A System Dynamics Model for Analysing Waiting Lists in Spanish Public Hospitals

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1. Introduction

Long waiting lists are one of the major problems faced by the Spanish National Health Service. Due to the political and social concern generated by the long periods of time patients have to wait to receive medical care, policies are designed in order to shorten or even eliminate these waiting lists. As, until now, most of the research works analyzing waiting lists in Spain have been based on the Queuing Theory, we considered building a simulation model in order to improve our understanding of how waiting lists behave over time and to analyze the long-term effectiveness of the policies commonly used when managing waiting lists.

This simulation model includes those policies currently in practice –subcontracting activities to public and privately owned hospitals, the so-called "special programs", waiting list updating or revision– and some proposals –capacity investment decision, staggering of the vacation periods. Simulation with the model enables us to detect leverage points in the system and make some recommendations as to the usefulness and the long-term impact of these policies.

2. Policies commonly used in the Spanish NHS to managing waiting lists

Nowadays, the Spanish National Health Service managers rely on three basic measures to shorten waiting lists that entail excessively long waiting periods for patients: subcontracting, "special programs" and waiting list updating.

Regarding subcontracting activity, currently, at the beginning of every year each hospital decides the number of patients to be sent to a subcontracted hospital (either private or public). This policy seems to be appropriate, in principle, as it implies the use of medical resources that would otherwise possibly be under-used. However, subcontracting health care services causes a fundamental problem related to the patients´ resistance to being referred to or treated in a subcontracted hospital. This resistance arises from the fact that, usually, the latter possess reduced or inferior health care resources compared to the center contracting the service. Besides, patients give great importance to continuity when requesting medical care. They prefer on most occasions, to wait longer and be treated by the same doctor throughout the service process, instead of being quickly attended and treated in a subcontracted hospital. Apart from this problem, it is necessary to question the long-term usefulness and effectiveness of this measure. We try to demonstrate that subcontracting health care services, in the way the Spanish NHS is doing so at the present time, does not affect the long-term behavior of waiting lists, due to their inflexibility; this lack of flexibility is due to rigid budgeting and bureaucratic restrictions that public hospitals are subject to.

The second policy usually employed to shorten waiting lists consists of the so-called "special programs". At the present time, the medical staff in public hospitals has an eight-to-three working day. In this sense, "special programs" involve extending the working day to the afternoons. This extra-work is remunerated with a fee-for-service system, depending, therefore, on the number of patients treated. In principle, this policy could seem to be efficient as it entails using the hospital resources –operating theaters and personnel– for more hours a day; however, the "special programs" give rise to perverse incentives that can lead to opportunist behavior by the medical personnel.

Remuneration of doctors, working in those departments where "special programs" are being implemented, increases when the department waiting list is high; therefore, these doctors have incentives to lengthen the waiting list, as this behavior implies an increase in their incomes. In this sense, doctors can make use of various mechanisms to artificially lengthen the waiting list: reducing their productivity during the mornings, increasing the average hospitalization stay or inducing demand. Lowering their productivity during the mornings can similarly be explained using the Equal Compensation Principle (Milgrom and Roberts, 1992): when applying two different incentive systems –salary during the eight-to-three working day and fee-for-service in the afternoons–, doctors will concentrate their effort on the activity with higher incentives, that is, the "special program" incentive, neglecting the activity providing them with less marginal profit. We, therefore, try to demonstrate how the effects of applying "special programs" are different and even quite the opposite in the short and long term: reducing the waiting list in the short-term but increasing it in the long-term.

The updating of the waiting list is the third policy, recently adopted, in order to manage waiting lists. The need for this lies in the differences observed between the officially recorded list and the real one; the former will be always be higher than the latter due to delays in recording decease and abandonment or giving up of patients included in the official one. Thus, periodically, a control is carried out by telephone calls to patients, excluding from the list those patients the hospital cannot contact –after trying a set number of calls. This policy can be applied in order to achieve a twofold aim:

- Improving the quality of decisions, which use the official waiting list as an information input. In this sense, delays in recording cases of patients giving up would be significantly reduced.
- Shortening the waiting list in order to show a better or more acceptable service indicator; as it is a measure usually employed to determine the effectiveness and quality of the health care services offered by the public sector.

