Medical practice variations. Reflections from the complex systems perspective

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Abstract

The aim of this work is to analyze medical practice variations (MPV) using a dynamic perspective. The relevance of this research lies in the fact that MPV can be considered one of the most inefficient and inequitable aspects of modern medicine. Several factors are commonly used to explain MPV such as morbidity, randomness, clinical issues or demand; being some of them, like morbidity, more "legitimate" than the others.

In this sense, we have built a simulation model, specifically excluding morbidity and demand factors, based on two main assumptions:

a) an important MPV is observed among different hospitals and health areas and

b) a smaller MPV is observed between doctors working in the same hospital.

This model is based on a main positive feedback loop, reflecting how greater experience in applying a particular course or procedure leads to a greater recommendation rate of this procedure. Therefore, the system will be highly sensitive to initial conditions, so the medical practice will become locked in a particular procedure, regardless of the other procedure advantages.

Through different simulations and sensitivity analysis, we will analyze the influence that factors, such as the experience, the system initial conditions, resource scarcity, the proportion of patients subjected to MPV and, finally, the waiting list and perverse incentives, have over MPV.

Introduction

The paper has a clearly speculative approach and aims to provide the reader with a new perspective to a long-standing problem, that is Medical Practice Variations (MPV) the only virtue of which is its ability to invite us to reflect on the nature of the problem, the bases of the solutions proposed and the implications which can be derived from this.

Our starting point for these reflections can be summarized in the following premises:

Factual:

1. Medical practice variation between different health centers or areas or intercenter variability is affirmed.

2. Lower medical practice variation within the same health care center or intracenter variability is also affirmed.

3. Explanations for intercenter variability are far from conclusive due to the multitude of factors involved[1].

Organizational:

1. A large part of the highly complex operative work is performed following protocols by highly qualified professionals working with a high degree of autonomy and therefore with a high decision-making capacity [2]. The doctors act as agents of both the patient and the hospital[3].
2. These are organisations providing services which are difficult to measure and control[4].

Systemic:

1. Health organizations are adaptive complex systems. These organizations frequently present counterintuitive behaviors which are contrary to the desires of the people in charge of them.
2. This structure is the main cause of the organization's behavior. The organizations often cause their own crises, which are not due to external causes or individual errors.
3. In the organizations, people often have a potential influence which they are incapable of exerting because they only concentrate on the effects of their decisions in their *local* organizational environment, unaware of how these decisions affect the rest of the organization and whose reaction in turn determines their performance. Only a global view allows this vicious circle to be avoided.

Learning and rationality

By way of initial reflection, we will consider an unquestionable premise: the appropriate management of any health organization is subordinate to the fit between the decisions adopted by it and the nature of the problems it

[1] See McPherson (1990) suggesting possible sources of MPV between different populations. Similarly, see Wennberg (1984), Evans (1990)and Peiró et al (1998) compiling different explanatory theories of medical practice variation.

[2] See Mintzberg (1984) and García R and Ventura, J. (1987) for a description of the organisational structure characteristic of professional organisations.

[3] See Wagstaff (1990), Mooney (1994) and Martín and López del Amo (1994) for a more detailed analysis of the relations of agency in the health field.

[4] See Valor and Ribera (1990) for a description of the particularities of hospitals as service companies.

faces. We must therefore reflect on the nature of the determinants, highlighted in the premise: the rationality of the decisions taken and the nature of the problems to be solved.
The rationality of the decisions implies finding processes capable of finding solutions with an acceptable amount of resources and capabilities. That is to say that although there exist optimal solutions, for a given problem, it may happen that such solutions are not procedurally feasible for the available resources and capabilities. In short, the rationality, is a limited rationality, which uses efficient processes in the search for satisfactory solutions. It is important to highlight the change of concern for optimal solutions to concern for satisfactory solutions.
On this point, and following the theory of resources and capabilities, we will distinguish two types of resources (Grant, 1991): tangible resources and intangible resources, emphasizing within the latter the decision-making skills of the organization. The established differentiation enables us to directly link the rationality of the decisions with the quality of the decision-making skills of the organization.
However, the organization's decision-making skills have a value in relation to the problems to be solved and , more specifically, to the nature of these problems in the extent that this nature acts as a factor limiting the rationality.
Similarly, it is possible to state the simultaneous existence of a vicious circle consisting in problems of increasing complexity and also the organizations increasing inability to solve them. In short, there seems to exist a lack of fit in the decision-making skills, which only go to reflect the discrepancy between the evolution of the complexity of the problems to be solved and our capabilities to solve them.
Figure 1 illustrates the situation: the complexity and uncertainty of the problems affecting the health organisations accentuate the limits to rationality originated, in the scarcity of tangible resources as well as in the limits of the decision-maker. In turn, a more limited rationality entails lower decision-making skills which cause a lower degree of rationality in the decisions. Finally, the lower degree of rationality in the decisions ends up aggravating the original problems, since it makes them more complex and uncertain, if this is possible. This situation reveals the existence of a feedback loop between the complexity and uncertainty of the problems and the rationality of the decisions, since the greater the complexity, the lower the rationality; and the lower the rationality, the greater the complexity and uncertainty. This vicious circle only goes to prove how a large part of the seriousness of the problems is not attributable to exogenous factors, but rather to the very measures designed to eliminate them. Consequently, a large part of the solution of these has to be on internal variables of the organisation.

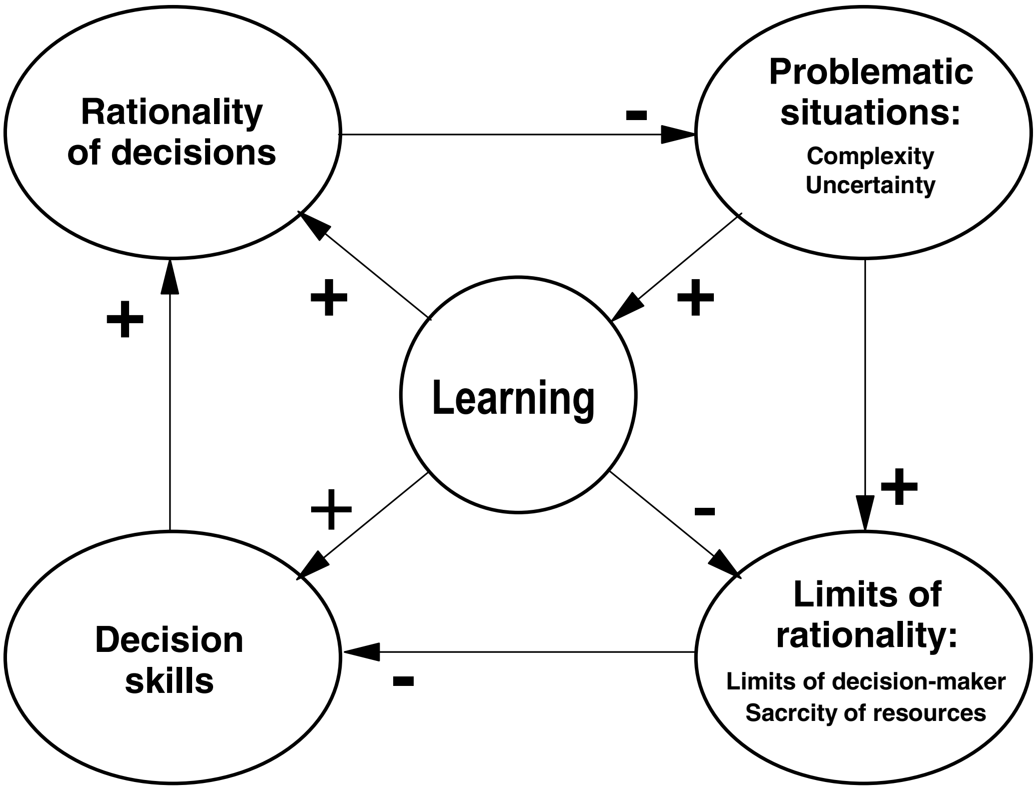


Figure 1. Elements resource of the intangible decision skill

As can be seen in Figure 1, learning as understood not only of the individual but also of the organisation enables the experience derived from the problems experienced by the organization to be exploited. Learning thus becomes the element capable of using the very problems of the organization as an element which simultaneously reduces the limits to rationality and multiplies the decision-making skills and the rationality of these decisions, which in the last analysis will contribute to reducing the seriousness of the future problems of the organization.

