REVISTA CIÊNCIAS EM SAÚDE
HEALTH SCIENCES JOURNAL e-ISSN 2236-3785

ORIGINAL ARTICLE

Incidence of infections associated with the use of invasive devices in an ICU after application of the Improvement Science Methodology

Vilto Michels Junior[1,2], Jiliélisson Oliveira de Sousa[1,*], Gabriel Oscar Cremona Parma[1], Fabiana Schuelter-Trevisol[1,3], Daisson José Trevisol[1,3]

[1]*Graduate Program in Health Sciences, University of Southern Santa Catarina at Tubarão, Tubarão, Santa Catarina, Brazil*
[2]*Intensive Care Unit, Nossa Senhora da Conceição Hospital, Tubarão, Santa Catarina, Brazil*
[3]*Clinical Research Center, Nossa Senhora da Conceição Hospital, Tubarão, Brazil*

Received 29 Jun 2023, accepted 28 Aug 2023, published 19 Sep 2023.

KEYWORDS
Intensive care
Catheter-related infections
Quality assurance
Quality of Health Care
Prevention

ABSTRACT

Objective: To reduce the incidence density of ventilator-associated pneumonia (VAP), central line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI) in the intensive care unit (ICU) using the Improvement Science method.
Methods: This was a single-center retrospective cohort study. A collaborative quality improvement team developed and implemented local changes to HAI-related processes and protocols. Pre-intervention, intervention, and post-intervention periods were compared. The study was conducted at the Adult ICU of a hospital in southern Brazil. Variables were analyzed using interrupted time series analysis with segmented linear regression, simple correlation, and hypothesis testing.
Results: There was a reduction in the incidence density of all infections. VAP was reduced from 27.2% to 7.2% ($p < 0.001$), CLABSI from 3.0% to 0.9% ($p = 0.017$), and CAUTI from 8.3% to 1.8% ($p < 0.001$). The ICU stay was also reduced from 6.7 to 6 days ($p = 0.018$).
Conclusion: There was an improvement in all the evaluated parameters. Ongoing monitoring of related indicators and adherence to implemented measures are essential to sustain improvements. Applying the Improvement Science methodology can reduce the incidence of HAIs in the ICU.

*Corresponding author:
Programa de Pós-graduação em Ciências da Saúde, Universidade do Sul de Santa Catarina.
Addr.: Av. José Acácio Moreira, 787 – Dehon. Tubarão, SC, Brazil | CEP: 88.704-900
Phone: +55 (48) 3621 3334
E-mail: jilielisson@gmail.com (Sousa JO)

The study was conducted at the University of Southern Santa Catarina.

https://doi.org/10.21876/rcshci.v13i3.1444

How to cite this article: Michels Junior V, Souza JO, Parma GOC, Schuelter-Trevisol F, Trevisol DJ Incidence of infections associated with the use of invasive devices in an ICU after application of the Improvement Science Methodology. Rev Cienc Saude. 2023;13(3):66-73. https://doi.org/10.21876/rcshci.v13i3.1444

INTRODUCTION

Healthcare-associated infections (HAIs) are the most common adverse events in healthcare settings worldwide[1,2]. In the United States, approximately 4% of all hospital admissions and 9% to 20% of all intensive care unit (ICU) admissions are complicated by HAIs[3,4]. Approximately half of all in-hospital HAIs develop in the ICU[3]. In developing countries, the incidence of HAIs in the ICU seems to be at least three times higher than that in the USA[2]. These infections are associated with increased morbidity, length of hospital stay, and hospital costs[5,6].

The application of evidence-based recommendations can significantly reduce the incidence of these complications[3-5]. However, uniform application of these measures often necessitates system-wide organizational changes[7-9]. Adapting to the local context significantly influences the success of an intervention[10,11]. Isolated interventions are not expected to lead to consistent improvements. Effective interventions must be systemic and multifaceted[12,13]. The development of an intervention must be a gradual process that continuously evolves to adapt to the local context and allow for the removal of unforeseen obstacles and unintended effects[10,13-15].

The Science of Improvement methodology[16], which uses the Improvement Model with PDSA cycles (Plan-Do-Study-Act), is used to promote and accelerate the improvement of healthcare[15-17]. This model is adopted by the Institute of Healthcare Improvement (IHI)[17], which also encourages and guides the organization of quality improvement collaboratives wherein several teams located in different health institutions or groups within the same institution work together to achieve an improvement[9,15,18].

