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From ICU to hospital-wide: extending central line associated bacteraemia (CLAB) prevention

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Abstract

Aim To decrease hospital-wide central line associated bacteraemia (CLAB) by spreading the prevention programme beyond the intensive care unit (ICU) in a secondary care hospital in Auckland, New Zealand.

Method Over 15 months, four general surgical wards, five inpatient units, and surgical theatres adopted the quality improvement initiative, and were followed for a further 15 months. The initiative included central line insertion and maintenance checklists, a central line insertion pack, training in central line care, and a dedicated database. In addition, a checklist to assess the readiness of each new area was developed; data collection and analysis processes embedded, with rapid feedback to staff and in-depth review of all CLAB events.

Results Compliance measures improved significantly (compliance with insertion increased from a mean of 84% to 92% p=0.001; maintenance from 64% to 85%, p=0.002). The absolute numbers of CLAB fell hospital-wide from a mean of 2.3/month to 0.56/month. The rate of CLAB hospital-wide decreased from 7.04/1,000 line days to 1.37/1,000.

Conclusion We have demonstrated that the CLAB prevention work proven effective in the ICU can be successfully adapted and expanded to the rest of the hospital. As central lines are increasingly inserted in units outside the ICU, and maintained in general wards, this work provides some useful insights into tackling this larger problem.

Central line associated bacteraemia (CLAB) ranks as one of the most frequent and serious nosocomial infections[1] with high mortality rates.[2] It also puts an economic burden on healthcare systems with increased hospital stays and total hospital costs.[3]

In 2004, Berenholtz et al[4] showed that it was possible to significantly reduce CLAB rates in an intensive care unit (ICU), and later this group extended the work to over 100 intensive care units in Michigan state, USA.[5] The improvement came through a multifaceted programme that included a checklist of evidence-based practices focussing on five key elements: maximal sterile precautions when central lines were inserted; hand hygiene, chlorhexidine skin antisepsis, optimal site selection for insertion and daily review of the need for a central line.

A review of this work identified that part of the success was the reframing of CLAB as a social problem and addressing it through a professional movement, strong networks, and "using several interventions that functioned in different ways to shape a

culture of commitment to doing better in practice."[6] This challenged the conventional wisdom that viewed CLAB as an inevitable complication of intensive care.[7]

We have previously published in this journal the results of the first New Zealand CLAB prevention initiative, which started in 2008. Our ICU CLAB rate was unacceptably high at 6.6/1,000 line days, and over the next 2 years—building on the Michigan work—we were able to reduce this to a mean rate of 1.3/1,000 and a median of zero.[7,8]

In this paper we report on how we have extended this quality improvement initiative to the rest of the hospital, with significant reductions in CLAB rates.

Auckland's Middlemore Hospital is a 900-bed secondary care hospital, providing some tertiary care including the National Burns Centre(NBC), serving a population of approximately 500,000. Although many central lines are inserted in the ICU, large numbers are also inserted in the Renal Service, Neonatal Unit (NNU), Theatre and Radiology. Radiologists predominantly insert peripherally inserted central venous catheters (PICC), though studies suggest that the rate of infection associated with these lines are similar to conventional central lines.[9] Increasingly patients with central lines *in situ* are nursed on the general wards.

A review of CLAB throughout the Hospital indicated that the Neonatal Unit, Renal Service and Surgical wards were key areas where CLAB rates were high.

A sequential approach was taken over 15 months, starting with areas that expressed willingness to be involved, and extending to include all that inserted or maintained a large number of central lines. In some areas (e.g. Theatres and the Renal Service) the initiative centred on ensuring safe central line insertions, and in others (such as the general surgical wards), the focus was on safely maintaining the line.

The wider hospital was a greater challenge than the circumscribed ICU, and required a different approach.

Method

A working group met for 1 hour each week. The team included the ICU Quality Coordinator, an Infection Prevent & Control Nurse, IV Clinical Nurse Specialist and the Clinical Director for the Centre for Quality Improvement. As each ward or unit joined the initiative, they added representatives to this group.