Learning of the organization

It is now fitting to distinguish between two types of learning (Argyris, Ch. & Schon, D.A., 1978; Argyris, Ch.1990): simple, unidirectional or single loop and complex, bi-directional or double loop. Simple learning consists in a process in which the consequences of past actions are the basis for correcting future actions. There exists a feedback loop which links the problem identification with decisions, the latter with actions and their consequences which condition the subsequent identifications. This type of learning usually solves current and short-term problems, but does not solve the basic problems, that is to say, the why of such problems. Bi-directional, complex or double loop learning adds an additional loop to the simple learning process since the consequences of the action lead not only to the correction of future actions, but rather also to the modification of mental models, to the modification of fundamental schemes which sustain the identification of the problems and the later decision-making. Consequently, complex learning not only modifies the actions but also the models supporting these actions. Figure 2 reflects the two types of learning. [5].

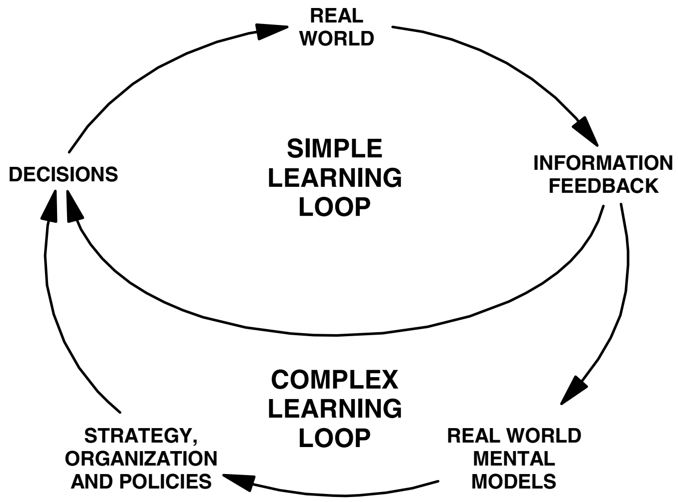


Figure 2. Types of learning

However, effective learning requires the correct working of the two previous loops. That is to say, that each of the existing relations is effective and that each of the loops is completed with the sufficient minimum speed to avoid the changes in the real world making the organization obsolete.

The long-term survival of an organization depends on its form of facing up to change, which in turn will be conditioned by the mental models upheld by the organization about the dynamics of change. This paper will explore the usefulness of the complexity theory to approach the development of appropriate mental models for understanding the medical practice variation phenomenon.

Characteristics of complex systems[6]

It is now possible to explain why the results of the decisions made are contrary to the previous expectations. The basic reasons for our mistakes when judging the behavior of organizations lies in the inability of the traditional problem analysis methods when faced with complex systems with a high level of interaction such as

[5] See García R. (1997a) for an application of organisational learning to health organisations

[6] The reader can find on internet a Web page on the analysis of complexity for health managers. The address is http://www.edgeplace.com/think/main_wel.html.

organizations. We should therefore suppose that the programs with which we try to correct their shortcomings will continue to be a disappointment to us, unless we revise our approaches to the problems.
We now refer to some of the characteristics of the organizations, which are commonly overlooked in the analysis of the different policies applied.

a). The *cause-effect* relations frequently include properties, which we can summarize in the following:

- There generally exists a basic conflict between the short-term and long-term consequences of a change in policies. The immediate conclusion is that, given the greater sensitivity of the people in charge to the short term, decisions are usually made which create long-term problems which are much more serious than those they "solve" in the short term.
- Cause and effect are usually very distant in space and time, which is in contrast to the common reaction of the organizations, characterized by attempting to identify the causes of the problems in the most recent decisions within the local limits of the problem to be solved.
- Even the simplest organizations have a structure dominated by policies containing important non-linearities and a high number of interconnected feedback loops[7] The dynamic behavior of any system with these characteristics overcomes the intuitive analysis of the most accustomed decision-maker.

b). Finally, the organizations are usually structurally insensitive to most of the policies, which are normally implemented in order to modify their behaviors and at the same time seem to possess sensitive influence points by which their behavior could be altered. However, these "vital points" are not usually located where most people would suppose, and, although some of them could be identified, there is a high likelihood that the behavior is altered in the wrong direction.

The immediate consequence of all of these is the unexpected and counterproductive counterintuitive behavior often presented by organizations.

Complexity

The conventional approach, still dominant in decision analysis can be characterised by the premises reflected in Figure 3 in schematic form.

[7] For an excellent overall view of the role played by the idea of feedback loop in the thinking of social science, see Richardson (1991). See also Forrester (1968).

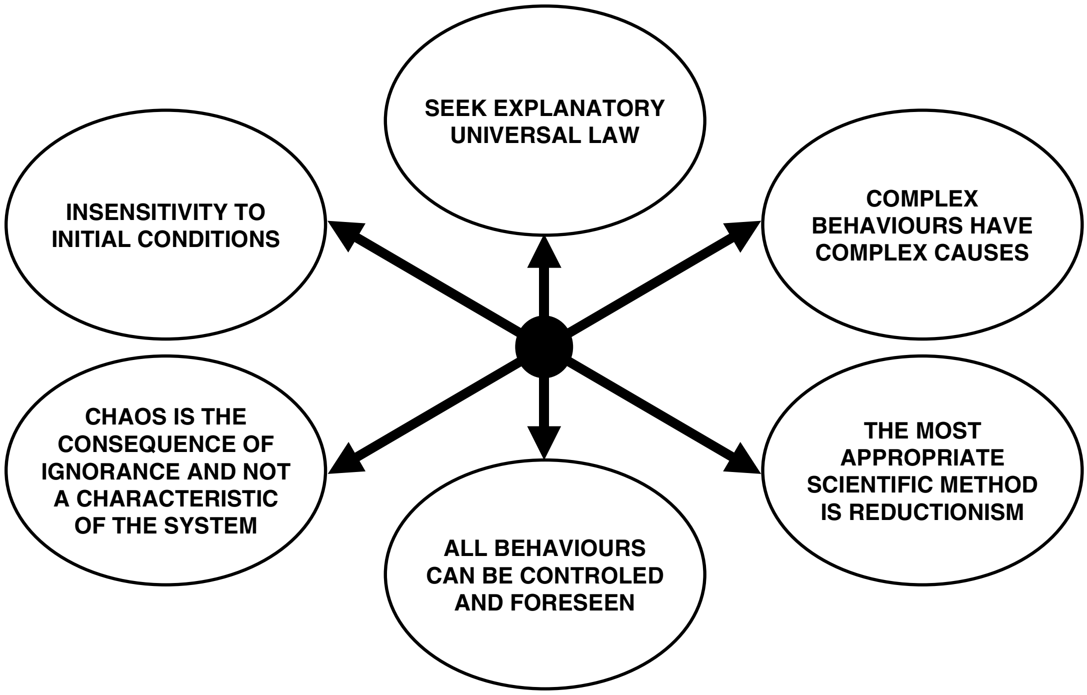


Figure 3. Basic principles of conventional approach

In the last decade, a great theoretical effort has been made to understand the behavior of complex systems. In fact, chaos, complexity and change are characteristics omnipresent in organizations (Gleick, J. 1988). The new theories provide us with information about the dynamics of change caused by the decisions taken and lead us to modify our premises, adapting our mental models and developing the capability of an effective complex learning. In fact, the premises underlying in the approach of the analysis of complexity oppose the premises of the conventional approach. Figure 4 reflects the sets of premises of the complex systems approach.

