

Evaluation of Control Activities through Diffuse Compensatory Logic in a Hospital Entity

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Abstract

Control is essential for the hospital to achieve its objectives and goals, otherwise it would be impossible to define the measures that must be taken to achieve them. Objective: to control the activities as a component of internal control in a Cuban hospital entity, showing the best direction to follow when making decisions, with a low level of uncertainties in the results. Method: a model was designed through the Compensatory Fuzzy Logic, composed by the fundamental elements of the control activities norm. Result: the control activities in the hospital are in a deficient category of something true, negatively influencing staff turnover and performance indicators. Conclusions: the control management index was obtained, evidencing that there are notable deficiencies in its implementation, allowing the hospital to establish an improvement strategy based on an action plan.

Keywords: internal control, control activities, diffuse compensatory logic, Cuban hospital entity

Introduction

It is an undoubted truth that the Cuban health system has reached a relevant importance on the world stage since the triumph of the Revolution, and that it represents a very important sector in the current Cuban economy. That is why our country graduates large numbers of doctors and health specialists every year, to meet their growing demand internationally.

Although it is true that the fundamental limitation of the Cuban health system to meet its challenges and perspective is the complex economic situation that the country is going through, which is notoriously aggravated by the economic and social blockade imposed for several decades. Cuba's achievements in the field of public health, accumulated in more than fifty years, are compared with those achieved by many developed countries. Given its obvious growth, it is vitally important to have institutions that function well, comparable with the quality of our professionals. To achieve this, adequate internal control is needed; parallel to this, innovative tools are both effective and flexible, that allow for their evaluation, are also needed.^{1,2}

The controls fulfill a fundamental role to carry out that goal, since these means of control do not exist, it is very probable that the budgets are never met in hospital entities^{3,4}. Currently, Resolution 60 of 2011⁵ is in force issued by the Comptroller General of the Republic of Cuba, which is a standard model of internal control, and approves the rules according to current circumstances. This control is composed of five components: control environment, management and risk prevention, control activities, information and communication, and supervision and monitoring, each structured in standards.

The control activities as a key component of internal control are implemented in Cuban hospital entities through a self - control guide adapted to the public health system. However, it is a bit subjective the compliance or not of the elements of the guide that affects the process of hospital decision-making in hospitals where the effective direction is still a pending chapter. Aspect, which is closely related to fuzzy logic⁶⁻⁹ Bearing in mind that this logic can take any value of truth within a set of values that oscillate between two extremes, absolute truth and total falsehood. This tool allows us to represent a management model through a non-linear mathematical model, for which the author of this research considers that it is of great importance for the evaluation of control activities in hospitals because both, its components and the norms that compose it, when evaluated will not always be located at the extremes. This is where the diffuse compensatory logic will give us more reliable results.

The objective of this article is to evaluate the control activities through the diffuse compensatory logic that allows an accurate decision making in a Cuban hospital entity. That is why; multicriteria modeling with a diffuse approach was used, allowing the entity to establish improvement strategies.

Methods

The Control Activities component establishes the policies, legal dispositions and control procedures necessary to manage and verify the quality of the management, its reasonable security with the institutional requirements, for the fulfillment of the objectives and mission of the organs, organisms, organizations and other entities. It is structured in the following rules: coordination between areas, separation of tasks, responsibilities and levels of authorization (C); documentation, timely and adequate recording of transactions and events (D); restricted access to resources, assets and records (AR); rotation of staff in key tasks (PR); control of information and communication technologies (ICT); and performance and performance indicators (SDI).

Fuzzy logic is a discipline proposed by Azerbaijani mathematician LoftiZadeh in 1962, which combines the concepts of logic and fuzzy sets by defining degrees of belonging. Unlike classical logic, it models inaccurate modes of reasoning, which play a fundamental role in the human ability to make reasonable decisions in an environment of uncertainty. This ability depends on the technique of inferring an approximate answer to a question that is based on inaccurate or incomplete knowledge (Manna, 2014). The main difference between these logics is that the classic uses only two values of truth: true and false, while the diffuse assigns other values of truth in addition to the classical, it is about degrees of truthfulness / falsity broader, being able to appreciate the facilities offered by fuzzy logic to deal with issues that due to their characteristics, the values are not specifically found in the extremes. Table 1 shows the superiority of fuzzy logic with classical logic is evident.

