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Costs analysis of a training intervention for the reduction of preanalytical errors in primary care samples

Adolfo Romero, PhD[a], Juan Gómez-Salgado, PhD[b,c,*], Adolfo Romero-Arana, MIH[d], Mónica Ortega-Moreno, PhD[e], Francisco Jódar-Sánchez, PhD[f], Carlos Ruiz-Frutos, PhD[b,c]

Abstract

Background: To perform a cost-error analysis based on a quasi-experimental pre-post study of the preanalytical errors in 2 hospital laboratories. The real cost and theoretical cost are defined as the cost resulting from errors with or without the training intervention. The real impact associated to the training program was estimated, calculated as the total associated to the preanalytical errors cost difference. The costs were measured using Andalusian Public Health Service fees. Cost analysis of an educational intervention presented in a previous study from 2017. Preanalytical errors were detected in the laboratories of the University Hospital Virgen de la Victoria (Málaga, Spain) and in the University Hospital Juan Ramón Jiménez (Huelva, Spain).

Methods: The founded errors were divided into blood and urine samples. Univariate sensitivity analysis was used to assess how parameter uncertainty impacted on overall results. Variations of parameters between 0% and 5% were substituted into the base case.

Results: The real impact associated with educational intervention in LAB1 was an increase of €16,961.378, and the expected impact was an increase €78,745.27 (difference of €61,783.9). In LAB2, the real impact in the same period amounted to €260,195.37, and the expected impact was €193,905.83 (difference of −€66,289.54). The results were different in the 2 laboratories, proving the intervention in only one of them to be more effective.

Conclusions: Costs analysis determined that this training intervention can provide saves in the costs, as the effectiveness of the educational sessions in reducing preanalytical errors currently results in a significant decrease of the costs associated with these errors.

Abbreviations: APEAS = Atención Primaria Efectos Adversos, LAB1 = Laboratory of the University Hospital Virgen de la Victoria, Málaga, LAB2 = Laboratory of the University Hospital Juan Ramón Jiménez, Huelva, PC = primary care.

Keywords: economic analysis, errors, laboratory, preanalytical, primary care

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

[a] Nursing and Podiatry Department, University Hospital Virgen de la Victoria, Health Sciences School, University of Málaga, IBIMA (Institute of Biomedicine Research, Málaga), Málaga, [b] Department of Sociology, Social Work and Public Health, Faculty of Labour Sciences, University of Huelva, Huelva, Spain, [c] Safety and Health Postgraduate Programme, Universidad Espíritu Santo, Guayaquil, Ecuador, [d] Andalusian Public Foundation for the Biomedical Research in Malaga (FIMABIS), Málaga, [e] Department of Economy, University of Huelva, Huelva, [f] Biomedical Informatics, Biomedical Engineering and Health Economy, Institute of Biomedicine Research of Seville (IBiS), Virgen del Rocío University Hospital, University of Seville, Seville, Spain.

[*] Correspondence: Juan Gómez-Salgado, Universidad de Huelva, Huelva, Spain (e-mail: salgado@uhu.es).

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1. Introduction

The presence of errors in health care is an indisputable fact which has been widely reported in the literature. In our field of action (laboratory preanalytical phase research), the time in which a higher number of errors have been classically detected is in this period, when professionals from different disciplines converge and collaborate.[1] The preanalytical phase is included into the laboratory process and involves since a sample is requested until is delivered and prepared into the laboratory for processing.[1]

For years, several lines of research have been developed that have influenced reports about the presence of errors in this laboratory process phase and, also, the establishment of actions that can minimize the impact of the problem, analyzing them in different laboratory areas and including samples from both primary and urgent care.[2–6]

Although the presence of errors in health care is a risk well known both by patients and professionals, we must insist on the responsibility health professionals have for the care of the population as something indisputable, so programs are needed to meet the principle "primus non nocere" and to prevent any damage to the population.[7] The prevalence of adverse effects in the laboratory process detected in the *APEAS* study (Study on the Safety of Patients in Primary Health Care - *Estudio de Efectos Adversos en Atención Primaria*) describes that 9.6 visits of every 1000 generated an adverse effect for the patient in primary care

(PC), although its severity level is low.[8] The nondetection of these errors causes a risk of potential harm, as they can induce false diagnoses or erroneous assessments in the evolution of the patients that may occur when a preanalytical error is not detected. These errors could become serious, so a proper management of them is essential.[9]

