

Preventing Central Venous Catheter Related-Bloodstream Infections

Toolkit

Published by the Rural and Regional Health and Aged Care Services Division,
Victorian Government Department of Human Services, Melbourne Victoria.

December 2005

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Department of Human Services website at www.health.vic.gov.au/sssl

Website www.health.vic.gov.au/sssl

Version history

Date	Version	Author	Comments
30 Sep 2005	1	Andrew Clarke	First version for general distribution.
14 Nov 2005	2	Andrew Clarke	Incorporates comments and feedback resulting from the orientation sessions.
14 Dec 2005	3	Andrew Clarke	Final version prior to implementation includes amendments from expert panel consultation.
8 June 2007	4	Andrew Clarke	Corrections to citation of Reference #3
14 June 2007	5	Jeannette Bell	Update contacts

Acknowledgements

This document is an adaptation of the Getting Started Kit: Prevent Central Line Catheter Related-Bloodstream Infections – How-to Guide prepared by the Institute for Healthcare Improvement www.ihl.org/IHI/Programs/Campaign/

The Department of Human Services (Victoria) would like to thank the expert panel members for their valuable contributions in the consultation process for the Preventing Central Venous Catheter Related-Bloodstream Infections toolkit. They have generously shared their insights, successes and lessons learned; in doing so, they have paved a path that many will follow.

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Foreword

Safer Systems – Saving Lives is a national collaborative initiated by the Australian Council for Safety and Quality in Health Care. The aim of the Safer Systems – Savings Lives project is to provide tangible evidence on the impact of six key interventions when applied consistently and comprehensively in Australian hospitals. The interventions are based on scientific evidence and known to improve patient care and prevent avoidable deaths. The six interventions are:

- Preventing ventilator-associated complications
- Preventing surgical site infection
- Preventing central venous catheter related-bloodstream infections
- Implementing a rapid response system
- Preventing adverse drug events
- Improving care for acute myocardial infarction.

The interventions are based on implementing a formalised process or applying a 'bundle' of care components. The care bundle builds on the concept that, whilst each component is of value, if all elements of the 'bundle' are used, the prevention factor is increased.

The Quality and Safety Branch of the Department of Human Services in Victoria will provide organisational lead and overarching project management for the SSSL project. Commencing in early 2006 the project will be implemented in hospitals across Australia. More information on the project and the interventions can be found on the Safer Systems – Saving Lives website at www.health.vic.gov.au/sssl

Safer Systems – Saving Lives project is based on the 100,000 Lives Campaign, an initiative by the Institute for Healthcare Improvement (IHI). The IHI care bundles and measures have been adapted to suit the Australian context with the assistance of expert panels. Through the implementation of the six interventions the 100K campaign aims to avoid 100,000 deaths by June 2006, and every year thereafter. More information on the institute and the 100K campaign can be found on the IHI website (<http://www.ihl.org>).

Introduction

What are central venous catheter related-bloodstream infections?

A central venous catheter related-bloodstream infection (CVC-BSI) is a bloodstream infection most likely caused by the presence of a central venous catheter (CVC).

What is the aim of preventing CVC-BSIs?

To prevent CVCR-BSIs by implementing the components of care called the 'CVC bundle'.

The case for preventing CVC-BSIs

CVCs are being used increasingly in the inpatient and outpatient setting to provide long-term venous access. CVCs disrupt the integrity of the skin, making infection with bacteria or fungi possible. Infection may spread to the bloodstream and hemodynamic changes and organ dysfunction (severe sepsis) may ensue, possibly leading to death. Approximately 90 per cent of the CVCR-BSIs occur with CVCs¹.

In addition, nosocomial bloodstream infections prolong hospitalisation by seven days. Estimates of attributable cost per bloodstream infection are between \$3,700 and \$29,000².

The current situation

It has been reported that in Australia more than 3,500 intravenous BSIs occur annually, with the number of CVCR-BSIs occurring at a rate of 23 per 1,000 catheters. A directly attributable mortality for all intravenous BSIs is reported as 12 per cent³.

With the establishment in Victoria of the VICNISS Hospital Acquired Infection Surveillance System, data for 2003–04 demonstrates CVCR-BSIs occurring in large Victorian hospitals at a rate of about six infections per 1,000 catheter days in intensive care unit (ICU)⁴.

