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APPLICATION OF CONTROL CHARTS FOR MONITORING THE WAIT ING TIME IN A BASIC HEALTHCARE UNIT IN BRAZIL

Abstract: *Brazilian public healthcare service is highly demanded. However, the system has been through a restrained scenario, with a long waiting time to have a doctor's appointment and scans. This research aims to analyze the waiting time in the services of a Basic Healthcare Unit (BHU) in a small city in the state of Sao Paulo, Brazil, by using statistical control charts. The field research relays on Taguchi's loss function smaller-the-better, in other words, the shorter the waiting time for patients, better is the perception of quality. A direct observation was carried out in order to acquire the patients' waiting time for a medical appointment and to evaluate the quality of the service. The patient waiting time was monitored with Control Chart for Individual Measurements and Moving Range and then it was determined the capability of the service by using the C_{pk} index. It was concluded that the service is inefficient based on Process Capability Index (C_{pk}=-0.15), being the average waiting time for a doctor's appointment around 121.88 minutes (approximately 2 hours).*

Keywords: *Quality Management; Control Charts; Public Health Service; Waiting Time.*

1. Introduction

The Brazilian Constitution (1988) says that access to healthcare is a right of all Brazilian citizens, either through the National Health Service, which is the public service offered by the government, or through private agreements with private companies. According to Tieghi (2013), the National Health Service serves 200 million people, of which 152 million are exclusive users of this system. Brazil has more than 6000 hospitals, 45000 Basic Healthcare Units (BHU) and 30300 family health teams.

It is evident, then, that public health services are the most demanded by the population. However, the system has flaws in its main programs and, as a consequence, there are crowded hospitals, lack of manpower, lack of training for professionals and problems related to National Health Service financing (Rossi, 2015). Thus, preserving a free universal health system is an obstacle for Brazil, mainly due to its territorial extension (Tieghi, 2013).

These flaws can also be evidenced through research carried out by the Brazilian Institute of Geography and Statistics (IBGE) (2015), which points out that 40.4% of the population cannot get care due to the absence of doctors and dentists, 32.7% do not have access to a BHU, 6.4% do not find specialized professionals to attend, 5.9% waited a long time and gave up, 2.3% due to unavailability

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of equipment, 2.1% due to the health service not working, 0.5% for not being able to pay for the consultation and 9.7% for other reasons.

Al-Shdaifat (2015) conducted a survey where TQM (Total Quality Management) was implemented in hospitals in Jordan. Results showed that less than 60% of hospitals implemented, being the main principle to be implemented costumer focus. Kalaja et al. (2016) conducted a study at the regional public hospital in Durrës, Albania, and reported that healthcare is on the rise in the country, receiving the attention of researchers and doctors, due to deficiencies that the sector faces and the challenges to be overcome. This situation is very similar to that faced by Brazil, which also faces deficiencies in the sector.

In this way, quality tools can help the limitations of the health sector. Control charts are an example of a quality tool used in this sector. According to Fry et al. (2012), even though these graphs have been developed to assist manufacturing quality control, control charts have been suggested for assessing clinical outcomes. It can be shown that Statistical Process Control (SPC) can bring many benefits to the health sector, reducing waste, reducing costs and making better use of resources, in order to prioritize patient satisfaction. In order to bring benefits to the services, the use of quality methods is increasing, concerned with the quality of service and improvements, with the consumer satisfaction as the main goal (Rosa and Broday, 2018).

The present research sought to evaluate the capability of the Health System, based on the C_{pk} index, in a small city in the state of Sao Paulo, Brazil. The patients' waiting time was monitored with Control Charts for Individual Measurements and Moving Range using data from the waiting time of patients collected in a Basic Healthcare Unit.

2. Literature Review

2.1. Statistical Process Control (SPC)

Statistical Process Control (SPC) is focused on quality improvement processes. This refers to the use of statistical methods, in order to monitor and supervise a process so that it can produce a product according to predetermined specifications (Madanhire and Mbohwa, 2016).

According to Costa, Epprecht and Carpinetti (2005) the intermittent control of the processes is the minimum condition to maintain the quality of the goods and services offered. Therefore, quality is paramount in processes and services. Montgomery (2009) states that the process of awareness of the need and the insertion of formal methods and tools to obtain control aimed at improving quality are progressive procedures.

SPC brings several benefits to organizations that use it. Nordström et al. (2012) point out that one of the benefits is that it allows a quantitative analysis of the variability of the process, with emphasis on the early verification and prevention of possible problems. According to Ho and Aparisi (2016), intervening in the production process seeks to minimize the production of nonconforming items.

