



DYNA  
ISSN: 0012-7353  
ISSN: 2346-2183  
Universidad Nacional de Colombia

# Multicriterial analysis for the prioritization of technological alternatives for POCT blood gas equipment procurement in a high-complexity healthcare institution

**Bocanegra-Villegas, Laura Valentina; Osorio-Salgado, Juan Camilo; Usaquén-Perilla, Sandra Patricia; García-Melo, José Isidro**

Multicriterial analysis for the prioritization of technological alternatives for POCT blood gas equipment procurement in a high-complexity healthcare institution

DYNA, vol. 87, no. 212, 2020

Universidad Nacional de Colombia

**Available in:** <http://www.redalyc.org/articulo.oa?id=49663642026>

**DOI:** 10.15446/dyna.v87n212.81192

# Multicriterial analysis for the prioritization of technological alternatives for POCT blood gas equipment procurement in a high-complexity healthcare institution

Análisis multicriterio para la priorización de alternativas tecnológicas en la adquisición de equipos POCT de gases sanguíneos en una institución de salud de alta complejidad

Laura Valentina Bocanegra-Villegas <sup>a</sup>  
laura.bocanegra@correounivalle.edu.co  
*Universidad del Valle, Colombia*

Juan Camilo Osorio-Salgado <sup>a</sup>  
juan.c.osorio@correounivalle.edu.co  
*Universidad del Valle, Colombia*

Sandra Patricia Usaquén-Perilla <sup>b</sup>  
sandra.usaquen@correounivalle.edu.co  
*Universidad Militar Nueva Granada, Colombia*

José Isidro García-Melo <sup>c</sup> jose.i.garcia@correounivalle.edu.co  
*Universidad del Valle, Colombia*

DYNA, vol. 87, no. 212, 2020

Universidad Nacional de Colombia

Received: 21 July 2019

Revised document received: 06 February 2020

Accepted: 17 February 2020

DOI: 10.15446/dyna.v87n212.81192

CC BY-NC-ND

**Abstract:** This study proposes a multi-criteria analysis for the prioritization of alternatives for POCT blood gas analysis equipment procurement in a high-complexity healthcare institution through the Analytic Hierarchy Process (AHP). This work is presented as a tool for hospitals and is based on the Health Technology Assessment (HTA) model that supports the decision-making process in the acquisition of medical equipment. For this, criteria, sub-criteria and assessment instruments were identified based on the Core and mini-HTA models, review of scientific articles and healthcare institution requirements for high-complexity healthcare. The proposed approach was applied to the procurement process of POCT equipment in a healthcare institution in the city of Santiago de Cali-Colombia. As a result, the current procurement process was simplified by identifying five criteria and eleven sub-criteria that allowed the prioritization of POCT blood gas analysis equipment alternatives. Furthermore, three criteria with greater relevance were identified in the technological selection process.

**Keywords:** POCT- Point of Care Testing, blood gas analyzer, HTA-Health Technology Assessment, MCDA- Multi-Criteria Decision Analysis, AHP- Analytic Hierarchy Process.

**Resumen:** Este estudio propone un análisis multicriterio para la priorización de alternativas de equipos POCT de gases sanguíneos en una Institución Prestadora de Servicios de salud (IPS) de alta complejidad mediante el Proceso de Análisis Jerárquico (AHP). El trabajo presenta una herramienta a nivel hospitalario basada en la Evaluación de Tecnologías en Salud (ETES) que apoya el proceso de toma de decisiones en la adquisición de equipos médicos. Se identificaron criterios, sub-criterios e instrumentos de evaluación basados en los modelos Core, mini-HTA, revisión artículos científicos y los requisitos de IPS para atención de alta complejidad. Fue aplicado al proceso de

selección de equipos POCT en una IPS de la ciudad de Santiago de Cali-Colombia. Se simplificó el proceso actual mediante la identificación de cinco criterios y once sub-criterios que permitieron la priorización de alternativas de equipos POCT de gases sanguíneos, identificando tres criterios con una mayor relevancia en la selección tecnológica.

**Palabras clave:** POCT- pruebas en el punto de cuidado, analizador de gases sanguíneo, ETES-evaluación de tecnologías en salud, MCDA- análisis de decisión multicriterio, AHP- proceso de análisis jerárquico.

## 1. Introduction

Currently, the medical devices industry is a highly relevant and dynamic healthcare sector. According to the World Health Organization (WHO), worldwide, the yearly sales of this type of technology exceeded USD\$ 210,000 million, representing an annual growth rate of approximately 6% [1]. In the area of clinical diagnosis, the technological advancement of these devices has brought laboratory tests closer to the patient. This type of testing is termed: Point of Care Testing (POCT) [2,3]. Considering the advantages of obtaining timely readings of the biological parameters required to define the patient's most appropriate treatment, these types of device have managed to permeate the organizational culture of the healthcare institution in departments / critical areas outside hospitals (home care, General Practitioner's surgery and primary care) and in hospitals (emergency rooms, conventional and intensive care units) [4]. As a result, currently, one in four tests is carried out at the patient care site, with a growth rate of 12% per year [5]. Specifically, for the global market of POCT diagnostic devices, a projection from USD\$ 23.7 billion in 2017 to USD\$ 38.1 billion in 2022 is estimated [6].

