



Original

Precision medicine in clinical laboratories in Spain: results from a survey addressed to Laboratory Medicine specialists

La medicina de precisión en los laboratorios clínicos en España: resultados de una encuesta dirigida a especialistas en Medicina de Laboratorio

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ABSTRACT

Introduction: precision medicine (PM) has become a reality in clinical practice, however implementation of this approach is challenging due to their novelty and the highly-specialized knowledge required. Our aim is to describe the situation of PM in clinical laboratories in Spain by reporting the results of a survey addressed to Laboratory Medicine specialists.

Materials and methods: the survey was created by the PM Committee of the Spanish Association of Medical Biopathology-Laboratory Medicine (AEBM-ML). The questionnaire was designed to assess several aspects of PM, mainly: knowledge, specific training, implementation in clinical practice and role of the clinical laboratory. Some survey results were analysed statistically employing Chi-square and Fisher's exact tests.

Results: a total of 113 responses were received from 68 different hospitals/clinics, 77.9 % from staff and 22.1 % from residents in training. Among

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those who had ever heard of PM, 84.9 % knew the concept of PM, but almost half of them did not know whether PM tests were incorporated into clinical guidelines in their centres and had never received any PM training. In 23 centres (33.8 %), an own PM portfolio was developed. In them, almost 40 % of the respondents stated that laboratory specialists have no role in management of PM tests, and that they do not participate or know about their participation in PM research projects.

Conclusions: although PM is a well-known concept among laboratory professionals, our survey shows that they have a limited role in implementing PM tests.

Palabras clave:

Medicina personalizada. Medicina de precisión. Medicina de laboratorio. Encuestas. Formación médica.

RESUMEN

Introducción: la medicina de precisión (MP) es una realidad en la práctica clínica, aunque su implementación supone un reto pues requiere un conocimiento altamente especializado. Nuestro objetivo es describir la situación de la MP en los laboratorios clínicos españoles mediante la descripción de los resultados de una encuesta dirigida a especialistas en Medicina de Laboratorio.

Material y métodos: la encuesta fue creada por el Comité de MP de la Asociación Española de Biopatología Médica - Medicina de Laboratorio (AEBM-ML) y diseñada para evaluar varios aspectos de la MP: conocimiento, formación, implementación en práctica clínica y papel del laboratorio clínico. Algunos resultados fueron analizados estadísticamente con los test chi-cuadrado y exacto de Fisher.

Resultados: se recibieron 113 respuestas de 68 hospitales/clínicas diferentes, un 77,9 % de especialistas y un 22,1 % de residentes. Entre los que señalaron haber oído sobre MP, un 84,9 % conocía el concepto. No obstante, casi un 50 % desconocían si las pruebas de MP estaban incorporadas en guías clínicas y un porcentaje similar no habían recibido nunca formación en MP. En 23 centros (33,8 %), existe una cartera propia de MP. En ellos, en torno a un 40 % de los participantes afirmó que los especialistas del laboratorio clínico no tienen un papel en la supervisión de pruebas de MP ni tampoco participan (o desconocen su participación) en proyectos de investigación en MP.

Conclusiones: aunque el concepto de MP es ampliamente conocido entre los profesionales del laboratorio clínico, nuestra encuesta muestra que su papel es limitado en la implementación de pruebas de MP.

INTRODUCTION

The development of high-performance “omic” technologies, such as genome and complete exomes sequencing, along with the advancement of others such as proteomics, metabolomics, pharmacogenomics, epigenomics, transcriptomics or metagenomics, is accelerating incorporation of personalized medicine into clinical practice (1).

Personalized or precision medicine (PM) is defined as the identification and application of the most effective preventive, diagnostic and therapeutic approaches for each patient (2). PM is a powerful tool to improve treatment effectiveness, avoid unnecessary side effects and rationalize healthcare spending (3).

In 1998 the US Food and Drug Administration (FDA) approved Herceptin for the treatment of breast cancer,

which laid the groundwork for what would be called PM. Herceptin was effective, but only in patients with mutations in the HER2 gene, thereby becoming the first drug in which a gene was associated with a specific treatment (4).

