






BMJ Open Quality Emergent themes from a quality improvement programme for CLABSI/CAUTI prevention in ICUs amid the COVID-19 pandemic

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ABSTRACT

Objectives Healthcare-associated infection (HAI) prevention has been difficult for healthcare providers to maintain during the COVID-19 pandemic. This study summarises themes for maintaining infection prevention activities learnt from the implementation of a quality improvement (QI) programme during the pandemic.

Methods We conducted qualitative analysis of participants' semistructured exit interviews, self-assessments on HAI prevention activities, participant-created action plans, chat-box discussions during webinars and informal correspondence.

Setting Intensive care units (ICUs) with elevated rates of central line-associated bloodstream infections (CLABSI) and/or catheter-associated urinary tract infections (CAUTI) participating in the Agency for Healthcare Research and Quality Safety Programme for ICUs: Preventing CLABSI and CAUTI.

Results Forty-nine ICU teams who participated in the programme between December 2019 and April 2021 found ways to maintain activities such as daily huddles, multidisciplinary rounds, and central line and indwelling urinary catheter monitoring despite barriers, including staff turnover, a lack of time, staff fatigue and pandemic-related guidelines limiting providers' time around patients. We use four themes to summarise the ICU teams' adaptations that allowed them to sustain infection prevention activities: (1) Units had CLABSI and CAUTI prevention teams, policies and practices established prior to the pandemic; (2) Units were flexible in their implementation of those policies and practices; (3) Units maintained consistent buy-in for and engagement in HAI prevention activities among both leadership and care teams throughout the pandemic and (4) Units looked to learn from other units in their facility and beyond.

Conclusions Future shocks such as the pandemic must be anticipated, and the healthcare system must be resilient to the resulting disruptions to HAI prevention activities. This study encountered four themes for successful maintenance of infection prevention activities during the current pandemic: the value of a pre-existing infection prevention infrastructure; a flexibility in approach; broad buy-in for maintaining QI programmes and the facilitation of idea-sharing.

INTRODUCTION

The COVID-19 pandemic created many new barriers to providing high-quality care,¹

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The COVID-19 pandemic disrupted routine healthcare-associated infection prevention activities and caused elevated rates of infections across different healthcare settings.

WHAT THIS STUDY ADDS

⇒ This study summarises key themes learnt by intensive care units participating in a quality improvement programme implemented during the pandemic. It describes how units may adapt infection prevention activities to address disruptions due to major shocks to the healthcare system.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study identifies key themes for success in maintaining infection prevention activities in the midst of major disruptions. Specifically, it is important for teams to have policies and practices in place before a major shock occurs, be flexible in their application of those policies and practices, maintain broad buy-in for sustaining infection prevention activities across the organisation, and share ideas and learn from others.

resulting in increased healthcare-associated infection (HAI) rates across the US.² Multiple articles focusing on central line-associated bloodstream infections (CLABSI)³ and catheter-associated urinary tract infections (CAUTI)⁴ rates and prevention activities in hospitals during the pandemic report that CLABSI and CAUTI rates increased as the COVID-19 burden in these facilities increased.^{5 6} The association between COVID-19 surges and elevated rates of most HAIs emphasise the need for careful balancing of pandemic-related demands with routine hospital infection prevention (IP).⁷

Common COVID-19-related challenges have been reported in high-acuity settings such as intensive care units (ICUs), and some of these challenges likely contributed to the increased HAI rates.⁸ Participants identified a



number of challenges: a shortage of personal protective equipment (PPE), staffing shortages, high turnover, an influx of floating staff unfamiliar with the ICU, a decrease in frequency and number of clinical rounds, and reconciling rapidly changing and conflicting guidance on caring for COVID-19 patients.¹⁹ Furthermore, ‘pandemic fatigue’—a concept that people working in the midst of pandemic-related stressors became unmotivated to follow recommended protective behaviours—emerged over time, driven by various emotions, experiences and perceptions.¹⁰ Staffing challenges were notable as hospital leaders and staff were, out of necessity, extensively focused on the pandemic. Staffing shortages resulted in a reduction and relocation of staff and less time available to implement activities focused on quality improvement (QI), such as infection surveillance.^{11–13}

