some of the ideas will be taken forward in two new TGs. The TG-Biological Variation Database, located within the WG-biological variation, will establish a database including APS for different measurands based on BV. The other TG on Performance Specifications based on Outcome Studies (TG-PSOS), within the WG-Test Evaluation, will establish the theoretical and practical basis for how to set performance specifications based on outcome studies. The intention is that a list of APS for different measurands shall be produced. The two TGs shall cooperate to allocate different measurands to the different models for setting APS and to develop APS that can be proposed for EQA organizations.

Harmonization activities in education and training

Harmonizing education and training is a cornerstone to assuring patients that laboratory medicine is practiced to high-quality, equitable standards across Europe. Ensuring harmonized practice can also help ensure patient safety when professionals seek to take their practice across country borders. For these reasons, EFLM and its predecessors have provided long-standing leadership in harmonizing the knowledge, skills and competence it identifies with the Specialist in Laboratory Medicine [37]. The fourth version of the syllabus published in 2012 [38] identified generic clinical/scientific/analytical/leadership skills and competencies associated with specialist practice. Version 5 (in press) builds on the expected knowledge in the individual disciplines of clinical biochemistry/immunology, hematology/blood transfusion, microbiology/virology and clinical/molecular genetics.

The syllabus has been widely adopted as a template from which recognized training programs have emerged. By setting an equivalence of standards, opportunities have evolved in individual countries to identify and support the emerging European Specialist in Laboratory Medicine (EuSpLM). EFLM's register of specialists [39] is widely seen as a charter mark of high quality practice (particularly in the absence of professional registration/regulation), and for some registrants, the EuSpLM title confers a unique recognition of contribution.

EFLM's harmonization initiatives ensure it is well placed to support objectives of the EU Commission's 2013/55/EC Directive (The Recognition of Professional Qualifications) to catalyze a more equitable distribution of human resource and services across the Union and obviate the need for member states to impose "compensation measures" (e.g. retraining, new qualifications, aptitude tests and adaptation periods) on each other's professionals. Furnished with the syllabus, a code of conduct for specialists [40], the register, and extensive information on the profession's demographics [41], EFLM's Profession Committee is taking forward the EU Commission's invitation to present Laboratory Medicine's Common Training Framework.

Going forward at national society level, EFLM supports harmonization activities through its Education and Training Committee (C-ET). Two new C-ET activities started in 2018. The Task Group EFLM European Syllabus (TG-EES) supports emerging EuSpLM in ensuring that a harmonized European syllabus is kept up to date in consultation with the national societies and that further training courses on the most important contents of the syllabus

will be offered on the EFLM e-Learning platform. In order to support the harmonization of professional training at European level, the Working Group Laboratory Medicine Credit Points (WG-LMCP) will establish a CPD crediting system awarding credit points for EuSpLM for educational events. Documents on accreditation of such events have been just developed in 2017 by an EFLM Task and Finishing Group.

Two established C-ET WGs make an important contribution to further training activities.

WG Congresses and Postgraduate Education (WG-CPE) is responsible providing and supporting postgraduate education. An EFLM exchange program for laboratory professionals (EFLMLabX) started in 2018, which also helps in the harmonizing process of continued practical education of laboratory professionals. The Working Group Distance Education (WG-DE) is responsible for the e-learning platform and the creation of e-learning material for professionals.

Conclusions

To be able to implement the harmonization initiatives from the EFLM WGs, active participation and support from the European national societies are needed. Together we will then develop a more consistent and evidence-based approach to our practice of laboratory medicine. Although we do not wish to lose the artistic flair or innovative thinking within our profession, at least the work of the different EFLM Groups might have been able to persuade William Osler that there is scientific merit in us also continuing to harmonize our practice.

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References

1. Plebani M, Laposata M, Lundberg GD. The brain-to-brain loop concept for laboratory testing 40 years after its introduction. *Am J Clin Path* 2011;136:829–33.