PM is no longer a novel concept, but has become an inherent part of medical practice. PM is especially relevant in pathologies such as cancer, where wide tumour heterogeneity is the main enemy in the fight against it (5,6).

The continuous and recent progress of technologies associated with obtaining molecular and genetic data in individuals, such as DNA sequencing platforms, is allowing an unprecedented advance in biomedical research, expanding knowledge of the molecular basis of genetic diseases and identifying a large number of biomarkers. The introduction of these new analytic techniques, as well as the processing of the associat-

ed data, constitutes a paradigm shift for healthcare, enabling new approaches to address multiple diseases. However, its application on a wide scale also poses important challenges to the incorporation into clinical practice of those approaches with demonstrated safety and cost-effectiveness (7,8).

Clinical laboratories are experiencing large organizational and management changes due to the introduction of PM tests into clinical practice. It is now widely accepted that laboratories should play a role in the four steps required to implement PM assays: research (identification of new biomarkers), internal development (analytical validation), clinical utility (in the context of cost-effectiveness) and data analysis (results report) (9,10). A recent paper showed the importance of laboratory data, both classical biomarkers and those from omics platforms, in longitudinal monitoring of patients, leading to actionable health measures based on PM (11). Therefore, it is important to know how laboratory professionals face this challenge and whether they are successful and recognized players in PM. To date, only one survey in Europe has specifically addressed evaluation of PM from the laboratory point of view. It showed that laboratory specialists were aware of the changes needed in terms of skills, organization and collaboration with other disciplines and specialists (12).

Our aim was to obtain an overall picture of PM situation in clinical laboratories in Spain. To achieve this aim, we designed a survey addressed to specialists in Laboratory Medicine which included questions regarding several aspects of PM: knowledge, specific training, implementation in clinical practice and the role of clinical laboratory professionals in management and research. Here, we describe the main results of this survey, and also some observed differences between professionals (staff vs. residents) regarding training in PM and about the role of clinical laboratory in PM depending on its centre (those in hospitals with their own PM portfolio vs. those without it).

MATERIAL AND METHODS

The survey was developed by the Personalized Medicine Committee of the Spanish Association of Medical Biopathology-Laboratory Medicine (AEBM-ML). The web link to the survey was sent through the email distribution list of the AEBM-ML comprising specialists and residents in the different specialties of Laboratory Medicine who agreed to receive information about news and initiatives of the association. Survey was opened during six months, from March to August in 2018. Participants/respondents were anonymous and a close-ended questionnaire with 30 items was used (Annex 1).

General demographic information requested in the survey included work centre, age, medical specialty, professional situation (staff or specialist in training) and academic degree.

The first questions in the survey aimed to determine overall knowledge about PM and training of participants in PM aspects (questions 0 to 6). In the preliminary question (question 0), participants were asked if they had ever heard of PM. If the answer was no, they were asked to stop and thus to have finished the survey. The subsequent questions concerned PM training: when did they receive the last training, which was the organism responsible for providing that training, what was the usefulness of PM training in daily work, and what was their knowledge of specific plans of regional authorities.

Questions 7 to 23 focused on the availability of PM services in the participant's work centre. If the answer to question 7 ("Has your institution developed a PM laboratory portfolio?") was "yes", respondents were instructed to skip to questions 8 to 19, and if it was "no", to questions 20 to 23. The first block of questions concerned the areas and departments providing PM tests, PM resources in the place of work, quality, residents' training in PM, and incorporation of PM data in the electronic health records. The second block was related to the possibility of requesting PM services from an external centre (public and/or private) and if there were plans to incorporate PM tests in their own centres.

The final block of questions was focused on research in PM and clinical guidelines incorporating PM tests in the place of work (questions 24 to 27), and on interest to reinforce knowledge in PM (questions 28 to 30).

The survey results were analysed statistically by creating contingency tables for categorical data. Chi-square and Fisher's exact tests were calculated using GraphPad v5.0. The level of significance was established at $p < 0.05$.

