National Institute for Health and Care Excellence

Draft for consultation

Addendum to Clinical Guidelines CG65, Inadvertent Perioperative Hypothermia

Clinical Guideline Addendum 65.1

Methods, evidence and recommendations

September 2016

Draft for Consultation

Developed by the National Institute for Health and Care Excellence

Disclaimer
Healthcare professionals are expected to take NICE clinical guidelines fully into account when exercising their clinical judgement. However, the guidance does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of each patient, in consultation with the patient and, where appropriate, their guardian or carer.

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Clinical guidelines update

The NICE Clinical Guidelines Update Team update discrete parts of published clinical guidelines as requested by NICE's Guidance Executive.

Suitable topics for update are identified through the NICE surveillance programme (see surveillance programme interim guide).

These guidelines are updated using a standing Committee of healthcare professionals, research methodologists and lay members from a range of disciplines and localities. For the duration of the update the core members of the Committee are joined by up to 5 additional members who are have specific expertise in the topic being updated, hereafter referred to as 'topic expert members'.

In this document where 'the Committee' is referred to, this means the entire Committee, both the core standing members and topic expert members.

Where 'standing committee members' is referred to, this means the core standing members of the Committee only.

Where 'topic expert members' is referred to this means the recruited group of members with topic expertise.

All of the core members and the topic expert members are fully voting members of the Committee.

Details of the Committee membership and the NICE team can be found in appendix A. A link to the Committee members' declarations of interest can be found in appendix B.

1 Summary section

1.1 Update information

A review of the NICE guideline CG65, Inadvertent Perioperative Hypothermia, published April 2008, was undertaken as part of the NICE guideline surveillance programme. This identified additional evidence relating to active warming devices that had been published since the guideline. This review also noted that NICE Medical Technology guidance (MTG7) had recommended the use of warming mattresses while CG65 recommended the use of forced air warming; It was agreed that it would be helpful to provide further clarity in this update. This with the additional evidence meant that the review area relating to the use of active warming devices in the prevention of inadvertent perioperative hypothermia (IPH) was selected for a guideline update. Discussion with topic experts during the devising of this review question identified that where warming devices are being used, and following the induction of anaesthesia, that temperature monitoring during the first hour of surgery may not be necessary as it considered unlikely that patients' temperature will exceed 37.5ºC during this period. Therefore, where available, information on temperature monitoring at the closest point to 60 minutes post induction of anaesthesia will be extracted.

The surveillance review also noted that the site and method of measuring temperature were not systematically reviewed in the 2008 guideline. Consultation feedback during the surveillance process identified that this is a topic where guidance would be clinically useful and should be included as part of an update to the guideline. A review question on the site and method of measuring temperature was added to this update.

Some recommendations can be made with more certainty than others. The Committee makes a recommendation based on the trade-off between the benefits and harms of an intervention, taking into account the quality of the underpinning evidence. For some interventions, the Committee is confident that, given the information it has looked at, most people would choose the intervention. The wording used in the recommendations in this guideline denotes the certainty with which the recommendation is made (the strength of the recommendation).

For all recommendations, NICE expects that there is discussion with the person about the risks and benefits of the interventions, and their values and preferences. This discussion aims to help them to reach a fully informed decision (see also 'Patient-centred care').

Recommendations that must (or must not) be followed

We usually use 'must' or 'must not' only if there is a legal duty to apply the recommendation. Occasionally we use 'must' (or 'must not') if the consequences of not following the recommendation could be extremely serious or potentially life threatening.

Recommendations that should (or should not) be followed– a 'strong' recommendation

We use 'offer' (and similar words such as 'refer' or 'advise') when we are confident that, for the vast majority of people, following a recommendation will do more good than harm, and be cost effective. We use similar forms of words (for example, 'Do not offer…') when we are confident that actions will not be of benefit for most people.

Recommendations that could be followed

We use 'consider' when we are confident that following a recommendation will do more good than harm for most people, and be cost effective, but other options may be similarly cost effective. The course of action is more likely to depend on the person's values and preferences than for a strong recommendation, and so the healthcare professional should spend more time considering and discussing the options with the person.

Information for consultation

You are invited to comment on the new recommendations in this update. These are marked as **[new 2016]**.

