Analysis and optimization of clinical pathway of a cancer patient in a University Hospital

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Abstract— **A clinical pathway can be defined as a macro process that includes the complete management of a health problem. It could be considered the equivalent of diagnostic and therapeutic pathway, but the word clinical includes also the person assistance to self-care and the psychological and social support. Managing and organizing a clinical pathway in order to exploit as efficiently as possible all available resources could be the aim of all hospitals.**

The simulation is a modern approach that allows understanding, with a logical sequence, the entire process, in order to identify, analyze and underline characteristics, advantages and problems of the specific context. Nevertheless, simulation is not effective if the process analysis and the mathematical model are overlooked.

The purpose of this work is to characterize clinical pathways, and try to understand and optimize weak points. The various phases of the work allowed conducting a precise, clear and detailed analysis, in order to develop a more efficient process. Finally, the simulation model is able to consider all possible variables that could modify the efficiency of the process and also confirms that the reorganization proposal could be effective and sustainable before a real implementation.

Keywords— **Simulation, Process analysis, Optimization.**

I. Introduction

Cancer patients show a set of physical and psychosocial complications that require additional attentions and specific therapeutic treatments [1] [2]. During the treatments, patients could develop symptoms related to the main disease and the anticancer therapies and additional health problems. For this reason, "supportive care" is essential to control side effects related to active therapies and to manage comorbidities connected to neoplasm [3] [4].

The clinical pathway related to these activities is complex. Generally it is organized between two different areas of activity, an outpatient area and a recovery area; the first is used for the check-up appointments (CU-A) and the second for the administration of drugs, usually in Day Hospital (DH).

Two types of patients could be examined during the day: one included patients who came for the first time or for a long check-up; the other one are patients attending for the therapy (PA-T). These two different types of patients are divided between morning and afternoon activities, in particular CU-A and PA-T during the morning, while the afternoon is reserved for first visits and long check-ups.

Because of physical and psychosocial conditions of patients, this clinical pathway is critical and strongly variable so its organization has to be robust and efficient [5].

The target of this work is to define a strategy for improving and optimizing the oncological outpatient pathway, through a more appropriate and efficient redeployment of workload of the structure. This result is obtained with the combination of a critical process analysis and the use of Discrete Event Simulation (DES) model [6].

II. Methods

The process analysis is an important coordination and orientation tool that allows improving the adequacy between activities and business objectives [7] [8] [9]. Different aspects of a healthcare process can be evaluate during the assessment; in this particular case the purpose is the evaluation of the process, in terms of relationships between available resources and appointments dispensed during the workday [10] [11].

This work followed these steps:

- Assessment and definition of number of patients that could be visited each day, validated with an observation phase;
- Application of personalized mathematical models;
- Use of DES for the validation of achieved results.

After these phases, corrective measures are simulated in order to assess their feasibility [12].

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A. Assessment of the workload of the structure

Information found in the corporate databases were compared with the information provided during a two weeks observation; the data have been shown in Table 1, where DB and OB indicates data from database and data collected during the observation, respectively.

Comparing data coming from two sources was necessary to establish an appropriate and exact strategy of rearranging.

Table 1: Health appointments of the principal structure.

	Expected Health Appointments (EA)		Duration (D) [minutes]		Available rooms (AR)
Source / Health Appointments	DB	OB	DB	OB	
PA-T	32	28.56	15	23.17	3
CU-A	23	12.29	30	22.86	1

B. Definition of mathematical model

The occupation time of the outpatient rooms was defined, for each appointment, with the formula (1)

$$T_V = (EA \times D)/AR \quad (1)$$

where EA was the number of expected appointment, D was the appointment duration calculated between entrance and exit of patient from the room, and AR was the number of available examination rooms where the activity was performed.

The occupation index O is calculated with the total opening time T_{TOT} and the time of activity T_A of the clinic, as shown in formula (2)

$$O = (T_A \times 100)/T_{TOT} \quad (2)$$

These factors were fundamental to define the workload and to assess the future state provided by the reorganization. The equation in (3) has permitted to define the number of patients that could be visited every day in each AR during the opening time, considering the visit duration D

$$P_V = T_{TOT}/D \quad (3)$$

Finally, the model is able to find how many patients could be examined every hour (4).

$$S_A = 60/D \quad (4)$$

This model were verified and validated with DES methodologies in order to perform a complete analysis of the clinical pathway.

III. Results

A. Occupation index

Outpatient rooms are open from 8:30 a.m. to 2:00 p.m., which correspond to 330 minutes of total opening time (T_{TOT}). Considering this aspect of the pathway it was possible to define the real utilization index of the opening total time by applying the mathematical method previously defined (see Table 1).

Data from DB, about preparatory appointments for therapy (PA-T) show that occupation is only 50% of the total time, while this index increase to 67% of the available total time using data from OB.

Furthermore, OB data show that there are less visits per day and that each visit involves a higher duration.

Reading DB data, Occupation index for CU-A is 118%, showing a daily overload of 60 minutes. The real data obtained from the observation, shows that occupation rate is about 85%. In fact the average duration of appointments is lower than what was described by physicians.

B. Structure reorganization

Results from the process analysis have been useful to understand the organization of the structure and provide a starting point for simulation and reorganization processes.

Adopting the formulas (3) and (4) for each types of appointment it was possible to define the number of patients that could be visited every day and how the temporal slot of data had to be arranged in the available time.

For each type of activity, organization solutions were the following:

1. PA-T:
   - 25 minutes of average duration of appointment;
   - 1 slot for each room every 25 minutes;
   - 2.4 slots every hour, which involve 13.2 patients that could be visited every day by each room, for a total of 39.6 patients.
2. CU-A:
   - 25 minutes of average duration of appointment;
   - 1 slot for each room every 25 minutes;
   - 2.4 slots every hour, which involve a total of 13.2 patients that could be visited every day.

All these solutions are based on the total occupation of the available time of activity with the target to arrange temporal slots according to the average duration of performances, without considering an important factor like the waiting time (WT).

This approximation of the model has to be considered by users in order to implement the re-organization.