



# Hospital capacity planning under conditions of uncertainty


## Planificación de la capacidad hospitalaria en condiciones de incertidumbre

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### Abstract

Hospital management must adapt to changes in its environment, where a balance between care and administrative processes predominates, requiring efficient planning. The research aims to propose a procedure for long-term capacity planning under conditions of uncertainty in hospital organizations. A four-stage, quantitative descriptive methodology was designed, including tools such as expert selection, patient flow representation through the different treatment stages, demand forecasting, and capacity calculation. Among the main results, the capacity of the groups related by the diagnosis of the surgical type defined in the service was determined, the operating room was identified as a limiting resource, as well as the percentage of utilization, obtaining 112 % in the operating rooms and 35.58 % of the beds. Among the limitations of the proposed procedure is the level of precision of the capacity calculations (medium-low), typical of long-term planning; however, it enables the heads of hospital government services to propose corrective actions to capacity problems based on a structured methodological procedure that shows how to do the following.

**Keywords:** Forecasting; demand; hospital management; health services; patient flow; strategic planning.

### Resumen

La gestión hospitalaria se debe adaptar a los cambios de su entorno, donde predomine un equilibrio entre los procesos asistenciales y administrativos, por lo que exige una planeación eficiente. El objetivo de la investigación es proponer un procedimiento para la planeación de la capacidad a largo plazo bajo condiciones de incertidumbre en organizaciones hospitalarias. Se diseñó una metodología estructurada en cuatro etapas, de tipo cuantitativa descriptiva, incluye herramientas como la selección de expertos, representación del flujo de pacientes por las diferentes etapas del tratamiento, previsión de la demanda y cálculo de la capacidad. Entre los principales resultados se determinó la capacidad de los grupos relacionados por el diagnóstico de tipo quirúrgicos definidos en el servicio, se identificó como recurso limitante al salón de operaciones, así como el porcentaje de utilización, obteniéndose un 112 % en los salones y 35,58 % de las camas. Entre las limitaciones del procedimiento propuesto está el nivel de precisión de los cálculos de la capacidad (medio – bajo), propios de la planificación a largo plazo, sin embargo, posibilita a los jefes de servicios de gobierno hospitalario proponer acciones correctivas a problemas de capacidad a partir de un proceder metodológico estructurado que muestra el cómo hacer.

**Palabras clave:** Previsión; demanda; gestión hospitalaria; servicios de salud; flujo de pacientes; planificación estratégica.

## INTRODUCTION

Health services have acquired increasing importance within service organizations due to their high level of contact with the population. In this context, the purpose of the healthcare sector is to provide quality service focused on patient satisfaction (Arboleda, 2023; KhanMohammadi, Talaie & Azizi, 2023), which is reflected in SDG [Sustainable Development Goal] number three (Tushar et al., 2023).

Within health services, hospitals play a significant role in promoting health (Kharbanda et al., 2021) by providing specialized services for complex medical needs (Corsi et al., 2023). Over time, different management tools have been developed for hospital institutions (Sánchez Suárez et al., 2022); processes have been standardized (Duplantier et al., 2015), and practices have been developed aimed at optimizing care while improving the well-being of patients (Akthar, Nayak & Pai P, 2023).

Hospital management must adapt to changes in the environment, achieving a balance between care processes and hospital governance and administration (Arancibia Alvarado, 2018). This requires adequate planning, organization, and control to achieve the expected results. In order to improve operations planning and to reduce the large number of patients with care needs, systems have been created to group and classify patients (Çetin, Cebeci & Eray, 2023; Yeramaneni et al., 2023).

Patient grouping systems in hospital management aim to optimize limited resources by scheduling the paths of groups of patients that consume the same resources or demand the same health technologies (Marqués León et al., 2017). One of health managers' main concerns is managing limitations and being prepared to cover the demand for care.

In this sense, demand management has become a necessity. Demand is the pattern of patients with care needs that arrive at hospital institutions (Ackermann & Sellitto, 2022). In this context, uncertainty is a relevant variable inherent to these services (Bhattacharjee & Ray, 2014). In order to reduce uncertainty, mathematical tools have been developed (Hernández González et al., 2022) that mainly focus on the output of equipment, productivity, the performance of personnel (Bron Fonseca & Mar Cornelio, 2020); clinical evolution (Cervera Vallejos, 2020); patient arrivals (Ramírez Amat, Barquet Abi Hanna & Santana Véliz, 2015) and the variability of scheduling of surgery rooms (Díaz López et al., 2015). All these elements influence capacity planning and must necessarily be known by managers.