Considering their characteristics, POCT equipment is instrumental to governments in developing economies when drafting proposals for improvement of healthcare quality and coverage in a decentralized manner. In [7] an evaluation of the implementation of decentralization policies in three Latin American countries: Chile, Bolivia and Colombia was carried out. In [8] the decentralization experience was analyzed in four developing countries: Ghana, Zambia, Uganda and the Philippines. In addition, [9] presents the evaluation of decentralization policies in Pakistan. In general terms, the results of these evaluations show the need for technological equipment, such as POCT, to consolidate improvements in these healthcare systems [10]. Specifically, according to [4], the growing demand for this type of analyzer ensures continuous evolution of different aspects, such as: manufacturing, design, cost reduction, portability and reduction of the exposure of personnel to waste, among others. As a consequence, multidisciplinary assessments of technology are increasingly necessary, taking into account the impact on the healthcare institution, benefits, risks and investments [11]. Additionally, decision making for the selection of medical devices should consider the characteristics of the user interfaces, given that the clinical outcomes may be influenced by the training, competence and experience

of the end user [12-14]. In this sense, Health Technology Assessment (HTA) is a comprehensive form of research that examines the short and long-term technical, social, economic, ethical and legal consequences derived from the use of technology (direct or indirect) and its desired and undesired effects [15].

Hospitals have been induced to incorporate robust methods or tools that support the decision-making process in the acquisition of medical devices. In addition to the accuracy of the device and its potential benefits, other indicators concerning the risks incurred by the technology are considered [16]. In [16] there is a tendency to evaluate the motivation of those responsible for the requisition of medical equipment, in the drive to implement more reliable methods than empirical ones. Accordingly, this work investigates the criteria for HTA by analyzing the concepts related to multi-criteria tools, specifically incorporating the Analytic Hierarchy Process (AHP) as a methodology for decision making.

## 2. Methods

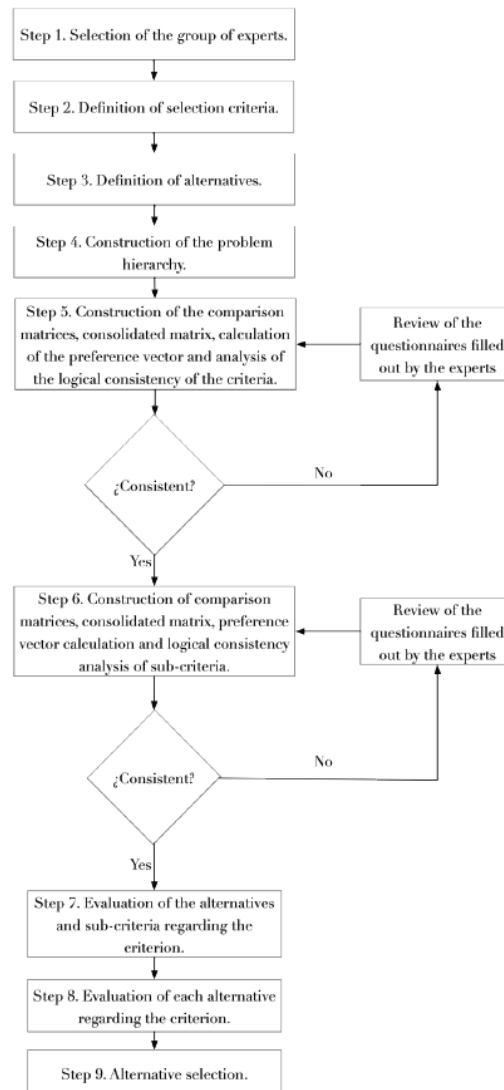
In this work, a literature review was carried out in order to identify the assessment models, criteria and institutions involved in HTA. The following search criteria were used: "HTA + medical devices / medical equipment"; "Point of care + HTA"; "Blood gas analyzer + HTA"; "Blood gas analyzer + errors"; "Blood gas analyzer + organization"; "Blood gas analyzer + clinical laboratory"; "Point of care + clinical laboratory"; "Blood gas analyzer + emergency"; "Blood gas analyzer + management"; "Blood gas analyzer + safety", both in Spanish and English languages. In relation to the analysis of the assessment models, and the criteria in institutions involved in HTA, the literature review identified 62 articles with which we compiled a digital database for the project. For this, the information is structured according to the following fields: names of the authors, title of the article, methodologies (HTA or mini-HTA or any other unspecified methodology), multi-criteria techniques and main assessment criteria (health problems and use of technology, description and technical characteristics, safety, clinical effectiveness, costs and economic evaluation, ethical analysis, organizational / institutional aspects and human resources, patient and social aspects, legal aspects, among others). In addition, 14 guidelines and methodologies proposed by international HTA agencies were reviewed, allowing the conceptualization of methodologies used internationally [11,12,16,23,24,30,31,33-44].