Resource constraints such as limited PPE and staff time led to delays in the provision of other care such as elective surgeries, which compete with patients suffering from COVID-19 for acute and critical care resources.¹⁴ Fu *et al* reported on the dangers of neglecting or delaying elective surgery due to COVID-19, stating delayed care will result in sicker patients.¹⁵ This conforms with earlier studies. Vogel *et al* found that in-hospital delay of elective surgery was associated with a significant increase in infectious complications.¹⁶ McMullen *et al* predicted increased use of femoral lines in the US during the pandemic due to the higher-than-average degree of acuity of patients being admitted to hospitals.¹⁷ As reported by Palmore *et al*, staff in COVID-19 wards in 2020 across the US reported an increased workload caring for these higher-acuity patients, resulting in a more challenging work environment that exacerbated the staffing problems outlined above.¹⁸ Other healthcare personnel reported needing to be re-educated or provided with reminders on basic IP to prevent HAIs due to conflicting guidance and various practice changes implemented during the pandemic or inexperience of staff reallocated to the ICU setting.¹ Furthermore, IP teams across the country reported changes to routine CLABSI and CAUTI prevention practices in ICUs, such as ‘less universal decolonisation, alterations in (central) line care due to intravenous pumps placed in hallways, line and dressing integrity gaps related to prone positioning of patients, opportunities in scrub-the-hub compliance, and increases in line draws for blood cultures.’¹⁹ These challenges only increased the burden on staff and made IP efforts more difficult.

Much of the published literature on CLABSI and CAUTI rates during the pandemic was concerned principally with the elevated rates of these infections and, to a lesser extent, the role QI programmes play in mitigating them.^{17 20 21} Yin *et al* conducted a broad-ranging literature review on the use of QI during the pandemic and found healthcare teams derived value from integrating QI into their pandemic response, specifically calling out benefits such as increased collaboration and learning from past emergencies.²² The value of a QI programme rests in units’ experiences and ability to tailor the usefulness

of the programme to local circumstances and external pressures.

McMullen *et al* recommended that IP specialists refocus on core IP surveillance tasks to decrease HAIs during the pandemic. These include increased central line and urinary catheter monitoring, emphasis on the importance of handwashing, and overall, the existence and implementation of IP surveillance.¹⁷ These common strategies had been significantly hindered by the onset of the pandemic.

However, to be successful, QI programmes should be well integrated into health systems to allow for closer collaboration with public health officials and subject matter experts (SMEs).²⁰ There is a strong need to develop effective tactics to support units to maintain the highest-quality IP and control activities while simultaneously promoting a strong response in the next pandemic. Basic IP practices must engage both IP specialists and bedside staff to integrate practices into routines. Training should be provided for all staff for the system to adapt when stressed.¹⁸ This paper seeks to elaborate on specific ways in which participating ICUs adapted an existing QI programme as well as their approaches to IP during the pandemic to meet their diverse and local needs.

Programme background

Launched in 2015 and running through 2021, the Agency for Healthcare Research and Quality (AHRQ) Safety Programme for ICUs: Preventing CLABSI and CAUTI, hereafter referred to as the AHRQ ICU Safety Programme, consisted of a series of six 12-month intervention periods aimed at helping ICUs with elevated CLABSI and/or CAUTI rates to reduce these rates using the AHRQ-developed Comprehensive Unit-based Safety Programme (CUSP). The CUSP model combines techniques to improve safety culture, teamwork and communications, together with clinical knowledge to provide a sustainable, actionable framework for teams to address quality issues.²³ Key elements of CUSP include guidelines for establishing a QI team within the care unit, understanding the science of safety, engaging leadership, identifying process defects that lead to harm and improving teamwork and communication across unit staff. The programme’s implementation team consisted of state leads from state hospital associations working directly with participating units and a national programme team (NPT) designing programme materials, such as webinars and on-demand learning modules, and facilitating cross-unit interaction and access to SMEs. Participating units agreed to implement several elements of CUSP, including the formation of a CUSP team, performing an ICU assessment to ascertain process defects, developing an action plan to ameliorate those defects, and engaging senior leadership and staff in the effort, but were otherwise self-directed in their implementation. This manuscript focuses on the sixth and final cohort of the programme, whose participation (December 2019–April 2021) overlapped with the pandemic.