In Operations Management, capacity enables knowing the resources available to the healthcare entity to meet care needs and can be measured from different perspectives (Hernández Rodríguez, 2021). The most common of these include the perspectives of quality (Cisnero-Piñeiro, Fernández Delgado & Ramírez-Mendoza, 2022), safety, and efficiency or effectiveness (Jiménez Paneque, 2004).

Based on interviews with management councils and the review of quality audit reports at the studied hospital, in the context of developing strategies for the hospital's accreditation, issues have been detected related to hospital capacity, including deficient information systems to enable monitoring demand as a function of the composition of cases; deficient scheduling of elective surgery activities; deficient use of the diagnostic means; deficient use of surgical rooms; inefficient scientific methods for determining the capacity of scarce resources, and being able to proactively prepare for fluctuations in demand due to external factors from the institution. In this sense, aligning demand to capacity proactively and

through constant adjustments would enable improving operational indicators (operations planning) with direct repercussions on patient satisfaction.

Consequently, the research proposes a procedure for long-term capacity planning under conditions of uncertainty in hospital organizations. This procedure proactively aligns service demand with hospital capacity to facilitate planning at the tactical and operational levels. Methods for expert selection, process representation, time-series demand forecasting, and hospital capacity planning are used to achieve this objective.

## **BACKGROUND**

Most developed countries spend much of their health budgets on hospital capacity and services for hospitalized patients. However, the capacities and services are often not planned comprehensively, which produces a vague direction in providing services and building hospital facilities that are not driven by need (Bleibtreu, Von Ahlen & Geissler, 2022).

According to Schroeder and Goldstein (2018), capacity enables measuring what services can or cannot be provided within a given period. On their part, Duarte Forero and Camacho Oliveros (2020) highlight the need to integrate patient flows, service processes' performance, and managing limited resources with hospital strategies and policies when defining strategic planning targets.

This element reinforces the need to perform strategic planning by identifying the variables whose behavior can be monitored over time. In turn, at the tactical-operational level, methodologies have been developed for the analysis of capacity based on relocating personnel in critical services (Chu, Li & Yuan, 2022), the behavior of the services (Song et al., 2023), quality (Klein et al., 2023), care and waiting times (Sosa et al., 2023) and the consumption of materials (Gonzatto Junior et al., 2022).

Based on the review of methodologies for capacity planning at hospital organizations (Table 1), the following gaps were identified:

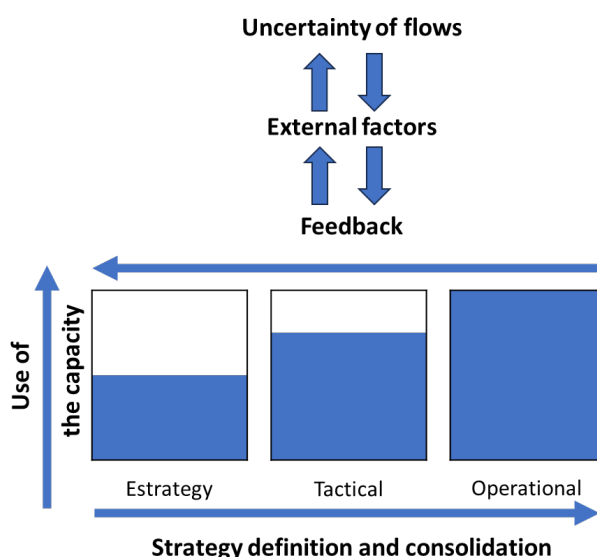
- There is a need to implement patient grouping systems that prepare studies of demand for care based on homogeneous clinical characteristics, similar use of resources, and possible care paths.
- Key variables such as uncertainty, variability, and complexity in the flow of patient arrivals must be considered and their influence on capacity studies.
- Strategic capacity planning is needed as part of the institution's policies to proactively satisfy demand and capacity utilization rates.
- There is a need for solutions to improve comprehensive capacity planning and enhance coordination between processes.

