'Quality Improvement Model in Radiology

Poster No.: C-2191
Congress: ECR 2013
Type: Scientific Exhibit
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Keywords: Health policy and practice, PACS, Management, Quality assurance
DOI: 10.1594/ecr2013/C-2191

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Purpose

1. To analyze the patients flow chain in our radiology clinic to detect bottle necks and consequently take corrective actions to achieve smooth workflow.
2. To set up a quality control model with key performance indicators (KPIs) and application metrics.
3. To monitor the productivity, professional outcome and customers satisfaction.
4. To set up a principle of quality assurance and future continuous quality improvement.

During the past several years, efforts have been initiated to reduce the number of medical errors and improve the quality of healthcare delivery.

Measuring the quality of imaging services is inherently difficult, and scientifically sound metrics are lacking. Nevertheless, there is increasing pressure from regulatory agencies, the Centers for Medicare and Medicaid Services, payers, and professional societies to implement quality metrics in radiology practice.

In this project we adopted lean approach and six sigma principle in the analysis of the whole process that the patients take to get their radiological examination performed. We used the main stream mapping for analyzing the current state of the process and identifying activities that add no value to patient care and the root causes of obstacles (bottle necks) in the work flow. The goal is to identify and remove all these blockages in patient’s flow and keep only the activities that add value to patients care in order to achieve smooth patients flow and consequently improve performance and efficiency of staff members and enhance customers satisfaction in the radiology clinic (Fig. 1).
**Fig. 1:** Figure 1: awareness of the employees and the top management about the risk of the current state of the organization and the willingness to change to a new dynamic situation by the means of a robust quality project.

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Methods and Materials

Methods:

1. Lead method.
2. Six Sigma principle.
4. Continuous Quality Improvement (CQI).

Although lean principles were first developed in the manufacturing industry, they are also ideally suited for application in a service industry such as radiology, which relies on customer flow and equipment function. In a radiology department, there are many opportunities for application of a lean approach: for example, to reduce clinical and technical errors and mistakes, reduce patient and report waiting times, improve patient outcomes, increase staff productivity, decrease costs, and improve employee and customer (both patient and referring clinician) satisfaction.

The lean approach demands a commitment to a set of principles that allow people and organizations to become and remain efficient. Wherever possible, all forms of waste are eliminated. The work environment is better organized, and safer. Less effort is required to provide services, and less investment and fewer resources are needed to achieve the same levels of productivity. Products and services are created in less time with fewer defects and abnormalities while using fewer resources in personnel, supplies, and equipment.

A constant focus is on providing value to customers, be they referring physicians or patients. The lean approach encourages continuous incremental improvement in performance with the goals of adding value to the services provided and achieving and maintaining the highest possible levels of customer satisfaction.

We also adopted the six sigma principle for the finalization of our radiologic reports and images. Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes. The term Six Sigma refers to a high state of engineering reliability where only 3.4 defects per million are encountered—a noble goal in the healthcare field.

Our target is that all radiologic reports are dictated, typed and validated within 24 hours.

The Model: (Fig. 2)
a) Internal Environment Analysis

- What are we doing? (actual real quality)
- What we want to do? (optimal quality)
- What we should do? (the expected quality)

b) External Environment Analysis

- How our customers (patients and referring clinicians) judge our service (perceived quality)
- Satisfaction of the patients and the referring doctors
- Strategic challenges: new opportunities and threats.

These four types of quality are related to each other and constitute together the global quality targeted.

The goal is to identify and measure the root causes of the lag between the optimal and the real quality and then to take the adequate corrective measures to achieve team change toward the optimal quality and to keep continuous improvement.

Data collection:

1. Patients Flow Chain "Main Stream Mapping".
2. Productivity Analysis.
4. Professional Outcome Analysis.

1. Patients Flow Chain "Main Stream Mapping": (Fig. 3)

We created a flow chart "main stream mapping" (Fig. 3) which illustrates all the steps of radiology exam generation starting from the demand by referring doctor until delivery of images and radiologic reports.

Process bottlenecks affecting areas such as scheduling, access to services, patient throughput, waiting time and report turnaround time offer opportunities for further analysis and improvement of service.

Once the process is measured, data can be analyzed, and performance goals can be set. Causes of problems become understood, and improvement solutions are discovered. Through testing of change solutions and using data, the best solution is identified. Once the improvement solution is implemented, the team works on a plan to monitor its results over time, making sure to sustain the project goals achieved.
The aim is to foster the work flow and to improve process efficiency, allowing for an increased capacity for patient appointments.
Fig. 2: The model of quality improvement. For internal analysis, we started by definition of the optimal quality then measurement of the real current quality. For external analysis we started by analysis of the expected quality aimed by our customers (patients and clinicians), then measurement of the real perceived quality.

