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Quality improvement collaborative for improving patient care delivery in Argentine public health sector intensive care units

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ABSTRACT

Background The demand for healthcare services during the COVID-19 pandemic was excessive for less-resourced settings, with intensive care units (ICUs) taking the heaviest toll.

Objective The aim was to achieve adequate personal protective equipment (PPE) use in 90% of patient encounters, to reach 90% compliance with objectives of patient flow (OPF) and to provide emotional support tools to 90% of healthcare workers (HCWs).

Methods We conducted a quasi-experimental study with an interrupted time-series design in 14 ICUs in Argentina. We randomly selected adult critically ill patients admitted from July 2020 to July 2021 and active HCWs in the same period. We implemented a quality improvement collaborative (QIC) with a baseline phase (BP) and an intervention phase (IP). The QIC included learning sessions, periods of action and improvement cycles (plan-do-study-act) virtually coached by experts via platform web-based activities. The main study outcomes encompassed the following elements: proper utilisation of PPE, compliance with nine specific OPF using daily goal sheets through direct observations and utilisation of a web-based tool for tracking emotional well-being among HCWs.

Results We collected 7341 observations of PPE use (977 in BP and 6364 in IP) with an improvement in adequate use from 58.4% to 71.9% (RR 1.2, 95% CI 1.17 to 1.29, p<0.001). We observed 7428 patient encounters to evaluate compliance with 9 OPF (879 in BP and 6549 in IP) with an improvement in compliance from 53.9% to 67% (RR 1.24, 95% CI 1.17 to 1.32, p<0.001). The results showed that HCWs did not use the support tool for self-mental health evaluation as much as expected.

Conclusion A QIC was effective in improving healthcare processes and adequate PPE use, even in the context of a pandemic, indicating the possibility of expanding QIC networks nationwide to improve overall healthcare delivery. The limited reception of emotional support tools requires further analyses.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Quality improvement collaboratives (QICs) are underpinned by the idea that leaders and institutions can leverage peer learning to accelerate improvement in healthcare performance and potentially achieve large-scale outcomes in a short time. The COVID-19 pandemic has exposed a very vulnerable system in which demand has exceeded resources and the healthcare facility capacity, particularly in low-income and middle-income settings.

WHAT THIS STUDY ADDS

⇒ A QIC was effective in improving essential healthcare processes in the intensive care unit (ICU) during a pandemic scenario. The use of the Breakthrough Series Model for quality improvement could be beneficial for both patients and healthcare providers when applied to the ICU environment.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The success in achieving target goals across the nation during the worst healthcare crisis of the last century indicates the possibility of expanding QIC networks nationwide to improve healthcare delivery in ICUs.

INTRODUCTION

The COVID-19 pandemic has exposed a very vulnerable system where demand has exceeded resources and the hospital system's capacity, particularly in low-income and middle-income settings.[1] Key factors for sustaining institutional performance include staff availability and emotional well-being. The pandemic has also created an environment which challenges these factors.

Staff availability was affected by hospital contagion, and emotional well-being was tested to the limits of working conditions. To mitigate system collapse, hospitals have to employ a clear strategy to ensure adequate patient flow and prevent time and resource wastefulness when delivering medical care (readmission, preventable harm, delay, among other factors).[2 3]

Latin-American countries faced an overwhelming situation given its limited resources and poor sociodemographic variables, which increased the risk of transmission and containment of the disease.[4] Intensive care units (ICUs) take the heaviest toll in terms of resources, staff affected and burden of disease.[5]

One of the most vital resources during the pandemic was personal protective equipment (PPE) owing to the risk of contagion. Although one study in Argentina reported having sufficient supplies and PPE,[3] this was not the case throughout Latin America where only 84%, 32% and 56% of healthcare workers (HCWs) had access to disposable surgical masks, facial protective shields and N95 respirators, respectively.[6] Although most HCWs had been trained in infection prevention and personal safety policies/procedures, practices were still below the performance needed to contain COVID-19 transmission prior to the outbreak.[7–10] For example, practices such as hand hygiene adherence, and standard isolation precautions were less than optimal. The COVID-19 pandemic has forced HCWs to adhere strictly to infection prevention practices and performance standards within a short period.[11]

The utilisation of daily goal sheets (DGS) is an exceedingly valuable instrument when a healthcare system faces heightened demands.[12] They allow essential processes of care to be addressed effectively, facilitating standardisation and adherence to the best practices to improve patient flow and ensure that patients receive the care and therapeutics they ought to.[12 13]

HCWs' mental status and how this influenced their return to work were also a matter of consideration. Less than 50% of HCWs surveyed in New York City stated that they would return to work during the pandemic, due to the risk of contagion, extended shifts and burn-out.[14] Burn-out has rarely been measured in Latin American ICUs. One study in paediatric ICUs in Argentina in 2012 identified a 41% burn-out prevalence among HCWs.[15] In Brazil, during the pandemic, higher burn-out levels were associated with two aspects: witnessing colleagues contracting COVID-19 at work during both surges and worries about finances and lack of ICU nurses.[16]

Our primary aim was aspirational and threefold: (1) to achieve adequate PPE use in 90% of patient encounters, (2) to achieve 90% compliance with the objectives of patient flow (OPF) using the DGS and (3) to detect and mitigate emotional distress in 90% of HCWs. A secondary aim was to sustain 90% unit performance on prepandemic metrics for selected patient safety indicators.

METHODS

This study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the Hospital San Martin de La Plata (approval number 8649/2020, 2020-47) and then approved in each participating hospital (online supplemental eTable 1). Patients and the public were not involved owing to COVID-19 pandemic restrictions.

We conducted a quality improvement collaborative (QIC) designed as a quasi-experimental, uncontrolled interrupted time series in 14 medical-surgical ICUs belonging to the Argentine public health sector over a 12-month period. The Breakthrough Series Model from the Institute for Healthcare Improvement was used. It involves the use of healthcare teams from different sites to improve performance on specific topics. This was achieved by collecting data and testing ideas with plan-do-study-act (PDSA) cycles supported by coaching and learning sessions.[17] To identify improvement initiatives, we developed a driver diagram (online supplemental eFigure 1).[18] The driver diagram consisted of four primary drivers, three related to our goals (PPE use, OPF and emotional support), and the fourth to the implementation of theory strategies.