**Table 1.** Capacity planning methodologies in hospital organizations

(Author, year)	Capacity approach	Comments / Limitations
(Canchanya Gago & Quispe Felipe, 2019)	Queues theory	Care capacity is assessed by reducing patient waiting times and economic assessments regarding capacity expansion (new service positions). Limitation: It does not consider the uncertainty in patient arrivals or classify patients, which would enable reorganizing the service stations' workload.
(Duarte Forero & Camacho Oliveros, 2020)	System dynamics	Capacity is assessed by focusing on the system's output, which is how well the system can meet demand from patient flows through optimizing material and information flows. Limitation: It does not include long-term strategies that enable alignment with the proposals made in the capacity analysis for consolidating policies covering the hospital system.
(Uribe Gómez & Barrientos Gómez, 2020)	System dynamics Simulation	Capacity is assessed by focusing on the actual possibilities of hospitalization (number of beds). This also highlights the importance of hospital classification in establishing comparative output measurements. Limitation: It does not consider other resources that may limit hospital capacity, such as human resources, diagnostic means, and surgery rooms.
(Suin Guaraca, Feijoo Criollo & Suin Guaraca, 2021)	DEA [Data Envelopment Analysis]	It highlights the role of strategic resource planning as an essential variable for capacity analysis. They analyze how to increase care (demand) and maximize the system's resources' efficiency without restructuring. Limitation: It does not consider critical variables for capacity management, such as uncertainty, fluctuations, and the complexity of the flows.
(Sánchez Suárez et al., 2023a)	Heuristic methods	A procedure is proposed for aggregate planning of hospital service capacity based on contextualizing the proportional method (Acevedo Suárez, 2008) developed in manufacturing environments. Limitation: It does not consider the uncertainty of the flows as a factor associated with planning errors in the medium term.

Source: prepared by the authors

The strategy analysis proposed by this study for hospital capacity planning under uncertainty (Figure 1) enables improving tactical and operational utilization rates.



**Figure 1.** Definition and consolidation of capacity strategies at the strategic level

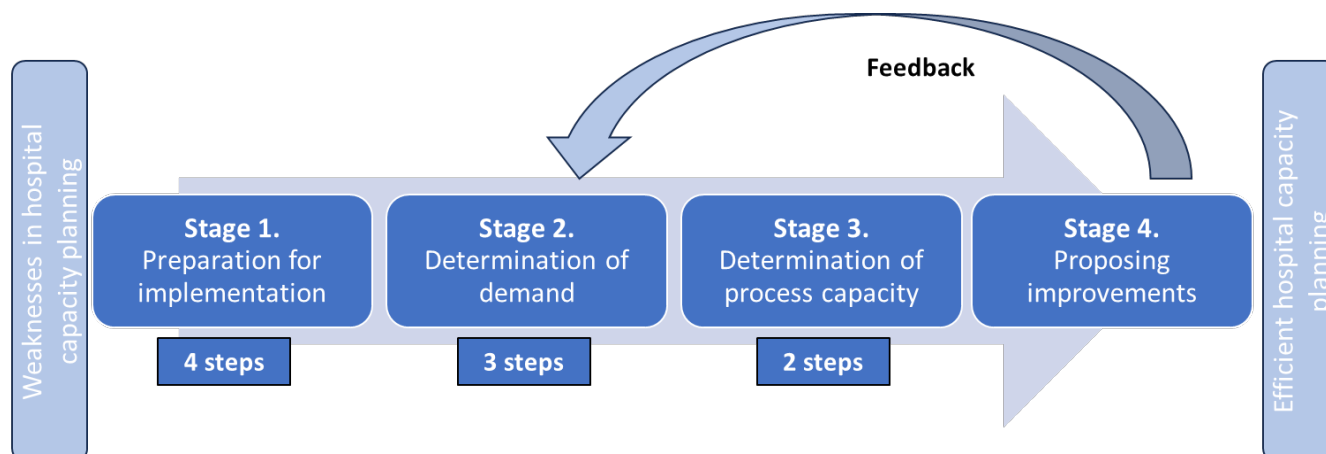
Source: prepared by the authors.

Long-term capacity planning (at the strategic level) requires considering critical variables related to the patients' paths at the healthcare entity, such as uncertainty, which may arise from the fluctuation in arrival rates or the complexity of the paths, and external factors that may considerably increase demand for care, such as epidemiological diseases (Sánchez Suárez et al., 2021). The study of these elements will provide inputs for the strategies or policies established by the hospital organizations to increase the installed capacity's utilization rates.

## METHODOLOGY

A quantitative-descriptive study was conducted (Manosalva, Yalta & Pérez, 2023) to propose a long-term capacity planning procedure for hospital services. A feedback and continuous improvement process was initiated based on a case study and the comparison of results. The case study for the deployment of the proposed procedure was selected by the decision of the hospital institution's management council, focusing on the service with the highest demand from June 2022 to September 2022, which was the Urology service at a Clinical Surgical Teaching Hospital.