As with previous cohorts, the last cohort, cohort 6, began with each unit providing a self-assessment of its current CLABSI and CAUTI prevention and safety culture practices to help the state leads and the NPT understand each ICU's unique needs. Using these ICU Assessments, units then worked to develop an action plan, which outlined the unit's goals for participation, the specific steps it would take to achieve them, and likely barriers. Units could participate in the programme's educational curriculum—a suite of webinars, on-demand learning modules and tools, coaching calls, training videos, and audio files—that emphasised both the technical and adaptive aspects of CLABSI and CAUTI prevention. Some units participated in site visits wherein state leads and, if requested by the state lead or unit, project-associated SMEs met with ICU staff to discuss the unit's challenges and provide coaching. When COVID-19 began to have a significant impact on participating units in March 2020, the programme instituted a 5-month pause, restarting in August 2020 after units communicated to state leads that they were ready to resume programme activities. At that time, units were given the opportunity to reassess their needs and alter their action plans if appropriate.

METHODS

This study involved a thematic analysis of qualitative data collected to facilitate implementation of the AHRQ ICU Safety Programme and the understanding of participants' experience. It provides a synthesis of data from the programme collected through: (1) ICU self-assessments, action plans and revised action plans; (2) interviews and conversations among the NPT, state leads and staff in participating units; (3) conversations between programme facilitators and unit staff under the aegis of state-led meetings held toward the end of the project; (4) conversations and chat logs from recordings of virtual learning group (VLG) webinars and (5) documentation of the monthly State Lead Action Council (SLAC) meetings, which consisted of regular discussions between NPT members and state leads.

Our study focuses on a series of four 30 min, semi-structured, retrospective exit interviews held between members of the NPT and 4 staff members, representing 11 of the participating units. These interviews were wide-ranging, aiming to obtain a holistic perspective from the units on the programme and their experience in it. These interviews did not use a previously validated questionnaire, instead aiming to gather feedback specific to the programme and its coincidence with the pandemic. Analytical methods used include coding of programme materials, review and synthesis of interview and conversation transcripts, and analysis for emerging themes.

RESULTS

Forty-nine ICUs from 37 hospitals across seven states (CT—12 units, IL—12 units, TN—11 units, PA—7 units, VA—4 units, RI—2 units and NH—1 unit) participated in

Table 1 Characteristics of participating intensive care units (ICUs) in the AHRQ ICU Safety Programme (final cohort)

Total no of units	49
No of beds per unit	
Mean (SD)	18.8 (8.2)
Median (range)	16.0 (8–40)
Unit size	N (per cent of total)
Small (1–5 beds)	0 (0.0)
Medium (6–15 beds)	20 (40.8)
Large (16–30 beds)	23 (46.9)
Very large (>30 beds)	6 (12.2)
National Healthcare Safety Network unit type*	N (per cent of Total)
Medical/surgical	25 (51.0)
Medical	8 (16.3)
Surgical	2 (4.1)
Surgical cardiothoracic	4 (8.2)
Medical cardiac	3 (6.1)
Neurosurgical	5 (10.2)
Neurologic	2 (4.1)

*The categorisation of ICU location types follows the definitions provided by the National Healthcare Safety Network (see 'Master Centers for Disease Control and Prevention Locations and Descriptions' table at https://www.cdc.gov/nhsn/pdfs/pscmanual/15locationsdescriptions_current.pdf).

cohort 6 of the AHRQ ICU Safety Programme. Characteristics of the participating ICUs appear below (see [table 1](#)). Participating ICUs tended to be larger, with no participating units having fewer than six beds. Participating units were predominantly medical/surgical units, though units specialising in cardiology and neurology were also represented. No oncology, burn or trauma units participated in this cohort. As for adoption of key CUSP principles, while there is no validated measurement tool for CUSP adoption, the state leads queried the participating units every quarter regarding their uptake of key CUSP principles. Between 80% and 90% of units adopted principles such as obtaining the support of senior leadership and identifying nurse and/or physician champions.

