Process Improvement in an Oncology Day Hospital: Design of a Traceability and Indicator System

Eduardo Cañada[1], Enrique Casado[1] and Ana M. Bernardos[2]
[1]*Hospital Universitario Infanta Sofía, San Sebastián de los Reyes, Madrid, Spain*
[2]*Universidad Politécnica de Madrid, Madrid, Spain*

Keywords: Process Improvement, Traceability, Oncology Day Hospital, Information System.

Abstract: Day hospitals (DH) are organizational structures that enable the supervision of patients who must go through diagnosis methods or treatments taking several hours, but not requiring inpatient hospitalization. Oncology Day Hospitals (ODH) are a particularly complex subset of DH, due to the variety and type of pathologies that are treated in them, the characteristics of cytostatic drugs, the involvement of different hospital units and professional profiles, the number of stages of the care procedure and the cost. In this paper, we describe the design of a traceability and indicator system for ODH, which aims at improving the performance and quality of service, providing three-folded benefits for patients, practitioners and hospital managers. The system is currently being tested in a public hospital in the Autonomous Community of Madrid. Their users perceive that they have access to a much more accurate fingerprint of everyday workflow, thus facilitating the design of improvement actions.

1 INTRODUCTION

Since their introduction in the 70s, Oncology Day Hospitals (ODH) have played a key role in the treatment of cancer: it is in this organizational structure where the oncology patients receive their chemotherapy treatment, with specifically tailored drugs. ODH are target of continuous improvement measurements: the disease impact in patients' quality of life, the nature of cytostatic drugs, the usually long visit protocols, the number of professionals involved in the treatment workflow and the cost of the attention require that ODH operations are revisited and optimized to guarantee safety, efficiency and quality of service. For example, in the last years, a particular effort has been done to deploy traceability systems for cytostatic drugs over all the clinical workflow, to provide maximum protection in drug administration. The works of Queralt et al. (2015), Kergosien et al. (2011) or Sini et al. (2011) focus on this issue, while the preparation and manipulation of the drugs themselves is also a matter of interest (Masini et al., 2014). From a more holistic approach, some other experiences, such as the one described by Galligioni et al. (2009), examine the hindrances and benefits of the use of specific tools to manage electronic oncological patient records.

This paper describes the process improvement analysis that has been carried out to have an accurate fingerprint of the activity and performance of the ODH at Hospital Universitario Infanta Sofía. Hospital Universitario Infanta Sofía is a public hospital in the Autonomous Community of Madrid (Spain), active from 2008. In 2015, 35515 care sessions where handled in its Day Hospital (SIAE, 2015); 7085 of those were oncology sessions (approximately 20%).

As a result of the procedural analysis, a Traceability and Indicators System (TIS) for the ODH has been designed; it is composed by a real-time visualization interface and a business intelligence tool (dashboard). On one hand, the visualization interface retrieves real-time timestamps at the different stages of the ODH operation workflow, so it can provide real-time data and alerts for health workers and managers, at the same time that facilitates the integration of information services for patients. On the other hand, the business intelligence tool enables the retrieval of a complete set of activity, performance, quality of care and procedure indicators that aims at providing information to design continuous improvement strategies.

CaÃśada E., Casado E. and Bernardos A.
Process Improvement in an Oncology Day Hospital: Design of a Traceability and Indicator System.
DOI: 10.5220/0006278506010608