Based on the analysis of the previous methodologies and because of the gaps found, the authors of this study propose a procedure for long-term capacity planning at hospitals (Figure 2).



**Figure 2.** Hospital strategic capacity planning procedure

Source: prepared by the authors.

### *Description of the strategic capacity planning procedure for hospitals*

#### *Stage 1. Preparation for implementation*

This stage was structured in four steps to identify the process that limits capacity at the hospital institution (the process with more demand than it can meet over a given time, also known as a bottleneck). The steps are related to (1) selection of the work team (research experts), (2) training of the work team, (3) selection and representation of the process, and (4) analysis of the selected process.

The starting point was a review of the characteristics of the hospital institution's activities to familiarize me with them and explore the main issues and factors that influence

capacity planning before training the workgroup. The work group comprised service specialists, department heads, and senior managers of the institution (Sánchez Suárez et al., 2023b). One of their members was appointed the project's leader, and an activity plan was established.

Several criteria were considered for selecting the process to be studied: the organization's interest, the key process, the degree to which the process is affected, and complaints or dissatisfaction with the process or its result (patient satisfaction).

Brainstorming sessions were held to diagnose the process. This tool enables the participants to jointly generate ideas with creative steering of the process, generating many ideas related to the problem or the improvement process.

#### *Stage 2. Determining demand*

This stage was structured into three (3) steps to forecast demand for the service. The steps involve (1) the clear identification of the forecast objectives, (2) the application of forecasting methods, and (3) determining the forecast (incorporation of factors that could affect the forecast of demand).

To facilitate the management of this study, patients were classified using the MDC [Major Diagnostic Categories] system and GRD [Groups Related by the Diagnosis], which described the service requirements as a function of the use of resources or similar paths. The GRDs were formed using the procedure proposed by Marqués León et al. (2017).

To simplify the selection of the forecasting method, it is recommended to use the *IBM SPSS Statistics 22* software, which includes the expert modeler feature. The forecasts incorporate the experts' criteria based on their knowledge and analysis of the factors that influence the uncertainty of planning, which enables obtaining a forecast.

#### *Stage 3. Determining the capacity of the process*

This stage was structured into two steps, and its purpose is to determine the capacity of the selected process over a one to three-year period (as a function of the identified factors that can produce fluctuations in demand). The steps involve (1) listing the primary resources that limit the service and (2) determining capacity.

Reviews of the literature, direct participative observation, and interviews with specialists enabled the identification of the resources that limit capacity in hospital organizations, which include beds, human resources, surgery rooms, and diagnosis means. To calculate capacity, the procedure proposed by Acevedo Suárez (2008) and supported by Padilla-Aguilar et al. (2023) is contextualized for the production sector, as is well as the procedure proposed by Sánchez Suárez et al. (2023a) for aggregate capacity planning in the hospital sector for the effects of long-term planning.

The defined MDCs and GRDs substitute the pieces resulting from the program reduction methods in manufacturing, and demand is related to the needs for care of the predefined MDCs and GRDs. The time spent is associated with the expenditure of resources in time, which defines whether the capacity of the process faces limitations based on the paths of the different MDCs and GRDs defined for the process. Equation 1 defines the time fund ( $F_j$ ), equation 2 the service load ( $Q_j$ ), equation 3 the proportionality coefficient ( $b_j$ ), equation 4 the capacity of the service (Cap), and equation 5 the percentage of utilization of the resources ( $\%U$ ).

$$F_j = \text{number of resources} * \frac{\text{hours}}{\text{days}} * \frac{\text{days}}{\text{week}} * \frac{\text{weeks}}{\text{month}} * \frac{\text{months}}{\text{year}} * (1 - P_s) \quad (1)$$

$$Q_j = \sum_{i=1}^n \text{Need for care (CDM o GRD)} * \text{time of care} \quad (2)$$

$$b_j = \frac{F_j}{Q_j} \quad (3)$$

$$\text{Cap} = b_j * \text{Need for care (CDM or GRD)} \quad (4)$$

$$\%U = \frac{1}{b_j} * 100 \quad (5)$$

Criteria for the selection of the limiting point of the process (limiting resources) and possible implications:

- $b_j < 1$ : It is a limiting resource or bottleneck (increased wait times and average stays).
- $b_j > 1$ : Resources that can meet the demand for care.