This study was part of the Salus Vitae project, a Quality Improvement Collaborative comprising 14 ICUs across four Brazilian states. The objective of this project was to reduce the incidence density of ventilator-associated pneumonia (VAP), central line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI) in ICUs using the Improvement Science method.

METHODS

Quality Improvement Collaborative - "Salus Vitae"

From July 2015 to December 2016 (18 months), a hospital ICU team participated in a quality improvement collaboration called Salus Vitae. The Salus Vitae project was organized and sponsored by the *Associação Congregação de Santa Catarina* (ACSC) in partnership with the IHI of the United States. A group of 14 ICUs in 12 hospitals managed by the ACSC across four Brazilian states participated in the project. Two physicians and two nurses from each ICU were selected. The teams were trained on the Science of Improvement, health-related infections, and their prevention methods via virtual meetings conducted every month and face-to-face meetings conducted every six months.

The objective of the project was to jointly develop improvement strategies (Table 1) using the Improvement Model with PDSA cycles to reduce the incidence density of VAP, CLABSI, and CAUTI. Measures to prevent these infections were already implemented in these hospitals, and the mandatory reporting of these indicators was already carried out by the Hospital Infection Control Commission, which forwarded these data to the *Agência Nacional de Vigilância Sanitária* (ANVISA) every month. The teams analyzed the processes related to infections and implemented improvement measures, changes, and strategies so that all stages of these processes were carried out more effectively and efficiently according to the local characteristics of each ICU. During the multidisciplinary visit, a checklist was introduced for the removal of invasive devices.

Population, location, duration, and sampling

The study was conducted at the Adult ICU of a hospital in southern Brazil, which is a regional referral center for cardiology, cardiac surgery, neurosurgery, orthopedics, oncological surgery, and trauma[19]. It is a 30-bedded general ICU for patients aged over 14 years and the only reference in Intensive Care Medicine of the Public Health System (SUS) in an 18 cities sub-region located in the south of Santa Catarina, which comprised a population of 363,565 inhabitants in 2017, according to the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística - IBGE*)[20]. The 18-month intervention period lasted from July 2015 to December 2016. All patients admitted to the ICU from 48 months before the start of the intervention (i.e., July 2011) to 24 months after the completion of the intervention (i.e., December 2018) were included in this study.

Table 1 — Strategies used in the Improvement Model.

Reduce complications associated with the use of mechanical ventilation (MV):
1. Consider non-invasive ventilation;
2. VAP bundle;
3. Venous thromboembolism (VTE) prophylaxis;
4. Sedation protocol, weaning, lung injury/acute respiratory distress syndrome, oral hygiene/aspiration precautions, enteral nutrition, mobility, stress ulcer;
5. Be careful with the ventilation circuit.
Reduce complications associated with the use of a central venous catheter (CVC):
1. CVC insertion bundle;
2. CVC maintenance bundle;
3. Standardization: kits/insertion carts/dressing;
4. Align with other sectors to standardize insertion;
5. Replace urgently inserted CVCs.
Reduce complications associated with indwelling bladder catheterization (IBC):
1. Avoid unnecessary use;
2. Develop criteria for insertion;
3. Ensure availability of alternatives to IBC;
4. IBC maintenance based on pre-established criteria in the literature.
5. Review IBC needs daily;
6. Perform intimate hygiene whenever appropriate;
7. Reminders, alerts, and locks in the prescription that pay attention to revising the need for the catheter.

This study was approved by the Research Ethics Committees of the University of Southern Santa Catarina (Registration no. 3,615,875 from 2 Oct 2019). Following the rules of Resolution 466/2012 of the National Council of Health, the anonymity of participants and the authorization/knowledge of the institution under study were respected. A waiver of written informed consent was requested because of the retrospective nature of the study.

Data collection

The diagnostic criteria, calculation of the incidence density of infections, and rates of use of invasive devices were established by the ANVISA[21]. These data were collected from the medical records of the Hospital Infection Control Committee team, which are mandatorily sent to ANVISA. Data for the evaluation of monthly averages, length of ICU stay, and ICU mortality were obtained using a digital report generated in the Tasy® (Phillps) electronic medical record system. No individual medical records of patients were used in this study.