We oversaw a baseline phase (BP) from July to August 2020 and an intervention phase (IP) from September 2020 to July 2021. Data were collected weekly during both phases. During BP, we collected data while conducting a formative evaluation of key stakeholders. We used the normalisation process theory before intervention deployment.[19] NPT is a theoretical framework designed to explain how actions are carried out and bridge the gap between research and practical implementation. It focuses on the actual work in which stakeholders normalise an intervention into clinical practice. NPT consists of four constructs (coherence building—the work to understand activities and intervention; cognitive participation—work done to create networks of participation, collective action, the work to enact the intervention and reflexive monitoring—the work to appraise the intervention) that are essential for embedding a new practice.[20] These results contributed to the adoption of the QI intervention.[21] During IP, a multidisciplinary improvement team consisting of 4–5 HCWs (ICU physicians, nurses and respiratory therapists) was formed in each unit. Teams were introduced to the 5 whys worksheet and fishbone diagram to identify barriers and facilitators to apply the given proposals.

The teams implemented a multimodal intervention to achieve objectives with components such as leadership commitment, training tools, visual and digital reminders, audits incorporating feedback, and direct observation.[22] We based the intervention on learning sessions and periods of action. A coordinating team trained the improvement teams of each ICU in three planned learning sessions. The training focused on QI knowledge and the implementation/generalisation of changes when they were effective. The improvement cycles (PDSA) proposed by each ICU were analysed considering the results obtained and the

applicability of the interventions. Between the learning sessions, there were periods of action where teams tested and executed changes in their units and collected data to measure the impact. If a team member resigned or fell ill, a prompt replacement was arranged to ensure a smooth transition with committed members. This scenario was unfolded in 80% of ICUs. Key aspects of the structural conditions, such as resource allocation, were ensured with a minimum baseline in each ICU.

The procedures, activities and different processes used in the intervention were uploaded to the LifeQI platform. We used the Template for Intervention Description and Replication to provide details on what, when, where and how the implementation was rolled out (box 1).

Outcomes and specific interventions

PPE use

We observed and registered adequate use of gloves, surgical masks, surgical or hydrorepellent coats, N95–N99 masks, and eye or face shields for both COVID-19 and non-COVID-19 patients. Observations were carried out considering PPE donning and doffing, tasks and expected risk (online supplemental eTable 2). Hand hygiene was evaluated as part of PPE use according to the WHO guidelines.[23] We used the situation-behaviour-impact model to deliver feedback after each observation.[24]

Objectives of patient flow

We evaluated the nine OPF during morning rounds (online supplemental eTable 3). An observation consisted of identifying the fulfilment of nine OPF in individual patients. We defined DGS compliance as the fulfilment of all nine OPF. Improvement experts and HCWs from the ICUs brainstormed change ideas to improve adherence and implemented them thereafter.

Detection and mitigation of emotional distress

HCWs willing to participate had to anonymously self-report their emotional/mental well-being scores biweekly based on the EASE test (SARS-CoV-2 Emotional Overload Scale, in Spanish named 'Escala Auto-aplicada de Sobrecarga Emocional') in digital or web-based app 'SER+contra COVID' (online supplemental eTable 4). This instrument was designed by a multidisciplinary team composed of physicians, nurses, pharmacists, biomedical engineers and health psychologists based on their previous collaboration in studies supporting healthcare professionals in highly stressful situations. It was part of a comprehensive approach to support professionals and served as a screening tool to provide guidance on the type of support that may be necessary in each case.[25] Depending on the score obtained, counselling interventions were offered to mitigate the mental health impact, either in person or by phone. HCWs who added 15 or more direct points were candidates to activate emotional support content in the app, and those who added 25 or more points were considered for individualised support

Box 1 Details about 5C programme based on Template for Intervention Description and Replication

Brief name

'5C programme: Quality Improvement Collaborative in Critical Care during COVID-19' (5C stands for the Spanish acronym: Colaborativa en Calidad durante COVID-19 en Cuidados Críticos).

Why

⇒ To mitigate system collapse, hospitals must have a clear strategy to ensure adequate patient flow and prevent time and resource waste when delivering medical care (eg, readmissions, preventable harm, delays).

What

⇒ To identify improvement initiatives that could influence the primary aims of the project we developed a driver diagram.
⇒ To improve quality improvement capacity, team intervention facilitators took virtual courses.
⇒ Instructional videos for adequate personal protective equipment (PPE) donning and doffing were provided and adapted for each intensive care unit (ICU).
⇒ We performed 12 random weekly observations of healthcare workers (HCWs) using PPE per unit. Observations were carried out considering PPE donning and doffing, tasks and expected risks.
⇒ Hand hygiene was evaluated according to the five WHO criteria.[23]
⇒ We used the Situation-Behavior-Impact-Feedback framework to deliver feedback after each observation.
⇒ We evaluated daily goal sheet (DGS) compliance during the morning rounds. Strategies to improve processes were (a) use of disposable paper measuring tape for calculating tidal volume in mechanical ventilation; (b) tables, and scores to improve patient sedation, enteral feeding reminders and tables for calculating caloric goals; (c) reminders for catheter discontinuation; (d) visual marks for reaching adequate bed elevation and (e) a wall checklist and email or text messages for care process reminders.
⇒ We used an application to monitor staff's emotional/mental well-being. HCWs self-reported biweekly scores based on the SARS-CoV-2 Emotional Overload Scale test in the digital or web-based app SER+contra COVID-19.

Who provided

⇒ Interventions related to PPE use were provided mostly by local nurses, especially hand hygiene. DGS interventions were provided by physical therapists and physicians (online supplemental eTable 8).

How

⇒ There were 1-hour biweekly virtual meetings among the 14 units and coordinating teams to share and discuss the results, lessons learnt, applicability of interventions, and modifications to work plans.
⇒ The creation of teams at each site involved the appointment of local facilitators, with at least one healthcare professional serving as an executive implementation leader responsible for planning, dissemination and development.
⇒ The overall coordination of the study was overseen by healthcare quality specialists (EGE, VR, JR and FJB), critical care specialists (CIL and RR), coaching for improvement specialists (FJB, VR, CM and SFN) and data collection advisors (MdPAL, MER and FJB).
⇒ Follow-up calls were conducted by a coach, with the aim of providing comprehensive support for implementation, analysing measurement

Continued

Box 1 Continued

results and identifying challenges in ongoing plan-do-study-Act (PDSA) cycles in order to agree on the next steps.
⇒ We maintained communication between the site coordinators and data collectors by telephone, Zoom meetings, email and WhatsApp. We shared run charts with the main outcomes of each team to monitor progress every 2 weeks during the study period.
⇒ LifeQI was used by each team to report the development of improvement opportunities and upload PDSA cycles.

