Enhancement for an adherence process on a Diabetes program at an IPS, through Chronic Care Model (CCM), Clinical Decision Support Systems (CDSS) and Lean Six Sigma

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Abstract

This paper examines the process of improving a diabetes disease program in a Promoting Health Institution (IPS, the Spanish acronym), in order to achieve a better adherence from the physician to the clinical guidelines, and from the patient to the program, through the application of the methodologies Chronic Care Model (CCM), Clinical Decision Support Systems (CDSS), and Lean Six Sigma.

This study analyzed a program in an uncomplicated diabetic population of one IPS, which has introduced a growth in diabetes prevalence over the last 3 years. Semi-structured interviews were carried out with the program managers, and secondary data were collected in order to identify the main causes of adherence process failure, through SIPOC, DMAIC, identification of potential failure modes, critical requirements analysis for quality, and necessary resources for timely and focused patient care.

It was found three main factors affecting adherence to the program. Therefore, several solutions were proposed based on: a) system capacity enhancement through care cells by patient profile. The above with the aim of improving the opportunity and the physician's resolution, using Jackson networks model (b) methods and processes enhancement by involving patients as partners in self-care; and (c) control mechanisms improvement through program adherence tools, in order to facilitate monitoring to the indicators of patient diabetes control as well as make better decisions.

The improvement proposals pointed to guarantee a better adherence control. It was also important to verify the practical validity of analyzing a health scenario, through sector-specific tools, and industrial engineering tools; which allow to solve issues of adherence lack to health programs.

Keywords
Lean Six Sigma, Chronic Care Model (CCM), Clinical Decision Support Systems (CDSS), Processes Enhancement, Health Programs.

Introduction

Diabetes is part of the diseases considered as a public health problem in the world, and for the year 2030 it is estimated to diagnose 552 million people with the disease. From the above, 39.9 million people correspond to the region of South America-Central America (Muñoz, Gómez, & Ballesteros, 2014). Although Diabetes has a medical treatment, it can lead to death as it happens with more than 80% of the low- and middle-income population affected by this disease.

The World Health Organization (OMS, Spanish acronym) has classified Diabetes among chronic degenerative diseases that require a treatment along the patient life. Hence, it is necessary to achieve the patient adherence to the treatment. In addition, the patient has to follow Healthy habits and to do exercise with the purpose of minimizing this disease complication.

The size of the world's population with diabetes has increased fourfold from 1980 to 201, with an increase in population from 108 million to 422 million, respectively. The most severe cases are reported in low- and middle-income countries, which is related to the impossibility of healthy food purchases and adherence to disease care programs. According to OMS projections, by 2030 they indicate that diabetes will be the seventh leading cause of death on the planet. In order to take care of this problem, it is required effective measures to monitor, prevent, and control the disease and its implications, mainly in low- and middle-income countries.

Colombia is a middle-income country, which is no stranger to this global reality. According to the dates of Así Vamos en Salud (Asívamosensalud, 2009), in 2013 the mortality due to diabetes mellitus in Colombia was 7,020 people, and at level Guainía, Meta, Norte de Santander, San Andrés and Providencia, Quindío, Risaralda, and Valle del Cauca presented rates higher than 20 deaths per 100,000 inhabitants. In the Valle del Cauca, the mortality rate in 2010 was 20.21 and in 2011, 21.16 per 100,000 inhabitants.

Although most research has focused on adherence to medication, it is important to consider that therapeutic adherence also includes several behaviors related to patients' health, habits, and context (OMS, 2004). In Figure 1. Influence of factors to adherence. There are additional factors that must be taking into account to facilitate patient adherence.

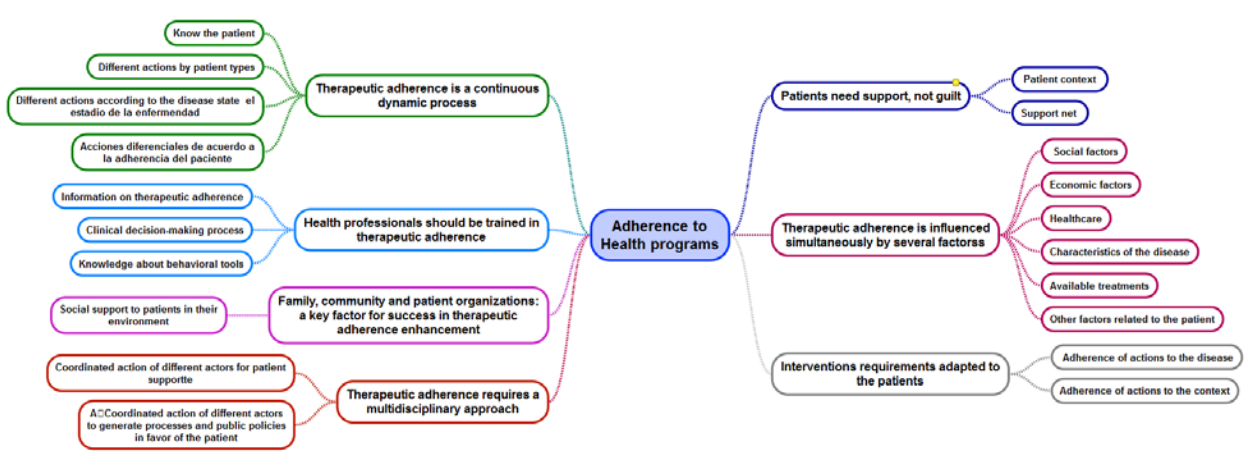


Figure 1. Factors Influence to adherence

Source: Own elaboration from OMS 2004

Therapeutic adherence is a factor that has an impact on the Health System effectiveness, as shown in Figure 2. Systemic cycle of adherence to disease treatment programs. By achieving a better adherence in health programs from patients, the burden of the disease will be reduced, positively influencing health outcomes and the number of people with chronic diseases.

Hence, there is a positive impact on the burden of the disease at the end of the cycle. On the other hand, if the cycle is observed from the perspective of Health System costs, having a reducing effect on the burden of disease, the adherence to disease treatment programs will have a positive impact on health costs, as well as in the budget of the health entities. The above with the aim of developing prevention and promotion programs to improve programs adherence by the population.