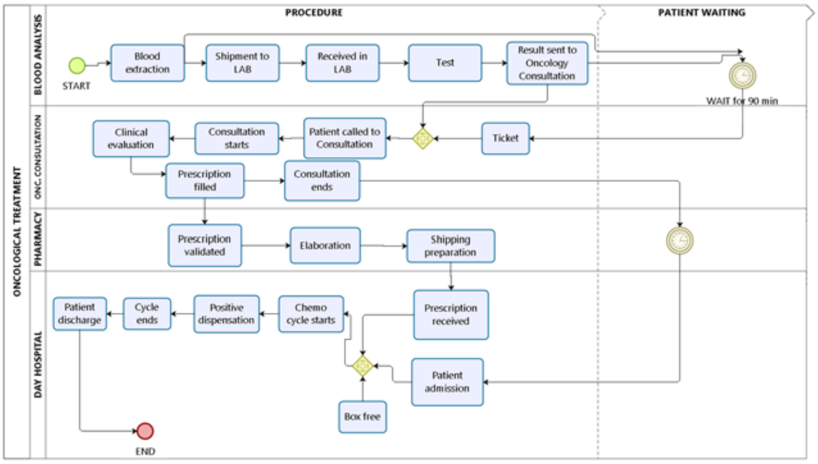


Figure 1: ODH workflow for a patient.

The TIS has been built on already available information that was not being retrieved in an easy-to-visualize way. The system aims at delivering three-folded benefits: for the patient, to reduce and lighten the time at the ODH; for the clinician, to facilitate the retrieval of real-time information about the workload and improved agenda management thanks to the existence of accurate and reliable indicators; for the manager, to facilitate the design of actions to raise of the perceived quality of service and to handle bottlenecks and process problems, so the impact of the investments agenda can be better evaluated.

In this context, the paper is structured as follows. Section II describes the operation workflow at the ODH and the subsequent TIS' functional and non-functional requirements. Section III describes the deployed architecture and the customized real-time visualization interface. Section IV describes the indicators. Finally, Section V concludes the work, stating the impressions gathered about the system and defining further steps.

2 OPERATIONAL CONTEXT

2.1 Workflow Analysis

A standard visit of a patient to the ODH is as follows: on arrival, the patient goes directly to take the 1) *preliminary blood tests*. After that, they head to the 2) *medical consultation*, where the practitioner examines the overall situation and *prescribes the cytostatic drugs*. The cytostatic drugs are then 3) *prepared* at the Pharmacy Service and *sent to the ODH for dispensation.* When the cytostatic drugs are prepared and delivered at ODH and the needed resources (seat, bed, pump, etc.) are ready, the 4) patient is *admitted to the ODH* for the 5) *drug administration*. When the treatment is over, the administrative staff in charge proceeds to the 6) *patient discharge*, who leaves the hospital. Figure 1 summarizes the full workflow.

In practice, during all the process, it is needed to do a follow up of the patients, personnel, resources and drugs. This tracking involves four Hospital Units: ODH, Laboratory, External Consultations and Pharmacy. The professional profiles participating in the workflow are oncologist (FAC), pharmacologists (PHAR), health staff (NUR), administrative staff (ADM) and ancillaries (ANC).

As our objective is to build a traceability and indicators system (TIS) that may report a real-time picture of the ODH operation and a full view of the service performance, it is important to analyze which milestones may be automatically retrieved through the APIs provided by the commercial information systems that are already deployed in the Hospital. In the particular case of Hospital Universitario Infanta Sofía, these systems include the Hospital Information System (Selene from Siemens), the Pharmacy Information System (FarmaTools from Dominion) and the Laboratory Information System (LIS-ServoLab from Siemens). Apart from those, an Appointment and Queue Tracking System for consulting rooms (AQ-Quenda from Plexus Technologies) is also in use.

Table 1 summarizes all the events in the operation workflow. As the reader will notice, there are events that are not being registered (e.g. when the patient enters the hospital or the NUR takes blood), and some others that are still being registered in manual way, thus their timestamps cannot be directly integrated into the TIS.

2.2 System Requirements

On this workflow analysis, the functional requirements for the TIS have been defined (i.e. what the system has to do in practice):

- Show the status (situation in the encounter workflow and particularities) of all the scheduled patients, both for regular visits and ODH.
- Include the non-scheduled patients that may appear during the day.
- Execute the automatic capture of information from all the hospital IS that provide information about the patient whereabouts and health records.
- Facilitate the input of relevant information in manual mode, in case it is not recorded at the HIS.
- Provide user management, so managers, clinicians, administrative staff may access to the information that is useful for them.
- Define specific rules for alerts and generate visual feedback when these rules are not satisfied.
- Generate alert messages for patients and clinicians to manage specific situations, both manually and automatically.
- Provide a dashboard of indicators that may provide an overview of the activity and resources occupancy.
- Generate and submit a daily report.

