Health Protection Scotland

NHS National Services Scotland

Targeted literature review:

What are the key infection prevention and control recommendations to inform a surgical site infection (SSI) prevention quality improvement tool?

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HPS ICT Document Information Grid

About the document	Document Information
Purpose:	To present a review of the evidence to inform the content of HAI related quality improvement tools for NHSScotland. This supports the functions of HPS in developing effective guidance, good practice and a competent workforce and translating knowledge to improve health outcomes.
Target audience:	All NHSScotland staff involved in patient care activities where interventions can lead to HAI. Infection prevention and control teams in NHS boards and other settings. Partner organisations particularly Healthcare Improvement Scotland and National Education for Scotland to ensure consistent information across similar improvement documentation.
Description:	Literature critique summary and presentation of key recommendations to inform HAI quality improvement tools, based around a framework that evaluates these against the health impact contribution and expert opinion/practical application.
Update/review schedule:	Every three years; however if significant new evidence or other implications for practice are published updates will be undertaken.
Cross reference:	Standard Infection Control Precautions Policies in the National Infection Prevention and Control Manual. HAI incidence and prevalence and process compliance data. Implementation support from Healthcare Improvement Scotland and/or others, education and training support from National Education Scotland.

Contents

1. Executive summary

Surgical site infection (SSI) is one of the most common healthcare associated infection (HAI), estimated to account for 16.5% of inpatient HAI in NHSScotland.[1] SSIs have serious consequences as they cause excess morbidity and mortality and are estimated to double the cost of treatment owing mainly to additional surgical interventions and increased length of stay.[2]

SSIs are the most preventable of all HAIs.[3-5] Multiple risk factors contribute to the development of a SSI, and these relate to the patient, the contaminating organism, and the surgical procedure itself.[6] Interventions focus on minimising or modifying these risk factors. Key recommendations result from the review of scientific evidence and the process of assessing these within a health impact and expert opinion framework. A quality improvement tool (QIT) encompasses these key recommendations for integration into clinical practice.

The key recommendations in this 2018 update remain unchanged from the 2015 review.

To facilitate the use of this QIT across different staff groups the key recommendations have been separated into two clinical areas – **ward and theatre**, and split into three phases - **preoperative, perioperative** and **postoperative**.

Clinical area – Ward

Preoperative phase – key recommendations

- Ensure that a clinical risk assessment for meticillin resistant Staphylococcus aureus
- (MRSA) screening is undertaken (Category 1B).
- Ensure that the patient has showered (or bathed/washed if unable to shower) on day of or day before surgery using plain soap (Category 1B).
- Ensure that body hair is not removed if at all possible; if hair removal is necessary, do not use razors (Category 1A).

Postoperative phase – key recommendations

- Ensure that the wound dressing is kept in place for 48 hours after surgery unless clinically indicated (Category II).

- Ensure that aseptic technique is used if there is excess wound leakage and need for a dressing change (Category 1B**).**

- Ensure that hand hygiene is performed immediately before every aseptic dressing change (WHO Moment 2) (Category 1A).

Clinical area – Theatre

Preoperative phase – key recommendations

- Ensure that prophylactic antibiotic is prescribed as per local antibiotic policy/SIGN guideline, for the specific operation category (Category 1A).

- Ensure that the antibiotic is administered within 60 minutes prior to the operation (blade to skin) (Category 1A).

Perioperative phase – key recommendations

- Ensure that single-use 2% chlorhexidine gluconate in 70% isopropyl alcohol solution is used for skin preparation (if patient sensitive, use povidone-iodine) (Category 1A)*.

- Ensure that the patient's body temperature is maintained above 36°C (excludes cardiac patients) (Category 1A).

- Ensure that the diabetic patient's glucose level is kept <11mmol/l throughout the operation (Category 1B).

- Ensure that the patient's haemoglobin saturation is maintained above 95% (or as high as possible if there is underlying respiratory insufficiency) (Category 1B).

- Ensure that the wound is covered with a sterile wound dressing at the end of surgery (Category 1A).

To find out more information on the categories of these recommendations see Appendix 2.

In summary: it is now advised that the key recommendations listed here as a result of this review and summarised in Appendix 4 are incorporated into local practice. This review did not aim to identify all elements of a checklist for surgical procedures, other locally available procedures and tools should address these. These activities are also supported by quality improvement tools such as care bundles and national patient safety/quality improvement work (as directed by Healthcare Improvement Scotland).

*Note

All medical and nursing staff involved in the use of all medical devices and medicinal products containing chlorhexidine should be aware of the risk of an anaphylactic reaction due to chlorhexidine allergy. The full details of the alert are available from the following weblink[74] http://www.mhra.gov.uk/Publications/Safetywarnings/MedicalDeviceAlerts/CON197918

2. Aim of the review

This targeted review of scientific literature aims to ascertain whether there is any new guidance or evidence to form the key recommendations included within a quality improvement tool for the prevention of SSI. The evidence base for these recommendations was last reviewed in 2015.

3. Background

3.1 The problem

SSIs are defined as infections that occur in a wound following invasive surgical procedures[6] and can be classified into three distinct types: superficial incisional (involving only the skin and subcutaneous tissue), deep incisional (involving deep soft tissues and muscle), and organ space. Most SSIs develop within 30 days of surgery.

Risk factors associated with the development of SSI are related to the patient, the contaminating organism, and the surgical procedure itself. Patient risk factors include existing co-morbidities such as diabetes and obesity, as well as smoking, old age and immuno-suppression.[6] Procedural risk factors are related to the complexity, type, and duration of procedure. The development of antimicrobial resistance is a challenge to the prevention of SSIs.

3.2 How infections associated with surgical procedures can be prevented

SSI can result from contamination of the wound site and microorganisms can gain access via a number of sources including:

- from the skin of the patient prior to surgery
- from surgical instruments
- from the environment during surgery
- during provision of care post surgery. The key interventions to prevent SSI focus on:
- removing microorganisms from the skin of the patient prior to surgery
- minimising the chance of multiplication of microorganisms during the surgical procedure
- minimising the impact of existing co-morbidities on the immune response of the patient
- reducing the risk of microorganisms gaining entry to the wound site post surgery.

3.3 Out of scope for this review

This literature review does not address any issues specific to:

- Hand hygiene or surgical scrub procedure – see National Infection Prevention and Control Manual http://www.nipcm.hps.scot.nhs.uk/
- Management of SSIs.

While this review does not directly address paediatric surgery, specialists may find that the key recommendations are transferable or provide a useful basis for locally amended specialist tools.

3.4 Assumptions – to ensure successful integration of recommendations into practice

- Staff are trained and competent in all aspects of the management of SSI prevention (including hand hygiene, aseptic technique and theatre etiquette), preferably using an approved educational package http://www.nes.scot.nhs.uk/education-and-training.aspx.
- The overall approach to the delivery of healthcare is supported by patient safety and improvement approaches and organisational readiness.

4. Results

The recommendations presented are based on a review of the current evidence. To further aid the process of deciding which final key recommendations to include, all the recommendations resulting from the review of the evidence were assessed using the 'health impact and expert opinion framework' as in Appendix 1. The final key recommendations were identified as a result of this evaluation as well as being informed by the process of wider consultation.

The methodology for this is described within Appendix 2; the specific research questions and search strategies in Appendix 3 and finally a summary page of the resulting recommendations can be found in Appendix 4.

4.1 Clinical area – Ward

4.1.1 Preoperative phase (ward)

4.1.1.1 Final recommendation - Ensure that a clinical risk assessment for meticillin resistant *Staphylococcus aureus* (MRSA) screening is undertaken (Category 1B)

Staphylococcus aureus (*S. aureus*) is the most common cause (23.9%) of surgical site infection (SSI) in Scotland.[7] Infections that result from meticillin resistant *S. aureus* (MRSA) are generally associated with higher morbidity and mortality than those due to meticillin sensitive *Staphylococcus aureus* (MSSA).[8-13] Approximately 30% of the healthy population are carriers of *S. aureus* and it is thought that, in the majority of cases, patients themselves are the source of infecting MRSA.[6;14;15]

S. aureus colonisation is most common on the skin and mucosal membranes of the nose however multiple body sites have been associated with infection including the pharynx, perineum and groin. Pre-screening to identify carriers followed by a decolonisation treatment when required has the potential to minimise the risk of SSI in MRSA positive patients. Decolonisation does not aim to eradicate MRSA completely (as patients can become re-colonised in relatively short periods of time), rather it endeavours to reduce the burden of MRSA carried by the patient when they are undergoing an invasive procedure and are likely to be at higher risk.

Health Protection Scotland (HPS) carried out a large prospective cohort study of MRSA screening that included decolonisation of approximately 80,000 admissions to acute settings within three NHS boards.[16] MRSA colonisation prevalence fell from 5.5% to 3.5% during the study and was associated with a reduction in MRSA SSI. In response, a national MRSA Screening Programme was established in Scotland in 2009 which adopted a three question clinical risk assessment (CRA) applied on admission or pre-admission.[16] If the answer to any of the three questions is 'yes' then the patient is swabbed on two body sites (nose and perineum). In addition all patients in five specialties where MRSA infection would have a high impact on patients' mortality (renal, cardiothoracic, vascular, intensive care and orthopaedics) are screened regardless of their CRA result.[17] There is generally a lack of high quality evidence to support or contradict the findings of the NHSScotland MRSA Screening Pathfinder Programme.[15] Several recent studies have failed to show a significant reduction in MRSA SSI following screening, however, these studies tended to be underpowered and did not use the targetted screening approach adopted by NHSScotland which is likely to increase the efficacy of screening.[4;18-21]

The Scottish protocol for nasal decontamination recommends that patients testing positive for MRSA are decolonised with mupirocin, an antibiotic ointment, which is self-administered by the patient three times daily for five days prior to surgery.[22] Patients must also use an appropriate body wash for five days, which for most patients is typically 4% chlorhexidine gluconate aqueous solution.[23] The decision to undertake decolonisation should be subject to CRA, patient agreement and local policies. A meta-analysis conducted to formulate WHO guidance demonstrated that the use of 2% mupirocin ointment with or without a combination of chlorhexidine body wash in surgical patients with *S. aureus* nasal carriage had significant benefit in reducing the *S. aureus* SSI rate compared to placebo/no treatment.[24] An update to NICE guidance, currently out for consultation and due for publication in April 2019, suggests using mupirocin in combination with a chlorhexidine body wash before procedures in which *S. aureus* is a likely cause of a SSI.[25] However without any pre-screening for carriers, universal application of mupirocin could increase the risk of antibiotic resistance.