An aggressive revision can lead to crossing off the list patients who have not really given up. This can cause two types of costs: firstly, costs in time for those patients who have been mistakenly crossed off but still want to receive the service, and secondly, costs for the hospital itself as its consultation demand will increase when these patients have to reinitiate the process.

3. Basic model loop structure

Once the main policies employed to shorten waiting lists have been analyzed, we go on to describe the simplified causal loop structure used to build the model. This shows the theoretical framework related to health care management and, more specifically, to hospital management:

1. Professional bureaucracy, the characteristic hospital organizational structure, and its peculiar coexistence with administrative bureaucracy, which is the organizational structure of the Spanish NHS (Mintzberg, 1979; Benveniste, 1987; Elola, 1994).
2. Agency relationships between doctor and patient, patient and hospital and, finally, doctor and hospital. Concerning the first, we have specially focused on the supplier-induced demand (SID) that can appear when this agency is imperfect (Jensen and Meckling, 1976; Mooney, 1994; Wagstaff, 1989; Ortún, 1992).
3. The incentive system applied to doctors in the Spanish National Health Service (Milgrom and Roberts, 1992; Ortún, 1992; Rosen, 1987; Kristiansen and Mooney, 1993).

Moreover, this loop structure includes qualitative information obtained from managers, staff and doctors working for the Spanish NHS through in-depth interviews.

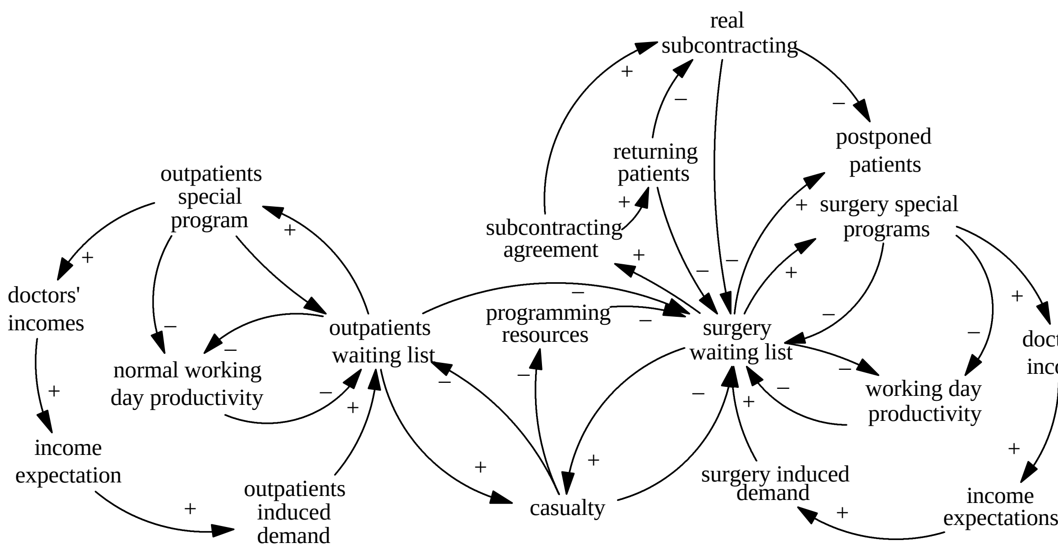


Figure 3.1: Basic Loop Structure

In Figure 3.1, we can detect several feedback loops:

A first feedback loop –Figure 2– shows the interrelations between the Outpatients waiting list, the waiting list for Surgery or operations and the Casualty or ER department. Thus, as the Outpatients waiting lists decrease, waiting lists for those patients needing an operation increase. Besides, the longer the list or waiting time in both cases, the higher the number of patients who try to jump the queue by going directly to Casualty. Should they be admitted here, the real waiting list decreases, although this decrease will not be immediately perceived, due to a delay equal to the time until the date set for the consultation or operation. In turn, this delay is due to the shortcomings in the internal information system.