For Montgomery (2009), the evolutionary process of this tool had its origin with Frederick W. Taylor with his first studies of division of tasks, which led to improvements in productivity and work patterns. These studies, however, sometimes took the focus away from the characteristics of the quality of work, thus opening gaps in aspects of quality, product and the work developed. Thus, it was only in 1924 that SPC started with the development of control charts by Walter Shewhart at Bell Telephones Laboratories. According to Fry et al. (2012), Shewhart noted the existing variability in the processes and developed the charts in order to understand and improve the production processes.

According to Ahmad et al. (2014), the control charts assist in the investigation of the process and in the differentiation of control and out-of-control situations for different parameters of interest. From this tool, it is possible to state whether or not a process is under statistical control. Dupont et al. (2014) claims that a process will be in statistical control when the value of its indicator varies between the lower and upper control limits. If it crosses one of the limits it will express the presence of a cause to be investigated, corrected and used for future improvements. Fry et al. (2012) state that Shewhart divided this variation in two ways: variations of common causes and variations of special causes.

Common causes are an intrinsic part of the process, that is, a process that operates with these causes will be under statistical control. Special causes are when internal or external failures occur in the processes. Montgomery (2009) complements stating that these causes can come from machines adjusted or mistakenly controlled, errors by the operators or even defects found in the raw material, being this out of statistical control.

Nordström et al. (2012) state that there are several types of control charts and the selection of the most suitable becomes a difficult task. This scope made it possible to reach new areas: the control charts at the beginning were exclusive to industrial processes, currently they are not limited to this sector, they are also used in the service sector (Nascimento and Broday, 2018). Control charts can be divided into attributes (quality characteristic that cannot be measured on a continuous scale) or variables (everything that can be measured on a continuous scale).

Shewhart Control Charts for Individual Measurements and Moving Range were used in this study, since the goal is to monitor one variable (waiting time). This chart is used when the sample size is equal to 1. For the I-MR graph the moving range is given by Equation 1 (Montgomery, 2009):

$$MR_i = |x_i - x_{i-1}| \qquad (1)$$

Equations 2, 3 and 4 present the control limits for the individual measurements chart:

$$UCL = \bar{x} + 3\,\frac{\overline{MR}}{d_2} \qquad (2)$$

$$Center\ line = \bar{x} \qquad (3)$$

$$LCL = \bar{x} - 3\,\frac{\overline{MR}}{d_2} \qquad (4)$$

where:

UCL = upper control limit;

LCL = lower control limit;

MR = moving range;

d_2 = constant value.

The moving range chart has center line $\overline{MR}$ and the Upper Control Limit as UCL = $D_4\overline{MR}$. In this graph, normally, LCL = 0. When using control charts for individual measurements, Montgomery (2009) claims the importance of performing a Normality Test, since this chart is sensitive to lack of normality. In order to obtain the potential capability, C_p index is used as shown in Equation 5:

$$C_p = \frac{USL - LSL}{6\sigma} \qquad (5)$$

where:

USL = upper specification limit;

LSL = lower specification limit;

σ = standard deviation.

As can be seen in equation 5, C_p does not take into consideration where the process mean is located relative to the specifications. Equations 6, 6.1 and 6.2 present the index C_{pk} (minimum value between C_{pu} and C_{pi}) that takes process centering into account:

$$C_{pk} = \min\,(C_{pu}, C_{pl}) \qquad (6)$$

$$C_{pu} = \frac{\mathrm{USL} - \mu}{3\sigma} \qquad (6.1)$$

$$C_{pi} = \frac{\mu - LSL}{3\sigma} \qquad (6.2)$$

By using the C_p index, it is possible to obtain the potential capability, that is, how much the process uses its capacity according to specification limits. While the C_{pk} index measures the effective (real) capability of the process, it then checks whether the activity is centered or not. Thus, the degree of similarity between C_p and C_{pk} has direct relation and indicates the magnitude of the centrality of the process (Montgomery, 2009).

2.2 Service Sector

Service sector has been gaining a large space within today's society. Borges (2007) states that it is possible to visualize the growth of this sector in recent years, as well as its contribution to the growth of the economy. In this way, it is possible to define the importance of services since it has a major contribution to the Gross Domestic Product and in the generation of jobs in developed and developing countries, including Brazil.

For Kotler, Hayes and Bloom (2002), services originated in the Middle Ages with professions focused on the law, since these together with the armed forces and the church were an acceptable social way of earn a living. The growth took place in the 16th century, with new professions originating from capitalism and the increase in industrial technology. Over time these activities have been improving and diversifying to escape from the market competition.

Meesala and Paul (2018) state that the concession of high-quality services is the basis for success in the service sector. Services can range from renting hotel rooms, making deposits at banks, consulting doctors, getting a haircut, traveling by plane, renting movies, etc. They may include physical components such as meals or not include physical components, such as consultancy services (Kotler, Hayes and Bloom, 2002).