RESULTS

Demographic data of survey participants

A total of 113 responses were received from 68 different public and private hospitals/clinics. Specialists in Clinical Analyses or Clinical Biochemistry represented 81.4 % of the participants while the remaining responders had other Laboratory-related (Genetics, Haematology or Immunology) or clinical specialties. Regarding professional status, 77.9 % were staff who had completed their specialty and 22.1 % were residents in training. Most respondents were between 20 and 40 years of age (50.5 %), while the remaining were equally distributed between those aged 41-50 years and senior professionals over 50 (23.7 % and 25.8 %, respectively).

Knowledge and training in Personalized Medicine

In the first block of questions (0 to 6) aimed to know about knowledge and training in PM among laborato-

ry professionals, current professional situation (staff or resident in training) was the variable considered for statistical analyses.

In the preliminary question (question 0), only seven respondents had never heard of PM (6.2 %), while the percentage of participants responding "Yes" was higher for specialists in training than for staff (68.0 % vs. 52.3 %) but significance was not reached ($p = 0.37$) (Fig. 1A). Therefore, 106 participants continued answering the entire survey. Among them, 84.9 % understood the concept of PM (question 1). Again, the percentage was higher for residents (95.8 % vs. 81.7 %) (Fig. 1B), although the difference was not statistically significant ($p = 0.11$).

Regarding training, almost half of the participants had never received any specific PM training (48.6 %) (question 2). Significant differences were detected between staff and residents ($p = 0.004$), with the latter showing a higher percentage with training on PM performed in the last year (17.1 % vs. 47.8 %) and a lower percentage with no training at all (50.0 % vs. 43.5 %) (Fig. 1C).

Although the higher interest of residents in PM training, responses regarding adequacy of training to implement PM in their daily work (question 4) showed

an opposite trend in favour of staff, but without statistical significance ($p = 0.16$) (Fig. 1D). Only 28.9 % of participants thought the training was adequate to perform their routine/daily work on PM or to implement new PM assays, and this percentage was higher among staff (33.8 % vs. 13.6 %). On the other hand, the respondents that considered their training adequate, but stated that no facilities for PM implementation were available in their hospitals were mostly residents (29.4 % for staff vs. 45.5 % for residents). Independently of their professional status, a relevant percentage of respondents stated that training was unnecessary as no PM tests were performed in their centres (37.8 %).

In addition, participants were also asked in question 27 if they knew whether PM tests were included in the clinical guidelines employed usually in their centres. Almost half of the participants (46.2 %) stated they did not know, while only one-third of them knew that PM tests were incorporated in their centre's clinical guidelines (34.1 %). In this case, staff showed a higher percentage of knowledge about clinical guidelines incorporating PM tests than residents (38.0 % vs. 20.0 %) (Fig. 1E), but the differences were not significant ($p = 0.15$).