The formulas for calculating the study variables were as follows:

- Density of the incidence of infection = (nº infections/nº patients with a day device during the period) * 1000
- Use rate = (nº patients with invasive device/nº patients during the period) * 100
- Average permanence = (nº day-patients in the period/ nº hospital discharges during the period) * 100
- Average mortality = (nº deaths in the period/ nº hospital discharges during the period) * 100

Study design and data analysis

This was a clinical, epidemiological study based on a retrospective cohort, with data collection from a secondary database, to evaluate the incidence density of VAP, CLABSI, and CAUTI before, during, and after implementing the changes based on the Improvement Science methodology.

IBM SPSS® v.21 software was used to analyze interrupted time series with segmented linear regression to analyze the effect of the intervention on the trend of variables and simple correlations and to assess the distribution of variables using the Shapiro-Wilk normality test. Continuous variables were reported as mean/standard deviation and median/interquartile range, and pre- and post-intervention values were tested using Student's t-test. P-values < 0.05 were considered indicative of statistical significance.

RESULTS

The results were divided into three periods: (1) pre-intervention, (2) intervention, and (3) post-intervention. The incidence density of CLABSI showed a non-normal distribution in all three periods. The incidence density of CAUTI showed a non-normal distribution only in the post-intervention period. All other variables had a normal distribution.

The time series analysis (Figures 1, 2, and 3) showed no cyclical or seasonal variations, allowing segmented linear regression to assess the trend of the variables in the different study periods.

The incidence densities of all infections showed a reduction at the end of the study. The incidence densities of VAP and CAUTI (Tables 2 and 3) showed a sustained decrease throughout the study. The regression showed a downward trend during and after the intervention. VAP decreased by 70.7% ($p < 0.001$) and CAUTI by 78.3% ($p < 0.001$) compared with the pre-intervention period. The incidence density of CLABSI showed the most significant reduction during the intervention but rose again after this period. Nevertheless, the final reduction was 70% ($p < 0.017$) compared with that in the pre-intervention period. The regression showed a slight downward trend during the intervention and an increase in the post-intervention period.

The time series of the invasive device utilization rates (Figures 1, 2, and 3) showed a similar pattern. They showed an initial drop at the beginning of the intervention period and a subsequent increase, with a final upward trend. After the intervention, the upward trend was maintained.

Table 2 — Densities of incidence of infections and rates of use of invasive devices, mortality, and length of stay in the ICU in the Pre-intervention, intervention, and post-intervention periods.

Periods	Pre-intervention	Intervention	Post-intervention
d-VAP‡	27.2 ± 9.6*	25.6 ± 8.8*	7.9 ± 4.5*
d-CLABSI§	3.0 (3.7)†	0.0 (0.0)†	0.9 (2.1)†
d-CAUTI//	8.3 ± 4.9*	6.0 ± 3.5*	1.8 (2.0)†
r-MV¶	68.3 ± 4.9*	61.9 ± 6.7*	65.2 ± 6.7*
r-CVC#	66.6 ± 6.6*	57.4 ± 5.2*	59.9 ± 5.0*
r-UC**	78.4 ± 6.3*	55.3 ± 7.0*	62.3 ± 5.1*
r-LOS††	6.7 ± 0.9*	5.6 ± 0.4*	6.0 ± 0.6*
r-Mortality‡‡	20.0 ± 4.7*	20.5 ± 3.9*	23.8 ± 3.9*

*Mean and standard deviation; †Median and interquartile range; ‡d-VAP - Incidence density of ventilator-associated pneumonia; §d-CLABSI – Central line-associated bloodstream infection incidence density; //d-CAUTI – Density of incidence of catheter-associated urinary tract infection; ¶r-MV - Rate of use of mechanical ventilation; #r-CVC – Rate of use of the central venous catheter; **r-UC – Rate of use of the urinary catheter; †† r-LOS – Length of stay in the ICU; ‡‡ r-Mortality – Mortality rate