Table 1: Events in the ODH workflow.

Unit	Event	Info. Sys.
ODH	PAT enters the hospital	-
ODH	PAT goes to ODH services for blood extraction.	-
ODH	NUR prints tags.	HIS
ODH	NUR takes blood.	-
ODH	NUR puts blood sample in the pneumatic tube.	-
LAB	LAB receives blood sample. *	HIS
LAB	LAB does blood analysis.	-
LAB	LAB provides the report. *	LIS+HIS
EXC	PAT takes the turn ticket. *	AQ
EXC	FAC calls PAT when LAB report ready. *	AQ+HIS
EXC	FAC provides subsequent appointments and lab requests. *	HIS
EXC	FAC fills in pharmacy prescription. *	PhIS
EXC	FAC fills in a form at HIS, updates the PAT record and copies the report in an unassigned note. The note is always assigned to protocols (colon, pulmonary, tumor committee). *	HIS
EXC	FAC finalizes consultation. *	HIS
PHAR	PHAR checks the prescriptions through the IS, following a stage-gate predefined process. *	PhIS
PHAR	The treatment is verified. *	PhIS
PHAR	PHAR prints the Report of Preparation to Administer. This report is signed by NUR and PHAR and it is taken to the clean room.	Manual
PHAR	Once the drug is ready, an ANC is called.	Manual
PHAR	ANC collects preparation at FAR.	Manual
ODH	ODH receives preparation.	Manual
ODH	ADM registers the patient and prints the identification bracelet.	HIS
ODH	PAT is admitted in ODH. *	HIS
ODH	NUR assigns a seat.	HIS
ODH	The administering process starts, guided by the pharmacy system for secure administration. *	HIS
ODH	PAT discharge. *	HIS

Events with asterisk are those that can be automatically retrieved from IS. PAT: patient. LAB: laboratory. EXC: External Consultation. ADM: Admissions. In the very specific case of ODH, patients go straight to the blood draw service without going through the reception desk.

Regarding the non-functional requirements (how the system has to be), the TIS must perform satisfactorily with respect to:

- Availability: it must be accessible and easy to configure from any connected workplace at the hospital, not needing any specific additional software.
- Concurrency: its performance must to be not penalized by the simultaneous use from different workplaces.
- Security: the system must manage and control every access and keep trace of them.
- Performance: the system response must be real-time (not above 3 seconds).
- Usability: the system must be easy and comfortable for the users. Not more than 10 minutes training should be necessary for the users to work with the system.

2.3 Design Methodology

The methodology utilized to design the system follows an iterative approach, in which iterations are composed by analysis, development and testing phases. In this case, the main users of the systems are practitioners and managers, so their permanent contribution on three prototyping stages that have been necessary to come out with a first stable version has been crucial.

3 SYSTEM ARCHITECTURE

The core of all the hospital information systems is the HIS (Selene from Siemens), which is used in Emergency Care, Hospitalization, External Consultations and Day Hospital. Through it, any patient appointment or request is managed (diagnostic tests, subsequent consultations, inter-consultations, follow-up notes, etc.). The HIS facilitates the elaboration of forms, the generation of reports and the visualization of the patient's Electronic Health Record.