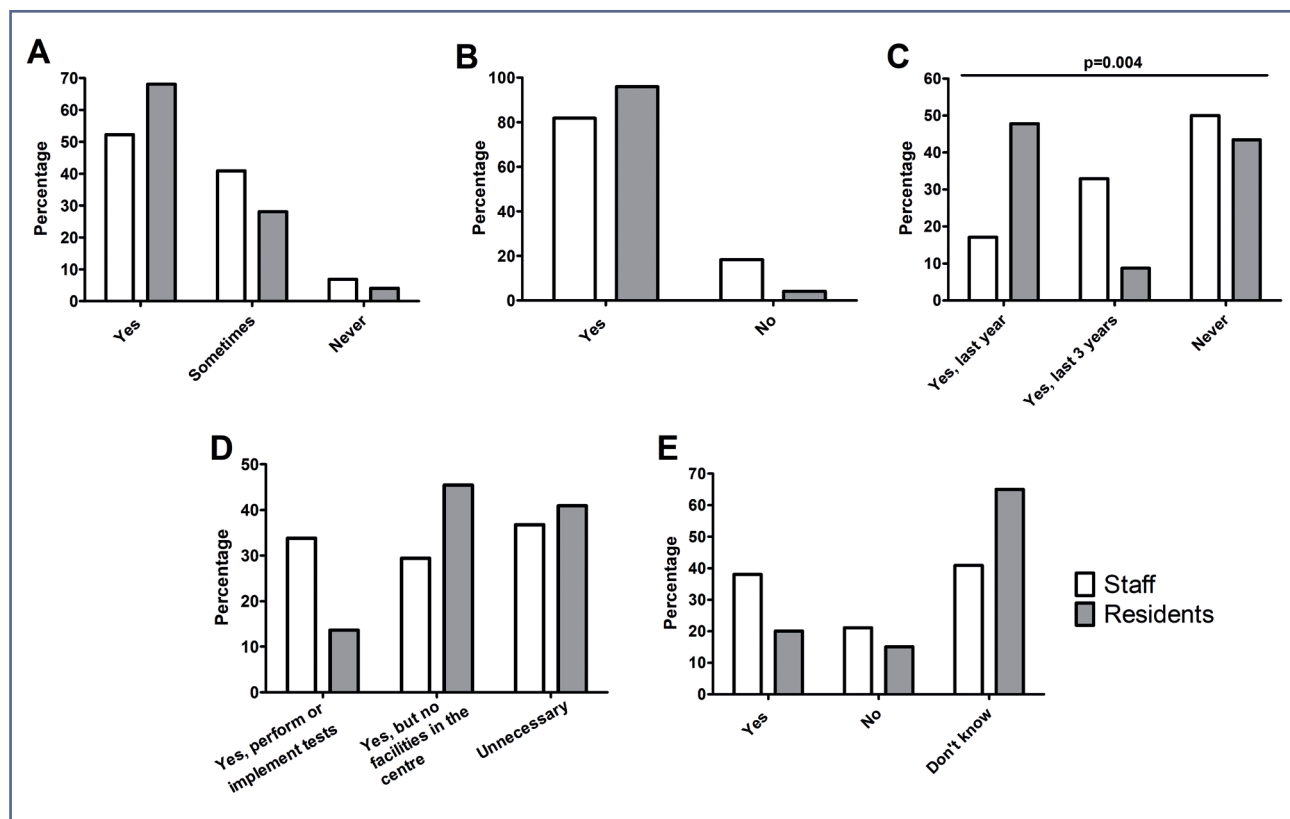


Figure 1 – Responses to survey questions related to knowledge and training in Personalized Medicine according to current professional status. A. "Have you ever heard of Personalized/precision medicine (PM)?" ($n = 113$). B. "Do you know the concept of PM?" ($n = 106$). C. "Have you had formal training in PM?" ($n = 105$). D. "Do you consider that your training is adequate to implement PM in your daily work?" ($n = 90$). E. "Do the clinical guidelines used at your centre incorporate PM tests?" ($n = 91$). p -value was shown for the only comparison between staff and residents that displayed significant differences.

Personalized Medicine implementation in hospitals with their own portfolio

When the participants were asked about the development of an own portfolio of PM in their centres (question 7), 28.7 % responded affirmatively, while most of them stated that there was no portfolio at their institution (32.7 %) or that they did not know (38.6 %). Among the affirmative responses, we observed that they corresponded to 23 different centres (33.8 %) with a mean of 787 beds of (range: 400-1300), and thus pertaining mainly to medium or large tertiary hospitals.

Table I shows relevant characteristics of these centres regarding various PM aspects (responses to questions 8, 12 and 18). The PM tests most readily available in these centres were those intended for targeted disease treatment (73.9 %), whereas PM assays for disease prevention were carried out in only a quarter of them (26.1 %). Regarding accreditation or certification of laboratories performing PM tests at those centres, less than half of them had a licensed laboratory (43.5 %). In over half of the centres (56.5 %), PM test results were regularly incorporated into electronic health records, but this was not the case according to 26.1 % of the respondents.

Finally, most participants (66.7 %) indicated that PM aspects were incorporated into training programs for residents (question 16), suggesting that a majority of future specialists will have at least some basic knowledge before finishing their training period in these centres.