Potential impact of preventing CVC-BSIs

Application of the CVC bundle has demonstrated striking reductions in the rate of CVCR-BSIs in many hospitals. Berenholtz et al. demonstrated that ICUs that have implemented multifaceted interventions similar to the CVC bundle have nearly eliminated CVC-BSIs⁵.

The success of these interventions is perhaps due to a combination of the mindfulness that develops when regularly applying the elements of the bundle and the particular bundle elements themselves. For example, as shown in table one, there have been two studies that have shown that the application of maximal barrier precautions substantially reduces the odds of developing a bloodstream infection.

Table one: Odds ratio for infection without maximal barrier precautions

Author/date	Design	Catheter	Odds Ratio for infection w/o MBR
Mermel 1991	Prospective Cross-sectional	Swan-Ganz	2.2 (p<0.03)
Raad 1994	Prospective Randomized	Central	6.3 (p<0.03)

Mermel et al. demonstrated that the odds ratio was 2.2 times greater for infection without maximal barrier precautions⁶, while Raad et al. demonstrated a 6.3 times greater likelihood for infection without precautions⁷.

The components of care

Care bundles, in general, are groupings of best practice interventions with respect to a disease process, which individually improve care, but when applied together result in a substantially greater improvement. The science supporting each bundle component has been sufficiently established as the standard of care.

The CVC bundle is a group of evidence-based interventions for patients with central intravascular catheters that, when implemented together, result in better outcomes than when implemented individually.

Compliance with the CVC bundle can be measured by simple assessment of the completion of each item. The approach has been most successful when all elements are executed together — an ‘all or none’ strategy.

A helpful guide to setting up care bundles is provided by the Department of Health (UK) ⁷.

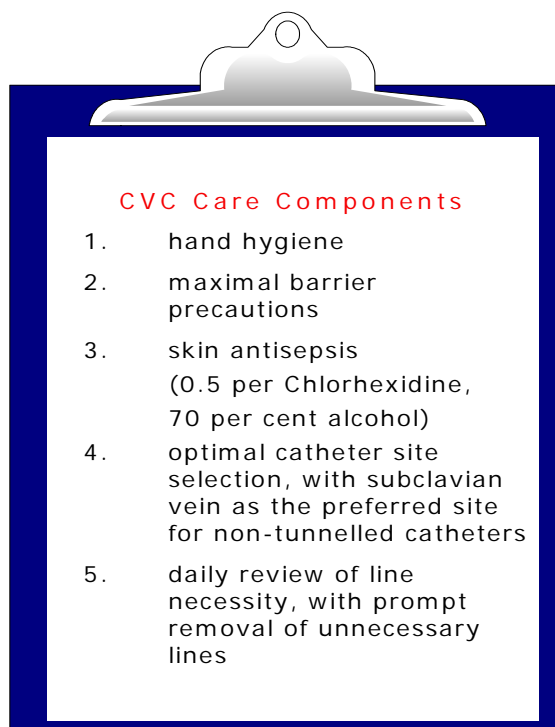


Figure one: CVC Care Components

1. Hand hygiene

One way to decrease the likelihood of CVC infections is to use proper hand hygiene. The use of a three minute surgical hand wash for insertion and replacement and using an alcohol-based waterless hand cleaner at all other times helps prevent contamination of CVC sites and resultant bloodstream infections⁸.

What changes can we make that will result in improvement?

When caring for CVCs, appropriate times for hand hygiene include:

- before and after palpating catheter insertion sites (palpation of the insertion site should not be performed after the application of antiseptic, unless aseptic technique is maintained)
- before and after inserting, replacing, accessing, repairing or dressing an intravascular catheter
- when hands are obviously soiled or if contamination is suspected
- before and after invasive procedures
- between patients
- before donning and after removing gloves, and
- after using the bathroom.

⁷<http://www.wise.nhs.uk/sites/wisemforum/High%20Impact%20Changes/High%20Impact%20Change%206/Toolkits%20or%20Guides/High%20Impact%20Change%206%20-%20How%20to.doc>

2. Maximal barrier precautions

A key change to decrease the likelihood of CVC infections is to apply maximal barrier precautions in preparation for line insertion.