For the identification of alternatives, the database of the Emergency Care Research Institute (ECRI Institute) [32] was used. Subsequently, a refinement of this database was carried out using five requirements: (i) existence of sanitary records in Colombia and the Techno-surveillance program, (ii) availability of technical and safety data sheets for the equipment and supplies, (iii) access to technical / scientific personnel for training or maintenance; (iv) connectivity capacity to the information

system of the healthcare institution and (v) technical capacity to meet the operational capabilities required by the health institution.

Concurrently, the current POCT equipment acquisition process was identified in the healthcare institution where the study was conducted. This allowed us to establish the complex integration of the requirements and criteria in an instrument of evolution with 180 indicators. From the information gathered in interviews with the personnel involved in the acquisition process, a SIPOC diagram was made. SIPOC is a modeling tool that facilitates the description of a given process in a simplified way, identifying suppliers, inputs or materials for activities, flow of activities, results of the activities and clients of each activity. All this allows the systematical analysis of the entire process and its environment [19].

Sequentially, the multi-criteria decision tool from AHP was selected, which is widely used in different areas, such as: health, political, economic, social and management sciences [20-26]. One of the relevant characteristics for the selection of this tool was its natural capacity to perform bi-univocal comparisons through matrix operations. In this way, it is possible to establish priorities among the elements of a level, with respect to an element of the next higher level. Fig. 1 shows the methodological scheme implemented for the blood gas analyzer equipment, based on Saaty and Lee [27].



**Figure 1**

Methodological scheme for the generation of the AHP model for the blood gas analyzer equipment.

Source: The Authors.

Step 1: Selection of the group of experts was made on the basis of their level of technical expertise and having the proficiency necessary to assess the criteria and alternatives.

Step 2: The definition of the criteria was based on judgments issued by the group of experts and on the review of the literature described above. Finally, the criteria were refined in conjunction with the healthcare institution management team.

Step 3: At this stage, a group of potential alternatives of POCT blood gas analysis equipment that met the minimum requirements from the healthcare institution was proposed.

Step 4: The results of the previous step were structured in three hierarchy levels. In the upper level the objective was defined. In the middle level the criteria were established. In the lower level the sub-criteria and research questions were determined.

Step 5: For the development of this step, the proposition in [27] was taken into account. As a result, the relative importance of the sub-criteria was calculated according to the proposed criteria. For this, a comparison was made in pairs of the importance of the control criteria in relation to the general objective. Additionally, a ponderation by pairs of the importance of the merits was carried out in relation to each control criterion.

As recommended in [20], once each of the comparison matrices were established by each expert, the information was consolidated into a square matrix quantifying the geometric mean, defined as the  $n^{\text{th}}$  root of the product of the comparisons. Subsequently, a numerical value was assigned to each criterion and its importance was quantified by the preference vector ( $N_i$ ). This definition was cyclically iterated until the preference vector reached a stable state.

Considering the need to define the random consistency index in the AHP model for the selection of the best alternative proposed, it was established that the paired matrices must be consistent ( $CI < 0.1$ ).

Step 6: In this step, the sub-criteria for each one of the defined criteria were established. For this, comparison matrices were generated based on the questionnaires applied in the previous steps. Then, the information from each of the comparison matrices for each criterion was consolidated in a matrix by quantifying the geometric mean.

Step 7: Based on the vector evaluated for each sub-criterion, the preference vector per alternative was generated following the procedure proposed in [29], which considers the grouping of each sub-criterion according to the defined criteria.

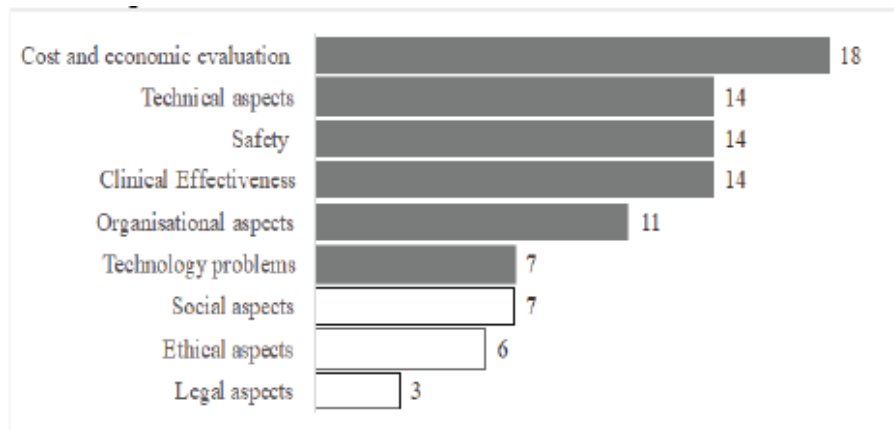
Step 8: Considering the vector evaluated for each criterion, we weighted by the preference vector of each consolidated sub-criterion until the vector preference per alternative was defined.