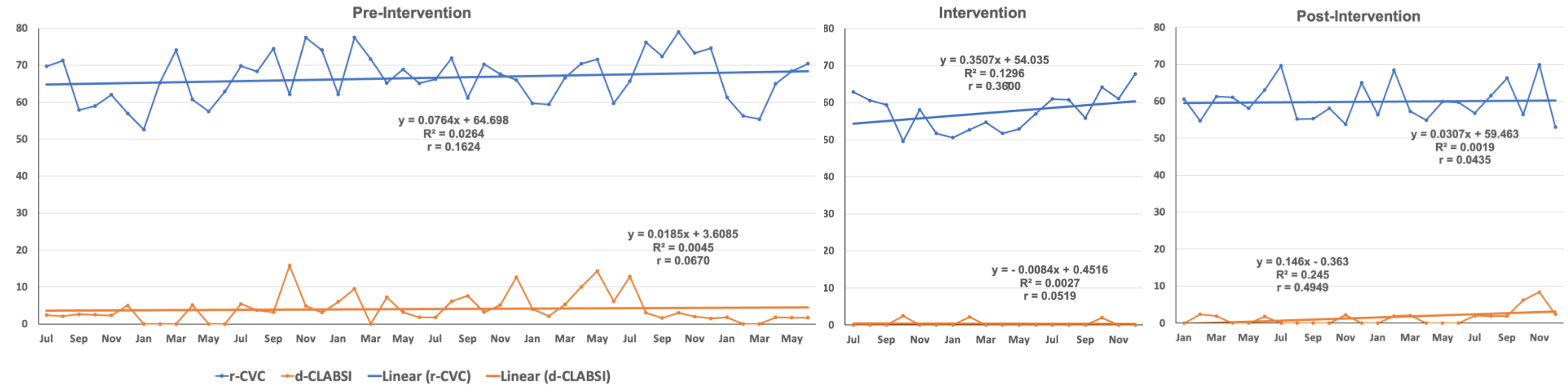

Figure 1 — Time series of incidence density of central line-associated bloodstream infection (d-CLABSI) and the rate of use of central venous catheter (r-CVC).

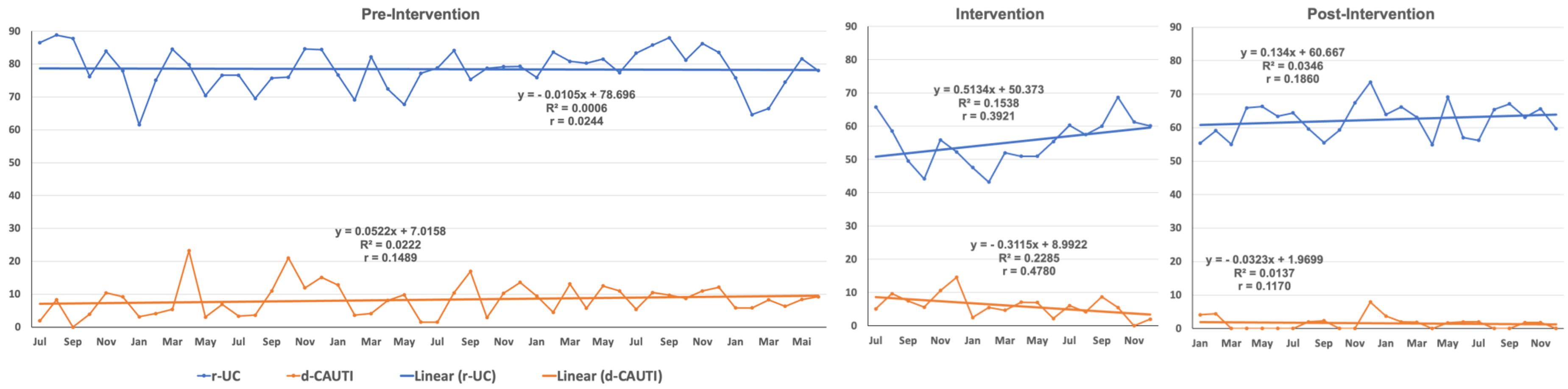

Figure 2 — Time series incidence density of catheter-associated urinary tract infections (d-CAUTI) and urinary catheter use (r-UC) rate.