1.2 Recommendations

1. **Offer active warming for at least 30 minutes before induction of anaesthesia to all patients having general anaesthesia or central neural blockade for surgery, unless this will delay emergency surgery. [new 2016]**

2. **Pay particular attention to the comfort of patients with communication difficulties during the preoperative phase. [new 2016]**

3. **Warm patients intraoperatively from induction of anaesthesia, using a forced air warming device, if they are:**
    - having anaesthesia for more than 30 minutes or
    - having anaesthesia for less than 30 minutes and are at higher risk of inadvertent perioperative hypothermia (see recommendation 1.2.1) **[new 2016]**

    Consider a resistive heating mattress or resistive heating blanket if a forced air warming device is unsuitable. [new 2016]

4. **Measure the patient's core temperature directly, using 1 of the following sites and basing the choice of site on its suitability for the patient, the type of surgery and the anaesthetic:**
    - bladder.
    - oesophagus
    - pulmonary artery catheter **[new 2016]**

5. **If direct core temperature measurement is not suitable, assess core temperature indirectly, using a site or device that produces a measurement accurate to within 0.5ºC of the true core temperature. At the time of consultation these are:**
    - deep forehead
    - infrared temporal
    - infrared tympanic
    - rectal
    - sublingual
    - thermocouple forehead with a +2ºC correction factor. **[new 2016]**

6. **Do not use any site or device to indirectly assess core temperature in adults having surgery that has not been shown in research studies to produce a measurement accurate to within 0.5ºC of true core temperature. [new 2016]**

1.3 Patient-centred care

This guideline offers best practice advice on the prevention of inadvertent perioperative hypothermia of adults undergoing surgery.

Patients and healthcare professionals have rights and responsibilities as set out in the NHS Constitution for England – all NICE guidance is written to reflect these. Treatment and care should take into account individual needs and preferences. Patients should have the opportunity to make informed decisions about their care and treatment, in partnership with their healthcare professionals. Healthcare professionals should follow the Department of Health's advice on consent. If someone does not have the capacity to make decisions, healthcare professionals should follow the code of practice that accompanies the Mental Capacity Act and the supplementary code of practice on deprivation of liberty safeguards. In Wales, healthcare professionals should follow advice on consent from the Welsh Government.

NICE has produced guidance on the components of good patient experience in adult NHS services. All healthcare professionals should follow the recommendations in Patient experience in adult NHS services.

1.4 Methods

This update was developed based on the process and methods described in the Developing NICE guidelines: the manual

2 Evidence review and recommendations

2.1 Introduction

Body temperature is usually maintained between 36.5ºC and 37.5 ºC by the body's thermoregulatory mechanisms. Exposure of skin and internal organs during the perioperative period can increase heat loss, and use of cool intravenous and irrigation fluids may cause direct cooling. Once anaesthetised, a person's thermoregulatory mechanisms are compromised.

Inadvertent perioperative hypothermia is a recognised occurrence during surgery. Hypothermia (defined as core temperature <36.0ºC) may be identified at any point in the perioperative pathway. Consequences of hypothermia can include; increased blood loss, longer recovery, shivering, cardiac events, delayed healing, longer hospital stay, unanticipated admission to high dependency units, reduced patient satisfaction.

A review of this area was undertaken for the development of recommendations in CG65 which recommended that forced air warming be used. A NICE Medical Technology guidance (MTG7) in 2011 on the Inditherm warming mattress for the prevention of inadvertent perioperative hypothermia noted that the clinical effectiveness of the Inditherm patient warming mattress in maintaining patient core temperature above 36ºC is similar to that of forced air warming. More clarity is now required as to what is recommended for use in practice. Additionally, the surveillance process for this guideline has identified additional evidence relating to different types of active warming device that haves been published since the publication of CG65. In addition the surveillance triage panel noted that the evidence base supporting the use of preoperative active arming had grown and this additional question now warranted full consideration in this update. This will be a new review area in the update of this guideline.

Various sites may be used for the monitoring temperature across the perioperative periods. Information assessed during the NICE surveillance process considered that information on accuracy of the measurement site (in terms of agreement with core body temperature) would be helpful in clinical practice. This question will make recommendations on the site of monitoring based on evidence for the different classes of device use (e.g. infrared thermometers or temporal artery scanners), not on the individual manufacturer technologies involved. This will be a new review area in the update of this guideline.