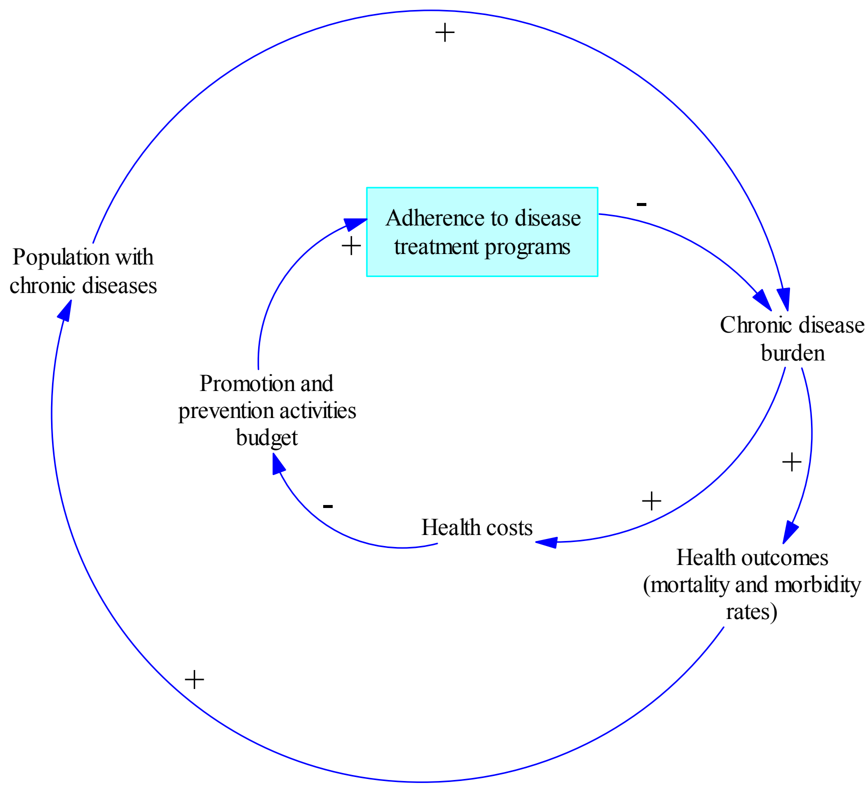


Figure 2. Systemic cycle of adherence to disease treatment programs

Source: Own elaboration

The above description allows us to conclude that the patient adherence to the disease treatment programs is really important to improve Health System efficiency. It is also relevant that the different actors act in a systemic way on the identified factors, and the passive patient becomes an active actor, committed and motivated by the health team in order to continue his/her treatment. Therefore, it will positively impact the burden of chronic disease and health costs, as well as benefit health outcomes of the population.

This paper presents the study of a Promoting Health Institution (IPS, the Spanish acronym), which analyzed a growth in the prevalence rate of patients with diabetes over the last 3 years, reaching 6.1% of them in 2015. The growth in diabetes prevalence is a challenge for IPS, considering a restricting care capacity and the importance of improving patients' adherence to the program in order to achieve better results.

The objectives of this study were: Identification of factors in the provision of medical services process, which obstruct adherence to the program and improvement actions. The above in order to achieve a better adherence of the physician to clinical guidelines, as well as the patient guidelines to this program, through Chronic Care Model (CCM), Clinical Decision Support Systems (CDSS), and Lean Six Sigma methodologies application.

This article presents the framework, the methodology, and the fieldwork development. The results of the main findings are related to three factors that affect adherence to the program a) system capacity b) the methods and processes to achieve patients' involvement as partners in self-care, and c) control mechanisms to facilitate adherence to the program through indicators monitoring of diabetes control in the patient with the aim of making better decisions.

The improvement proposals aimed at ensuring greater control in the face of adherence. It was also important to verify the practical validity of analyzing a health scenario, using sector-specific tools and industrial engineering to respond to problems of lack of adherence to health programs.

Framework

Diabetes and risk factors

Diabetes is a chronic disease generated once the pancreas is not able to produce enough insulin (hormone committed to have control over sugar level or glucose on blood), also once the body is not able to use the produced insulin efficiently. Diabetes is a significant public health concern and one of the four not transmittable diseases chosen by worldwide leaders to be aware of on a high priority basis, (OMS, 2016). The given disease is classified as diabetes type 1 which is related to a lack of insulin synthesis and diabetes type has its source at the incapacity on the body to use the insulin efficiently, which it is often a consequence of overweight and no physical activity.

Diabetes Mellitus is classified on the population at risk and brain – cardio – vascular – metabolic disturbances by established risk groups on the Ministry for health and social security (MSPS). Given diabetes is known to be a chronic disease it is important to also have in mind in Colombia from 2005 to 2010 chronic diseases increased from 76% to 83%, at zones with higher rate for epidemiologic transition rate and inequality for effective access, hence the significance to design solutions differed by geography stating their more significant needs.

Risk factors for DM2 development at a clinical level are non-healthy feeding with high fat concentrations, high levels of alcoholic drinks consumption, sedentariness, high risk ethnic groups, people older than 30 years old, with a high body-mass index greater than 25kg/m2, first grade relatives with diabetes diagnostics, visceral obesity, arterial hypertension, polycystic ovary syndrome, gestational diabetes, a mother with children whose weight is over 4 kg at birth and male hypogonadism. Metabolic risk factors are altered glycemia on fast, glucose test intolerance, dyslipidemia, triglyceride particularly greater than 150 mg/dL and HDL-C less than 35 mg/Dl, unusual fat tolerance test (lipemiapostprandial), high levels for basal insulin, HOMA greater than 2.5, hyperuricemia, microalbuminuria and hyperfibrinogenemia.

Customizable risk factors for DM2 development are overweight, obesity, sedentariness, ITG and GAA, metabolic syndrome, arterial hypertension, low HDL-C, hypertriglyceridemia, dietary factors, intrauterine environment and inflammation. The non-modifiable are race, family history, age, sex, history of gestational diabetes and polycystic ovary syndrome.