Quantitative evaluation of the programme revealed the unique circumstances of the sixth cohort and their impact on outcomes.²⁴ Cohorts 1–5 saw statistically significant decreases in device utilisation as well as CLABSI and CAUTI rates during both the preintervention period and during the year-long intervention. Cohort 6 saw decreasing trends in urinary catheter and central line utilisation in the preintervention period, which yielded to increasing device utilisation during the intervention. CLABSI and CAUTI rates were declining in the preintervention period and held steady during the intervention. No information on unit performance was collected after the yearlong intervention period. The analysis presented



here began largely as an attempt to understand the difference in the context and experience in the programme between cohort 6 and its earlier counterparts.

Participating units and the hospitals in which they resided reported experiencing the following aspects of the pandemic, similar to other hospitals across the nation. They described high rates of burnout among regular ICU staff. Float and contract staff brought in to support regular staff had limited experience with unit policies, protocols and interactions with the regular staff, and finding adequate time and resources to provide sufficient training to staff reallocated to ICUs was difficult. Units struggled, especially early in the pandemic, with obtaining access to sufficient PPE, leading to less time spent in patient rooms and limiting the capability to perform rounds at the bedside. Units also reported that non-COVID patients were generally more severely ill than prior to the pandemic, possibly due to delays in routine preventative care and deferrals of non-emergent care. Units described difficulty contending with rapidly changing and conflicting guidance from healthcare authorities. Finally, and most critically, participating units described having limited time to dedicate to core HAI prevention activities during the pandemic, with one unit explaining: ‘We fell, like, so flat on our face with ... CLABSI during the pandemic.... I think we were just in survival mode’ (Exit Interview, Participating Medical Critical Care ICU, 2021). Despite these barriers, teams found ways to return to QI and HAI prevention activities. Analysis of the qualitative data collected as part of the AHRQ ICU Safety Programme showed several emerging themes as to how they did so.

The value of an existing QI framework

Participants described the value of having a QI framework in place prior to the occurrence of a major systemic shock such as a pandemic. These ICUs were already engaged in a multistate QI programme before the pandemic began. When the cohort was reengaged in August 2020 following the March–July pause, ICUs reported that having the programme in place prior to the pandemic aided in continuing to focus on HAI prevention activities. One unit’s revised action plan named the fact that ‘protocols were already developed’ (revised action plan, Participating Neurological/Neurosurgery Critical Care ICU, 2020) as a major strength for them to lean on following reengagement. A participant from another unit stated: ‘Despite all the challenges, our rates of CAUTI and CLABSI remained below target level. This was due to our many initiatives already in place pre-COVID-19. We had just implemented our CUSP project’ (VLG Discussion, 20 August 2020).

Flexibility in application of policies and protocols

Participants reported that flexibility was key for teams to find ways to apply principles and adapt best practices amid pandemic challenges. This became particularly clear through the revised action plans and other materials

submitted during the pandemic. Unit goals were the most frequently changed section in revised action plans, with 20 of 49 participating units reporting changes. While most only adjusted the timeline for their goals to account for the gap period, two ICUs reported switching their focus from CLABSI or CAUTI alone to focus on both HAIs, indicating that once the programme restarted, some participants were able to scale up the programme, not roll it back, despite the pandemic: ‘So, we ended up doing Action Plans for both. Our primary focus was CAUTI, but we also included CLABSI in our rounding, and then (in) our action plan’ (Exit Interview, Participating Cardio/Cardiothoracic Critical Care Unit, 2021). Another ICU explained its ability to transfer the skills learnt prior to the pandemic to respond to shifting challenges: ‘We started off with CLABSI issues [we were able to resolve], and then we ended up with CAUTI issues. But we reapplied the same exact techniques’ (Exit Interview, Participating Medical Critical Care ICU, 2021).