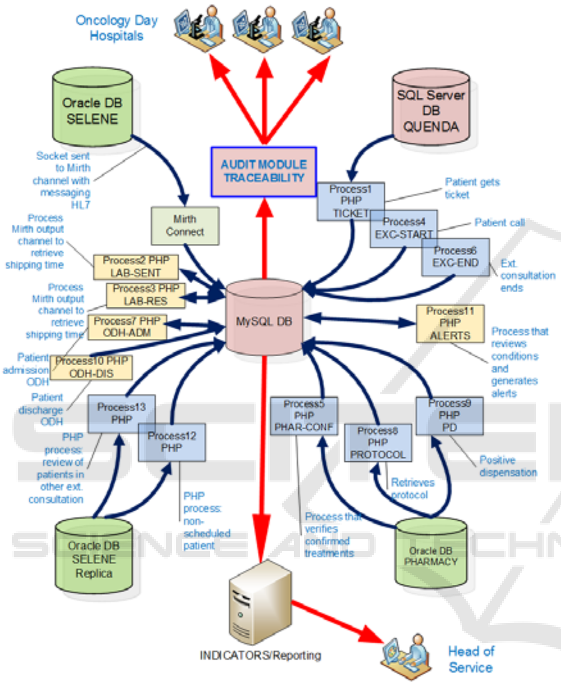


Figure 2: System architecture.

Departmental applications are deployed to cover the specific needs of a given Department or Service. For example, FarmaTools is the departmental tool for Pharmacy (drugs purchase, store distribution, and in this case, cytostatic drug prescription, verification and management). The appointment system (Quenda) avoids voice calls and guarantees privacy overall the hospital consultations. It enables to put in order the waiting rooms and provides indicators for consultation management (arrival time to the hospital, consultation call time, finalization time). The traceability and indicator system for ODH connects to the APIs provided by these three tools to automatically retrieve the data of interest.

Figure 2 shows the TIS architecture, which is in practice deployed over Linux in a virtual machine. The traceability and indicator system is composed by several modules developed in PHP and HTML; these modules retrieve real time information from the mentioned systems. For integration with HIS Selene, HL7 messaging is used, through a channel in the integration engine MirthConnect. For Quenda, FarmaTools and Selene's mirror DB, direct access to the databases is implemented (SQL Server and Oracle DB in the last two cases). The TIS is composed by four main elements: 1) a MySQL database, 2) a main module in PHP/HTML that shows the current state of the ODH patients, 3) eleven processes that update the information in the MySQL database through *cron* programmed jobs (Table 2) and 4) the indicators module.

Table 2: Description of *cron* jobs.

Job	Description	Provider
TICKET	Patient takes the turn ticket on arrival the hospital.	Quenda DB
LAB-SENT	Patient goes to ODH for blood test. Blood draw is notified.	HL7 ORU^R01, HIS Selene
LAB-RES	Lab result is received.	HL7
EXC-START	Timestamp when the oncologist calls the patient for consultation.	Quenda DB
PHAR-CONF	Timestamp for confirmation of the drugs for the day, enabled by the oncologist. When PHAR is notified with the treatment confirmation, the pharmacologist in charge verifies the order and submits it to the technicians, who start working on the preparation.	FarmaTools Oracle DB
EXC-END	Timestamp when the oncologist finishes the consultation.	Quenda DB
ODH-ADM	After leaving the consultation, the patient goes to the ODH and admission verifies the appointment and provides the identification wristband.	HL7 ADT01
PROTOCOL	The drug protocol is obtained from the PHAR database, together with the number of components to administer to the patient.	FarmaTools Oracle DB
PD	When the administration of a component is completed, it is registered in the positive dispensation module.	FarmaTools Oracle DB
ODH-DIS	When the administration is completed, the patient is discharged.	HL7 ADT^03
ALERTS	It checks if the alerts' conditions are fulfilled and generate the defined alerts if so.	MySQL DB

Figure 3: a) Main dashboard for traceability. From the fourth column on, it is possible to find the timestamps for the 10 jobs in Table 2. The 11th job generates the alerts, marked as blocks in orange. In the top right corner of the Figure, a shortcut to filter the available agendas is provided.

Everyday at 7:00 am, a *cron* job initiates the patients' registry for the day, by using the agendas of the ODH and the monographic agendas (related to the oncology specialties) or nominative ones (related to specific practitioners). *Cron* jobs are executed each 5-10 minutes (configurable time), updating the data for real-time visualization and feeding the indicators' database.