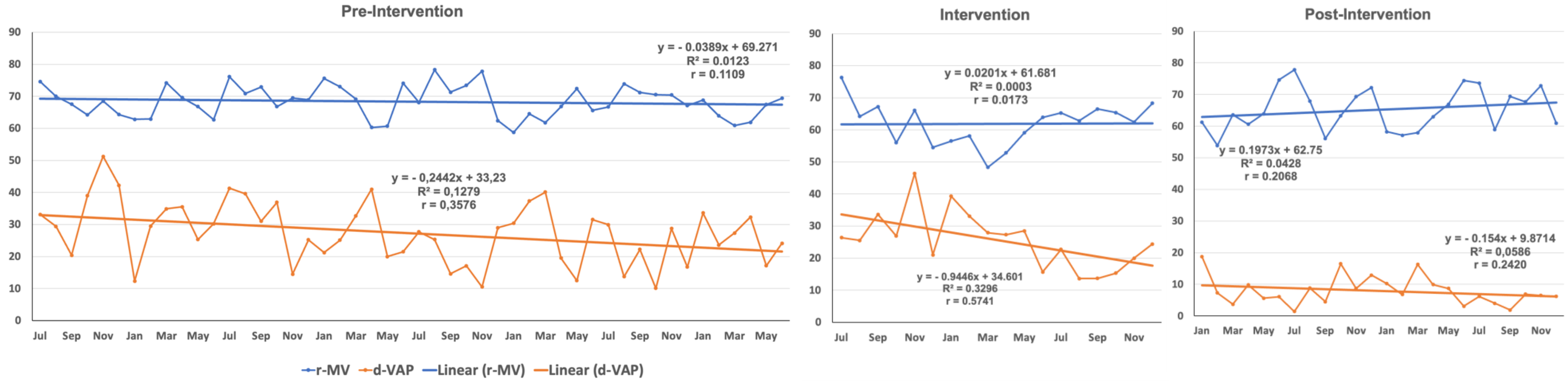

Figure 3 — Time series of incidence density of ventilator-associated pneumonia (d-PAV) and rate of use of mechanical ventilation (r MV).

Table 3 — Differences between incidence densities and rates of invasive device use, mortality rates, and length of stay in the following time intervals: (1) Pre-intervention versus intervention period; (2) Intervention versus post-intervention period; and (3) Pre-intervention versus post-intervention period. The arrows represent the change over the specified period of the column.

Difference	(1) Pre/Int*	(2) Int/Post*	(3) PrePost*
d-VAP†	↓1.6 (0.070)	↓17.7 (< 0.001)	↓19.3 (< 0.001)
d-CLABSI‡	↓3 (0.003)	↑-0.9 (0.395)	↓2.1 (0.017)
d-CAUTI§	↓2.3 (0.249)	↓4.2 (< 0.001)	↓6.5 (< 0.001)
r-MV¶	↓6.4 (< 0.001)	↑-3.3 (0.280)	↓3.1 (0.120)
r-CVC#	↓9.2 (<0.001)	↑-2.5 (0.221)	↓6.7 (0.002)
r-UC**	↓23.1 (< 0.001)	↑-7 (0.007)	↓16.1 (< 0.001)
r-LOS††	↓1.1 (< 0.001)	↑-0.4 (0.057)	↓0.7 (0.018)
r-Mortality‡‡	↑0.5 (0.041)	↑-3.3 (0.012)	↑-3.8 (0.194)

*Difference in percentages and p-value; †d-VAP - Incidence density of ventilator-associated pneumonia; ‡d-CLABSI - Central line-associated bloodstream infection incidence density; §d-CAUTI - Density of incidence of catheter-associated urinary tract infection; ¶r-MV - Rate of use of mechanical ventilation; #r-CVC - Rate of use of the central venous catheter; **r-UC - Rate of use of the urinary catheter; ††r-LOS - Length of stay in the ICU; ‡‡r-Mortality - Mortality rate

At the end of the study period, the utilization rates of all invasive devices and the incidence densities of all infections were reduced (Tables 1 and 2). However, the reduction in the rate of use of mechanical ventilation (4.6%) ($p = 0.120$) was not statistically significant. Urinary and central venous catheter use rates were reduced by 10.1% ($p = 0.002$) and 20.6% ($p = 0.001$), respectively. The regression showed an increased trend during and after the intervention.

The ICU length of stay initially reduced from 6.7 days to 6.0 days in the final period, representing a 10.4% decrease ($p = 0.018$). There was a weak correlation between ICU length of stay and infection incidence densities ($r = 0.08$ for VAP and $r = 0.18$ for CLABSI). Analyzed together, the reduction of the three infections had $r = 0.12$. The regression showed a slight upward trend in all three periods.

The mortality rate increased in all periods. The difference between the mortality rate in the initial period (20.0%) and the end (23.8%) was not statistically significant ($p < 0.194$). There was a weak correlation ($r = 0.09$) between infection incidence density and mortality rate. The regression showed a slight upward trend during (regression coefficient = 0.2991) and after (regression coefficient = 0.2046) the intervention.

