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Improving the Drug Dispensing Process at the National Institute of Respiratory Diseases by Applying the Six Sigma Methodology

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Abstract— **The purpose of this work was to improve the drug dispensing process at the National Institute of Respiratory Diseases of Mexico by applying the six sigma methodology, identifying the non-value added activities as well as the areas of opportunity, in order to make proposals to ensure the supply of prescription drugs to the patient in a timely manner. Seven variables were defined and three indicators were generated, which were implemented in three clinical services of the Institute to measure the current performance of the drug distribution process. With the obtained results, a proposed set of eight improvements were subsequently implemented in a pilot program.**

I. Introduction

The dispensing of medications is the pharmaceutical act associated with the delivery and distribution of medications in response to a prescription made by a licensed professional. At the hospital level, the pharmacy service is responsible for the proper dispensing of medications in the establishment [1], the clinical service is responsible for the adequate supply of drugs to the patient.

The American Society of Hospital Pharmacists prepared a guide to a better quality control system for drugs repackaged by hospital pharmacists for use in a unit dose drug distribution system, in order to ensure that patients receive safe and effective drugs [2].

In recent years, it has been found that in Mexico the efficient and timely supply of medications in the public healthcare units have been a problem for users and health institutions. In this regard, the National Health Program [3] proposes to design and implement a national drug policy that promotes the development of models for efficient and timely supply of medications and health supplies.

The National Institute of Respiratory Diseases of Mexico (INER) is a third level hospital, in addition to attend the general population with respiratory diseases; it conducts research and specialized education in this area [4]. In the first half of 2009, problems related to the dispensing of medications were detected, such as capturing and updating medical indications that caused the deterioration in the timeliness, effectiveness and safety of delivering medications to the patient, as well as a delay in charging, or the absence of the charge of medications to the patients' account in the Health Information System (HIS), which impacts negatively on the pharmacy's inventory system. In this regard, the Department of Biomedical Engineering developed a project to improve the medication supply process, identifying deficiencies and proposing solutions, using the six sigma methodology, a strategy for improving the quality of processes to increase benefits by eliminating defects, waste and variability, finding the causes for the errors in products, processes or services in order to enhance their performance [5]. It has been shown that the application of the six sigma methodology in the health area has been very positive, in the United States for example, it was used in the Rapides Regional Center (Lousiana) to solve the problem of large waiting times; in the Women and Infants Hospital of Rhode Island, was used to standardize operational procedures in the movement of embryos [6]. In Mexico, it has been applied in the innovation of processes in the imaging department [7, 8], as well as improving the process of health technology management [9].

Therefore, the project's objective was to identify the deficiencies in the process of dispensing drugs in the INER and to propose appropriate improvements in order to perform the process more effectively.

II. Methodology

As follows we describe each of the five stages of Six Sigma Methodology [5], applied in order to improve the drug distribution process at the INER:

1. Define. In this stage, we define the problem and the objective of the project. A process flow diagram was realized to study its actual performance, identifying non-value added activities, which are related to one of the seven defined wasted products [5]: overproduction (O), wait time (W), transportation (T), inventory (I), movement (M), quality defect (Q) and rework (R). Areas of opportunity were also detected, activities which modification help to optimize the process.

2. Measure. This stage consists in characterizing the current status of process of medication delivery. Defining variables and data sources, and measuring the current process performance.

3. Analizing. The results of the measurement stage are analized in order to determine the causes of the process failure.

4. Improvement. Improvement proposals are generated and a pilot program is realized for implementation so that the process is executed in an optimal manner.