The strategy for patient recruitment may focus on the evaluation of overweight adults whose BMI is over 25 kg / m2, physical inactivity, first-degree relatives with diabetes, members of high-risk ethnic groups. Women with children over 4 kg or 9 pounds or a history of DMG, blood pressure (> 135/85 mmHg) or under antihypertensive treatment, HDL-C <35 mg / dL and / or TG> 150 mg / dL, Diagnosis of PCOS, Other clinical conditions associated with insulin resistance (severe obesity, acanthosis nigricans), history of CVD, and male hypogonadism. For patients who do not show the above factors, the evaluation for prediabetes and diabetes should begin at age 45 and if the oral glucose tolerance test is normal, the evaluation should be repeated at least every 3 years and considered more frequently depending of the initial results and the risk status.

Mechanisms used to improve outcomes for chronic disease care programs

In the document Evidence on The Chronic Care Model (CCM) In The New Millennium (Coleman, Austin, Brach, & Wagner, 2009), CCM is established as a way to improve care and better health outcomes in patients with chronic diseases because they are currently the leading cause of death and disability worldwide (59% of deaths and 46% of the global burden) and sometimes do not receive the care they require.

The six areas of CCM are support for self-management, design decision delivery system, clinical information systems, support, health care organization and community resources. The purpose of CCM is to increase the knowledge of providers and educate patients to create a planned follow-up based on the recorded information for the patient. The objectives of CCM are to improve quality, care for chronic diseases and health resources.

CCM focuses on the relationship of an activated patient with a proactive and prepared health care team. According to the CCM requires a properly organized health system and linked with the necessary resources in the community at large.

Another important factor is to establish a productive relationship between the informed and activated patient with the well-prepared health team, where the main protagonist continues to be the patient, so it is necessary to ensure a patient-centered care strategy as the cornerstone of a successful CCM implementation.

Regarding the usability and clinical impact of a decision support system (CDSS) in patients with diabetes in primary care (Maia et al., 2016), it was considered by 99% of health professionals that it is easy to use and by the 100% that provided useful information for the care of patients. In the same study it was evidenced that the most decompensated patients improved with the glycemic control (hemoglobin glycosylated).

The new approach to health on the empowerment of patients with non-communicable chronic diseases (Rolando et al., 2012) highlights the importance of health coaching in health promotion and education at the primary level of care, aimed at achieving empowerment and self-control of patients with chronic non-communicable diseases. The model is advocated by OMS as the innovative care for chronic diseases where it would foster a patient's empowerment by facilitating the patient to become more responsible and involved in their treatment by developing and stimulating their own abilities. When this type of education is supported by the health system, its organizations and management professionals are called "self-management support".

Coaching is a method of directing, instructing and training a person or a group of them, with the goal of achieving some goal or developing specific skills. The person who performs the coaching process is called the coach and the person who receives it is called the coach. In health, the goal is to help patients gain knowledge, skills, tools and confidence to become active participants in their care, so that they can reach their health goals, identified by themselves. Achievement of goals is achieved by modifying behavior related to lifestyle, with the aim of reducing health risks, improving the self-management of chronic conditions and increasing health-related quality of life, reducing treatment costs and increase the effectiveness of the program.

Structure and Processes Impact on Health Outcomes

The concepts raised by Donabedian (1980) about "quality in health care" consider three (3) fundamental elements for its measurement: 1) the structure of resources measurement and infrastructure characteristics, as well as the sufficiency (quantity) of the same for health services provision; 2) the process to measure, directly or indirectly, the quality of the activity carried out during patient care (guidelines or care protocols), and 3) the outcome indicators to measure the level of health achieved in the population, quality of the health system, user satisfaction, and finally the effectiveness in the use of the resources allocated for health services provision (Donabedian, 1980).

Contributions of Industrial Engineering to the health sector

In the last decade, the implementation of methodologies, techniques and tools have been considered in the health sector, in order to improve processes and influence positively the results.

Some cases found through the application of Industrial Engineering tools are related to Lean and Six Sigma. The case study described in the document Reducing Patient Waiting Time in Outpatient Department Using Lean Six Sigma Methodology (Gijo & Antony, 2014) was developed in a hospital in India, with the aim of reducing patient care times. The scope inclides the main processes of registration, consultation and dispensing of medicines. The most relevant results were the decrease in the mean and standard deviation of patient care time, customer satisfaction, improvement in performance indicators, creative thinking development by the participants in the project, as well as improvement of the employees' morale.

The study An overview of six sigma applications in healthcare industry (Tolga Taner, Sezen, & Antony, 2007) determines the importance of Six Sigma implementation in the health sector, in which the inclusion of this methodology is relatively new. The above has the objective of reducing delay times, medical errors and variability in safe and effective care to patients, improve patients' quality of life, operational efficiency, cost-effectiveness, as well as quality. The center of improvement should consider clinical outcomes, patient satisfaction, and efficiency in medical service provision. In order to diagnose the problem are suggested the use of the main tools such as cause and effect analysis, SIPOC, process diagram and fishbone, hypothesis testing, and frequency in errors. In terms of improvement, best practices, experimental designs, DMAIC, and DFSS can be extrapolated.

Other applications of Industrial Engineering to the health sector have been found through probabilistic or deterministic models simulations in order to optimize processes or define service models.

One of the models used in health, is open networks based on probabilistic distributions. Jackson networks with a type of this type, where the time between external arrivals to the station is distributed exponentially. In each of the nodes there are S identical and independent servers whose service time has an exponential distribution, exponential times are also independent. The capacity of each node is infinite and the stability condition of the node is given when $U = \rho < 1$. A Jackson network is fulfilled in stable state. Each node is behaving as M / M / S / GD / ∞ / ∞ Also all nodes are independent.

Research questions

What are the factors that, from medical service processes, affect adherence to the diabetes program?

What kind of Industrial Engineering tools support models implementation, such as Chronic Care Model (CCM) and systems based on Clinical Decision Support Systems (CDSS) with the purpose of improving adherence to the diabetes program?

