Colombian Journal of Anesthesiology

OPEN

Received: 12 June, 2023 ▸ Accepted: 26 February, 2024 ▸ Online first: 19 March, 2024

DOI: https://doi.org/10.5554/22562087.e1106

Reduction of catheter-associated bloodstream infections: Effectiveness of the continuous quality improvement method at a university hospital in Colombia

Reducción de las infecciones del torrente sanguíneo asociadas a catéter: efectividad del método de mejora continua de la calidad en un hospital universitario en Colombia

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Abstract

Introduction: Central Line-Associated Bloodstream Infections (CLABSI) are preventable and potential fatal events, frequent in critical patient care. By mid-2018 an increase was noted in the incidence rate of CLABSI at a high complexity institution in Colombia, demanding immediate interventions to lower those numbers.

Objective: To assess the effectiveness of the continuous quality improvement methodology (CQI) to lower the incidence rate of CLABSI at a university hospital in Bogotá, Colombia.

Methods: Longitudinal, prospective study implementing a multifaceted intervention in accordance with the CQI methodology. The project was developed at a high complexity university hospital in Bogotá, Colombia, between July 2018 and December 2019. A root cause analysis was consecutively conducted prioritizing contributing factors, gathering ideas for improvement, building a strategy and prioritizing the implementation plan.

Results: The CQI methodology enabled the identification of areas susceptible of catheter insertion and management errors at the institution; additionally, it allowed for the prioritization of the areas requiring intervention through consecutive test cycles for improvement ideas. The reduction and sustainability of insertion-related CLABSI was accomplished three months after the start of the interventions, achieving a zero value. The implementation of improvement ideas aimed at reducing the events associated with catheter maintenance was also able to reduce the incidence to zero, until the end of the period of observation of the study.

Conclusions: It is feasible to implement CQI in settings similar to the one herein described, in order to efficiently reduce CLABSIs.

Keywords: PDSA; Infection control; Patient safety; Quality improvement; Catheter-related infection.

What do we know about this problem?

Central Line Associated Bloodstream Infections (CLABSI) are preventable and potentially fatal events, usual in the context of critical care patients. By mid-2018 an increase was noted in the incidence rate of CLABSI at a high complexity institution in Colombia, demanding immediate interventions to lower those numbers.

What does this study contribute with?

This study showed the effectiveness of the CQI method in achieving a significant reduction in CLABSI in the institution, its sustainability and changes in the healthcare processes, which suggests changes in the patient safety culture among all the teams involved. These lessons learned and improvement cycles may be used by other institutions and applied in other contexts.
The results show that the continuous quality improvement cycle facilitated the identification of areas susceptible to errors in catheter insertion and maintenance in the institution. Moreover, it allowed for prioritizing the areas in need of intervention, and the team-building to design the interventions to be implemented in consecutive test cycles.

How to cite this article

Estrada-Orozco K, Cantor-Cruz F, Pérez Cely J, Rojas C, Aguilera M, González N, et al. Reduction of catheter-associated bloodstream infections: Effectiveness of the continuous quality improvement method at a university hospital in Colombia. Colombian Journal of Anesthesiology. 2024;52:e1106.

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Resumen

Introducción: Las infecciones del torrente sanguíneo asociadas a catéter (ITS/AC) son eventos prevenibles y potencialmente fatales, comunes en el contexto del cuidado de pacientes críticos. A mediados de 2018 se presentó un incremento en la tasa de incidencia de ITS/AC en una institución colombiana de alta complejidad, obligando a realizar intervenciones inmediatas para lograr una reducción de estas cifras.

Objetivo: Evaluar la efectividad del método de mejoramiento continuo de la calidad (MCC) para la reducción de la tasa de incidencia de ITS/AC en un hospital universitario en Bogotá, Colombia.

Métodos: Estudio longitudinal, prospectivo, en el que se implementa una intervención multifacética siguiendo la metodología de MCC. El proyecto se desarrolló en un hospital universitario de alta de complejidad de Bogotá, Colombia, entre julio de 2018 y diciembre de 2019. Se realizaron consecutivamente un análisis de causa raíz, priorización de factores contribuyentes, recuperación de ideas de mejora, construcción de la estrategia y priorización del plan de implementación.

Resultados: El método de MCC permitió la detección de zonas susceptibles de presentación de errores en la inserción de catéteres y su mantenimiento en la Institución, además permitió priorizar las áreas por intervenir mediante ciclos consecutivos de prueba para las ideas de mejora. Se logró la reducción y sostenibilidad de la ITS/AC asociada a inserción luego de tres meses de iniciar las intervenciones, logrando valores de cero. La implementación de ideas de mejora dirigidas a reducir los eventos relacionados con el mantenimiento de catéteres también logró reducirlos a cero hasta la terminación del periodo de observación de este estudio.

Conclusiones: Es factible implementar MCC en contextos como el aquí presentado para reducir de manera eficiente las ITS/AC.

Palabras clave: PDSA; Control de infecciones; Seguridad del paciente; Mejora de la calidad; Infección asociada a catéter.

INTRODUCTION

Central Line Associated Bloodstream Infections (CLABSI) are defined as a laboratory confirmed bloodstream infection, not associated with an infection at a different site, which develops within 48 hours following the insertion of a central line. These events are mostly preventable and potentially lethal, usually occurring in the critical patient setting. (1)

The incidence reported worldwide is variable, averaging 4.1 per 1,000 days-catheter, in accordance to the surveillance data of the International Nosocomial Infections Control Consortium (INICC) from January 2010 to December 2015 and a result of the analysis of 703 intensive care units in 50 countries. (2) In Colombia, the incidence reported has also changed over time; in 2018 a minimum was reached of 2.5 per 1,000 days-catheter which gradually increased up to 3.6 per 1,000 days-catheter in 2020, in accordance with the data from the National Surveillance System – SIVIGILA. (3)

It is estimated that CLABSI is one of the most expensive healthcare-associated infections for health services. In the United States it represented an increase in care costs of at least 23,751 dollars in 2011. (4,5) The care of this condition, with proper adherence to the infection control guidelines, could save between 5,520 and 20,239 lives per year. (4) In Colombia, this is the most frequent device-associated infection, with higher incidences than ventilator-associated pneumonia and catheter-related urinary tract infections. (3)

In July 2018 an increase in the incidence rate (IR) of CLABSI was reported at a high complexity institution in Colombia, amounting to 12.7 cases per 1,000 days-catheter and an average incidence rate for the first quarter of 2018 of 7.5 cases per 1,000 days-catheter, which exceeded the national average for the same period by about 5 cases per 1,000 days-catheter; this situation demanded immediate interventions to be able to reduce those numbers.

One of the proposed strategies was the use of a widely studied methodology known as Continuous Quality Improvement (CQI); a risk management intervention that promotes the sustained reduction in the incidence of infections in the institution. The continuous quality improvement methods have proven to be useful for the implementation of interventions in hospitals in developing countries. (6-9) For instance, a multinational collaborative project recently developed in Latin America, managed to reduce the incidence rate in 83 intensive care units by 22 % in average. (6)

Based on the available evidence on CQI as an effective intervention and the institutional need to significantly reduce the IR of CLABSI and ensuring the sustainability of such improvement over time, this project was suggested with a view to assess the effectiveness of the continuous quality improvement method to reduce the incidence rate of CLABSI at a university hospital in Bogotá, during 2018 and 2019.