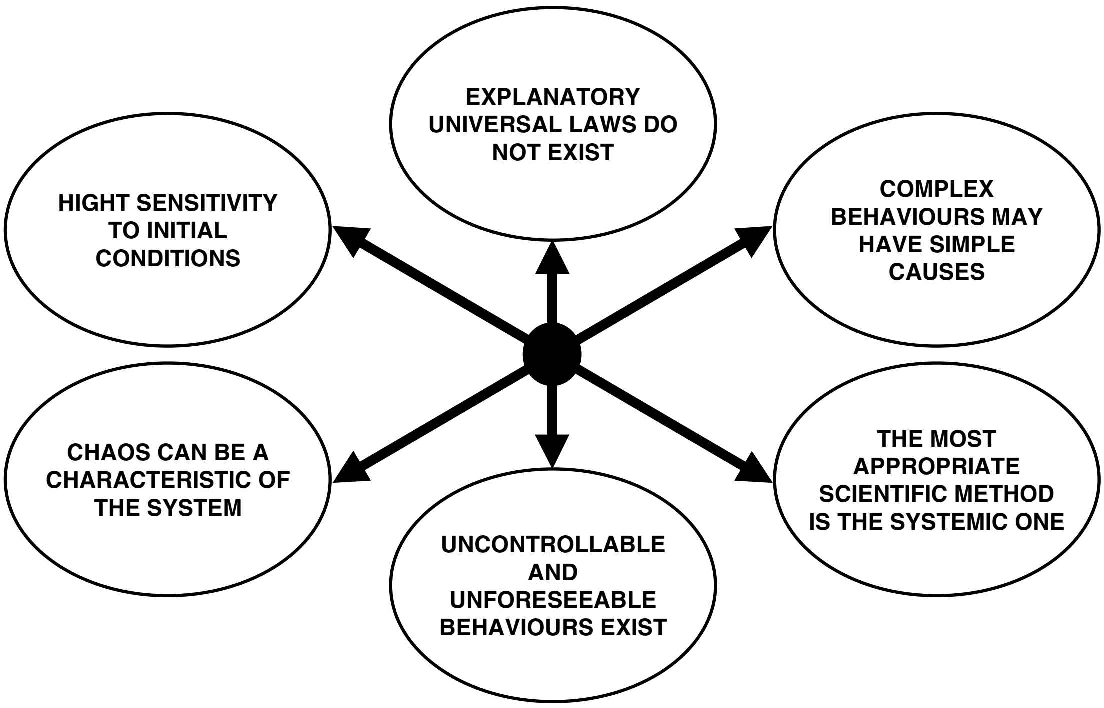


Figure 4. Basic principles of complex systems approach

The science of complexity represents an attempt to understand the dynamic behavior of systems. The complexity of this behavior is related to the amount of behavioral patterns or models, which the system can show. In fact, between the two possible extremes, a random approach and an ordered behavior, many patterns are possible with a considerable variation in their degree of complexity.

Positive feedback loops and sensitivity to initial conditions

In the previously mentioned conventional approach, the idea of negative feedback loops is underlying, that is to say, that any change or variation, which may occur, triggers a compensatory mechanism which eliminates this variation. According to this supposition, balance, control and ability to foresee constitute inevitable properties of the system (Arthur, 1990 and 1996).
Nevertheless, in many complex systems instead of negative stabilizing feedback loops, there arise positive feedback loops able to amplify small changes and provoke behaviors of the systems with a high sensitivity to initial conditions. The immediate consequence is the inability to foresee such behaviors and even more importantly with a view to this work: makes variability/variations in their behaviours unavoidable.

Dynamic analysis of MPV

Applying complex systems analysis to real problems requires using simulation as a methodology capable of instrumenting this and promoting, at the same time, the previously mentioned complex learning. For this reason, and in order to analyse the MPV from a dynamic perspective, we have used a simple simulation model, using the methodology of system dynamics[8], Applying complex systems analysis to real problems requires using simulation as a methodology capable of instrumenting this and promoting, at the same time, the previously mentioned complex learning. For this reason, and in order to analyze the MPV from a dynamic perspective, we have used a simple simulation model, using the methodology of system dynamics.

The aim is therefore not to obtain conclusive results but rather simply make a reflection on MPV and to show the usefulness of this methodology as a learning mechanism and support for decision-making.
The positive feedback loop [9] underlying the model presented as follows is reflected in Figure 5. On this point, it is necessary to indicate that in order to construct this we have started from the hypothesis that the doctor is more at ease in the use of a protocol or procedure with the increase in his knowledge, information and expertise of this.

[8] An introductory description of the origins, evolution and perspectives of system dynamics can be found in Forrester (1995).

[9] Feedback exists when the mechanism leads to a decisive act whose result is an action which influences the mechanisms and therefore future decisions (Forrester, 1961). This feedback is compiled in the feedback loops or closed circuit structures, which reflect cause-effect relations between variables. In particular, there exist two types of feedback loops: positive loops and negatives ones. A positive feedback loop occurs when all the signs of relation between the variables are positive- direct relations- or there exist an even number of negative signs- inverse relations. On the contrary, a loop is negative when there exist an odd number of negative signs.

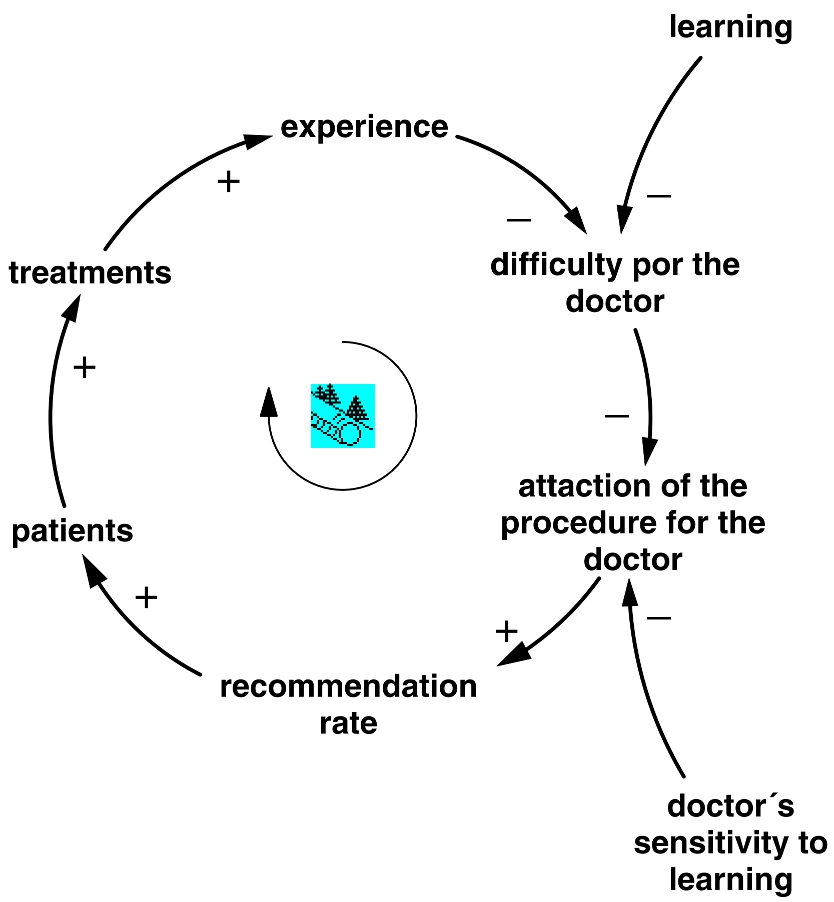


Figure 5. Causal diagram of the simulation model

The same figure shows how, the more the doctor employs a given treatment, the greater his experience regarding this, lowering the difficulty entailed. In this way, the lower this difficulty, the higher the attraction for using the treatment in similar situations in the future, the recommendation rate of the treatment, the patients treated and in short, the treatments made following this protocol thus increasing. Based on this causal diagram, a flow diagram is constructed in which the experience variable is reflected as a level, its input being determined by the number of treatments of a certain type made by the doctor.