2. Sandberg S, Fraser CG, Horvath AR, Jansen R, Jones G, Oosterhuis W, et al. Defining analytical performance specifications: Consensus Statement from the 1st Strategic Conference of the European Federation of Clinical Chemistry and Laboratory Medicine. *Clin Chem Lab Med* 2015;53:833–5.
3. Ceriotti F, Fernandez-Calle P, Klee GG, Nordin G, Sandberg S, Streichert T, et al. Criteria for assigning laboratory measurands to models for analytical performance specifications defined in the 1st EFLM Strategic Conference. *Clin Chem Lab Med* 2017;55:189–94.
4. Bartlett WA, Braga F, Carobene A, Coşkun A, Prusa R, Fernandez-Calle P, et al. A checklist for critical appraisal of studies of biological variation. *Clin Chem Lab Med* 2015;53:879–85.
5. Aarsand AK, Raas R, Fernandez-Calle P, Ricos C, Díaz-Garzón J, Jonker N, et al. The biological variation data critical appraisal checklist: a standard for evaluating studies on biological variation. *Clin Chem* 2018;64:501–14.
6. Carobene A, Strollo M, Jonker N, Barla G, Bartlett WA, Sandberg S, et al. Sample collections from healthy volunteers for biological variation estimates' update: a new project undertaken by the Working Group on Biological Variation established by the European Federation of Clinical Chemistry and Laboratory Medicine. *Clin Chem Lab Med* 2016;54:1599–608.
7. Carobene A, Røraas T, Sølvik UØ, Sylte MS, Sandberg S, Guerra E, et al. Biological variation estimates obtained from 91 healthy study participants for 9 enzymes in serum. *Clin Chem* 2017;63:1141–50.
8. Carobene A, Marino I, Coşkun A, Serteser M, Unsal I, Guerra E, et al. The EuBIVAS project: within- and between-subject biological variation data for serum creatinine using enzymatic and alkaline picrate methods and implications for monitoring. *Clin Chem* 2017;63:1527–36.
9. Carobene A, on behalf of the EFLM Working Group on Biological Variation. The European Biological Variation Study (EuBIVAS): delivery of updated biological variation estimates, a project by the Working Group on Biological Variation in the European Federation of Clinical Chemistry and Laboratory Medicine. *J Lab Precis Med* 2017;2:70.
10. Ricós C, Alvarez V, Cava F, García-Lario JV, Hernández A, Jiménez CV, et al. Current databases on biological variation: pros, cons and progress. *Scand J Clin Lab Invest* 1999;59:491–500.
11. Plebani M. Errors in clinical laboratories or errors in laboratory medicine? *Clin Chem Lab Med* 2006;44:750–9.
12. Cornes MP, Church S, van Dongen-Lases E, Grankvist K, Guimarães JT, Ibarz M, et al. The role of European Federation of Clinical Chemistry and Laboratory Medicine Working Group for Preanalytical Phase in standardization and harmonization of the preanalytical phase in Europe. *Ann Clin Biochem* 2016;53:539–47.
13. Simundic AM, Cornes M, Grankvist K, Lippi G, Nybo M. Standardization of collection requirements for fasting samples: for the Working Group on Preanalytical Phase (WG-PA) of the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM). *Clin Chim Acta* 2014;432:33–7.
14. Lippi G, Cornes MP, Grankvist K, Nybo M, Simundic AM, Working Group for Preanalytical Phase (WG-PRE), et al. EFLM WG-Preanalytical phase opinion paper: local validation of blood collection tubes in clinical laboratories. *Clin Chem Lab Med* 2016;54:755–60.
15. van Dongen-Lases EC, Cornes MP, Grankvist K, Ibarz M, Kristensen GB, Lippi G, et al. Patient identification and tube labelling – a call for harmonisation. *Clin Chem Lab Med* 2016;54:1141–5.
16. Lippi G, Nybo M, Cadamuro J, Guimaraes JT, van Dongen-Lases E, Simundic AM. The effect of different tube additives on blood glucose measurement: systematic overview of the literature. *Adv Clin Chem* 2017; in press.
17. Simundic AM, Cornes MP, Grankvist K, Lippi G, Nybo M, Ceriotti F, et al. Colour coding for blood collection tube closures – a call for harmonisation. *Clin Chem Lab Med* 2015;53:371–6.
18. Cornes M, van Dongen-Lases E, Grankvist K, Ibarz M, Kristensen G, Lippi G, et al. Order of blood draw: Opinion Paper by the European Federation for Clinical Chemistry and Laboratory Medicine (EFLM) Working Group for the Preanalytical Phase (WG-PRE). *Clin Chem Lab Med* 2016;55:27–31.
19. Lippi G, Cadamuro J, von Meyer A, Simundic AM, on behalf of the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Working Group for Preanalytical Phase (WG-PRE). Practical recommendations for managing hemolyzed samples in clinical chemistry testing. *Clin Chem Lab Med* 2018;56:718–27.
20. Lippi G, Baird GS, Banfi G, Bölenius K, Cadamuro J, Church S, et al. Improving quality in the preanalytical phase through innovation, on behalf of the European Federation for Clinical Chemistry and Laboratory Medicine (EFLM) Working Group for Preanalytical Phase (WG-PRE). *Clin Chem Lab Med* 2017;55:489–500.
21. Lippi G, Banfi G, Church S, Cornes M, De Carli G, Grankvist K, et al. Preanalytical quality improvement. In pursuit of harmony, on behalf of European Federation for Clinical Chemistry and Laboratory Medicine (EFLM) Working group for Preanalytical Phase (WG-PRE). *Clin Chem Lab Med* 2015;53:357–70.
22. Lippi G, Becan-McBride K, Behúlová D, Bowen RA, Church S, Delanghe J, et al. Preanalytical quality improvement: in quality we trust. *Clin Chem Lab Med* 2013;51:229–41.
23. Lippi G, Chance JJ, Church S, Dazzi P, Fontana R, Giavarina D, et al. Preanalytical quality improvement: from dream to reality. *Clin Chem Lab Med* 2011;49:1113–26.
24. Available at: www.eflm.eu/site/page/a/1170. Accessed: 1 Mar 2018.
25. Aakre KM, Langlois MR, Watine J, Barth JH, Baum H, Collinson P, et al. Critical review of laboratory investigations in clinical practice guidelines: proposals for the description of investigation. *Clin Chem Lab Med* 2013;51:1217–26.
26. Nordestgaard BG, Langsted A, Mora S, Kolovou G, Baum H, Bruckert E, et al. Fasting is not routinely required for determination of a lipid profile: clinical and laboratory implications including flagging at desirable concentration cutpoints – a joint consensus statement from the European atherosclerosis society and European federation of clinical chemistry and laboratory medicine. *Clin Chem* 2016;62:930–46.
27. Ceriotti F. Harmonization initiatives in Europe. *EJIFCC* 2016;27:23–9.
28. Ajzner É, Rogic D, Meijer P, Kristoffersen AH, Carraro P, Sozmen E, et al. An international study of how laboratories handle and evaluate patient samples after detecting an unexpected APTT prolongation. *Clin Chem Lab Med* 2015;53:1593–603.
29. Kristoffersen AH, Ajzner E, Rogic D, Sozmen EY, Carraro P, Faria AP, et al. Is D-dimer used according to clinical algorithms in the diagnostic work-up of patients with suspicion of venous thromboembolism? A study in six European countries. *Thromb Res* 2016;142:1–7.