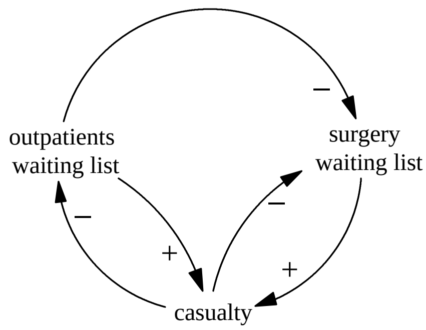


Figure 3.2: Waiting lists and Casualty loop

Secondly, a positive feedback loop can be detected –Figure 3– caused by interactions between the variables of the Surgery waiting list, Casualty and available resources for planned activities. The longer the waiting list, the more patients will attempt to avoid this by going to Casualty. This subsequent increase in the Casualty activity will entail the need for redistributing resources –beds and operating theaters–, increasing those of the Emergency department and, therefore, reducing their availability for the rest of the departments to reach their goals of planned activity.

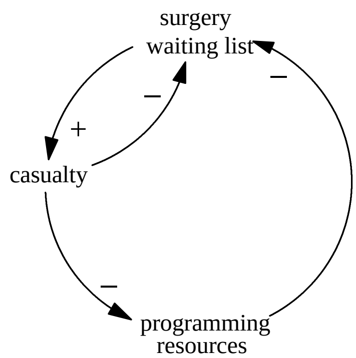


Figure 3.3: Available resources loop

Next, we can detect a third loop –Figure 4– related to the variables of waiting list for operations, "special programs" and productivity during the eight-to-three working day. "Special programs" are activated when waiting time or the number of patients waiting is excessive. As mentioned in Section two, these programs involve extending activity to the afternoons, using a fee-for-service remuneration mechanism. Thus, their short-term effect is a shorter waiting list; however, they can cause, as an indirect effect, lower productivity in the usual working hours, as a mechanism to maintain a long waiting list in the long-term which obliges a "special program" to be reestablished. In this respect, in order to support the latter interaction, it has been demonstrated that when applying "special programs", productivity in terms of time is much higher during the afternoons, compared with that observed during the mornings. This fact is a direct consequence of the fee-for-service system used.

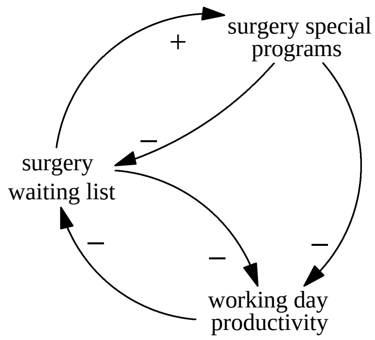


Figure 3.4: Surgery special programs loop

The following feedback loop –Figure 5– reflects the SID that can appear as a result of the implementation of "special programs" and, moreover, of any measure for shortening waiting lists which benefits those departments with longer ones. When applying this kind of measure, doctors' incomes temporarily increase, causing an increase in future income expectations. In this sense, doctors can feel motivated to induce demand in order to artificially increase their department waiting list, which guarantees the maintenance of these measures in the future.

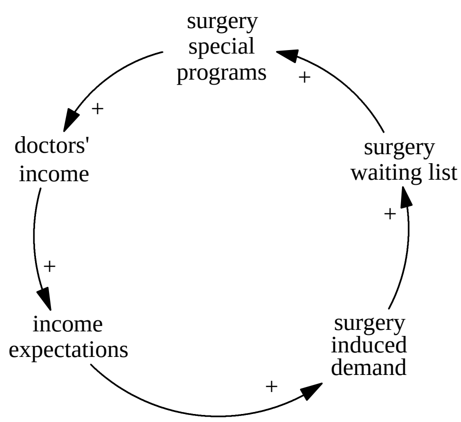


Figure 3.5: Surgery induced demand loop

Similar to the Surgery waiting list, and in relation to the Outpatients waiting list, we can detect two feedback loops corresponding to the “special programs” and SID –figures 4 and 5– respectively. In this case, interactions detected for the Outpatients have the same sign as those corresponding to Surgery, even though we must mention that the doctors’ capacity for inducing demand is greater and easier to generate in case of Outpatients as opposed to Surgery.