The specific approach of the model is based on a fundamental supposition:

The difficulty a given protocol entails for a doctor decreases by a constant percentage every time the experience is duplicated.

Symbolically:

$$(1) \quad D_n = D_1 * n^{-\delta}$$

D_n difficulty of the protocol when performed n times

D_1 difficulty of the protocol applied for the first time

n experience (number of times the protocol has been performed)

δ coefficient which will depend on the type of protocol [10]

[10] It is usual to define a new parameter (K) or experience slope as the percentage of difficulty of applying a protocol compared to the difficulty existing with half the experience. It can be demonstrated that $\delta = -\log K/\log 2$.

In order to analyze the MPV, comparing different health care centres or areas as well as the use of alternative treatments in each of them, this model includes two different areas or centres -ONE and TWO- there existing in each area or center two alternative treatments for a given pathology -A and B-[11]. It is also supposed that treatment A requires surgery and so hospitalization whereas B does not. Figure 6 illustrates the flow diagram of the simulation model developed [12].

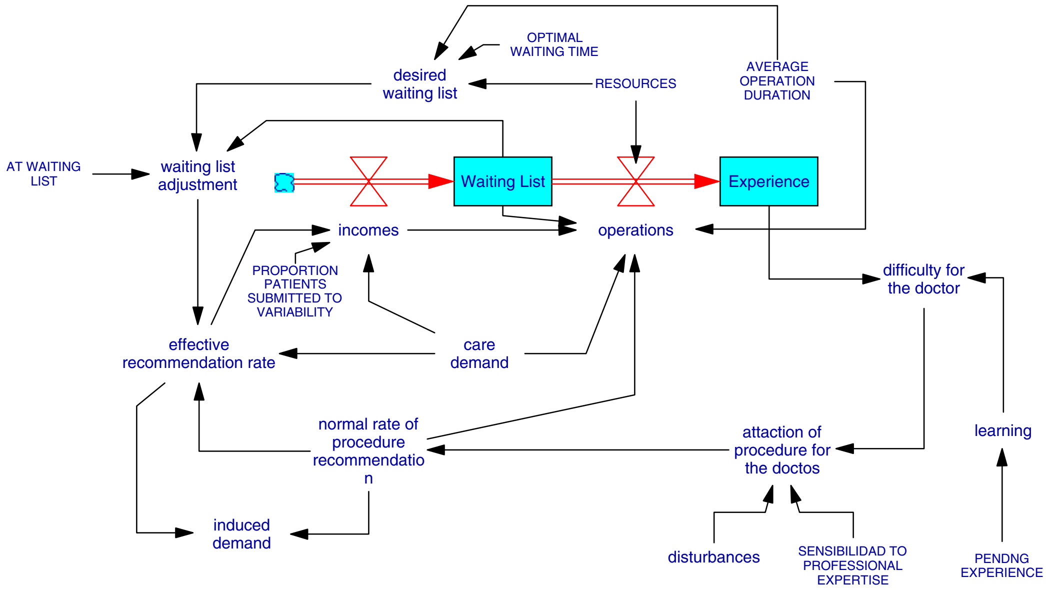


Figure 6. Flow Diagram.

Faced with a given health care demand, a percentage of this - PROPORTION OF PATIENTS TO VARAIBILITY-, can be attended by any of the two treatments available. The rest of the patients must receive treatment A. In principle, the normal recommendation rate of each of the two treatments will depend on the attraction of the procedure which in turn will depend, as we have already pointed out in the flow diagram of Figure 5, on the difficulty it entails for the doctor, difficulty which we suppose is inversely related to the experience the professional has in its application. The attractiveness of the procedure for the doctor depends, as we have just mentioned, on the difficulty it supposes for him and on the degree of sensitivity the doctors have to their degree of skill.

The basic effect to be taken into account lies in the fact that the greater the tendency of a group of doctors to use a certain type of intervention for a pathology, the more expertise and information they will have about this, thus detecting a positive feedback in the tendency for its use.

This argument can also be used for those doctors who do not make use of such an intervention; that is to say, the lower the use made of this, the lower their expertise, the perfecting of its use and the information they have about it, and so the number of patients they recommend such an intervention will be lower.

[11] The model developed incorporates vector variables whose components are each of the areas and each of the two procedures and so the model, in reality this will be a flow diagram, similar to that in Figure 6 for each area and each procedure. Similarly, the number of areas and protocols has been reduced to two, without this simplification lessening the robustness of the model in the least.

[12] This was performed using the simulation programme Vensim DSS 32 V.3.OA. The reader interested in a description of this methodology and of the commercial software available can consult No. 10 of the Revista Asturiana de Economia devoted to Simulation and company games. The journal is accompanied by a CD-ROM in which the reader can find the demos of the main commercial programmes of system dynamics development as well as a fully operative version of Vensim and documentation related to system dynamics.

In order to reflect the possible impact that a high MPV may have on the level of the waiting list for hospitalization, we consider the waiting list as a level affected by an input -hospitalization admissions[13]– and an output -operations performed[14]–. In this way, if the recommendations for surgery are greater than the operations performed, the waiting list will increase and on the contrary, if the latter are higher than the former, the list will decrease.
The difficulty in establishing the net effect on the list is based on the fact that, for example, for those areas in which the use of this procedure is greater, the number of recommendations will be higher. Hence, if the greater tendency to use this type of intervention is based on the greater availability of resources, theoretically, the output or what amounts to the same, the number of interventions performed, will also be greater. If both input and output vary in the same proportion, the level will remain constant. However, if we take into account the shortage of resources, that acts as a brake or restriction to the output, the level of resources available for surgical operations in each of the areas has to be included in the model, as a parameter.
Finally, maintaining an optimal waiting time together with the dependence on the level of resources of the level of the waiting list could bring it about that, either more resources are allocated to those services with a longer waiting list or else maintaining the waiting list is a requisite for maintaining the level of existing resources. In the first case, upon increasing the number of recommendations above the maximum activity that a service can carry out will increase the waiting list. This increase will put pressure on a greater allocation of resources for this service that, in turn, could originate a greater tendency to recommend on operations by the professional. On the other hand, in the second case, respecting the waiting time considered as normal, when the reduction of the level of the waiting list threatens the future allocation of available resources, a deviation of recommendations will be generated towards the generating procedure of the waiting list, to the detriment of the alternative procedure. Hence, if the greater resource allocation aimed to stop the growth of the waiting list, by means of an increase in the output of the level, this variable will also positively affect the input….and so, again, the net effect on the list will be highly difficult to establish[15].
In short, we note a positive feedback loop, which can originate a growth behaviour- in the first supposition mentioned- or of exponential decrease- in the second supposition. Should this loop act in one direction in some areas and differently in other areas, the MPV, or what amounts to the same, the difference between areas with a high and low index of using a given protocol, will be increasingly greater.
With regards to the impact or effect of the incentives system on the MPV, a certain incentive-for example, allocating more resources to services with longer waiting lists the use of piecework or payment per operation, may affect the doctor's behaviour, in this case increasing the recommendations in order to achieve more resources for service, a fact which is particularly important in organisations which present a structure of administrative bureaucracy. However, in this case, it is fitting to question to what extent this behaviour can be included in MPV rather than being considered an opportunistic behaviour, in particular of demand induction. In this sense, the model contemplates the possibility of the existence of professional incentives for maintaining a desired level of the waiting list.