No correlation was found between the use rate of mechanical ventilation and VAP ($r = −0.05$). Correlations between the rate of central venous catheter use and CLABSI ($r = 0.34$) and the rate of urinary catheter use and ICU ($r = 0.38$) were weak.

DISCUSSION

In this study, the initial densities of infection incidence and the rates of use of invasive devices were high compared with those in other studies[4,22]. The incidence densities of all infections and the utilization rates of all invasive devices in the post-intervention period were lower than those in the pre-intervention period. Similar results have been reported in reviews of the effectiveness of improvement measures in the Quality Improvement Collaborative[23-25].

In addition to reducing ICU and VAP incidence densities, the regression showed a downward trend post-intervention, a result considered ideal. The incidence density of the CLABSI time series indicated a significant reduction in infection before intervention initiation. This was likely attributable to the implementation of a chlorhexidine bath for the patient in the ICU nine months before the initiation of the intervention. Even so, there was a reduction in the intervention period, but in the post-intervention period, the incidence density of CLABSI increased again, and the regression showed an increase.

The rates of invasive device use and incidence density of CLABSI declined during the intervention period, followed by an increase in the post-intervention period. The regression trend of these variables also increased. The various study interventions were progressively implemented during the 18-month intervention period but were concentrated in the initial period. Control of adherence to intervention measures was performed only during implementation, and adherence likely decreased over time. This result shows the importance of maintaining the improvement effort, with periodic reinforcement of the importance of measures and the need to ensure adherence to the implemented changes.

The study showed no decrease in the rate of MV use. Among the invasive devices, MV is the most difficult to remove. It depends on the severity of the patient, and the decision-making process is more complex and involves more professionals.

There was a significant reduction in the ICU length of stay, but it was not possible to demonstrate the benefit related to mortality. There was an increase in the mortality rate, but this was not statistically significant. Some variables could not be considered in the study, such as demographic variables and severity scores, which may have potentially influenced the results.

No correlation was observed between the rate of use of MV and VAP. The baseline rate of VAP in this study (19.9 per 1,000 MV-days) was higher than the VAP rate reported by the National Healthcare Safety Network of the Centers for Disease Control and Prevention (0.8 per 1,000 MV-day in 2013)[26]. However, the rate in this study was lower than that reported by Rosenthal et al. in Argentina, i.e., 46.3 and 51.28 VAPs per 1,000 MV-day[27].

The correlation between central venous catheter use, CLABSI, urinary catheter use, and UTI was weak. This shows that the study's multifaceted interventions were critical in reducing infection incidence densities. The early withdrawal of these devices, which reduced their utilization rate, may decrease infection incidence densities.

The widespread implementation of CLABSI prevention packages has significantly reduced the overall prevalence of CLABSI in some countries[28]. A meta-analysis of 79 studies evaluating the impact of CLABSI prevention packages in adult, pediatric, and neonatal ICUs demonstrated a 60% reduction in CLABSI rates (i.e., from 6.4 [interquartile range (IQR), 3.8 – 10.9] to 2.5 [IQR, 1.4 – 4.8] CLABSI per 1,000 catheter days and incidence rate [IRR], 0.44; 95% CI, 0.39 - 0.50; $p < 0.0001$; $I^2 = 89\%$)[29].

A study evaluating the impact of a suite of interventions, including staff education, a daily electronic checklist, and an indwelling urinary catheter removal protocol, found no CAUTIs reported during the intervention period, reducing the rate to 1.33 per 1,000 catheter days[30].

Some limitations of this study should be acknowledged. This was a single-center, retrospective, nonrandomized study with no control group. Therefore, the results should be interpreted with caution. However, several factors support a strong correlation between the intervention measures and the results. There was at least a transient reduction in the incidence density of all infections and utilization rates during the intervention period. The upward trend in the post-intervention period also suggests that the control of adherence to changes made during the intervention was effective. We did not quantify the degree of adherence to the different improvement measures. In addition, the relative importance of individual interventions in this multifaceted intervention was not assessed. Finally, patient demographic data and other variables that could influence the results were not collected.

The study showed a significant reduction in the incidence densities of VAP infection, CLABSI, and UTI in the ICU. It also showed a reduction in the length of ICU stay. Although not directly demonstrated in the study, this results in decreased ICU cost, morbidity, and mortality. Using the Improvement Science methodology, better patient care and a safer ICU were obtained using the same human resources and equipment.