From medical service processes, how to achieve that the patient becomes an active actor within a diabetes program?

Methodology

This study was focused on the provision of care services to uncomplicated patients affiliated to a Promoting Health Entity (EPS, the Spanish acronym) in the city of Cali - Colombia, which belong to the Contributory Regime (CR). From the analysis unit of the IPS Renoprotection program, which provides services to the uncomplicated diabetic patients of the EPS, who provides interventions with the program's medical evaluations, the nephrologist, the head nurse, and the exterior team as the base system. The study was conducted during 2016, year in which the IPS was found in the planning process and the beginning of the units' implementation of the basic integrated practice under the CCM model.

The data collection methodology, data analysis, and improvement proposal design were developed at the insurer level (program manager - EPS) and the supplier (administrative and operational staff - IPS).

This research was divided into three stages: care program characterization and barriers identification to achieve adherence to the program, prioritization of the needs identified in the characterization and design of an improvement proposal aimed at reducing barriers to adherence to the program diabetes.

In order to obtain the program characterization, it was collected: a) qualitative data through semi-structured interviews acquired from the literature studied. These interviews were applied to officials responsible for the program at the levels of the EPS and IPS, b) quantitative data obtained through the High Cost Account that manages the rectory of the program. The analysis of the data collected in this stage required SIPOC Diagram, flow chart, Identification of potential issues and effects through Failure Mode, Effects, and Analysis (FMEA), descriptive statistics and Jackson Networks.

The prioritization was performed using the Quality Function Deployment (QFD) methodology, based on the potential causes of failure found in the FMEA and the 6 M's, having into account a rating scale that classifies a) the relationship between causes and 6 M's: 0 if the relation is non-existent, 1 if the relation is weak, 3 if the relation is medium, and 9 if the relation is strong; and b) the impact of 1 to 5 depending on how relevant is the requirement for adherence to the diabetes.

Lean, Six Sigma and Jackson Networks tools were used to design the improvement proposal aimed at reducing barriers of adherence to the program.

The stages validity of this study was made through the triangulation of information for the case of semi-structured interviews, methods validation to be used by experts, and validation of the proposed improvement by insurer level (program manager - EPS), and the supplier (administrative and operational staff – IPS).

Results

Program Characterization

- ***Program Process Flow and Features***

The diabetes care program has as main actors the program doctor, nurse promotion health programs, auxiliary nursing promotion health programs, social worker, psychology, nutritionist, drugstore, and laboratory. Figure 3. SIPOC Diagram - IPS Diabetes Program shows the interrelationships of the main actors with providers, inputs, process, outputs, and customer.

In Figure 3, the entries correspond to the documentation and the results of each actor decision, which enter to other actors flow in order to define actions on the patient. The processes describe in a general way the role of each one of the actors. Outcomes are laboratory results and decisions of service suppliers, delivery of medications, documentation and recommendations. The customer is the patient enrolled in the diabetes program.

In the EPS of the diabetes program rectory, 42% of patients are recruited for hypertension and diabetes programs, with a study of 3% and 72% of the patients captured. The majority of the patients belong to socioeconomic strata 0,1, 2, and 3. There are 3 drugstores that deliver analog insulins (IPS studied, 2013 report).

The payment of the EPS to the IPS due to the provision of its services to the diabetes program, is given by training per 100 users and UPC that has a cost depending on the age, eg. the elderly and children under 1 year have a higher cost than the rest of the population. The payment per patient includes the external consultation, taking of examinations, promotion and prevention, the payment of additional people generated by hospitalization, special examinations, renal transplantation, specialized consultation, and medicine distribution (IPS studied, 2015 report).

According to IPS information systems, SAP is the platform used. They also have a PMD that are pre-configurable formats with parameterized interface for registration of medical history, nutrition, and psychology. In the PMD, anamnesis can be consulted, which includes information about the medical consultation, clinical examinations results, diagnosis, behaviors, clinical orders, and medications.
The episode is a consecutive of attention and inside it there is an order by packages. For example, inside an episode content, information of blood pressure and heart rate is stored. Datalab is the Enterprise program interface, an application that stores the exams results.