ICUs embraced the opportunity to innovate on best practices amid pandemic challenges. During a VLG webinar, a representative from one unit described that ‘rapid change is now an everyday way of life’ (VLG Discussion, 17 December 2020). Another described her unit’s approach, saying, ‘We were a COVID ECMO [Extracorporeal Membrane Oxygenation] unit and were able to evolve and make improvements as time went on... In the beginning it was ... placement of IV lines outside rooms, writing basic info on patient doors, limiting and cooperating with housekeeping’ (VLG Discussion, 17 December 2020).

Considering the pandemic, other ICUs were able to find ways to flex key activities, such as their daily huddles. Huddles are short standup meetings (generally 10 min or fewer) involving frontline staff typically convened at the start of each shift, designed to give the care team a forum to maintain a focus on safety. One provider explained: ‘We still kept our morning huddle, which is just a period of time where we kind of talk about all things, all new information; it’s an opportunity for everybody to get together. It’s multidisciplinary where we talk about changes in policies or safety events or whatever it might be. Despite having COVID-19 [present in the ICU], we were able to modify ... but still maintained our huddle, which really allowed us to still disseminate information about CLABSI and provide information about how we were doing and what ... our project was and things that we were witnessing’ (Exit Interview, Participating Medical Critical Care ICU, 2021).

Participants also shared in webinars that multidisciplinary rounds were modified but still maintained to accomplish established protocols, such as discussion of line necessity. Multidisciplinary rounding is a strategy used by care teams to communicate and coordinate patient care plans. Ideally occurring at bedside, these rounds allow the care team to discuss, make joint decisions and manage responsibilities with the patient. Multiple teams among the participating units reported

conducting multidisciplinary rounds to discuss a patient's status and goals outside of the room and in an abridged form. This pandemic-induced practice change did not allow rounds to occur as they typically did pre-pandemic (ie, at the bedside) but still enabled cross-team communication and collaboration—keys to providing high-quality care. For example, these adapted rounds served as a venue for discussion around central line and indwelling urinary catheter necessity.

Importance of broad buy-in

The third key theme identified was continued buy-in from teams engaged in IP activities. Respondents to exit interviews reported higher team cohesiveness and commitment than they experienced prior to the pandemic. Participating units reported high levels of commitment to reducing CLABSI and CAUTI rates prior to the pandemic in their original action plans and ICU Assessments. Twenty-eight of the 49 units also reported that all members of their CUSP teams would continue to be engaged in their revised Action Plans. Unit leads were then able to capitalise on this high buy-in as the programme restarted. With COVID-19 waning in early 2021, ICUs reported more engaged physicians and nurses, more involved leadership, the resumption of daily multidisciplinary rounds, central line and indwelling urinary catheter insertion and maintenance audits, and more immediate root cause analyses of CLABSI and CAUTI events.

A revised action plan from one ICU described the unit's bolstered teamwork as the pandemic progressed, explaining that the group became 'more cohesive through the pandemic with the interventions to reduce CLABSI' (revised action plan, Participating Medical/Surgical ICU, 2020). Revised Action Plans noted greater buy-in of units on IP practices. During a monthly SLAC call, one of the state leads described the power of 'hearing what units had been through during reengagement calls ... and their commitment to CAUTI and CLABSI prevention amidst

COVID' (Monthly SLAC Call, State Lead, April 2021). One unit identified 'teamwork' (revised action plan, Participating Neurological/Neurosurgery Critical Care ICU, 2020) among the strengths that would help it tackle CLABSI and CAUTI during the pandemic.

Another strength was the engagement of leadership and champions as support for this work. During the pandemic, many ICUs noted, through action plans and interviews, facility leadership's engagement and strong messaging in support of the maintenance of IP activities. One unit's representative in an October 2020 virtual learning group webinar on leadership described that their 'senior team has taken on line utilisation as one of the daily PI [performance improvement] monitors so we report out [on] lines at our daily safety huddles' (VLG Discussion, 15 October 2020). Another stated, 'Our senior leadership is very engaged. The[y] round on CVADs [central venous access devices] and IUCs [indwelling urinary catheters]; we meet twice monthly' (VLG Discussion, 15 October 2020). Such strong signals of staff and leader involvement in the maintenance of IP activities, going as far as active leadership participation in rounds, became increasingly apparent once the programme restarted: 'Our medical director was on board; we had some of the NPs [nurse practitioners] that completely owned this, went all days, went all nights. So that was very helpful as well because to have them push to get these catheters out as early as possible really made a big difference' (Exit Interview, Participating Medical Critical Care ICU, 2021). Leadership across many participating units was clearly more engaged in IP by the end of 2020, relative to the pre-pandemic norm.