Table I.

Some characteristics of centres with a Personalized Medicine portfolio (n = 23), according to participants' responses

Aspects covered by PM assays (multi-response allowed)	Number of hospitals	%
Targeted treatment of diseases	17	73.9
Diagnosis of monogenic diseases	15	65.2
Support to diagnosis of polygenic diseases	10	43.5
Prevention of diseases	6	26.1
Laboratory accredited or certified		
Yes	10	43.5
No	9	39.1
Don't know	4	17.4
PM test results incorporated into EHR		
Yes	13	56.5
Yes, but only available for certain services	4	17.4
No	6	26.1

PM: Personalized Medicine; EHR: electronic health records.

Role of clinical laboratories in Personalized Medicine

Four of the survey questions aimed to determine the involvement of clinical laboratories in the development and evaluation of PM tests. The factor considered for statistical comparison was whether or not the centre had its own PM portfolio.

Since other medical specialists sometimes request PM tests directly from external centres without any involvement of medical laboratory professionals, the survey asked about the role of the clinical laboratory in prior evaluation of PM tests before they were requested (questions 10 and 22; same question but the first addressed to hospitals with own PM portfolio and the latter to those without it). Although the percentage of responses stating that laboratory medicine specialists always evaluate the PM tests to be requested was higher in centres with their own PM portfolio (31.0 % vs. 16.3 %), the percentage of negative answers was similar for both types of centres (37.9 % vs. 37.2 %), and no statistical differences were found ($p = 0.26$) (Fig. 2A).

As expected, more respondents stated that PM based research projects are developed in centres with their own PM portfolio compared to centres without it (75.9 % vs. 19.7 %; $p < 0.001$) (question 25). Participants responding affirmatively to this question were next asked about the participation of the clinical laboratory in PM research areas (question 26). While 57.7 % of responses indicated that laboratories are somewhat involved in PM research in centres with their own PM portfolio, this percentage decreased to 21.2 % in other centres without such a portfolio due mainly to a high percentage of participants (51.2 %) ignoring if clinical laboratories are involved or not (Fig. 2B). If the three types of responses were considered for the statistical comparison between centres with or without own PM portfolio, significant differences were observed ($p = 0.009$).

DISCUSSION

The development of patient-focused medicine is changing the way clinical laboratories work. The results from emerging techniques such as genomics, transcriptomics, proteomics, metabolomics or metagenomics, together with their integration with classical biochemical and immunological tests, represent a challenge for laboratory professionals. As one of the leading societies of laboratory medicine professionals in Spain, our interest in knowing the current situation of PM led us to develop a survey addressed to laboratory specialists to obtain a global vision of PM in Spanish clinical laboratories. To our knowledge, no previous studies have analyzed that situation. We describe here the results of the first survey in Spain aimed to elucidate some aspects of PM (knowledge, training, implementation and role of clinical laboratories) from the point of view of Laboratory Medicine specialists.