Table 1. Comparison between fuzzy logic and classical logic

Classical Logic	Diffuse logic
A property p has two values: true or false	There may be other values. The sets can be finite or infinite
There are proposals for entry and exit	The degrees of veracity of the exit proposals are described in terms of the entries
The predicates must be non-diffuse subsets of the universe	There can be diffuse and non-diffuse predicates
Allows only two quantifiers: all and some	Allows others such as: few, many, frequently, etc. In addition to linguistic variables: old or young for the age variable

Source. Own elaboration

In the hospital processes that require decision-making, the exchange with the experts leads to obtain complex and subtle¹⁰⁻¹³ formulations that require compound predicates. This need is satisfied with the use of diffuse compensatory logic, which renounces compliance with the classical properties of conjunction and disjunction, opposing to these the idea that the increase or decrease in the truth value of the conjunction or disjunction caused by the change of the truth value of one of its components. It can be "compensated" with the corresponding decrease or increase of the other. A growth or decrease in the truth value of the conjunction or disjunction as a result of a change in the truth value (Table 2) of some component, can be compensated by the growth or decrease in another component¹⁴

Table 2. A correspondence between truth values and categorical values

Value of truth	Category
0	Absolutely false
0.1	Almost false
0.2	Fairly false
0.3	Something false
0.4	More false than true
0.5	As true as false
0.6	More true than false
0.7	Something true
0.8	Fairly true
0.9	Almost true
1	Absolutely true

Source. González Caballero, 2013¹⁴

Architecture of the model

The fundamental elements that will be part of the network of the decision model are defined. They will not change at the time of their application in different hospitals because they are based on Resolution 60/11, which is why they are defined in the design of the model. The control activities constitute the initial node integrated by C, D, AR, RP, TIC and IDE because the logic predicate consists of simple and compound ones. In order to establish it, it is necessary to start from the nodes defined in the previous step, as well as the graph that they compose. To do this, the following verbal formulations are constructed, using linguistic modifiers and then for their translation into mathematical language.

A good functioning of the control activities is maintained. It is excellently fulfilled with the documentation, timely and adequate registration of the transactions and facts; to a large extent with restricted access to resources, assets and records; and control of information and communication technologies; in addition to keeping in good condition what refers to the coordination between areas, separation of tasks, responsibilities and levels of authorization; rotation of staff in key tasks; and performance and performance indicators. In addition, it is known that:

- ❖ The organization has a correct coordination between areas, separation of tasks, responsibilities and levels of authorization if it has a great deal of manuals and procedures approved for this purpose, this is specifically defined, documented, assigned and communicated to the person responsible for its execution.
- ❖ The entity has a correct documentation, timely and adequate record of transactions and events if all the activities carried out have a documentary support, guarantee to a great extent the traceability of the documentation of the nominal and real accounts, documentation of the accounts is evidenced for long periods of time.
- ❖ The entity has restricted access to resources, assets and records if only the authorized persons have access to the different resources, the assets are duly registered and physical inventories with accounting records are checked to a great extent.
- ❖ The entity has an adequate rotation of the staff in the key tasks if the workers are periodically employed in various functions or increase the periodicity of the supervision and control actions.

❖ The entity presents an adequate control of the information and communication technologies if the IT security plan is implemented, the necessary control activities are defined based on the importance of the goods and information to be protected or the risks are managed. Those that are submitted, are in correspondence with the current legislation. The defined access permits the different levels of automated information or is duly registered by the corresponding document.

❖ The entity correctly possesses the performance and performance indicators if they are defined according to their size, productive process and level of competence or there is a procedure for the evaluation of personal performance and the aspects indicated in said evaluation are improved; the evaluation of institutional performance is carried out.