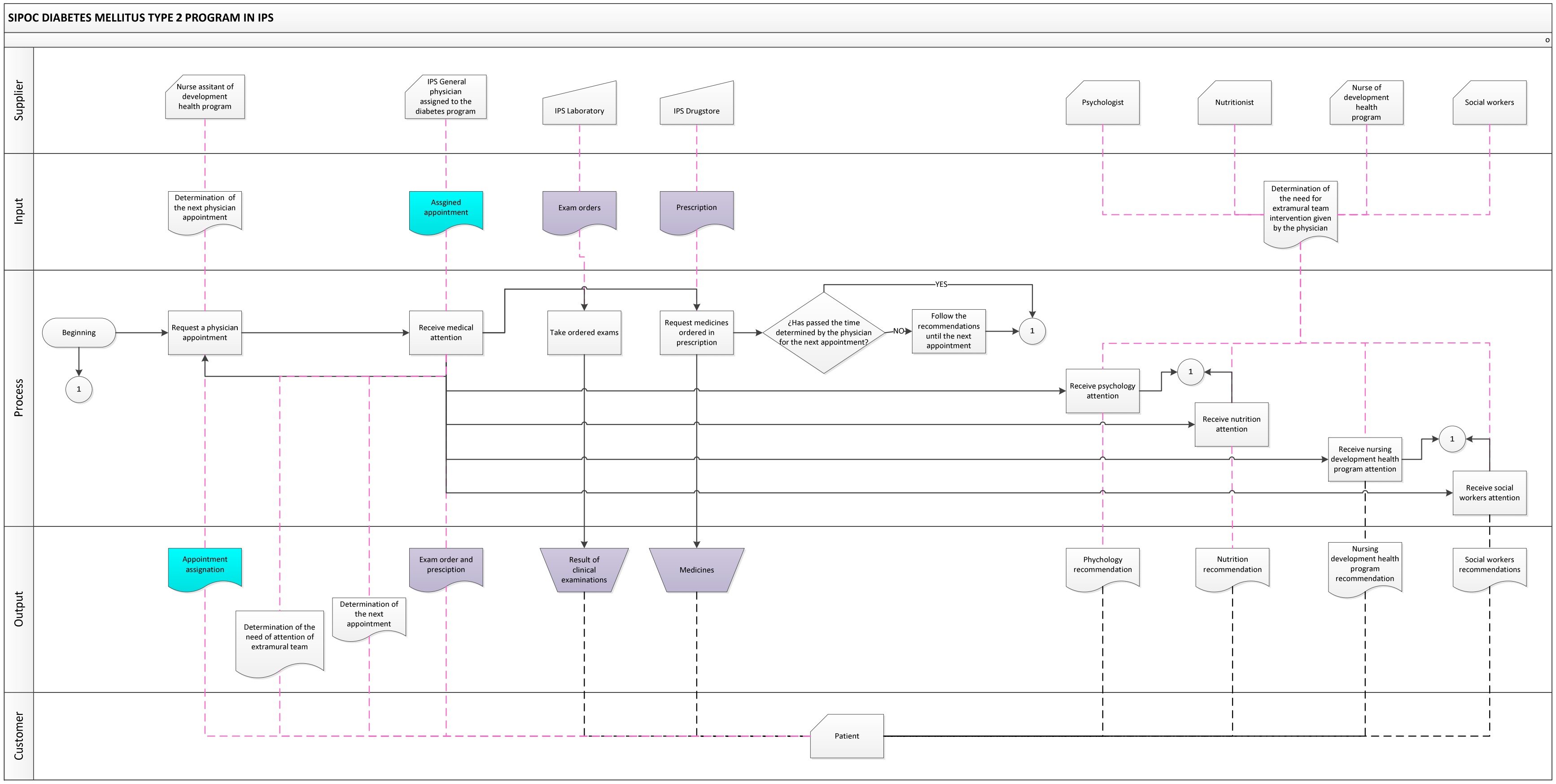


Figure 3. SIPOC Diagram – IPS Diabetes Program - Diabetes Mellitus Type 2

Source: Own elaboration based on interviews and analyzed protocols of the IPS

- ***Failure, Mode, Effect, and Analysis (FMEA) of the diabetes program***

The FMEA was developed from the stages and interrelations identified in figure 3. For each activity was determined the potential mode failure in the process, the effect that can cause the failure and the cause generated. This analysis was performed taking into account the 6M approach and the failures that influence the adherence to the program, the implementation of the Chronic Care Model (CCM) model, and the information for medical decision making through Clinical Decision Support Systems (CDSS), which are in the SAP system. In Figure 4. Results of FMEA vs Adherence to the program, the results are classified by: information system, system capacity (resources to serve users), attention process and adherence of the patient, as well as adherence to protocols.