METHODS

Design

This is a longitudinal, prospective, quality improvement study implementing a

multifaceted intervention following the continuous quality improvement methodology.

The project was developed at a high complexity university hospital in Bogotá, Colombia, from July 2018 to December 2019. At the time of the study, the serviced provided by the institution included Cath Lab, surgery, intensive care unit (ICU) and Step-Down Care Unit (SDCU), with a total of 324 beds throughout the institution and specifically 37 ICU beds.

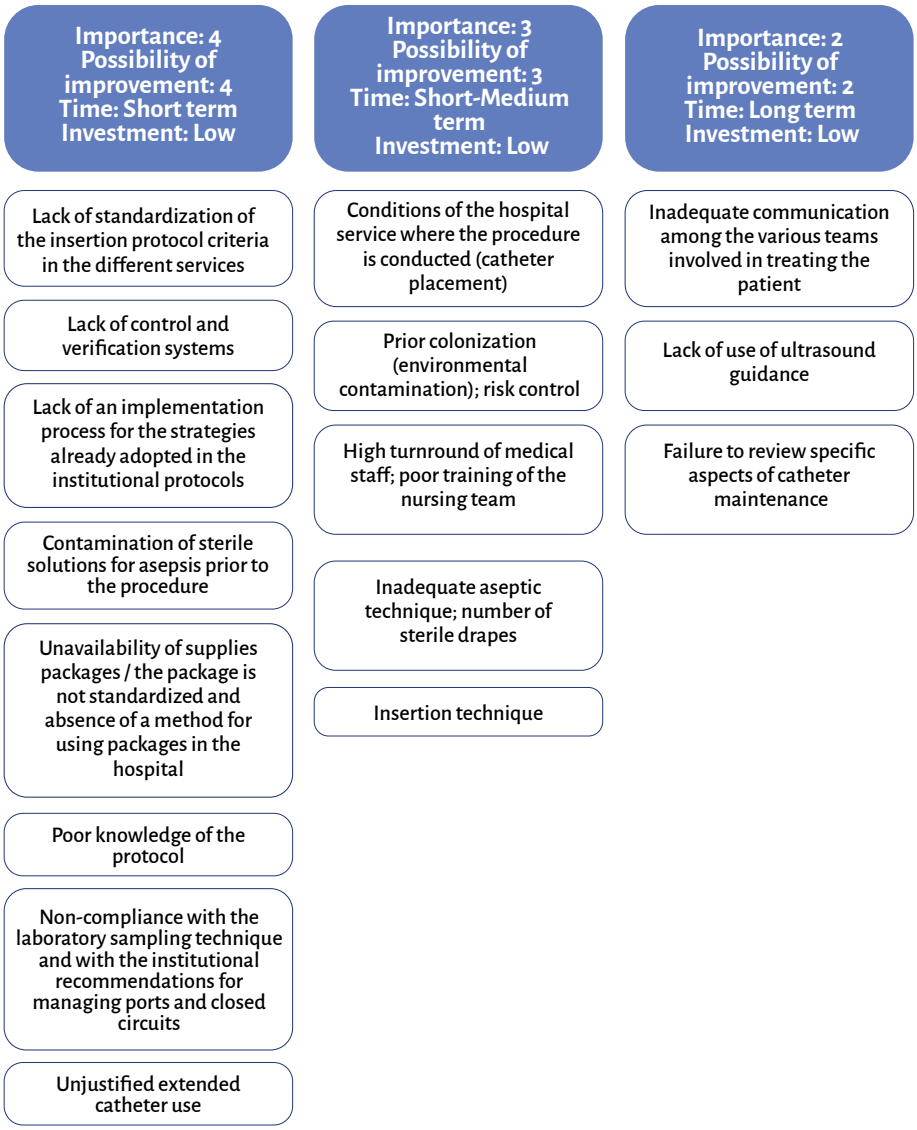
Intervention

CQI is a progressive incremental improvement of processes, safety and patient care. The objective of CQI may include improving operations, results, system processes, work environment or regulatory compliance. Process improvement may be "gradual" or "innovative"- The development of CQI projects usually includes the definition of the problem, a comparative assessment, goal setting, and then iterative quality improvement cycles. Through the iterative process, improvements are made, the effect of the improvements is measured and then the process is repeated until the desired result is achieved. (10,11)

To intervene the hospital, the improvement team was made up by ten people who were part of the hospital clinical team: the medical director of the intensive care unit, the ICU head nurse, a professional nurse member of the institutional infections committee, a professional nurse head of the Patient Safety Directorship, a medical director of the Quality Office, a bacteriologist and three epidemiologists from the Patient Safety Research Unit.

An analysis was conducted of the causes associated with the increase in the incidence rate of CLABSI using the root cause analysis methodology (Figure 1). Once the causes were identified, these were prioritized by the improvement team, in accordance with the following criteria: the importance of the cause as a contributor to the problem, the possibility of improvement, the expected time frame for achieving an improvement or correction of the cause, and finally the investment in human and financial resources required for the intervention. The details of this prioritization analysis are shown on Figure 1. The following causes were prioritized in this exercise: 1. Lack of standardization of the insertion protocol criteria in the various services; 2. Lack of control and verification systems; 3. Inadequate implementation of the existing strategies; 4. Contamination of sterile solutions; 5. Non-availability of inputs or standardized packages or implementation methods; 6. Poor knowledge of the insertion protocols by all the staff members responsible for the procedure; 7. Poor compliance with the laboratory sampling technique, ports management, closed circuit; and 8. Unnecessary long term use of catheters.

Figure 1. Prioritization of CLABSI causes. A score between 1 and 4 was used; the causes with higher scores were prioritized for intervention.



Source: Authors.

The causes prioritized were also classified into two groups, depending on the stage of care of the patient with a central catheter: stage 1: catheter insertion; stage 2: catheter care and maintenance.

Based on the above, the project was divided into two intervention phases, each with a direct goal which could contribute to achieving a reduction in the Incidence Rate of CLABSI.

The following goal was established by the improvement team for Phase 1: A reduction in the rate of bacteremia associated with catheter insertion in adult ICU patients to less than 50 % of the last year average in a period of 12 months (a reduction to 3.5 cases × 1,000 days – catheter).

The second goal was to reduce the incidence of events in the institution involving care and maintenance of catheters in services outside the ICU. Phase II goal of the project: to reduce the rate of catheter-related bacteremia due to catheter care and maintenance in hospitalized adults, to 0 % within a period of 12 months (reduce the incidence of catheter-related bacteremia to 0 cases × 1,000 days-catheter outside the ICU).

Once the goals were established, a flow diagram was developed indicating the primary and secondary aspects requiring intervention, and what had to be improved based on the hypothesis submitted by the improvement team. The details of the flow diagram are illustrated in Figures 2 and 3.

To assess the effectiveness of the CQI intervention, a time series analysis was conducted on the effects of improving the care systems based on quantitative indicators of processes and outcomes. These indicators were identified during the development of the program through continuous quality improvement methods. The outcome indicator was the rate of catheter-related bloodstream infections expressed in number of cases per 1,000 days – catheter.