Results of the simulation

From the model described in the previous section, we made various simulations, which enable us to draw a series of reflections on variability in medical practice. It is necessary to indicate on this point that these reflections are of a theoretical nature and are limited by the premises and starting hypotheses reflected in the simulation model. It must be emphasized that, both procedures have an initial starting situation, that is to say, each of them enjoys 50% of the demand submitted to variability.

[13] It should be remembered that only patients subjected to treatment A will be hospitalisation admissions.
[14] Similarly, only those patients receiving treatment A will leave the waiting list.
[15] See González-Busto Múgica (1998) for a complete simulation model of the management of waiting lists for surgery.

Impact of experience on the system behavior

Firstly, we analyse the importance of the experience accumulated by the doctor on clinical practice. For this, an initial simulation was performed in which it is supposed that the experience accumulated in the application of a given procedure does not affect the doctor's future decisions with regards to applying this procedure or other alternatives. In short, the previously described positive loop is eliminated.

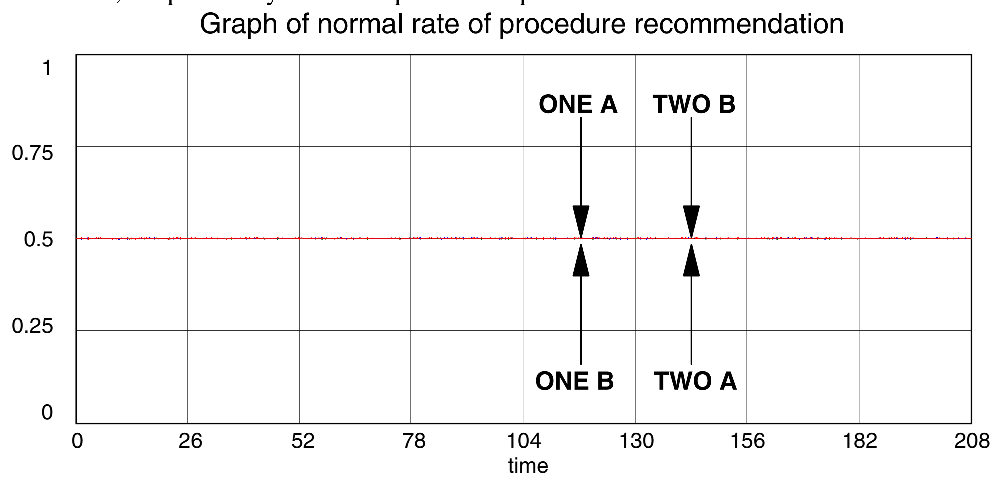


Figure 7. Evolution of normal rate of procedure recommendation without experience effect

In Figure 7 we can see how should there not exist an experience effect the recommendation of both procedures A and B coincide in 50% in both areas- ONE and TWO. Definitively, if the experience accumulated does not affect future recommendations, MPV will not arise.

We proceed to question what will happen should the positive loop of experience reflected in figure 5 really be present in the behavior of the system. For this, the impact of the accumulated experience on the rate of recommendation is activated and a value of 0.8[16] is allocated to the experience slope. Figure 8 illustrates how, should there exist an experience effect and should this affect the doctor's future behaviour, there emerges a variability between areas. It is also observed how procedure A tends to prevail or predominate in area ONE, whereas procedure B tends to become hegemonic in area TWO compared to A.

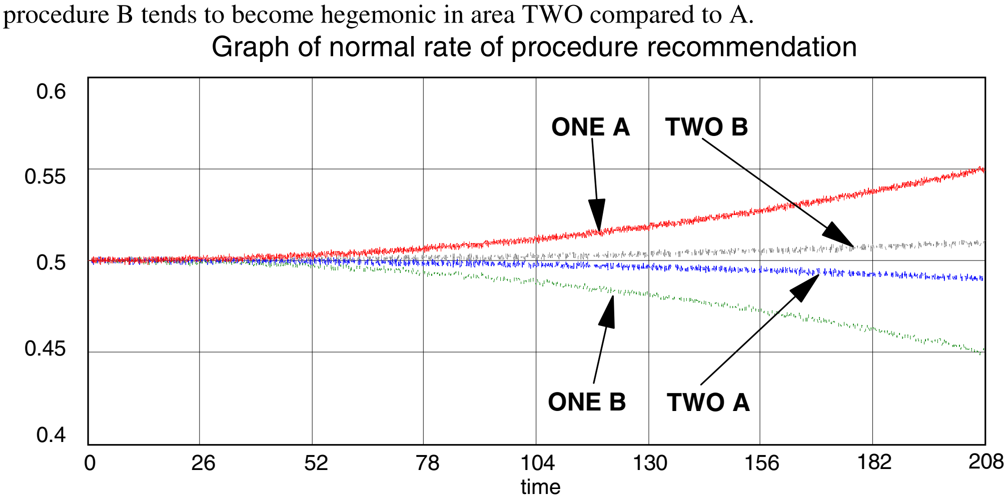


Figure 8. Evolution of normal rate of procedure recommendation with experience effect

However, in order to test whether the value adopted by the experience slope significantly affects the behaviour of the system, a sensitivity analysis regarding this parameter was performed. The results obtained in this analysis are shown in Table 1.

[16] The value of 0.8 of the slope has been taken as a reference for this simulation as higher values of this cancel the impact of the experience. This fact can be checked assigning this parameter a value of 0.9.