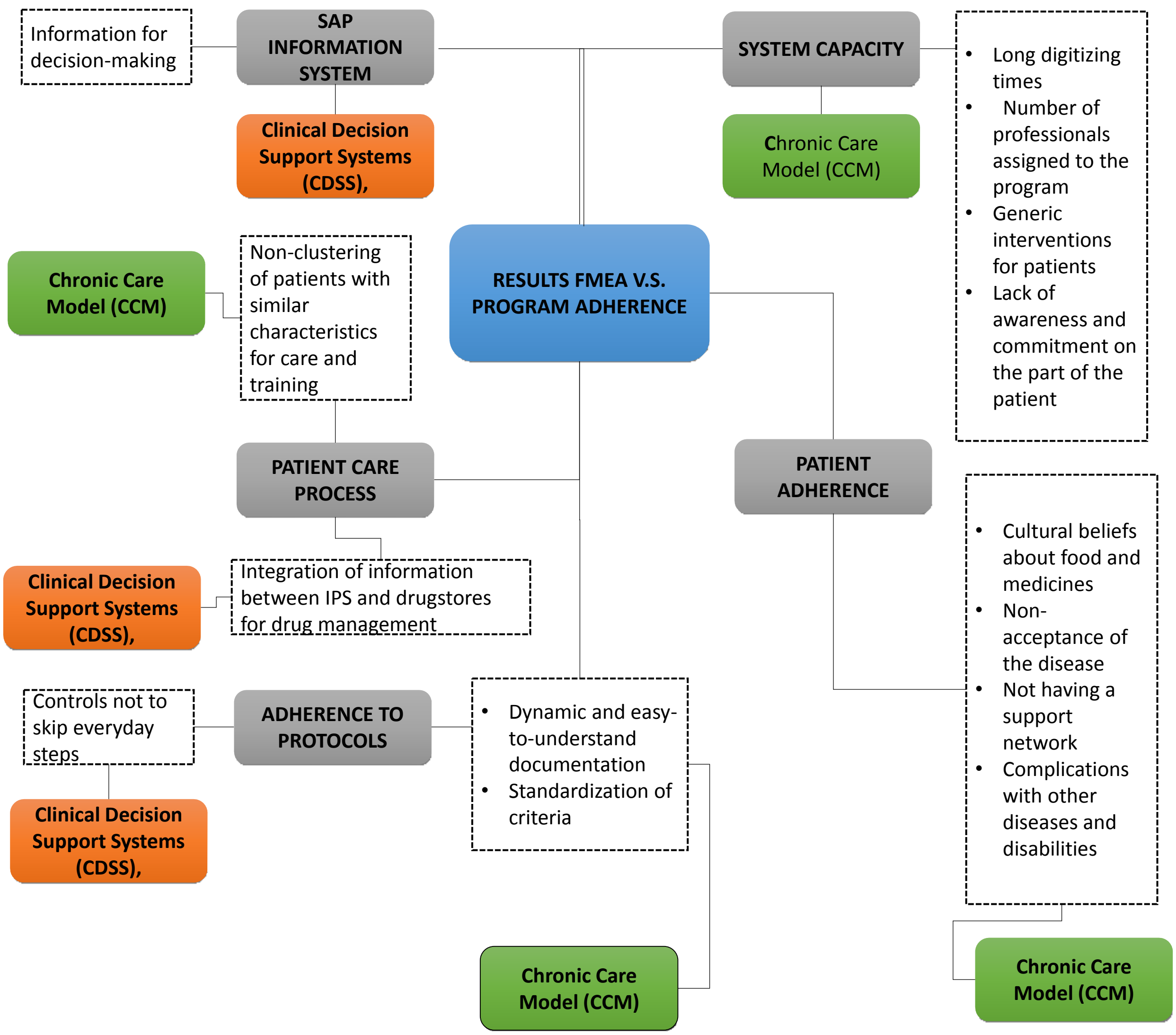


Figure 4. Results of FMEA vs. Adherence to the program

Source: Own elaboration from OMS 2014

Priorization of adherence improvement opportunities to the diabetes program

The main causes identified in the FMEA were prioritized through the application of QFD, taking into account the criteria described above in the methodology, as well as the categories identified in Figure 4, and the actors presented in Figure 3. In Figure 5, priority rating matrix and the results are presented.

Figure 5. Priority Rating Matrix

Supplier (Actor))	**Requirements of the client (CTQ - Critical for Quality) and (CTB - Critical for Business)**	System capacity	Control Mechanisms	Diabetes Control	Methods / Processes	Workforce / Personas	Equipment / Systems	Materials / Process Inputs	Measurements / Indicators	Menvironment/ Context
Results		**1170**	**1494**	**1608**	**1637**	675	651	846	828	441

Source: Own elaboration

According to the results and score obtained in the QFD, through the Pareto diagram it was found that 17.5% of the needs are focused on the intervention of methods / processes, 17.2% of them are focused on the control of diabetes, 16% on control mechanisms, and 12.5% on system capacity, summarizing 63.2% of weight with respect to the total value.

Prioritized factors contribute to the best adoption of the CCM and CDSS in the IPS studied, as follows:

1. According to Pillar 1, support for clinical decisions, through improved methods, processes and diabetes control.
2. According to Pillar 2, patients as partners in self-care, with methods, processes that favor adherence, diabetes control and program control mechanisms.
3. According to Pillar 3, design or redesign of service delivery with the system capacity, method, and processes.
4. According to Pillar 4, clinical information system and service integration with methods, processes, and diabetes control.

Enhancement Proposal

Having into account the results of the previous phases, it was designed a proposal, which are presented in table 1, with the aim of improving the adherence to the program of diabetes mellitus type 2 in the IPS.

Table 1. Enhancement proposal to improve adherence to the diabetes program

Proposal	Justification	Tool
Improving care capacity through care cells by patient profile through a resource allocation model and patients through Jackson networks	Improve the opportunity for care and resolution of the doctor	Jackson Networks Model
Improve methods and procedures by involving patients in self-care	Empowering the patient's self-care and facilitating adherence to the program	Visual self-management of the patient related to his habits and the results obtained
Improve control mechanisms through tools for adherence to the program	Facilitate follow-up on the indicators of diabetes control in the patient and favor the best decision-making	Control panel that supports physician decisions based on high cost account information and patient follow-up

Proposal 1. Model of Patient Allocation Cells through Jackson Networks

A model of Patient Allocation Cells was developed by profiles for IPS, headquarters B, taking into account the following considerations for the System:

1. Determination of specialized cells, it means that physicians should focus in only one type of patient, thus standardizing the service provision, increasing the adherence of physicians to clinics and reducing potential failures during the medical service provision.

2. The proposal of number of physicians requested starts with the cells design and the patients' attention time, a) new and uncontrolled patient: 30 minutes, and b) controlled: 20 minutes as currently determined in protocols.

3. The patient's condition for cell allocation is determined by the program physician as a result of the patient profile analysis.

4. The patient cells require a variable number of physicians per month, depending on the demand variation, requiring also multipurpose physicians between care or cells.

A simulation model was developed, using Jackson general networks in which the external arrival rates to the system are Rn, Rd, and Rc, the routing probabilities are Pnd and Pnc, the service rates are μn, μd, and μc, the probabilities of internal routes are Pdc and Pcd; and the system outputs are Pds and Pcs. The above in order to determine the required distribution of physicians in each of the cells with the current parameters of the IPS system in the health business unit at headquarters B.

The Kendall-lee notation for each of the attention processes is M / M / S / GD / ∞ / ∞ which means that the time between arrivals and attention times follow an exponential distribution. There is S physicians, the row discipline is general, the number of patients allowed in the system is simultaneously, and the size of the potential population is infinite. Assuming that all the times mentioned above are exponential and independent of each other. In Figure 6, the Jackson network model is proposed for the IPS, headquarters B.