A higher frequency of errors is detected in samples from PC,[6] so the line of action was focused on intervening in this health area. For this, a standardized educational intervention aimed at nurses was chosen, which proved to be effective in the hospital environment.[10] However, its first application in PC was not successful,[11] which forced to rethink the design of the intervention, extending it to all the staff involved in the preanalytical phase and including 2 health areas of similar characteristics. For this, different actions were established such were to directly ask the sources,[12–14] thus revealing that 2 of the most identified aspects by those involved in the preanalytical phase are the lack of coordination and the lack of training. These interventions proved to be completely effective in one of the laboratories involved, while in the other, for different reasons, it was not.[14] In fact, a research line was developed, with several grants funding from different national and regional institutions, which included the study on the presence of this kind of errors in different health environments, including a qualitative approach (never made before).[12,13]

Within the same research line, a specific objective was included to perform costs analysis so as to assess the possible cost saving resulting from the reduction of errors (decrease of medical consultations, sampling, and laboratory analysis). This is a scarcely reported aspect in the literature, especially in this specific field, although the implementation of such measures could result in cost saving, both direct and indirect.[15,16]

It is necessary to bear in mind that although the laboratory expenditure usually represents slightly <5% of the total hospital expenditure, analytical tests influence two-thirds of the total number of clinical decisions, and to perform them in excess can contribute to the increase of clinical practice-related adverse events and also an increase in health expenditure, being preventable many of these procedures.[17] Therefore, the objective of the present study is to assess the possible cost saving related to an educational intervention designed to reduce preanalytical errors in samples from PC analyzed in a previous study.[14]

2. Methods

2.1. Study design

A follow-up cost analysis of an educational intervention presented in a previous study from 2017 was performed.[14] Firstly, preanalytical errors detected in the University Hospital Virgen de la Victoria, Málaga (LAB1) and in the University Hospital Juan Ramón Jiménez, Huelva (LAB2) laboratories were determined, considering their similar characteristics.

Then, a series of training sessions for all the PC staff involved in the preanalytical phase were subsequently carried out. Once these series of sessions in both health areas were performed, a new determination of preanalytical errors (1 year after the first one, both during October and November) was carried out, whose data have been previously reported.[14]

2.2. Training sessions

We planned and conducted a series of 1-hour clinical update sessions, which were adapted and standardized for each group of professionals and consisted of:

1. Introduction
2. Urine and blood analyses: paper request form and intranet formularies
3. Withdrawal of blood samples: peculiarities
4. Causes of analytical interferences
5. Sample delivery circuit

The physicians' sessions were prepared and implemented by a general practitioner, a clinical chemistry specialist, and a hematologist. The nurses' sessions were prepared and implemented by community nurses. Auxiliary and administrative personnel were instructed by both physicians and nurses from our research group.[14]

2.3. Costs

It is assumed that a preanalytical error brings a 2nd medical consultation, a 2nd nursing consultation, and another sample test (blood or urine). The costs of the process were calculated using prices from the Andalusian Health Service,[18] in which the 2nd medical consultation (medical review) is considered to have a cost of €17.84. The nursing consultation (includes sampling) has a cost of €20.88, and the test average is of €16.1 (with determination of blood count, blood glucose, uremia, ions, creatinine, total cholesterol, high-density lipoprotein and low-density lipoprotein, alanine aminotransferase (ALT), and systematic urinalysis - urine test included urinary sediment), taken by following the standard analytical method for being the most requested tests to PC patients in our health areas. The blood test presupposes a cost of €13.77 and the urine test (urinary sediment cost, including systematic urinalysis) of €2.33.

The real cost is defined as the cost resulting from errors after the intervention, while the theoretical cost is defined as that which would have resulted from the same errors as those in the previous period of study, that is, without performing the intervention.

Cost of training actions was obtained from the computing of 1 teaching hour, according to the current regulation in the Health Ministry of the Government of Andalusia for Andalusian public health system academic fees (€62 in the first session and €52 in the successive ones), by the number of sessions to perform in the field.

The impact associated to the training program was estimated. This has been calculated as the total expense minus the difference in the cost of preanalytical errors (posteducational intervention vs pre-educational intervention), and subtracting the cost of the training program.