Oversight of catheter-related bloodstream infections

The CLABSI concept by Shah et al. was adopted. Their definition is a bloodstream infection due to an intravascular catheter based on a quantitative culture of the catheter tip, or on growth differences between catheter blood culture specimens and peripheral venipuncture. (12)

Active and prospective oversight of the bloodstream infections was implemented by anesthesiologist and infectious disease specialists, residents and nursing staff, during bedside rounds three times per day.

Collection of indicators

The data from six process indicators designed for the program were collected based on active surveillance. These were the indicators:

1. Compliance with maximum barrier measures consistent with the protocol (1-[health personnel who required corrective measures with regards to the use of maximum barriers / total number of staff members present during the insertion]).

2. Hands hygiene compliance according to the protocol (1-[health personnel who required corrective measures with regards to hands hygiene / total number of staff members present during the insertion]).

3. Compliance with the skin cleansing technique according to the protocol (number of procedures involving skin cleansing according to the protocol / number of procedures completed).

4. Compliance with complete delivery of supplies from the pharmacy (complete packages from pharmacy / total number of pharmacy packages used).

5. Use of packages with fabric garments (number of complete garment packages dispensed by the pharmacy / total number of procedures).

6. Use of supplies from the pharmacy packages without requesting additional supplies (number of procedures for which additional supplies were requested / number of procedures).

With regards to the indicators reflecting the percentage compliance with hands hygiene and the use maximum barriers, a member of the institutional infections and patient safety team assessed through direct verification the number of practitioners (professors, residents, students and nursing staff) who complied with these activities in accordance with the protocol. Individuals who failed to comply with the protocol were corrected on the spot by the unit personnel present, using the institutional protocol as a guide.

Analysis

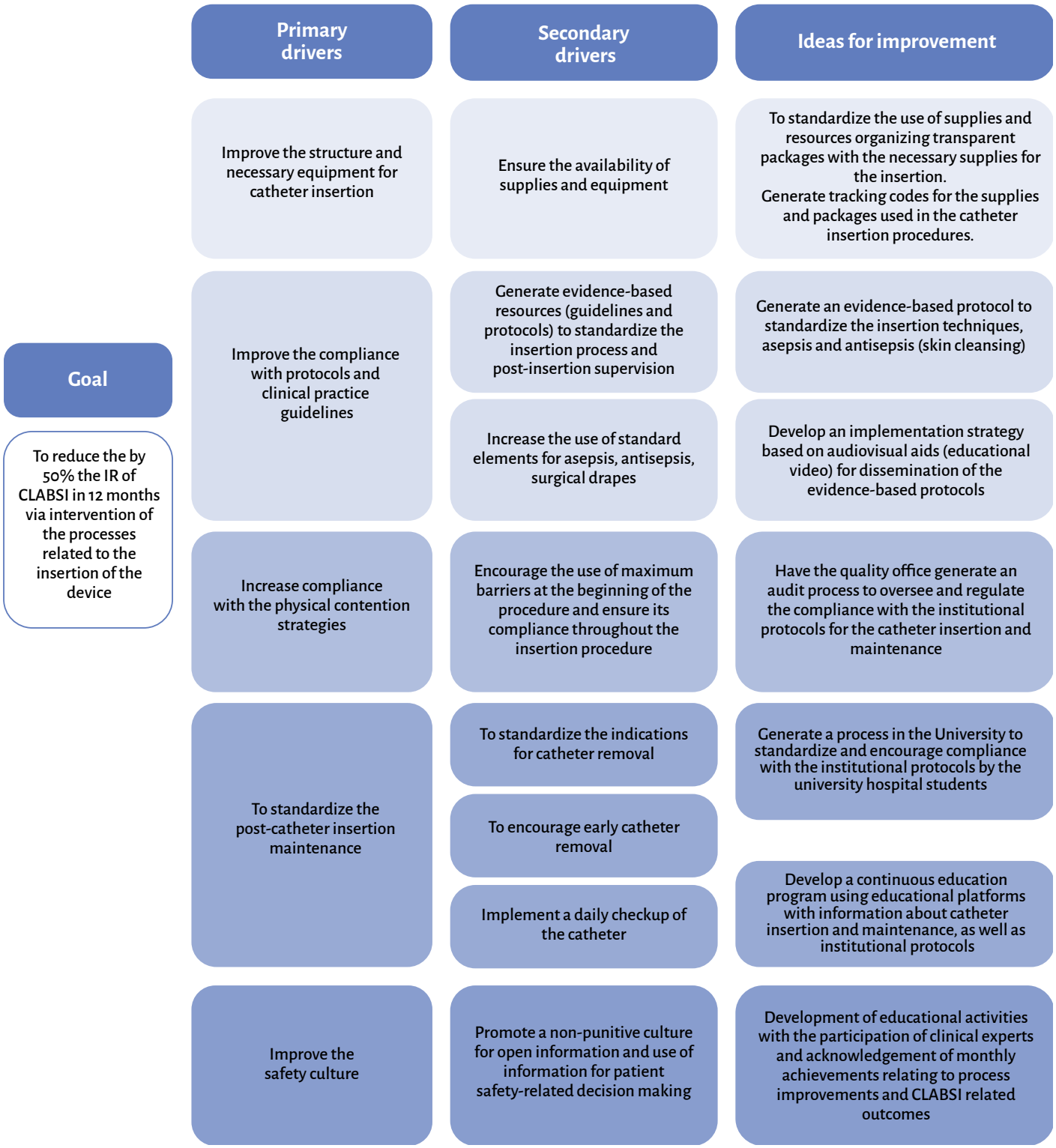
Trends and control charts were developed to monitor the behavior of indicators over time, estimating the rate of compliance for each goal. Descriptive statistics were used based on relative or mean frequencies to report the results, in accordance with the type of variable. Control charts were developed for each goal of the project, in accordance with the time of implementation of the improvement ideas: 1. ideas aimed at reducing CLABSIs during the insertion process (up to 72 hours after inserting the catheter); and b. ideas aimed at reducing maintenance associated CLABSIs (72 hours post-catheter insertion).

QI macros and Stata 14 were used for the statistical analysis.

Ethical considerations

This project was approved by the Ethics Committee of the School of Medicine of Universidad Nacional de Colombia, minutes 013-229-18.

Figure 2. Flow diagram to guide the CQI strategy during Phase I of the project.



Source: Authors.

Figure 3. Flow diagram to guide the CQI strategy during Phase II of the Project.