In this way, it is possible to perceive the intangibility, simultaneity and the participation of the customer throughout the process in the service sector. For Grönroos (1990), the service refers to the activity or set of activities with a usual relationship between customers, employees, physical resources or goods and service providers, and may be intangible in nature with the aim of solving customer problems. Services are intangible because they are experienced by customers, while products can be purchased. As a result, the evaluation of quality becomes more complex for the customer, as it is based on the opinion of third parties and the image of the company, which is responsible for the service provided (Carpinetti, 2012).

Customer has a role in the service process, since the consumer is present in the front office of the companies, thus the quality of the service provided is influenced according to the environment where it is offered. The services are simultaneous due to the lack of an intermediate stage between production and delivery. Thus, services cannot be stored, that is, when the productive capacity of the system is not used, it will be wasted and lost forever (Fitzsimmons and Fitzsimmons, 2014).

The service sector also has a service package that must be offered to the customer, and this refers to a set of products and services, which are offered in a given environment and have five aspects, as shown in Table 1.

Hora, Moura and Vieira (2009) emphasize that organizations and companies must aim for the excellence of the services provided, aiming at satisfaction and even exceeding customer expectations. The service provider system should be able to meet these expectations in a short time, since it is in relation to them that the service will be judged. Minimizing customer waiting time makes it possible to improve the quality of service and increase satisfaction with the service (Nascimento and Broday, 2018).

Table 1. Service Package (Adapted from Fitzsimmons and Fitzsimmons, 2014)

Aspect	Characteristic	Example
Support Facilities	Physical resource needed to offer the service	Hospital, Airplane, Mall
Facilitating Goods	Items to be offered or purchased by customer	Snacks during the flights, meals
Informations	Offered to the customer or supplier, in order to obtain an effective and customized service	Information on hotels in the region, medical records, seat availability, GPS location
Explicit Services	Inherent and essential characteristic perceived by the customer	Car runs smoothly, no pain after medical procedure, waiting time for firefighters after an emergency call
Implicit Services	Features beyond the service, that is, psychological advantages perceived by the customer	Status obtained after obtaining a degree, privacy obtained by a credit company

2.3 Healthcare Services

Despite the fact that healthcare services may be private or public origin, Kalaja et al. (2016) claim that is important measuring, evaluating and monitoring the quality of health services. Mohebifar et al. (2016) state that since the 90s one of the methods to measure patients' perception of the quality of the health service provided takes into account satisfaction.

Thus, Kalaja et al. (2016) state that the sector that targets health care is a growing sector receiving attention from doctors and researchers. Caldwell (2008) reports that one of the goals of improving quality in relation to healthcare is through the increase in human factors engineering and systems engineering principles in the predominance of adverse events.

Meesala and Paul (2018) claim that hospitals seek to identify the most critical factors and that solving and managing these problems will guarantee survival and success in the future, and that it is necessary to identify strategic factors. But, in addition, it is necessary to have the satisfaction of your patients in order to ensure the quality of the service. It is important than to identify the specific characteristics of a service so that they contribute especially to patient satisfaction, with which the hospital can focus on these characteristics.

Mohebifar et al. (2016) add that customers (patients) assess quality by comparing their expectations with understandings of actual performance. If the patient's understanding exceeds their expectations, then the services provided are of a high quality. However, Senot et al. (2016) state that patients have different needs in a hospital environment, varying in relation to severity, such as a simple cold, heart attack, fracture, among others. Thus, quality is a multidimensional concept, but it has customer satisfaction as one of the essential aspects that reflects the quality of service in a hospital environment.

Greer et al. (2014) claim that the perceptions of service quality of customers and service providers may not be aligned, as in the perception of employees they may judge that there was no failure, that is, that the service was delivered with quality.

Many companies in the manufacturing or service sector use quality management and quality assurance as a way to achieve the desired quality of their product or service and meet customer needs and expectations. Rath (2008) reports that in order to have a successful management and quality assurance, it is necessary to focus on the processes and empower the people involved in it with the necessary tools and give them the responsibility to improve the quality of the service. However, this approach is not adopted due to the non-use or misuse of the proposed tools; most organizations adopt only the removal of the defective product or rework or hope that there will be a failure so that they can subsequently search for its causes so that they do not occur again.

Thus, service companies in the health sector seek tools with the objective of improving the quality of the services provided, thus obtaining greater satisfaction from their customers. As reported by Plantier et al. (2017), the processes of using quality indicators in hospitals are being encouraged as a way to assess quality in these environments in order to improve the quality care and patient safety.

3. Methods

3.1 Data Collection

Waiting time data were collected in a BHU in a small city located in the state of Sao Paulo, Brazil. This city is located in the administrative region of Bauru, as shown in Figure 1.