Access and interface personalization is carried out through IP control. ODH or Consultation users can access the ODH TIS through any browser in an authorized computer. The main interface, in Figure 3, is daily initialized and dynamically completed throughout the day, it starts "growing" when the ODH activity begins. The interface provides visual alerts (in orange) indicating when issues occur in the workflow. These alerts are informative up to now, being generated e.g. when "the laboratory results are taking too long" or "the patient is not in the next step of the workflow". In the future, it is desired that these alerts may trigger automatic or supervised responses, such as "recall results from the laboratory" or "send a notification to the patient".

In the right side of the real-time interface, there are several options that enable to parametrize the TIS, showing information from a) all the agendas, only from the ODH agendas or the Oncologists Consultations agendas, b) detailed information about the patient and c) day indicators.

4 REPORTING

Apart from the visualization interface, the TIS provides a business intelligence tool that summarizes a set of relevant key indicators, which can be classified into four different groups: a) activity, b) performance, c) procedural and d) quality of care indicators.

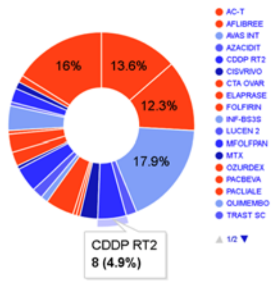
Activity indicators reflect the day dynamics at the Oncology Service (both at ODH and consultations).

These six indicators are directly accessible from the interface in Figure 3 and include aspects such as snapshot of number of active patients in ODH and patient distribution per agenda (in ODH and consultations), protocol, visit type and treatment type. Table 3 shows an example of a protocol indicator, in particular the one in which each chemotherapy protocol for a given cancer type is retrieved (an example of protocol is FOLFOX – oxaliplatin, fluorouracil, folinic acid - for gastric cancer).

Table 3: Activity indicator example.

Activity indicator no. 4	
Scope	ODH, Oncology Consultations and Pharmacy.
Definition	Patient distribution per protocol.
Info. source	Selene Replica, FarmaTools
Formula	Query that retrieves the total number of patients in the agendas of a) ODH (non-scheduled patients included) and b) Oncology Consultations, classified by protocol.
Goal	To be defined by the evaluator / manager.

Table 3: Activity indicator example (Cont.).

Activity indicator no. 4	
Responsible	Exploitation: Hospital Management. Evaluation: Oncology Service Head
Visualization	

The rest of indicators are retrievable from a specific interface. There are nine *performance indicators*, which aims at providing a view of the service efficiency. This group of indicators include e.g. the average number of admissions per hour, the appointments' status (cancellations, completed, not registered), the number of non-scheduled patients, the resource use or the real duration of the treatment. The information available about an example of performance indicator, the average duration of the patient's stay at ODH, is showed in Table 4.

There are six *quality of care indicators* that are focused on compiling information about how the patient's perception may be. These indicators include issues such as the delay of the patient with respect to the appointment for blood extraction, the delay at the oncology consultation, the time between the patient's appointment and the call time in the oncology consultation or the delay in the start of the treatment, etc. An example is available in Table 5.

Finally, there are some specific *procedural indicators* that are focused on measuring the evolution of procedure errors (e.g. admissions without discharge time, number of never ended consultations, number of non-called patients, etc.).

Table 4: Performance indicator example.

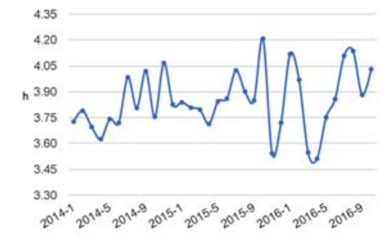
Performance indicator no. 8	
Scope	ODH
Definition	Average stay duration at ODH.
Info. source	Selene Replica, MySQL indicators database
Formula	Query, average duration of admitted patients in ODH.
Goal	To be defined by the evaluator / manager.
Responsible	Exploitation: Hospital Managmnt. Evaluation: Oncology Service Head
Statistics	Mean: 3.85 h.; Standard deviation:0.17; Min: 3.51; Max: 4.21.
Visualization	

Table 5: Example of Quality of care indicator.