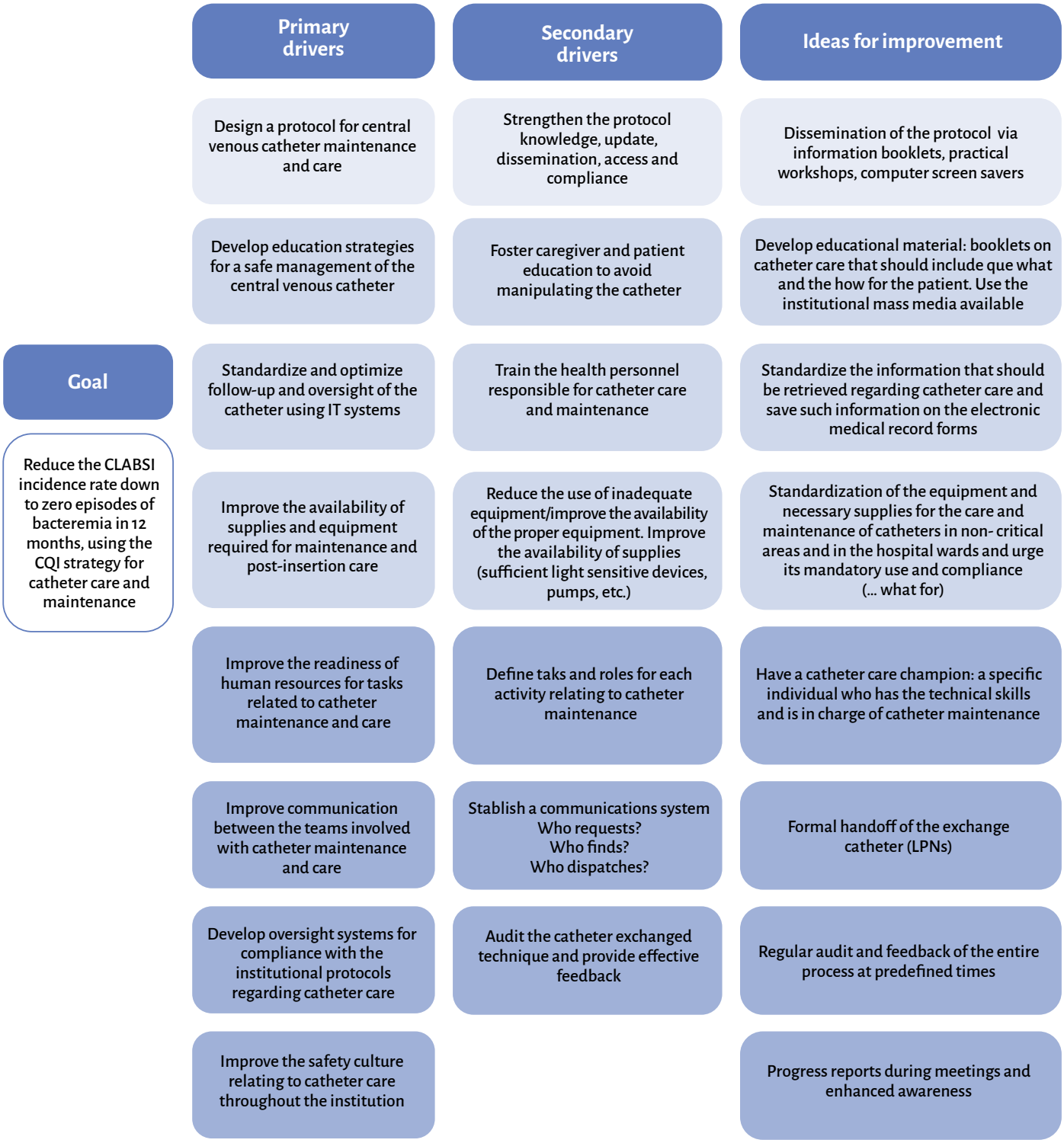


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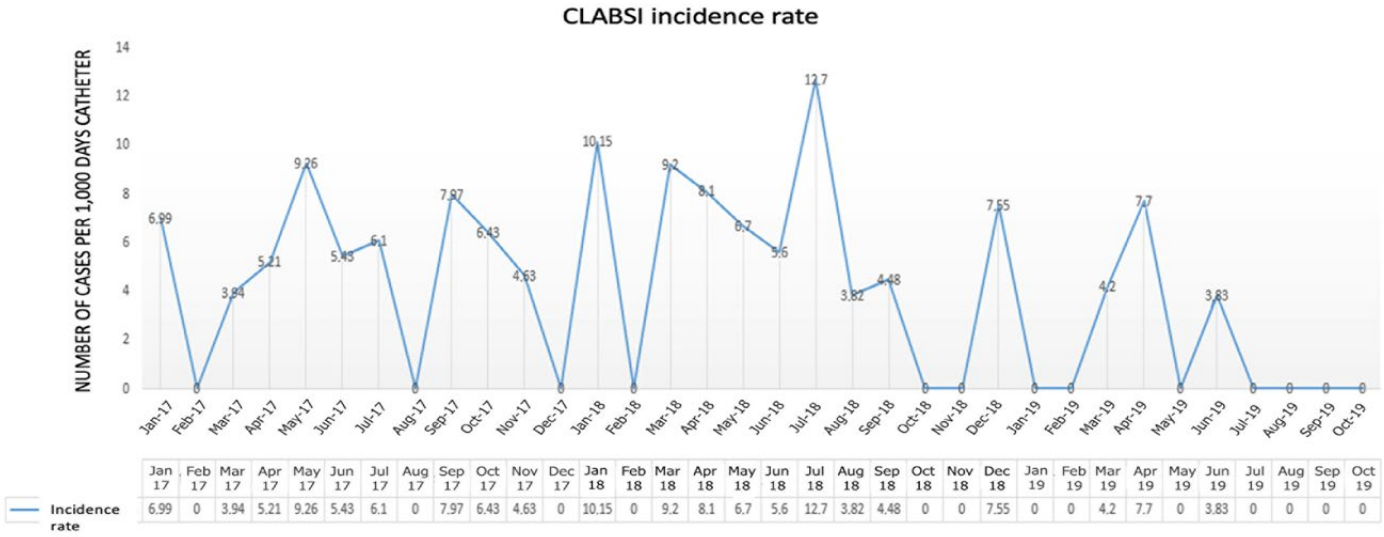
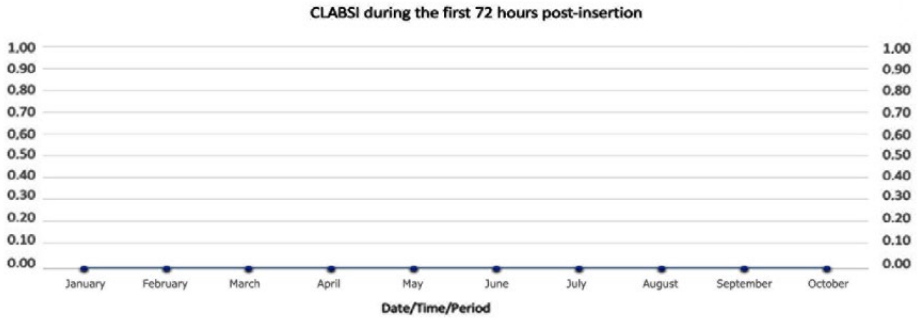
Figure 4. Behavior of pre-implementation CLABSI and changes during the implementation of the CQI strategies.



	Jan 17	Feb 17	Mar 17	Apr 17	May 17	Jun 17	Jul 17	Aug 17	Sep 17	Oct 17	Nov 17	Dec 17	Jan 18	Feb 18	Mar 18	Apr 18	May 18	Jun 18	Jul 18	Aug 18	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19	Jun 19	Jul 19	Aug 19	Sep 19	Oct 19
Incidence rate	6.99	0	3.94	5.21	9.26	5.43	6.1	0	7.97	6.43	4.63	0	10.15	0	9.2	8.1	6.7	5.6	12.7	3.82	4.48	0	0	7.55	0	0	4.2	7.7	0	3.83	0	0	0	0

Source: Authors.

Figure 5. CLABSI incidence rate over the first 72 hours post-insertion, from January through October, 2019.



Source: Authors.