Checklists

From October 2010 to February 2012, 10 clinical areas engaged with the CLAB prevention programme, starting with Emergency Care and ending with Radiology. A separate roll-out checklist was developed that identified critical aspects to address prior to implementation. This ensured that the leadership (clinical and managerial) in each unit was supportive, all staff were informed, and a clinical champion was identified.

Responsibility for data collection in each area was assigned and supported. Data on CLAB numbers were presented to meetings of clinician's along with both local and international evidence of CLAB prevention success.

Working with the staff involved, the central line insertion and maintenance checklists developed in ICU were modified where necessary to incorporate any unit-specific

differences (see Figure 1). Changes included accommodating different insertion sites (e.g. umbilical for neonates) and nursing shifts (12 and 8 hour shifts). Definitions of what constituted a 'high-risk' line were refined (e.g. inserted under emergency conditions, line used for total parenteral nutrition) for each area.

Each unit developed their own way of collecting the checklists and assigned staff to enter the data.

Figure 1. Maintenance Checklist

COUNTIES MANUKAU DISTRICT HEALTH BOARD
A Community Partnership

CLAB MAINTENANCE CONTINUATION CHECKLIST

Preventing Central Line Infections in CMDHB

ID

CONTINUATION SHEET
To be attached to the CLAB Insertion Checklist

Patient Name
NHI Number
Affix patient's identification label here

PLEASE COPY FOLLOWING INFORMATION FROM INSERTION CHECKLIST

Date Line Inserted	Time Line Inserted:

Insertion side: Right Left
Insertion site: Subclavian Jugular Basilic Cephalic Femoral Sapheneous
Umbilical Other: _____
Catheter Type: Non-Tunnelled PICC Vas Cath Tunnelled Implanted Vascular Device
Other: _____

High Risk Line/Patient
Burns, emergency insertion, TPN, ICU stay >7 days, immunocompromised, rewired
Consider using preventative strategies e.g. Chlorhexidine Impregnated Dressing, Antibacterial Line

Ward/Unit:	Line Day:	Today's Date:	Yes	No	Time Removed:
Was the Central Line reviewed for necessity today?					
Was the Central line removed today?					
Is IVN/TPN being infused?					Comments:
If yes, is dedicated port being used for the IVN/TPN?					
Did you check the site today for inflammation? **If any signs of infection present review the catheter promptly**					
Is this a High Risk Line/Patient? (See Criteria over page)					
Is there a prevention measure in place? e.g. CHG Impregnated Dressing					
Did you scrub the hub for 15 seconds with 2% CHG in 70% alcohol prior to accessing the injection ports each time?	AM Shift	8hr / 12 hr			☐ Not accessed
	PM Shift	8 hr			☐ Not accessed
	Night Shift	8 hr / 12 hr			☐ Not accessed

The insertion pack previously developed for the ICU was modified to suit different patient needs. The renal patients required a different sterile drape (with a larger aperture) and the neonatal unit needed a drape for their small patients (prior to this initiative they had made do with four small drapes held together with bull clips). Both these drapes were developed and procured.

The pack was designed to decrease the time taken by staff putting together all the equipment needed for each insertion, and to encourage compliance. On opening the