We also note that broader re-engagement following the restart of the programme across participating units is evident in programmatic data, primarily in ICU access of educational resources (webinars with NPT members and SMEs, on-demand training modules, recordings of

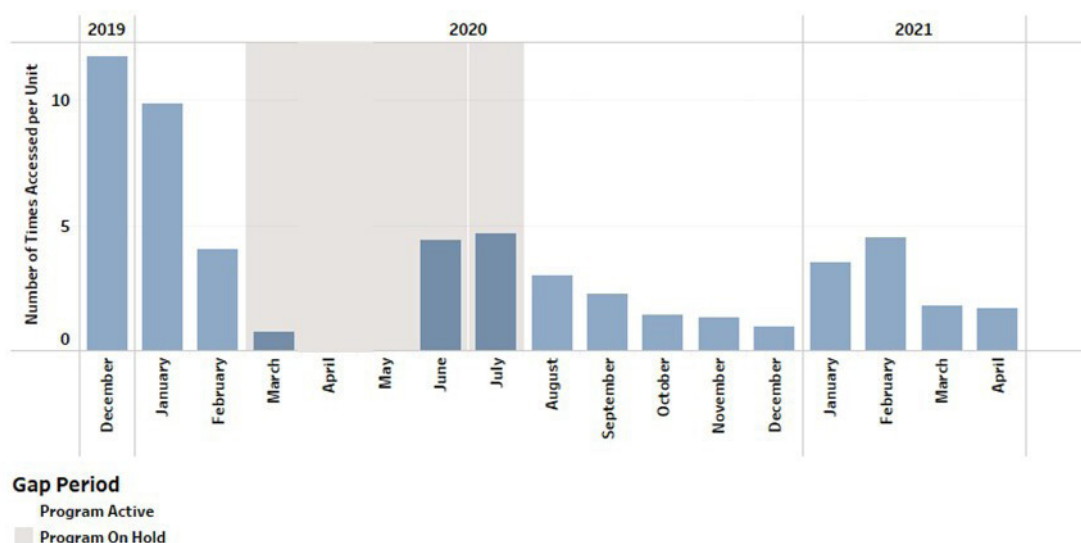


Figure 1 Rate of access of educational resources via website by participating ICUs. ICUs, intensive care units.

interviews with SMEs, onboarding webinars and tip/worksheets for CUSP concepts). In [figure 1](#), we show the patterns in educational resource access for cohort 6.

Offerings include webinars with NPT members and SMEs, on-demand training modules, recordings of interviews with SMEs, onboarding webinars and tip/worksheets for CUSP concepts.

After the programme pause, cohort 6 participants began accessing the educational materials at higher rates than other cohorts at the midpoint of the programme, when earlier cohorts had begun to see declining engagement (data not shown).

Utility of a peer network for knowledge sharing

Finally, units described that the ability to work with individuals outside their four walls was beneficial. Some units in the exit interviews reported increased overall communication and collaboration both within the unit and among different ICUs in their hospital because of the programme's focus on collaboration and networking described earlier. For example, several ICUs independently learnt lessons for CLABSI prevention for proning patients and thus were able to share and confirm best practices with each other, helping to deal with a novel issue around central line and indwelling urinary catheter maintenance. One unit described how the rounding process had been adjusted to account for staff's limited time, saying, 'With the surge [in COVID-19 cases], we have functional nursing roles that are supporting our intensive care staff so they have taken on dressing changes, etc, eg, central line and indwelling urinary catheter monitoring]' (VLG Discussion, 17 December 2020). During the pandemic, many new practices were rapidly developed, including adaptations to rounding in the halls with a reduced team described earlier and the central line monitoring for prone patients just described. The inter-facility communication facilitated by participation in the programme was crucial in sharing these new insights quickly.