Simple predicates are defined from those nodes that in the network (Fig. 1) are independent. Defining X as the organization object of study, its formulation is as follows:

C 1 (X): has approved manuals and procedures

C 2 (X): this is specifically defined, documented, assigned and communicated to the person responsible for its execution

D 1 (X): the activities carried out have a documentary support

D 2 (X): guarantee the traceability of the documentation of the nominal and real accounts

D 3 (X): there is documentation of the accounts for long periods of time

AR 1 (X): authorized persons have access to the different resources

AR 2 (X): the assets are duly registered

AR 3 (X): Physical inventories are checked against accounting records

RP 1 (X): workers are periodically employed in various functions

RP 2 (X): increase the periodicity of supervision and control actions

TIC 1 (X): the computer security plan is implemented

TIC 2 (X): the necessary control activities are defined

TIC 3 (X): the risks to which they are subject are managed

TIC 4 (X): they are in correspondence with the current legislation

TIC 5 (X): access permissions to automated information are defined

TIC 6 (X): they are registered by means of the corresponding document

IDE 1 (X): are defined according to their size, production process and level of competence

IDE 2 (X): there is a procedure for the evaluation of personal performance and the aspects indicated are improved

IDE 3 (X): evaluation of institutional performance is carried out

The compound predicates are those that are defined from the dependent nodes, their formulation is as follows:

C (X): develops coordination between areas, separation of tasks, responsibilities and levels of authorization

D (X): complies with the documentation, timely and adequate registration of transactions and events

AR (X): performs restricted access to resources, assets and records

RP (X): develops staff turnover in key tasks

ICT (X): controls information and communication technologies

IDE (X): has performance and performance indicators

A logical tree is made where the simple predicates, compounds, as well as the operators and linguistic modifiers used are represented (Figure 1). From the tree we obtain the calculation expressions that will allow us to obtain the result of the evaluation of the control activities. The expressions are the following:

$$AC(X) = C(X) \wedge D^3(X) \wedge AR^3(X) \wedge RP(X) \wedge TIC^2(X) \wedge IDE(X)$$

$$C(X) = C_1^2(X) \wedge C_2(X)$$

$$D(X) = D_1(X) \wedge D_2^2(X) \wedge D_3(X)$$

$$AR(X) = AR_1(X) \wedge AR_2(X) \wedge AR_3^2(X)$$

$$RP(X) = RP_1(X) \vee RP_2(X)$$

$$TIC(X) = TIC_1(X) \wedge [TIC_2(X) \vee TIC_3(X)] \wedge TIC_4(X) \wedge [TIC_5(X) \vee TIC_6(X)]$$

$$IDE(X) = [IDE_1(X) \vee IDE_2^2(X)] \wedge IDE_3(X)$$

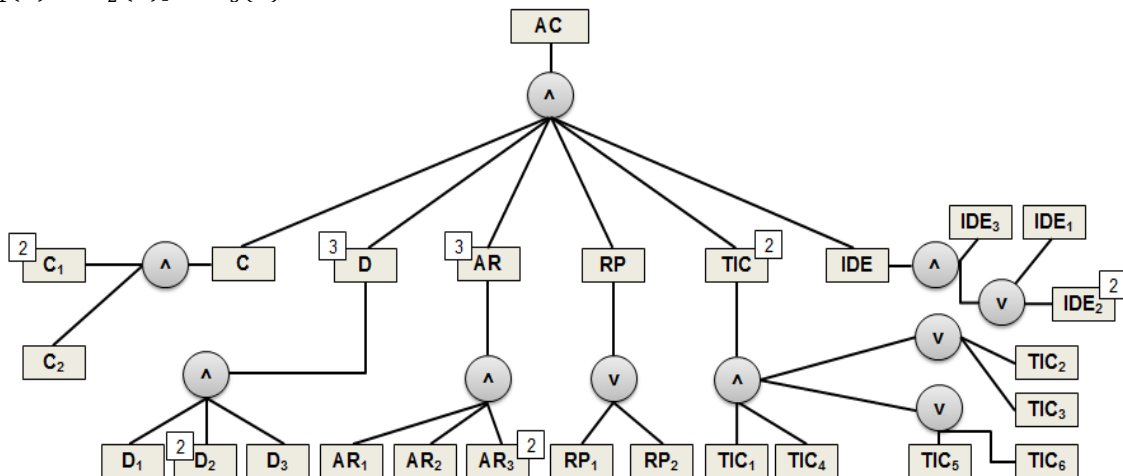


Figure 1. Logical tree of control activities in hospitals. Source. Own elaboration