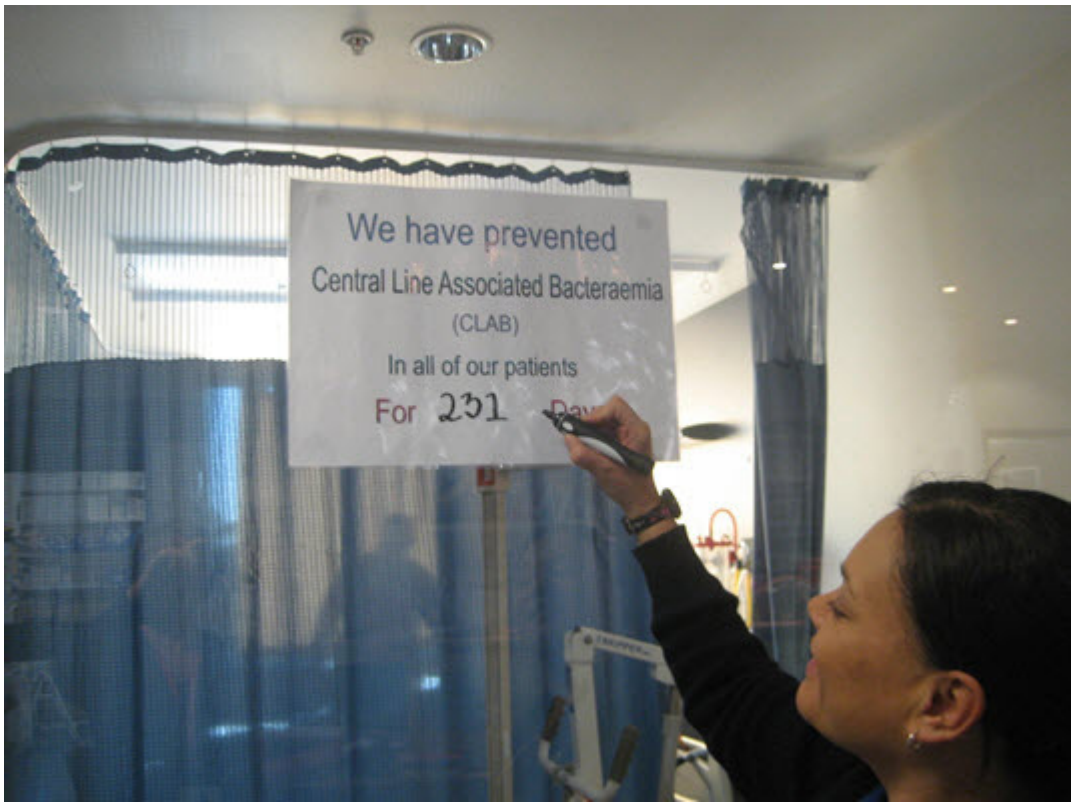
sterile pack, the first thing the clinician sees is the hat and mask, after putting these on, the pack opens further and the sterile gown is presented, before the insertion tray is found, including the appropriate skin preparation (e.g. for adults chlorhexidine 2% in 70% alcohol). The pack was entered into the hospital ordering system so that units could order their own supply.

The central line database developed for ICU was modified to allow each unit/ward to record line insertion and line maintenance data for their patients.

On the wards, at least two staff (usually nursing) were identified to input the central line data, with rapid summary results available (no more than two mouse clicks to produce graphs of outcomes and compliance).

Each unit placed a poster in a prominent place that recorded the number of CLAB-free days (see Figure 2)

Figure 2. Daily feedback by staff on CLAB-free days



Each CLAB was identified independently by a microbiologist and Infection Prevention & Control nurse specialist, using the CDC surveillance definition for CLAB. [10]

If a CLAB occurred, the clinical team were notified immediately. Each CLAB was treated as a sentinel event and the clinical staff were provided with a standardised electronic form to record their investigation findings. These were reviewed at the

working group meetings and learning's from these investigations were shared with all areas, with an emphasis on quality improvement rather than criticism.

Data analysis

Process measures—Compliance with the insertion checklist was measured for units that only inserted lines (Theatre, Radiology, Emergency Care and Renal Services). The compliance with the maintenance checklist was measured for those units that did not insert lines, but only cared for patients with central lines already in situ (NBC, and Surgical wards). And both processes were measured for the NNU, which inserted and maintained lines.

Balancing measures—We retrospectively measured the number of blood cultures completed from the surgical wards, NBC and NNU. A significant drop in blood cultures could have affected the determination of a CLAB, which is reliant on adequate blood cultures being taken. We were unable to retrospectively measure blood cultures per 1,000 line days so have instead used a proxy measure of blood cultures/1,000 bed days.