This update is concerned with the following topics.

- Forced air warming compared with other active warming devices in the intraoperative phase.
- Preoperative active warming compared with no preoperative active warming.
- The best site for accurately measuring temperature in different phases of perioperative care

Furthermore, CG65 included a recommendation to monitor temperature every 30 minutes. Topic experts considered that where warming devices are used following the induction of anaesthesia, monitoring temperature during the first hour of surgery may not be necessary as it is unlikely that the patients' temperatures will exceed 37.5ºC during this period. Where studies on warming devices have included intermittent temperature monitoring during the first 120 minutes of surgery this will be extracted and the need for 30 minute monitoring will be considered.

2.2 Review questions 1 & 2

Are warming devices/mechanisms effective in preventing inadvertent perioperative hypothermia in adults in the different phases of perioperative care, specifically comparing classes of active warming device?

Do active warming devices/ mechanisms delivered in the pre-operative phase prevent inadvertent perioperative hypothermia in adults?

2.3 Clinical evidence review

A single systematic search for both intervention questions was conducted (see appendix D) which identified 3661 articles. The titles and abstracts were screened and 75 articles were identified as potentially relevant. A further 16 studies were identified by reference checking of existing systematic reviews and 15 from the original guideline Full-text versions of these 106 articles were ordered and reviewed against the criteria specified in the review protocol (appendix C).Of these 106 articles, 68 were excluded and 38 were included (26 included in the comparison of active warming devices in the intraoperative phase and 12 in the comparison of active warming devices used preoperatively).

A review flowchart is provided in appendix E, and the excluded studies (with reasons for exclusion) are shown in appendix F.

2.3.1 Methods

The populations of the included studies (intraoperative warming only comparison - Brandt 2010; Calcaterra 2009; Egan 2011; Fanelli 2009; Hasegawa 2012; Hofer 2005; Hynson 1992; Ihn 2008; Janicki 2001; Janicki 2002; John 2015; Kadam 2009; Kim 2014; Kurz 1993; Lee 2004; Leung 2007; Matsuzaki 2003; Negishi 2003; Ng 2006; Ruetzler 2011; Russell 1995; Suraseranivongse 2009; Tanaka 2013; Torrie 2005; Trentman 2009; Wong 2004 and preoperative with or without intraoperative warming comparison - Andrzejowski 2008; De Witte 2010; Erdling 2015; Fossum 2001; Hirvonen 2011; Horn 2012; Horn 2016; Kim 2006; Melling 2001; Perl 2014; Shin 2015; Wong 2007) included people undergoing planned surgery; types of surgery included coronary artery bypass graft (CABG), abdominal surgery, liver transplants, hysterectomy and orthopaedic surgery. Only one study included people undergoing emergency as well as planned elective surgery (Lee 2004). All other studies included people undergoing planned elective surgery.

There was variation between the studies with regards to:

- The manufacturer of the warming devices (within the same class of warming device),
- The percentage coverage of the patient’s body with the warming device, and whether it was applied to the upper or lower body or whole body,
- The temperature that the warming device was set at.

While the evidence review included all studies of active warming devices, the committee agreed post-hoc, in committee meeting 1, to focus their deliberations on forced air warming and resistive heating as both of these methods are used in clinical practice in England and Wales, whereas the other active warming methods are no longer routinely used. As the review had been completed this post-hoc decision had no impact on study inclusion or exclusion. A second post-hoc decision was to perform a sensitivity analysis by removing the Hofer 2005 study from the as this study was carried out in patients undergoing coronary artery bypass grafting surgery and the core temperatures at the end of surgery were very low compared to core temperature in the other studies. Another study in similar population (Calcaterra 2009) did not compared forced air warming with either of the resistive heating devices of interest to the committee so no sensitivity analyses was performed in the instance.

2.3.1.1 Analyses

Risk ratios were used for all dichotomous outcomes and mean difference for all continuous outcomes. A random effects analysis was used because a fixed treatment effect cannot be assumed throughout for the following reasons:

- The populations in the study were undergoing different types of surgery
- Different devices were included as comparators
- Different types of anaesthesia were used
- Core temperature was measured at different locations in the included studies and these cannot be assumed to be equivalent.