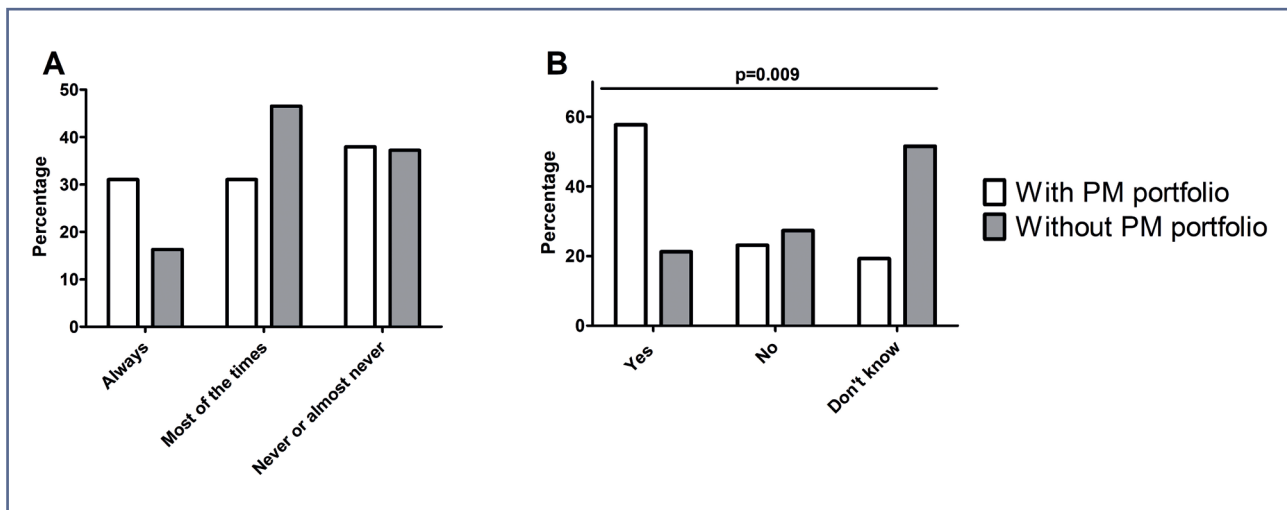


Figure 2 – Responses to survey questions related to the role of clinical laboratories in Personalized Medicine according to development of an own PM portfolio in the centre/hospital. A. “Is there a prior assessment performed by medical laboratory staff on requested PM tests?” (n = 72). B. “Are the clinical laboratories participating in PM based research projects?” (n = 59, limited to those responding “Yes” to the question “Are there PM based research projects in your hospital?”). p-value obtained in the statistical comparison between both groups of centres is shown when significant.

Compared to the survey conducted by the joint working group “Personalized Laboratory Medicine” of the EFLM (European Federation of Clinical Chemistry and Laboratory Medicine) and ESPT (European Society of Pharmacogenomics and Personalised Therapy) (12), our survey has two main differences. First, since our survey was addressed to specialists in Laboratory Medicine, and thus participants were directly involved in laboratory work, whereas the previous survey was directed to “decision markers” in health-care policy of each hospital, and only 50 % of respondents performed laboratory activities. Second, we also received responses from residents in training (22 % of respondents), which allowed us to analyse differences in knowledge and training between this group and staff specialists. In addition, our survey had good national coverage as it was completed by specialists from all autonomous regions in Spain except one (Balearic Islands), representing 68 different public and private hospitals and clinics.

We observed relatively high knowledge of the concept of PM among clinical laboratory professionals (85 %). However, only 34 % of respondents said that PM tests were incorporated in routine guidelines for patient management. Although these results cannot be compared with other countries or regions given that specific surveys for laboratory professionals have not been performed, several surveys have been published regarding physicians’ knowledge and attitudes on PM. The percentage of PM knowledge among Spanish laboratory professionals was higher than that reported for American and German physicians (53 % and 67 %, respectively) (13). Regarding PM skills, the percentage of physicians using PM tests and able to analyse them was slightly lower than the 34 % found in our

survey (20 % for pharmacogenetics and around 30 % for genetic testing). In a survey addressed to physicians working in American projects implementing genomics in clinical practice, one-third of the respondents stated they had adequate training to work with patients who needed PM tests, a percentage similar to that observed in our survey for Spanish laboratory specialists (14). However, only 15 % felt confident enough about their ability to use results from PM tests in clinical practice. Those percentages were markedly higher in surveys of oncologists, as they work in the main area of current PM applications. For example, in a multinational survey of oncologists from 12 countries, 90 % of respondents used PM biomarkers and 63 % reported using them because they were recommended in clinical guidelines (15).

An important finding in our survey is that almost half of the respondents (49 %) had not received any specific training in PM. The main explanation could be the belief that training was unnecessary since no PM tests were performed in their laboratories (38 % of respondents). Conversely, a third of participants had received training even though there were no facilities for PM implementation in their hospitals. This interest in PM training was significantly higher for residents than for staff, showing that future laboratory medicine specialists are increasingly attracted to PM. In agreement with this observation, a previous survey provided data indicating an increase in PM contents at university level, such as in pharmacogenomics (16), which would provide medical and life science students with basic knowledge that could be further expanded. Likewise, another survey addressed to medical students showed their high interest in learning about PM (79 %), although only 6 % considered their university education sufficient to carry

out PM in their professional practice (17). Given this finding, and the fact that PM is a rapidly evolving field, continuous training is essential for professionals to carry out routine PM activities. In addition to conferences and face-to-face courses, online programmes have been reported as a useful tool to improve the use of PM in daily clinical practice (18).