Results

In order to fulfill its social purpose, it has been defined as a mission to pay Cuba's status as a world medical power, applying science and technological innovation, promoting the ideals and philosophy of Cuban Public Health, prioritizing the comprehensive training of our personnel, such form that allows us to form and consolidate ethical, moral, political, cultural and professional values, which ensure to raise the quality of specialized emergency medical assistance service, outpatient consultation and hospitalization.

In the projection of goals that is outlined, it is presented as a vision: it is a national reference center in medical assistance, teaching and research, with a moral group of excellence in the services provided to the population, where good treatment is combined, courtesy and ethics, with quality at work.

To determine the values of these predicates, the selection of experts was first given, as well as the amount needed. To make the selection, it was taken into account that the chosen personnel must have the competences, motivation and experience required in internal control. After the values of the simple predicates were determined, the calculation of the compound predicates was made. Finally, the value of AC (x) is obtained. The results of these are shown below in Table 3. In order to determine the final value according to the experts, the mode criterion was used if the coefficient of variation is greater than 0.2 and the arithmetic mean otherwise. Since the p-value is equal to 0.764 greater than 5 %, it is concluded that there is agreement among the experts.

Table 3. Determination of the truth values in the control elements

Parameters	Experts										Values and category					
	1	2	3	4	5	6	7	8	9	10	Mode	Mean	S	Cv	Truthvalue	Category
C ₁	0,8	0,9	0,9	0,9	0,7	0,8	0,9	0,7	0,9	0,9	0,9	0,84	0,084	0,100	0,84	Fairly true
C ₂	0,7	0,9	0,8	0,9	0,8	0,8	0,6	0,8	0,8	0,9	0,8	0,8	0,094	0,118	0,8	Fairly true
D ₁	0,9	0,9	0,9	0,8	0,8	0,8	0,9	0,9	0,9	0,8	0,9	0,86	0,052	0,060	0,86	Fairly true
D ₂	0,8	0,9	0,9	0,6	0,8	0,9	0,7	0,8	0,8	0,8	0,8	0,8	0,094	0,118	0,8	Fairly true
D ₃	0,8	0,8	0,8	0,9	0,8	0,8	0,0	0,8	0,9	0,9	0,8	0,75	0,268	0,357	0,8	Fairly true
AR ₁	0,9	0,8	0,8	0,8	0,9	0,8	0,8	0,9	0,9	0,6	0,8	0,82	0,092	0,112	0,82	Fairly true
AR ₂	0,8	0,9	0,7	0,6	0,9	0,8	0,8	0,8	0,8	0,7	0,8	0,78	0,092	0,118	0,78	Something true
AR ₃	0,8	0,7	0,8	0,9	0,7	0,8	0,7	0,8	0,9	0,8	0,8	0,79	0,074	0,093	0,79	Something true
RP ₂	0,4	0,6	0,6	0,8	0,5	0,6	0,7	0,7	0,5	0,7	0,6	0,61	0,120	0,196	0,61	More true than false
TIC ₂	0,7	0,8	0,7	0,8	0,9	0,7	0,9	0,8	0,9	0,8	0,8	0,8	0,082	0,102	0,8	Fairly true
TIC ₃	0,8	0,8	0,7	0,8	0,5	0,7	0,6	0,8	0,8	0,6	0,8	0,71	0,110	0,155	0,71	Something true
TIC ₄	0,6	0,8	0,8	0,6	0,7	0,9	0,6	0,6	0,8	0,8	0,6	0,72	0,114	0,158	0,72	Something true
TIC ₅	0,8	0,7	0,7	0,9	0,8	0,6	0,7	0,7	0,8	0,6	0,7	0,73	0,095	0,130	0,73	Something true
TIC ₆	0,6	0,7	0,6	0,7	0,8	0,7	0,6	0,8	0,8	0,7	0,7	0,7	0,082	0,117	0,7	Something true
IDE ₁	0,5	0,8	0,8	0,5	0,4	0,9	0,7	0,8	0,5	0,7	0,5	0,66	0,171	0,259	0,5	As true as false
IDE ₂	0,6	0,7	0,5	0,5	0,7	0,4	0,7	0,5	0,7	0,8	0,7	0,61	0,129	0,211	0,7	Something true
IDE ₃	0,7	0,6	0,7	0,7	0,6	0,9	0,8	0,6	0,9	0,6	0,6	0,71	0,120	0,169	0,71	Something true
Statistic of contrast Test of Fiedman											Composite parameters					
N										17		C(X)		0,83	Fairly true	
Chi-cuadrado										0,453		D(X)		0,81	Fairly true	
gl										9		AR(X)		0,79	Something true	
sig. asintot.										0,764		RP(X)		0,48	More false than true	
												TIC(X)		0,77	Something true	
												IDE(X)		0,67	More true than false	
												AC(X)		0,76	Something true	