The training program's expected impact was estimated in the same way, although the assumed theoretical cost was calculated taking into consideration the overall number of tests performed after the educational intervention if the previous percentage of errors was the same than the one found before the intervention.

2.4. Statistical analysis

We performed a descriptive analysis of preanalytical errors found in both laboratories, and they were divided into blood and urine samples.

Univariate sensitivity analysis was used to assess how parameter uncertainty impacted on overall results of the training program (posteducational intervention cost vs pre-educational intervention cost). All parameters were subjected to sensitivity analysis: blood test number (pre and post period), urine test number (pre and post period), blood test cost, urine test cost, PC

consultation cost, nursing consultation cost, and training sessions cost. Variations of parameters between 0% and 5% were substituted into the base case.

2.5. Ethics approval and consent to participate

This study was approved by an Ethics Committee in Clinical Investigation. The participants were invited to participate voluntarily in these sessions. This manuscript does not report human data.

3. Results

3.1. Participants in the educational intervention

Overall, 637 nurses, 573 physicians, and 435 members of the auxiliary and administrative staff of the Malaga hospital were invited to participate, of whom 578 (91%), 544 (95%), and 386 (89%), respectively, attended the sessions. In Huelva, 363 nurses, 362 physicians, and 343 members of the auxiliary and administrative staff were invited, and 323 (89%), 350 (97%), and 304 (89%), respectively, attended the sessions.[14]

3.2. Preanalytical errors

The incidence of preanalytical errors in the 2 included centers was analyzed. In LAB1, in the first period (2013), a preanalytical error percentage of 3.46 was observed. In the 2nd period (2015), the percentage was 2.43. In blood samples, in the first period, the percentage was 4.16, and 1.32 in urine samples, while in the 2nd period it was 3.48 and 0.94, respectively. In LAB2, 2.97% of errors was found in 2013, and 3.79% in 2015. Regarding blood samples, errors in both periods were, respectively, 2.2% and 3.61%; and as for urine samples, 4.98% and 4.01%, respectively (Table 1).

The theoretical number of errors in LAB1 was calculated assuming the number of tests performed in 2015 and applying the errors percentages of 2013 (previously to the training session program), so these errors would have been 5523 for blood samples and 1254 for urine samples. In LAB2, it would have been 2909 for blood samples and 4298 for urine samples, respectively.

3.3. Costs of preanalytical errors

The costs of a preanalytical error is calculated as the total expense minus the difference in the cost of preanalytical errors, obtained from the expenditure generated from a 2nd medical consultation, the nursing action, and the repeated test, stating an average cost of these errors, regarding the basis described in the public fees[18]:

Table 1

Preanalytical errors in both laboratories.

	Laboratory 1	Laboratory 2
Preeducational intervention		
Blood errors	4651 (4.16)	1543 (2.2)
Urine errors	486 (1.32)	1342 (4.98)
All errors	5137 (3.46)	2885 (2.97)
Posteducational intervention		
Blood errors	4624 (3.48)	4776 (3.61)
Urine errors	898 (0.94)	3526 (4,01)
All errors	5522 (2.43)	8302 (3.79)

Data are presented as n (%).

Table 2

Impact of educational intervention (€)*.

Cost component	Laboratory 1	Laboratory 2
Preeducational intervention	€264,081.29	€136,081.17
Blood samples	€244,130.99	€80,992.07
Primary care consultation	€82,973.84	€27,527.12
Nursing consultation	€97,112.88	€32,217.84
Samples test	€64,044.27	€21,247.11
Urine samples	€19,950.30	€55,089.10
Second primary care consultation	€8670.24	€23,941.28
Nursing consultation	€10,147.68	€28,020.96
Samples test	€1132.38	€3126.86
Posteducational intervention	€279,576.66	€395,434.54
Blood samples	€242,713.76	€250,692.24
Primary care consultation	€82,492.16	€85,203.84
Nursing consultation	€96,549.12	€99,722.88
Samples test	€63,672.48	€65,765.52
Urine samples	€36,862.90	€144,742.30
Second primary care consultation	€16,020.32	€62,903.84
Nursing consultation	€18,750.24	€73,622.88
Samples test	€2092.34	€8215.58
Theoretical	€341,360.56	€329,145.00
Blood samples	€289,881.69	€152,702.33
Primary care consultation	€98,523.33	€51,899.59
Nursing consultation	€115,312.06	€60,743.47
Samples test	€76,046.31	€40,059.27
Urine samples	€51,478.87	€176,442.67
Second primary care consultation	€22,372.30	€76,680.57
Nursing consultation	€26,184.62	€89,747.21
Samples test	€2921.94	€10,014.89

* Unit cost: Blood samples €13.77. Urine test €2.53. Second doctor consultation €17.84. Second nursing consultation €20.88 (this consultation includes blood sampling cost).