In two studies (as cited in table one), the odds of developing a CVC infection increased if maximal barrier precautions were not used. For pulmonary artery catheters, the odds ratio for developing infection was more than two times greater for placement without maximal barrier precautions⁶. This rate was six times higher for placement of CVCs⁷.

A more recent randomised trial demonstrated no difference in rate of CVCR-BSI between institutions implementing maximal sterile barrier precautions and a control group using only hand washing, sterile gloves and skin disinfection⁹.

The Guidelines for the Prevention of Intravascular Catheter-Related Infections, released by the Centers for Disease Control and Prevention (CDC)⁸, remain the benchmark for prevention of CVC-BSIs^Φ.

For the operator placing the CVC and for those assisting in the procedure, maximal barrier precautions means strict compliance with hand hygiene and wearing a cap, mask, sterile gown and gloves. The wearing of cap and mask may not be mandatory in some organisations, however, when they are worn the cap should cover all hair and the mask should cover the nose and mouth tightly. These precautions are the same as for any other surgical procedure that carries a risk of infection.

For the patient, applying maximal barrier precautions means covering the patient from head to toe with a sterile drape, with a small opening for the site of insertion⁸. Some organisations may not provide large sterile drapes in the sterile bundle for insertion of CVC. The rationale for a large sterile drape is to ensure sterile field is maintained and that the catheter is not exposed to contamination during the procedure.

What changes can we make that will result in improvement?

Suggested changes include:

- Developing and implementing a protocol for CVC insertion that identifies the minimum standard for maximum barrier precautions. In developing the protocol consider the need to provide an adequate sterile field to ensure the catheter is not exposed to contamination during insertion.
- Empowering all nurses to enforce use of a CVC checklist to be sure all processes related to CVC placement are executed for each line placement. (A sample checklist may be downloaded from the project website www.health.vic.gov.au/sssl)
- Keeping equipment stocked on a trolley for CVC placement to avoid the difficulty of finding necessary equipment to institute maximal barrier precautions.

^Φ CDC Guidelines for the prevention of intravascular catheter-related infections can be downloaded from: <http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5110a1.htm>

3. Chlorhexidine skin antisepsis

Chlorhexidine skin antisepsis (using 1 per cent Chlorhexidine, 75 per cent alcohol) has been proven to provide better skin antisepsis than other antiseptic agents such as povidone-iodine solutions¹⁰.

What changes can we make that will result in improvement?

Follow the technique, recommended for most kits, as follows:

- Prepare skin with antiseptic/detergent 0.5 per cent chlorhexidine in 70 per cent isopropyl alcohol.
- Press sponge against skin; apply chlorhexidine solution using a back-and-forth friction scrub for at least 30 seconds. Do not wipe or blot.
- Allow antiseptic solution time to dry completely before puncturing the site (approximately two minutes).

4. Optimal catheter site selection

Percutaneously inserted catheters are the most commonly used central catheters. Several risk factors have been identified, however, that are associated with bloodstream infections. These include the site of placement.

Mermel et al. were able to demonstrate that the great majority of infections develop at the insertion site⁶. Other risk factors included use of the jugular insertion site over the subclavian site. In addition, for use of total parenteral nutrition, McCarthy demonstrated similar findings¹¹.

Whenever possible, and not contraindicated, the subclavian line site should be preferred over the jugular and femoral sites for non-tunnelled catheters in adult patient⁸. In selecting the appropriate site for insertion of a CVC it will be necessary to consider the risk and benefits of each site.

For the inexperienced medical officer the subclavian site may present a significant risk of 'pneumothorax, subclavian artery puncture, subclavian vein laceration, subclavian vein stenosis, hemothorax, thrombosis, air embolism and catheter misplacement'⁸. The subclavian site may also be unavailable due to chest injury.

What changes can we make that will result in improvement?

Suggested changes include:

- Empowering nurses to enforce use of a CVC checklist to be sure all processes related to CVC placement are executed for each line placement.
- Including optimal site selection as part of the checklist for CVC placement with room to note appropriate contraindications, for example, bleeding risks.

5. Daily review of CVC necessity with prompt removal of unnecessary lines

Daily review of CVC necessity will prevent unnecessary delays in removing lines that are no longer clearly needed for the care of the patient. Many times, CVCs remain in place simply because they provide reliable access and because personnel have not considered removing them. However, it is clear that the risk of infection increases over time as the line remains in place and that the risk of infection decreases if the line is removed.