Figure 1. BHU's Location (Adapted from Portalpower, 2016)

The city has five HBUs strategically distributed to serve the residents and anyone in the city can have access to these units. They operate from Monday to Friday from 7am to 5pm. The HBU has a team of six nursing technicians, one nurse, three janitors, one pharmacy technician, five community agents, one dentist, one speech therapist, one psychologist and eight doctors, being: an otorhinolaryngologist, an orthopaedist, a cardiologist, a gynecologist, two pediatricians, a gastroenterologist and a general practitioner.

Among the services offered in the HBU, there are consultations and scans such as electrocardiogram, rapid tests, PAP test and vaccination, which are performed weekly. Medical, dental, psychologist and speech therapist consultations work with appointments. In this case, the system is computerized, when the patient arrives, a number is generated in order of arrival, then it goes through a pre-consultation, only to perform the scheduled consultation afterwards. Vaccination works under the condition of scheduling or spontaneous demand, whereas rapid tests and PAP tests are performed by means of scheduling with a password.

Regarding the population, patients can come from all regions of the city, however due to the presence of more units in the city, the majority of them serve an audience from the nearest neighborhoods. Only people who had preferential care were not counted for the study, since their time at the UBS is reduced. Regarding sex, both genders will be included in the research, since there is no distinction in treatment in relation to waiting time.

3.2 Data Analysis Procedures

After obtaining the waiting time of patients at the HBU, two types of analysis were performed: a qualitative analysis and a quantitative analysis. The qualitative analysis was made using the Ishikawa Diagram, in order to verify the reasons for the waiting time in the analyzed HBU being so high. The Kolmogorov-Smirnov normality test was performed, with 95% confidence, using the *SPSS 23* software. After verifying the normality of the data, the control charts of the individual measurements and moving range were then constructed, in order to perform a quantitative analysis.

For the control chart for individual measurements, the parameters were calculated using equations 1-4, as described in section 2.1. Calculations can be performed using $\bar{x}$ which is the mean, MR which is the moving range and d_2 which is a constant value according to the number of observations in the sample. Since the sample size is one, d_2 always takes the value of 1.128. In order to perform the moving range calculation, sample must take two by two.

It is noteworthy that for this research, Taguchi's loss function smaller-the-better is used, because smaller the time the patient waits to be seen, the better it will be for the quality perception. For the preparation of the control charts, *Action Stat 3.2* was used. Subsequently, from the waiting times, the UCL (Upper Control Limit), CL (Center Line) and LCL (Lower Control Limit) were calculated. In this way, it was possible to carry out a more detailed analysis

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Finally, the effective process capability index (C_{pk}) was calculated. In this situation, it has only the upper specification limit (USL), since there is no minimum value for the patient to wait for a medical consultation. So, there isn't a lower specification limit. As an upper limit of specification, the waiting time was considered, since in Brazil there is no legislation determining the maximum waiting time for patients in the HBU.

4 Data Analysis and Discussion

4.1 General Data

Sixty patients who would have medical appointments in the three days of field study were analyzed (otorhinolaryngology (A), pediatrics (B), orthopedics (C), dentistry (D) and general practitioner (E)). Through the waiting times obtained, it was possible to perform a statistical analysis by medical specialty and a general value for the HBU, as shown in Table 2.

Table 2. Mean Waiting time (The Authors, 2020)

Statistical Analysis by medical specialty						
	A	**B**	**C**	**D**	**E**	**HBU**
Sample (n)	12	12	11	7	18	60
Minimum waiting time (min)	50	125	33	101	40	33
Maximum waiting time (min)	200	255	275	260	194	275
Mean waiting time (min)	114	187	110	159	100	134
Standard Deviation (min)	42.91	42.72	78.22	59.82	40.09	60.78

When observing data in Table 2, it is possible to conclude that the specialty that obtained the longest average waiting time was Pediatrics. It is also noted that pediatrics and dentistry have an average waiting time greater than the average waiting time at the BHU in general.

It was also concluded through Table 2 that orthopedics is the specialty that has the shortest minimum waiting time; however, it is also the one that has the longest maximum waiting time. Consequently, it is the specialty that has the highest standard deviation.