RESULTS

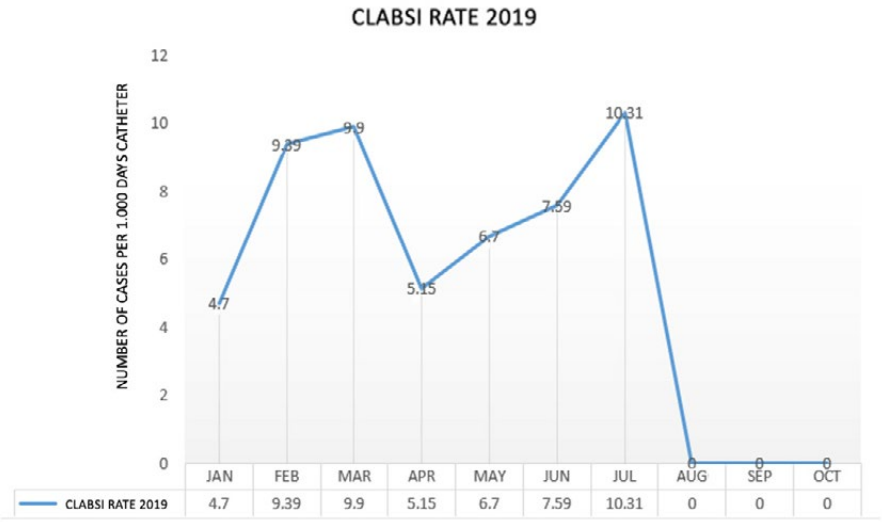
After completing the root cause analysis and prioritizing the areas and processes requiring intervention at each phase of the project, a number of ideas for improvement were submitted and approved. The improvement team, together with several members of the clinical teams, held a number of discussions that led to the proposal and prioritization of ideas for improvement. Then, using prioritization matrixes considering the impact criteria and the time required for implementation and results, the improvement ideas were prioritized and a schedule for the interventions was set. Phase I of the project began on September 2018, and nine months later – June 2019 – Phase 2 was initiated. Figure 6S of the Complementary material summarizes by way of an example, three aspects and processes subject to intervention with the ideas approved in each cycle during Phase I of the improvement project.

The process indicators and outcomes suggested were measured on a weekly basis.

During the intervention phase in 2018, an immediate reduction down to zero was observed in the incidence rate for October and November of that same year. However, there was an increase in December – 7,7 cases per 1,000 days – catheter - (Figure 4). Considering that the interventions being implemented in the institution were for the period consistent with Phase 1 of the project, intended to improving catheter insertion and hence reducing de development of bacteremia during the first 72 hours, the team conducted a stratified analysis of the incidence of CLABSI cases that became symptomatic after 72 hours. The analysis which began in January 2019, showed that the incidence rate of CLABSI in the institution over the first few hours was zero, from January through October 2019, when the measurements were discontinued (Figure 5).

On the other hand, the cases that developed after 72 hours whose cause – based on time criteria - could be attributed to catheter maintenance was variable, with values ranging from 4.7 to 10.31 cases per 1,000 days-catheter, between January and July, 2019. These values decreased down to zero, after one month of initiating Phase 2 of the project which focused on improving the processes relating to catheter maintenance in the institution, and extended to hospitalization areas and other areas delivering care to patients users of this device. The trend observed in this analysis, considering that the cases developed 72 hours after the catheter insertion, also showed a decreasing trend

Figure 6. Incidence rate of CLABSI events developed over the 72 hours post-insertion, from January to October, 2019.



Source: Authors.

with constant zero values for the months of August, September and October, when the measurements were discontinued (Figure 6).

Significant improvements were also visible in terms of process changes, with regards to compliance of the hands hygiene protocol, skin preparation, use of garment packages and catheter insertion supplies prepared by the pharmacy, and uses of the personal protection equipment throughout the insertion procedure by the team members. Sustained improvements were achieved in all the indicators, exceeding the thresholds established as process goals by the project improvement team; this is indicative of a change in the patient safety culture of the healthcare team. The behavioral details of these indicators according to the control charts, are illustrated in Figures 1S to 5S of the supplements.

The qualitative analysis of the factors accounting for the variability of the processes, and hence of the results of the measurements of the process indicators, showed that employee turnover with new residents or new staff joining the clinical teams, as well as end-of-the-year season, which is consistent with changes in work hours, were all factors associated with the decline of some indicators. Consequently, catheter insertion and maintenance protocols dissemination and training were implemented as mandatory activities at the institution, in addition to academic activities for students specializing in the ICU.

DISCUSSION

Healthcare associated infections represent a major challenge for most health institutions, not only because of the implications with regards to compliance with quality standards, but also because of the potentially catastrophic consequences for patients and high utilization of health system resources.

In this study, the implementation of measures aimed at standardizing the insertion, asepsis and antisepsis processes, and the use of maximum barriers – all evidence-based measures which responded to the needs identified in the root-cause analysis – led to a rapid and sustained decline in the incidence of CLABSI in the institution. Maintaining these measures required auditing, strict feedback, and dissemination of all the measures among the clinical and administrative staff of the institution.

The segmentation of the catheter insertion process and maintenance helped to accomplish the goal with the resources available in the institution, while educating the clinical team members and the leadership of the institution, on the improvement methodology. This finding may be helpful for the implementation of measures addressed to complex systems and processes in settings introducing the CQI method to manage clinical risk. Efficiency improves based on the prioritization of actions and compromised process areas whose intervention results in a rapid impact on clinical outcomes.

Beyond showing a reduction in clinical outcomes, which is consistent with similar projects in other geographies (13-16), this study is intended to show practical details that facilitate the implementation of strategies designed for a swift and efficient achievement of the goals, particularly with regards to strengthening the patient safety culture, focusing mainly on events associated with intravascular devices and others routinely used as a patient monitoring strategy.

The immediate impact after introducing the interventions may be partly due to the effectiveness of such recognized and evidence-based interventions, but also due to the Hawthorne effect; However, their sustainability over time is an indication of the cultural change in the standardized practices of processes such as catheter insertion and maintenance.

Some of the limitations of this study include: first, there were no longer term measurements available to establish the definitive reduction in the maintenance-related CLABSI incidence rate, in addition to the sustainability of the improvement achieved towards this goal. Second, failure to establish indicators to quantify the changes in the culture of safety over time. These aspects support ongoing and future research projects.

CQI is a feasible risk management system to be implemented in the search of solutions to complex situations affecting patient safety at high complexity healthcare institutions in the Colombian setting. It is important to consider future studies addressed to estimate the impact in terms of use of resources and institutional cost savings, in order to establish the cost-effectiveness of these measures.

CONCLUSION

This paper showed the effectiveness of the CQI method to achieve a significant reduction in CLABSI at the institutional level, its sustainability and resulting healthcare process changes, suggesting changes in the patient safety culture of the participating teams. These lessons and improvement cycles may be used at other institutions and applied to the context of other various devices.

The results show that the continuous quality improvement method enabled the identification of areas susceptible to errors in the insertion of catheters and their maintenance at the institution. Additionally, CQI allowed prioritizing the areas to be intervened and building work teams that defined interventions to be implemented in consecutive test cycles. Finally, the process indicators were developed and the outcomes identified to measure the impact of the interventions. The goals initially set for the incidence rate of CLABSI were accomplished in several process indicators.