An alternative to decolonisation with nasal antibiotics is application of a nasal antiseptic (e.g. povidone-iodine or alcohol-based products), either in combination with MRSA pre-screening or as a universal treatment for all patients prior to surgery regardless of their MRSA status. Universal application of an antiseptic could mitigate under-treatment of false-negative carriers and lessen the burden of antibiotic resistance resulting from overtreatment of false-positives carriers. Application would be suitable for emergency surgeries and where a 5 day preoperative

mupirocin treatment window is not available, and could provide protection from multiple microorganisms in addition to *S. aureus*, much in the same way as preoperative skin antisepsis of the surgical site provides. Application of nasal antiseptics is less burdensome than the 5 day mupirocin schedule as it is carried out by a healthcare professional usually on the day of surgery, and is likely to overcome the issue of low patient compliance. There is very limited evidence to determine the effect of nasal antiseptics at preventing SSI. A 2017 Cochrane review identified only two RCTs therefore was unable to draw a conclusion.[26] MRSA carriers decolonised with two applications of nasal povidone-iodine within 2 hours of incision were significantly less likely to develop a SSI following arthroplasty or spine fusion than those carriers decolonised with mupirocin ointment.[27] A retrospective study at a single institute following a change in protocol from MRSA screening to universal application of a nasal povidone-iodine swab found no difference in the SSI rates pre and post protocol change however the pre-protocol SSI rate was low and the study was statistically underpowered.[28] Cost analysis studies have demonstrated greater savings with universal decolonisation with povidone-iodine antiseptics[28;29] and patients report greater satisfaction compared to mupirocin.[27]

Regardless of the decolonisation protocol, MRSA pre-screening allows clinicians to manage the risk of environmental contamination and of cross-contamination of MRSA to vulnerable non-carriers, and has benefits that extend beyond the prevention of SSI. Further research is required to determine the most effective decolonisation protocol for the prevention of SSI.

4.1.1.2 Final recommendation - Ensure that the patient has showered (or bathed/washed if unable to shower) on day of or day before surgery using plain soap (Category 1B)

As patients' skin will have transient and resident microorganisms present, it is a reasonable precaution to ensure that the skin is as free as possible of microbial flora prior to surgery.[6;30] Options for preoperative showering or bathing include using an antimicrobial or nonantimicrobial soap, or, use of chlorhexidine gluconate impregnated cloths (body wipes). The type and concentration of antimicrobial product and the timing of use prior to surgery vary considerably which limits the comparison of studies. Evidence to date, including a Cochrane review, has failed to demonstrate conclusive benefit of one product over another.[31;32] An exception is the use of chlorhexidine gluconate impregnated wash cloths prior to hip and knee arthroplasty which was associated with significantly lower SSI rates compared to standard preoperative wash protocols.[33;34] A large meta-analysis (n=8787) found that the use of chlorhexidine-impregnated cloths prior to total knee arthroplasty was associated with a reduction in the total incidence of

SSI and a reduction in the incidence of SSI in moderate- and high-risk category patients, but not low- risk categories.[33] Retrospective studies assessing data pre and post implementation of preoperative antiseptic wash protocols have failed to demonstrate product-specific differences in SSI rates.[35;36] One study demonstrated significantly lower SSI rates resulting from *Staphylococcus aureus* and MRSA after introduction of showering with a chlorhexidine-based antiseptic however this was a between-hospitals comparison study which, by its design, is at risk of confounding.[36]

The US Centres for Disease Control (CDC) recommend patients to shower or bathe (full body) with soap (antimicrobial or nonantimicrobial) or an antiseptic agent on at least the night before the operative day.[37] The World Health Organization (WHO) recommends the use of soap (antimicrobial or nonantimicrobial) for bathing prior to surgery but did not state any preference for timing.[24] Both the CDC and the WHO made no recommendation on the use of chlorhexidine cloths owing to the limited and low quality evidence. NICE guidelines conclude that while there is a consensus of evidence that demonstrates that pre-operative showering with detergents or soap is associated with a reduction in SSI there is no evidence to suggest that antiseptics are more effective, therefore advocate the use of soap.[6]

No evidence was identified with respect to the optimal timing of preoperative bathing or whether more than one shower resulted in increased effect [6;38] It was therefore concluded based on best practice and expert opinion, that showering should take place on the day of the surgery if possible or otherwise the day before. Further studies are required to determine the most effective product and timing of application for the prevention of SSIs.

4.1.1.3 Final recommendation - Ensure that hair is not removed if at all possible; if hair removal is necessary, do not use razors (Category 1A)

Preparation of the skin site prior to the surgical procedure minimises the presence of microorganisms on the surface prior to incision. This historically included the routine removal of hair due to concern that the presence of hair would result in an increased presence of contamination.[6] This view was challenged citing the possibility that shaving using razors causes skin damage in the form of micro-abrasions potentially causing multiplication of microorganisms at the surgical site. Shaving is frequently used because it is relatively cheap and quick however the blade cuts the hair very close to the skin surface. Clippers leave longer hair stubble while chemical depilatory creams result in a more complete hair removal but can take up to 20 minutes.

Depilatory creams can cause skin irritation and allergic reactions so patch tests need to be carried out 24 hours before the cream is applied for the first time. The practice of hair removal varies across the world and therefore guidelines vary. A Cochrane systematic review examined the effect of different methods of hair removal (shaving, clippers and depilatory creams) on incidence of SSI.[39] There was insufficient evidence to indicate an effect of preoperative hair removal on rates of SSI however the evidence did suggest that clippers are associated with fewer SSIs than razors.

These findings were mirrored in a 2016 meta-analysis conducted to formulate WHO guidance in which three hair removal methods (shaving, clipping, depilatory cream) were assessed.

Meta-analysis of 10 studies indicated lower risk of SSI following hair removal with clippers or no hair removal, while comparison of shaving with clipping indicated a lower risk of SSIs with clipping.[40] In general, there is insufficient evidence to determine the effect of depilatory creams. The WHO recommend that '*hair should either not be removed or, if absolutely necessary, it should be removed only with a clipper. Shaving is strongly discouraged at all times, whether preoperatively or in the operating room'.* No recommendation could be formulated on the timing of hair removal as only one study assessed this question. The 1999 CDC guidance, which did not include a review of the evidence pertaining to hair removal in the 2017 update, states that ***'****If hair removal is necessary, remove immediately before the operation, with clippers'*[41]

A 2015 meta-analysis found that the relative risk of SSI was higher when hair removal was performed on the day before surgery than when it was removed on the day of surgery, regardless of the method of removal.[42] The main consensus is to ensure that hair removal takes place as close in time to the surgical procedure as possible. It is acknowledged that hair removal prior to surgery may be required in order to enable visualisation of the surgical site during the procedure. If hair removal is necessary then the use of razors is contraindicated. Further research is required to determine the effect of depilatory creams however the use of electric clippers carries less risk in terms of skin irritation and is faster.

4.1.2 Postoperative phase (ward)

4.1.2.1 Final recommendation - Ensure that the wound dressing is kept in place for 48 hours after surgery unless clinically indicated (Category II)

The other aspect of wound dressing which has been examined is the time that they should be left in place post-surgery with periods of time of 12-48 hours studied. There was no statistical differences found within any of the studies, however it is generally concluded based on best practice and expert opinion that the wound should remain covered for 48 hours following surgery as this is the period where initial healing over the wound takes place.

4.1.2.2 Final recommendation - Ensure that aseptic technique is used, if there is excess wound leakage and need for a dressing change (Category 1B)

4.1.2.3 Final recommendation - Ensure that hand hygiene is performed immediately before every aseptic dressing change (WHO Moment 2) (Category 1A)

There is consensus of evidence that the use of an aseptic technique should be used when there is a need to change a dressing of a surgical wound. [30;43;44] This can include the use of aseptic non- touch technique (ANTTTM) as used in some parts of the UK.[45] Aseptic technique is a broad term for a number of actions which prevent cross transmission of microorganisms.[46;47] These include requirements not to touch 'critical parts'; preparation of a surface area which prevents touch contamination of equipment; use of sterile equipment; and use of personal protective equipment.

The importance of hand hygiene performance is consistent with all current evidence and guidelines.[6;48] The World Health Organization (WHO) Guidelines on Hand Hygiene in Health Care[49] clearly describe the indications for hand hygiene and present these within the WHO 'My 5 Moments for Hand Hygiene' approach, including emphasising the importance of performing hand hygiene before clean/aseptic procedures to prevent HAI.

4.2 Clinical area – Theatre

4.2.1 Preoperative phase (theatre)

4.2.1.1 Final recommendation - Ensure that prophylactic antibiotic is prescribed as per local antibiotic policy/SIGN guideline, for the specific operation category (Category 1A)

Antibiotic prophylaxis has been used as a method to prevent SSI, particularly for surgical procedures deemed as high risk.[6;50] Antibiotic prophylaxis differs from treatment as it typically involves a single dose of antibiotic which is administered prior to surgery. There is a consensus of evidence that the use of prophylactic antibiotics is associated with a reduction in SSI.[6;51;52] The usefulness of this technique varies across the types of surgical procedures and potential consequences of SSI. The potential benefits must be assessed alongside an increased risk of adverse drug reactions and the potential for an increase in antimicrobial resistance. SIGN Guideline 104, 'Antibiotic Prophylaxis in Surgery', gives clear recommendations for practice on the use of antibiotic prophylaxis to reduce the overall risk of SSI during specific procedures while minimising the possibility of adverse events occurring.[50] This guideline emphasises that although the use of prophylaxis is not a way of overcoming shortcomings in surgical technique it is recommended for specific procedures when the individuals' risk of adverse reaction has been considered. It is recommended that this guideline, which was updated in 2014, should be consulted for recommendations for when the use of prophylaxis is appropriate.[50]

4.2.1.2 Final recommendation - Ensure that the antibiotic is administered within 60 minutes prior to the operation (blade to skin) (Category 1A)

The timing of prophylactic antibiotic administration is critical to ensure maximum benefit i.e. the antibiotic is at the most effective concentration within the tissues at the time of the surgical procedure.[53;54] General consensus is that prophylaxis should be administered within 60 minutes prior to surgery; however, there are conflicting reports of the optimum administration time within this window, which varies according to antibiotic and type of surgery.[53-56] Accordingly, guidance published by both CDC and NICE offer no specific timeframe for antibiotic prophylaxis, instead referring to an optimum time 'such that a bactericidal concentration of the agents is established in the serum and tissues when the incision is made'.[41;57]

A previous version of the SIGN guidelines recommended antibiotics be administered ≤30 minutes prior to incision, however, in the most recent update this was changed to ≤60 minutes.[50]

Specifically; ‘For surgical procedures, intravenous prophylactic antibiotics should be given within 60 minutes before the skin is incised and as close to time of incision as practically possible’.

A recent large RCT (n=5580) found no benefit of reducing the administration time from 60 minutes prior to incision.[58] WHO guidelines recommend a wider window of within 120 minutes, based on a systematic review that found no evidence of benefit with administration within 60 minutes.[59] Notably, the evidence to support this recommendation was of very low quality (6 observational studies) and the guideline authors state that clinical practice would require a shorter time of 60 minutes for antibiotics with shorter half-lives. After consultation with the Scottish Antimicrobial Prescribing Group when this review was updated in 2015, it was agreed there was insufficient evidence to move from within 60 minutes.

