Towards a Lean Six Sigma Sanitary System – Changing Patients’ Perspective by Improving the Medical Processes’ Variation

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Abstract: In almost every year, the Romanian sanitary system brings different changes for its patients, more or less beneficial for their interest. New development opportunities should take into consideration the main consumers’ needs. Last year’s profits confirm the fact that the sanitary system cannot have a sudden improvement, most certain a detailed analysis and a deficiencies’ gradual improvement it’s necessary in order to be able to realize a change.

One thing is clear for the sanitary system, as long as the hospitals’ and clinics’ managers are not able to clearly and correctly define the “quality” notion, most certainly quality management is almost impossible. This is why, we consider that the first steps for starting an improvement process must have as a departure point the “patients’ voice”, what displeases the patients as well as its needs regarding a qualitative sanitary system and the aspects on which the ordinary Romanian patient can’t even imagine.

This paper will analyze an apparently minor aspect, but mostly with dramatically consequence, which is the phenomenon of waiting time in front of the medical cabinet, a analyze realized with the help of two statistical tools-ANOVA analyses and regression analyses.

Keywords: sanitary system; statistical tools; Lean Six Sigma.

1. Introduction

The Romanian sanitary system needs an urgent evolution before it reaches its collapsing period. Nowadays, people trust less in the sanitary system due to its numerous errors. Thus, in a difficult economic period, people are tempted more than ever to apply quick fixes and ad hoc solutions [1] including treating themselves at home instead of going to the doctors.

For reorganizing the Romanian sanitary system, a method should be applied in order to increase patients’ faith in sanitary organizations; this method is called Lean Six Sigma.

Lean Management methodology suggests a completely approach of the system but with a reduced number of details, organizational structures and analytical instruments for diagnosis, while Six Sigma, presents a reduced number of standard solutions, but proposes a general analytical framework for
problems’ solving and for creating an organizational infrastructure. This is why, the ideal solution for the Romanian sanitary system is that these two methodologies to be used together, as a whole. At a first glance, an integral framework of the sanitary system for applying the Lean Six Sigma methodology would take into consideration the following aspects:

- A structural approach;
- A projection based on implementation. A project represents a chronic problem which needs a solution; problems can be solved only with a project approach [2]. Lean projects apply good practices, focusing on implementing standard solutions, while Six Sigma projects are applied for general and complex problems which imply solid analytical and statistical solutions;
- Resources’ rational organization. For securing solutions’ implementation and avoiding their waste, well defined attributes and responsibilities are demanded, standard procedures and an adequate process’ control;
- Transposing strategic objectives in performance indicators and achievable objectives [3].

In quality management the evaluation is realized through a performance management system. Basically, at this level, the sanitary institution must decide whether the performance level is acceptable or not. If the level is acceptable, then the sanitary institution continues to measure this level for ensuring that, as time goes by, this will not decrease. On the contrary (if a low level is detected) the sanitary institution should take into consideration an improvement step.

![Figure 1. The performance management system](image)

2. Literature Review

2.1 Romania’s position among European countries

Before defining and managing the quality of a healthcare system, this must be, in the first place, understood. Within a general framework, quality refers to a service’s or a product’s attribute, but if we refer to the sanitary field, this presents special particularities and involves distinct approaches (reporting to other activity fields), an appearance that sets its mark also on the issues regarding the quality performance in the sanitary system [4].

According to the research conducted by Health Consumer Powerhouse company, which deals with comparisons between countries’ different healthcare systems, on the Healthcare European Index in 2017,
from a total of 34 countries, unfortunately, we can observe that Romania is placed the last on the ranking, with a score of only 439 points from a total of 1000 points, Holland being at the top of the ranking, with a score of 924 points (see figure 2):

![Figure 2](image)

**Figure 2.** Romania’s 2017 Euro Health Consumer Index score compared with the European countries. Source: adapted from Björnberg, A., 2018 [5]

For this index’s calculation there have been taken into consideration the following aspects:
- Patients’ right to information;
- Access to medical treatments;
- Quality of the medical results;
- Access to medications, etc.

The score obtained by our country shows a very low level regarding the quality of the medical system, since, in the moment the study was built, people from Health Consumer Powerhouse have considered that the simple existence of a sanitary system brought the countries a score of 333 points. The simple enumeration of the above mentioned aspects, following which Romania is situated on the last place, demonstrates the poor quality of the Romanian healthcare system compared to the other countries. Although in Romania there are doctors with a high degree of qualification, the logistic conditions offered by the public healthcare system (old medical equipment, lack of funds, unsecure buildings etc) affect in a high degree their work, reaching as, in the end, doctors and nurses to migrate in different countries from European Union, which will allow them to unfold the medical practice in normal conditions [5].