ETHICAL DISCLOSURES

Ethics committee approval

This project was approved by the Ethics Committee of the School of Medicine of Universidad Nacional de Colombia, minutes 013-229-18.

Protection of human and animal subjects

The authors declare that no experiments were performed on humans or animals for this study. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics commit-tee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data

The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy

The authors declare that no patient data appear in this article.

ACKNOWLEDGEMENTS

Authors' contributions

All the authors contributed to the design of the original project, study planning, data collection, interpretation of results, data analysis, and writing of the manuscript.

Assistance for the study

None declared by the authors.

Financial support and sponsorship

This project was funded by the Universidad Nacional de Colombia through an internal call for proposals as part of project 40454 "Assessing the effectiveness and safety of a clinical risk management system for the prevention of adverse events at the Hospital Universitario Nacional".

Conflicts of interest

Kelly Estrada-Orozco is a Faculty and Improvement advisor at the Institute for Healthcare Improvement (IHI). The other authors have no conflicts of interest to disclose.

Presentations

None declared by the authors.

Appreciation

None declared by the authors.

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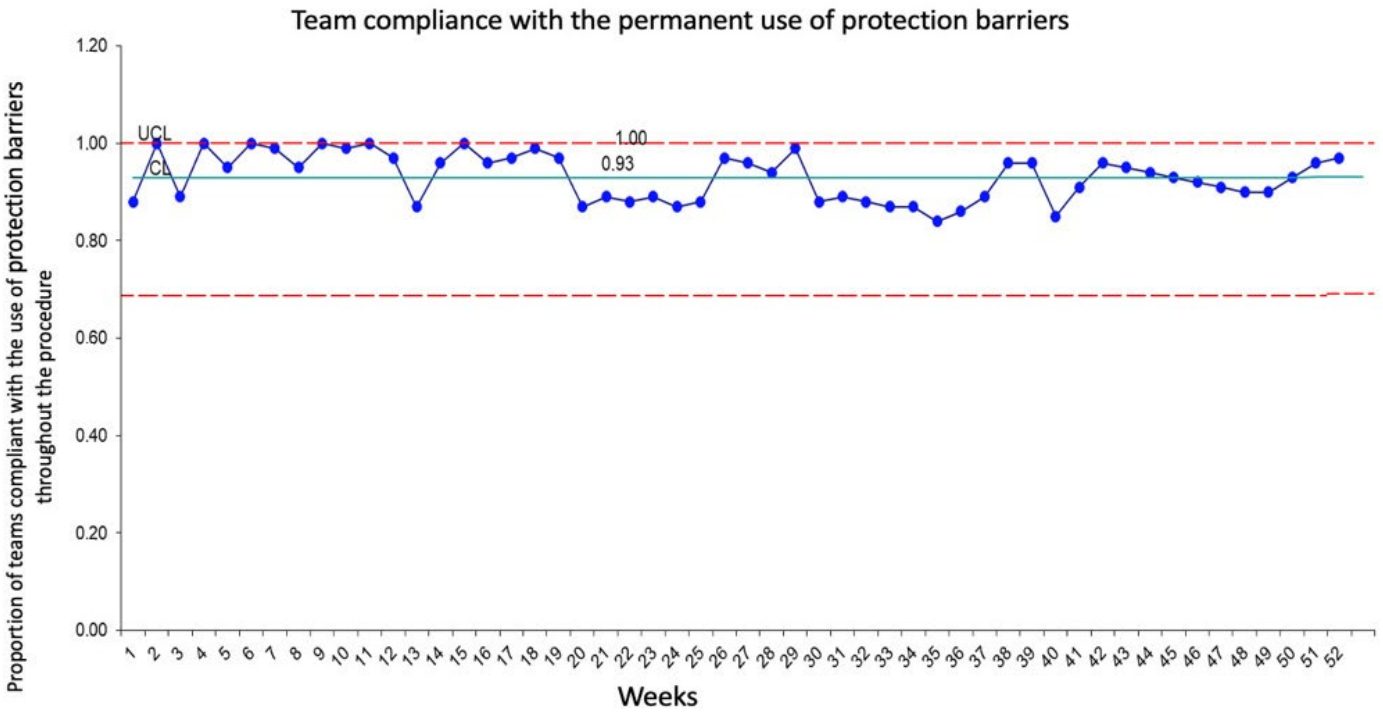
COMPLEMENTARY MATERIAL

Figure 1S. Process indicator control graph: Maximum barrier measurements. Proportion of teams in charge of insertion who complied with the use of all the protection barriers.

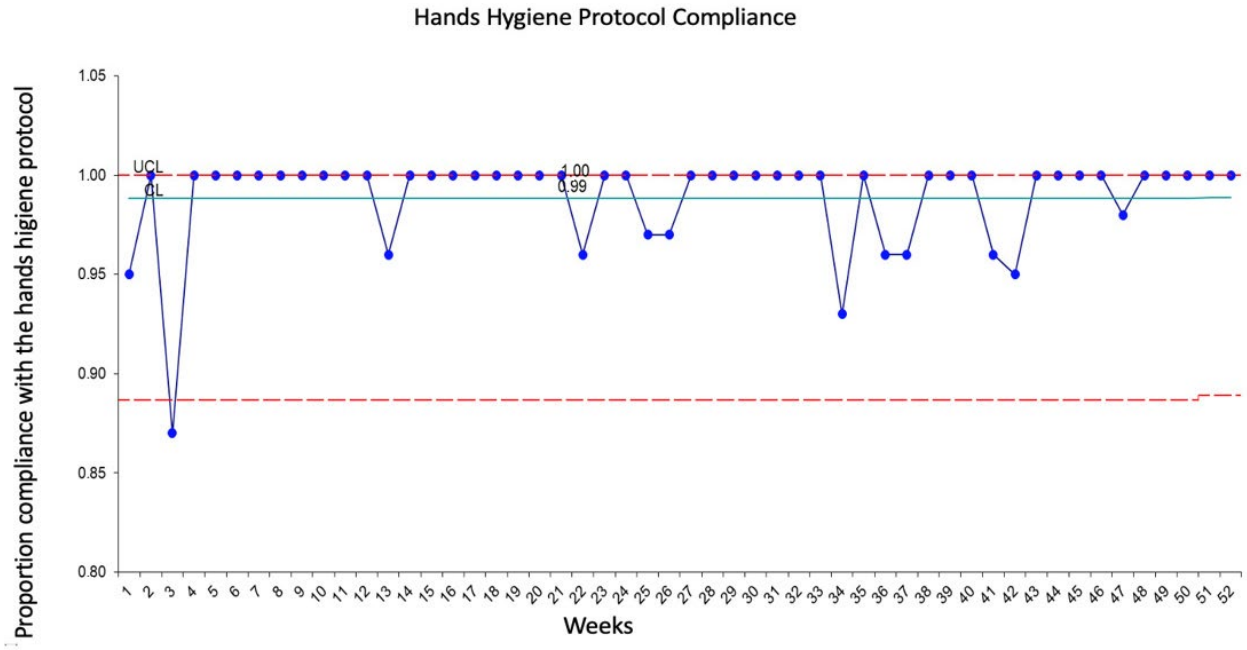
Source: Authors.

Figure 2S. Process Indicator Control graph: Compliance with maximum barriers throughout the procedure .



Source: Authors.

Figure 3S. Process Indicator Control Graph: Hands Hygiene protocol compliance.