2.3.1.2 Quality appraisal

The quality of the evidence for each outcome was assessed using GRADE methodology as follows;

- Risk of bias was assessed using the RCT checklist to identify any concerns over study methodology or the reporting of study methodology.
- Inconsistency was assessed using the I^2 statistic using categories as below
    - No heterogeneity if I^2 was between 0 and 40%, or if no events were reported for that outcome
    - Moderate heterogeneity if I^2 was greater than 40%
    - Severe heterogeneity if I^2 was greater than 70%
- Indirectness was assessed by the divergence of a study population, interventions and outcome from those specified in the review protocol.
- Imprecision was assessed using the 95% Confidence Interval (CI) around the point estimate of effect size. For dichotomous outcomes a default minimal important difference (MID) of 0.8 and 1.25 was used with the exception for the outcome of hypothermia where the line of no effect was used as the MID. For core temperature at different time-points, 0.5 ºCelcius was used as MID as advised by the topic experts. The MID for blood loss was agreed by the topic experts to be 500mL. No MID for length of hospital stay was agreed so a default 50% of larger SD of the two groups was used.

2.3.2 Results - Intraoperative active warming

The 26 included studies all compared forced air warming with other active warming method and different analyses were undertaken by comparator group as follows;

- Circulating water blanket (Hynson 1992)
- Circulating water garment (Hasegawa 2012; Hofer 2005; Ihn 2008; Janicki 2001; Janicki 2002; Ruetzler 2011; Suraseranivongse 2009; Trentman 2009)
- Circulating water mattress (Kim 2014; Kurz 1993; Matsuzaki 2003; Negishi 2003)
- Electric blanket (Russell 1995)
- Electric heating pads (Leung 2007; Ng 2006)
- Radiant heating (Kadam 2009; Lee 2004; Torrie 2005; Wong 2004)
- Resistive heating blanket (Brandt 2010; Fanelli 2009; Hasegawa 2012; Hofer 2005; Matsuzaki 2003; Negishi 2003; Tanaka 2013)
- Resistive heating mattress (Egan 2011; John 2015)
- Warming pads (Calcaterra 2009)

The studies all differed with regards to the devices used, the temperature used, the location of core temperature measurement and the proportion of the body that the warming device covered.

For a summary of included studies please see table 1 (for the full evidence tables, GRADE profiles and forest plots please see appendices G.1, H.1 and I.1).

2.3.3 Results - Preoperative active warming

The 12 included studies all compared preoperative active warming with no preoperative active warming. The majority of the studies used forced air warming in the preoperative phase. Some of the studies used intraoperative active warming and some did not so the analysis included subgroups according to use of intraoperative active warming as follows:

- With intraoperative (Andrzejowski 2008; De Witte 2010; Erdling 2015; Horn 2016; Kim 2006; Perl 2014; Wong 2007)
- Without intraoperative. (Fossum 2001; Hirvonen 2011; Horn 2012; Melling 2001; Shin 2015)

For a summary of included studies please see table 2 (for the full evidence tables, GRADE profiles and forest plots please see appendices G.2, H.2 and I.2).

Table 1: Summary of included studies – Intraoperative

Study reference (including study design)	Study population	Type of anaesthesia	Intervention & comparator	Outcomes reported
Brandt (2010)	Elective orthopaedic surgery, N=80	General / combined or regional	Forced air warming Resistive-heating blanket	Core temperature at the end of surgery (oesophageal / bladder) Core temperature over time Blood loss (mean mLs) Infusion Thermal comfort
Calcaterra (2009)	Off-pump coronary artery surgery, N=50	General	Forced air warming Warming pads,	Core temperature at the end of surgery Wound infections
Egan (2011)	Elective major open abdominal surgery, N=71	Spinal	Forced air warming Resistive warming	Core temperature at end of surgery (oesophageal) Core temperature over time (oesophageal)
Fanelli (2009)	Elective total hip replacement, N=56	General	Forced air warming Resistive warming	Core final temperature (tympanic) Core temperature over time Intraoperative blood loss (median, range) Total blood loss / 24hrs (mean mLs) Burns
Hasegawa (2012)	Major abdominal surgery, N=36	General + continuous epidural	Forced air warming Resistive warming Circulating water garment	Core temperature over time (1 hr, 2 hr) Core temperature at end of surgery
Hofer (2005)	Coronary artery bypass grafting N=90	General	Forced air warming Resistive heating blanket Circulating water garment	Core temperature (rectal) at intervals throughout the operation (60,90,120 mins) Core temperature at the end of the operation Temperature changes