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**Fig. 3:** Flow chart illustrates the steps that occur between generation by referring doctor until delivery of images and radiologic reports. The diagram was constructed to analyze possible bottlenecks in patient flow (throughput).

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Results

First: Analyse the Real Quality

I) Patients Flow Chain "Main Stream Mapping" (Fig. 3)

1. Access time: time to arrive to radiology clinic (Fig.4)

From this graph (Fig.4) we can see that most of the patients take more or less the same time to come to the radiology clinic; about 95% of them take 1-3 min/km to arrive. So, there is no problem in access time.

2. Examination Time

- CT (Fig.5)

This graph (Fig.5) shows the waiting time in minutes that patients take to have their CT scan performed which reflects the duration of the CT of the previous patient.

The average waiting time was 38 minutes varying from 10 to 90 minutes. The variation (standard deviation) was 20.37.

This high variability is mainly due to the heterogeneity in CT protocols between radiologists (absence of standard protocols).

Other non-avoidable causes were mainly the old patients and those with comorbidity and obese patients difficult to put a venous line to inject contrast.

- MRI (Fig.6)

This graph (Fig.6) shows the waiting time in minutes that different patients take to have their MRI exam performed which reflects the duration of the MRI of the previous patient.

The average waiting time is 28 minutes varying from 5 to 75 minutes. The variation (standard deviation is 17.15).

We can clearly notice that there is a quite important variability in waiting time for MRI exams between patients that varies from 15 minutes to more than an hour. The main reason was the difference of MRI protocols between radiologist (absence of standard protocols) and difference in the experience of the technologists; new people and those with less experience tend to maximize MRI sequences and exams to be on the safe side.
3. Interpretation and Finalization time:

- **Images:**

We discovered that there was an extra 20 minutes waiting time for image printing at the end of the exam before giving them to the radiologist to see the patient and give him the result and the images.

- **Reports:** (Fig.7)

From this graph (Fig.7) we can see that radiologists have a good performance in the interpretation time; 92% of cases are interpreted and dictated in the same day (24hr).

However, there is an inefficiency in the finalization of the radiologic reports (time for typing, correction, signature and faxing the final reports). Only 57% of cases are finalized within the same day, 20% after 48hr and the rest 23% after 72hr.

So, we have got a problem in the reports turnaround time.

**II) Productivity:** (Fig.8)

from Fig.8, Note the decline in number of CT exams on Thursdays, almost the half of that of Wednesday. Such information can be used to assign an appropriate number of technical staff for the scanner on the basis of daily volumes or also to dedicate special CT scan sessions like interventions and virtual colonoscopy on Thursday for example.

**III) Professional outcome measurement : follow up of interventions results**

We carried out surveys about the success and complication rate of all therapeutic interventional procedures was measured by means of follow up survey with 1 - 10 rating of pain at before, one day, 3days, 10 days and 30 days after procedure

The aim is analytic (search for factors related to satisfaction) and evaluative (assessing the effectiveness of an intervention by a measure of a comparative satisfaction before and after the therapeutic intervention). The Satisfaction is used as an outcome indicator.

- **Shoulder injections:** (Fig.9)

Success rate of 77% (> 50% improvement in the scale of pain and declare that they are satisfied about the procedure).

- **Rspinal injections:** (Fig.10)
Success rate of 66% (> 50% improvement in the scale of pain and declare that they are satisfied about the procedure).

IV) **Customers satisfaction** : (Fig.11)

Loyal customers advocate for a business and are effective in marketing to others by word of mouth. Improvements in satisfaction cannot occur until the problems are identified by listening to the voice of the customer.

We used a quantitative method to measure the satisfaction of patients and referring doctors.

We applied a monthly satisfaction survey distributed to all patients in the last week of each month. The survey includes many satisfaction criteria (appointment time, situation, opening hours, reception, waiting room, time before and after exam) with 1 - 10 rating (Figure. 11). It also includes also open ended questions about the expected quality by their point of view.

We put a threshold of 95% for satisfaction. Any issue with less than 95% score of satisfaction will be the subject of discussion for improvement. For example, satisfaction about comfort in the waiting rooms was 94% and that of the waiting time before examinations was 89% and after the exam was 90%. This goes in concordance with the results mentioned earlier about the high variation in waiting time for radiologic examinations. So, we have three areas (as red flags) in which patients are less satisfied and will be targeted for improvement.