The guidelines state that 'catheter replacement at scheduled time intervals as a method to reduce CVCR-BSI has not lowered rates of infection'. Additionally, routine replacement is 'not necessary for catheters that are functioning and have no evidence of causing local or systemic complications'. The guidelines further note that 'replacement of temporary catheters over a guide-wire in the presence of bacteremia is not an acceptable replacement strategy, because the source of infection is usually colonisation of the skin tract from the insertion site to the vein'⁸.

What changes can we make that will result in improvement?

Suggested changes include:

- daily review of line necessity as part of multidisciplinary rounds
- assessment for removal of CVCs as part of daily goal sheets, and
- recording time and date of line placement for record keeping purposes and evaluation by staff to aid in decision making.

Other considerations

Antimicrobial-impregnated catheters

Studies have shown a decreased incidence of CVCR-BSI with the use of antimicrobial-impregnated catheters^{12,13,14}. The CDC guidelines recommended (based on category 1B evidence) that antimicrobial-impregnated catheters be used in adults where catheters are expected to remain for >5 days⁸.

The increased cost of antimicrobial-impregnated catheters may be considered to outweigh the benefits derived from their use. Veenstra et al. argued that when these catheters are used for high-risk patients in whom hypersensitivity to the impregnated agents is not an issue cost savings may be an added benefit arising from their use¹⁵.

Dressing

At the time of the CDC guidelines the use of chlorhexidine sponge dressings (CXD) was considered an 'unresolved issue' due to the failure of studies to show any significant difference in the efficacy of CXD over transparent, semipermeable polyurethane⁸. While CXD have been known to decrease the incidence of CVC colonisation¹⁶, the results for CVC-BSI fail to reach significance in repeated studies¹⁷.

The SSSL project recommends the development of local protocols for the dressing of CVC sites. For recommended frequency of dressing changes see the next section on management of lines.

Management of lines

Appendix A of the CDC guidelines⁸ summarises recommendations for the ‘frequency of replacements for catheters, dressings, administration sets and fluids’. The recommendations for CVCs, including peripherally inserted central catheters and haemodialysis catheters are presented in the table below.

Table two: CVC Replacement Guidelines

Replacement and relocation of device	Replacement and relocation of device	Replacement of administration set	Hang time for parenteral fluids
<p>In <i>adults</i>, do not replace catheters routinely to prevent catheter-related infection.</p> <p>In paediatric patients, no recommendation for the frequency of catheter replacement.</p> <p>Replace disposable or reusable transducers at 72-hour intervals.</p> <p>Replace continuous flush device at the time the transducer is replaced.</p>	<p>Replace gauze dressings every 2 days and transparent dressings every 7 days on short-term catheters.</p> <p>Replace the dressing when the catheter is replaced, or when the dressing becomes damp, loosened, or soiled, or when inspection of the site is necessary</p>	<p>Replace intravenous tubing and add-on devices no more frequently than at 72-hour intervals.</p> <p>Replace tubing used to administer blood products or lipid emulsions within 24 hours of initiating the infusion</p>	<p>No recommendation for the hang time of intravenous fluids, including nonlipid-containing parenteral nutrition fluids.</p> <p>Complete infusions of lipid-containing fluids within 24 hours of hanging the fluid.</p>

Who should insert a CVC?

It is strongly recommend that organisations:

‘Delegate personnel who have been trained and exhibit competence in the insertion of catheters to supervise trainees who perform catheter insertion⁸.

The SSSL project recommends that the most suitable person available insert the catheter and where a junior doctor performs the procedure appropriate supervision is provided.

Establishing the strategy

Successful implementation of a strategy is motivated by leadership and commitment to provide adequate resources and attention. Prior to the implementation of a CVC-BSI strategy, the following should be considered:

- engaging senior leadership support
- determining the best structure for a team
- providing education and training
- using a structured documentation tool
- establishing feedback mechanisms, and
- methods for measuring the strategy's effectiveness.

Establish the team

A team based on the key stakeholders essential in ensuring that patients receive the care components for the bundle should be developed. For example, consider the area in which the bundle will be implemented (for example ICU), consider the clinicians who will be involved (for example, intensivists and nursing staff), so it will be important to include representatives from this area and these disciplines. The team should also include an infection control professional and a nursing clinical coordinator or educator.