€13.77 blood sample errors and €2.33 for urine. The associated cost to a blood and urine error was respectively of €52.49 and €41.05, respectively. Table 2 shows the cost analysis.

The real impact associated with educational intervention in LAB1 was an increase of €16,961.378, and the expected impact was an increase €78,745.27, which represents a difference of €61,783.9. In LAB2, the real impact in the same period amounted to €260,195.37, and the expected impact was €193,905.83, with a difference of −€66,289.54, as depicted in Figure 1.

3.4. Cost of training actions

Based on the standardized prices,[19] the cost of the training sessions was €1466 and €842 in LAB1 and LAB2, respectively.

3.5. Sensitivity Analysis

Both Figures 2 and 3 show the effect of parameters' variation on the real impact of the training program. In LAB1, the parameter of greater uncertainty in the sensitivity analysis was the number of blood test (pre- and postintervention). In LAB2, the parameters of greater uncertainty in the sensitivity analysis were the number of blood and urine test (pre and post intervention).

The real impact in LAB1 was estimated at €16,961.37 (base case). Variation in the number of blood tests in the post-intervention period caused an increase in the real impact of €12,135.69, so this cost is estimated at €29,097.06. On the contrary, variation in the number of blood tests in the preintervention period was associated with a decrease in real impact of €12,206.55, so this impact is estimated at €4754.82.

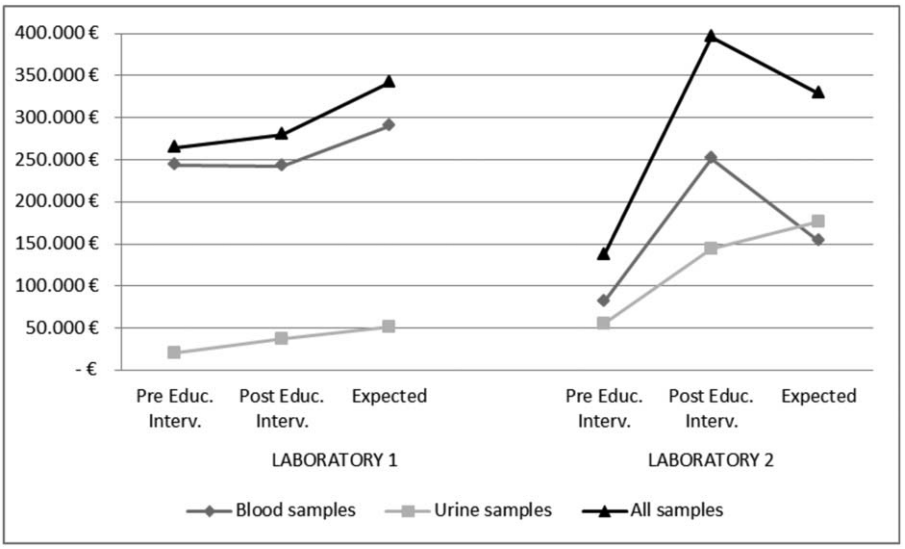

Figure 1. Real and expected costs in pre- and postintervention periods.

The same trend has been found in LAB2, with an intervention's real impact estimated at €260,195.37 (base case). Variation in blood test number in the postintervention period caused an increase in real impact of €12,534.61, which is estimated at €272,729.98. On the contrary, the variation in the number of blood tests in the preintervention period was associated to a decrease in the real impact of €4049.60, which is estimated at €256,145.77. Variation in urine test number in the post-intervention period caused an increase in real impact of €7237.12, which is estimated at €267,432.48. On the contrary, the variation in the number of urine tests in the preintervention period was associated to a decrease in the real impact of €2754.46, which is estimated at €257,440.92.