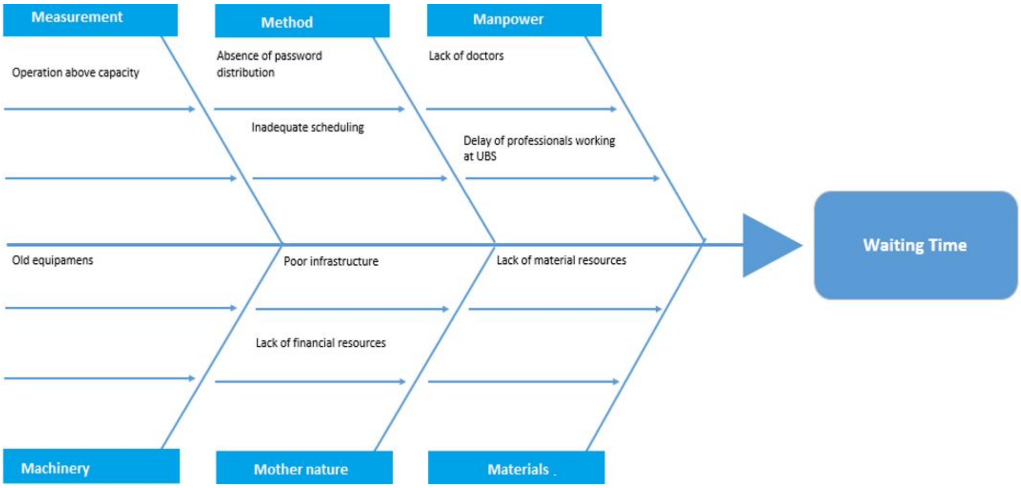

Figure 2. The Ishikawa Diagram (The Authors, 2020)

4.2 Ishikawa Diagram

To better understand the reasons that generates a long waiting time, the Ishikawa Diagram was used, with the main objective of listing the root causes of this problem. The Ishikawa Diagram is illustrated in Figure 2.

Possible main causes for the problem were divided in the following categories: measurement, method, manpower, machinery, mother nature and materials. From these causes and the conversations with patients at the HBU, it was possible to obtain the secondary causes that originated the main problem.

In relation to the mother nature (environment), it was possible to list the lack of structure as secondary causes, since there is no infrastructure for the queues before and when opening the HBU. Lack of material and financial resources, because if there was a password system when the patient arrives at the HBU it could be easier to organize the screening and with that the service would be faster. The screening time increases the patient's waiting time and occurs on the same day as the consultation. As, for example, in the case of pediatric consultations, children must be weighed beforehand, so this weighing could occur on the previous day in order to optimize services on the day of the consultation.

Regarding to the manpower, the secondary causes related are the lack of professionals, their delay and even the lack of specialties. In view of the high demand for people, it appears that there is a lack of professionals to serve everyone, as well as specialties. The HBU in question has only an otorhinolaryngologist, gastroenterologist, orthopedist, pediatrician and gynecologist, when interviewing the patients, they reported the need for more specialties such as dermatologists, urologists, neurologists, among others, as well as more doctors of the specialties already offered.

The method, that is, the way services are offered at the HBU stands out as secondary causes for political changes, which refer to the strategy that will be adopted by the health department. In addition to problems already addressed, such as lack of organization, since patients line up outside the HBU, however when it opens the first in line, it is not always the first to be attended. As well as, the lack of passwords and inadequate scheduling, since more appointments are often scheduled than the medical service hours tolerate.

In relation to the measurement, the complementary causes are attributed to the lack of prioritization, that is, in addition to scheduling, a new prioritization scale could be created according to the urgency of the service according to the patients' symptoms and with that the assistance would be more agile. As well as, the operation above capacity, that is, due to the high demand, doctors are few for the number of patients to be treated.

In addition, old equipments to perform the exams and the lack of some basic materials, such as gloves and masks, complete the problems that make the waiting time so long. In this way, it is possible to attribute the long waiting time to the most varied causes and with this setting priorities in order to eliminate root causes.

4.3 Normality Test

In order to be able to use the Control Charts for Individual Measurements and Moving Range, data must be normal. Therefore, the Kolmogorov-Smirnov normality test, with 95% confidence, was performed. The results obtained are shown in Table 3.

Thus, it is observed through the software result table that the data have a normal distribution, since the significance is greater than 0.05 (0.089 > 0.05). Therefore, data can be used to build the control charts for individual measurements and moving range.

Table 3. Kolmogorov-Smirnov test for data

		Waiting Time
N		60
Normal Parameters	Mean	127.95
	Std. Deviation	59.825
Most Extreme Differences	Absolute	0.106
	Positive	0.106
	Negative	-0.067
Test Estatistic		0.106
Asymp. Sig. (2-tailed)		0.089

4.4 Control Charts

For the construction of the charts, the Action Stat 3.2 software was used. Initially, a table was built with the waiting time data obtained through observations to patients in the three days analyzed. The data obtained are shown in Table 4.