Step 9: As a final step, the alternatives were ordered in ascending order, with 1 being the highest priority, according to the value  $C_k$  found in the previous step.

### 3. Results

From the literature review, two main assessment models were identified: i) Core model, developed by the European Network for Health Technology Assessment (EUnetHTA), ii) mini-HTA, developed by the former Danish Center for Health Technology Assessment, and the model developed by the project Adopting Hospital Based Health Technology Assessment (AdHopHTA), in the European Union. Fig. 2 shows the criteria frequently used in the assessment of medical devices, highlighting those used in the model. This result shows that internationally, multidisciplinary assessments which consider factors other than purely economic aspects are conducted and include factors such as: technical, safety, clinical effectiveness, organizational, social, ethical and legal.



**Figure 2**

Criteria reported in the literature.

Source: The Authors.

In developing the methodology of Fig. 1, the following results were obtained:

Based on the levels of information and expertise, five professionals who participated in the process of technology procurement within the healthcare institution were selected to jointly analyze the opinion of all those involved. The profiles are described in Table 1.

**Table 1**

Profile of the decision-making group

Expert	Description
1	Responsible for the entire process of acquiring medical equipment and part of the decision-making committee.
2	Conducts research and technical assessment of medical equipment.
3	Makes the request for new technology, and evaluates POCT equipment from the clinical point of view.
4	Negotiates with suppliers.
5	Performs software and hardware evaluation of the technologies to be acquired by the health institution.

Source: The Authors.

Based on the literature review, the Core model, Mini-HTA model, the needs of the health institution and recommendations by the panel of experts, five criteria and eleven sub-criteria were defined. For this, it was verified that each of the sub-criteria were complete, not redundant and independent. A classification and description of this information is presented in Table 2. It is important to highlight that the after-sales service sub-criterion is highly relevant to the healthcare institution, defined as aspects related to training, repairs and requested maintenance.



**Table 2**  
Decision criteria and sub-criteria

Criteria	Sub Criteria	Description
SAFETY	Risks to the patient while using the technology.	Analysis of adverse events, discontinuation, interruption and reduction of equipment. Likewise, the contraindications, dangers and precautions regarding the patient [23,28-31].
	Safety risks for the user	Analysis of the possible impact on the health and physical wellbeing of the user (who uses the technology on the patient) [23,28-31].
	Environmental safety	Final disposal of waste, reagents and samples [23,28-31].
ECONOMIC	Equipment price	Commercial market price of the equipment [23,28-31].
	Use of resources	Amount of personnel and resources needed to implement the technology in the health institution [23,28-31].
ORGANIZATIONAL	Training programs	Training programs provided by the supplier to the users, who are the ones who manage the equipment in the health institution [23,28-31].
	Spatial modification	Physical spatial requirements for the final location of the equipment in the institution [23,28-31].

**Table 2 (cont.)**  
Decision criteria and sub-criteria

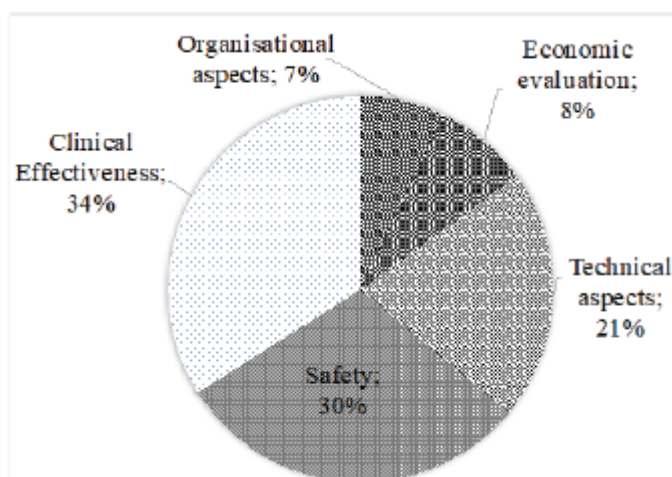
Criteria	Sub Criteria	Description
CLINICAL EFFECTIVENESS	Precision measurements	Analysis of sensitivity, specificity, repeatability and accuracy of measurements compared to a reference standard [23,28-31].
	After-sales service	Response time, availability of qualified personnel to attend on-site technical faults.
TECHNICAL	Technological characteristics	General technical characteristics of the equipment: analytical panel, automatic fault resolution, productivity of the technology, connectivity and system interfaces - hardware and software [23,28-31].
	Sample processing times	Total time used by the equipment to perform a complete test [23,28-31].