Outcome measure—The absolute numbers of CLAB for each unit and the hospital overall (excluding ICU) were measured and combined with the total line days to get a rate of CLAB per 1,000 line days.

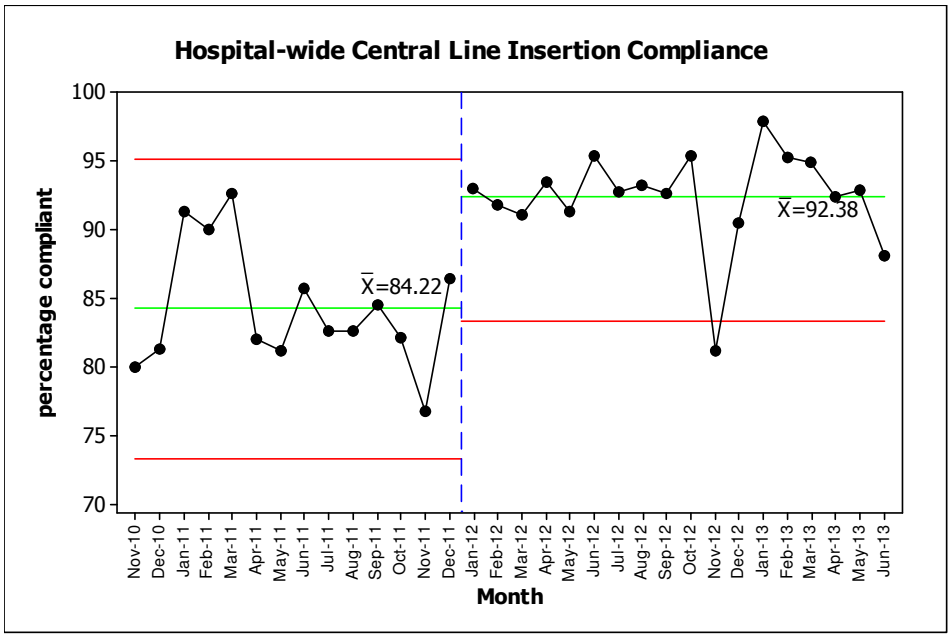
Mintab® was used to produce statistical process control charts. The process measures were plotted as an "I chart" (using % compliance) while the CLAB rate used a "U chart." [11] A two-sampled t-test was used for the difference in means when a statistically significant shift was demonstrated. The blood culture rate over three years was evaluated using the non-parametric Mann-Whitney U test.

Results

Process measures

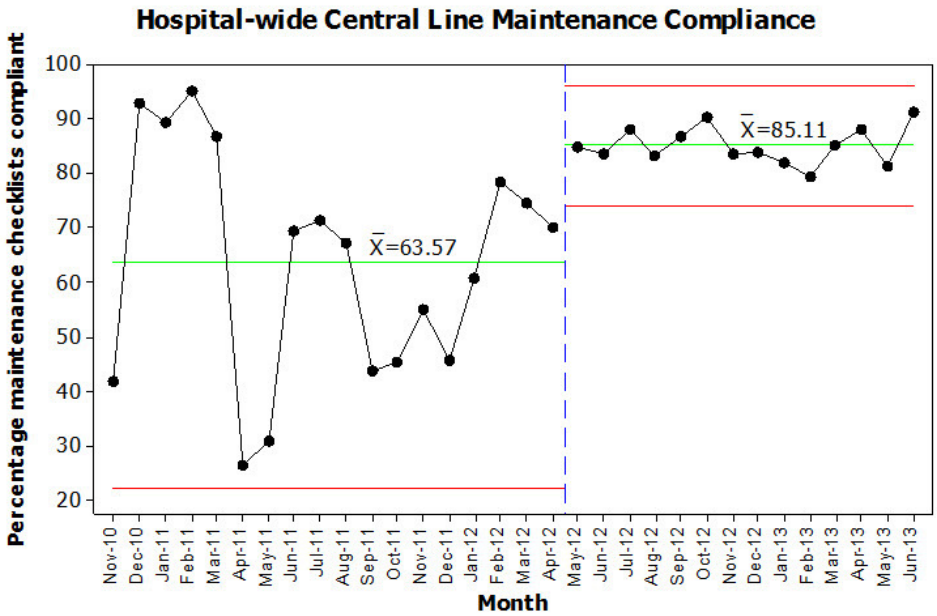
Compliance with the Insertion Checklist—This measured compliance in Theatre, NNU, Emergency Department, Renal Unit and Radiology. The 'I chart' demonstrates a statistically significant shift in January 2012, with an increase in the mean compliance from 84.22 to 92.38% (see Figure 3). The difference between these two means was significant at the 0.05 level (p=0.001).