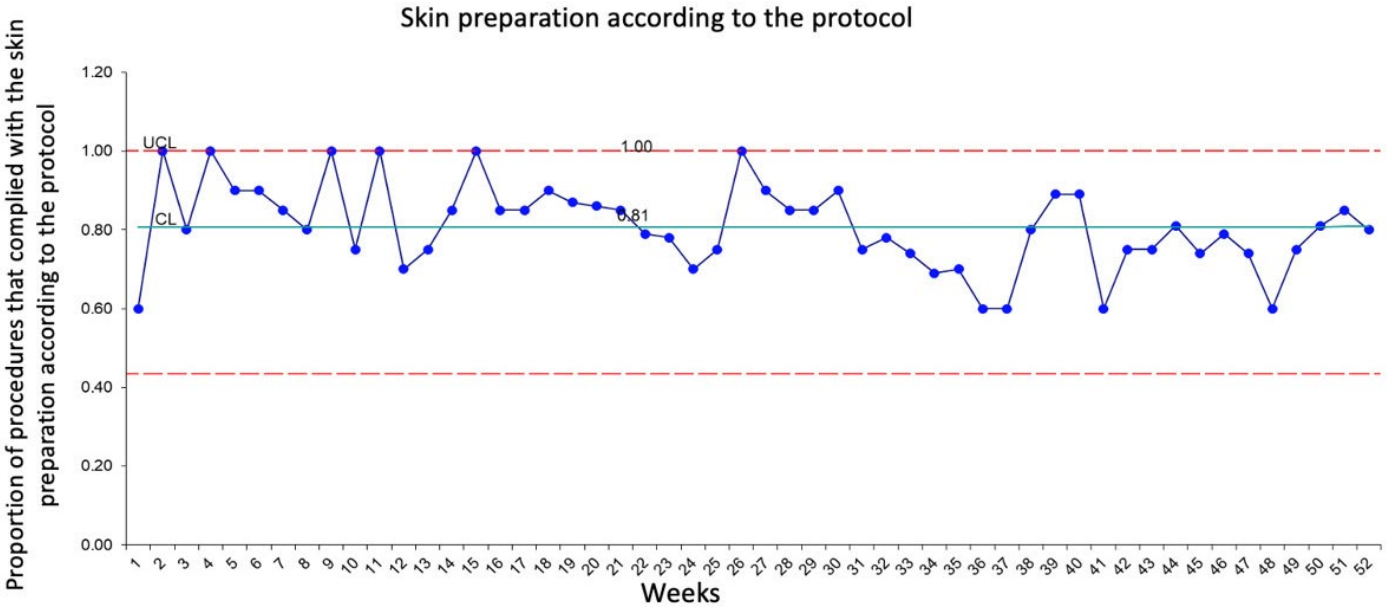


Source: Authors.

Figure 4S. Process indicator control graph: Use of pharmacy package supplies.

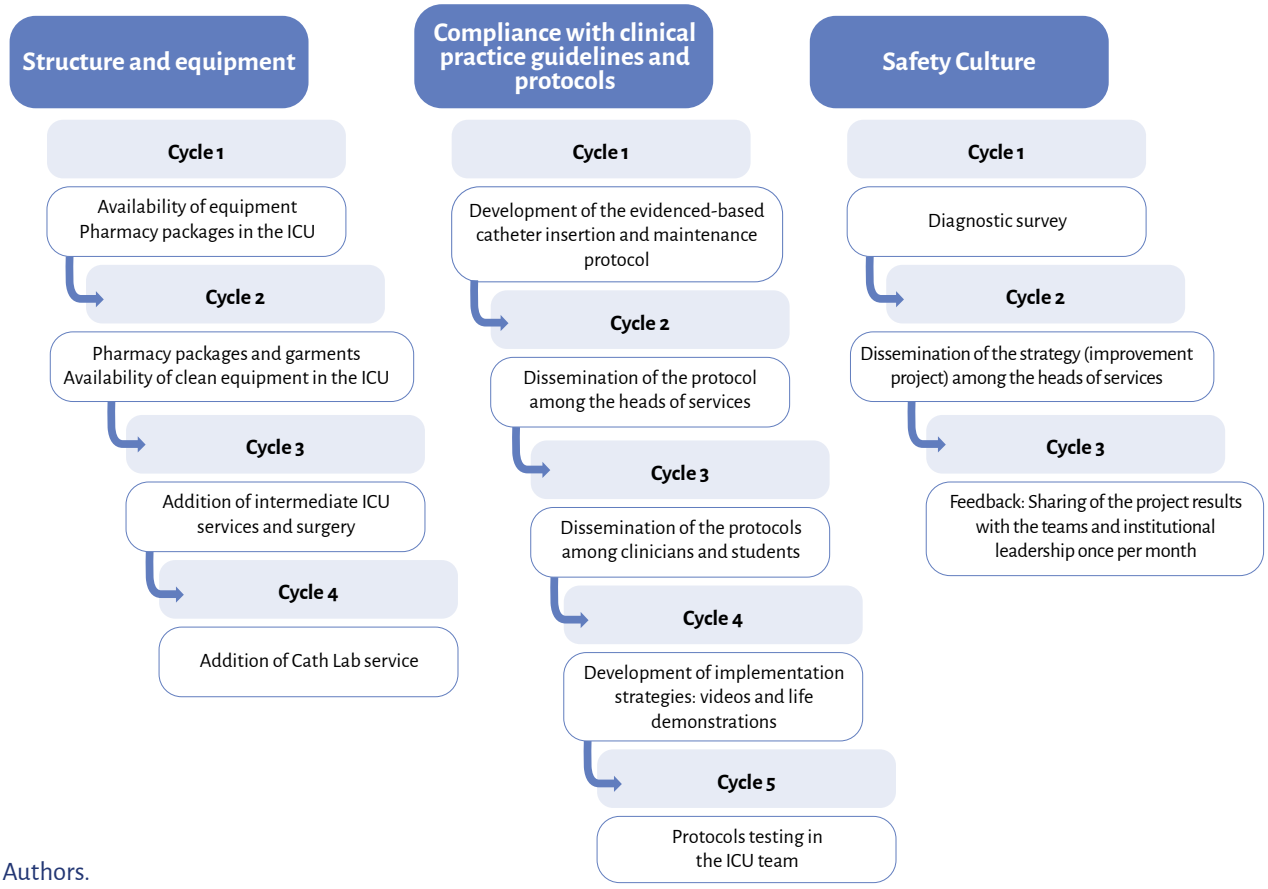
Source: Authors.

Figure 5S. Process indicator graph: Compliance with the skin cleansing technique according to the protocol.