This recommendation also applies to women undergoing caesarean section; previously, antibiotic prophylaxis was withheld until after cord-clamping due to concerns over foetal exposure to antibiotics. This targeted review identified no evidence to support the administration of antibiotics after cord clamping for the prevention of SSIs in caesarean section. Recent systematic reviews and meta-analyses found significant reductions in post-operative infections when antibiotics were administered preoperatively[60;61] as did two large RCTs.[62;63] Neither RCT identified any adverse neonatal outcomes. A committee opinion document, published by the American College of Obstetricians and Gynaecologists in 2010[64] and Canadian guidelines published in 2017[65] concurred that the timing of administration should be within 60 minutes of surgery.

4.2.2 Perioperative phase (theatre)

4.2.2.1 Final recommendation - Ensure that single-use 2% chlorhexidine gluconate in 70% isopropyl alcohol solution is used for skin preparation (if patient sensitive, use povidone-iodine) (Category 1A)

For most SSIs, a source of invading pathogens is thought to be the patient’s skin.[66] Consequently, optimisation of preoperative skin antisepsis is required to decrease postoperative infections. The focus of this intervention is the removal of both the transient and resident skin flora. Although transient microorganisms at the surgical site can be readily removed by soap and water, the use of antiseptics is required to remove resident flora prior to surgical incision. Choice of antiseptic is based on ease of use (ease and speed of application and drying time), safety (fast drying = lower fire risk), allergenicity, and proven clinical effectiveness. The

antimicrobial activity of the antiseptic is a major consideration as there may be a requirement for a residual action to provide additional protection during the surgical procedure itself.[6] The three main types of antiseptics are alcohol, iodine/iodophors (i.e. povidone-iodine), and chlorhexidine gluconate. The latter two are sometimes mixed with alcohol or an aqueous base which, along with the application technique, can influence their efficacy. Chlorhexidine is known to have a sustained presence on the skin. When combined with alcohol, which is fast drying, 2% chlorhexidine in 70% isopropyl alcohol is a suitable product.[67]

Evidence from multiple surgical fields suggests greater efficacy of chlorhexidine in alcohol, as measured by a greater reduction in skin flora at the surgical site and a strong association with lower SSI rates, compared to alternative antiseptics including povidone-iodine (both aqueous and alcohol-based).[68-73] Six studies (including five RCTs)[74-79] found no difference in SSI rates between chlorhexidine in alcohol and controls, however three of these studies were underpowered[75;77;79] and one trial had skin patted dry after antiseptic application instead of correctly allowing to air dry and this is likely to have decreased its efficacy.[76] A Cochrane review that compared four different skin antiseptics for the prevention of SSIs following caesarean section reported a slight benefit of chlorhexidine over povidone-iodine but the evidence was limited.[80] Regarding the strength of the chlorhexidine, 2% has shown greater efficacy than lower concentrations (i.e. 0.5%) at reducing microbial load at the surgical site.[81] Chlorhexidine is known to cause skin irritation in some individuals therefore it is essential to have a suitable alternative available for use, for example povidone-iodine.

A Cochrane systematic review suggested that alcohol-containing products had the highest probability of being effective.[82] There is evidence to suggest a superior synergistic effect of chlorhexidine in alcohol in comparison to alcohol alone.[72;83]

Guidance from national bodies is mixed however all recommend an alcohol-based antiseptic.[6;24;41] The WHO recommend alcohol-based antiseptic solutions based on chlorhexidine. The National Institute of Health and Clinical Excellence (NICE) guideline recommends using an antiseptic (aqueous or alcohol-based) preparation, stating that povidone-iodine or chlorhexidine are most suitable.[6]

Further review specifically on whether the solution should be single-use or from multi-use containers:

A further rapid review was conducted to provide clarity with regards to whether the 2% chlorhexidine gluconate in 70% isopropyl alcohol skin preparation solution should be single-use or from a multi-use container. A Cochrane review on preoperative skin antiseptics for preventing

surgical wound infections after clean surgery (updated in 2013) noted that multiuse bottles of antiseptic can become contaminated once opened.[84] This evidence has been added to by reports of outbreaks of HAI associated with contaminated aqueous solutions of chlorhexidine.[68-72] There were no reports identified in this search specifically associated with contaminated 2% chlorhexidine 70% isopropyl alcohol however outbreaks of infection have been associated with 70% isopropyl alcohol skin preparation pads, which may show a potential for this solution to become contaminated.[73] Therefore for the purposes of skin preparation prior to surgical procedures, the use of single-use sterile containers of 2% chlorhexidine 70% isopropyl alcohol should be considered best practice.

In summary, there is robust evidence to support the application of single-use 2% chlorhexidine 70% isopropyl alcohol to minimise and prevent the development of SSI.

Note:

All medical and nursing staff involved in the use of all medical devices and medicinal products containing chlorhexidine should be aware of the risk of an anaphylactic reaction due to chlorhexidine allergy. The full details of the alert are available from the following weblink[74]
http://www.mhra.gov.uk/Publications/Safetywarnings/MedicalDeviceAlerts/CON197918

4.2.2.2 Final recommendation - Ensure that the patient's body temperature is maintained above 36°C (excludes cardiac patients) (Category 1A)

Ensuring that patient homeostasis is maintained during general anaesthesia is vital for the health and wellbeing of the patient for most categories of surgical procedure. This includes ensuring optimal oxygenation, perfusion and body temperature during surgical procedures. An evidence based guideline produced by NICE; Inadvertent perioperative hypothermia (2008) defines normothermia as the body temperature being within the range of 36.0°C and 37.5°C.[85] Perioperative hypothermia can occur as a result of the initial redistribution hypothermia that follows induction of anaesthesia, from the skin cooling effects of skin prep agents, and from skin exposure during the procedure.[86] There is a consensus of evidence consisting largely of retrospective cohort studies which demonstrates an association of perioperative hypothermia with numerous health complications including SSI.[85;87-89] A substantial volume of largely observational studies show overall net clinical benefit with the use of perioperative warming devices.[90-92] Evidence directly linking the maintenance of body temperature to a reduction in SSI is limited, in part due to the ethical limitations of inducing or allowing hypothermia. Two RCTs conducted in the past 25 years, published in 1996[93] and 2001[94], were the only studies

identified for inclusion in the meta-analysis conducted for the 2016 WHO guideline. Both had significant methodological limitations. WHO guidance does not state specific temperatures, rather "*the use of warming devices in the OR and during the surgical procedure for patient body warming with the purpose of reducing SSI"* is recommended.[95] Providing clear criteria allows clinicians to monitor and audit the recommendation in practice, therefore specifying a minimum of 36.0°C is both intuitive and logical. NICE provide comprehensive and detailed guidelines relating to temperature maintenance for the preoperative, intraoperative, and postoperative stages.[96] Maintenance of normothermia (in this case 35.5°C or more) is also recommended by the Society for Healthcare Epidemiology of America (SHEA).[97] The exact method for active warming is not specified however evidence indicates that warming immediately prior to indication of anaesthesia combined with intraoperative warming may better preserve intraoperative normothermia compared with intraoperative warming alone.[98] An exception is during open cardiac surgery when hypothermia is widely used to protect against perioperative brain ischemia and to protect the myocardium.[99] Patient comfort and wellbeing should always be taken into consideration and most would argue that warming devices are essential in this regard.

4.2.2.3 Final recommendation – Ensure that the diabetic patient's blood glucose level is kept <11mmol/l throughout the operation (Category 1B)

Hyperglycemia is known to impair the immune response through a number of mechanisms resulting in increased susceptibility to infection. Perioperative hyperglycemia and the associated increase in morbidity and mortality have been well studied in diabetic patients in multiple surgical fields[100], and in both diabetic and non-diabetic patients undergoing cardiac surgery.[101] Diabetes is widely recognised as a risk factor for SSI and evidence-based clinical guidelines for perioperative glucose control are embedded in practice for diabetic patients. The Association of Anaesthetists of Great Britain & Ireland and The Joint British Diabetes Societies (JBDS) for Inpatient Care group recommend an intra-operative capillary blood glucose (CBG) range of 6–10 mmol/l.[102] Despite implementation of patient care pathways targeting glucose control during the time of surgery, diabetic patients continue to demonstrate poorer clinical outcomes compared to non-diabetics.[100]

Research has identified that 12 to 30% of patients who experience intra- and/or postoperative hyperglycemia do not have a history of diabetes before surgery[103] a state often described as "stress hyperglycemia" which is associated with an increased risk for postoperative complications including SSI.[104-107] A large observational study (n=3150) demonstrated an association between intraoperative hyperglycemia and an increased risk of SSI following

non-cardiac (general, vascular, urological) surgery, both in patients with and without diabetes.[108] There is evidence of a paradox whereby patients without a history of diabetes who had perioperative hyperglycaemia had a higher risk of infection, re-operative intervention, in-hospital death and 30-day mortality compared to diabetic patients.[103;109] this is likely due to under-diagnosis of diabetes in the preoperative setting and under-treatment of intra/postoperative hyperglycaemia inn truly non-diabetic patients. Indeed, patients with no history of diabetes who experienced hyperglycaemia on the day of surgery and received insulin had no significant increase in risk of infection or death.[109] The fact that patients without a history of diabetes experienced worse outcomes and higher mortality at similar glucose levels experienced by diabetic patients could indicate a lack of adaptation to stress hyperglycemia brought about by trauma/illness/surgery and its associated inflammatory/oxidative state.

Despite the above associations, there is limited evidence to determine whether controlling perioperative hyperglycemia reduces SSI and improves clinical outcomes for all patients regardless of their diabetic history. This review did not identify any prospective studies that assessed the effect of perioperative glucose control for the non-diabetic patient, in part due to the fact that perioperative glucose monitoring (and control) is not considered routine practice for the non-diabetic patient. A retrospective study found that, following implementation of a glycaemic control initiative to reduce SSI following major gynecologic oncology surgeries, there was an over 2-fold reduction in SSI rates (14.6% down to 5.7%, p=0.001) with an adjusted risk ratio of 0.45 (95% CI, 0.25-0.81).[110] The initiative included preoperative diabetic screening and rigorous preoperative/intraoperative/postoperative glucose monitoring with control targets set to maintain blood glucose under 10 mmol/L. Approximately 19% of patients were newly diagnosed with either prediabetes or diabetes as a result of the preoperative screening.

The CDC recommend implementing perioperative glycaemic control [using] blood glucose target levels less than 200 mg/dL (11.1 mmol/l) in patients with and without diabetes (*category IA – strong recommendation; high to moderate-quality evidence*).[41] WHO suggests the use of protocols for intensive perioperative blood glucose control for both diabetic and non-diabetic adult patients undergoing surgical procedures to reduce the risk of SSI. *(Conditional recommendation, low quality of evidence)* but do not specify a blood glucose range or upper limit, possibly owing to the low quality of evience.[24] NICE guidance recommends that *'insulin should not be given routinely to patients who do not have diabetes to optimise blood glucose postoperatively as a means of reducing the risk of surgical site infection, as the lowering of glucose in the immediate postoperative period may have unwanted complications and will require added careful surveillance'*.[6]

Although the evidence indicates a net clinical benefit to controlling blood glucose in the perioperative period, there are numerous confounding factors and uncontrolled variables which limit the reliability of the evidence base and prevent analysis of the independent effect of hyperglycaemia. Prospective randomised controlled studies are required to confirm the effect of perioperative blood glucose control on SSI for all patients across all surgical fields. In the meantime, routine preoperative diabetic screening followed by the appropriate clinical response (i.e. perioperative glucose control only for those patients identified as diabetic) would improve clinical outcomes, and might mitigate the premature implementation of potentially costly and labour-intensive intra/post operative blood glucose monitoring and control for all surgical patients. The Endocrine Society guidelines indicate that patients with hyperglycemia and hemoglobin A1c (HbA1C) of 6.5% or higher can be identified as having diabetes[111], therefore measurement of HbA1c in patients with preoperative hyperglycemia during hospitalisation would allow clinicians to differentiate between stress hyperglycemia (induced by trauma or illness) and undiagnosed diabetes.