Where
⇒ Interventions related to PPE use and DGS were deployed in each ICUs and were facilitated by local champions.
⇒ Interventions related to emotional/mental well-being were self-developed using a smartphone or web-based application. People could also take phone or in-person assistance. We offered an open space for psychological consultations. Reminders for application use were distributed at each site.

When and how much
⇒ Teams worked on 23 change ideas and did 40 PDSA cycles of PPE use, most of which (nearly 20) were based on hand hygiene. The other PDSA cycles were related to the downing-doffing of PPE through videos or face to face capacitation and face-shield use.
⇒ The teams worked on 26 change ideas and performed 47 PDSA cycles of patient flow processes. There were 27 PDSA cycles of DGS use, and the rest were divided into improvements in mechanical ventilation, nutrition, sedation and analgesia. There was a cycle related to improving nurses' participation in ICU rounds.
⇒ Teams worked 7 change ideas and did 12 PDSA cycles on emotional support, most of them (11) were related to enhance the app 'SER+contra COVID' use.
⇒ Teams also worked on 6 change ideas and performed 11 PDSA cycles on applying implementation strategies to obtain programme components.
⇒ The quality improvement implementation course comprises four modules, each lasting five educational hours and includes two synchronous virtual sessions, each spanning 90 min. Reading and learning materials are accessible on the virtual campus, providing permanent access for participants.
⇒ Networking sessions occur biweekly, with each session lasting 60 min, commencing from week 10 and continuing until the end of the study.
⇒ Monthly coaching sessions were provided, with durations ranging from 30 to 60 min, beginning at week 8 and continuing until the end of the study.
⇒ Additionally, three extended learning sessions were conducted, each lasting 180 min (weeks 8, 48 and 50).
⇒ Teams' internal meetings were encouraged twice a month.

Tailoring.
None.

Modifications.
None.

How well.
⇒ We could not assess fidelity.
⇒ We measured adherence to the different components of the intervention.

Continued

Box 1 Continued

⇒ We have shown the compliance with the intervention under the main text results and in online supplemental appendix.

consultations to be enabled by their centre. The app is available for Android and iOS from official download platforms or online (https://segundasvictimascovid19.umh.es/p/test-argentina.html).

Secondary outcomes

We selected patient safety indicators to gauge institutional performance on prepandemic metrics (central line-associated bloodstream infection rate, catheter-associated urinary tract infection rate, bed falls and self-extubation rates).

Data collection

Redcap was used to record data and LifeQI to report the development of improvement opportunities. Data were collected through direct observation. Secondary data were obtained from the following sources: Programa de Calidad de la Sociedad Argentina de Terapia Intensiva (SATI-Q) Programme (https://www.satiq.net.ar/informes), Programa Vigilancia de Infecciones Hospitalarias de Argentina (VIDHA) National Programme (https://vihda.anlis.gov.ar/) and ICU databases. Aggregated data from the patients' age, sex, Acute Physiology and Chronic Health Evaluation (APACHE II)[26] and Sequential-related Organ Failure Assessment (SOFA)[27] scores, ICU length of stay (LOS), use of invasive or non-invasive ventilation and ICU mortality from each ICU were collected.

Data collectors were virtually trained, and instructional materials were developed owing to the high staff turnover. Each site received biweekly advice from a data collection specialist, who helped in training new data collectors. There were 60 min biweekly meetings between all the data collectors and the coordinating team. During this meeting, teams shared barriers, facilitators and possible solutions to problems in data collection.

Statistical analysis

The unit and patient characteristics of BP and IP are reported. To evaluate the effects of the intervention programme, the percentage of appropriate PPE use and compliance with all nine OPF before and after the intervention was compared. The χ^2 test was employed because of the independence between the preobservations and postobservations. Additionally, the same analysis was conducted based on the HCWs' category. Control charts were generated to illustrate the improvements across the entire study period.

Summary measures of the biweekly use rate and the score of the EASE test were reported globally and by HCWs category and plotted in a figure together with the

Table 1 ICU aggregated characteristics and description of patient population#

	Baseline	Intervention
Total beds availability	255	317
Admissions in each unit per month*	43.9 (27.1–55.7)	36.9 (29.4–51)
ICU length of stay (days)*	8.6 (6.3–11.8)	11.3 (10.5–15.7)
COVID-19 admissions†	63.9 (41.2–89.7)	68.9 (38.6–93.1)
Age (years)‡	53±16	56.3±14
Female†	34.9 (31.3–37.9)	36.9 (34.5–44.4)
Diagnostic admissions:		
Medical†	90.6 (75.3–96.6)	89.1 (83.9–95)
Surgical†	4.5 (0.9–12.4)	5.7 (0–8.6)
Trauma†	2.3 (0–0.8)	3.6 (0.2–8.5)
APACHE II score†‡	16.9±7.7	16±8
SOFA score (day 1)‡	5.7±2.3	5.7±2.4
Nasal high-flow oxygen use†	0 (0–0)	0.4 (0–1.5)
Non-invasive mechanical ventilation rate of use†	0 (0–0.2)	0.3 (0.1–0.8)
Invasive mechanical ventilation rate of use†	63.5 (11.5–70.8)	77.2 (42.5–95.4)
Mortality rate in ICU†	33.3 (24.9–47.7)	45.3 (35.7–52.7)

To construct the table, we considered aggregated data from each ICU
*Median (IQR).
†% (range).
‡Mean±SD.
APACHE II, Acute Physiology and Chronic Health Evaluation II; ICU, intensive care unit; SOFA, Sequential-related Organ Failure Assessment.