Study reference (including study design)	Study population	Type of anaesthesia	Intervention & comparator	Outcomes reported
				Blood loss (perioperative) Wound infection
Hynson (1992)	Kidney transplantation N=20	General	Forced air warming Circulating water blanket Heated humidifier Control (no extra warming)	Change in temperature (tympanic membrane) from baseline over time
Ihn (2008)	Total abdominal hysterectomy, N=90	General	Forced air warming upper body Forced air warming lower body Circulating water mattress	Core temperature over time Shivering
Janicki (2001)	Open abdominal surgery, N=60	General	Forced air warming Water warming garment	Body core temperature (rectal & oesophageal) (60 mins) Final core temperature Hypothermia Shivering
Janicki (2002)	Orthotopic liver transplantation N=24	General	Forced air warming Water warming garment	Mean core temperature (oesophageal) at intervals throughout the operation (60 mins) Mean core temperature during skin closing
John (2016)	Elective surgery, N=160	General	Forced air warming Resistive heating	Core temperature at the end of surgery Blood loss (mLs) Blood transfusion
Kadam (2009)	Laparoscopic cholecystectomy, N=29	General	Forced air warming Radiant warming	Core temperature over time (oesophageal) (graph) Hypothermia
Kim (2014)	Total knee arthroplasty, N=46	Spinal	Forced air warming Circulating water garment	Core temperature over time (rectal) Thermal comfort Shivering

Study reference (including study design)	Study population	Type of anaesthesia	Intervention & comparator	Outcomes reported
Kurz (1993)	Adults: major maxillofacial surgery (N=16); hip arthroplasty (N=53) Paediatric: maxillofacial surgery (N=20); orthopaedic surgery (N=10)	General	Forced air warming Circulating water mattress	Core temperature over time, ºC – mean (SD)
Lee (2004)	Non-surgical cardiac surgery N=60	General/ spinal/ other	Forced air warming Local radiant warming	Final core temperature (tympanic) Core temperature over time (tympanic) VAS thermal comfort
Leung (2007)	Laparotomy N=60	General	Forced air warming Electric heating pad	Final core temperature (nasopharyngeal) Core temperature over time (nasopharyngeal) VAS Thermal comfort Shivering Blood loss (mL)
Matsuzaki (2003)	Laparoscopic cholecystectomy, N=24	General	Forced air warming Circulating water mattress Carbon fibre resistive heating blanket	Core temperature at the end of the operation (tympanic) Change in core temperature over time (tympanic)
Negishi (2003)	Major abdominal surgery, N=24	General	Forced air warming Circulating water mattress Resistive heating blanket	Core temperature (tympanic) at the end of the operation Changes in core temperature over time Blood loss (mL x kg^{-1})
Ng (2006)	Total knee replacement, N=60	Combined spinal epidural	Forced air warming Electric heating pad	Final core temperature (rectal) Core temperature (rectal) over time VAS Thermal discomfort Shivering Hypothermia Blood loss

Study reference (including study design)	Study population	Type of anaesthesia	Intervention & comparator	Outcomes reported
Ruetzler (2011)	Open abdominal surgery, N=73	General	Forced air warming Circulating water garment	Core temperature over time Burns
Russell (1995)	Orthotopic liver transplantation, N=60	General	Forced air over blanket Forced air under blanket Electric under blanket	Core temperature (pulmonary artery) at intervals throughout the operation (anhepatic 30 & 60 mins) Core temperature at closure
Suraseranivongse (2009)	Vascular surgery, N=44	General or general + regional	Forced air warming Circulating water mattress	Core temperature over time (graph) Blood loss (median, IQR)
Tanaka (2013)	Major abdominal surgery N=70	General and epidural	Resistive heating Forced air (Convective) warming	Core temperature over time (oesophageal) (1, 2, 3 hrs) Core temperature at end of surgery Blood loss
Torrie (2005)	Transurethral prostatic resection, N=60	Spinal anaesthesia	Forced air warming Radiant warming	Mean temperature during 1st hour of surgery (rectal) Core temperature (rectal) at the end of surgery Hypothermia on arrival at post anaesthesia unit Thermal comfort Shivering
Trentman (2009)	Total knee arthroplasty, N=55	General	Forced air warming Circulating water garment	Core temperature over time (oesophageal) (60mins) Mild hypothermia
Wong (2004)	Laparoscopic cholecystectomy, N=42	General	Forced air warming Radiant warming	Core temperature (oesophageal) at the end of surgery