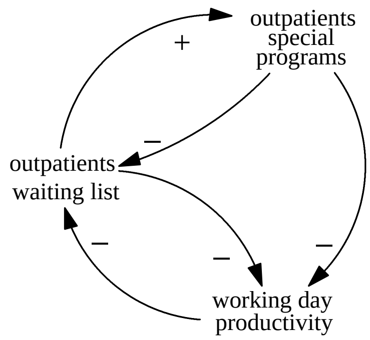


Figure 3.6: Outpatients "Special programs" loop

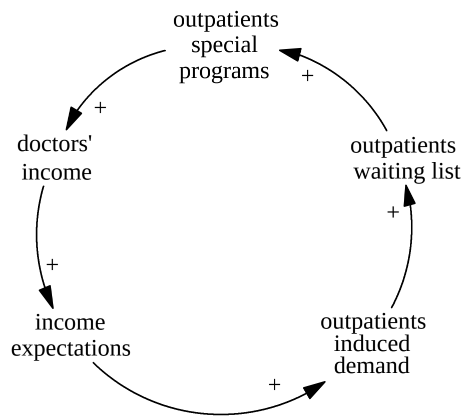


Figure 3.7: Outpatients SID loop

Finally, related to subcontracting activity as a common measure for shortening waiting lists, as these are observed to rise, the number of patients sent to a subcontracted hospital increases. However, the subcontract initially established does not coincide with the one really implemented due to the return of patients to the contractor hospital. This return can be caused by the decision of either the patient –preferring to receive the service in the contractor hospital– or the decision of the subcontractor hospital –considering that the operation involves higher risks than it is willing to take. The postponed patients –including those who decide not to receive the service when it is their turn according to their position on the list– are then sent to the contractor hospital, thus reducing the amount of subcontracting activity initially established. The real subcontracting agreement reduces the initial waiting list, causing a negative feedback loop.

Besides, it should be mentioned that some hospital departments show a certain reticence to subcontracting activity, based on the following facts: patients have placed their trust in them and the fewer resources, lower service quality and staff training perceived by patients in the subcontracted hospitals.