4.2.2.4 Final recommendation - Ensure that patient's haemoglobin saturation is maintained above 95% (or as high as possible if there is underlying respiratory insufficiency) (Category 1B)

It is known that all tissues heal most effectively in optimal conditions of oxygenation, perfusion and body temperature. Therefore during surgical procedures, particularly with a general anaesthetic, patient homeostasis has to be maintained by the operating team.[6] Arguments for providing oxygen levels above the standard 30% are largely based on the theory that the surgical incision may not be adequately perfused and would therefore receive a greater oxygen supply if there was higher partial pressure of oxygen in the blood. Additionally, provision of higher oxygen levels may improve host defence systems particularly by enhancing the immune response.

Studies assessing the effects of high oxygen therapy on SSI rates, including meta-analyses[112-115] and RCTs,[116-122] have identified mixed results. Only one RCT demonstrated significantly lower SSI rates with high inspired oxygen in patients undergoing open appendectomy.[122] Six RCTs[116-123] (involving patients undergoing caesarean section (2), colorectal surgery (1), laparotomy (1), major intra-abdominal (1) and mixed (abdominal, gynaecological, breast) (1)) found no benefit of high inspired oxygen. One of these trials (involving major intra-abdominal surgery) identified a significantly higher rate of SSI in the high oxygen therapy group indicating a deleterious effect.[119] Two meta-analyses, including a Cochrane systematic review, found no association between SSI

and high oxygen therapy however trial sequential analyses of both studies determined that sample size was underpowered to detect a significant effect on SSI.[112;113] A third meta-analysis demonstrated a benefit for high inspired oxygen therapy of decreasing SSI only when surgeries using neuraxial anesthesia were excluded, and, in a separate sub-group analysis, only for colorectal surgeries.[114] This finding was mirrored in a meta-analysis by Wang and colleagues in which a sub-group analysis of studies with intestinal tract surgery demonstrated less SSI when high concentration inspired oxygen was administrated, however the overall pooled results of this study showed no benefit of high oxygen therapy.[115]

Delivery of oxygen in the postoperative period is routinely provided via facemask or nasal cannula to maintain peripheral oxygen saturation. Two RCTs studied the effects of postoperative oxygen therapy delivered via nasal cannula (post knee arthroplasty)[124] and non-rebreathing facemask (post bariatric surgery in the morbidly obese in which intraoperative 80% inspired oxygen was routine for all patients).[123] Neither study demonstrated any benefit in terms of SSI however the rate of wound hyperaemia was significantly lower following cannulated oxygenation.[124] It not possible to determine the effect of postoperative high oxygen therapy on SSI rates due to the low number of appropriately powered high quality studies.

World Health Organization (WHO) recommends providing 80% inspired oxygen (FiO_2) for patients undergoing general anesthesia with endotracheal intubation during and after surgery to reduce the risk of SSI. [24] In surgeries using neuraxial anaesthesia with a facemask or nasal cannula there was no evidence of a benefit of high oxygen. WHO states a "strong recommendation" despite self-rating the arguably low quality of evidence as moderate, and despite the potential for deleterious effects arising from hyperoxia as previously observed in critically ill patients with acute myocardial infarction, ischemic stroke, sepsis and circulatory arrest.[125] The US Centers for Disease Control also recommend providing inspired oxygen for patients undergoing general anesthesia with endotracheal intubation during and after surgery however, unlike WHO, do not specify what percentage of inspired oxygen to provide.[41]

Acknowledging the potential risk from high inspired oxygen (FiO_2 >40%) to patients with chronic obstructive pulmonary disease (COPD), the NICE guidance recommends giving patients sufficient oxygen during major surgery and in the recovery period to ensure that a haemoglobin saturation of more than 95% is maintained.[6]

There is currently a lack of evidence to support routine use of perioperative high-oxygen therapy to prevent SSI. Further studies are required to determine whether this intervention is effective

and safe for reducing SSI following specific procedures and in patient groups that are deemed 'high- risk'.

4.2.2.5 Final recommendation - Ensure that the wound is covered with a sterile wound dressing at the end of surgery (Category 1A)

Surgical wound dressings are important to absorb leakage and for protection from microorganisms and should ideally promote or maintain an optimal environment to aid the healing process.[6] A sterile dressing is taken as standard. There are many products available for use in chronic wound care and numerous studies examining their potential to reduce SSI. Results vary depending on the surgical field and dressing type making it difficult to determine superiority of a particular dressing type over another for the reduction of SSI.[126-128] WHO guidance suggests not using any type of advanced dressing over a standard dressing on primarily closed surgical wounds for the purpose of preventing SSI.[129] NICE conducted a review of the evidence of a number of dressing types including hydroactive, hydrocolloid, polyurethane and absorbent dressings.[6] It was concluded that surgical incisions should be covered with 'an appropriate interactive dressing at the end of the operation'. Acknowledging the lack of robust evidence to support the use of one dressing over another to reduce SSI, they recommend that for the majority of clinical situations a semi-permeable film membrane with or without an absorbent island is preferable. This was substantiated by the findings of a Cochrane systematic review of dressings for reduction of SSI (updated in 2016) which concluded that decisions on wound dressings should be based on cost, clinician and patient preference.[44]

In conclusion: it is now advised that the key recommendations listed as a result of this review and summarised in Appendix 4 are incorporated into practice as supported by quality improvement tools including care bundles. These activities can also be supported by national patient safety/quality improvement work (as directed by Healthcare Improvement Scotland).

4.2.3 Review of additional evidence

4.2.3.1 Additional consideration: The use of incise drapes in the prevention of surgical site infection (SSI) (no recommendation)

Preoperative skin preparation is intended to leave the skin as free as possible from microorganisms which may potentially access the surgical wound. Incise drapes, with or without impregnation of an antiseptic (commonly iodine) are an additional intervention and comprise of

adhesive films which cover the skin at the incision site to further minimise the risk of contamination of the wound by acting as a barrier to microorganisms.[130] A Cochrane review of seven studies reported a greater risk of SSI with the use of adhesive drapes compared to no adhesive drapes, and no effect on SSI rate with use of iodine-impregnated adhesive drapes compared with no drapes.[82] Although study quality was rated moderate to high, the most up-to-date study in the Cochrane review was published in 2002 and, bar one from 2001, the remainder published from 1971 to 1993. There were significant limitations with only two performing a power calculation to determine sample size and in five studies no information was given on baseline comparability of intervention groups. There is a need for current research with robust methodology to corroborate the findings of this review. Also acknowledging the lack of quality evidence, WHO guidelines recommend that plastic adhesive incise drapes with or without antimicrobial properties should not be used for the purpose of preventing SSI.[131] It is possible that any benefit of using incise drapes may be dependent on the type of surgery. For example, incise drapes may be ineffective in preventing SSIs resulting from open 'dirty' surgeries like emergency appendectomies, in which the source of infection often originates from the infected appendix rather than contamination by skin microbes.[132] Skin recolonisation was shown to be faster with the use of (non-iodine-impregnated) adhesive plastic drapes compared to bare skin, possibly due to moisture build-up between the skin and the drape.[133] A recent RCT assessing skin colonisation and SSI rates in patients undergoing hip surgery found that patients with an iodine-impregnated incise drape were significantly less likely to have a positive skin culture than those without drapes.[134] The study was underpowered to test for a direct association between skin colonisation and SSI therefore any effect on SSI rates owing to the drapes could not be determined. Until a clinical benefit can be proven, a recommendation cannot be made on the use of iodine-impregnated incise drapes for the reduction of SSI. NICE guidelines recommend against the use of non-iodophor-impregnated drapes and state that *'if incise drapes are used they are impregnated with an antiseptic'*.[6] An experimental study found that choice of skin antisepsis can affect the adhesion of incise drapes to treated skin and this should be considered if the decision to use incise drapes is made.[135]

5. Implications for research

A number of gaps in current evidence have been identified as a result of this review, which may have implications for future research priorities. These are summarised below:

- Further research to evaluate the role of meticillin sensitive *Staphylococcus aureus* (MSSA) screening in the reduction of SSI as well as optimum screening strategies.
- Further research to determine the most effective MRSA decolonisation protocol for the prevention of SSI.
- Further research on the role of negative wound pressure in the reduction of SSI would be useful to inform practice.
- Formulation of a research question and new search strategy to determine the effect of wound protector devices for the prevention of SSI.

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Note: A number of references listed above are cited within the literature review methodology which has been placed in Appendix 2 for ease of reading of this document.

Appendix 1: A framework tool to evaluate evidence based recommendations alongside the health impact contribution & expert opinion (based on the target group covered by this review)

Recommendation for review	**Ensure that a clinical risk assessment for meticillin resistant *Staphylococcus aureus* (MRSA) screening is undertaken**
Grade of recommendation (based on review of evidence)	Category 1B
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: This recommendation supports reducing the risk of harm to the patient resulting from surgery
	Effective: This step is a suitable and accepted method of supporting the reduction of risk of SSI resulting from MRSA which may be colonising the patient
	Efficient: This recommendation may reduce complications and therefore NHS costs associated with complications resulting from MRSA
	Equitable: This assessment promotes a standard of care for all patients that may result in avoidable personal and NHS costs resulting from elective surgery
	Timely: The recommendation should form part of the natural flow of perioperative patient care
	Person Centred: This is a person centred recommendation aimed at reducing risk of SSI occurring in every patient and allows for communication with the patient

Expert opinion/consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause &	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	?	Y	Y	Y	?	Y	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that body hair is not removed if at all possible; if hair removal is necessary, do not use razors.**
Grade of recommendation (based on review of evidence)	Category 1A
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this may put the patient at risk of harm
	Effective: This recommendation reduces the risk of infection complications from surgery
	Efficient: This recommendation reduces the risk of SSI and therefore results in releasing time for other aspects of care delivery and a reduction in avoidable NHS costs
	Equitable: This recommendation promotes a standard of care for all patients that may result in a reduction in avoidable personal and NHS costs applicable to all patients and should positively manage avoidable NHS costs, which is also beneficial to all
	Timely: This recommendation should form part of the natural flow of preoperative care
	Person Centred: This is a person centred recommendation aimed at reducing risk of SS in every patient and allows for communication with the patient including their role in supporting this action