Figure 3. Insertion Checklist compliance



Compliance with Maintenance Checklist—This included the NNU, the NBC, and four general surgical wards. The chart (figure 4) shows a statistical shift (p=0.002) in February 2012, with an increase in mean compliance from 63.5 to 85.1%. The degree of variation also decreased significantly with a SD of 21.2 in the first phase and 3.76 in the second.

Figure 4. Maintenance Checklist compliance



Balancing measures—There was no statistically significant differences found between the blood culture rate per 1,000 bed days taken on the surgical wards, the NBC or the NNU in 2010 and 2011 (p=0.13), 2011 and 2012 (p=0.18) or 2010 and 2012 (p=0.86). See Figure 5.

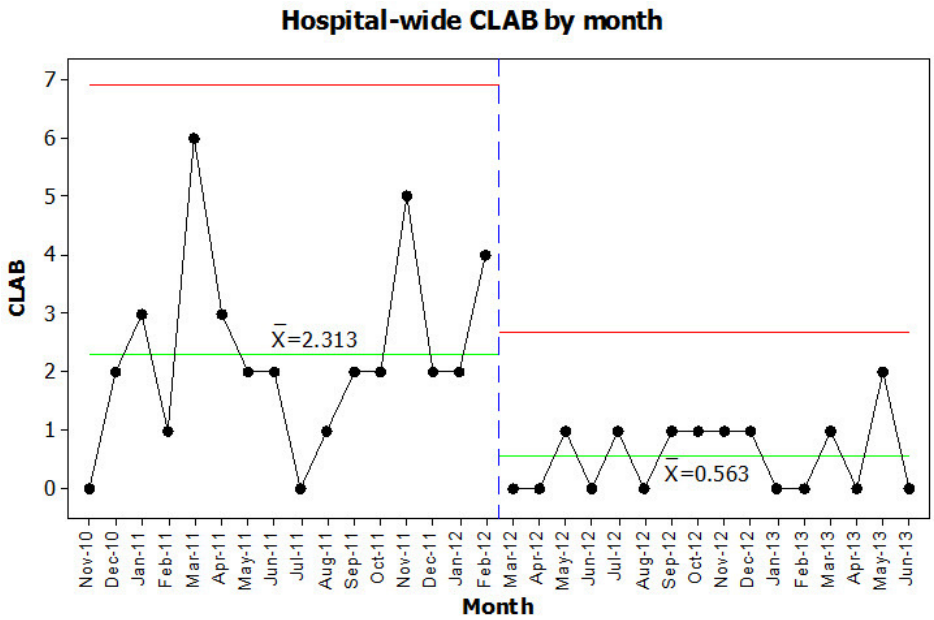
Figure 5. Blood culture numbers/1,000 bed-days

Ward	Blood cultures/1,000 bed-days		
	2010	2011	2012
Gen Surg A	35.24	26.74	27.52
Gen Surg B	21.53	22.17	27.76
Gen Surg C	23.36	20.77	25.14
Gen Surg D	24.96	18.28	22.07
National Burns Centre	26.46	16.00	28.56
Neonatal Unit	75.69	51.41	66.21
Median	33.14	30.04	34.33

Outcome measures—The absolute numbers of hospital-wide (excluding ICU), inpatient CLAB (Figure 6) fell significantly in March 2012, with 8 months in which there were zero in-hospital CLAB infections.