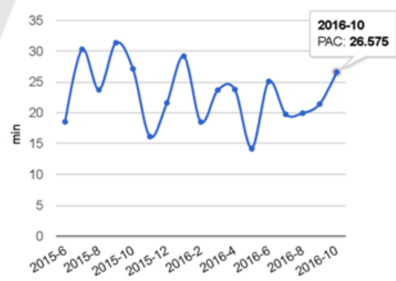
Quality of care indicator no. 4.	
Scope	ODH
Definition	Delay between the patient's scheduled appointment time and the call time to consultation.
Info. source	Selene Replica, Oncology Consultation Agendas.
Formula	Query, mean delay between the scheduled time and the real call time to consultation, filtered for days, months or years.
Goal	0 minutes.
Responsible	Exploitation: Hospital Managmnt. Evaluation: Oncology Service Head
Statistics	Mean: 22.97 m.; Standard deviation: 4.77; Min: 14.21; Max: 31.25.
Visualization	

Figure 4 shows the components for the extract, transform and load (ETL) process necessary to generate the indicators. All these data are stored in the MySQL database and queried from a PHP service that uses Google Chart libraries to generate the final interface. Everyday, a *cron* job captures the main dashboard screen of the traceability system and emails it to the designated receivers (e.g. Director of the Oncology Service).

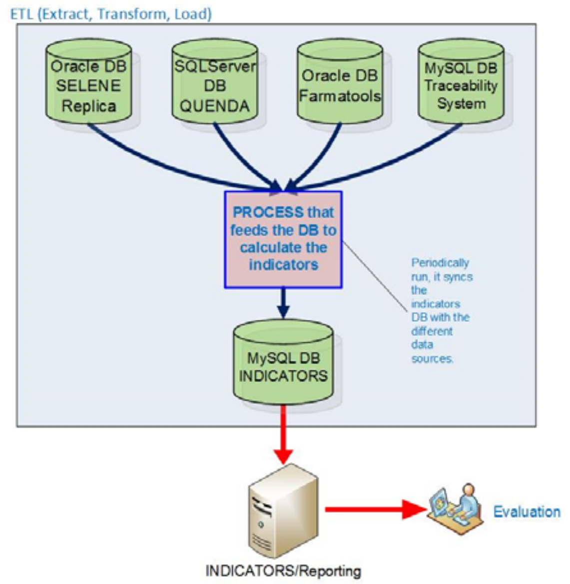


Figure 4: Extract, Transform, Load process for indicators. DB stands for database.

5 CONCLUSIONS

The Traceability and Indicators System described in this paper facilitates the retrieval of significant information in an ODH, with the purpose of improving daily operation and patient satisfaction. Traditionally, part of the information retrieved by the TIS has been manually recorded and processed to obtain indicators, and only significant deviations, detected. The TIS has been designed upon request of the Oncology Service Management to have a better view of the ODH workflow, so specific organizational and technical actions can be designed on a solid informational input.

The TIS has been designed in tight collaboration with practitioners and administrative staff, with the objective that it can fulfil the real requirements of day-to-day operation in the Oncology Service of a hospital, providing added value and avoiding problems in the organizational change that the availability of this tool may suppose.

The TIS relies on information that can be automatically retrieved from the existing systems in the hospital. This entails that the deployment does not require complex technology or significant investments, while providing relevant information of the workings of the oncology day hospital. The design process has been useful to identify information gaps (e.g. part of the processes that are not automatized, still done in manual ways), so their improvement can be added to the strategic agenda of investments.

The system has been technically evaluated against the design requirements in Section 2.2. Although it fulfils them reasonably well, there are several aspects that need to be improved. For example, the management of both alerts and notifications still need to be better implemented, and the set of indicators, polished. Additionally, although the available presentation interfaces have been incrementally improved with the help of the users, different presentation formats should be benchmarked. This can also be applied to indicators; it is also necessary to systematically analyse the causes of the detected deviations to feed the TIS.