Source. Own elaboration

Taking the results of both simple predicates and compounds can emit criteria about their behavior. They turned out to be the parameters corresponding to the norms (simple predicates) of which the organization RP₁, RP₂, IDE₁ suffers the most. There is an incidence values between the categories as true as false and more true than false. Among the compound predicates corresponding to the norms are those that most negatively affect the entity are RP, IDE, finding these predicates between the categories more false than true and more true than false. This is due to the bad incidence of the parameters corresponding to these predicates.

The projection of actions improves before the deficiencies detected with the control. The value of the IC (X) obtained is considered acceptable; however, it has notable deficiencies, so that special attention and follow-up must be given to it in order to control compliance with the objectives. An action plan was carried out in order to measure proposed by the team. These measures required the consent of senior management

Table 4. Action plan for affected standards

Elements	Action	Execute (n)	Responsible (s)	Date of compliance
Rotation of staff in key tasks	Periodically employ care workers in various functions, as long as this is possible	GRH specialist	Head of DRH	Permanent
Performance and performance indicators	Define the performance and performance indicators according to their size, service process and competence level	Head of Areas	Managing Director Subdirectors	June 2017
	Conduct the evaluation of institutional performance	Head of Areas	Managing Director Subdirectors	Permanent (everymonth)

Source. Own elaboration

Discussion

In recent times the activities of control of internal control in hospitals is carried out in Cuba through the Self-Control Guide issued by the Comptroller General of the Republic, which, although it is a good control mechanism, becomes a bit subjective when marking compliance with the requirement or not by internal or external auditors^{1,2} The control in hospitals has been demonstrated in these from other edges such as the quality, effectiveness in students and human resources, leaving the gaps from the point of view of internal control. This research reduces these deficiencies by using multicriteria modeling through Fuzzy Compensatory Logic, providing a greater contribution to decision making in the hospital management.

The study carried out has an important impact on the entity. Regarding the social part, it provides top management with an instrument that gives a global view of the behavior of control activities. It makes it possible to achieve a superior management and operational status by helping the decision-making process. In addition, with application of Compensatory Fuzzy Logic, it contributes to defining critical elements of this component in the organization, while the action plan constitutes a guide to carry out the improvement of these unfavorable elements. The applied tool is based on the Cuban legislation in force for internal control (Resolution 60/2011) and does not contradict the opinions that govern the organic life of the sector.

The economic component is favored from the perspective that links it to improve control activities, which allows properly use the material and financial resources, from planning, organizing and controlling them. Finally, in relation to the environment or the work done, or the proposed improvement actions cause negative impacts on the environment, but they do help to prevent and limit risks in this regard.

Conclusions

Architecture of a mode for the evaluation of control activities through the compound compensatory diffuse logic was designed. The proposed model was applied in a hospital entity, which allowed contributing to the improvement of its evaluation, allowing to identify the incidence in the implementation of the control activities in this hospital with a category of something true and where to direct a greater control according to the most unfavorable results, emphasizing in the rotation of the care personnel and the indicators of performance and performance.

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Biographies

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