DISCUSSION

The COVID-19 pandemic represented an overwhelming disruption to the US healthcare system. QI programme participants can offer a rich perspective into how they worked to mitigate that disruption and how they used QI resources to sustain a patient safety mindset during this challenging time. The themes that emerged from a review of these perspectives offer insights that can be applied within ICUs and other hospital units when caring for patients in the face of disruptions.

Responding units found great value in having a programme in place prior to the disruption of the pandemic. Flexibility in healthcare teams' approaches to IP allowed units creative space to overcome novel challenges. Broad buy-in from both leadership and staff ensured a structure to promote increased cohesiveness and commitment. In the context of a pandemic, team

cohesiveness and teamwork are essential for patient safety as they minimise adverse events caused by miscommunication and misunderstandings of roles and responsibilities.²⁵ Using the programme's communication network allowed key insights and adaptations to be shared and scaled up quickly. Taken together, these themes constitute a nimble approach to HAI prevention crucial to the maintenance of IP activities in the context of a major, disruptive shock.

Limitations

There are several limitations to our study. The primary limitation is that exit interviews were not conducted with all units. The analysis draws heavily from those voluntary exit interviews, and we lacked the same detailed insight into other units' thoughts and adaptations during the pandemic. Units who volunteered to offer feedback on their experience in the programme may have had different experiences than those who participated in the programme but did not volunteer for a qualitative exit interview.

In addition, the 11 ICUs about which we have detailed interviews had some similarities. The facilities were all large, university-affiliated teaching hospitals near a major city. Seven of the 11 units were large (>15 beds), with 3 of these having more than 30 beds. As a result, the findings of this study may not be generalisable to other healthcare settings.

In addition, some units provided more expansive and detailed descriptions of their goals, activities and challenges in action plans and ICU assessments. It is possible some underlying nuances regarding the challenges and barriers experienced by units that provided less detailed feedback were missed. To account for the relatively narrow subset of units on which our findings are based, we focused on the most broadly applicable themes for which there was saturation across sources rather than adaptations any particular unit made that may not be as useful to others.

Conclusion

We provided a summary of the themes for success uncovered from an analysis of qualitative data collected during the implementation of a QI programme focused on CLABSI and CAUTI reduction, which overlapped for the most part with the COVID-19 pandemic. We found that it is important for teams to have an infrastructure in place prior to the shock to ensure continuity of high-quality care, to remain flexible in the application of that infrastructure to account for barriers to the provision of routine care, to maintain broad buy-in for sustaining QI activities, and to participate in and take advantage of peer networks to share best practices and learn from others. We believe these themes for success are broadly applicable to addressing the QI challenges in many different settings and are likely effective methods for ensuring care that is both resilient and high quality.