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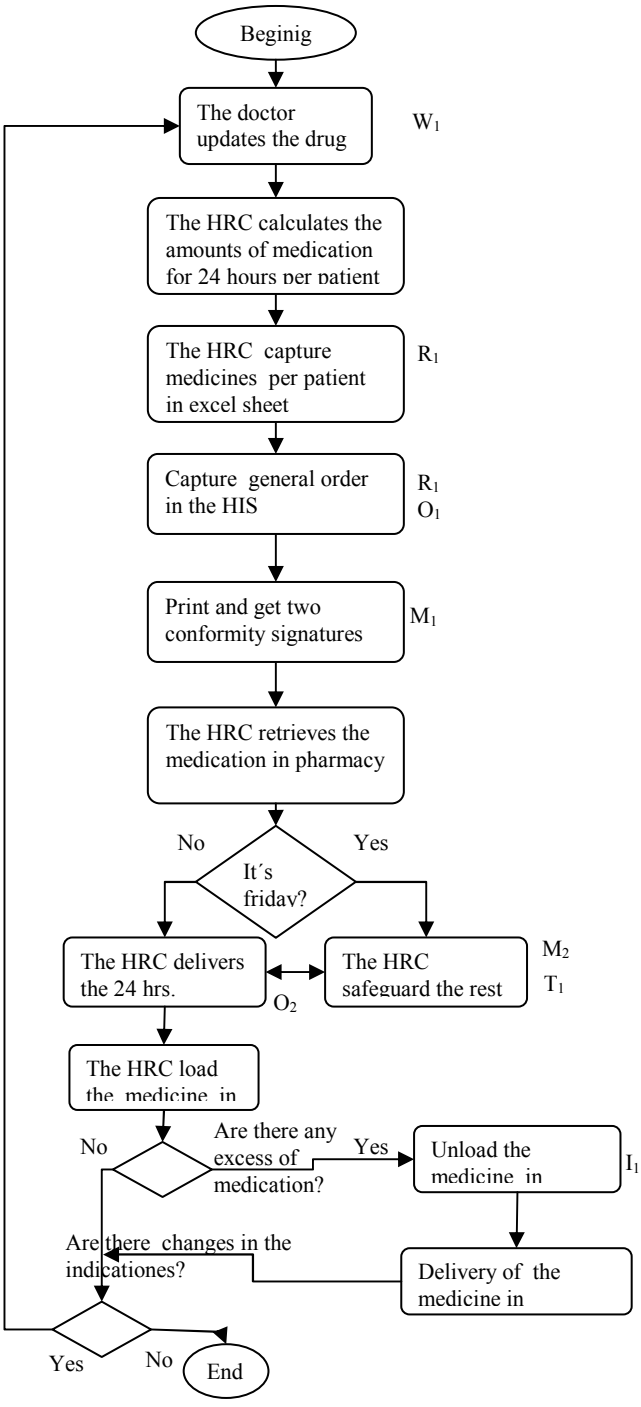

Fig. 1. Diagram of the process of dispensing medications

5. Control. Control mechanisms are designed to ensure that the improved process is maintained.

III. RESULTS

1. Define. We obtained the complete diagram of the process of dispensing medications (Fig. 1). Non-value added activities were identified with the initial of the corresponding wasted product and a sequential number. Areas of opportunity identified with the letter "O" also in a consecutive manner. The process actors are doctors, nurses, hospital records chief (HRC), in charge of soliciting the medication; and the pharmacy services.

The dispensing process (Fig. 1) begins with updating the prescriptions during the physician's visit; in this activity was detected waste of waiting time (W_1), since the visit can be done at any time during the morning. Then, the HRC estimates and captures in Excel the medication quantities required for each patient for the next period of 24 hours or all weekend, then he makes a second capture of the order in the HIS to request it to the pharmacy. In these two activities it generates a waste of rework (R_1), when the medication is captured twice in two different systems. Likewise, considering that there is the HIS, this could automatically calculate the amount of medication required, which creates an area of opportunity (O_1). Previous confirmation by the pharmacy, the order is printed and the HRC collects two signatures (clinical service chief and hospitalization chief) for their authorization, which reflects a waste of movement of staff to the administrative offices (M_1). Subsequently, the HRC retrieves the medication in pharmacy and delivers it to the corresponding clinical service. In this activity, lack of control was detected in the delivery-receiving of medication, an opportunity (O_2) is observed if the receiving of the medication is monitored by the nursing staff.