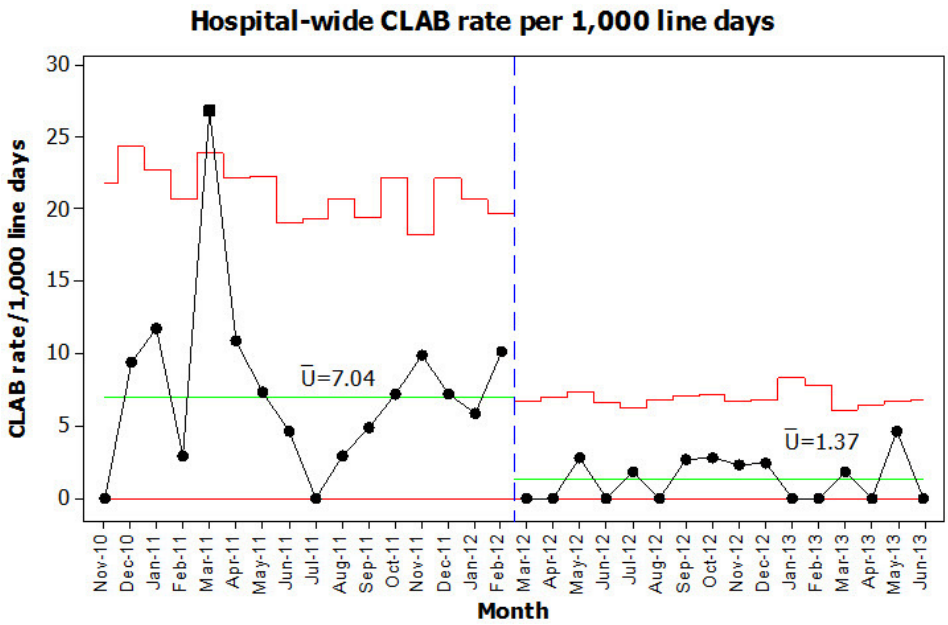
The NNU, that previously had 2 or 3 CLAB per month prior to the initiative, went several months without a CLAB. Likewise several surgical wards had over 200 days between CLAB infections.

Figure 6. Hospital-wide CLAB numbers



The rate of CLAB/1,000 days also showed a shift in March 2012 (Figure 7), which has been maintained for more than a year, with a mean of just over 1 CLAB/1,000 line days, down from 7.04/1,000. The degree of variation also decreased in the second phase (SD 6.30 to 1.5).

Figure 7. Rate of hospital-wide CLAB per 1,000 line days



Discussion

Central line associated bacteraemia is a serious healthcare associated infection, and our study has shown that the lessons learned in ICU CLAB prevention can be extended into other units and wards in the hospital.

We have shown a reduction in the rate of hospital CLAB to just over 1/1,000 line days. The improvement came after an increase in compliance with the insertion checklist, and a little later, an improvement in compliance with the maintenance bundle. This improvement and the decrease in CLAB rate has been maintained for over a year.

The effort to engage the ICU in CLAB prevention was considerable, as it challenged the attitudes of healthcare professionals, their wariness of standardised medicine, their reticence to use checklists,[12] and their concerns about having their practice scrutinised by other staff members.[13]

The challenge was far greater outside the ICU with many more staff involved, and some of the same attitudes. Although we had shown that our checklists had been part of the improvement in the ICU, medical professionals in particular wanted to be shown the evidence for each component of the checklist and some routinely refused to comply (one clinician steadfastly refused to wear a hat and mask when inserting a central line meaning that none of his insertions were compliant).

One of the biggest challenges was having a system to measure line days. We had managed this in the ICU, but line days and indeed patients with central lines were not routinely measured on the wards. Systems also had to be developed to measure compliance with the maintenance of the line; this is considerably more complicated than compliance with line insertion which is a one-off event.