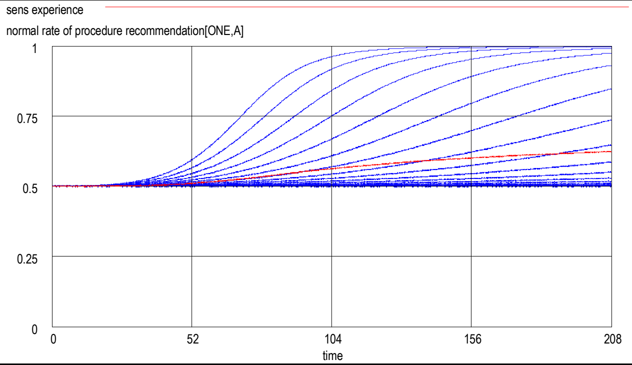
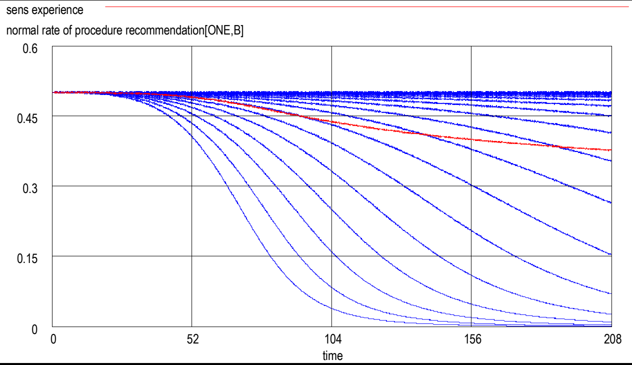
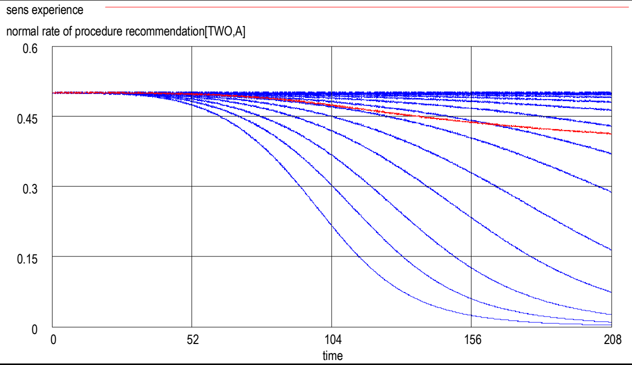
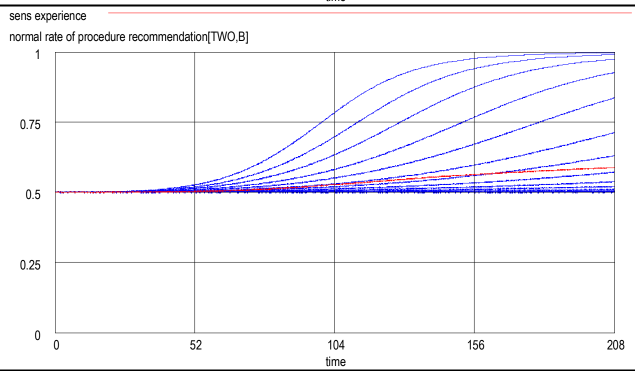
Procedure ONE in Area A	
Procedure ONE in Area B	
Procedure TWO in Area A	
Procedure TWO in Area B	

Table 1. Results of analysis of sensitivity to the experience slope

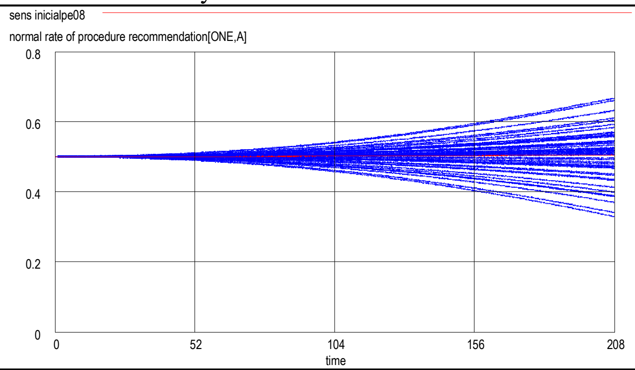
Based on the graphs contained in the table we can conclude the high sensitivity regarding the experience slope parameter, and so this parameter can be considered as a leverage point or “vital point” of the system. In this sense, as experience increases a certain procedure is implanted in each area with greater speed. As a result, in the extent that experience can be braked, if the experience slopes are not very high/steep, the process of the dominion of one of the protocols may be reversible.

However, the fact that one protocol predominates in one area and the other alternative in the other has to be confirmed by an analysis of sensitivity to the initial conditions has not been performed. Hence, the following logical step is to analyse the sensitivity of the model to the initial conditions.

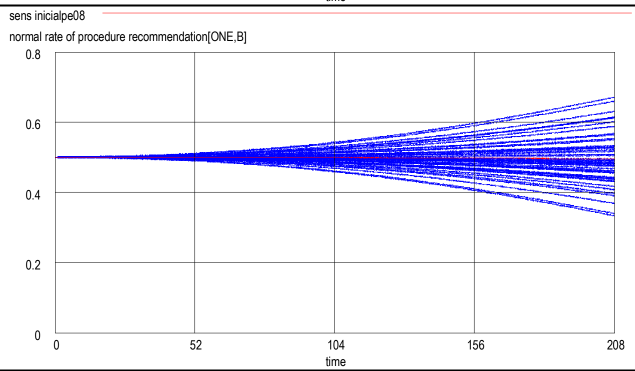
Impact of the initial conditions on the system behaviour

Just as we mentioned in a previous section, many complex systems are submitted to a high sensitivity to initial conditions. This fact clearly reveals, the need to test to what extent the MPV phenomenon is sensitive to the initial conditions[17] that affect the attraction of the use of each procedure for the doctor. For this, 50 simulations were conducted with the same starting situation but randomly varying the doctor's sensitivity to the experience minimally…in a random fashion. In these conditions, if the system was not sensitive to the initial conditions the recommendation rate for each of the protocols will be very similar in each of the simulations.

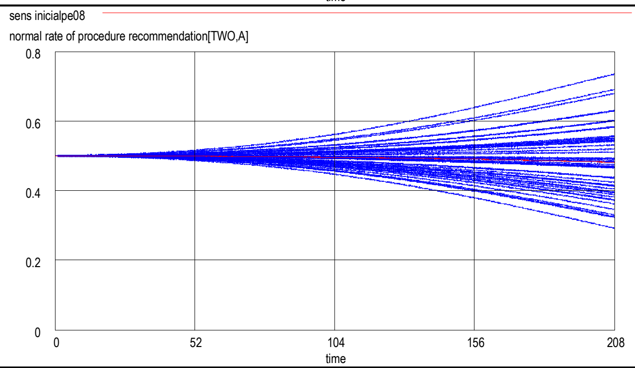
Recommendation rate of protocol A in Area ONE



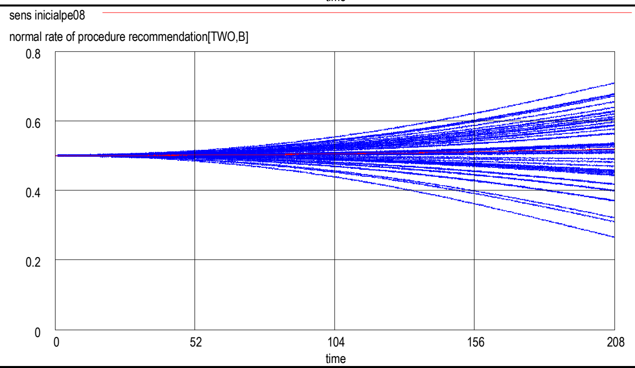
Recommendation rate of protocol B in Area ONE



Recommendation rate of protocol A in Area TWO



Recommendation rate of protocol B in Area TWO



[17] To simplify, all the following simulations are made assigning a value of 0.8 to the experience slope.

Table 2. Results of analysis of sensitivity to initial conditions

In the previous graphs it can be seen how, faced with slight variations, the behaviour of the recommendation rate for each protocol in each of the areas considered varies ostensibly, and can become the most used procedure or just the opposite in a random fashion. In this way, we conclude what has been previously above: variability is inevitable when the system is highly sensitive to the initial conditions.

Impact of shortage of resources on MPV

Simulations performed to date have been based on the supposition of the unlimited availability of those resources necessary to develop each of the procedures. Therefore, we go on to analyse whether the scarcity of resources can affect the preponderance of one procedure over the other. For this, we establish as a starting hypothesis that there exist a lack of those resources used by procedure A whereas B is not submitted to any type of restriction[18].