### 2.2 Lean Six Sigma in the Romanian sanitary system

The sanitary system is far from being a system with zero defects. As we have mentioned above, Six Sigma is a method necessary for recognizing, analyzing and solving variations (too many) from a project.
This thing appears because every process has its own variations [6], including medical processes. Thus, because of numerous variations a series of internal deficiencies appear as well as discontents from the clients’ part. That’s why, Six Sigma offers a number of tools capable of minimizing the variations from a process.

Unfortunately, in every medical process, defects’ producing (errors) is inevitable [7]. In Six Sigma methodology defects’ number can be seen as a quality parameter. Mostly we use a so called “Six Sigma road map” used for improving a certain quality. The used steps are the following:

1. identifying the most important processes and most important clients;
2. defining clients’ needs;
3. measuring the actual performance;
4. analyzing and introducing improvements;
5. Implementing Six Sigma process in the organization.

Once the third step is finished it can be measured the number of defects that take place at every process’ step. The defects’ sum, expressed as a percentage, defines the probability that a defect could happen. The Six Sigma process helps the hospital, in our case, to define a standard for the maximum admitted probability that a defect could happen (this action is called process variation).

Still, over time, the Lean Six Sigma methodology showed us that 99.9% (as a 5 sigma level) is not enough. However, for anyone who would hear an affirmation like this, the first question would be the following: “the 99.9% is very high, still why isn’t it enough?”. The answer at this question has its place within the complexity and process technology, as well as in their safety (figure 1).

Figure 3. What means 99.9% perfection?

As an example, we will present a number of reasons why 99.9% perfection is not enough:

- Almost 4 million children are annually born in America. If the probability for taking home your own child, from the maternity, would be only 99.9%, then this would result in the fact that 4000 families would leave home with another child (not their own) every year;
If there were more than 14 million plastic surgeries, with a perfection rate of 99.9%, this would mean that 14,000 plastic surgeries would have been wrong;

In America, there are 15,000 dentists who graduate, then at a perfection rate of 99.9% would mean that 15 of them don’t practice very well their job (this aspect could be extended to every medical specialization, of course, the following rhetorical question would be: who would like to be treated by them?).

As we have mentioned at the beginning, Six Sigma represents a methodology which follows the quality improvement, by reducing defects and their causes. The method concentrates on those outputs which present a high importance for clients and also have the possibility to transpose their needs in measurable requirements.

2.3 Prioritizing actions which present importance for the patients – Priority calculator

The Romanian medical system would need a series of improvements, in order to be able to offer to its patients a high satisfaction level. But, these actions can’t be realized in a short time, this means that an organizational culture is needed to be created and also, focusing on each problem. This is why, we decided to build a so called “priority calculator”. This has the role of presenting the main directions which should be adopted, respectively the main deficiencies to solve, and then these should be classified, according to some indices, in the priority order set by the patients.

Within this “priority calculator” each problem or deficiency which needs a special attention is seen as a project which presents the following aspects:

- A certain importance level for the client;
- A certain necessary cost for implementation;
- A certain feasibility degree;
- An impact on those around it.

In table 1, this aspect is exemplified taking the case of a public Clinique from Bucharest:

**Table 1. Priority calculator in a public Clinique from Bucharest**

<table>
<thead>
<tr>
<th>Project</th>
<th>Importance For client</th>
<th>Implementing cost</th>
<th>Feasibility (Success rate)</th>
<th>Cost reduction</th>
<th>Lever (Positive impact on other processes)</th>
<th>Total Project Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Eliminating bureaucracy</td>
<td>3</td>
<td>x 4</td>
<td>x 3</td>
<td>x 3</td>
<td>x 4</td>
<td>= 432</td>
</tr>
<tr>
<td>2) Reducing waiting time</td>
<td>5</td>
<td>x 3</td>
<td>x 4</td>
<td>x 4</td>
<td>x 5</td>
<td>= 1200</td>
</tr>
<tr>
<td>3) Trainings for doctors</td>
<td>2</td>
<td>x 5</td>
<td>x 3</td>
<td>x 2</td>
<td>x 3</td>
<td>= 180</td>
</tr>
<tr>
<td>4) Modern medical equipment</td>
<td>4</td>
<td>x 5</td>
<td>x 3</td>
<td>x 2</td>
<td>x 4</td>
<td>= 480</td>
</tr>
<tr>
<td>5) Medical safety</td>
<td>4</td>
<td>x 3</td>
<td>x 3</td>
<td>x 3</td>
<td>x 5</td>
<td>= 540</td>
</tr>
</tbody>
</table>