4. Discussion

As we reported in the introduction, laboratory expenditure represents a relatively important cost of the hospital budget, but it greatly influences clinical decisions, so it can indirectly influence more than what figures show in these budgets.[18] In addition, a good laboratory management can reduce direct and indirect costs if the results are safer,[18] and in this case, it can be argued that the presence of preanalytical errors can compromise the validity of the results, so the actions aimed to prevent them or to avoid them must be considered.[19] On the contrary, we did not find in the literature any report dealing with the economic impact of this kind of intervention, which seems to be cost effective. The only study that we found was a cost analysis and cost effectiveness in

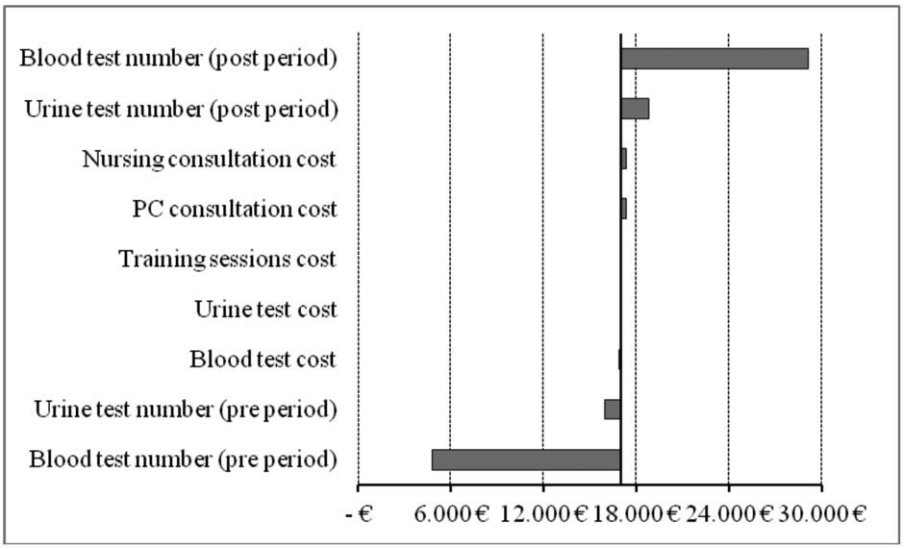

Figure 2. Sensitivity analysis of real impact (LAB1).

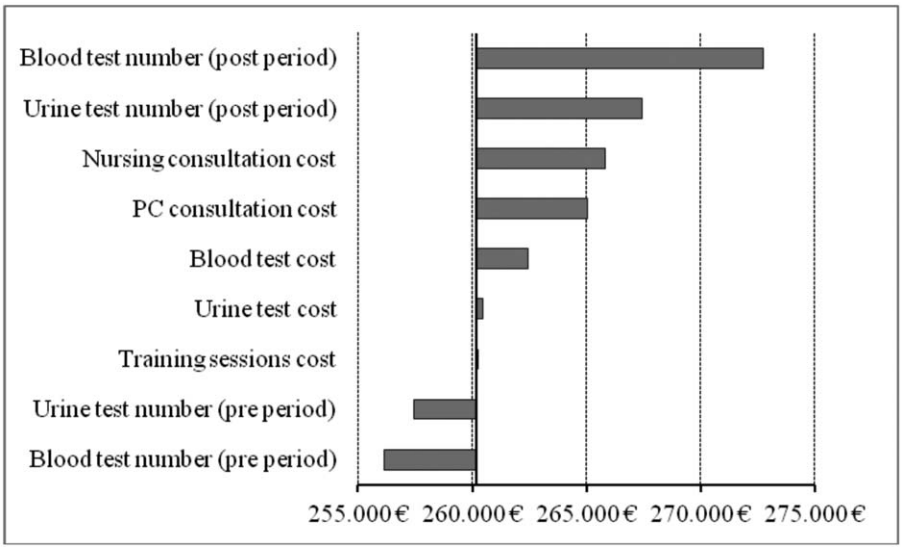

Figure 3. Sensitivity analysis of real impact (LAB2).

PC nurses acting as diabetes educators.[20] Further, we did not found studies that focused the attention into preanalytical phase.

The results obtained offer us different interpretations; first, due to its low cost and its potentially high usefulness, the standardization of clinical update sessions on the preanalytical phase can be a strategy towards the reduction of the number of errors and, therefore, of its economic impact in our public health system, as can be seen in the data obtained from LAB1.