For referring doctors, we send them all an email twice per year containing a survey of satisfaction. This includes open ended questions and their propositions to improve the quality of our services.

**Second, Define the Optimal Quality**:

The optimal quality or what we want to achieve must be clearly defined by the chiefs of the radiology clinics together with the chief technologists and secretariat.

To be concrete and precise, this should be translated into clear and defined key performance indicators and performance metrics of each sector and assign responsible persons for each one.

**Key Performance Indicators (KPIs)**: (Fig.12)
Key performance indicators (KPIs) are measures that may be used to assess the health care of an organization and define and quantitatively measure progress toward organizational goals. KPIs also may be linked to an organization's strategy for success.

Communication and discussion with workers gave us the chance to listen to their opinions and their vision to the current situation. We have got many brilliant ideas; simple and effective. For the sake of simplicity and practicability and after multiple discussions with workers in every sector we came out with one table addressed to the three main working sectors; secretary, technologists and radiologists (Table 1, Fig.12). All KPIs have been agreed and approved by the corresponding workers who participated to put and to adapt many of them.

**Third: Take Corrective Actions:**

Main stream mapping lean method allowed us to identify two main process bottle necks: (a) The big variability in examinations time; (b) Finalization of radiology reports (reports turnaround time) and images delivery.

After a big effort on the communication by holding presentations, meetings and tough discussions with all staff members of all sectors we came up with a couple of corrective actions to solve these problems.

**Corrective actions:**

1. **Appropriateness**

   Appropriateness measures the frequency with which the referring physician ordered the most appropriate examination to answer the clinical question. This could be measured by using American College of Radiology (ACR) Appropriateness Criteria, measuring compliance with clinical prediction rules, using insurance precertification denial rates, or using other local rule-based methods. We decided to enhance the communication with the referring doctors either to discuss the pertinence of the exam indication or to give the result by telephone.

2. **Engagement of all staff members in the quality process**

   We engaged one representative of each sector inside the quality cellule to participate in decision making. So, in order to integrate the new cellule of quality in the organization design, many employees of different work sectors will have a second parallel function i.e defined role in the cellule of quality dealing with one quality item in parallel with their daily work. This will provide the sense of team work and will motivate employees by giving them responsibilities as they become engaged in decision making of the organization.
Engaging all staff from the beginning of the process reduces resistance to change because people are involved and empowered to solve their own problems. Engaged employees are much happier and more productive and have fewer sick days and lower job turnover rates than employees who are not engaged or satisfied.

3. Eliminate waste

waste is simply all activities that do not add value to the patient's care.

We found that the most important route causes of waste are: a) lack of standardization in protocols of exams (every radiologist or technologist has his way to perform the examination); b) Time buffers taken by workers to be in the safe side; c) unplanned events e.g. obese patients, comorbidities; d) overuse of equipment: unnecessary studies and preparation (e.g. oral and rectal contrast), many patients scheduled for the same time slot.

We introduced paper forms to be filled for every patients which demonstrates the expected and the real time of patient's arrival, the preparation time, the start and the end of the examination, time when images are printed and put on the table of the radiologist and finally the time the radiologist sees the patient and give him the oral result and provide him the images (Fig.13). This action has enhanced the responsibility of every worker to perform his task in time. For example we discovered that image printing takes 20 minutes in average. Also, we noticed that there is often a considerable gap between the end of the exam of one patient and the start of the next one.

For finalization of the reports we decided to reduce substantially the reports turn around time. One secretary will do a check round to collect the ready reports twice a day (11 and 17 Oclock). Radiologists will be called to check their folders of reports twice a day (at 11:30 and 17:30).

4. Minimize variation by standardizing work

by standardizing processes and exam protocols, variation can be minimized or even eliminated and quality improved. After multiple discussions during meetings of the medical counsel, we all agreed to put standard protocols based on recent guidelines for all CT and MRI examinations.

We already introduced structured reports in our system which helped a lot in economizing the time of radiologists and secretary.

5. Keep lean and swiftly flow
Main stream mapping is a good tool to improve patient throughput in radiology practice by identifying bottle necks. After showing the above results to all staff members, all employees agreed to get rid of all unnecessary steps that do not add value to the patients care and to abandon all time margins and buffers. Better communication is to be enhanced between different sectors; for example a technologist should inform the radiologist about time delay of more than 15 minutes in order to adapt the exam protocol to catch up this delay.