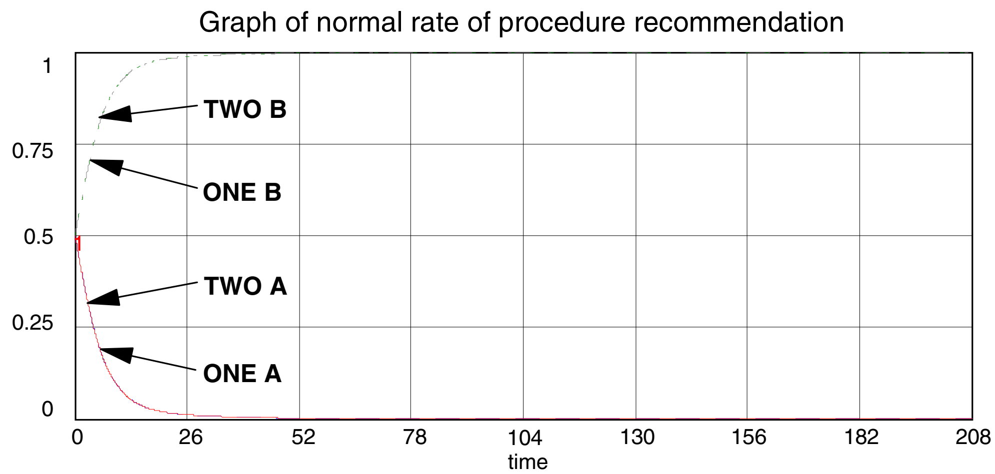


Figure 9. Evolution of normal rate of procedure recommendation with limitation of resources for procedure A

It is observed in figure 9 how, assuming resources to be scarce for one of the procedures that which is not limited by any scarce resource in both areas will end up predominating. In short, it could be concluded that the lack of available resources to perform a certain protocol can brake its establishment and, on the contrary, the practically unlimited availability of resources can lead to the preponderance of others[19].

Finally, the results of the analysis of the sensitivity to the parameter reflecting the availability of resources for a procedure demonstrate that the protocol which is not submitted to any limitation-in this case procedure B- will always end up predominating although the lower the shortage for A, the longer B will take to definitively establish itself and vice versa

Effect of the proportion of patients subject to variability on the system behavior

Up to this point, we have supposed that all the patients presenting a certain pathology can, indistinctly and on the doctor's orders be submitted to any of the alternative treatments. In this way, the parameter contained in the model and termed proportion of patients submitted to variability took a value

[18] This supposition could either correspond to the selection of two alternative procedures, one of which entails a surgical operation with later hospitalisation. In this case the possibility of make recommendations and accumulating experience with respect to this procedure is limited by the availability of beds and operating theatres.

[19] This result is in concordance with the statement that greater supply generates greater demand, in the sense that if the doctor has, in a practically unlimited fashion, a certain technology at his disposal, he will tend to increase the demand and use he makes of it.

equal to unity. We now question what would happen if, for a given number of patients, there exists a clear consensus regarding the treatment they have to be submitted to-procedure A-, in such a way that only a proportion of patients-the remaining ones- are submitted to MPV. For this, we performed an analysis of sensitivity to the previously mentioned parameter.

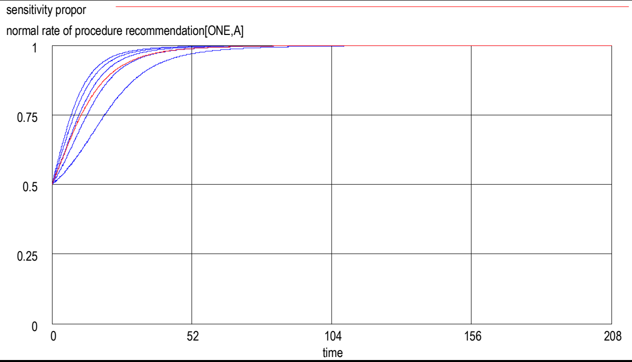
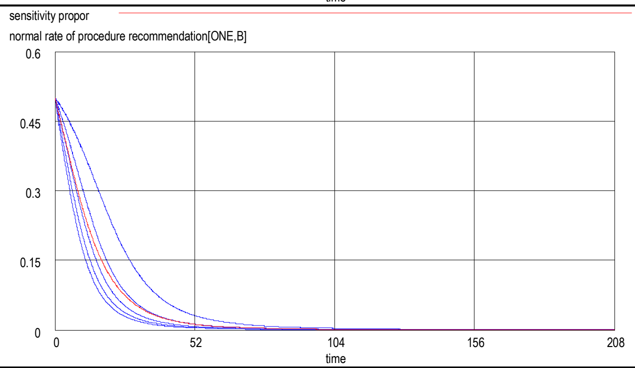
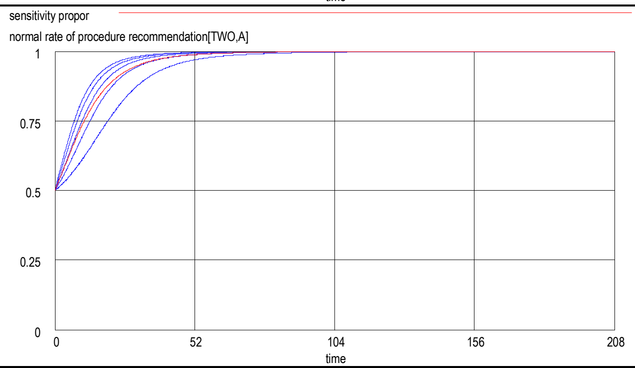
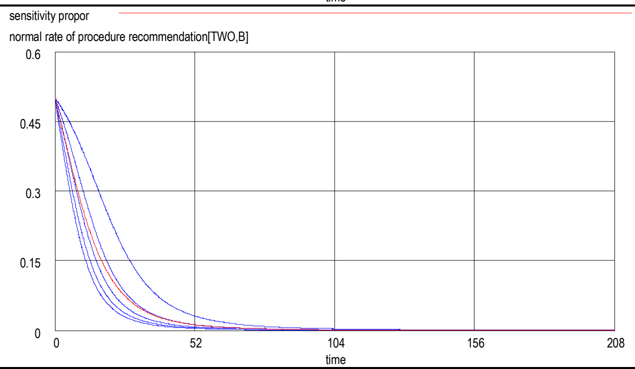
<table>
<tr><td>Rate of recommendation of protocol A in Area ONE</td><td>
</td></tr>
<tr><td>Rate of recommendation of protocol B in Area ONE</td><td>
</td></tr>
<tr><td>Rate of recommendation of protocol A in Area TWO</td><td>
</td></tr>
<tr><td>Rate of recommendation of protocol B in Area TWO</td><td>
</td></tr>
</table>

Table 3. Results of analysis of sensitivity to proportion of patients subjected to variability

Just as seen in Table 3, the fact that the proportion of patients submitted to MPV varies, only affects quantitatively and not significantly the recommendation rate of each procedure. It can only be concluded that the greater the proportion submitted to variability, the more quickly a procedure tends to predominate. The graphs show that, in this case, procedure A is the one, which tends to prevail. This is due to the fact that, in the extent that for a percentage of patients however small, there exists professional consensus that they have to be submitted to protocol A, the latter procedure will always have the advantage, in the sense that it will allow more experience to be accumulated, thus increasing the tendency of the doctors to when there does not exist unanimity as to the efficacy of the different alternatives.

Impact of waiting lists and perverse incentives on MPV

When analysing the lack of resources, we started from the supposition that procedure A implied a surgical operation and hospitalisation. In this case, therefore, the doctor's decision to opt for this procedure implies the increase in the waiting list for his service. We go onto establish the hypothesis that the system of incentives applied at a central level to control the waiting lists generates perverse incentives to maintain them. This would be the case of those measures that entail allocating more resources to those services which present longer waiting times: the service will have incentives to maintain or increase its list, as the latter is an instrument of power and bargaining for the service[20].