The 2nd interpretation has to do with the "extra cost" of LAB2, at the expense of, firstly, the increase in the percentage of total errors (though there is a decrease in urine samples) and, secondly, to the increase in the number of samples. This makes the possible saving or the decrease in expenditure associated with the educational intervention invaluable, since in the 2nd period of the study 121,665 more samples were processed than in the first period (more than double the total). The main cause of this increase was the reception of samples from another laboratory due to the centralization of samples, which explains, without any doubt, the figures disparity in both periods.[14] At the same time, this justifies that despite a decline of the percentage of errors in urine samples, the cost increase is kept.

On the contrary, and as we previously mentioned in another study, there is a delay between the acquisition of knowledge and its application to the clinical practice, which could explain the increase of errors in LAB2.[14] In fact, when these changes are proposed out of the training sessions experience, it is necessary to provide with measures that ensure a periodicity to prevent both the loss of expertise and its lack of updating.[14,21] The cost associated with these activities (a total of €2308) should not be an obstacle for this purpose, especially when it is found that the total expenditure in each laboratory is practically balanced, so reducing costs might be possible in case of a reduction of errors in LAB2, as we expect in a near future.

The sensitivity analysis shows how the variations in each of the elements included may affect the overall results. Although the major costs are associated to blood samples, urine samples have more influence in this analysis due to the elevated number of urine tests. The cost is only one of the components of the sensitivity analysis, but the variations in this parameter, in this case, have little effect on the overall results.

The main limitation of our study is that we could not find out when a preanalytical error really caused a new visit to PC. This leads us to assume that every error causes a visit but, actually, this assumption cannot be taken as exactly valid, so probably the amounts showed in this study could be higher than the real costs, although the possible costs saving remains high. As for the clinical laboratory, errors that occur in the preanalytical phase may imply up to 75% of the total laboratory errors. It is estimated that 26% may have detrimental effects on patient care, including unnecessary investigations or inappropriate treatment, increasing lengths of hospital stay, as well as dissatisfaction with the healthcare services.[22]

For all these reasons, it needs to be considered that the data provided by the clinical laboratory should be seen as a key part of the health system and must be assessed accordingly.[23] Therefore, all measures related to improving the management in these areas should promote efficiency, as it seems to happen with our training session's program. The expenditure associated with this process is significantly lower than the associated cost, for example, to pharmaceuticals,[23] and the effectiveness of the training sessions in reducing preanalytical errors currently result in a significant decrease of the costs associated with these errors.

We keep in mind that, although the differences between Spanish and American health systems are remarkable, the interest in cost savings is present throughout the world, and the strategies to achieve it must be taken into consideration.

An improvement procedure might be the utilization of internet services, as a study performed in the United States did. Authors found that the online in-service provided training that was equivalent to in-person sessions based on first-hand supervisor observation, participant satisfaction surveys, and follow-up results. The method saves time and money, and requires fewer personnel and would not need to travel to health centers.[24] We pretend to continue investigating this economical approach.

Author contributions

Conceptualization: Adolfo Romero, Juan Gómez-Salgado.
Data curation: Adolfo Romero-Arana, Mónica Ortega-Moreno, Francisco Jódar-Sánchez.
Formal analysis: Adolfo Romero, Adolfo Romero-Arana, Mónica Ortega-Moreno, Francisco Jódar-Sánchez.
Investigation: Juan Gómez-Salgado, Mónica Ortega-Moreno.
Methodology: Adolfo Romero, Juan Gómez-Salgado, Francisco Jódar-Sánchez, Carlos Ruiz-Frutos.
Project administration: Adolfo Romero, Juan Gómez-Salgado.
Resources: Juan Gómez-Salgado, Adolfo Romero-Arana, Mónica Ortega-Moreno, Francisco Jódar-Sánchez.
Software: Mónica Ortega-Moreno, Francisco Jódar-Sánchez.
Supervision: Adolfo Romero, Juan Gómez-Salgado.
Validation: Adolfo Romero-Arana, Mónica Ortega-Moreno, Carlos Ruiz-Frutos.
Visualization: Francisco Jódar-Sánchez.
Writing – original draft: Adolfo Romero, Juan Gómez-Salgado, Adolfo Romero-Arana, Mónica Ortega-Moreno, Francisco Jódar-Sánchez, Carlos Ruiz-Frutos.
Writing – review & editing: Adolfo Romero, Juan Gómez-Salgado, Carlos Ruiz-Frutos.

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