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	Y	Y	Y	?	Y	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that the patient has showered (or bathed/washed if unable to shower) on day of or day before surgery using plain soap.**
Grade of recommendation (based on review of evidence)	Category 1B
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put the patient at increased risk of harm
	Effective: This recommendation reduces the risk of introducing infection complications, resulting in releasing time for other care and a reduction in associated NHS costs
	Efficient: This recommendation reduces the risk of SSI resulting in releasing time for other care and a reduction in NHS costs
	Equitable: This recommendation promotes a standard of care for all patients that may result in a reduction in avoidable personal and NHS costs applicable to all patients and should positively manage avoidable NHS costs, which is also beneficial to all
	Timely: This recommendation fits with the natural flow of care and aspects of routine personal hygiene
	Person Centred: This is a fundamental care activity that allows for meaningful and beneficial interaction between patient and healthcare worker

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	?	Y	Y	Y	Y	N	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that prophylactic antibiotic is prescribed as per local antibiotic policy/SIGN guideline, for the specific operation category**
Grade of recommendation (based on review of evidence)	Category 1A
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put the patient at risk of harm.
	Effective: This recommendation could reduce the risk of SSI
	Efficient: This recommendation reduces the risk of infectious complications resulting in releasing time for other care and a reduction in NHS costs
	Equitable: This recommendation promotes a standard of care for all patients that may result in a reduction in avoidable personal and NHS costs which is also beneficial to all
	Timely: This recommendation fits within the natural flow of patient care and other medication administration
	Person Centred: This is a person centred recommendation for every patient undergoing a specific operation category

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	?	Y	Y	?	Y	Y	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that the antibiotic is administered within 60 minutes prior to the operation (blade to skin).**
Grade of recommendation (based on review of evidence)	Category 1A
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put the patient at risk of harm
	Effective: This recommendation reduces the risk of SSI
	Efficient: This recommendation will reduce the risk of infection complications resulting in releasing time for other care and reduction in associated NHS cost
	Equitable: This recommendation promotes a standard of care for all patients that may result in a reduction in avoidable personal and NHS costs
	Timely: This recommendation fits within the natural flow of patient care and other medication administration
	Person Centred: This is a person centred action to reduce infection complications in every patient undergoing a specific operation category

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of	Potential for consistent delivery	Easily implemented based on reliably available resources/ products	Stealth integration into natural workflow/ logical clarity of concept	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and
	Y	Y	?	Y	Y	Y	Y	Y	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that 2% chlorhexidine gluconate in 70% isopropyl alcohol solution is used for skin preparation (if patient sensitive, use povidone-iodine).**
Grade of recommendation (based on review of evidence)	Category 1A
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put the patient at risk of harm
	Effective: This recommendation reduces the risk of SSI
	Efficient: This recommendation reduces the risk of introducing infection complications, resulting in releasing time for other care and a reduction in associated NHS costs
	Equitable: This recommendation promotes a standard of care for all patients that may result in a reduction in avoidable personal and NHS costs which is beneficial to all
	Timely: This recommendation fits with the natural flow of preoperative patient care
	Person Centred: This is a person centred activity to reduce harm and that allows for meaningful and beneficial interaction between the patient and healthcare worker

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	Y	Y	Y	Y	Y	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that the patient's body temperature is maintained above 36°C in the perioperative period (excludes cardiac patients)**
Grade of recommendation (based on review of evidence)	Category 1A
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put the patient at risk of harm
	Effective: This recommendation reduces the risk of infection complications occurring
	Efficient: This recommendation fits within the natural flow of perioperative patient care
	Equitable: This recommendation promotes a standard of perioperative care for all patients that may result in avoidable personal and NHS costs
	Timely: This recommendation fits with the natural flow of perioperative patient care
	Person Centred: This is a person centred action to reduce harm; in every patient receiving surgery

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products /prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause &	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	Y	Y	Y	Y	Y	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that the diabetic patient's glucose level is kept <11mmol/l throughout the operation.**
Grade of recommendation (based on review of evidence)	Category 1B
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put certain patients at risk of harm
	Effective: This recommendation may reduce the risk of SSI in certain patients
	Efficient: This recommendation fits with the perioperative care for certain patients and reduces the risk of SSI associated increased effects on vulnerable diabetic patients
	Equitable: All diabetic patients should be supported by this recommendation
	Timely: This recommendation fits with the flow of perioperative patient care
	Person Centred: This is a patient centred action to reduce harm; in every diabetic patient receiving surgery

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	Y	Y	Y	Y	N	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that patient's haemoglobin saturation is maintained above 95% (or as high as possible if there is underlying respiratory insufficiency).**
Grade of recommendation (based on review of evidence)	Category 1B
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put patients at risk of harm
	Effective: This recommendation reduces the risk of SSI occurring particularly in certain patient groups
	Efficient: This recommendation reduces the risk of infection complications resulting an releasing time for other care activity and a reduction in the associated NHS cost
	Equitable: This recommendation promotes a standard of care for all patients that may result in a reduction in avoidable personal and NHS costs
	Timely: This recommendation fits with the flow of perioperative patient care
	Person Centred: This is a patient centred action to reduce harm; in every patient receiving surgery

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and	Potential for consistent delivery	Easily implemented based on reliably available	Stealth integration into natural workflow/logical clarity	Unambiguous	Potential for applicability to a wide range of	Avoids unintended consequences /perverse	Potential for congruency in design and meaning, with HCW, trainer
	Y	Y	Y	Y	Y	Y	Y	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that the wound is covered with a sterile wound dressing at the end of surgery**
Grade of recommendation (based on review of evidence)	Category 1A
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put certain patients at risk of harm
	Effective: Based on available evidence, not implementing this recommendation may lead to an increase in infections in certain patients and implementing it leads to increased comfort and quality patient experience
	Efficient: This recommendation fits within the flow of perioperative care for surgical patients
	Equitable: All patients should be supported by this recommendation
	Timely: This recommendation fits with the flow of perioperative patient care
	Person Centred: This is a patient centred action to reduce harm and increase comfort following surgery

Expert opinion/ consultation and practical considerations	Measurement and feedback (Y/N/?)	Feasibility and sustainability (Y/N/?)				Applicability and reach (Y/N/?)			Training and informing (Y/N/?)
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prom pts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	Y	Y	Y	?	Y	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that the wound dressing is kept in place for 48 hours after surgery unless clinically indicated**
Grade of recommendation (based on review of evidence)	Category II
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put certain patients at risk of harm
	Effective: Based on available evidence, not implementing this recommendation may lead to an increase in infections in certain patients and implementing it leads to increased comfort and quality patient experience
	Efficient: This recommendation fits within the flow of postoperative care for surgical patients
	Equitable: All patients should be supported by this recommendation
	Timely: This recommendation fits with the flow of postoperative patient care
	Person Centred: This is a care activity that allows for meaningful and beneficial interaction between patient and healthcare worker

Expert opinion/ consultation and practical considerations	Measurement and feedback (Y/N/?)	Feasibility and sustainability (Y/N/?)				Applicability and reach (Y/N/?)			Training and informing (Y/N/?)
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	Y	Y	Y	?	Y	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that aseptic technique is used, if there is excess wound leakage and need for a dressing change**
Grade of recommendation (based on review of evidence)	Category 1B
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put certain patients at risk of harm
	Effective: Not implementing this recommendation may lead to an increase in infections in patients
	Efficient: This recommendation fits with the postoperative care for patients and reduces the risk of SSI
	Equitable: All patients should be supported by this recommendation
	Timely: This recommendation fits with the flow of postoperative patient care
	Person Centred: This is a care activity that allows for meaningful and beneficial interaction between patient and healthcare worker

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences /perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	Y	Y	Y	?	Y	?	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Ensure that hand hygiene is performed immediately before every aseptic dressing change (WHO Moment 2).**
Grade of recommendation (based on review of evidence)	Category 1A
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put certain patients at risk of harm
	Effective: There is substantial consensus of evidence that the contamination on hands of healthcare workers is associated with transmission of infection and could lead to postoperative complications to patients and the healthcare setting
	Efficient: The simple action of hand hygiene results in a reduction of complications and therefore in the NHS cost associated by avoiding further complications and in releasing time for other care
	Equitable: All patients receiving care can have safer care if supported by application of this recommendation
	Timely: Hand hygiene is an integral part of patient care and this recommendation fits with best practice in management of postoperative wounds, already recognised by healthcare workers
	Person Centred: This is a person centred action to reduce harm in every patient who has had a surgical procedure and allows for communication with patients as well as engaging individuals on the importance of hand hygiene and their role in this

Expert opinion/ consultation and practical considerations	Measurement and feedback (Y/N/?)	Feasibility and sustainability (Y/N/?)				Applicability and reach (Y/N/?)			Training and informing (Y/N/?)
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see Cause & Effect Chart)	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences/perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	Y	Y	Y	Y	?	Y	Y	Y
Is this a key recommendation?	Yes								

Recommendation for review	**Use of incise drapes in the prevention of SSI**
Grade of recommendation (based on review of evidence)	Category II
Health impact contribution (based on Healthcare Quality Strategy for NHSScotland)	Safe: Not implementing this recommendation may put certain patients at risk of harm
	Effective: Not sufficient evidence to support the effectiveness of this recommendation
	Efficient: This recommendation could fit with the perioperative care
	Equitable: If proven to have an impact this recommendation would be important for all patients but currently there is insufficient evidence
	Timely: This recommendation could fit with the flow of perioperative patient care
	Person Centred: Not sufficient evidence to support the use of this recommendation

Expert opinion/ consultation and practical considerations	**Measurement and feedback (Y/N/?)**	**Feasibility and sustainability (Y/N/?)**				**Applicability and reach (Y/N/?)**			**Training and informing (Y/N/?)**
	Potential for measurement through e.g. observation	Easily implemented within current culture and will improve the quality of care now	Potential for consistent delivery	Easily implemented based on reliably available resources/ products/ prompts	Stealth integration into natural workflow/ logical clarity of concept (also see	Unambiguous	Potential for applicability to a wide range of settings	Avoids unintended consequences/perverse behaviour	Potential for congruency in design and meaning, with HCW, trainer and observer training and education
	Y	N	?	?	?	N	N	N	?
Is this a key recommendation?	No								

Appendix 2: Literature review methodology

The evidence underpinning the criteria for a quality improvement tool was reviewed using a targeted systematic approach to enable input and resource to be concentrated where needed. This methodology is fully described within a separate HPS paper '*Rapid method for development of evidence based/expert opinion key recommendations, based on health protection network guidelines'.*

Initial rapid search and review

The initial search rapid literature search was carried out to identify mandatory guidance, or recent national or international evidence based guidance which either agrees or refutes that the current key recommendations are the most important to ensure optimal PVC care:

- The main public health websites were searched to source any existing quality improvement tools
- Relevant guidance and quality improvement tools e.g. Department of Health (DH), Centers for Disease Control and Prevention (CDC) etc were reviewed
- Additional literature identified and sourced e.g. from the relevant Cochrane reviews.

The quality of evidence based guidance was assessed using the AGREE instrument[136] and only guidance which achieved either a strongly recommend or recommend rating was included.