CONCLUSION

Applying the Improvement Science methodology can reduce the incidence of HAI in the ICU. This study showed that implementing multifaceted interventions developed using this methodology can lower the incidence of VAP, CAUTI, and CLABSI. It also reduced the rates of use of related invasive devices and length of stay in the ICU.

Similar improvement projects should be encouraged to help achieve the highest quality of care and patient safety, further decreasing morbidity, mortality, and costs.

ACKNOWLEDGMENTS

We would like to thank As*sociação Congregação de Santa Catarina* for carrying out the Salus Vitae Project and *Hospital Nossa Senhora da Conceição* for the opportunity to participate.

REFERENCES

1. Allegranzi B, Bagheri Nejad S, Combescure C, Attar H, Donaldson L, Pittet D. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. Lancet. 2011;377: 228-41. https://doi.org/10.1016/S0140-6736(10)61458-4
2. Burke JP. Infection control - a problem for patient safety. N Engl J Med. 2003;348(7):651-6. https://doi.org/10.1056/NEJMhpr020557
3. Magill SS, Edwards JR, Bamberg W, Beldavs ZG, Dumyati G, Kainer MA, et al. Multistate point-prevalence survey of health care-associated infections [published correction appears in N Engl J Med. 2022 16 Jun;386(24):2348. N Engl J Med. 2014;370(13):1198-208. https://doi.org/10.1056/NEJMoa1306801
4. Strich JR, Palmore TN. Preventing Transmission of Multidrug-Resistant Pathogens in the Intensive Care Unit. Infect Dis Clin North Am. 2017;31(3):535-50; https://doi.org/10.1016/j.idc.2017.05.010
5. Vincent JL, Rello J, Marshall J, Silva E, Anzueto A, Martin CD, et al. International study of the prevalence and outcomes of infection in intensive care units. JAMA. 2009;302(21):2323-29. https://doi.org/10.1001/jama.2009.1754
6. Ylipalosaari P, Ala-Kokko TI, Laurila J, Ohtonen P, Syrjälä H. Intensive care acquired infection is an independent risk factor for hospital mortality: a prospective cohort study. Crit Care. 2006;10(2):R66. https://doi.org/10.1186/cc4902
7. Garland A. Improving the ICU: part 1. Chest. 2005;127(6):2151-64; https://doi.org/10.1378/chest.127.6.2151
8. Garland A. Improving the ICU: part 2. Chest. 2005; 127(6):2165-79; https://doi.org/10.1378/chest.127.6.2165
9. Mauger B, Marbella A, Pines E, Chopra R, Black ER, Aronson N. Implementing quality improvement strategies to reduce healthcare-associated infections: A systematic review. Am J Infect Control. 2014;42(10 Suppl):S274-83; https://doi.org/10.1016/j.ajic.2014.05.031
10. Pronovost PJ, Berenholtz SM, Needham DM. Translating evidence into practice: a model for large scale knowledge translation. BMJ. 2008;337:a1714; https://doi.org/10.1136/bmj.a1714
11. Kaplan HC, Brady PW, Dritz MC, Hooper DK, Linam WM, Froehle CM, et al. The influence of context on quality improvement success in health care: a systematic review of the literature. Milbank Q. 2010;88(4):500-59. https://doi.org/10.1111/j.1468-0009.2010.00611.x
12. Oxman AD, Thomson MA, Davis DA, Haynes RB. No magic bullets: a systematic review of 102 trials of interventions to improve professional practice. CMAJ. 1995;153(10):1423-31.
13. Plsek PE, Wilson T. Complexity, leadership, and management in healthcare organisations. BMJ. 2001;323(7315):746-9. https://doi.org/10.1136/bmj.323.7315.746
14. Kaplan HC, Brady PW, Dritz MC, Hooper DK, Linam WM, Froehle CM, et al. The influence of context on quality improvement success in health care: a systematic review of the literature. Milbank Q. 2010;88(4):500-59. https://doi.org/10.1111/j.1468-0009.2010.00611.x
15. Courtlandt CD, Noonan L, Feld LG. Model for improvement - Part 1: A framework for health care quality. Pediatr Clin North Am. 2009;56(4):757-78. https://doi.org/10.1016/j.pcl.2009.06.002
16. Langley GJ, Moen RD, Nolan KM, Nolan TW, Norman CL, Provost LP. The improvement guide: a practical approach to enhancing organizational performance. 2nd ed. San Francisco: Wiley; 2009.
17. IHI Innovation White Paper. The breakthrough series: IHI's collaborative model for achieving breakthrough improvement. Boston: Institute for Health Improvement; 2003. Available at: https://bit.ly/3sSrFKs
18. Randolph G, Esporas M, Provost L, Massie S, Bundy DG. Model for improvement - Part Two: Measurement and feedback for quality improvement efforts. Pediatr Clin North Am. 2009;56(4):779-98. https://doi.org/10.1016/j.pcl.2009.05.012
19. Hospital Nossa Senhora da Conceição. Tubarão. Accessed 09 Mar, 2022. Available at: https://bit.ly/3PCRarS
20. IBGE. Panorama da cidade de Tubarão-SC. Accessed 12 Sep 2023. Available at: https://bit.ly/45LvHmz
21. Agência Nacional de Vigilância Sanitária. Critérios Diagnósticos de Infecção Relacionada à Assistência à Saúde. Série: Segurança do Paciente e Qualidade em Serviços de Saúde. Brasília; 2013. Accessed 9 Sep 2023. Available at: https://bit.ly/455uMMF
22. Gandra S, Ellison RT 3rd. Modern trends in infection control practices in intensive care units. J Intensive Care Med. 2014;29(6):311-26. https://doi.org/10.1177/0885066613485215
23. Dudeck MA, Horan TC, Peterson KD, et al. National Healthcare Safety Network (NHSN) report, data summary for 2009, device-associated module. Am J Infect Control. 2011;39(5):349-67. https://doi.org/10.1016/j.ajic.2011.04.011
24. Watson SR, Scales DC. Improving intensive care unit quality using collaborative networks. Crit Care Clin. 2013;29(1):77-89. https://doi.org/10.1016/j.ccc.2012.10.008
25. Wells S, Tamir O, Gray J, Naidoo D, Bekhit M, Goldmann D. Are quality improvement collaboratives effective? A systematic review. BMJ Qual Saf. 2018;27(3):226-40; https://doi.org/10.1136/bmjqs-2017-006926
26. Centers For Disease Control and Prevention. NHSN Surveillance Definitions for Specific Types of Infections. Atlanta (US): CDC; 2014.
27. Rosenthal VD, Desse J, Maurizi DM, Chaparro GJ, Orellano PW, Chediack V, et al. Impact of the International Nosocomial Infection Control Consortium's multidimensional approach on rates of ventilator-associated pneumonia in 14 intensive care units in 11 hospitals of 5 cities within Argentina. Am J Infect