Source: The Authors.

Initially, the identification of technological alternatives considering the Emergency Care Research Institute (ECRI) database resulted in 43 blood gas analyzer POCT devices.

However, a refinement of these options considering the five criteria allowed the assessment of five potential medical equipment alternatives. The safety criteria assessment was performed according to the historical analysis of adverse events presented by the national health agency, FDA, and the structured interview made to the brand representatives in Colombia. The evaluation of the economic criterion was based on the sale price information reported by ECRI and the cost of supplies and technical personnel. The evaluation of the organizational criteria was based on the information declared by the manufacturer, in terms of training and infrastructure needed to operate the equipment. The clinical effectiveness and technique criteria were evaluated based on technical information given by the service manuals of each equipment and by the brand representative in Colombia and also an expert in clinical laboratory test was consulted.

Results of the hierarchical level structuring and the device alternatives are presented in the tree diagram, see Fig. 3.



**Figure 3**

Decisional tree. Results of the hierarchical level structuring and the alternatives

Source: The Authors.

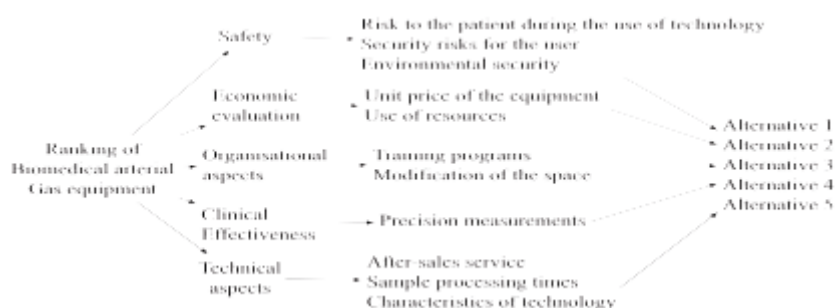
For the classification of the information by the experts, a questionnaire was elaborated for the comparison of criteria by pairs. A consolidation of the expert's answers is shown in Table 3, the preference vector of the criteria, Table 4, and the consistency index, of 1,120, calculated based on [20]. Considering that these results depend upon the institutional orientations and the expertise of the evaluators, a regular update of Fig. 4 is recommended.

**Table 3**

Consolidated criteria matrix

	Consolidated Matrix				
	Safety	Economical	Organizational	Clinical Effectiveness	Technological
Safety	1,0	5,2	3,5	0,6	1,6
Economical	0,2	1,0	0,9	0,4	0,4
Organizational	0,3	1,1	1,0	0,2	0,3
Clinical Effectiveness	1,6	2,3	5,9	1,0	1,4
Technical	0,6	2,5	2,9	0,7	1,0

Source: The Authors.



**Figure 4**

Criterial Weights

Source: The Authors.

The experts evaluated the sub-criteria by pairs, the results were consolidated in four matrices using the geometric mean function as an indicator. As in the previous step, the vector preference for each of the

sub-criteria was found, i.e., information was processed to obtain the weights of each of the sub-criteria with respect to the corresponding criteria and the consistency index. This process was carried out from the previously obtained consolidated matrices and the values recorded in Table 4 were achieved.

**Table 4. Preference vector**

VECTOR PREFERENCE									
Risks to the patient during the use of technology 35%	Security risk for the user 49%	Environmental security 16%	Unit price of the equipment 46%	Use of resources 54%	Training programs 84%	Modification of the space 16%	Precision measurements 100%	After sale services 31%	Sample processing times 19%
Safety 30%			Economic evaluation 9%		Organisational aspects 7%		Clinical effectiveness 34%		Technical aspects 21%

Source: The Authors.

According to the results, the criteria related to clinical effectiveness, safety and technical aspects are the most relevant. It is important to note that the criteria described above are related to patient safety, while the other criteria are related to administrative and economic aspects.

Each alternative was evaluated with respect to each sub-criterion based on information provided by commercial advisors from the distribution companies, the user manual and the expert's criterion, translated into the tool with the Saaty scale. On this occasion, a series of questions were asked regarding each sub-criterion.

The corresponding values for each criterion were multiplied by the auto vector calculated in step 5 to obtain the vector preference for the alternative and a partial qualification of each alternative with respect to each criterion.

With the result of the preference vector (step 8), the selected alternatives were prioritized, the results are presented in Table 5.

**Table 5**  
Results of the assessment

Vector preference of the alternatives, according to the criteria	
Alternative 2	36,4%
Alternative 1	24,2%
Alternative 3	21,3%
Alternative 5	11,2%
Alternative 4	7,7%

Source: The Authors.

Based on the results, the option prioritized was Alternative 2, a piece of equipment that was characterized by different aspects, such as: after-sales service, ease of integration with the information system of the health institution, among others.