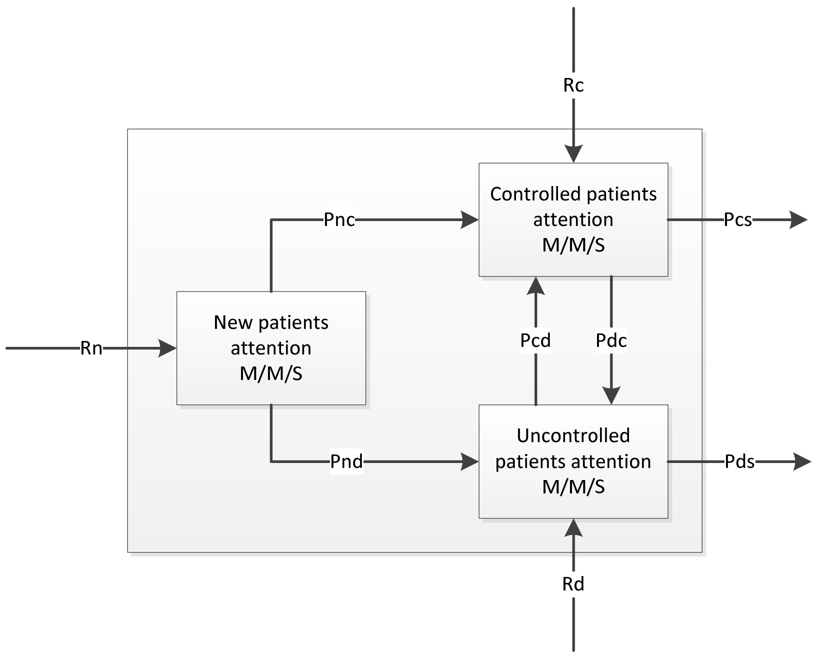


Figure 6. Jackson Network model proposal

Source: Own elaboration

The simulation parameters about the ability of physicians to treat complicated and uncomplicated patients with diabetes in the headquarters B of the IPS are as follows: The entry of new patients' rate (Rn) is determined from the inscriptions of new patients to the program with diagnosis of diabetes (10 patients / month). The probability of moving from being an uncontrolled to controlled patient, and vice versa comes from the monitoring database that has the IPS of the patients attending the appointments, as well as the evolution between each control crossing each of the mentioned states (Pdc = 57 % and Pcd = 68%).

It was obtained the data of controlled and uncontrolled patients from the high-cost account, with the results of glycosylated hemoglobin and the % of patients withdrawn or dead. The frequency of care need is determined by the IPS and with this information are calculated the % of patients / type and the number of patients / month as presented in Table 2 and 3.

Table 2. Jackson network simulation for patients with diabetes

Diabetes mellitus patients simulation					
Type of patient	# Patient	% Patient / Type	Frecuency attention / month	# Patient / month	% Patient retired or dead
Controlled	1600	64%	3	533	0,80%
Uncontrolled	904	36%	1	904	1,20%
Total	2504	100%		1437	

The table presents: Rd and Rc: entry rate of uncontrolled patients, Pnc and Pnd: probability of moving from being a new patient to a controlled patient, Pds and Pcs: Probability of switching from uncontrolled patient to leaving the system.

Table 3. Type of patients and care capacity month

Type of patient	Hours / week	Hours / month	Attention (hours) / patient	Patient care capacity / month
New	33	149	0,5	298
Controlled	33	149	0,5	298
Uncontrolled	33	149	0,3	447

The results of the stable model showed a low level of occupancy in the station of new patients and in the station of patients in the control of surplus capacity, therefore it is proposed that 5 doctors / month can be contracted to care for uncontrolled patients, and 4 physicians / month to attend controlled patients in which one of them also attend new patients. Currently the diabetes program at headquarters B has 7 doctors / month and according to the simulation, 9 doctors / month are required only to treat patients with diabetes who have or do not have complications, and not with other basic chronic diseases included in the program.

Most of the patients in the model are located in the station of patients with complications, this condition represents an important challenge in the physician to revert that behavior to uncomplicated.

The current behavior of having more complicated patients implies an increase in the cost of administration of these patients in the system. Hence, it is worth the implementation of cells per patient profile that support the CCM model at the head of each team of IPS actors to be in charge of a group of patients in their cell, which an incentives plan is generated for the patient and the care team (remuneration variable for results based on these savings due to patient noncomplication) that result in the improvement of the patient's health and quality of life. The above translates into better results for the IPS, minimizing health costs.

Proposal 2. Control mechanisms Improvement

Consists of simple tools that allow the patient to make decisions about their behaviors, with the aim of participating in disease control and adherent to the program. This information will be input source for the medical control appointment.

Given the characterization of the population by the team of social workers, in headquarters B of the IPS to 2016, 23.5% of patients have incomplete primary and 76.5% can read, and most patients do not have access to technology, a tool consisting of 3 checklists was developed, see figure 7. The first one is the format of laboratory tests ordered by the physician, the second one is the physician format, exercise, and patient follow-up, and finally the format of patient's blood glucose monitoring.

The purpose of the monitoring and self-care checklists is for the patient to follow up on his / her process and to identify important changes that must be informed to the IPS for a real-time decision making by the attending physician and the extramural team assigned (CCM cells).