Targeted systematic review

As a result of initial rapid search and review, recommendations requiring a more in depth review were identified. This involved searching of relevant databases including OVID Medline, CINAHL, EMBASE. All literature pertaining to recommendations where evidence was either conflicting or where new evidence was available were critically appraised using SIGN checklists and a 'considered judgement' process used to formulate recommendations based on the current evidence for presentation and discussion with the National HAI Quality Improvement Tools Group in Scotland.

Grading of recommendations

Grading of the evidence is using the Healthcare Infection Control Practices Advisory Committee (HICPAC) method.[137] In addition to the overall assessment of the evidence underpinning the recommendation, other factors are considered which affect the overall strength of the recommendation such as the health impact and expert opinion on the potential critical outcomes.

The HICPAC categories are as follows:

Category	Recommendation
Category 1A	Strong recommendation based on high to moderate quality evidence
Category 1B	Strong recommendation based on low quality of evidence which suggest net clinical benefits or harms or an accepted practice (e.g. aseptic technique)
Category 1C	A mandatory recommendation
Category II	A weak recommendation which shows evidence of clinical benefit over harm
No recommendation	Not sufficient evidence to recommend one way or another

Framework for identifying final key recommendations

One way of improving implementation of evidence based guidance is by the identification of key recommendations which if applied will improve practice and outcome.[138-144] This is the foundation of ‘care bundles’ and other quality improvement tools which rely on the identification of key evidence based recommendations to ensure application in practice.[145]

A method has been developed which aims to reflect graded recommendations in line with ensuring healthcare quality, attention to cost and practical application. It combines approaches used by the Institute of Healthcare Improvement (IHI) and World Health Organization, among others, in identifying the critical factors from the evidence to ensure patient safety in a range of fields.[144;146] The method considers the current NHSScotland Quality Strategy dimensions and finally expert opinion applied within a formal framework. This framework includes a range of practical considerations under the headings measurement and feedback, feasibility and sustainability, applicability and reach, training and informing.

Ultimately, HPS key recommendations are presented taking all of these factors into account, with the aim of improving practice and outcome.

Appendix 3: Research Questions and Search Strategies

The following research questions were developed for the purpose of this literature review:

- For surgical procedures, what timing should be used for the administration of appropriate antibiotic prophylaxis prior to incision?
- For surgical procedures, should the patient's skin be prepared using an antiseptic solution prior to surgical incision, and if so, what is the best method?
- For surgical procedures, should patients shower pre-op and if so what is the best method?
- For surgical procedures, should patients be been screened for MRSA?
- Should patients' hair be removed prior to surgery, and if so, what is the best method?
- Is patient perioperative oxygenation clinically effective for the prevention of surgical site infection?
- Is perioperative blood glucose control clinically effective for the prevention of surgical site infection?
- Is hand hygiene effective for the prevention of surgical site infection?
- What surgical dressing are the most effective for the prevention of surgical site infection?

Key literature from e.g. the relevant Cochrane reviews were also sourced and critically appraised using SIGN methodology.

Search Strategies

SSI antibiotic prophylaxis timing

Database: Ovid MEDLINE(R) <1948 to July Week 4 2011> Search Strategy:

1 exp Surgical Procedures, Operative/ (2082785)

2 exp Arthroplasty, Replacement, Hip/ or exp Hip Prosthesis/ (24670)

3 exp Cesarean Section/ (30978)

4 exp Colorectal Surgery/ (1571)

5 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (13979)

6 1 or 2 or 3 or 4 or 5 (2094209)

7 exp Antibiotic Prophylaxis/ (7128)

8 timing.mp. (62431)

9 6 and 7 and 8 (129)

10 limit 9 to (english language and humans) (110)

11 limit 10 to yr="2000 -Current" (96)

Search strategy for 2014 update

Database: Ovid MEDLINE(R) < July Week 4 2011 to October 2014> Search Strategy:

1 exp surgical procedures, operative/ (2438142)

2 exp arthroplasty, replacement, hip/ or hip prosthesis.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (30333)

3 exp cesarean section/ (35844)

4 exp colorectal surgery/ (2075)

5 knee prosthesis/ or arthroplasty, replacement, knee.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (18528)

6 1 or 2 or 3 or 4 or 5 (2450515)

7 exp antibiotic prophylaxis/ (8943)

8 timing.mp. (78968)

9 6 and 7 and 8 (184)

10 limit 9 to (english language and humans and yr="2011 -Current") (53)

11 from 10 keep 1-53 (53)

Search Strategy for 2018 update

Database: Ovid MEDLINE(R) ALL <1946 to November 16, 2018> Search Strategy:

1 exp surgical procedures, operative/ (7229486)

2 exp arthroplasty, hip/ or exp hip prosthesis/ (91773)

3 exp cesarean section/ (126667)

4 exp colorectal surgery/ (22748)

5 knee prosthesis/ or arthroplasty, replacement, knee.mp. (33439)

6 1 or 2 or 3 or 4 or 5 (7317046)

7 exp antibiotic prophylaxis/ (41245)

8 timing.mp. (271119)

9 6 and 7 and 8 (826)

10 limit 9 to english language (771)

11 limit 10 to human (723)

12 limit 11 to yr="2014 -Current" (264)

13 remove duplicates from 12 (217)

Skin prep to prevent SSI

Database: Ovid MEDLINE(R) <1948 to July Week 4 2011> Search Strategy:

1 exp Surgical Procedures, Operative/ (2082785)

2 exp Cesarean Section/ (30978)

3 exp Arthroplasty, Replacement, Hip/ or exp Hip Prosthesis/ or exp Arthroplasty/ (40826)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ or Joint Prosthesis/ or Arthroplasty/ (26258)

5 exp Colorectal Surgery/ (1571)

6 1 or 2 or 3 or 4 or 5 (2098174)

7 exp Povidone/ or exp Chlorhexidine/ or exp Anti-Infective Agents, Local/ or exp Povidone-Iodine/ or exp Antisepsis/ (166142)

8 exp Surgical Wound Infection/ (25598)

9 exp Bacteremia/ (17709)

10 8 or 9 (43118)

11 6 and 7 and 10 (848)

12 exp Preoperative Period/ or exp Preoperative Care/ (54030)

13 11 and 12 (213)

14 limit 13 to english language (168)

15 limit 14 to yr="1995 -Current" (90)

Search strategy for 2014 update

Database: Ovid MEDLINE(R) <July Week 4 2011 to October 2014> Search Strategy:

1 exp surgical procedures, operative/ (2438142)

2 exp cesarean section/ (35844)

3 exp arthroplasty, replacement, hip/ or exp hip prosthesis/ or exp arthroplasty/ (53767)

4 knee prosthesis/ or arthroplasty, replacement, knee/ or joint prosthesis/ or arthroplasty.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (57692)

5 exp colorectal surgery/ (2075)

6 1 or 2 or 3 or 4 or 5 (2456613)

7 exp povidone/ or exp chlorhexidine/ or exp anti-infective agents, local/ or exp povidone-iodine/ or exp antisepsis/ (189319)

8 exp surgical wound infection/ (28970)

9 exp bacteremia/ (21690)

10 8 or 9 (50432)

11 6 and 7 and 10 (1025)

12 exp preoperative period/ or exp preoperative care/ (61953)

13 11 and 12 (272)

14 limit 13 to (english language and humans and yr="2011 -Current") (50)

Search strategy for 2018 update

Database: Ovid MEDLINE(R) ALL <1946 to November 16, 2018> Search Strategy:

1 exp surgical procedures, operative/ (7229486)

2 exp cesarean section/ (126667)

3 exp arthroplasty, hip/ or exp hip prosthesis/ or exp arthroplasty/ (164847)

4 knee prosthesis/ or arthroplasty, replacement, knee/ or joint prosthesis/ or arthroplasty.mp. (180662)

5 exp colorectal surgery/ (22748)

6 1 or 2 or 3 or 4 or 5 (7340823)

7 exp povidone/ or exp chlorhexidine/ or exp anti-infective agents, local/ or exp povidone-iodine/ or exp antisepsis/ (544193)

8 exp surgical wound infection/ (72910)

9 exp bacteremia/ (71181)

10 8 or 9 (143082)

11 6 and 7 and 10 (2898)

12 exp preoperative period/ or exp preoperative care/ (348136)

13 11 and 12 (763)

14 limit 13 to english language (676)

15 limit 14 to human (644)

16 limit 15 to yr="2014 -Current" (226)

17 remove duplicates from 16 (184)

MRSA Screening

Database: Ovid MEDLINE(R) <1948 to July Week 4 2011> Search Strategy:

1 exp Cesarean Section/ (30978)

2 exp Surgical Procedures, Operative/ (2082785)

3 Arthroplasty, Replacement, Hip/ or Hip Prosthesis/ or Arthroplasty/ or Hip Joint/ (43389)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (13979)

5 exp Colorectal Surgery/ (1571)

6 1 or 2 or 3 or 4 or 5 (2104275)

7 Surgical Wound Infection/ (25598)

8 Bacteremia/ (14767)

9 7 or 8 (40179)

10 mrsa screening.mp. (140)

11 6 and 9 and 10 (12)

Search strategy for 2014 update

Database: Ovid MEDLINE(R) < July Week 4 2011 to October 2014> Search Strategy:

1 exp cesarean section/ (35844)

2 exp surgical procedures, operative/ (2438142)

3 arthroplasty, replacement, hip/ or hip prosthesis/ or arthroplasty/ or hip joint.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (55084)

4 knee prosthesis/ or arthroplasty, replacement, knee.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (18528)

5 exp colorectal surgery/ (2075)

6 1 or 2 or 3 or 4 or 5 (2464422)

7 Surgical Wound Infection/ (28970)

8 Bacteremia/ (18138)

9 7 or 8 (46884)

10 mrsa screening.mp. (226)

11 6 and 9 and 10 (18)

12 limit 11 to (english language and humans and yr="2011 -Current") (7)

Search strategy for 2018 update

Database: Ovid MEDLINE(R) ALL <1946 to November 16, 2018> Search Strategy:

1 exp cesarean section/ (126667)

2 exp surgical procedures, operative/ (7229486)

3 arthroplasty, hip/ or hip prosthesis/ or arthroplasty/ or hip joint.mp. (119200)

4 knee prosthesis/ or arthroplasty, replacement, knee.mp. (33439)

5 exp colorectal surgery/ (22748)

6 1 or 2 or 3 or 4 or 5 (7331465)

7 surgical wound infection.mp. (36795)

8 bacteremia.mp. (83485)

9 7 or 8 (119742)

10 mrsa screening.mp. (932)

11 6 and 9 and 10 (32)

12 limit 11 to english language (32)

13 limit 12 to human (30)

14 limit 13 to yr="2014 -Current" (11)

15 remove duplicates from 14 (8)

Pre-op showering

Database: Ovid MEDLINE(R) <1948 to July Week 4 2011> Search Strategy:

1 exp Cesarean Section/ (30978)

2 exp Surgical Procedures, Operative/ (2082785)

3 Arthroplasty, Replacement, Hip/ or Hip Prosthesis/ or Arthroplasty/ or Hip Joint/ (43389)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (13979)

5 exp Colorectal Surgery/ (1571)