There is a cap on hiring administrative staff in New Zealand hospitals so this data entry tended to be done by frontline staff. Though not an ideal use of their time, it did mean that they could spot problems with compliance and discuss directly with medical or nursing staff. It also ensured clinical engagement and a clinical champion or champions in each area.

It took just over a year to engage all the wards/units and there were several false starts. This can be seen in both the insertion and maintenance compliance charts. Maintenance compliance improved from 40% to over 90% in the first few months; however, this was only sustained for four months before decreasing again to 20%.

Sometimes this was due to changing personnel (a supportive charge nurse resigning), new units coming on board and taking time to come up to speed, and sometimes the collective focus on the initiative was lost amongst all the other quality improvement initiatives going on in the hospital.

Perseverance from the working group, and a focus on providing support and education to staff, along with the identification of CLAB as a preventable sentinel event, helped to ensure high compliance for the last year with the insertion and maintenance checklists, and this is mirrored in the continued low rate of CLAB.

The CVL insertion compliance showed a statistical shift starting in January 2012. The improved compliance with the maintenance checklist started in February 2012 and the shift was confirmed in May. The CLAB rate shift started in March – at a time when both compliance rates were high.

Standardising the care of all central lines ("its what we do") and incorporating the maintenance checklist into the record of nursing care was useful to build buy-in from the nursing staff.

The insertion pack also proved to be an advantage in spreading the improvement outside the ICU. The packs were very tangible symbols, and they were also designed to encourage good, safe central line insertion practice - it made doing the right thing the easy thing to do.

There have been few other studies reporting CLAB prevention initiatives outside the ICU. A recent Spanish study in a 350-bed hospital,[14] estimated that more than 85% of CLAB occurred in the non-ICU setting and they were also able to demonstrate a decrease in CLAB rate from 15.1/1,000 line days to 10.1 after introducing an insertion checklist.

A Thai tertiary hospital, using a mixture of QI methods with a strong emphasis on hand hygiene, resulted in a decrease in CLAB rates from a high starting point (14/1,000 line days) to 1.4/1,000.[15] They had an endemic rate of *Acinetobacter baumannii* in their ICU at the start of the project and initiated a number of interventions to get this under control.

Cincinnati Children's Hospital—a quaternary centre—used a QI collaborative in 3 critical care units, oncology and bone marrow transplant units, and medical and surgical wards. They started with a low rate of catheter-associated bloodstream infections (3.0/1,000 line days) and decreased this further to less than 1.[16]

Another American paediatric tertiary hospital also showed a reduction in CLAB in their 18-bed paediatric oncology unit with the introduction of the maintenance bundle.[17]

These studies were carried out in tertiary/quaternary hospitals and included the ICU in their work. Our study was in a large secondary care hospital and excluded ICU. The studies mentioned above, used a variation on the Michigan work and our paper lends support to the evidence that such improvement work can be successful outside the ICU.

There are some limitations to our study. First, we cannot rule out that other unknown influences led to the reduction in CLAB rates outside the ICU. We have no data from other centres in New Zealand to compare ourselves with as no other hospital was collecting line days outside the ICU. Second, we were unable to measure blood culture rates in patients with lines in situ and had to use a proxy measure of blood cultures/1,000 bed-days. We were not able to detect a significant difference in these rates over the study period which gives us some confidence that the decrease in CLAB rates was not due to decreases in blood cultures taken, but it is only an approximation. Third, like the other studies in this area, this work was done in a single institution. The success may not be replicable at other centres with different organizational cultures.

The group is now working on decreasing CLAB further with a focus on outpatient haemodialysis and maintenance of central lines in theatre.

Conclusion

CLAB prevention strategies that have been shown to work in the ICU can be amended and successfully used in other hospital areas. The challenges in CLAB prevention are similar, albeit on a wider scale.

We have shown a significant reduction in CLAB rates for the last 12 months—we were able to decrease CLAB rates from 7.04/1,000 lines days down to 1.37 hospital-wide—and the CLAB prevention initiative is now business as usual in 10 units/wards.

Competing interests: Nil.

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