Source: Author’s computation
So, for creating the “calculator” there were 5 main projects chosen, which, if correctly fulfilled, would help creating a better development for the Romanian sanitary system. In the above constructed matrix, we granted, based on the surveys made for patients and on the doctors’ answers from a public Romanian Clinique, a score for each project, taking into consideration the 5 listed features. In this way the scores were multiplied, obtaining a so called “priority total”. The project with the highest score will be the project which will be prioritized. Per se, from the calculations made, we can observe that the projects which needs special attention is “reducing the waiting time in front of the cabinet”, cu a total score of 1200, followed by “medical safety” (this category includes hospitals’ cleaning, admission rooms, working medical equipment which don’t emit radiations etc) with a score of 540 points.

The role of this instrument is to help identify the projects with the highest potential benefits, in order to indicate a starting direction for improving the Romanian clinics and hospitals.

Once the “calculator” is build, the main project has been discovered and based on this, a analyze will be made, in order to be able to better predict the waiting time.

2.4 Analyzing the variation of patients’ waiting time

The basic philosophy behind the Lean Six Sigma system is to remove variation from a process. Thus, most of the time the inputs are marked with “X”, and the outputs with “Y”. This is why a Lean Six Sigma project aims to facilitate understanding between the independent variables (the inputs-Xs) and the dependent variables (the outputs-Ys). If this process would be put as a mathematical equation, and Y would be a function of X, it would be written as following: Y=f((X_1; X_2;...X_n). Transforming process’ inputs in outputs is represented by the so called transfer function, mentioned above. In other words, any inputs’ variability will cause a series of outputs’ errors or defects.

The main purpose is to identify the Xs (the inputs), to determine which Xs are important, and to quantify the relation between those Xs and Ys (outputs).

Nowadays, we can affirm that the term variation is met in every process. Each industry confronts with a lower or higher level of variation (by the term variation we can describe a process that alternates, doesn’t present constant parameters every time when analyzed; obtaining a different result in comparison with the one expected at a certain point in the process). Of course, the medical system, as well as any other system, presents variation at different steps of the process: variation in patients’ waiting time, variation in treatments, etc.

These variations are (figure 4):

- Normal/natural
- Special

- Results from the factors outside the process;
- Minimum effect over the process’s performance;
- Results from the process’s regulated rhythm.
- Met in every process, no matter the industry field;
- Significant impact over the process’s performance.
In the present case, the focus will be on the variation of patients’ waiting time in front of the cabinet. The calculation of waiting times’ central tendency presents only a data centering, but not the way the data are spread. Because of this, we will use the dispersions’ measure or variability. If the values of dispersions’ measures present the fact that the observations are concentrated around the mean, then the mean would be a good representation of those observations.

As it was mentioned, the variation level is extremely important when we refer to quality control, because it induces the conformity level of process production, according to standards. Also, variability study helps us comparing the data spread in more than one distribution. Assuming that the arithmetic mean of patients’ waiting time, daily, for two medical cabinets, is 8 minutes, we can conclude that the patients of both cabinets wait for 8 minutes in front of the medical cabinet before the examination. However, observing for a period of time, can present us the fact that for the first medical cabinet, patients wait between 5 and 9 minutes until the examination, while for the second cabinet, patients wait between 4 and 20 minutes. In this way, the conclusion would be that the organization of the second cabinet presents a lower efficiency level than the first one.

Per se, the most used dispersions’ measures are the amplitude, the variation and the standard deviation. The amplitude is the simplest variability measure. This is calculated as being the difference between the highest and the lowest value from a set of observations. For example, if we would have 140 observations, and from those we would extract 84 observations and divide them in 14 samples, then the amplitude would look like this (table 2):

**Table 2. Patients’ waiting time amplitude in front of the medical cabinet**

<table>
<thead>
<tr>
<th>Crt.nr.</th>
<th>Waiting time (minutes)</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>3</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>5</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>5</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>3</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>6</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>3</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td>11</td>
<td>18</td>
<td>6</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>6</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>6</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>11</td>
<td>6</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

Source: Author’s computation
Even if before arriving at the doctor, the patients call for an appointment, once they arrive at the cabinet’s door, there are situations in which they have to wait some extra 30 minutes more than the initial appointment, for entering the cabinet. This fact represents a source of dissatisfaction for them, decreasing, in the same time, their trust in the public sanitary system [Y].

Medium deviation of an observation measures the average distance for which the values are situated from the average. Medium deviation will be computed as the absolute values’ amount for deviations towards the average, divided by the numbers of observations from a population. As a general formula we will have:

$$DM = \frac{\sum_{i=1}^{N}|x_i - \mu|}{N},$$

where $x_i =$ the value of each observation;

$\mu =$ arithmetic mean.