The criteria for selecting the key points are consistent with those set out by **Sánchez Suárez et al. (2023a)** for aggregate capacity planning.

*Stage 4. Proposed improvements*

Implementation of the proposed procedure at any hospital (always as a function of the complexity level) enables proposing a set of corrective actions that will contribute to improving capacity planning of the services in the long term. **Table 2** is suggested by this study for handling proposals of improvements (corrective actions).

**Table 2.** Corrective action summary table

Capacity problem	Corrective action	Responsible Party

Source: prepared by the authors

## RESULTS

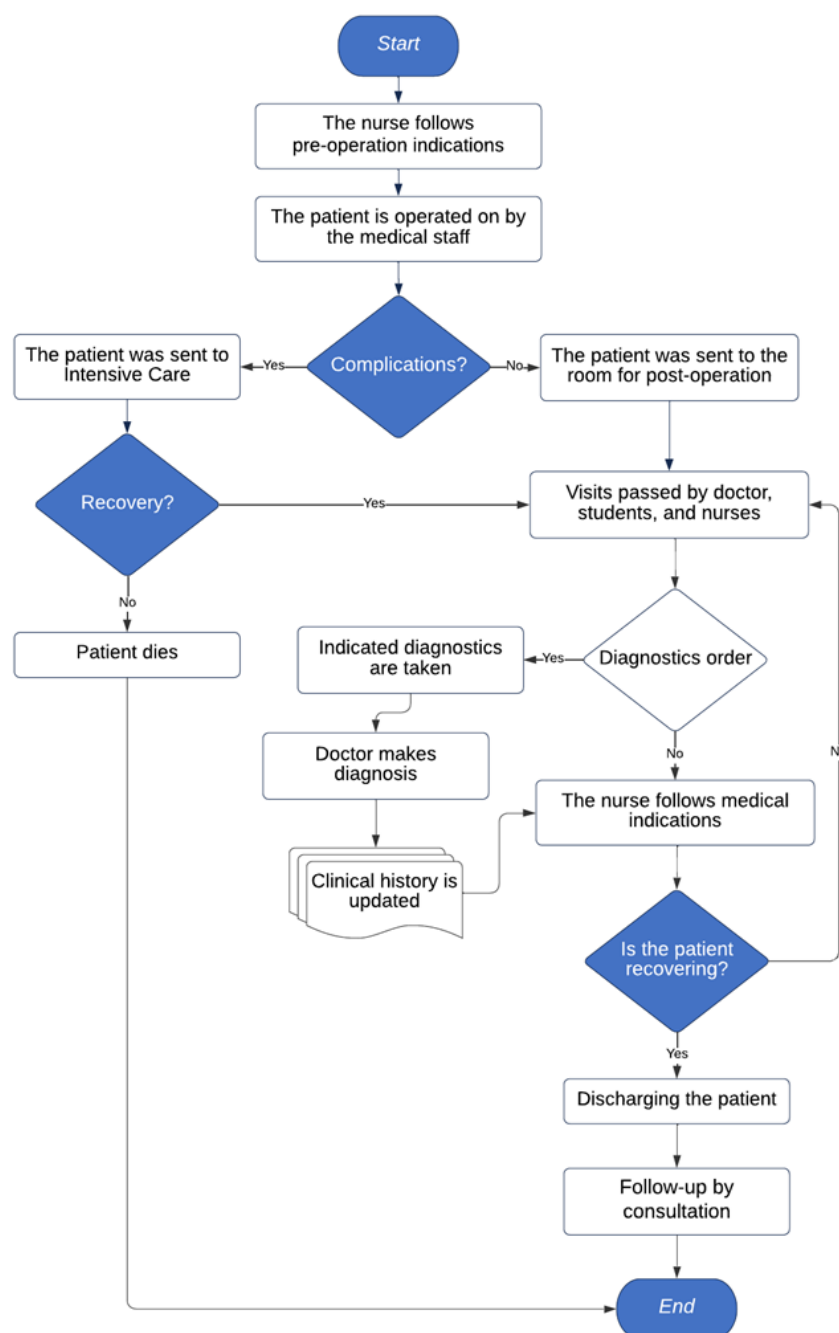
The long-term capacity planning procedure was applied to the Urology service, with the following results:

The hospital selected as the case study is a second-tier institution by the Cuban national health system’s classification. Based on the scope of its essential services, it is classified as a Clinical Surgical Teaching hospital, which provides services in 36 specialties. Based on its territorial scope, it is a province-level entity. It cares for patients referred from primary care areas of all the province’s municipalities and regional hospitals with lower levels of specialization.