## 4. Conclusions

The proposed model, presented a systematic approach for the multi-criteria evaluation of alternatives for POCT blood gas analysis equipment in a healthcare institution using the hierarchical analysis process. The general problem was summarized by criteria and sub-criteria which were evaluated based on technical information, information from health agencies and the information declared by the brand representatives in Colombia. which allowed the identification of the best alternative via a mathematical tool, thereby helping to reduce subjectivity and uncertainty from the decision-making process.

Multi-criteria tools allow us to recognize and work within the framework of the existing organizational culture, for example, in the pilot healthcare institution, the staff are aligned with the organizational strategy, regardless of the area in which they work.

When comparing the existing process and the one proposed here, it was observed that there is an 88% reduction in the questions asked to the equipment supplier, which allows the process to be completed in less time and decisions can be made in an efficient way, based on information collected clearly and consistently, resulting in reliable data. The bibliographical references do not consider the after-sales service due to the culture of the countries where they were developed. In Colombia, this criterion is necessary considering that the need for training, maintenance, and short response times may be affected in cities where there are no brand representatives.

For the institution, the most relevant criteria were those related to the patient and their safety, while administrative aspects are considered secondary.

## References

- [1] Organizacio#n Mundial de la Salud, Dispositivos m#dicos: la gesti#n de la discordancia [en l#nea]. 2012, 128 P. Disponible en: <https://apps.who.int/medicinedocs/documents/s23211es/s23211es.pdf>
- [2] Kazmierczak, S., Improving healthcare through advances in point-of-care technologies. Clin Chem Lab Med., 46, pp. 1-2, 2008. DOI: 10.1515/CCLM.2008.028
- [3] Banks, G., Bedini, J.L., Buno, A., Cava, F., Castano, J.L., Diaz, R., et al., POCT implementation guide. Spanish Society of Clinical Biochemistry and Molecular Pathology (SEQC), Barcelona, Spain, 2006.
- [4] Oliver, P., Gui#a sobre las pruebas de laboratorio en el lugar de asistencia al paciente (POCT), Revista del Laboratorio Cli#nico, 9(2), pp. 60-80, 2016. DOI: 10.1016/j.labcli.2016.03.003
- [5] Plebani, M., Does POCT reduce the risk of error in laboratory testing?, Clin Chim, 404(1), pp. 59-64, 2009. DOI: 10.1016/j.cca.2009.03.014
- [6] Acolet, D., Ahmet, Z., Houang, E., et al. Enterobacter cloacae in a neonatal intensive care unit: account for an outbreak and its relationship to the use

- of third generation cephalosporins. *J. Hosp. Infect.*, ELSEVIER; 28, pp. 2732-86, 1994. DOI: 10.1016/0195-6701(94)90091-4
- [7] Bossert, T., Decentralization of health systems in Latin America: a comparative analysis of Chile, Colombia, and Bolivia, Latin America and the Caribbean Regional Health Sector Reform Initiative, 2000, 175 P.
- [8] Bossert, T. and Beauvais, J., Decentralization of health system in Ghana, Zambia, Uganda and Philippines: a comparative analysis of decision space, *Journal Health Policy and Planning*, 17(1), pp. 14-31, 2002. DOI: 10.15171/IJHPM.2016.51
- [9] Zaidi, S.A., et al., Health systems changes after decentralization: progress, challenges and dynamics in Pakistan, *BMJ Glob Health*, 4(1), pp. e001013, 2019. DOI: 10.1136/bmjgh-2018-001013
- [10] Nichols, J.H., Point of care testing. *Clin Lab Med*, 27, pp. 893-908, 2007. DOI: 10.1016/j.cll.2007.07.003
- [11] Miniati, R. et al., Hospital-based expert model for health technology procurement planning in hospitals. In: *Conf. Proc. IEEE Eng. Med. Biol. Soc.* 2014, pp. 3504-3507. DOI: 10.1109/EMBC.2014.6944378
- [12] Ministério da Saúde, Secretária da Ciência-Tecnologia e Insumos Estratégicos. Departamento de Ciência e Tecnologia., Diretrizes Metodológicas - elaboração de estudos para avaliação de equipamentos médico-assistenciais, Brasil, 2013.
- [13] Rothery, C., Claxton, K., Palmer, S., Epstein, D., Tarricone, R. and Sculpher, M., Characterising uncertainty in the assessment of medical devices and determining future research needs, *Health Econ.*, 26, pp. 109-123, 2017. DOI: 10.1002/hec.3467
- [14] Ramsay, C.R., Wallace, S.A., Garthwaite, P.H., Monk, A.F., Russell, I.T. and Grant, A.M., Assessing the learning curve effect in health technologies. Lessons from the nonclinical literature., *Int. J. Technol. Assess. Health Care*, 18(1), pp. 1-10, 2002.
- [15] Pinzón-Flórez, C., Pierre-Gauvin, F. y Calderón-Herrera, J. y Nates, F.R., Incorporación del marco de valor en las evaluaciones de tecnología en salud en el sistema de salud colombiano, Instituto de Evaluación Tecnológica en Salud (IETS), 2018.
- [16] Sampietro-Colom, L., Hospital-Based health technology assessment, Springer International Publishing Switzerland, Barcelona, Spain, 2016. DOI: 10.1007/978-3-319-39205-9
- [17] Urbano, L.C., Muñoz, L.S. y Osorio, J.C., Selección multi-criterio de aliado estratégico para la operación de carga terrestre. *Estudios Gerenciales*, 32(138), pp. 35-43, 2016. DOI: 10.1016/j.estger.2015.09.002
- [18] Cubillos, L., Evaluación de tecnologías en salud: aplicaciones y recomendaciones en el sistema de seguridad social en salud colombiano. Ministerio de la Protección Social (MPS) y El Programa de Apoyo a la Reforma de Salud (PARS), 2006, 156 P.
- [19] De la Vara, R. y Gutierrez, H., Control estadístico de la calidad y Seis Sigma. 3ra Ed. McGraw-Hill, 2013.
- [20] Saaty, T.L., Analytic hierarchy process. McGraw-Hill, 1980.
- [21] Castro, H., Tringali, M., Cleemput, I., et al. , Advancing MCDA and HTA into coverage decision-making. In: Marsh, K., Goetghebeur, M., Thokala, P., et al., Eds., *Multicriteria Decision Analysis to Support Health*