Establish the aim

Before starting any improvement work, it is always wise to establish the aim of the work. In this area of SSSL, the aim is to significantly reduce CVC-BSIs by the end of 2006. A more specific aim should be developed by the team responsible for implementing the care components for this bundle.

The aim should be 'SMART':

- Specific
- Measurable
- Achievable
- Realistic and
- Timely.

Example Aim

'To reduce the number of central venous catheter-related bloodstream infections by 80 per cent by December 2006 through implementing the components of care called the central venous catheter bundle'.

Implementing the strategy

Once a team has prepared the way for change by studying the current process and educating the affected parties, the next step is to begin testing the CVC bundle.

At the beginning of implementation it is suggested that teams conduct small tests of change to start improvement work. With this approach, team members can learn quickly what works or how changes need to be refined before full implementation.

- Begin using the bundle with one patient from the time of catheter placement.
- Work with each nurse who cares for the patient to be sure they are able to follow the bundle and implement the checklist and daily goals sheet.
- Make sure that the approach can be carried over from shift to shift to eliminate gaps in teaching and utilisation.
- Process feedback and incorporate suggestions for improvement.
- Once the bundle has been applied to one patient and several shifts, increase utilisation to the remainder of the ward/unit.
- Engage in additional Plan Do Study Act (PDSA) cycles to refine the process and make it more reliable.
- After achieving reduction in CVCR-BSI in the pilot ward/unit, spread the changes to other wards/units, and eventually to all areas in the hospital where CVCs are inserted.

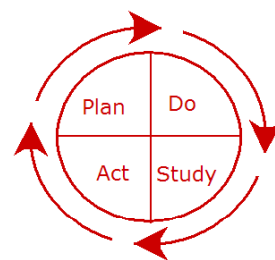


Figure two: PDSA cycle

General considerations for improvement

Hospitals may experience a range of challenges while attempting to improve processes and systems. Any successful process of improvement is driven by leadership and commitment to provide adequate resources and attention.

To be successful, the CVC improvement process must involve multidisciplinary teams and incorporate the following actions in order to find the ones that lead to improvement in a particular setting:

- set clear aims for the process
- establish baseline measurements of performance
- regularly measure and study the results of the improvement, and
- test various process and systems changes over a range of conditions.

Implementing a CVC checklist at the time of insertion will help to ensure a reliable process. Nurses should be empowered to supervise the preparations using the checklist prior to line insertion and to stop the process if necessary.

Use a form that allows you to record your efforts and track your success. In addition to helping improvement teams create run charts each month, a contemporaneous record documenting line placement and site care can help with prompting early removal.

These strategies are particularly effective if used in conjunction with a daily goals assessment sheet. This form can be completed during daily rounds on the patient. Many organisations implement the CVC bundle in tandem with the ventilator bundle to improve systematic care to patients in ICUs. (For information on the ventilator bundle, see Preventing ventilator-associated complications toolkit.)

Barriers that may be encountered

Teams working on preventing CVCR-BSIs may face resistance and other barriers to improvement. The following table identifies some common challenges and suggested solutions.

Table three: Challenges and solutions

Challenges	Solutions
Fear of change	The antidote to fear is knowledge <ul style="list-style-type: none"> • Inform staff about the deficiencies of the present process and • Provide reasons to be optimistic about the potential benefits of a new process.
Lack of support by leadership	<ul style="list-style-type: none"> • Use opinion leaders (physicians) and data. • A business case for the project may help to win leadership support.
Uneven acceptance of new practices	<ul style="list-style-type: none"> • Use physician opinion leaders. • Review medical literature and feedback data on a physician-specific level. • Work first with early adopters and use their stories to convince the majority. • Share baseline data that demonstrates the reliability of the process.
'Isn't this the doctor's job?'	<ul style="list-style-type: none"> • Educating staff that preventing CVC-BSIs is a team process. All disciplines must be involved and complete portions of the process.
Communication breakdown.	<ul style="list-style-type: none"> • Communicating the importance of preventing CVC-BSIs to staff. • Ongoing education of staff.

Conducting a review

For the reporting period (weekly, fortnightly or monthly), collect a random sample of 20 closed patient records from patients with a minimum two-day length of stay.