Another interesting observation from our survey was that only one-third of the centres have developed their own portfolio of PM tests. As expected, these centres were mostly large tertiary hospitals, which indicates that PM is far from being implemented in regional or primary hospitals in Spain. In hospitals with their own PM portfolio, pharmacogenetic assays were the mostly widely employed, while tests to support diagnosis of polygenic diseases or to assess disease prevention were only available in less than half of them. As pharmacogenetic testing is crucial for efficient use of certain cancer drugs (19), this finding is consistent with the results of a survey addressed to pathology leaders of 13 centres in the USA and Canada considered as "early adopters" of PM tests: ten of these institutions considered cancer genomics as the primary application of PM, while the remaining three reported that medical genetics was their primary aim in PM (20).

Surprisingly, we observed an unexpectedly low percentage of laboratory certification and incorporation of PM tests in electronic health records (EHR) in hospitals with their own PM portfolio. Respondents were aware of laboratory accreditation or certification in only 44 % of the centres, and they believed that PM test results were regularly incorporated and available in EHR in 57 % of them. Both facts suggest that relevant improvements should still be carried out in Spanish clinical laboratories performing PM tests. Thus, further steps in PM implementation, like whole genome sequencing, do not seem to be feasible at present, as they entail more challenging requirements (21). However, it is widely accepted that clinical integration of whole genome sequencing data will be inevitable in the near future (22). Furthermore, although some genetic data and biological markers are currently available in clinical practice and EHR, the situation of PM remains far from ideal, as clinical decisions must also involve environmental factors and patients' preferences (23).

Although laboratory societies recognize that specialists in Laboratory Medicine should play a key role in PM implementation (24), our survey suggests a disturbing situation for laboratory professionals in Spain. Actually, regardless of whether or not the centre had its own PM portfolio, almost 40 % of respondents stated that PM tests were not supervised by Laboratory Medicine specialists, suggesting a limited role of clinical laboratories in PM management in routine work. In addition, the percentage of participation in research projects related to PM varied significantly between centres with and without their own PM portfolio, with the latter having only 21 % of respondents stating that labora-

tories were involved in PM research. These findings suggest that clinical laboratories need to work toward a more active and higher-profile role in PM research projects, especially in centres that lack their own PM portfolio but are involved in research. In the same way, the results of the EFLM survey showed that laboratory professionals are aware of their role in PM, but also that PM implementation will require relevant changes in specialists' skills, service organization and enhanced collaboration within laboratory disciplines and with clinicians (12). The activities and harmonization initiatives led by the EFLM working group on Personalized Laboratory Medicine should help to stimulate a more active role of laboratory professionals in PM (25).

Our survey and the results obtained from it have some limitations that should be mentioned. First, it is likely that a bias towards a reported higher percentage of knowledge and training in PM exists, since more Laboratory Medicine specialists with strong interest in PM were probably responding to the survey than those with no interest neither previous experience with PM. Second, the number of responses could have been larger given that our society comprises almost 1300 members. Finally, some of the participants that should have completed the whole questionnaire ($n = 106$) did not provide responses for several questions, which explained the reduced number of responses in the informed results.

In conclusion, PM is a well-known concept among Laboratory Medicine specialists in Spain, although only one-third of them are involved in routine implementation and clinical application of PM tests. There is a growing interest in PM-related training, especially among residents, even in those centres where PM tests were not performed. Several large Spanish hospitals have developed their own PM portfolio, which facilitates laboratory residents' contact with PM and the participation of clinical laboratories in research projects related to PM. However, our survey results also reflect a limited role for specialists in Laboratory Medicine in Spain, or at least a smaller role than would be expected, with regard to implementation and surveillance of the demand for PM tests. Therefore, Spanish laboratory specialists will have to make an effort to adapt their curriculum and abilities to the challenge represented by PM if they want to be acknowledged as key players.