Table 2: Table of included studies: Preoperative

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Study reference (including study design)	Study population	Type of anaesthesia	Intervention & comparator	Outcomes reported
Andrzejowski (2008)	Spinal surgery, N=68	General	Forced air warming pre and intra-operatively Forced air warming intra-operatively	Core temperature Shivering
De Witte (2010)	Laparoscopic colorectal surgery, N=27	General	Forced air warming Resistive warming No active warming	Core temperature Blood loss
Erdling (2015)	Colorectal surgery N=43	General and spinal	Forced air warming pre and intra-operatively Forced air warming intra-operatively	Core temperature
Fossum (2001)	Mixed surgery N = 100	General	Forced air warming preoperatively Usual care	Hypothermia
Hirvonen (2011)	transurethral resection of the prostate N = 40	Spinal	Thermal suit Usual care	Core temperature at end of surgery Hypothermia Shivering
Horn (2012)	laparoscopic cholecystectomy; inguinal hernia repair; breast surgery; minor orthopaedic surgery; and ENT surgery N = 200	General	Forced air warming Usual care	Hypothermia Shivering
Horn (2016)	Major abdominal surgery N=99	General and epidural	FAW prewarming after epidural; FAW prewarming before and after epidural;	Temperature at end of surgery (skin) prewarming) Hypothermic patients Shivering

Study reference (including study design)	Study population	Type of anaesthesia	Intervention & comparator	Outcomes reported
			FAW intraoperative only	
Kim (2006)	Off-pump coronary artery bypass, N=40	General and epidural	Forced air warming (pre) with circulating water mattress Circulating water mattress	Core temperature over time (30, 60, 90 mins)
Melling (2001)	Hernia repair, varicose vein surgery, breast surgery – scar <3cm in length, N=421	Unknown (breast, hernia and varicose vein surgery)	Forced air warming Radiant heat dressing Standard care (no warming)	Core temperature end of surgery Wound infection
Perl (2014)	Mixed surgery – mainly abdominal (54%) and lower limb (29%) N=68	General	Control (standard pre-warming) Passive pre-warming (insulation blanket) Active (forced-air) pre-warming blanket	Core (oesophageal) temperature at end of surgery Core temperature over time Rate of hypothermia Postoperative oral temperature (in PACU) over time Incidence of shivering
Shin (2015)	Endovascular coiling N = 72	General	Preoperative forced air warming Usual care	Hypothermia Core temperature during surgery Shivering
Wong (2007)	Major abdominal surgery N=103	General	Resistive warming pre warming + FAW intraoperative FAW intraoperative only)	Core temperature (nasopharyngeal) at end of surgery (median, range) Surgical site infection Cardiac complications Blood loss Blood transfusion Patients requiring blood transfusion Duration of hospital stay

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2.4 Health economic evidence review (review question 1 & 2)

2.4.1 Methods

Evidence of cost effectiveness

The Committee is required to make decisions based on the best available evidence of both clinical and cost effectiveness. Guideline recommendations should be based on the expected costs of the different options in relation to their expected health benefits.

Evidence on cost effectiveness related to the key clinical issues being addressed in the guideline update was sought. The health economist:

- undertook a systematic review of the published economic literature; and
- undertook a basic cost consequences analysis based on the net benefit calculations from the original guideline.

Economic literature search

A systematic literature search was undertaken to identify health economic evidence within published literature relevant to the review questions. The evidence was identified by conducting a search relating to inadvertent perioperative hypothermia in the NHS Economic Evaluation Database (NHS EED) and the Health Technology Assessment database (HTA). The search also included Medline and Embase databases using an economic filter. Studies published in languages other than English were not reviewed. The search was conducted on 9 March 2016. The health economic search strategies are detailed in appendix J.