6 1 or 2 or 3 or 4 or 5 (2104275)

7 Surgical Wound Infection/ (25598)

8 Bacteremia/ (14767)

9 7 or 8 (40179)

10 shower.mp. (890)

11 exp Baths/ (3853)

12 bathing.mp. (8026)

13 10 or 11 or 12 (12006)

14 6 and 9 and 13 (68)

Search strategy for 2014 update

Database: Ovid MEDLINE(R) <July Week 4 2011 to October 2014> Search Strategy:

1 exp cesarean section/ (35844)

2 exp surgical procedures, operative/ (2438142)

3 arthroplasty, replacement, hip/ or hip prosthesis/ or arthroplasty/ or hip joint.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (55084)

4 knee prosthesis/ or arthroplasty, replacement, knee.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (18528)

5 exp colorectal surgery/ (2075)

6 1 or 2 or 3 or 4 or 5 (2464422)

7 Surgical Wound Infection/ (28970)

8 Bacteremia/ (18138)

9 7 or 8 (46884)

10 shower.mp. (1048)

11 exp baths/ (4191)

12 bathing.mp. (8741)

13 10 or 11 or 12 (13089)

14 6 and 9 and 13 (89)

15 limit 14 to (english language and humans and yr="2011 -Current") (20)

Search strategy for 2018 update

Database: Ovid MEDLINE(R) ALL <1946 to November 14, 2018> Search Strategy:

1 exp cesarean section/ (126571)

2 exp surgical procedures, operative/ (7225050)

3 arthroplasty, hip/ or hip prosthesis/ or arthroplasty/ or hip joint.mp. (119148)

4 knee prosthesis/ or arthroplasty, replacement, knee.mp. (33412)

5 exp colorectal surgery/ (22716)

6 1 or 2 or 3 or 4 or 5 (7326971)

7 surgical wound infection.mp. (36788)

8 bacteremia.mp. (83400)

9 7 or 8 (119650)

10 shower.mp. (3703)

11 exp baths/ (14293)

12 bathing.mp. (21718)

13 10 or 11 or 12 (35472)

14 6 and 9 and 13 (168)

15 limit 14 to english language (155)

16 limit 15 to human (151)

17 limit 16 to yr="2014 -Current" (60)

18 remove duplicates from 17 (48)

Oxygenation to prevent SSI

Database: Ovid MEDLINE(R) <1948 to July Week 4 2011> Search Strategy:

1 exp Cesarean Section/ (30978)

2 exp Surgical Procedures, Operative/ (2082785)

3 Arthroplasty, Replacement, Hip/ or Hip Prosthesis/ or Arthroplasty/ or Hip Joint/ (43389)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (13979)

5 exp Colorectal Surgery/ (1571)

6 1 or 2 or 3 or 4 or 5 (2104275)

7 Perioperative Care/ or Oxygen/ or Postoperative Complications/ (388914)

8 Hemoglobins/ or Hemoglobins, Abnormal/ (60603)

9 Homeostasis/ (37883)

10 7 or 8 or 9 (478015)

11 Surgical Wound Infection/ (25598)

12 Bacteremia/ (14767)

13 11 or 12 (40179)

14 6 and 10 and 13 (4133)

15 limit 14 to (english language and yr="2000 -Current") (1264)

16 perioperative oxygenation.mp. (6)

17 oxygen supplementation.mp. (584)

18 hyperoxygenation.mp. (271)

19 Hyperoxia/ (2063)

20 oxygen therapy.mp. (6108)

21 16 or 17 or 18 or 19 or 20 (8876)

22 15 and 21 (14)

Search strategy for 2014 update

Database: Ovid MEDLINE(R) <July Week 4 2011 to October 2014> Search Strategy:

1 exp cesarean section/ (35844)

2 exp surgical procedures, operative/ (2438142)

3 arthroplasty, replacement, hip/ or hip prosthesis/ or arthroplasty/ or hip joint.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (55084)

4 knee prosthesis/ or arthroplasty, replacement, knee.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (18528)

5 exp colorectal surgery/ (2075)

6 1 or 2 or 3 or 4 or 5 (2464422)

7 perioperative care/ or oxygen/ or postoperative complications.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (452792)

8 hemoglobins/ or hemoglobins, abnormal/ (65969)

9 homeostasis/ (45775)

10 7 or 8 or 9 (554336)

11 surgical wound infection/ (28970)

12 bacteremia/ (18138)

13 11 or 12 (46884)

14 6 and 10 and 13 (5072)

15 limit 14 to (english language and yr="2000 -Current") (1989)

16 perioperative oxygenation.mp. (7)

17 oxygen supplementation.mp. (709)

18 hyperoxygenation.mp. (304)

19 hyperoxia/ (2606)

20 oxygen therapy.mp. (7192)

21 16 or 17 or 18 or 19 or 20 (10615)

22 15 and 21 (21)

23 limit 22 to (english language and humans and yr="2011 -Current") (9)

Search strategy for 2018 update

Ovid MEDLINE(R) ALL <1946 to November 16, 2018> Search Strategy:

1 exp cesarean section/ (126667)

2 exp surgical procedures, operative/ (7229486)

3 arthroplasty, hip/ or hip prosthesis/ or arthroplasty/ or hip joint.mp. (119200)

4 knee prosthesis/ or arthroplasty, replacement, knee.mp. (33439)

5 exp colorectal surgery/ (22748)

6 1 or 2 or 3 or 4 or 5 (7331465)

7 perioperative care/ or oxygen/ or postoperative complications.mp. (819313)

8 hemoglobins/ or hemoglobins, abnormal.mp. (207047)

9 homeostasis.mp. (423736)

10 7 or 8 or 9 (1425643)

11 surgical wound infection.mp. (36795)

12 bacteremia.mp. (83485)

13 11 or 12 (119742)

14 6 and 10 and 13 (7238)

15 perioperative oxygenation.mp. (27)

16 hyperoxygenation.mp. (796)

17 hyperoxia.mp. (18899)

18 oxygen therapy.mp. (43839)

19 oxygen supplementation.mp. (2660)

20 15 or 16 or 17 or 18 or 19 (63952)

21 14 and 20 (58)

22 limit 21 to english language (55)

23 limit 22 to human (55)

24 limit 23 to yr="2014 -Current" (16)

25 remove duplicates from 24 (13)

Surgical dressings

Database: Ovid MEDLINE(R) <1948 to July Week 4 2011> Search Strategy:

1 exp Cesarean Section/ (30978)

2 exp Surgical Procedures, Operative/ (2082785)

3 Arthroplasty, Replacement, Hip/ or Hip Prosthesis/ or Arthroplasty/ or Hip Joint/ (43389)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (13979)

5 exp Colorectal Surgery/ (1571)

6 1 or 2 or 3 or 4 or 5 (2104275)

7 Surgical Wound Infection/ (25598)

8 Bacteremia/ (14767)

9 7 or 8 (40179)

10 surgical dressing.mp. (109)

11 6 and 9 and 10 (8)

Search strategy for 2014 update

Database: Ovid MEDLINE(R) <July Week 4 2011 to October 2014> Search Strategy:

1 exp Cesarean Section/ (36037)

2 exp Surgical Procedures, Operative/ (2478091)

3 Arthroplasty, Replacement, Hip/ or Hip Prosthesis/ or Arthroplasty/ or Hip Joint/ (52713)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (19087)

5 exp Colorectal Surgery/ (2124)

6 1 or 2 or 3 or 4 or 5 (2502277)

7 Surgical Wound Infection/ (29353)

8 Bacteremia/ (18505)

9 7 or 8 (47626)

10 surgical dressing.mp. (122)

11 6 and 9 and 10 (9)

12 limit 11 to (english language and humans and yr="2011 -Current") (0)

Search strategy for 2018 update:

Ovid MEDLINE(R) ALL <1946 to October 17, 2018>Search Strategy:

1 exp Cesarean Section/ (125421)

2 exp Surgical Procedures, Operative/ (7179138)

3 Arthroplasty, Replacement, Hip/ or Hip Prosthesis/ or Arthroplasty/ or Hip Joint/ (125732)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (34629)

5 exp Colorectal Surgery/ (22247)

6 1 or 2 or 3 or 4 or 5 (7295667)

7 Surgical Wound Infection/ (40848)

8 Bacteremia/ (59581)

9 7 or 8 (100104)

10 surgical dressings.mp. (242)

11 6 and 9 and 10 (20)

12 limit 11 to english language (20)

13 limit 12 to humans (20)

14 limit 13 to yr="2014 -Current" (13)

15 remove duplicates from 14 (11)

Hand hygiene to prevent SSI

Database: Ovid MEDLINE(R) <1948 to July Week 4 2011> Search Strategy:

1 exp Cesarean Section/ (30978)

2 exp Surgical Procedures, Operative/ (2082785)

3 Arthroplasty, Replacement, Hip/ or Hip Prosthesis/ or Arthroplasty/ or Hip Joint/ (43389)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (13979)

5 exp Colorectal Surgery/ (1571)

6 1 or 2 or 3 or 4 or 5 (2104275)

7 Surgical Wound Infection/ (25598)

8 Bacteremia/ (14767)

9 7 or 8 (40179)

10 hand hygiene.mp. (1269)

11 6 and 9 and 10 (17)

Search strategy for 2014 update

Database: Ovid MEDLINE(R) <July Week 4 2011 to October 2014> Search Strategy:

1 exp cesarean section/ (35844)

2 exp surgical procedures, operative/ (2438142)

3 arthroplasty, replacement, hip/ or hip prosthesis/ or arthroplasty/ or hip joint/ (51753)

4 knee prosthesis/ or arthroplasty, replacement, knee/ (18526)

5 exp colorectal surgery/ (2075)

6 1 or 2 or 3 or 4 or 5 (2461948)

7 surgical wound infection/ (28970)

8 bacteremia/ (18138)

9 7 or 8 (46884)

10 hand hygiene.mp. (2025)

11 6 and 9 and 10 (28)

12 limit 11 to (english language and humans and yr="2011 -Current") (10)

Search strategy for 2018 update

Ovid MEDLINE(R) ALL <1946 to July 30, 2018>Search Strategy:

1 exp cesarean section/ (128018)

2 exp surgical procedures, operative/ (7292652)

3 arthroplasty, replacement, hip/ or hip prosthesis/ or arthroplasty/ or hip joint/ (130624)

4 knee prosthesis/ or arthroplasty, replacement, knee/ (34157)

5 exp colorectal surgery/ (22024)

6 1 or 2 or 3 or 4 or 5 (7415488)

7 surgical wound infection/ (41775)

8 bacteremia/ (59609)

9 7 or 8 (101079)

10 hand hygiene.mp. (9608)

11 6 and 9 and 10 (73)

12 limit 11 to english language (69)

13 limit 12 to human (58)

14 limit 13 to yr="2014 -Current" (27)

15 remove duplicates from 14 (23)

Hair removal to prevent SSI

2018 search strategy

Database: Ovid MEDLINE(R) ALL <1946 to September 06, 2018> Search Strategy:

1 exp surgical procedures, operative/ (713123)

2 exp cesarean section/ (124464)