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REFERENCES

- Rebmann T, Alvino RT, Mazzara RL, *et al*. Infection preventionists' experiences during the first nine months of the COVID-19 pandemic: Findings from focus groups conducted with Association of Professionals in Infection Control & Epidemiology (APIC) members. *Am J Infect Control* 2021;49:1093–8.
- Weiner-Lastinger LM, Pattabiraman V, Konnor RY, *et al*. The impact of coronavirus disease 2019 (COVID-19) on healthcare-associated infections in 2020: a summary of data reported to the National healthcare safety network. *Infect Control Hosp Epidemiol* 2022;43:12–25.
- Centers for Disease Control and Prevention. Central line-associated bloodstream infection (CLABSI). Available: <https://www.cdc.gov/hai/bsi/bsi.html> [Accessed 4 Feb 2022].
- Centers for Disease Control and Prevention. Catheter-Associated urinary tract infections (CAUTI). Available: https://www.cdc.gov/hai/ca_uti/uti.html/ [Accessed 4 Feb 2022].
- Knepper BC, Wallace K, Young H. 95. CAUTI and CLABSI in hospitalized COVID-19 patients. *Open Forum Infect Dis* 2020;7:S178.
- Baker M, Sands K, Huang S. The impact of coronavirus disease 2019 (COVID-19) on healthcare-associated infections. *Clin Infect Dis* 2021;ciab688.
- Centers for Disease Control and Prevention. COVID-19 impact on HAIs in 2020. Available: <https://www.cdc.gov/hai/data/portal/covid-impact-hai.html> [Accessed 4 Feb 2022].
- Baccolini V, Migliara G, Isonne C, *et al*. The impact of the COVID-19 pandemic on healthcare-associated infections in intensive care unit patients: a retrospective cohort study. *Antimicrob Resist Infect Control* 2021;10:87.
- US Department of Health and Human Services: Office of the Inspector General. Hospital experiences responding to the COVID-19 pandemic: results of a national pulse survey March 23-27, 2020. Available: <https://oig.hhs.gov/oei/reports/oei-06-20-00300.pdf> [Accessed 4 Feb 2022].
- World Health Organization. Pandemic fatigue: reinvigorating the public to prevent COVID-19. Available: <https://apps.who.int/iris/bitstream/handle/10665/335820/WHO-EURO-2020-1160-40906-55390-eng.pdf> [Accessed 4 Feb 2022].
- Bailey H, Kaplan LJ. Enhancing non-ICU clinician capability and ICU bed capacity to manage pandemic patient surge. In: Vincent JL, ed. *Annual update in intensive care and emergency medicine 2021*. Springer, 2021: 295–304.
- Vera San Juan N, Clark SE, Camilleri M, *et al*. Training and redeployment of healthcare workers to intensive care units (ICUs) during the COVID-19 pandemic: a systematic review. *BMJ Open* 2022;12:e050038.
- Marks S, Edwards S, Jerge EH. Rapid deployment of critical care nurse education during the COVID-19 pandemic. *Nurse Lead* 2021;19:165–9.
- Krishnamoorthy V, Ohnuma T, Bartz R, *et al*. Acute care resource use after elective surgery in the United States: implications during the COVID-19 pandemic. *Am J Crit Care* 2021;30:320–4.
- Fu SJ, George EL, Maggio PM, *et al*. The consequences of delaying elective surgery: surgical perspective. *Ann Surg* 2020;272:e79–80.
- Vogel TR, Dombrovskiy VY, Lowry SF. In-Hospital delay of elective surgery for high volume procedures: the impact on infectious complications. *J Am Coll Surg* 2010;211:784–90.
- McMullen KM, Smith BA, Rebmann T. Impact of SARS-CoV-2 on hospital acquired infection rates in the United States: predictions and early results. *Am J Infect Control* 2020;48:1409–11.
- Palmore TN, Henderson DK. Healthcare-Associated infections during the coronavirus disease 2019 (COVID-19) pandemic. *Infect Control Hosp Epidemiol* 2021;42:1372–3.
- Fakih MG, Bufalino A, Sturm L, *et al*. Coronavirus disease 2019 (COVID-19) pandemic, central-line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI): the urgent need to refocus on hardwiring prevention efforts. *Infect Control Hosp Epidemiol* 2022;43:26–31.
- Dhar S, Sandhu AL, Valyko A, *et al*. Strategies for effective infection prevention programs: structures, processes, and funding. *Infect Dis Clin North Am* 2021;35:531–51.
- Stifter J, Sermersheim E, Ellsworth M, *et al*. COVID-19 and nurse-sensitive indicators: using performance improvement teams to address quality indicators during a pandemic. *J Nurs Care Qual* 2021;36:1–6.
- Yin XC, Pang M, Law MP, *et al*. Rising through the pandemic: a scoping review of quality improvement in public health during the COVID-19 pandemic. *BMC Public Health* 2022;22:248.
- Agency for Healthcare Research and Quality. AHRQ's healthcare-associated infections program. Available: <https://www.ahrq.gov/hai/cusp/index.html> [Accessed 4 Feb 2022].
- Molefe A. AHRQ Safety Program for Intensive Care Units: Preventing CLABSI and CAUTI - Final Report. Available: <https://www.ahrq.gov/sites/default/files/wysiwyg/hai/tools/clabsi-cauti-icu/clabsi-cauti-icu-report.pdf> [Accessed 29 Aug 2022].
- Babiker A, El Hussein M, Al Nemri A, *et al*. Health care professional development: working as a team to improve patient care. *Sudan J Paediatr* 2014;14:9–16.