30. Kristoffersen AH, Ajzner E, Bauça JM, Carraro P, Faria AP, Hillarp A, et al. Pre- and post-test probabilities of venous thromboembolism and diagnostic accuracy of D-dimer, estimated by European clinicians working in emergency departments. *Thromb Res* 2017;159:19–23.
31. Watson ID, Oosterhuis WP, Jorgensen PE, Dikmen ZG, Siodmiak J, Jovicic S, et al. A survey of patients' views from eight European countries of interpretive support from Specialists in Laboratory Medicine. *Clin Chem Lab Med* 2017;55:1496–500.
32. Horvath AR, Lord SJ, StJohn A, Sandberg S, Cobbaert CM, Lorenz S, et al. From biomarkers to medical tests: the changing landscape of test evaluation. *Clin Chim Acta* 2014;427:49–57.
33. Monaghan PJ, Lord SJ, St John A, Sandberg S, Cobbaert CM, Lennartz L, et al. Biomarker development targeting unmet clinical needs. *Clin Chim Acta* 2016;460:211–9.
34. Malentacchi F, Mancini I, Brandslund I, Vermeersch P, Schwab M, Marc J, et al. Is laboratory medicine ready for the era of personalized medicine? A survey addressed to laboratory directors of hospitals/academic schools of medicine in Europe. *Clin Chem Lab Med* 2015;53:981–8.
35. Pazzagli M, Malentacchi F, Simi L, Orlando C, Wyrich R, Günther K, et al. SPIDIA-RNA: first external quality assessment for the pre-analytical phase of blood samples used for RNA based analyses. *Methods* 2013;59:20–31.
36. Panteghini M, Ceriotti F, Jones G, Oosterhuis W, Plebani M, Sandberg S. Strategies to define performance specifications in laboratory medicine: 3 years on from the Milan Strategic Conference. *Clin Chem Lab Med* 2017;55:1849–56.
37. Zerah S, McMurray J, Horvath AR. Our profession now has a European name: specialist in laboratory medicine. *Biochem Med (Zagreb)* 2012;22:272–3.
38. Wieringa G, Zerah S, Jansen R, Simundic AM, Queralto J, Solnica B, et al. The EC4 European syllabus for post-graduate training in clinical chemistry and laboratory medicine: version 4 – 2012. *Clin Chem Lab Med* 2012;50:1317–28.
39. McMurray J, Zerah S, Hallworth M, Schuff-Werner P, Haushofer A, Szekeres T, et al. The European Register of Specialists in Clinical Chemistry and Laboratory Medicine: guide to the Register, version 3 – 2010. *Clin Chem Lab Med* 2010;48:999–1008.
40. McMurray J, Zerah S, Hallworth M, Koeller U, Blaton V, Tzatchev K, et al. The European Register of Specialists in Clinical Chemistry and Laboratory Medicine: Code of Conduct, Version 2 – 2008. *Clin Chem Lab Med* 2009;47:372–5.
41. Oosterhuis WP, Zerah S. Laboratory medicine in the European Union. *Clin Chem Lab Med* 2015;53:5–14.

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