With a view to the simulation model, therefore the possibility that the service, upon observing that the list decreases, decides to increase the recommendation of the procedure that entails an operation is activate. Firstly, a simulation is performed without taking into account the lack of resources that procedure A is submitted to.

[20] This behaviour is characteristic of bureaucratic organisations in which the main source of power and prestige is the size of the departments or areas as well as the amount of resources allocated to them.

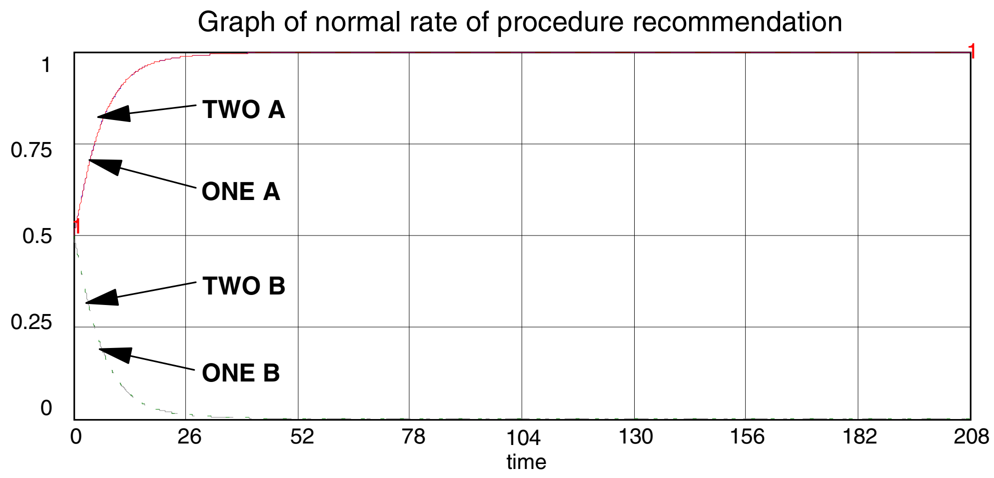


Figure 10. Evolution of the normal rate of procedure recommendation without limitation of resources for procedure A and with perverse incentives on the waiting list

It is observed in figure 10 how, following these suppositions, procedure A tends to predominate in both areas. However, the starting hypotheses of this simulation are contradictory since one of the basic reasons for the existence of waiting lists is, precisely, the shortage of resources or the existence of a supply lower than demand. For this reason, we conducted a second simulation activating the restriction of resources.

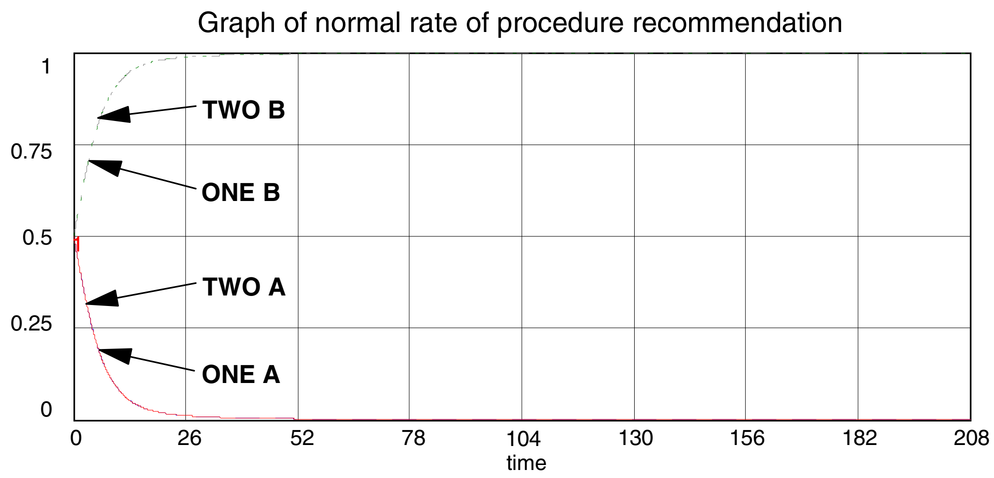


Figure 11. Evolution of the normal rate of procedure recommendation with limitation of resources for procedure A and with perverse incentives on the waiting list

In this case, procedure B is imposed in both areas. In view of Figure 11 we can conclude that, definitively, the restriction of resources will have, in this case, a greater importance than the attempt to maintain a long waiting list. It can also be appreciated how this result coincides with that obtained in the simulation referring to the lack of resources.

Finally, in order to test whether the excessive limitation of resources contained in the model is the only cause of the previous result, a new simulation is made, notably increasing the resources available for activity A[21].

[21] In particular, the availability of resources is multiplied by five in the model.

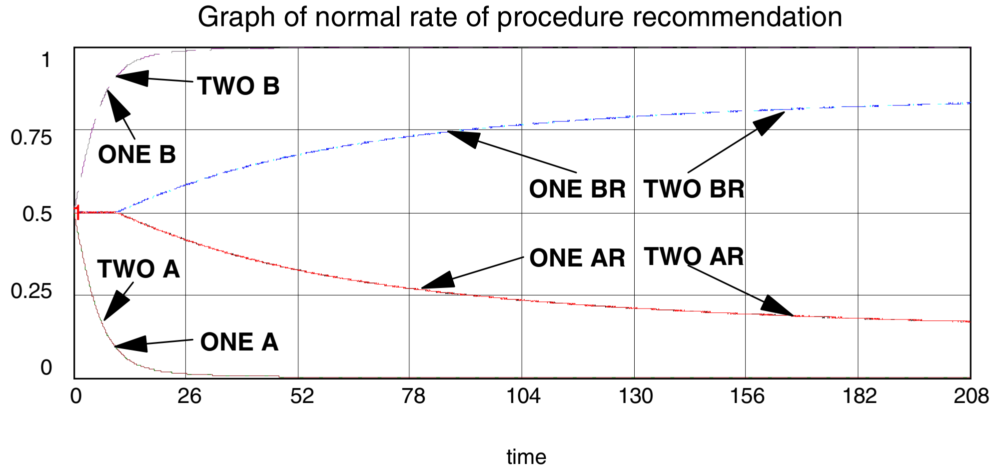


Figure 12. Evolution of the normal rate of procedure recommendation with less limitation of resources for procedure A and with perverse incentives on the waiting list

Figure 12 reflects, overall, the situation shown in Figure 11- TWO A, TWO B, ONE A and ONE B- and the result of the previously described simulation- TWO AR, TWO BR, ONE AR and ONE BR-, with increase of resources. In the same figure we can see how despite this increase, the use of procedure A equally ends up stagnating, although this does so more slowly than in the previous supposition. In this way, the conclusion drawn from figure 11 can be generalized in the extent that there exists certain restriction of resources.

Conclusions

Health organizations present a structural and dynamic complexity, which make it difficult and even impossible to apply the traditional analysis methods and intuitive understanding of their behaviour. For this reason, we consider an approach of the analysis of MPV from the perspective of the complex systems theory.
The operativeness of this approach is obtained with the development of simulation models. The methodology of systems dynamics also enables the facilitation of complex learning in health organizations.
The simulation model developed enables us to make the following reflections on MPV:

1. Variations in medical practice, in presence of an experience effect in the professional activity can be inevitable emerging property in a complex system such as a health organization.
2. This variable basically depends on the high sensitivity to initial conditions caused by the amplifying action arising from the experience effect. As a result MPV is a property of health organizations, which is very difficult to foresee and control.
3. Finally, we highlight the importance of the availability of resources and the applied incentive system for the management of MPV.

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