Collect baseline data as described in the measurement section. This information will help you to determine how effective your current process is and help you make the case for implementing medication reconciliation.

An example of a small test of one component, daily review of CVC necessity. Note the size and scale of the test: very focused and specific. It would not take much time to plan this test, do it, assess if it worked, and then perhaps test it again on the same scale or expand the scale of the test.

Goal: CVCs not left in-situ unnecessarily.

Change: Include checklist in patient chart.

Scale: Record daily review of CVC necessity.

Plan: Educate staff on small test of change.

Strategy Test

1. Adopt checklist for CVC.
2. Include checklist in patient chart.
3. Record daily review of CVC necessity.

Measurement

Measurement is the only way to know whether a change represents an improvement. There are two measures of interest for CVCR-BSIs.

To measure the effectiveness of the preventing CVCs strategy, accurate and pertinent data is required.

Compliance process measurement

Compliance measurements as taken for the entire bundle of care components, not just parts of the bundle. Where there is an optional component, if an organisation elects to include it then it is considered a part of the bundle to be measured for compliance.

Select one location for investigation, such as ICU. Undertake the audit for all patients, to a maximum of 20 patients, with CVCs and assess their care for compliance with the CVC bundle. If even one element is missing, the case is not in compliance with the bundle. For example, if there are seven patients with CVCs, and six have all five bundle elements completed, then 6/7 (86 per cent) is the compliance with the CVC bundle. If all seven patients were missing even a single item, compliance would be zero.

Examples of compliance

15 of the 20 histories record the process in full, 75% comply.

All histories had all steps; the compliance would be 100%.

If any histories were missing a single step, compliance is

Hospital sites will submit by means of an eForm just two numbers.

1. The number of patients receiving all components of the CVC bundle, and
2. The number of patients with CVCs on the day of the sample

The SSSL project team will calculate a hospital site's compliance to the VAC bundle by:

1. Dividing the number of patients receiving all components by the number of ventilated patients.
2. Then multiplying the result by 100, this will provide the percentage of compliance to the CVC intervention.

$$\frac{\text{Number of patient receiving all components}}{\text{Number of patient with CVCs on the day of the sample}} \times 100 = \text{percentage of compliance}$$

Outcome measurement

The outcome measure is a rate. In this case, for a particular time period, we are interested in the total number of cases of CVC-BSIs. For example, if in February there were 12 cases of CVC-BSIs, the number of cases would be 12 for that month. We want to be able to understand that number as a proportion of the total number of days that patients had CVCs. Thus, if 25 patients had CVCs during the month and each, for purposes of example, kept their line for three days, the number of catheter days would be $25 \times 3 = 75$ for February. The CVC-BSI rate per 1,000 catheter days then would be $(12/75) \times 1000 = 160$.

Hospital sites will submit two numbers by means of an eForm.

1. The number of CVC-BSI cases during the reporting period, and
2. The number of catheter days during the same period.

The SSSL project team will calculate a hospital site's CVC-BSI rate by:

$$\frac{\text{Number of CVC-BSI cases}}{\text{Number of catheter days}} \times 1000 = \text{CVC-BSI}$$

1. Dividing the total number of CVC-BSI cases for that period of time by the number of catheter days during the time period.
2. Then multiplying the result by 1000, the result will be the CVC-BSI rate for the time period.

Conclusion

SSSL is a national collaborative being undertaken by 50 Australian hospitals. Commencing in early 2006 six key interventions will be implemented and data will be collected for analysis. These interventions are based on scientific evidence and known to improve patient care and prevent avoidable deaths.

The CVC intervention has the main objective of providing tangible evidence to support the SSSL methodology. The SSSL project aims to prove that by consistently and comprehensively applying the five care components as outlined in this document there is a noticeable increase in the prevention of CVC-BSIs.

Abbreviations

CDC	Centers for Disease Control and Prevention (United States)
CVC	Central venous catheter
CVCR-BSI	Central venous catheter related-bloodstream infection
CXD	Chlorhexidine sponge dressing
DHS	Department of Human Services (Victoria)
ICU	Intensive Care Unit
IHI	Institute for Healthcare Improvement
PDSA	Plan Do Act Study
SSSL	Safer Systems – Saving Lives
VAC	Ventilator-associated complications
VICNISS	Victorian Nosocomial Infection Surveillance System

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