Thereby, according to the calculations made, the medium deviations for all the 84 observations, is 5.09. In other words, it can be stated that the waiting time for the 14 samples deviates with 5.09 from the mean.

The standard deviation is one of the most used measures of the variability. The smaller the standard deviation is, the closer the data will be from the mean. Taking into consideration the sample provided, respectively 84 patients (from a total of 104 patients) and also that the maximum upper control limit admitted by the patient, concerning the waiting time, was 15 minutes, we want to see how many patients waited above this limit. Thus, considering the mean values, 8.10 minutes, and the standard deviation ($\text{distance of an observation from the mean}$), 5.09 minutes, we will identify, based on the calculation derived from the standard score (Z score), how many values exceed the score of 1,355.

$$z = \frac{x_i - \mu}{\sigma} = \frac{15 - 8.10}{5.09} = 1.355$$

Table 3. Patients’ waiting time Z score

<table>
<thead>
<tr>
<th>Z score</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.3945</td>
<td>8.10</td>
<td>5.09</td>
</tr>
<tr>
<td>-1.5907</td>
<td>-0.021</td>
<td>-0.609638</td>
</tr>
<tr>
<td>-0.021</td>
<td>-0.4134</td>
<td>0.37138889</td>
</tr>
<tr>
<td>1.54862</td>
<td>2.92206</td>
<td>-0.609638</td>
</tr>
<tr>
<td>1.35242</td>
<td>-0.6096</td>
<td>0.37138889</td>
</tr>
<tr>
<td>0.6075943</td>
<td>-0.805844</td>
<td>0.37138889</td>
</tr>
<tr>
<td>0.17518344</td>
<td>0.1751834</td>
<td>0.1751834</td>
</tr>
<tr>
<td>-0.2172</td>
<td>-0.805844</td>
<td>0.1751834</td>
</tr>
<tr>
<td>-0.413433</td>
<td>0.1751834</td>
<td>0.1751834</td>
</tr>
<tr>
<td>0.56759</td>
<td>1.9410325</td>
<td>0.960005247</td>
</tr>
<tr>
<td>0.37138889</td>
<td>2.33344</td>
<td>0.37138889</td>
</tr>
<tr>
<td>1.94103</td>
<td>-0.2172</td>
<td>0.37138889</td>
</tr>
<tr>
<td>2.33344</td>
<td>-0.805844</td>
<td>0.37138889</td>
</tr>
</tbody>
</table>

Source: Author’s computation
From all the 84 patients, it is easily observed that 9,52% of them will wait at least 15 minutes in front of the medical cabinet. In a significant measure, it is considered that the patients’ waiting time was caused by bottlenecks appeared in the informatics system (mentioning also that the informatics system of Romanian clinics and hospitals still presents important deficiencies).

3. Conceptual Model - Forecasting patients’ waiting time according to the informatics system’s duration with the help of the regression analyze

Another statistical instrument which could confirm or infirm the connection between the 2 above variables (informatics system’s blocking duration and patients’ waiting time) is also the regression analysis. This method shows us that according to the initial data, predict the results that will follow. The simplest type of known regression is the linear regression.

This analysis, as it was already mentioned, helps us predict the value of a variable, when we already know the value of another variable. In other words, there will be 2 types of variables, such as the independent variable (the one whose value is known) and the dependent variable (the value we want to find based on the already known variable).

The linear regression function looks like this:

\[ Y = b \times X + a \]

where (Isaic-Maniu, 1995):

- \( Y \) = dependent variable;
- \( X \) = independent variable;
- \( a \) = the intercept (the place where the regression line intersects the OY axes);
- \( b \) = regression slope (shows with how much \( Y \) modifies when \( X \) increases or decreases with one unit).

Basically, the regression shows how a variable is dependent on another variable, and the correlation shows the degree in which a variable is dependent on another variable [9].

3.1 Methodology’s results

Table 3 presents 48 values of waiting times during 1 week, in ascending order (48 patients that visited the cabinet, randomly chosen, within 1 week), based on which the regression analyze will be constructed using Excel program, which will helps us discover how much the patients’ waiting time varies (considered as the dependent variable-Y variable), according to the informatics system’s blocking duration (considered as the independent variable – X variable).