*Stage 1. Preparation for implementation*

A working group was created with nine experts: three service specialists (urologists), two clinicians, two surgeons (urology specialists), the head of the quality department, and the sub-director of medical care. Seven (77.78 %) are members of the key result areas (urology service). The head of the quality department was named coordinator of the process. Training was provided on healthcare management processes, hospital management, capacity planning, and implementing the *IBM SPSS Statistics 22* software.

The entity has 19 identified and defined processes: seven strategic, six key, and six support processes. Of the critical processes, hospitalization is the most important in limiting the capacity for admissions (bed resources). During a work session, it was decided to study the Urology process because it was the service with the most significant number of complaints and unsatisfied patients. The service process is represented in an As-Is diagram (Figure 3).



**Figure 3.** Graphic representation of the Urology service process

Source: prepared by the authors.

From the observation of the process and brainstorming, the problems that could affect the service’s capacity planning were identified:

1. Inefficient management of patient flows.
2. Deficient information system (disperse and disorganized data).
3. Deficient structure and information in clinical histories.
4. Deficient assignment of healthcare personnel to work shifts.
5. Insufficient medical resources.
6. Deficient coordination between the processes involved in the patient’s path.

*Stage 2. Determining demand*

An objective of the study was to assess the needs for care of the GRDs: Urethral stricture with medical treatment (ICD 10 N35), Benign Prostatic Hyperplasia with medical treatment (ICD 10 N40.1), Prostatic adenocarcinoma with medical treatment (ICD 10 C61.1), Urethral stricture with endoscopic treatment (ICD 10 N35. 2), Urethral stricture with open surgery (ICD 10 N40), Benign Prostatic Hyperplasia with open surgery (ICD 10 C61), Prostatic adenocarcinoma with endoscopic treatment (ICD 10 C61.2), Prostatic adenocarcinoma with laparoscopic treatment (ICD 10 C61. 3), and Prostatic adenocarcinoma with open surgery (ICD 10 N65). The database records were between June 2019 and June 2022.

The study only considers the GRDs involving surgery because the surgery room is the most limited resource of the service. Table 3 shows the projection (P) of the GRDs, which incorporates the projection’s value (VR) based on the specialists’ criteria.

**Table 3.** Forecast of care needs

ICD Jul		Year 2022					Year 2023					Total		
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May		Jun	
ICD 10 N35.2	P	6	4	4	5	6	6	8	7	4	5	4	6	72
	UCL <sup>1</sup>	8	5	6	7	8	8	9	9	6	7	5	8	
	LCL	5	2	3	4	4	5	6	5	3	4	2	5	
	VR	7	5	4	6	6	7	8	7	4	6	5	7	
ICD 10 N40	P	8	7	4	5	7	6	6	4	7	6	6	7	75
	UCL	9	9	6	7	9	8	8	5	9	8	8	9	
	LCL	6	5	3	4	6	5	5	2	6	5	5	6	
	VR	8	7	4	6	7	7	7	5	7	7	7	9	
ICD 10 C61	P	6	8	7	4	5	4	5	7	5	6	6	4	75
	UCL	8	9	9	6	7	6	7	9	7	8	8	5	
	LCL	5	6	5	3	4	3	4	6	4	5	5	2	
	VR	7	8	7	4	6	4	6	8	6	7	7	5	
ICD 10 C61.2	P	4	4	7	6	6	7	8	7	4	6	6	8	80
	UCL	6	5	9	8	8	9	9	9	6	8	8	10	
	LCL	3	2	6	5	5	6	6	5	3	5	5	6	
	VR	4	5	7	7	7	9	8	7	4	7	7	8	
ICD 10 C61.3	P	6	6	8	4	4	7	6	7	5	6	6	6	75
	UCL	8	8	10	6	5	9	8	9	7	8	8	8	
	LCL	5	5	6	3	2	6	5	6	4	5	5	5	
	VR	7	7	8	4	5	7	7	8	6	7	7	7	
ICD 10 N65	P	8	7	4	6	6	4	4	7	4	4	5	6	70
	UCL	9	9	6	8	8	5	5	9	6	6	7	8	
	LCL	6	5	3	5	5	2	2	5	3	3	4	4	
	VR	8	7	4	7	7	5	5	7	4	4	6	6	

Source: prepared by the authors

<sup>1</sup> UCL: Upper control limit, and LCL: Lower control limit.