Control. 2018; 46:674-9; https://doi.org/10.1016/j.ajic.2017.11.021
28. Schechner V, Wulffhart L, Temkin E, Feldman SF, Nutman A, Shitrit P, et al. One-year mortality and years of potential life lost following bloodstream infection among adults: A nation-wide population-based study. Lancet Reg Health Eur. 2022;23:100511. https://doi.org/10.1016/j.lanepe.2022.100511
29. Ista E, van der Hoven B, Kornelisse RF, van der Starre C, Vos MC, Boersma E, et al. Effectiveness of insertion and maintenance bundles to prevent central-line-associated bloodstream infections in critically ill patients of all ages: a systematic review and meta-analysis. Lancet Infect Dis. 2016;16(6):724-34. https://doi.org/10.1016/S1473-3099(15)00409-0
30. Shadle HN, Sabol V, Smith A, Stafford H, Thompson JA, Bowers M. A Bundle-Based Approach to Prevent Catheter-Associated Urinary Tract Infections in the Intensive Care Unit. Crit Care Nurse. 2021;41(2):62-71. https://doi.org/10.4037/ccn2021934

Conflicts of interest: No conflicts of interest were declared concerning the publication of this article.

Indications about the contributions of each author:
Conception and design: VMJ, DJT
Data analysis and interpretation: VMJ, JOS, GOCP, FST, DJT
Data collection: VMJ
Writing of the manuscript: VMJ, JOS, GOCP, FST, DJT
Critical revision of the text: FST, DJT
Statistical analysis: GOCP, FST, DJT
Final approval of the manuscript*: VMJ, JOS, GOCP, FST, DJT
Overall responsibility for the study: VMJ, JOS, GOCP, FST, DJT
*All authors have read and approved the final version of the manuscript submitted to the Rev Cienc Saude.

Funding information: Not applicable.