Table 4. Informatics system’s blocking duration and patients’ waiting time
Before that, it is necessary to mention that a linear regression demands that the link between the dependent and independent variable to be linear [10]. This assumption can be tested with the help of a Scatter diagram (created also in Excel), as it can be seen below:
Figure 5. Scatter plot between informatics system’s blocking duration and patients’ waiting time
Source: Author’s computation

Based on the plot diagram, the correlation coefficient resulted, or Pearson coefficient (also calculated with Excel program and =CORREL(x,y) function) was 0.912552, which indicates a very high correlation between the 2 variables, concluding with the fact that one variable influences the other.

Below, the regression function resulted:

\[ Y = -0.53 + 0.58X \]

Even if at a first glance it may seem a complicated table, we will summarize at only 2 coefficients, respectively \( a = -0.53 \) and \( b = 0.58 \). Thus, the resulted function will be

\[ Y = -0.53 + 0.58X \]

Having this function, and also knowing the informatics system’s blocking duration (variable \( X \)), we can start predicting now how long will take for the patients to enter the medical cabinet (how long will be their waiting time).

Another action taken, in order to prove the correlation between the variables mentioned above, was the hypothesis testing [11] for which we used the ANOVA method.

The two hypotheses were:

- \( H_0 \) (the null hypothesis): the informatics system does not influence the patients’ waiting time
- \( H_1 \) (the accepted hypothesis): the informatics system does influence the patients’ waiting time

The ANOVA table can be seen below (based on the measures from table 3):
From ANOVA analysis, we have depicted two coefficients that can demonstrate if we should accept or reject the null hypothesis:

- \( F = 13.896 \)
- \( F_{\text{crit}} = 3.9423 \)

As it can be easily seen the value of \( F \) is bigger than the value of \( F_{\text{crit}} \). In this situation, we will reject the \( H_0 \), meaning that, indeed the informatics system does influence the patients’ waiting time.

In conclusion, for a Six Sigma process, a regression analysis is very useful when we have to face two variables and we want to see how a variable is influenced by another variable [12]. In this case, according to the results discovered, we have managed to estimate the patients’ waiting time in front of the medical cabinet (assuming that there is no emergency which could intervene at that time), if the informatics system blocks between 1 and 30 minutes.

4. Conclusions

Lean represents a management system, a philosophy or a toolkit, according to the amplitude, strategy and the development level of the organization and culture in which it applies. Eliminating or reducing losses is specifically made, and it requires the ability of choosing the right instrument at the proper place and at the proper moment [13]. The Romanian sanitary system could reach a superior performance regarding the quality level with the help of Lean Six Sigma tools. The two methodologies complete each other in order to decrease the waste from the sanitary system and also, decrease the processes’ variation level. Their purpose is that, at the end, the patient get confidence in process and change the initial perception regarding the low quality level from the sanitary system.

From the current research, aimed for analyzing a part of the benefits brought by Lean Six Sigma tools and potentially applicable in the Romanian sanitary system, it can be affirmed that in order to create a
The Romanian sanitary system, focused on patients’ needs, it is necessary that the following aspects to be accomplished:

- The improvement and efficiency process must be driven and managed by a person capable of sustaining this action, more specifically, a leader in that field;
- Focusing on customers’ needs is as important in the sanitary system as in any other field. Once the leaders from the sanitary industry become more receptive to this concept, they will understand the fact that they need to serve and answer not only to patients’ needs, but as well as patients’ family’s needs, community’s needs, institutions’ needs, etc. For increasing patient’s satisfaction, the Romanian sanitary system must ensure a plus of quality regarding the offered sanitary services.
- The existence of a comparative analyze could be useful [14]. Even if in Bucharest there are a lot of doctors who work in public hospitals, as well as in private clinics (part-time, for example), in this way having the possibility to compare the conditions regarding the efficiency level and also the quality level from the private sanitary system, compared to the public sanitary system, there isn’t a program which could allow doctors and leaders to benefit from a sort of an “experience exchange” at clinics and hospitals outside the Romanian territory, where Lean Six Sigma methodology is present, in order to observe the changing degree and the innovations brought by this. It is considered that this action could be beneficial by observing changes and practices existing in Six Sigma hospitals, thus increasing doctors’ confidence in Lean Six Sigma.
- Involving all the employees in the improvement process [15]. When the clinic will start a Six Sigma process, the duty of the implementation team is to inform the employees regarding Lean Six Sigma, to familiarize them with Lean Six Sigma concepts, and most of all, to mention them that any improvement is possible only with their help and dedication. The clinic’s employees must know the fact that they can contribute any time to the improvement processes, and that their ideas will be welcomed and also taken into consideration by the managers.

In conclusion, one thing is for sure: the Romanian sanitary system needs a change. There is a high potential of the sanitary system, but without a correct direction, this could remain as it is in the present – a criticized system by the patients and avoided by the new doctors.

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