The Simple Seasonal forecasting method was applied to ICD 10 C61, ICD 10 C61.2, ICD 10 C61.3, and ICD 10 N65, while the Winters Additive Method was applied to ICD 10 N35.2 and ICD 10 N40.

*Stage 3. Determining the capacity of the process*

The relevant information was recovered from the GRDs selected for this study to deploy the method. The data were taken from the review of medical histories, documents from the statistics and admissions departments, direct observation—time measurement of the activities—and interviews with experts. Initially, it was found that the service’s limiting resources were the surgery rooms and beds.

Based on the information gathered, the service has one surgery room that provides services three days a week, and the defined GRDs are operated on these days in the room. Five beds are allocated for hospitalization (the ones used explicitly for the hospitalization of surgical activities). The service works six hours per day, three weeks per month, and twelve months of the year. It is also known that they suspend 3% of scheduled interventions.

**Table 4** lists the values related to the duration of the surgeries and room stays of the defined GRDs and the average time of hospitalization (time the patient remains at the hospital using a bed). The proposed method was used to calculate capacity (**Table 5**).

**Table 4.** Information collected for GRDs

GRDs	Duration of surgery (minutes)	Time in the Surgery room (minutes)	Average duration of stay (unit/days = bed)
ICD 10 C61	60	90	3
ICD 10 C61.2	60	90	2
ICD 10 C61.3	60	90	2
ICD 10 N65	70	100	2
ICD 10 N35.2	75	105	2
ICD 10 N40	60	90	4

Source: prepared by the authors

**Table 5.** Capacity analysis by the proposed method

GRDs	Need for care	Limiting resources		Capacity	
		Room	Beds	Room	Beds
ICD 10 C61	75	90	3	66	210
ICD 10 C61.2	80	90	2	71	224
ICD 10 C61.3	75	90	2	66	210
ICD 10 N65	70	100	2	62	202
ICD 10 N35.2	72	105	2	64	202
ICD 10 N40	75	90	4	66	210
<b>Number of resources available</b>		1	5		
	<b>bj</b>	0,89	2,81		
	<b>% U</b>	112 %	35,58 %		

Source: prepared by the authors

The fund of time available in the surgery rooms is 37,714 minutes per year, and for staying in beds, it is 188,580 minutes per year to ensure bed turnover. On the other hand, the workload of the rooms is 42,010 hours per day, and the time spent in hospital beds is 67,140 hours per year. The process capacity is 66, 71, 66, 62, 64, and 66 for the GRDs ICD 10 C61, ICD 10 C61.2, ICD 10 C61.3, ICD 10 N65, ICD 10 N35.2, and ICD 10 N40, respectively. The key limiting point of the process is the surgical room, which has the lowest bj. It is an activity all patients must undergo, consuming the most resources.

*Stage 4. Proposal for improvements*

Based on the restrictions found in calculating the process’s capacity, a series of corrective actions were proposed to ensure the fulfillment of the estimated needs for specialist care (Table 6).

**Table 6.** Proposed corrective actions

Capacity problem	Corrective action	Party responsible
Deficient scheduling of surgery activities	<ol style="list-style-type: none"> <li>To schedule surgical activities, it was decided to rank priorities according to medical criteria as a function of time in the room for endoscopic, laparoscopic, and open surgeries.</li> <li>The most experienced specialists established the following ranking of priorities: (1) oncological surgeries, (2) urinary obstructive syndrome, (3) lithiasis, (4) urinary tract infections and inflammations, (5) urology, and (6) congenital malformations.</li> </ol>	Head of Services
Deficient coordination of activities	<ol style="list-style-type: none"> <li>It was proposed to create a new work role for an employee responsible for coordinating patient flows.</li> </ol>	Human Resources
Deficient assignment of specialists for the surgical teams	<ol style="list-style-type: none"> <li>It was proposed to assign two teams of surgical staff to surgeries of minimum access and two for the most invasive ones.</li> </ol>	
Deficient information system	<ol style="list-style-type: none"> <li>Creation of a comprehensive information system from admissions to patient discharge.</li> <li>Digitize clinical histories.</li> <li>It was proposed to use electronic documentation related to discharging patients.</li> </ol>	IT

Source: prepared by the authors

**DISCUSSION OF THE RESULTS**

A procedure was proposed for long-term capacity planning under uncertainty at hospital organizations (see Figure 2) that enables managing capacity at a strategic level based on the identification of factors that create uncertainty for management, including the fluctuations in patient arrivals in exceptional situations such as pandemics and massive catastrophic events and accidents; long-term management of medical and non-medical resources to guarantee their availability at all times to provide care, and with flexibility or response capacity of the system in the event of changes in the environment, without affecting the efficient performance of critical processes, which are elements that represent contributions to administrative theory and practice.