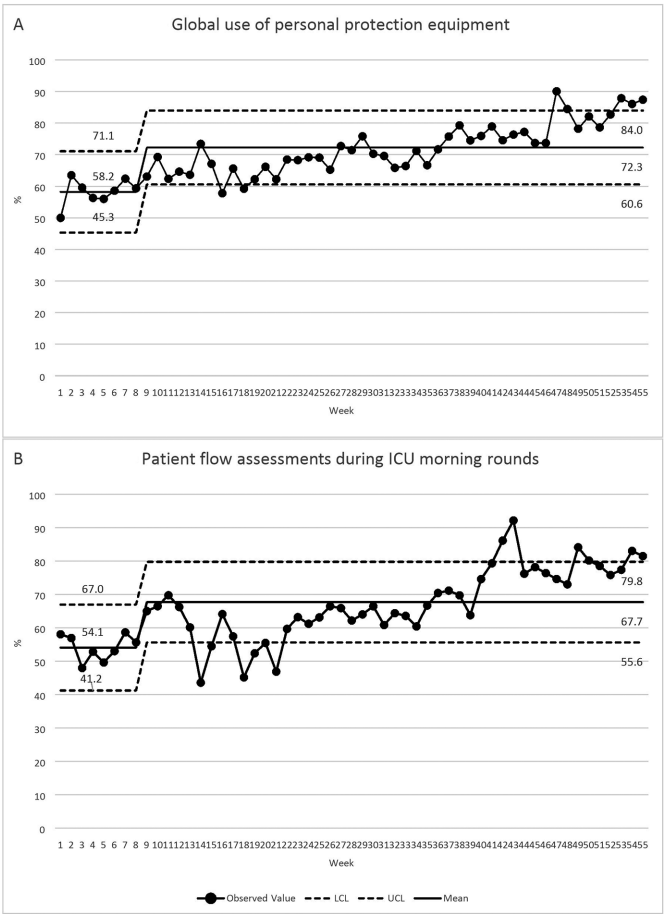

Figure 1 (A) PPE global compliance control chart. The mean, lower control limit (LCL) and upper control limit (UCL) in BP (weeks 1–8) and IP (weeks 9–55). A significant improvement was noted from week 38 until the end of treatment (values above the mean). (B) Patient flow objective assessments on ICU morning round control charts. It is indicated mean, LCL and UCL in BP (weeks 1–8) and IP (weeks 9–55). A significant improvement was noted from week 41 until the end of the study (values above the mean). BP, baseline phase; ICU, intensive care unit; IP, intervention phase; PPE, personal protective equipment.

COVID-19 waves during the study period. The statistical package R V.4.0 was used (The R Foundation).

RESULTS

14 ICUs were enrolled in this study. All ICUs were public level 1 (the highest level according to the Argentine Ministry of Health) and teaching centres with undergraduate and postgraduate programmes. During IP, there was a 24% increase in the bed capacity of the ICUs. The patient characteristics were similar; however, the percentage of invasive mechanical ventilation and ICU mortality was higher in the IP group (table 1). The teams worked on 62 change ideas and tested 110 PDSA cycles for improvements: 40 for PPE use, 47 for OPF, 12 for emotional support and 11 for implementation of theory strategies to obtain programme components.

PPE use

There were 7341 observations on how PPE was used, 977 observations in BP and 6364 in IP. Compliance with PPE use improved from 58.4% in BP to 71.9% in IP (RR 1.2, 95% CI 1.17 to 1.29, p<0.001). The improvement was significant in COVID-19 patients (65.9% in BP vs 79.6% in IP, RR 1.21, 95% CI 1.16 to 1.26, p<0.001) and in non-COVID-19 patients (40.4% in BP vs 51.7% in IP, RR 1.28, 95% CI 1.10 to 1.48, p<0.001). We observed a consistent improvement in PPE utilisation in the p-control chart, which remained above the mean from week 38 until the end of the study (figure 1).

PPE compliance was compared among the three HCWs categories: physicians, nurses and physical therapists. There was globally an enhanced use of proper PPE in IP; however, when analysing each group separately, there was lower compliance for nurses and physical therapists in non-COVID patient observations (online supplemental eTable 5).

We analysed the primary reasons for improper utilisation of PPE, identifying hand hygiene as the main issue at baseline, followed by incorrect usage of gloves, hydrorepellent/surgical gowns and eye/facial shields. While there was a significant improvement in the proper use of gloves and N95–N99 masks during IP, the correct

Table 2 Patient flow objectives compliance

Patient care processes	Baseline (N=879) N (%)	Intervention (N=6549) N (%)	P value*
Receive enteral or oral feeding	761 (86.7)	5953 (90.9)	<0.001
The head of the bed is elevated 30° or more	797 (90.8)	6213 (94.9)	<0.001
The patient is sedated and with analgesia according to the clinical situation.	814 (92.7)	6085 (92.9)	0.880
Mechanical ventilation tidal volume is less than or equal to 8 mL/kg of ideal body weight	844 (96.1)	6299 (96.2)	1.000
The patient receives adequate prophylaxis for venous thromboembolism	833 (94.9)	6332 (96.7)	0.007
The need for the use of the central venous catheter and possible withdrawal date were evaluated	783 (89.2)	6085 (92.9)	<0.001
The need, suitability for microbiological rescue and end date of antibiotics and drugs for the treatment of COVID-19 were evaluated	829 (94.4)	6329 (96.7)	0.001
The need for permanent use of the urinary catheter and eventual withdrawal date were evaluated	779 (88.7)	5953 (90.9)	0.044
The possibility of discharge from the ICU was evaluated	757 (86.2)	5847 (89.3)	0.008
Full compliance of all nine care processes per patient	473 (53.9)	4383 (67.0)	<0.001

*Chi2 test
ICU, intensive care unit.

use of eye or facial shields decreased significantly (online supplemental eTable 6). When we observed PPE use in each group of HCWs, hand hygiene was the main cause of failure (online supplemental eTable 7).

Objectives of patient flow

A total of 7428 observations of OPF assessment in the ICU morning rounds (879 in BP and 6549 in IP) were observed. Compliance with all nine OPF improved significantly from 53.9% in BP to 67% in IP (RR 1.24, 95% CI 1.17 to 1.32, p<0.001). In the p-control chart, we noticed a consistent improvement among all nine OPF, which remained above the mean from week 41 to the end of the study (figure 1).

Following the implementation of the DGS, improvements were observed in seven of nine care processes for critical patients. The remaining two care processes demonstrated high compliance at the baseline, which was sustained throughout the IP (table 2).

Detection and mitigation of emotional distress

The aggregate population comprised 1238 HCWs, categorised into nurses (58.0%), physicians (26.8%) and physical therapists (15.2%). The median age of the HCWs was 39 years (IQR 34–45), and their median years of experience was 10 (IQR 5–15). The median staff turnover rate was 35% (IQR 25–40). A total of 1290 self-reported mental health evaluations were collected using the 'Ser+Contra COVID' app and webpages, with nurses (40.6%), physicians (38.7%) and physical therapists (20.7%) contributing to the completion of all evaluations.

Despite the availability of the tool throughout the study period, usage rates remained low, with a global mean use of 4.3%±3.0%. The global median EASE test score was 6 (IQR 2–12). Figure 2 displays the global usage rate of the EASE test and score in comparison with the COVID-19 waves during the study period.