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Annex 1

English translation (originally in Spanish) of the questionnaire survey used in the study.

Web: <https://form.jotform.com/73371324111949>

DEMOGRAPHIC DATA:

- a) Hospital/Centre
- b) Age
- c) Medical specialty
- d) Staff or resident in training
- e) Academic degree

QUESTIONS

0. Have you ever heard about Personalized/precision medicine (PM)?
(Yes/ Sometimes/Never)
If "Never", participants were requested to not continue and finish the survey.
1. Do you know the concept of PM?
(Yes/No)
2. Have you had formal training in PM?
(Yes, in the last year/Yes, in the last three years/Never)
3. Which organization has provided this training?
(Hospital/ University/Commercial/ Scientific Society/Regional stakeholder)
4. Do you consider that your training is adequate to implement PM in your daily work?
(Yes, to perform routine tests or implement new ones/Yes, but there are no facilities in my centre/It is unnecessary as I don't perform any MP tests)
5. Do you know if there is a PM program in your area/region?
(Yes/No/I don't know)
6. If there is one, do you know which organism developed it?
(Yes/No/I don't know)
7. Has your institution developed a PM laboratory portfolio?
(Yes/No/I don't know)
If "Yes", participants were requested to answer questions 8 to 19, and not to respond to questions 20 to 23.
If "No" or "I don't know", participants were requested to skip directly to question 20.
8. If there is one, in what areas?
(Prevention of diseases/Diagnosis of monogenic diseases/Support to diagnosis of polygenic diseases/ Targeted treatment of diseases)
9. What departments offer MP tests and/or contributed to their implementation and demand management?
(Pharmacy/Genetics/Clinical Laboratory/Oncology/Pathology)
10. Is there a prior assessment performed by medical laboratory staff on requested PM tests?
(Always/Most of the times/Almost never/Never)
11. Detail PM assets available at your institution
(Pharmacogenetics/Genomics/Onco-genetics/Bioinformatics/Other: transcriptomics, proteomics, metabolomics)
12. At your institution, are the laboratories performing PM tests certified, or do they have any other kind of license?
(Yes/No/I don't know)
13. Do they participate in quality control programs?
(Yes/No/I don't know)
14. Is there a registry for all the tests performed (in house and externalized)?
(Yes/No/I don't know)

15. Does your institution have an annual report compiling PM tests performed and their results? (Yes/No/I don't know)
16. Are there PM subjects in the resident's training programs? (Yes/No/I don't know)
17. How frequently are PM tests requested at your institution? (Weekly/Monthly/Every 3 months)
18. Are PM results regularly incorporated into electronic health records? (Yes/Yes, but only available for certain services/No)
19. Do you consider that PM tests available at your institution are adequate? (Yes/No)
20. If the PM tests are not performed in your hospital, can you request them from external laboratories? (Yes/No)
21. If yes, to which kind of laboratory are the samples sent? (Public/Private/Academic-research)
22. Is there a prior assessment performed by medical laboratory staff on requested PM tests? (Always/Most of the times/Almost never/Never)
23. Is there a roadmap design to implement PM at your hospital? (Yes/No/I don't know)
24. Are there joint sessions involving several departments to discuss PM patients/items? (Yes/No/I don't know)
25. Are there PM based research projects in your hospital? (Yes/No/I don't know)
26. If "Yes," are the clinical laboratories participating in them? (Yes/No/I don't know)
27. Do the clinical guidelines used at your centre incorporate PM tests? (Yes/No/I don't know)
28. Do you feel that you should reinforce your knowledge of PM aspects? (Yes/No)
29. If "Yes," what would be the best option? (Clinical sessions/Online courses/Postgraduate courses/Symposia/Conferences)
30. Propose a title for a training course on MP that you would like to attend.

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