The care needs are calculated as the sum of monthly forecasts. It should be noted that they incorporate a small amount of error arising from the subjective opinions of the specialists in correcting the forecast, which is an element to be taken into consideration depending on the type of hospital and considerations as to how often the forecasts must be updated in response to social developments.

Even though the study used time series to describe the behavior of the selected GRDs, it may not be possible to characterize the behavior of other MDCs and GRDs using time series. In this regard, [Ackermann and Sellitto \(2022\)](#) summarize the main methods used to forecast demand. These can be classified into three major groups: qualitative methods or methods based on expert opinion, quantitative methods or mathematical models, and methods based on artificial intelligence.

Capacity was calculated by comparing the time fund available for the services that limit the service and the need for care or workload to obtain a coefficient of proportionality ( $b_j$ ). A value of less than one (1) means that the resource does not have the capacity to cover demand, and measures must be taken to reduce patient wait times. These resources, operations, or stages of treatment are known as bottlenecks that produce interruptions in the service. On the other hand, a  $b_j$  value greater than one (1) means that the available resources can meet demand. However, values greater than 1.5 represent large reserves and may represent underutilization of capacity, as in the case of those with %U of 35.58%.

One of the limitations of the proposed procedure is the level of accuracy of the capacity calculations (medium-low), which is typical of long-term planning ([Sánchez Suárez et al., 2023a](#)). Additionally, even though it is a feasible model, it is not optimal, and the weights of factors that produce uncertainty in the strategic planning of capacity are not calculated. This element can be further developed in future studies and by identifying strategies and good practices at the international level to further align the strategic, tactical, and operational levels of capacity. The methodology may be supplemented with strategic perspective tools ([Acero et al., 2023](#)).

In a manner consistent with this study, [Marrero Otero et al. \(2022\)](#) apply a capacity planning model to a polyclinic, focusing on the limiting resources of doctors and nurses. [Sánchez Suárez et al. \(2023a\)](#) apply heuristics to a hospital general surgery service with similar conditions regarding the number of beds and territorial scope to this study.

The procedure has positive implications for hospital organizations:

1. Knowing the possible behavior of demand enables increasing the output of the activities through proactive planning.
2. It enables optimizing resource use by maximizing utilization rates.
3. It increases patient satisfaction by reducing wait times and average hospital stays.

The new procedure highlighted the need to train the team to perform the hospital's capacity scheduling. It also contemplates using patient grouping systems by casuistic for the organization to subsequently coordinate the patients' paths through the different hospital services under the principle of patient-centered management ([Hernández Nariño, 2010](#)). It also contemplates solutions to improve capacity problems that provide feedback to the procedure.

## CONCLUSIONS

A procedure was proposed for long-term capacity planning under uncertainty for hospital organizations, which fulfills the proposed objective. The procedure was structured in four stages, starting with creating the workgroup, then analyzing and representing the selected process, concluding with forecasting demand, calculating the process's capacity, and identifying the process's limiting point.

Strategic capacity planning using the proposed method enabled the identification of the limiting resource of the Urology service, namely the surgery room. To meet forecast demand, the number of rooms and their utilization rates will need to be increased, obtaining 112% for the rooms and 35.58% for the beds.

Some of the positive implications for the heads of the services and the hospital's governance bodies were the possibility of proposing corrective actions to address capacity problems through a structured, methodical procedure that is easy to follow and enables knowing the factors that produce uncertainty in capacity planning to consider them during planning. It also enables monitoring demand by tracking homogeneous groups of patients at both the strategic and operating levels.

## CREDiT AUTHORSHIP CONTRIBUTION STATEMENT

Sánchez Suárez: conceptualization, methodology, research, writing - original draft, project management. Gómez Cano: methodology, data curation, software, validation. Sánchez Castillo: formal analysis, supervision, writing - review and editing.

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## DECLARATION OF COMPETING INTEREST

The present research does not represent any conflict of interest with them, the journal, the publishing entity and the funding entities.

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