While physical therapists demonstrated the highest EASE score (8 (IQR 4–13)), their population of HCWs was the smallest. The EASE scores for nurses and physicians were comparable (5 (IQR 1–11) and 5 (IQR 2–12), respectively). A statistically significant difference was observed in the EASE scores between male and female HCWs, with male HCWs having a higher score (8.5±6.7 vs 7.3±6.3, p=0.004).

Patient safety indicators

Among all the ICUs, only nine reported results on the selected patient safety indicators. However, no discernible changes in the patient safety trends were observed throughout the study period (online supplemental eFigure 2).

DISCUSSION

The aim of the QIC was to achieve an aspirational goal of 90% performance in three main outcomes during the pandemic. To ensure quality of care in this dramatic scenario, we successfully achieved improvement in

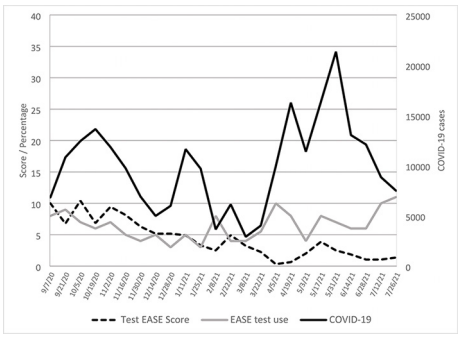

Figure 2 EASE test usage rate and EASE score compared with COVID-19 waves during the study period. EASE, SARS-CoV-2 Emotional Overload Scale.

correct PPE use, improved compliance with OPF using the DGS and addressed HCWs' mental health. We also sustained the prepandemic metrics of the selected patient safety indicators. Even though we had anticipated that our ability to reach goals would be affected (due to the unequal distribution of pandemic surges and their impact on resources), success did not depend on and was not negatively affected by staff turnover or baseline drawbacks. This achievement was made possible through the diligent maintenance of supportive QI teams in each ICU. External support plays a crucial role in sustaining coaching efforts. Our study was carried out during the first and second COVID-19 waves in Argentina, with a peak of 35.000 daily cases during the second wave, with most of the population without full vaccination.[28] ICU mortality increased from 33.3% to 45.3% from baseline to IP. This result was expected because two peaks of the waves occurred in the IP. Data from COVID-19 patients across Argentina indicated that ICU mortality were 57% during the same period.[29]

PPE use

We were close to reach our initial global goal of 90% correct PPE use by the end of the study period. Adherence to proper PPE use differed depending on whether the interaction was with COVID-19 or non-COVID-19 patients. In non-COVID-19 encounters, PPE use was inadequate until the end of the intervention period. It is important to highlight that the non-COVID-19 patients' PPE use provides a more accurate representation of HCWs' behaviour outside the specific context of this pandemic.

Throughout our study, we addressed two main causes of inadequate PPE use: improper hand hygiene and face shield/goggle use. Improper hand hygiene was homogeneous across all sites. Other publications have also reported issues with adherence to proper hand hygiene, such as a study conducted in Brazil which found that compliance with hand hygiene was lower during the pandemic.[30] Similarly, in a Danish and French study, hand hygiene compliance was higher before the pandemic.[31 32] However, it is possible to improve adherence to hand hygiene through multifaceted interventions.[33] In a study conducted in 11 ICUs in Buenos Aires, a multimodal intervention improved compliance with hand hygiene by 10%. In this study, to reach a target of 90% hand hygiene compliance, sites ran PDSA cycles using different strategies.[7]

The use of face shield/goggles was initially consistent; however, once vaccination of HCWs was completed, their use declined. In virtual meetings, discussions with staff, face shields and goggles were considered cumbersome, problematic due to fogging, and less necessary, given their vaccination status. Finally, we were unable to recover the proper use for these items. In a recent voluntary survey on different continents, the use of goggles or face shield/visors for routine care was 93% among HCWs; however, this was not confirmed by audit.[34] Our data were collected through direct observation to evaluate both the use and the correct application.

Objectives of patient flow

In the last 16 weeks of the study, we achieved over 75% compliance for all 9 OPF using DGS. Moreover, at specific time points during the study, we achieved our target of 90% compliance. Baseline data for the processes evaluated independently indicated high performance at the start, limiting the amount of improvement possible. Quality/safety processes with more room for improvement were those related to enteral nutrition administration, central venous and urinary catheter discontinuation, and evaluation of the possibility of discharge from the ICU; all these OPF improved significantly.

DGSs are used to ensure that essential elements of care are addressed routinely, thereby facilitating standardisation and adherence to essential guidelines. Although there is no definitive evidence that implementation of DGSs reduces mortality or other patient-relevant outcomes,[35 36] there have been positive experiences using them. One of these was the implementation of a DGS in a single ICU that demonstrated a 50% reduction in LOS.[13] Another study was conducted in 14 med-surg ICUs, in which it was observed that when DGSs were used ≥60% of the time, the ICU ran more efficiently by reducing costs and LOS.[12] Until now, there has been no literature on implementing DGSs during a pandemic, as in our study.

Detection and mitigation of emotional distress

Although many PDSA cycles were proposed in each ICU to improve adherence to mental status self-testing, the percentage of app use was low during the entire IP and especially low over the second COVID-19 wave. Interestingly, the highest EASE scores coincided with the peaks of the first and second waves. In a recent study that also used the EASE score, acute stress coincided with an increase in the number of COVID-19 cases. Questions with higher scores were related to the domains of fear, anxiety and doubt about HCWs being infected. Among the four countries investigated, Argentina had the lowest score.[37] However, in our study, we did not analyse why HCWs were unwilling to self-test. Some of the possible causes considered were distrust of the app, severe emotional distress, lack of emotional openness or feeling that they did not need additional support. Many studies have addressed the issues of burn-out, stress and emotional impact of the pandemic.[38–42] However, our study was the only one to evaluate the emotional impact on HCWs over 47 consecutive weeks during the first two pandemic waves.