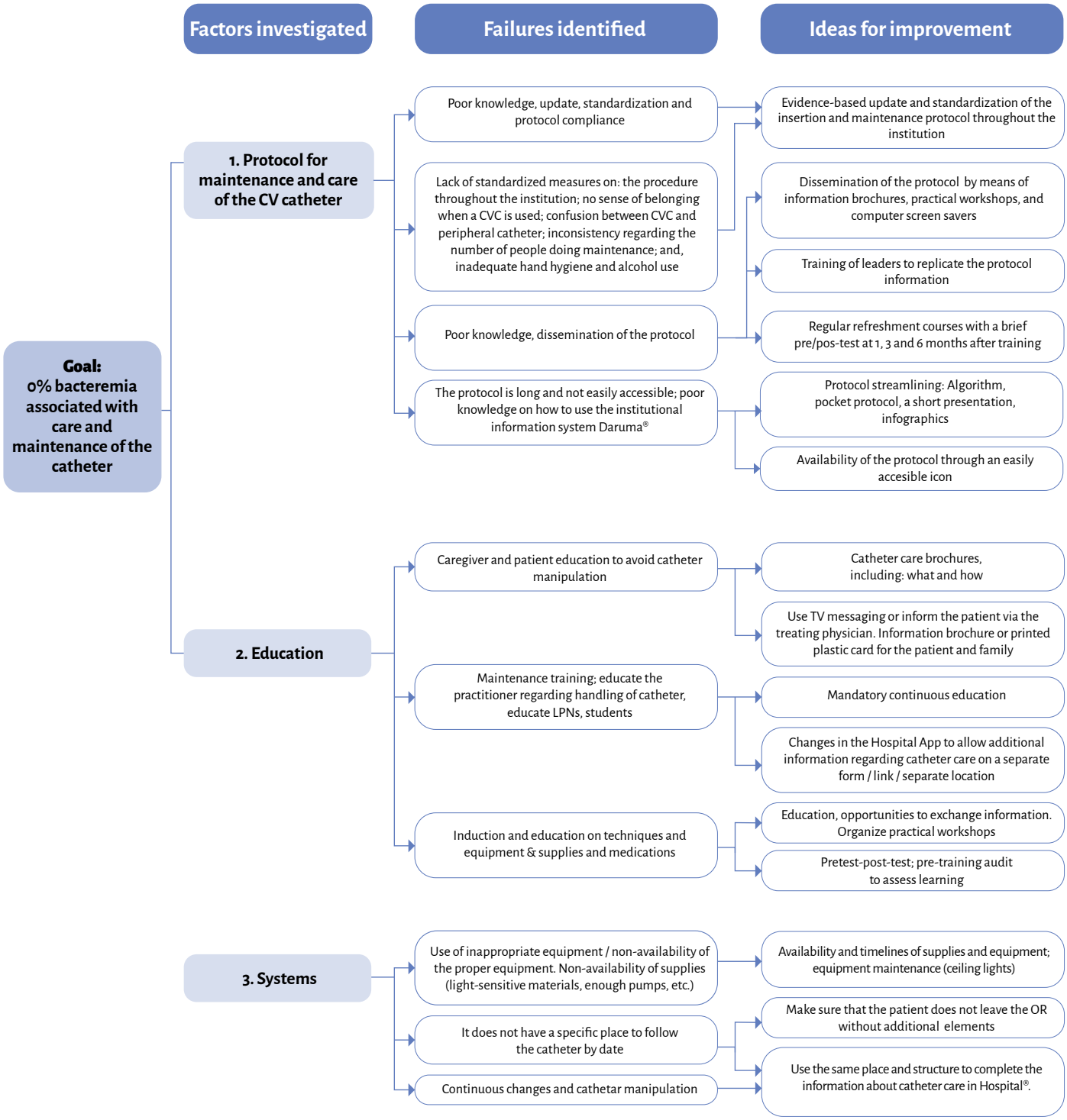
Source: Authors.

Figure 6S. Improvement cycles implemented within the project framework.



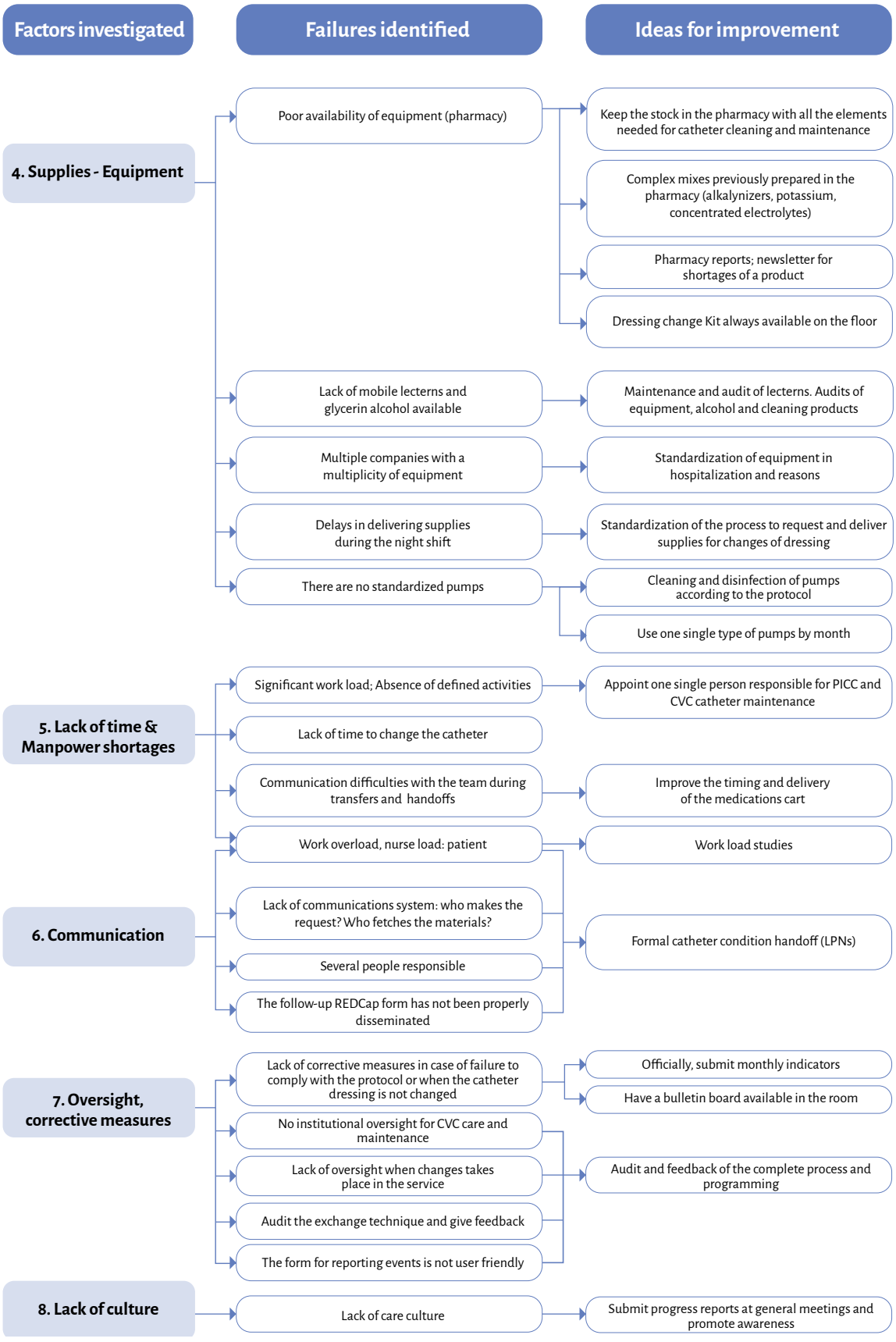
Source: Authors.

Figure 7S. Root cause analysis diagram and improvement ideas retrieved from the project.



Source: Authors.

Figure 7S. Root cause analysis diagram and improvement ideas retrieved from the project.



Source: Authors.