Table 4. Waiting Time data (The Authors, 2020)

Sample	Waiting time (min)	Sample	Waiting time (min)	Sample	Waiting time (min)
1	65	**21**	135	**41**	33
2	45	**22**	165	**42**	168
3	115	**23**	220	**43**	135
4	90	**24**	165	**44**	260
5	120	**25**	177	**45**	218
6	109	**26**	240	**46**	101
7	65	**27**	152	**47**	110
8	50	**28**	215	**48**	122
9	120	**29**	225	**49**	182
10	137	**30**	255	**50**	95
11	200	**31**	275	**51**	139
12	137	**32**	227	**52**	93
13	155	**33**	103	**53**	40
14	55	**34**	55	**54**	94
15	110	**35**	88	**55**	70
16	115	**36**	55	**56**	85
17	117	**37**	90	**57**	194
18	105	**38**	58	**58**	92
19	165	**39**	163	**59**	88
20	125	**40**	67	**60**	88

The Action Stat generated for the sample of the values of the time that the users waited for the attendance in the Health Care Unit the following parameters: UCL = 255.80, center line = 128.95 and the LCL = 2.10 for the Chart of Individual Values. Using the same data, but for the Moving Range chart, the UCL values = 155.87, the center line = 47.74, the LCL = 0 and the σ = 42.28. Figure 3 illustrates both charts:

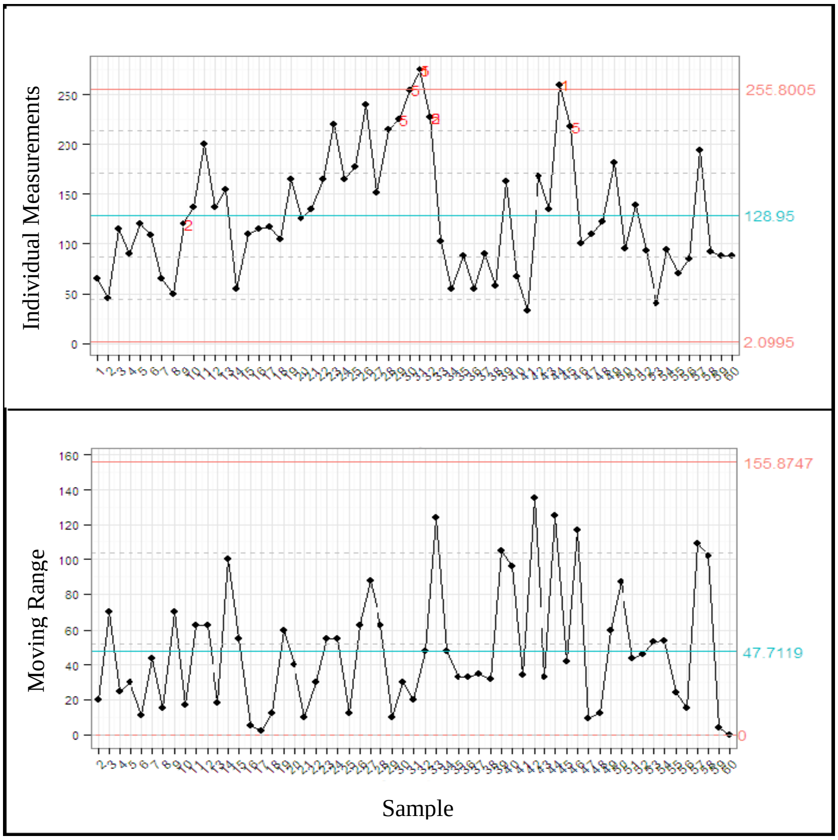

Figure 3. Control Charts

When analyzing the control charts constructed from the waiting time of patients at the BHU, it is possible to verify that for the moving range graph all values were within the determined control limits and show a behavior random. However, for the graph of individual measurements it is possible to check two points outside the control limits, which refer to samples 31 (275min) and 44 (260 min) indicating special causes.

When investigating the special cause found in sample 31, it was found that it refers to a patient who was waiting for a withdrawal to undergo a medical consultation with the orthopaedist. So, he arrived at HBU earlier in order to ensure that he would be attended to that day. However, as this is a case of withdrawal, this is the last patient to go through the consultation, so it is the one that presented a long waiting time. When investigating the special cause identified in the sample 44, it was found that it also refers to a patient who was waiting for withdrawal, however to undergo a dental consultation. Like the other patients who are waiting to give up, he arrived early to guarantee the appointment that day. In addition to the longer waiting time, it was found that the times for dental consultations are also long.

As a result, samples 31 and 44 were eliminated and the control limits for the control charts of individual measurements and moving range were recalculated.The new values obtained were: UCL = 249.69, center line = 124.17 and the LCL = 0 for the Chart of Individual Values. Using the same data, but for the Moving Range chart, the UCL values = 154.24, the center line = 47.21, the LCL = 0 and the σ = 41.84. Figure 4 illustrates both charts:

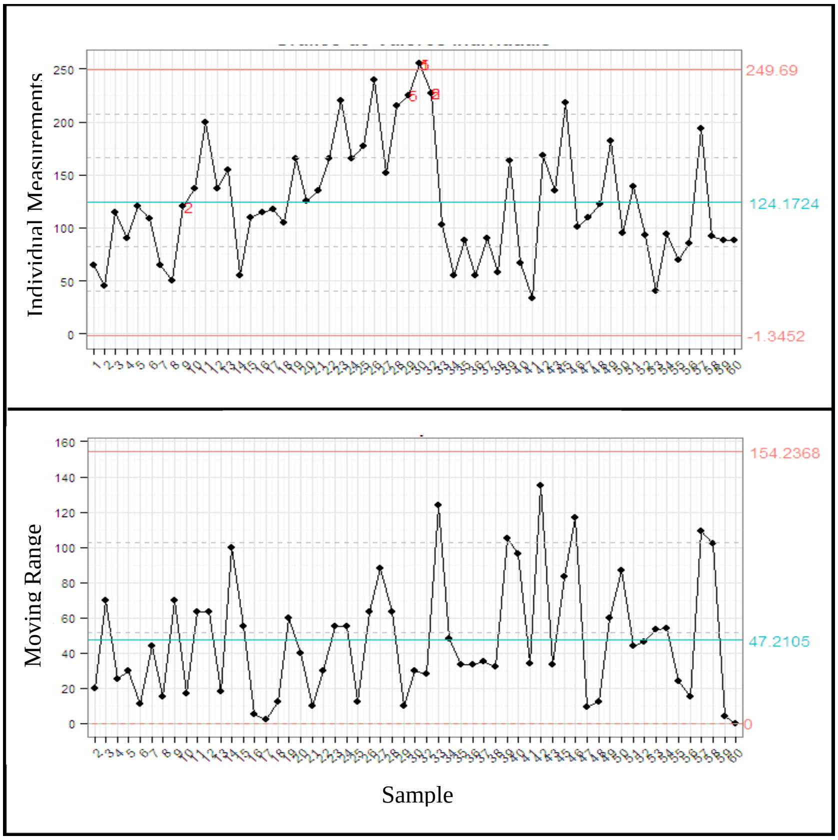

Figure 4. Control charts without samples 31 and 44

When analyzing the control graphs of individual measurements and moving range without the samples 31 and 44 presented in Figure 4, it is possible to verify that their control limits were shifted downwards, that is, the values of upper control limit and average limit decreased. Thus, it is possible to identify that for the moving range control graph all points are within the established control limits and that they behave in a random manner. However, for the control chart of individual measurements, it is possible to check a point outside the limits, which refers to the sample 30 (255 min).

When investigating the special cause found in sample 30, it was found that it refers to the last child who went to the pediatric consultation on the first day of research, who was also awaiting withdrawal. The mother arrived very early with the child to guarantee the withdrawal and waited until everyone was attended to. When eliminating sample 30, the control limits were recalculated again.

The following parameters were obtained: UCL = 246.98, center line = 121.88 and the LCL = 0 for the Chart of Individual Values. Using the same data, but for the Moving Range chart, the UCL values = 153.75, the center line = 47.05, the LCL = 0 and the σ = 41.70. Figure 5 illustrates both charts:

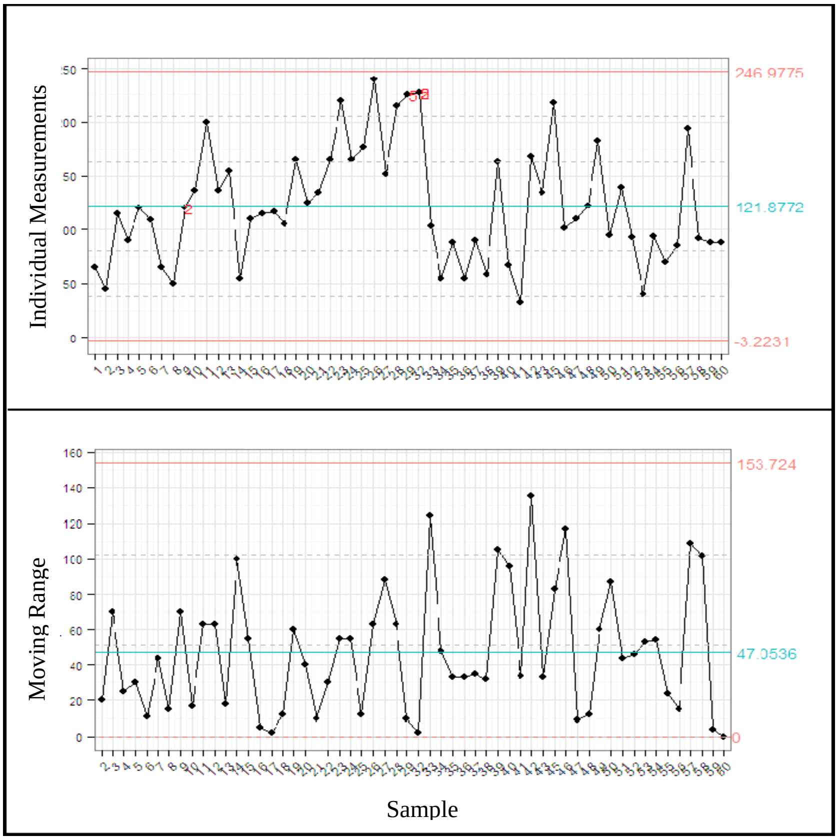

Figure 5. Control charts without samples 30, 31 and 44 (The Authors, 2020)