If it is Friday, the HRC delivers the 24 hrs. medication at the service and safeguard the rest at the hospital headquarters, which implies a waste of transportation (T_1) because its safeguard is not done in the corresponding clinical service. In the weekend, a waste of movement is detected, because the nurse has to get to that office to acquire the medication that is needed for the patients. Subsequently, the HRC or the nurse must enter the medication charge in the HIS to the corresponding patient's account. In case there is an excess of medication, the HRC must download the patient's account and make the return to the pharmacy; sometimes a delay is generated or the omission of such activity causing a waste in inventory (I_1), meaning, the accumulation of medications that cannot be returned if the patient's account is closed. Otherwise, verification should be made if there is a change in the medical indications before 24 hours, if so the process is restarted, otherwise ends.

2. Measure. Seven variables (V_i) and three indicators (In_i) were defined, and they are described below:

V_1. Time the medical visit is finalized.

V_2. Time the medical indications were updated.

V_3. Number of orders delivered late in each clinical service (after 12 pm).

V_4. Number of returned medications to pharmacy

V_5. Number of medications dispensed by pharmacy

V_6. Number of medications requested by the clinical service.

V_7. Number of changes in medical indications. Medications that were suspended, or new medications

prescribed by a change in indications, were considered as changes. From an operative view, this means two things: 1) Make a new order for new medications; and/or 2) Return to pharmacy the suspended medications.

Three indicators were designed that are described below:

In_1. Time spent between the medical visit and the updated indications. This time impacts the medication request to pharmacy.

$$In_1 = V_2 - V_1 \qquad (1)$$

In_2. Percentage of unused medications. This indicator quantifies the percentage of returned medications to pharmacy done by different reasons, such as: patient deceased or suspended medication; and also indirectly reflects the delayed update of medical indications.

$$In_2 = (V_4/V_5)\ 100 \qquad (2)$$

In_3. Percentage of supply of medication orders by the pharmacy for each clinical service.

$$In_3 = (V_5/V_6)\ 100 \qquad (3)$$

The data were acquired over a period of 5 days in three clinical services (A, B and C) during the morning shift. In total 15 medication orders were requested to pharmacy. Table II shows the data obtained for the six variables. Subsequently, the indicators for which results are shown in table III were applied.

TABLE II
VARIABLES DATA

Variables	Clinical Service A	Clinical Service B	Clinical Service C	Average
V1	10:00	09:06	10:04	09:43
V2	10:06	10:32	10:48	10:28
V3	0	2	3	1.66
V4	2	15	16	11
V5	13	25	19	19
V6	19	32	26	25.6
V7	10	23	14	15.66

TABLE III
INDICATORS

Clinical Service	In_1 (minutes)	In_2 (%)	In_3 (%)
A	6	15	68
B	84	60	78
C	44	84	73

In relation with the percentage of unused medications, in the clinical service, 15% of medications were returned; this reflects that the patient received the correct medication in most cases. In contrast, in the clinical service C, 84% of medications were not used due to the late update of medical indications.

With respect to the efficiency of supply of medications (In_3), Table III shows that the service A obtained the lowest percentage of supply (68.42%) and service B the highest (78%). In this regard, note in Table II that the number of medications requested (V_6) by service A was 19 and the number of supplied medications (V_5) by pharmacy was 13. The same occurs in service B, where the number of medications requested (V_6) was 32 and the number of supplied medications (V_5) was 13.

4. Improvement. The proposals for improving the process are described in Table IV.

TABLE IV
PROBLEMS AND INNOVATIONS RELATED WITH WASTES AND OPPORTUNITIES DETECTED IN THE DRUG DISTRIBUTION PROCESS.