- Technology Assessment Agencies: Benefits, Limitations, and the Way Forward, 2019.
- [22] Wahlster, P. et al., Balancing costs and benefits at different stages of medical innovation: a systematic review of Multi-criteria decision analysis (MCDA). *BMC Health Services Research*, 15, art. 262, 2015. DOI: 10.1186/s12913-015-0930-0.
  - [23] Mobinizadeh, M., Raeissi, P., Nasiripour, A., Olyacemanesh, A. and Tabibi, S., A model for priority setting of health technology assessment: the experience of AHP-TOPSIS combination approach, *Daru-Journal Pharm. Sci.*, 24, art. 10, 2016. DOI: 10.1186/s40199-016-0148-7
  - [24] De Morales, L., Garcia, R., Ensslin, L., da Conceição, M.J. and de Carvalho, S.M., The multicriteria analysis for construction of benchmarkers to support the Clinical Engineering in the Healthcare Technology Management, *Eur. J. Oper. Res.*, 200(2), pp. 607-615, 2010. DOI: 10.1016/j.ejor.2009.01.018
  - [25] Martelli, N. et al., Combining multi-criteria decision analysis and mini-health technology assessment: a funding decision-support tool for medical devices in a university hospital setting, *J. Biomed. Inform.*, 59, pp. 201-208, 2016. DOI: 10.1016/j.jbi.2015.12.002.
  - [26] Morton, A., Treacle and smallpox: two tests for multicriteria decision analysis models in health technology assessment, *Value Heal.*, 20(3), pp. 512-515, 2017. DOI: 10.1016/j.jval.2016.10.005
  - [27] Lee, A.H.I., A fuzzy supplier selection model with the consideration of benefits, opportunities, costs and risks. *Expert Systems with Applications*, ScienceDirect, 36(2), pp. 2879-2893, 2009. DOI: 10.1016/j.eswa.2008.01.045
  - [28] Hwang, J.-J. and Tzeng, G.-H., Multiple attribute decision making, *Journal of Experimental Psychology: General* 136, 2011.
  - [29] EUnetHTA., HTA Core Model Handbook, 2, Denmark, 2008.
  - [30] Ritrovato, M. et al., Adopting European Network for health technology assessments (EunetHTA) core model for diagnostic technologies for improving the accuracy and appropriateness of blood gas analyzers' assessment, *Clin. Chem. Lab. Med.*, 52(11), pp. 1569-1577, 2014. DOI: 10.1515/cclm-2014-0087
  - [31] Ritrovato, M. et al., Decision-oriented health technology assessment: one step forward in supporting the decision-making Process in Hospitals, *Value Heal.*, 18(4), pp. 505-511, 2015. DOI: 10.1016/j.jval.2015.02.002
  - [32] ECRI. (). Institute ECRI. [online]. 2018. Available at: <https://www.ecri.org/about/>
  - [33] Angelis, A. and Kanavos, P., Value-Based assessment of new medical technologies: towards a robust methodological framework for the application of multiple criteria decision analysis in the context of health technology assessment, *Pharmacoeconomics*, 34(5), pp. 435-446, 2016. DOI: 10.1007/s40273-015-0370-z
  - [34] Ayhan, M.B., A fuzzy ahp approach for supplier selection problem: a case study in a Gearmotor Company, *Int. J. Manag. Value Supply Chain.*, 4(3), pp. 11-23, 2013. DOI: 10.5121/ijmvsc.2013.4302
  - [35] Ciani, O., et al., Health technology assessment methods guidelines for medical devices: how can we address the gaps?. The International Federation of Medical and Biological Engineering perspective, *Int. J.*