After analysing the three different outcomes, most ICUs, irrespective of their differences, were able to meet their goals. This indicates that the use of PDSA protocols across multiple ICUs with a locally tailored approach can be beneficial in ICU environments. The improvement of target goals and outcomes was due to several issues: availability of databases updated and accessible in real time, coordinating

teams to ensure adherence to data collection and furthering communication, training, peer-to-peer shared learning and leveraging expertise. This process also highlights QICs as a relevant and low-cost approach to bring about positive advancements in healthcare.[43 44]

Limitations

This study had some limitations. First, as the study was conducted under pandemic conditions, only internal audits were conducted. Second, some ethics committees were not working during the pandemic causing delays in approval. For this reason, some sites reported only one biweekly period at the baseline. Third, a high staff turnover was observed during the study. Many HCWs with COVID-19 and other comorbidities were sent home. Additionally, owing to strain and increased demand, several observers and data collectors quit the programme. To overcome these challenges, new teams were comprehensively trained in all aspects of the programme during the intervention, ensuring the completion of all QI teams to sustain the intervention. Although we used the EASE cut points to recommend diverse support tools, no analysis was conducted to ensure that workers were adhering to the recommendations. Fourth, resource shortages in some ICUs cannot be resolved. However, a minimum baseline for essential resources was ensured in each ICU. Finally, we could not measure sustainability beyond the intervention period, but according to run chart rules, the 9 points above the median in the control charts of DGS and PPE use indicate that implemented changes were sustained to the extent that the process shifted.[45]

CONCLUSION

This QIC was effective in improving healthcare delivery and adequate PPE use even in the context of a pandemic. The success in achieving target goals across the nation during the worst healthcare crisis of the last century indicates the possibility of expanding QIC networks nationwide to improve overall healthcare delivery. However, the limited scope of the emotional support aspect requires further consideration in the future analyses.

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Contributors CIL, FJB, EGE and VR made substantial contributions to conceptualisation and design, management and coordination responsibility for the research activity planning and execution, and analysis and interpretation of data; CIL and FJB drafted the submitted article and revised it critically for important intellectual content. CIL, FJB and LG were involved in formal analysis of data. SLA, CdVB, RB, MLC, ERC, MAG, GI, MNL, MLR, AMS, AT, LJU and GZ, conducted data acquisition in each ICU. RR, MdPAL, SFN, CM and MER were involved in management and coordination responsibility for the research activity planning and execution, and in coordination of data acquisition in each ICU. JR and JJM were involved in provision of study materials. CIL is responsible for the overall content as the guarantor. All authors reviewed, edited, and approved the final manuscript. 5C Study Group members collaborators were involved in acquisition of data in each ICU.

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A QUALITY IMPROVEMENT COLLABORATIVE FOR IMPROVING PATIENT CARE DELIVERY IN ARGENTINE PUBLIC HEALTH SECTOR INTENSIVE CARE UNITS

Appendix 1

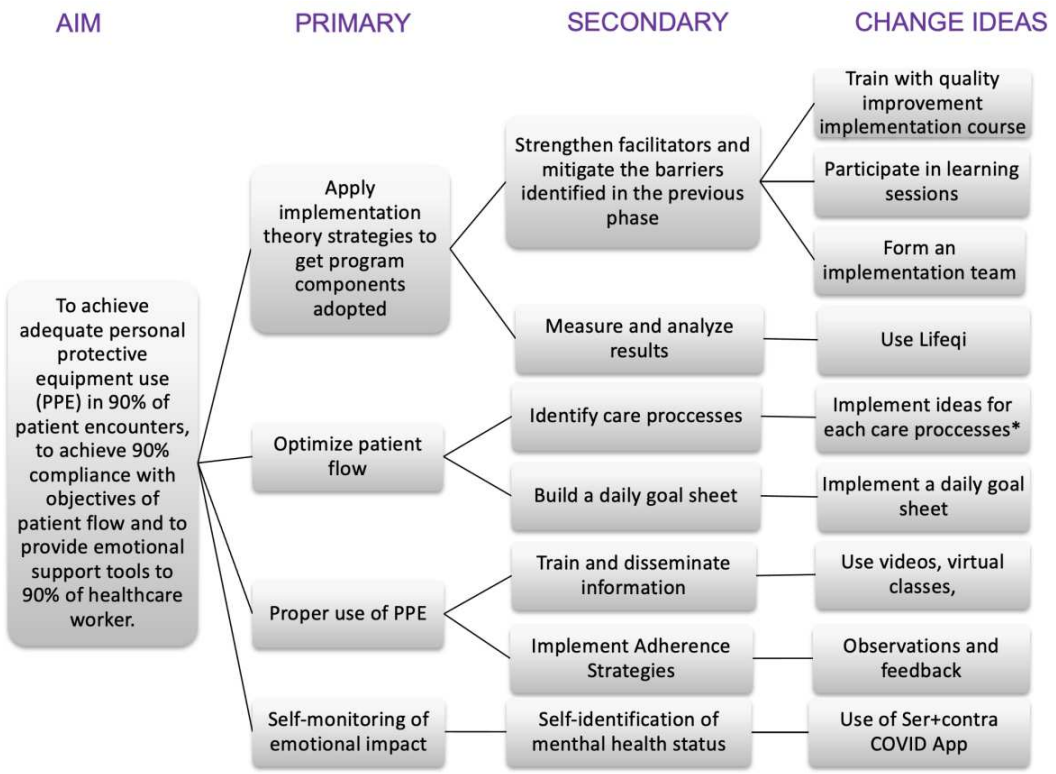
Table of contents

Loudet CI, *et al. BMJ Open Qual* 2024; 13:e002618. doi: 10.1136/bmjoq-2023-002618

Supplemental eTable 1. Institutional Review Board approvals

Institutional Review Board	Original Title	Approval Date	Approval Number
Comité de Ética en la Investigación, Hospital Dr. Julio C. Perrando	Apoyo a los sistemas de salud en la era de COVID -19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina - Proyecto 5C (Colaborativa en Calidad durante Covid en Cuidados Críticos)	7/10/2020	-
Comité de Bioética Área Programática Comodoro Rivadavia	Apoyo a los sistemas de salud en la era de COVID-19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina	7/6/2020	01/2020
Comité de Ética en la Investigación, Hospital Pirovano	Apoyo a los sistemas de salud en la era de COVID -19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina	7/17/2020	47
Comité Provincial de Ética de la Investigación de la Provincia De Jujuy	"Programa 5 C" (programa colaborativo en calidad de atención para unidades de terapias intensivas en el contexto de pandemia)	10/16/2020	-
Comité de Ética en la Investigación, Hospital San Martin De La Plata	Apoyo a los sistemas de salud en la era de COVID -19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina - Proyecto 5C (Colaborativa en Calidad durante Covid en Cuidados Críticos)	7/1/2020	HSMLP2020/0024
Comité de Bioética del Hospital Francisco López Lima	Apoyo a los sistemas de salud en la era de COVID -19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina - Proyecto 5C (Colaborativa en Calidad durante Covid en Cuidados Críticos)	6/24/2020	CE 00026
Departamento de Capacitación, Docencia e Investigación, Hospital Provincial Florencio Díaz	Apoyo a los sistemas de salud en la era de COVID -19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina - Proyecto 5C (Colaborativa en Calidad durante Covid en Cuidados Críticos)	6/16/2020	-
Comité de Bioética, Hospital Iturraspe	Apoyo a los sistemas de salud en la era de COVID -19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina - Proyecto 5C (Colaborativa en Calidad durante Covid en Cuidados Críticos)	6/30/2020	-
Comité de Ética en la Investigación, Hospital Luis C. Lagomaggiore	Apoyo a los sistemas de salud en la era de COVID 19: colaborativa para la mejora del desempeño en las unidades de cuidados	6/8/2020	-