Up to now, practitioners and nurses have partly tried the system in oncology consultations, ODH and Service Head offices, but their experience with the TIS is still brief to extract conclusive comments. In any case, from their feedback it is possible to say that:

- The system gathers real-time information in a reliable way, although it is still necessary to make some procedural changes to better contextualize some data. For example, due to specific instructions given to ODH patients, the time when these patients take the turn ticket for consultation is stored, but the entry time at the hospital is not (ODH patients are told to go directly for blood draw service).
- It is necessary to provide better traceability at resource level (seat or bed), with the purpose of optimizing its occupation. This traceability is manually done and may not be accurate enough due to human errors. A technical solution involving RFID or barcodes is currently being designed to address this issue, and it will be integrated at the TIS when ready.
- Alerts in the real-time visualization interface need to include specific management options, to track if the alert has been handled. Up to now, they are merely informative and no action is triggered from them.
- One of the possibilities to manage alerts is to make them trigger SMS both to patients or care professionals, as there is a corporate existing platform for this purpose. Other options, such as instant messaging, involve technology and organizational changes and may delay the integration with the service. In any case, it is necessary to study to which extent these SMS may be effective and useful for their recipients (misleading or spam effects). In particular, it is necessary that involved users express their

opinion about the best means and configuration of alerts.

An important issue is related to human factors: to assure the full exploitation of the visualization tool for real time patient-flow management purposes wide acceptance within the health team is needed. All health staff members need to understand the ultimate instrumental goal, focused on improving delivery of quality of care and not staff monitoring. Specific communication initiatives are needed to guarantee that this fact is correctly understood. In this sense, the involvement of navigator nurses in key steps control has been shown of great help. In the next months, it is expected that the tool is integrated in the daily activity of the ODH and improved following the users suggestions.

Taking into consideration this TIS, another tool is currently being designed to monitor the workflow in the 200 hospital consultations, so delay times and bottlenecks can be identified.

ACKNOWLEDGMENT

Authors want to acknowledge the Hospital Universitario Infanta Sofía Management for the support to this initiative.

REFERENCES

Queralt M., Frías M.C., de Pedro, V., Ramírez, J., Mesalles, M. 2015. Sistema de trazabilidad integral de administración de citotóxicos. *Boletín de Prevención de Errores de Medicación de Cataluña, Vol. 12*, no.4.

Kergosien, Y., Tournamille, J.F., Laurence, B. and Billaut, J.C., 2011. Planning and tracking chemotherapy production for cancer treatment: A performing and integrated solution. *International journal of medical informatics, 80(9),* pp.655-662.

SIAE (2015). Información estadística de hospitales. Estadística de Centros Sanitarios de Atención Especializada (National statistic information about hospitals). Available at: *https://www.msssi.gob.es/estadEstudios/estadisticas/estHospiInternado/inforAnual/homeESCRI.htm.*

Sini, E., Torresani, M., Locatelli, P., Restifo, N. and Facchini, R., 2011. Information and communication technologies enable a comprehensive governance of patient safety in chemotherapy. An Italian framework project. *In 24th International Symposium on Computer-Based Medical Systems (CBMS)* (pp. 1-7). IEEE.

Masini, C., Nanni, O., Antaridi, S., Gallegati, D., Marri, M., Paolucci, D., Minguzzi, M. and Altini, M., 2014. Automated preparation of chemotherapy: quality improvement and economic sustainability. *Am J Health Syst Pharm, 71(7),* pp.579-85.

Galligioni, E., Berloffa, F., Caffo, O., Tonazzolli, G., Ambrosini, G., Valduga, F., Eccher, C., Ferro, A. and Forti, S., 2009. *Development and daily use of an electronic oncological patient record for the total management of cancer patients: 7 years' experience. Annals of Oncology, 20(2),* pp. 349-352.