We introduced visual system and cues which help staff immediately identify the current status of a work area; for example dashboards showing list of non-dictated and non-validated cases distributed every morning to every radiologist (Fig.14).

6. Professional outcomes

- **Peer review:**

Is a good method for assessing colleague competence by asking a peer radiologist to reread cases and determine if he or she agrees with the initial report. Radiologists who are outliers among their peers for the number of reports in disagreement can be identified and improvement plans implemented. Missed findings or other material disagreements from these reviews can be a source of learning for other members in the group. We decided to apply peer review surveys about the quality of our reports based on the agreed KPIs; e.g compliance to standard protocols, application of guidelines, answering the referring doctor question and clinical correlation. This is essential in risk management in radiology aiming to reduce errors in radiologic reports.

- **Pay for performance:**

We will envisage short term and long term wins and rewards. We will consider also adding the performance issue in the yearly bonuses. We will do also do awards for the best performers (the employee of the year).

7. Anticipation

Review of the program the day before. Systematic preparation of examination rooms in advance. For materials stock we will use Kanban principle: a message that signals depletion of product or inventory that when received will trigger the replenishment of that product. Timely replenishment of supplies so that smaller quantities can be purchased and less storage place is required is better than maintaining large inventories of materials.

8. Patients and providers perspective
We have got to put the patients' as well as referring doctors' perspectives in the core of our strategy in order to add real value and to improve the services provided. It is important to understand how patients and referring doctors perceive the quality of our services (Perceived Quality) and also how they define value in the context of the services and products we provide (Expected Quality). Are we creating value in their terms? The provision of services is a value stream that can be mapped, but it is most effectively mapped from the patients' perspective as well as the providers'. For example, providing the correct interpretation of a CT scan may be the greatest value from the perspective of the radiologist, but obtaining a correct diagnosis without unnecessary delays in scheduling of the CT examination and communication of the results may be the value sought by the patient. Some patients described their big distress to stay still inside MRI machine for more than 30 minutes and asked to have frequent voice communication with the responsible technologist. Likewise, ease of scheduling and rapid communication of accurate results with reasonable recommendations for any follow-up may be the value sought by the referring clinician.

**Implementation: (Execute quickly)**

**Results of the action plan:**

- **For CT scan, (Fig. 15, 16, 17)** we can notice a good change in reducing the waiting time as well as the variability. The mean waiting time for CT has decreased by 24.5% (from 38 to 28.8 minutes) and the variation (standard deviation) has decreased by 44%.

- **For MRI, (Fig. 18, 19, 20)** the results showed less significant improvement in reducing waiting time. However, we can see that there are clearly now less patients waiting more than 30 minutes for their MRI compared with the previous situation. The mean waiting time for MRI has decreased by 20% (from 28 to 22 minutes) and the variation (standard deviation) has decreased by 19%.

- **For reports turn-around time, (Fig. 21)** unfortunately, no change in the reports turn around time. We hit a strong cultural resistance. Some radiologists still don't see this as priority. As we just changed our RIS-PACS system, we asked the new supplier to integrate a traceability system of the work flow that shows the timing of each step of the main stream mapping of patients path with red flags for any delay in waiting time more than 15 minutes. We also decided to introduce voice recognition reporting system. The new RIS-PACS system is equipped with program of direct correction and validation of the reports by means of electronic signature which will certainly improve the reports turnaround time. Our target is to achieve a Just in time delivery with Six-Sigma principle: All reports and images delivered within 24hr.
Quality Assurance (QA) and Continuous Quality Improvement (CQI): (Fig. 22)

In order to have this quality control model sustainable we adopted the principle of quality assurance (QA) and continuous quality improvement (CQI).

Continuous quality improvement methods provide a relatively new way to improve quality in healthcare by using a systems approach with key features of customer-mindedness, data collection, experimentation, and teamwork. CQI is not meant to solve simple problems but is increasingly applied in our complex healthcare organizations.

Our quality control system will be based on the principle of continuous quality improvement using Deming cycle of quality (Fig. 22), also known as PDCA (Plan, do, Check, Act). Most good hospitals use this approach.

1. **Plan**: Set objectives: Establish standards (KPIs), mission, values.
2. **Do**: Measure performance
3. **Check**: Determine the reason for deviation (dysfunction): why has the organization performance not met the established performance standards?
4. **Act**: Take corrective action:

With the PDCA approach health care sites can solve many of the problems it encounters and plan for future changes which will go much more smoothly.
Fig. 3: Flow chart illustrates the steps that occur between generation by referring doctor until delivery of images and radiologic reports. The diagram was constructed to analyze possible bottlenecks in patient flow (throughput).