	críticos del sector de salud pública de Argentina-proyecto 5C		
Comité de Ética, Hospital Simplemente Evita	Apoyo a los sistemas de salud en la era de COVID -19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina - Proyecto 5C (Colaborativa en Calidad durante Covid en Cuidados Críticos)	7/3/2020	-
Dirección General, Hospital Escuela y de Clínicas Virgen María de Fátima	Apoyo a los sistemas de salud en la era de COVID 19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina-proyecto 5C	7/13/2020	90006227
Departamento de Docencia e Investigación, Hospital Provincial Neuquén Dr. Eduardo Castro-Rendón	Apoyo a los sistemas de salud en la era de COVID -19: colaborativa para la mejora del desempeño en las unidades de cuidados críticos del sector de salud pública de Argentina - Proyecto 5C (Colaborativa en Calidad durante Covid en Cuidados Críticos)	6/29/2020	HN Nº8649/2020



*Each team use different change ideas to improve the 9 care patient processes included in the daily goal sheet

eFigure 1. Driver Diagram

Supplemental eTable 2. Protection personal equipment use moments.

Level of care
1. Suspected or confirmed case COVID-19 requiring medical care admission to facility, NO aerosol generation procedure or contact with secretions
2. Suspected or confirmed case COVID-19 requiring medical attention facility admission, WITH aerosol generation procedure
3. Suspected or confirmed case COVID-19 requiring medical care admission to facility, WITH procedure involving contact with secretions
4. Suspected or confirmed case COVID-19 requiring medical attention admission to facilities, WITH procedures involving aerosol generation and contact with secretions
5. non-COVID-19 case requiring medical care admission to the facility, NO aerosol generation procedure or contact with secretions
6. non-COVID-19 case requiring medical care admission to facilities, WITH aerosol generation procedure
7. non-COVID-19 case requiring medical care admission to the facility, WITH procedure involving contact with secretions
8. non-COVID-19 case requiring medical care admission to the facility, WITH procedure involving aerosol generation and contact with secretions

Supplemental eTable 3. Daily goal safety sheet.

Care processes
1. Receive enteral or oral feeding (record does not apply if the patient presents: ileus, gastrointestinal bleeding, hemodynamic instability, unstable respiratory status, or any specific contraindication to enteral feeding)
2. The head of the bed is elevated at 30° or more (recording does not apply if the patient is in a prone position or has any specific contraindication to elevating the head of the bed)
3. The patient is sedated and with analgesia according to the clinical situation
4. The tidal volume of mechanical ventilation is less than or equal to 8 ml / kg of ideal body weight (record does not apply if the patient does not receive mechanical ventilation)
5. The patient receives adequate prophylaxis for venous thromboembolism (VTE) (it can be mechanical or pharmacological, recording does not apply if there is a specific contraindication for its use)
6. The need for the use of the central venous catheter and the possible date of withdrawal were evaluated.
7. The need for microbiological rescue and the end date of antibiotics and drugs for the treatment of Covid-19 were evaluated.
8. The need for permanent use of the urinary catheter and possible date of withdrawal were evaluated.
9. The possibility of discharge from the ICU was evaluated

Supplemental eTable 4. Acute Stress of Health Professionals Caring COVID-19 Scale (EASE SCALE)

Please answer the following questions according to the thoughts, emotions, sensations, and actions you are experiencing during these days of crisis:

	It's not happening to me	**It happens to me in concrete situations**	**It often happens to me**	**I'm like this all the time**
I cannot help but think of the recent critical situations. I can't get out of work				
I have completely lost the taste for things that gave me peace of mind				
I keep my distance, I resent dealing with people, I'm irascible even at home				
I feel that I am neglecting many people who need my help				
I have difficulty thinking and making decisions, I have many doubts, I have entered a kind of emotional blockage				
I feel intense physiological reactions (shocks, sweating, dizziness, shortness of breath, insomnia, etc.) related to the current crisis				
I feel a permanent alert. I believe that my reactions now put other patients, my colleagues or myself at risk				
Worrying about not getting sick causes me a strain that's hard to bear				
I'm afraid I'm going to infect my family				
I have difficulty empathizing with patients' suffering or connecting with their situation (emotional distancing, emotional anesthesia)				

https://segundasvictimascovid19.umh.es/p/app-ser-contra-covid.html

Supplemental eTable 5. Protection personal equipment use among healthcare workers.

	Nurses (N=3125)			Physical therapists (N =2007)			Physicians (N=2207)		
	Baseline (N=450)	**Intervention (N =2675)**	**p-value***	**Baseline (N=246)**	**Intervention (N=1761)**	**p-value***	**Baseline (N=281)**	**Intervention (N=1926)**	**p-value***
PPE use rate N (%)	249 (55.3)	1772 (66.6)	<0.001	172 (69.9)	1417 (80.6)	<0.001	150 (53.4)	1368 (71.4)	<0.001
PPE use rate – in COVID-19 N (%)	178 (64.5)	1382 (78.4)	<0.001	142 (72.1)	1150 (85.1)	<0.001	135 (62.2)	1129 (75.9)	<0.001
PPE use rate – in Non COVID-19 N (%)	71 (40.8)	390 (43.4)	0.522	30 (61.2)	267 (65.9)	0.513	15 (23.4)	239 (74.9)	<0.001

* Chi-squared test

Supplemental eTable 6. Causes of improper PPE use among healthcare workers.