3 exp arthroplasty, hip/ or exp hip prosthesis/ or exp arthroplasty/ (161606)

4 knee prosthesis/ or arthroplasty, replacement, knee/ or joint prosthesis/ or arthroplasty.mp. (177119)

5 exp colorectal surgery/ (22043)

6 1 or 2 or 3 or 4 or 5 (7240709)

7 exp hair removal/ (2264)

8 exp surgical wound infection/ (71214)

9 exp bacteremia/ (70263)

10 8 or 9 (140489)

11 6 and 7 and 10 (136)

12 exp preoperative period/ or exp preoperative care/ (340184)

13 11 and 12 (92)

14 limit 13 to english language (79)

15 limit 14 to human (77)

16 limit 15 to yr="2014 -Current" (19)

17 remove duplicates from 16 (18)

Incise drapes to prevent SSI

Database: Ovid MEDLINE(R) <1948 to July Week 4 2011> Search Strategy:

1 exp Cesarean Section/ (30978)

2 exp Surgical Procedures, Operative/ (2082785)

3 Arthroplasty, Replacement, Hip/ or Hip Prosthesis/ or Arthroplasty/ or Hip Joint/ (43389)

4 Knee Prosthesis/ or Arthroplasty, Replacement, Knee/ (13979)

5 exp Colorectal Surgery/ (1571)

6 1 or 2 or 3 or 4 or 5 (2104275)

7 Surgical Wound Infection/ (25598)

8 Bacteremia/ (14767)

9 7 or 8 (40179)

10 Adhesives/ or incise drapes.mp. (3884)

11 6 and 9 and 10 (10)

Search strategy for 2014 update

Database: Ovid MEDLINE(R) <July Week 4 2011 to October 2014> Search Strategy:

1 exp cesarean section/ (35844)

2 exp surgical procedures, operative/ (2438142)

3 arthroplasty, replacement, hip/ or hip prosthesis/ or arthroplasty/ or hip joint/ (51753)

4 knee prosthesis/ or arthroplasty, replacement, knee/ (18526)

5 exp colorectal surgery/ (2075)

6 1 or 2 or 3 or 4 or 5 (2461948)

7 surgical wound infection/ (28970)

8 bacteremia/ (18138)

9 7 or 8 (46884)

10 adhesives/ or incise drapes.mp. (4456)

11 6 and 9 and 10 (11)

12 limit 11 to (english language and humans and yr="2011 -Current") (2)

Search strategy for 2018 update

Ovid MEDLINE(R) ALL <1946 to November 16, 2018> Search Strategy:

1 exp cesarean section/ (126667)

2 exp surgical procedures, operative/ (7229486)

3 arthroplasty, replacement, hip/ or hip prosthesis/ or arthroplasty/ or hip joint/ (126424)

4 knee prosthesis/ or arthroplasty, replacement, knee/ (34881)

5 exp colorectal surgery/ (22748)

6 1 or 2 or 3 or 4 or 5 (7347006)

7 surgical wound infection/ (42038)

8 bacteremia/ (59928)

9 7 or 8 (101625)

10 adhesives/ or incise drapes.mp. (17709)

11 6 and 9 and 10 (29)

12 limit 11 to english language (28)

13 limit 12 to human (26)

14 limit 13 to yr="2014 -Current" (13)

15 remove duplicates from 14 (12)

Blood glucose control to prevent SSI

Search strategy for 2018 update:

Database: Ovid MEDLINE(R) ALL <1946 to November 09, 2018> Search Strategy:

1 exp cesarean section/ (126509)

2 exp surgical procedures, operative/ (7221296)

3 arthroplasty, hip/ or hip prosthesis/ or arthroplasty/ or hip joint.mp. (119108)

4 knee prosthesis/ or arthroplasty, replacement, knee.mp. (33394)

5 exp colorectal surgery/ (22703)

6 1 or 2 or 3 or 4 or 5 (7323155)

7 surgical wound infection/ (41910)

8 exp Bacteremia/ (71072)

9 7 or 8 (112634)

10 exp blood glucose/ (375867)

11 exp glycemic index/ (7462)

12 exp hypoglycemia/ (97942)

13 exp hyperglycemia/ (118794)

14 exp insulin/ (483104)

15 exp hypoglycemic agents/ (671884)

16 exp blood glucose control/ (22061)

17 exp glycemic control/ (43166)

18 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 (983057)

19 6 and 9 and 18 (524)

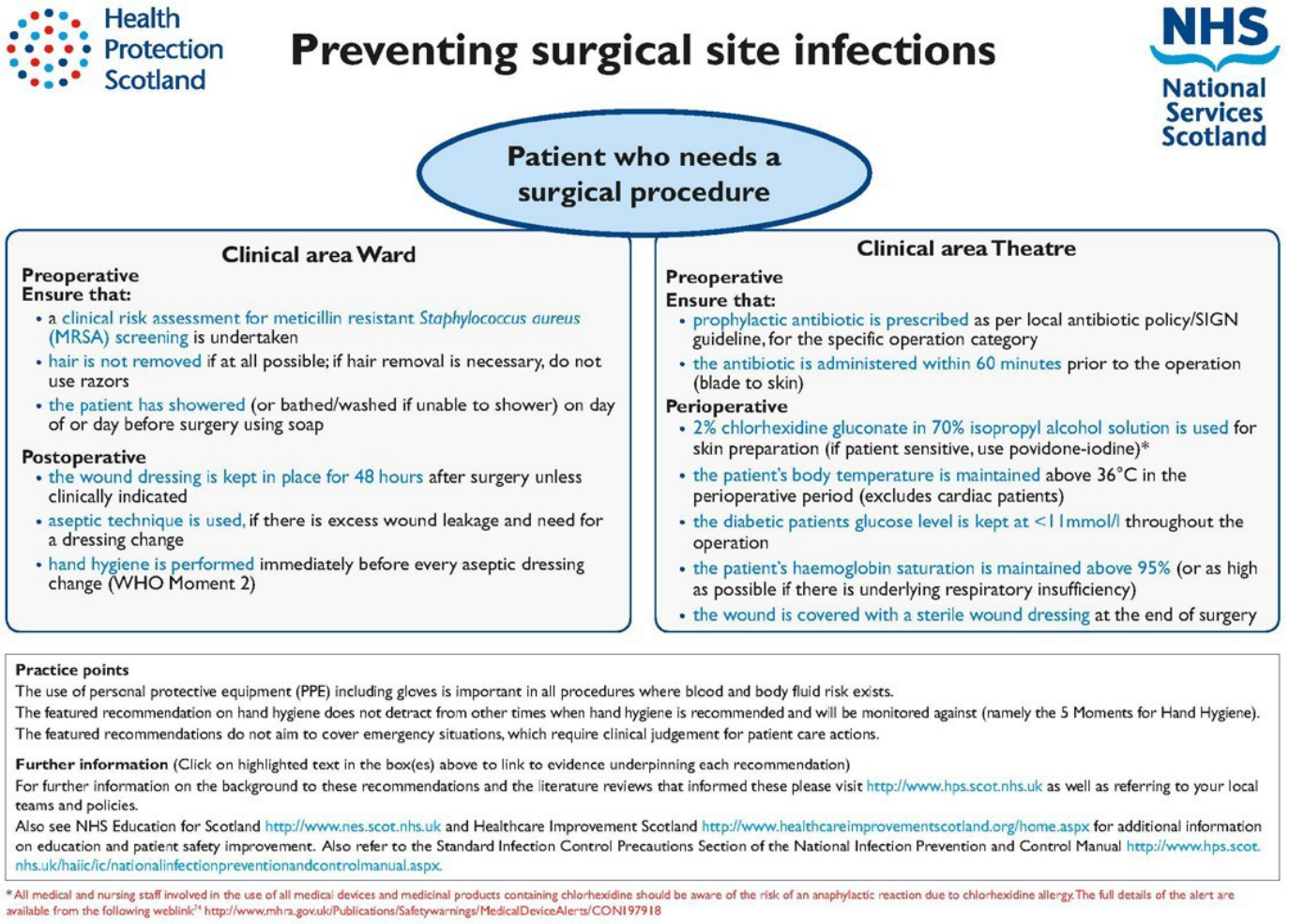
20 limit 19 to english language (507)

21 limit 20 to human (482)

22 limit 21 to yr="2014 -Current" (209)

23 remove duplicates from 22 (198)

Appendix 4: Summary of key recommendations to minimise surgical site infection (SSI)



Health Protection Scotland

Preventing surgical site infections

NHS National Services Scotland

Patient who needs a surgical procedure

Clinical area Ward

Preoperative
Ensure that:

- a clinical risk assessment for meticillin resistant *Staphylococcus aureus* (MRSA) screening is undertaken
- hair is not removed if at all possible; if hair removal is necessary, do not use razors
- the patient has showered (or bathed/washed if unable to shower) on day of or day before surgery using soap

Postoperative

- the wound dressing is kept in place for 48 hours after surgery unless clinically indicated
- aseptic technique is used, if there is excess wound leakage and need for a dressing change
- hand hygiene is performed immediately before every aseptic dressing change (WHO Moment 2)

Clinical area Theatre

Preoperative
Ensure that:

- prophylactic antibiotic is prescribed as per local antibiotic policy/SIGN guideline, for the specific operation category
- the antibiotic is administered within 60 minutes prior to the operation (blade to skin)

Perioperative

- 2% chlorhexidine gluconate in 70% isopropyl alcohol solution is used for skin preparation (if patient sensitive, use povidone-iodine)*
- the patient's body temperature is maintained above 36°C in the perioperative period (excludes cardiac patients)
- the diabetic patients glucose level is kept at <11mmol/l throughout the operation
- the patient's haemoglobin saturation is maintained above 95% (or as high as possible if there is underlying respiratory insufficiency)
- the wound is covered with a sterile wound dressing at the end of surgery

Practice points

The use of personal protective equipment (PPE) including gloves is important in all procedures where blood and body fluid risk exists.
The featured recommendation on hand hygiene does not detract from other times when hand hygiene is recommended and will be monitored against (namely the 5 Moments for Hand Hygiene).
The featured recommendations do not aim to cover emergency situations, which require clinical judgement for patient care actions.

Further information (Click on highlighted text in the box(es) above to link to evidence underpinning each recommendation)

For further information on the background to these recommendations and the literature reviews that informed these please visit http://www.hps.scot.nhs.uk as well as referring to your local teams and policies.
Also see NHS Education for Scotland http://www.nes.scot.nhs.uk and Healthcare Improvement Scotland http://www.healthcareimprovementscotland.org/home.aspx for additional information on education and patient safety improvement. Also refer to the Standard Infection Control Precautions Section of the National Infection Prevention and Control Manual http://www.hps.scot.nhs.uk/haiic/ic/nationalinfectionpreventionandcontrolmanual.aspx.

* All medical and nursing staff involved in the use of all medical devices and medicinal products containing chlorhexidine should be aware of the risk of an anaphylactic reaction due to chlorhexidine allergy. The full details of the alert are available from the following weblink[4] http://www.mhra.gov.uk/Publications/Safetywarnings/MedicalDeviceAlerts/CON197918