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Fig. 4: Graph showing access time for patients to arrive to the radiology clinic. Y-axis: time in minutes per kilometer. X-axis: simple numbering of exams. Each dot represents a patient coming for radiologic exam.

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**Fig. 5:** Graph showing waiting time between admission and start of CT exam. Y-axis: time laps in minutes between admission and start of CT. X-axis: simple numbering of exams. Each dot represents a CT exam.

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**Fig. 6:** Graph showing waiting time between admission and start of MRI exam. Y-axis: time laps in minutes between admission and start of MRI. X-axis: simple numbering of exams. Each dot represents an MRI exam.

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Fig. 7: Graph showing delivery punctuality of reports. Variation in dictation and finalization of reports. X-axis: Delay Time in days. Y-axis: percentage of dictated and finalized (delivered) reports.

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Fig. 8: Productivity run chart depicts the mean number of MRI and CT examinations performed each day of the week over four months. This type of chart plots the variables in a process—in this case, the number of examinations (y-axis) versus days (x-axis).

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Fig. 9: Follow up of shoulder subacromial infiltration shows a nice success with a reduction in the mean pain scale from about 7.2/10 before the infiltration to 4.5/10 three days after to 3.5/10 ten days after to 2.7/10 a month after the maneuver.

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Fig. 10: Follow up of spinal nerve block under CT scan guide shows a pretty nice success too with a reduction in the mean pain scale from about 7/10 before the infiltration to 5/10 three days after to 4.2/10 ten days after to 3.8/10 a month after the maneuver.

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Fig. 11: Patients satisfaction according to different criteria.

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**Fig. 12:** Table 1: key performance indicators (KPI's) of the three main sectors of workflow and their corresponding metrics of application.

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**Fig. 13:** Paper forms to be filled for every patient's which demonstrates the expected and the real time of patient's arrival, the preparation time, the start and the end of the examination, time when images are printed and put on the table of the radiologist and finally the time the radiologist sees the patient and give him the result with the images.

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**Fig. 14:** Dashboard of a summary of the non-dictated and the non-validated cases. A more detailed list is also joined and displayed on dashboard every morning. A copy is also distributed in the signature folder of each radiologist. This list is continuously updated.
every morning and helps for the monitoring of the flow in reporting of radiologic imaging results.

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Fig. 15: Effect of the implementation of the corrective actions on CT waiting time. Nice improvement with visible reduction in variability.

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Fig. 16: Graf showing change in the distribution of CT waiting time. Notice the drastic reduction in percentage of patients waiting more than 40 minutes.

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<th>CT wait.time</th>
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<td>SD</td>
<td>20.37</td>
<td>11.48</td>
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Fig. 17: Table 2: The mean waiting time for CT has decreased by 24.5% (from 38 to 28.8 minutes) and the variation (standard deviation) has decreased by 44%.

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Fig. 18: Effect of the implementation of the corrective actions on MRI waiting time. we can notice the less number of patients waiting more than 30 minutes.

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Fig. 19: Graf showing change in the distribution of MRI waiting time. Notice, increase in percentage of patients with small waiting time and reduction those waiting long time.

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<th>MRI wait.time</th>
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<tr>
<td>Average</td>
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<td>SD</td>
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Fig. 20: Table 3: The mean waiting time for MRI has decreased by 20% (from 28 to 22 minutes) and the variation (standard deviation) has decreased by 19%.

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Fig. 21: Unfortunately, no change in the reports turn around time. There are still only about 50% of reports were validated and faxed within 24 hours.

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Fig. 22: Continuous Quality Improvement (CQI) using Deming cycle of quality, also known as PDCA.

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Conclusion

Conclusion:

This project has allowed us to become familiar with the principles of quality improvement methodologies to better understand our internal processes, identify bottle necks in the workflow, and to take effective measures to foster improvement. Waste elimination and keeping only tasks that add value to patients care by an entire team work is paramount to success.

The ultimate goal is a cultural shift in which all departmental workers assume responsibility for quality and safety improvements and behave consistently with the core values of the organization in order to shift from the actual stagnant state to a new, dynamic and competitive organization based on an excellent and sustainable quality control system.

Nevertheless, the main stream mapping method of lean management constitutes just one facet of the global quality. Yet, It could open up avenues towards Total Quality Management (TQM).
References