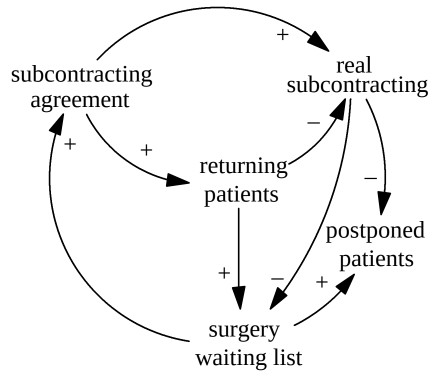


Figure 3.8: Subcontracting loop

4. Building the model and statistical validation

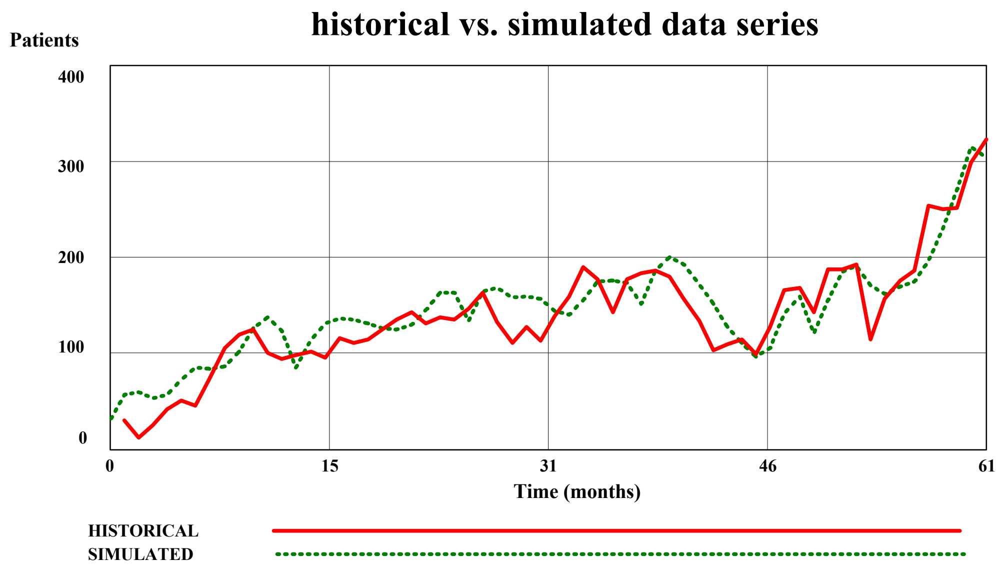
The basic loop structure, described in Section three, was converted into a flow diagram, containing ten levels –real and official waiting lists for Outpatients and Surgery, Casualty department patients, ongoing "special programs", the number of outstanding special programs operations and, finally, those levels reflecting the availability of beds, operating theaters and personnel. Concerning the distinction between official and real waiting lists, this is necessary for the reasons mentioned in Section two: the official one, used as an information input for decision making, will always be longer than the real one due to delays in recording those patients who abandon the list and to the shortcomings of the communication/information system between departments and Admissions, which manages waiting lists.

Once the model was constructed, it was put to the statistical test. We selected the General Surgery department of the Asturias Hospital, as its activity mostly involves operations[1], and used historical data from five years (1989/1993) in order to verify if the model was able to reproduce the behavior observed in reality.

The following graph shows the combined evolution of the real waiting list (historical) and the one simulated by the model [2] (*simulated*).

[1] We have selected this department because the model largely reflects the Surgery waiting list

[2] We took as the initial value of the level the historical value of the waiting list in January 1989. Besides, the subcontracting and "special programs" measures are activated, as they were commonly used during the simulated period (January 1989/December 1993).



Graph 4: Historical vs. simulated evolution of the General Surgery department waiting list[3]

Intuitively, we can state that the evolution generated by the model almost fits the historical data. However, we then analyze a series of statistics, following Oliva (1996) in order to determine model reliability.

The following table of contents shows the numerical results obtained:

SUMMARY STATISTICS	
N	60 months
R^2	0.79816
Mean Absolute Percent Error (MAPE)	0.26552
Mean Square Error (MSE)	673.88513
Root Mean Square Error (RMSE)	25.95930
Bias (U^M)	0.10102
Variation (U^S)	0.07626
Covariation (U^C)	0.82272

Table 4: Summary statistics

Values of MSE and RMSE[4] as well as the R^2–shown above–, allows to affirm the reliability of the model.

It is interesting to analyze the sources of the total error. Discrepancies observed between historical and simulated data can be due to model errors or to a high degree of randomness in the historical data evolution (Sterman, 1984), hence the usefulness of distinguishing between different sources of error. With this aim, the statistics obtained from splitting the MSE into three components and proposed by Theil (1966) are applied.

[3] The evolution of the General Surgery waiting list corresponds to the period between January 1989 and December 1993.

[4] Value of the RMSE can only be analyzed taking into account the mean value of the variable (Pindyck and Rubinfeld, 1980). In this case, the waiting list mean value is $\overline{A}$ =139.11.

In this case, most of the error is caused by the third component, due to differences in the covariance, whereas the first and second components present relatively low values. This result demonstrates that, although the model does not perfectly reproduce historical data at each moment it does, however, adequately reflect the mean value and the main trends observed in the historical data evolution of the variable. The more the greater part of the error is due to the third component, this implies that the error is small and not systematic.