When analyzing the control charts illustrated by Figure 5, it is possible to verify that both are in control, since all waiting times are within the control limits and these are randomly arranged. Thus, it is possible to conclude that the waiting times are between 0 to 246.98 minutes (4.12 hours) and that the difference between the current patient's time and the one previously analyzed varies from 0 to 153.72 minutes (2,56 hours).

Thus, it is possible to conclude that by eliminating patients waiting for withdrawal, it can be said that the waiting time for patients is in statistical control. Thus, we classify dropouts as special causes of this process and should be eliminated. As a way of eliminating these causes, patients should be shown that there is no need to arrive at HBU 4 or 5 am for care. To do this, it should have an order for the waiting list too, so that the patient already has a password among the patients who are waiting to give up for their care, that is, a queue must be created between the patients who are waiting withdrawal.

4.5 Capability of the HBU Service

To calculate the process capability, the pre-determined specification limits are necessary. In the case of waiting time, there is no lower specification limit, since the ideal is that the patient did not wait to be seen. With this, there is a unilateral specification presenting only the upper specification limit.

The upper specification limit will be the maximum time the patient must wait for a medical appointment. This limit is related to the function smaller-the-better, meaning, the shorter the waiting time for patients, better is the perception of quality. In Brazil, there is currently no law that limits the maximum waiting time for a patient for a medical consultation in HBU, hospitals or even in private offices. In this sector, there is only the resolution of the Federal Council of Medicine, CFM 2.077/14. This resolution states that the maximum waiting time for patients with less urgency should be around 120 minutes.

Therefore, considering that the patient is waiting for a screening and a medical evaluation to classify his degree of urgency, the waiting time of 120 min was considered as the upper specification limit for the calculation of the effective process index (C_{pk}). The mean and standard deviation of the process are described in Figure 5, with the mean being the center line of the control chart of individual measurements (121.88 minutes) and the standard deviation (41.70 minutes). By using equation (6) it is possible to obtain the effective capability index of the HBU:

$$C_{pk} = \min\,(C_{pu}, C_{pl})$$

$$C_{pu} = \frac{\mathrm{USL} - \mu}{3\sigma}$$

$$\mathrm{C_{pk}} = \frac{120 - 121{,}88}{3 \text{ x } 41{,}70} = -0{,}015$$

The C_{pk} index demonstrates that the service in the HBU is not capable to attend patients in 120 minutes, since its value is less than one ($C_{pk} < 1$). Changes in the way of attendance are required in order to improve the service. This result goes against the resolution of the Federal Council of Medicine.

4. Final Considerations

According to the established objectives, it is verified that the present research made it possible to analyze the waiting time by means of statistical control charts and how they influence the capability of the service offered. Through the research, the functioning of the HBU was better understood through the direct observation, since it was possible to experience the unit's routine.

It was found that the health service has been going through some changes in order to improve the services offered and increase the satisfaction of its patients. The introduction of the time clocking system, for example, is an improvement to be made in the unit, since it will be possible to avoid delaying professionals and thereby reduce the waiting time for patients. Another improvement that has been observed is the reduction in the daily workload of doctors, as this way they will be available on more days of the weeks and will be less idle, in order to provide care more quickly.

With that, it is possible to observe that changes in the sector are appearing in order to reduce the waiting time of patients for medical care. However, there is also a cultural change in patients that needs to occur. Many of them arrive at the HBU before it even opens. Currently, as consultations are scheduled there is no longer a need for patients to arrive at the unit so early, however it is still a common habit among them, especially when it comes to dropouts.

Therefore, through the research it was possible to verify that the HBU still has restrictions and improvements to be carried out in order to improve and optimize the services offered. However, it was found that there are already some actions being taken to reduce this waiting time and improve the quality of the service. In general, it was found that patients evaluate the service offered as good.

Thus, it was proved that in times of crisis or difficulties, quality engineering becomes more important, because through tools it seeks to bring solutions in order to improve the services offered, bringing a new view of the system. It was found that the health sector has space for future projects involving engineering tools and that through them it is possible to improve the quality of services offered and optimize material and financial resources. In this way, in future research it is possible to go deeper into the waiting time by making a comparison between units or applying in new locations, but different studies involving forecasts and demand monitoring, materials, exams and other resources can be carried out. make analyzes necessary.

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