Problem	Innovation
W_1: There is a *wait time* in the drug prescription actualization due to the delay in the physician visit.	The physician visit must be done from 7:00am to 8:00am. [Easy implementation]
R_1: There is a *rework* capturing twice the medicine required, in Excel and in HIS.	The medicine required must be captures just in the HIS [Easy implementation]
M_1: The HRC must *go out* to obtain the two signatures needed for the medicine request authorization.	The medicine request must be signed just by the clinical service chief. [Complex implementation]
T_1: In order to safeguard the medicine at the weekend, it is *transported* to the hospitalization chief office.	The medicine can be safeguarded in the clinical service itself, where the patients are, in order to avoid the nurse movement. [Complex implementation]
M_2: If is weekend the nurse must *go out* to the hospitalization chief office in order to get the medicine for the patients.	The medicine can be safeguarded in the clinical service itself, where the patients are, in order to avoid the nurse movement. [Complex implementation]
I_1: Medicine discharge omission (because of a patient decease, a delay in the drug prescription actualization, or a delay greater than 48 hrs. in the discharge process), which cause a medicine accumulation (*inventory*) that won't be utilized.	It is necessary to generate a control mechanism, in order to guarantee the medicine discharge before closing the patient bill. [Easy implementation]
O_1: The HRC calculates by hand (in Excel) the quantity of medicine required in the next 24 hrs.	Use the HIS for calculates automatically the medicine required. [Complex implementation]
O_2: Lack of control in the delivery-reception of the medicine at the clinical service	Medicine reception must be supervised by nursing personnel at the clinical service. [Easy implementation]

To avoid delays in updating medical indications due to delays in the medical visit (W_1), it is proposed that the visit is made from 7 to 8 hours, so that the update is ready in the 9th hour. In relation with rework R_1, it is proposed that the capture is made only in HIS. With regard to the movement of HRC (M_1), it is proposed that the order is signed only by the head of the service which the patients will receive the

medication. In regards to keeping the medication in the hospitalization office over the weekend (T_1), it is proposed that the medication is kept in the same medical service where the patients are, in order to avoid the movement of nurse (M_2). In regards to the omission of discharge of medication from the patient's account (I_1), it is proposed to create a control mechanism that ensures the effective discharge of medication before the patient's account is closed. In regards to the areas of opportunity detected, it is propose to use the HIS to calculate the amount of required medication automatically (O_1) and the medication reception be supervised by the nursing staff (O_2).

Currently, a pilot program is being designed in which one of the three clinical services with which have been worked, will be selected and the modifications in the process of dispensing medications will be implemented. There will be a comparative performance analysis of the process before the proposals for improvement and once they have been implemented; we should get feedback and be able to know what the impact of the process improvements was. If the improvements are implemented properly, the process should show improvement.

5. Control. The control mechanisms suggested are as follows:

- Supervise that the medical visit is being done from 7 to 8 hours so that the indications are updated before the 9th hour, in order to the request to pharmacy and the medication can be delivered to the patient before 12.
- Supervise that the medication is received by the nursing staff of each clinical service.
- Verify that effectively there is a decrease in the amount of medications returned.
- Supervise that the effective discharge is done before the patient's account is closed.
- Verify that there is a decrease in the amount of medications accumulated in the service.

IV. Conclusion

The Six Sigma methodology was very useful in the analysis and improvement of the process of dispensing medications in the Institute. It provided concrete elements to find deficiencies in the process and propose improvement solutions that will contribute to improve the efficiency in carrying out the process.

Such studies allow making decisions on the processes as well as the technology that impact the process optimization, such as the integration of the automated systems of dispensing medications or the pneumatic delivery systems of medications, which is the process tendency in advanced countries [2].

Finally it is important to mention that the problem in the dispensing medications can occur in any health institution, no only in Mexico but also in other countries. In this regard, it is noteworthy that the methodology Six Sigma can be applied to any process aimed to improve any health process.

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