- Technol. Assess. Health Care, 34(3), pp. 276-289, 2018. DOI: 10.1017/S0266462318000314
- [36] Sampietro-Colom, L. et al., Guiding Principles for good practices in hospital-based health technology assessment units, *Int. J. Technol. Assess. Health Care*, 31(06), pp. 457-465, 2015. DOI: 10.1017/S0266462315000732
- [37] Diaconu, K., Chen, Y.-F., Cummins, C., Jimenez-Moyao, G., Manaseki-Holland, S. and Lilford, R., Methods for medical device and equipment procurement and prioritization within low- and middle-income countries: findings of a systematic literature review, *Global Health*, 13(1), art. 59, 2017. DOI: 10.1186/s12992-017-0280-2
- [38] Diaby, V., Sanogo, V. and Moussa, K.R., ELICIT: an alternative imprecise weight elicitation technique for use in multi-criteria decision analysis for healthcare, *Expert Rev. Pharmacoecon. Outcomes Res.*, 16(1), pp. 141-147, 2016. DOI: 10.1586/14737167.2015.1083863
- [39] Garrido, M.V., Kristensen, F.B., Nielsen, C.P. and Busse, R., Health technology assessment and health policy-making in Europe: current status, challenges and potential. *European Observatory on Health Systems and Policies*. 14, pp. 53-79, 2008.
- [40] Kristensen, F et al., Practical tools and methods for health technology assessment in Europe: structures, methodologies, and tools developed by the European Network for Health Technology Assessment, *EUnetHTA. Health Technology Assessment Handbook*. 2, pp. 1-8, 2009.
- [41] McGregor, M. and Brophy, J.M., End-user involvement in health technology assessment (HTA) development: a way to increase impact. *International Journal of Technology Assessment in Health Care*, 21(2), pp. 263-267, 2005. DOI: 10.1017/S026646230505035X
- [42] Nusrullah, M., Younus, M. and Nasir, Y., Relationship between Arterial and venous blood gases in patients presenting with chronic obstructive pulmonary disease, *Annals of King Edward Medical University*, 24(1), pp. 684-688, 2018. DOI: 10.21649/akemu.v24i1.2343
- [43] Rosselli, D. et al., HTA implementation in Latin American countries: comparison of current and preferred status, *Value Heal. Reg.*, 14, pp. 20-27, 2017. DOI: 10.1016/j.vhri.2017.02.004
- [44] Zaman, Z. and Demedts, M., Blood gas analysis: POCT versus central laboratory on samples sent by a pneumatic tube system, *Clin. Chim. Acta*, 307(1-2), pp. 101-106, 2001. DOI: 10.1016/s0009-8981(01)00439-9

## Notes

**L.V. Bocanegra-Villegas**, is BSc. in Industrial Engineer in 2019, from the Universidad del Valle, Colombia. She is currently in the second semester of the Master's in Industrial Engineering at the Instituto Tecnológico de Orizaba, Veracruz, México. ORCID: 0000-0001-6452-5269.

**J.C. Osorio-Salgado**, is BSc. in Industrial Engineer in 2019, from the Universidad del Valle, Cali, Colombia. He is currently a special projects programming engineer in Constructora Bolívar - Cali. ORCID: 0000-0003-3875-2681.

**S.P. Usaquén-Perilla**, is a MSc. in Biomedical Engineering in 2008, from the Universidade Federal do Rio de Janeiro, Brazil. She is currently a PhD student in Industrial Engineering in the Universidad del Valle, Cali, Colombia. She is a professor of

the biomedical engineering program at the Universidad Militar Nueva Granada, Bogotá, Colombia. Her research approach covers topics such as: Health technology assessment, technology management and clinical engineering. ORCID: 0000-0003-1614-1898.

**J.I. García-Melo**, is PhD. in Mechanical Engineering in 2011 from the Universidade De São Paulo, São Paulo, Brazil. From 1999 to 2017, he worked in teaching, administrator and researcher activities in the Universidad del Valle, Cali, Colombia. Currently, he is a full professor in the Mechanical School of the Universidad del Valle. His research interests include: bioengineering, modeling and analysis of products and systems, system integration and design of biomechanical devices. ORCID: 0000-0003-1672-7768

**How to cite:** Bocanegra-Villegas, L.V, Osorio-Salgado, J.C, Usaquén-Perilla, S.P. and García Melo, J.I, Multicriterial analysis for the prioritization of technological alternatives for POCT blood gas equipment procurement in a high-complexity healthcare institution. DYNA, 87(212), pp. 219-225, January - March, 2020.