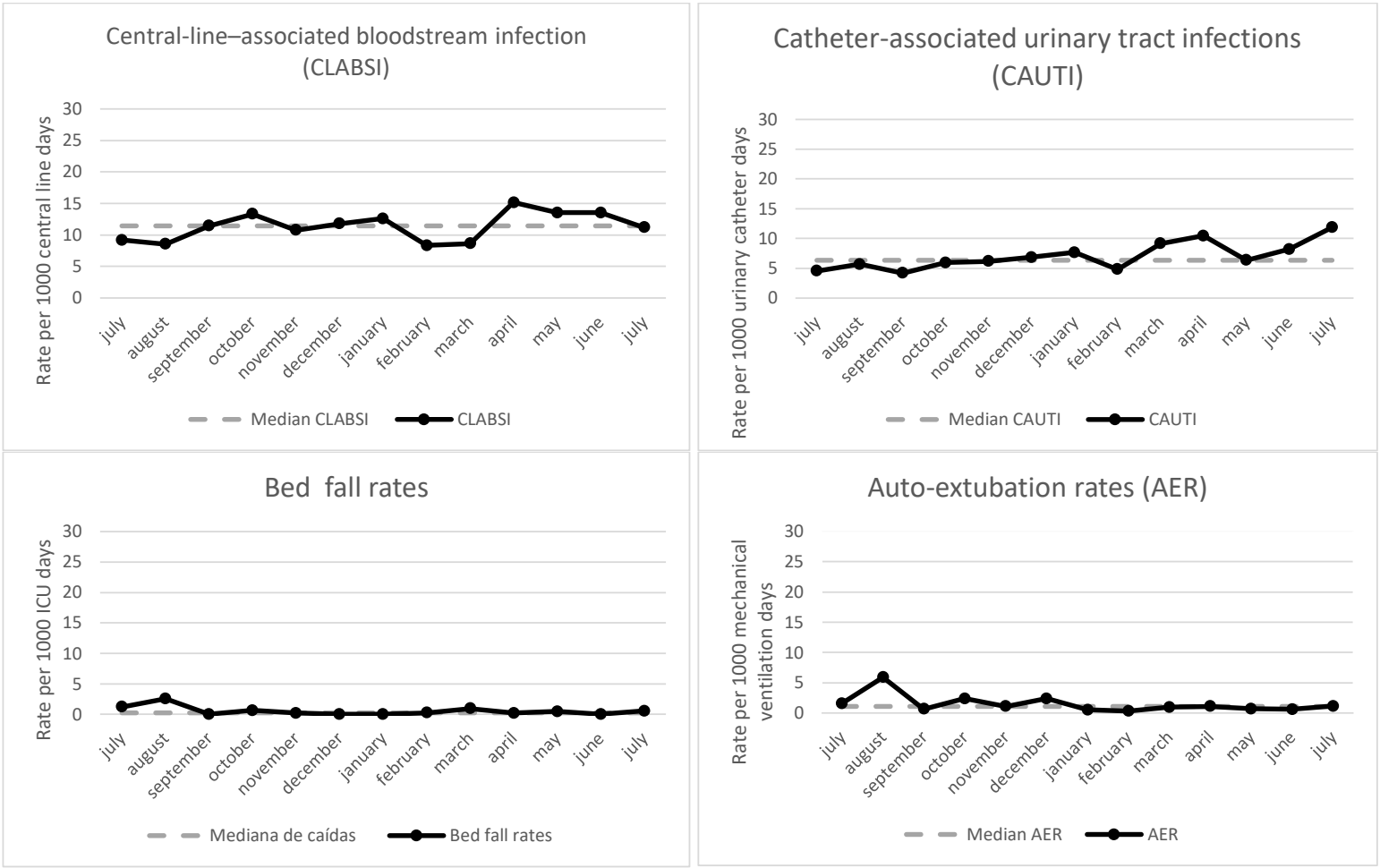
	Baseline (N=315)	Intervention (N =1480)	p-value
Hand hygiene N (%)	233 (74.0)	1037 (70.1)	0.167
Gloves N (%)	43 (13.7)	88 (5.9)	<0.001
Surgical Mask N (%)	10 (3.2)	25 (1.7)	0.083
N95-N99 Mask N (%)	19 (6)	52 (3.5)	0.037
Eye or facial shield N (%)	33 (10.5)	315 (21.3)	<0.001
Surgical gowns N (%)	36 (11.4)	149 (10.1)	0.471
Hydro-repellent gowns N (%)	40 (12.7)	149 (10.1)	0.167

* Chi-squared test

Supplemental eTable 7. Causes of improper PPE use among healthcare workers.

	Nurses (N=832)			Physical therapists (N=374)			Physicians (N=589)		
	Baseline (N=143)	**Intervention (N =689)**	**p-value***	**Baseline (N=67)**	**Intervention (N=307)**	**p-value***	**Baseline (N=105)**	**Intervention (N=484)**	**p-value***
Hand hygiene N (%)	103 (72.0)	452 (65.6)	0.138	50 (74.6)	192 (62.5)	0.061	80 (76.2)	393 (81.2)	0.242
Gloves N (%)	23 (16.1)	35 (5.1)	<0.001	10 (14.9)	21 (6.8)	0.030	10 (9.5)	32 (6.6)	0.293
Surgical Mask N (%)	4 (2.8)	19 (2.8)	1.000	1 (1.5)	1 (0.3)	0.327	5 (4.8)	5 (1.0)	0.019
N95-N99 Mask N (%)	15 (10.5)	24 (3.5)	<0.001	3 (4.5)	19 (6.2)	0.778	1 (1.0)	9 (1.9)	1.000
Eye or facial shield N (%)	20 (14.0)	175 (25.4)	0.003	6 (9.0)	63 (20.5)	0.027	7 (6.7)	77 (15.9)	0.014
Surgical gowns N (%)	15 (10.5)	84 (12.2)	0.567	11 (16.4)	21 (6.8)	0.011	10 (9.5)	44 (9.1)	0.889
Hydro-repellent gowns N (%)	24 (16.8)	76 (11.0)	0.054	4 (6.0)	31 (10.1)	0.293	12 (11.4)	42 (8.7)	0.376

* Chi-squared test



Supplemental eFigure 2. Patient safety indicators along the study period.

Supplemental eTable 8. Intervention providers

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LAURA ANAHÍ PAGGI	Fellow, MD	HIGA San Martín de La Plata	Intensive care	Quality improvement basic skills course	Participated in LS and biweekly meetings, onsite intervention facilitation
CAROLINA ESTELITA	Fellow, MD	HIGA San Martín de La Plata	Intensive care	Quality improvement basic skills course	Participated in LS and biweekly meetings, onsite intervention facilitation
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