Finally, the fact that the first component is not closer to zero can be due to errors when specifying parameter values or, alternatively, to the model initial assumptions being so simplified, which does not negatively affect the validation of the model.

5. Conclusions

The simulation model incorporating the main theoretical aspects explaining the behavior of public hospitals, and qualitative information obtained through in-depth interviews of members of the Spanish NHS, enables, following validation, the simulation of the long-term effects of the main policies employed in order to manage, control and reduce waiting lists[5].

After running simulations for each of the policies described in Section two, we can draw the following conclusions:

- Policies currently used to manage waiting lists do not affect their long-term evolution.
- The trend to use this kind of policy, with positive effects only in the short term, is due to the fact that the political cycle is shorter than the time needed to observe the positive effects of long-term policies.

According to these facts and the results obtained from the simulation, the following recommendations can be made:

- The appropriate management of subcontracting activities to other hospitals will cause positive long-term effects. This implies the need for flexibility in the subcontracting decision in two different ways: eliminating the lack of flexibility caused by its periodical nature, becoming an adaptable decision and allowing variability in the number of patients sent to other hospitals. This number should be established depending on the capacity of each department as well as the waiting time established as a goal.
- "Special programs" must be carefully used, limiting these to departments with high continuous demands and where hospital beds are not a scarce resource. Only in this way, can it be avoided that the perverse incentives turn into opportunist behavior. Besides, "special programs" should be used in a specific manner as otherwise they would generate perverse incentives for those departments which do not benefit from this kind of policy.

[5] Graphs corresponding to simulation results are not included due to the limited amount of pages per communication.

- Updating or revision of the waiting list must be performed only in order to improve the quality of the information available for decision making and, in no case for "manipulating" long waiting lists.
- Finally, the appropriate management of resources is a key point for improving the long-term evolution of waiting lists, making forecasts about the department demand using sufficiently long forecasting periods and smoothing times.

The combination of all these proposals allows the long-term evolution of waiting lists to be improved. Finally, it is necessary to mention the need for a structural change, in terms of mostly eliminating the bureaucratic behavior associated with public hospitals and increasing their management autonomy.

6. Bibliography

BENVENISTE, G. (1987): **Professionalizing the Organization, Reducing Bureaucracy to Enhace Effectiveness**. London: Jossey-Bass Publishers.

ELOLA, J. (1994): **Sistema Nacional de Salud: Evaluación de su Eficiencia y Alternativas de Reforma.** SG Editores, Barcelona.

KRISTIANSEN, I. S., and MOONEY, G. (1993): «The General Practicioners Use of Time: Is It Influenced by the Remuneration System?», **Social Science and Medicine**, vol. 37, nº 3, pp. 393-399.

MOONEY, G. (1994): **Key Issues in Health Economics.** Harvester Wheatsheaf.

OLIVA, R. (1996): «Empirical Validation of a Dynamic Hypothesis», **System Dynamics 96, System Dynamic Society,** Richardson, G. P. Y Sterman, J. D. ed., vol. 2, pp. 405-408.

OLIVA, R. (1997): «A VENSIM Module to Calculate Summary Statistics for Historical Fit», **D-4584,** Sloan School of Management, Massachussets Institute of Technology.

ORTÚN RUBIO, V. (1992): **La Economía en Sanidad y Medicina: Instrumentos y Limitaciones.** Editorial La Llar del Llibre, Barcelona.

MILGROM, P. and ROBERTS, J. (1992): **Economics, Organization and Management.** Prentice Hall International Editions.

PINDYCK, R. S. and RUBINFELD, D. L. (1980): **Econometric Models,** Ed. Labor Universitaria, Manuales.

ROSEN, S. (1987): «Transaction Costs and Internal Labor Markets», Working Paper nº. 2407, **Working Paper Series, National Bureau of Economic Research, Inc.**

WAGSTAFF, A. (1989): «Econometric Studies in Health Economics. A Survey of the British Literature», **Journal of Health Economics,** vol. 8, pp. 1-51.