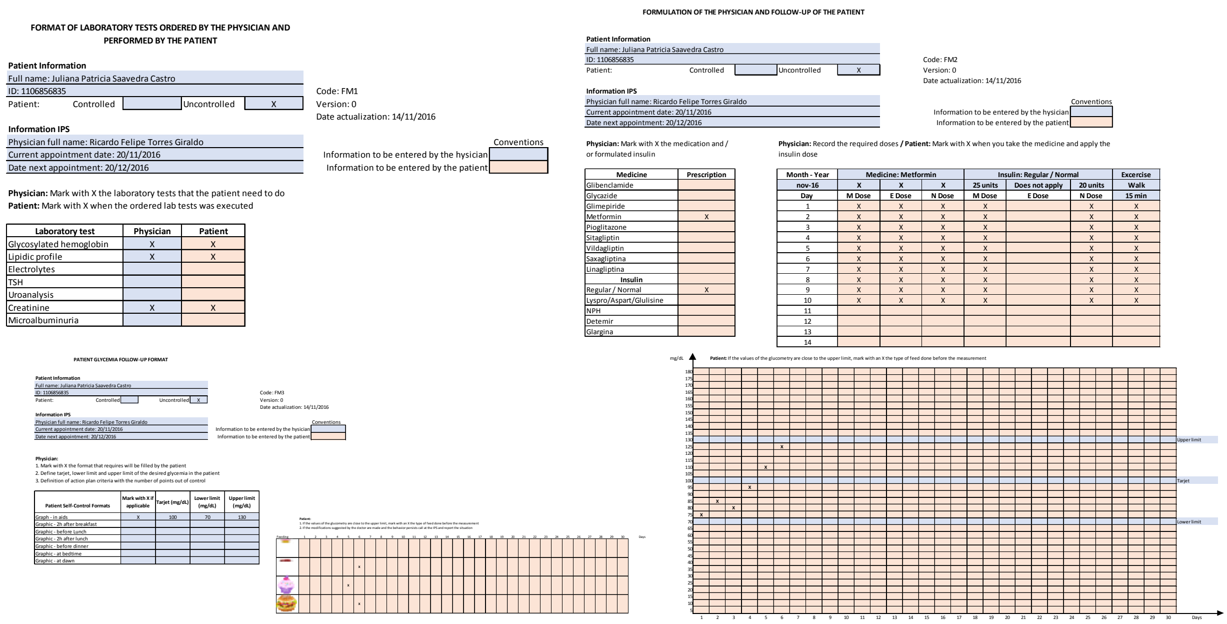


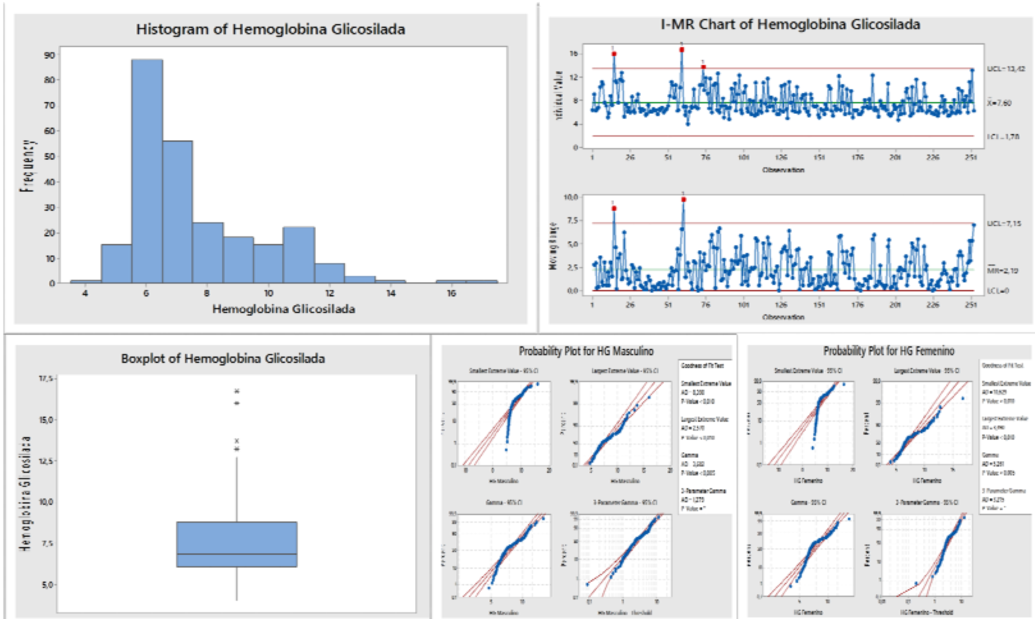
Figure 7. Checklists

Source: Own elaboration

Proposal 3. Control mechanisms improvement

The third improvement proposal is adressed to design a support system for clinical decision making, through a dashboard of patient indicators, from existing information. This tool is used to determine the number of patients without entry control as an external arrival rate in the Jackson red model (proposal number 1), where the most relevant indicator is the glycosylated hemoglobin, which the physician makes the decision of the frequency at which the next patient of the control (1 month or 3 months) should attend and the cell in which the patient is (controlled or uncontrolled). In this board the doctor includes the information that the patient gives in his control appointment. In this way the self-care that the patient performs and it can count on more information about the daily routine of the patient in order to make decisions CDSS, based on the data of patients exams and results of adherence to the program. It will also allow to define the incentives for both the patient and the physician, as well as the function of the results. In Figure 8, the proposed control board is presented.

Patient:	ID:	Age:	Gender :	dd/mm/yy



Patient follow-up		
Item to check	**Result**	**Status**
Trend of results		
Taking medicine		
Exercise		
Diet		
Support group		
Training assistance		
Concept period analyzed		
Recommendations and / or incentives		

Figure 8. Control panel for patient follow-up

Source: Own elaboration

CDSS facilitates the visualization of other important clinical outcomes of the patient that will allow the physician to make decisions regarding the treatment to be ordered and the need for external equipment support. The indicators table can also be consulted by any of the other actors of the system (extramural equipment) as support for decision making in the system.

The information displayed per patient corresponds to the variables contained in the high cost account ie. diagnoses, test results and the dates in which they were taken, the information can be visualized by means of semaphore as a validator of the patient's condition and the physician can make pharmacological treatment decisions, clinical examinations, date for the next control, assignment of the patient's cell, and need for referral to extramural team actors.

Conclusions

- It is corroborated that the factors defined in the OMS literature regarding the causes of non-adherence to chronic disease programs are support to patients, social factors, patient-related factors, adherence of doctor and family support.
- For the analyzed program the factors to intervene as a priority were the improvement in the resolution capacity of the doctor and the base team, the patient's involvement and the improvement of the control mechanisms that include the patient and generate information closer to the decision making.
- The Chronic Care Model (CCM) and Clinical Decision Support Systems (CDSS) are complementary and allow defining standardized processes, traceable, and with information for the analysis of results and improvement of the program.
- Industrial Engineering tools such as SIPOC, 6Ms, FMEA, QFD and Visual Management, which are part of methodologies such as Six Sigma and Lean, allowed us to contribute to the diagnosis of the processes related to the identification of failure modes associated with non-adherence Program and define improvements to the processes that are part of the Chronic Care Model (CCM) and the determination of controls and information to make Clinical Decision Support Systems (CDSS) more robust and reliable
- Jackson's network model can be used to plan future medical capacity for short-, medium- and long-term forecast demands. In addition, the model can be replicated for the measurement of the number of actors necessary for extramural equipment and for the design of training and retraining workshops for the evolution of the disease in patients.
- From Industrial Engineering, through the tools of analysis and improvement of processes used in this research, it is considered that influences on the process variable, proposed by Avedis Donabedian (1980) that finally influences the results in health.
- The enhancement proposals aim to guarantee greater control and audit in the health team of adherence to guidelines and clinical pathways, and contributes to the program adherence by the patient.
- The enhancement proposals should be holistically implemented in the diabetes program in such a way as to involve all the actors of the service and the patient, in order to guarantee results that can positively influence adherence to the program as presented in the Figure 2. Systemic cycle of adherence to disease treatment programs with the aim of improving health outcomes.

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