The health economist also sought out relevant studies identified by the surveillance review or Committee members.

Economic literature review

The health economist:

- Identified potentially relevant studies for each review question from the economic search results by reviewing titles and abstracts. Full papers were then obtained.
- Reviewed full papers against prespecified inclusion and exclusion criteria to identify relevant studies.
- Critically appraised relevant studies using the economic evaluations checklist as specified in *Developing NICE Guidelines: the manual 2014*.
- Extracted key information about the studies' methods and results into full economic evidence tables (appendix M).
- Generated summaries of the evidence in economic evidence profiles.

Inclusion and Exclusion criteria

Full economic evaluations (studies comparing costs and health consequences of alternative courses of action: cost-utility, cost-effectiveness, cost-benefit and cost-consequence analyses) and comparative costing studies that address the review question in the relevant population were considered potentially includable as economic evidence.

Studies that only reported burden of disease or cost of illness were excluded. Literature reviews, abstracts, posters, letters, editorials, comment articles, unpublished studies and studies not in English were excluded.

Remaining studies were prioritised for inclusion based on their relative applicability to the development of this guideline and the study limitations. For example, if a high quality, directly applicable UK analysis was available, then other less relevant studies may not have been included. Where selective exclusions occurred on this basis, this is noted in the excluded economic studies table (appendix L).

For more details about the assessment of applicability and methodological quality see the economic evaluation checklist contained in *Appendix H* of *Developing NICE Guidelines: the manual 2014*.

Economic evidence profile

The economic evidence profile summarises cost-effectiveness estimates. It shows an assessment of the applicability and methodological quality for each economic evaluation, with footnotes indicating the reasons for the assessment. These assessments were made by the health economist using the economic evaluation checklist from *Appendix H* of *Developing NICE Guidelines: the manual 2014*. It also shows the incremental cost, incremental effect and incremental cost-effectiveness ratio for the base case analysis in the evaluation, as well as information about the assessment of uncertainty.

The information contained in the economic evidence profile is explained in Table **3**.

Table 3: **Explanation of fields used in the economic evidence profileItem**	**Description**
Study	This field is used to reference the study and provide basic details on the included interventions and country of origin.
Applicability	Applicability refers to the relevance of the study to specific review questions and the NICE reference case. Attributes considered include population, interventions, healthcare system, perspective, health effects and discounting. The applicability of the study is rated as: • Directly applicable – the study meets all applicability criteria or fails to meet one or more applicability criteria but this is unlikely to change the conclusions about cost effectiveness. • Partially applicable – the study fails to meet one or more applicability criteria and this could change the conclusions about cost effectiveness. • Not applicable – the study fails to meet one or more of the applicability criteria and this is likely to change the conclusions about cost effectiveness. Such studies would usually be excluded from the review.
Limitations	This field provides an assessment of the methodological quality of the study. Attributes assessed include the relevance of the model's structure to the review question, timeframe, outcomes, costs, parameter sources, incremental analysis, uncertainty analysis and conflicts of interest. The methodological quality of the evaluation is rated as having: • Minor limitations – the study meets all quality criteria or fails to meet one or more quality criteria, but this is unlikely to change the conclusions about cost effectiveness. • Potentially serious limitations – the study fails to meet one or more quality criteria and this could change the conclusions about cost effectiveness • Very serious limitations – the study fails to meet one or more quality criteria and this is highly likely to change the conclusions about cost effectiveness. Such studies would usually be excluded from the review.
Other comments	This field contains particular issues that should be considered when interpreting the study, such as model structure and timeframe.
Incremental cost	The difference between the mean cost associated with one strategy and the

Table 3: Explanation of fields used in the economic evidence profileItem	**Description**
	mean cost of a comparator strategy.
Incremental effect	The difference between the mean health effect associated with the intervention and the mean health effect associated with the comparator. This is usually represented by quality-adjusted life years (QALYs) in accordance with the NICE reference case.
Incremental cost effectiveness ratio (ICER)	The incremental cost divided by the incremental effect which results in the cost per quality-adjusted life year gained (or lost). Negative ICERs are not reported as they could represent very different conclusions: either a decrease in cost with an increase in health effects; or an increase in cost with a decrease in health effects. For this reason, the word 'dominates' is used to represent an intervention that is associated with decreased costs and increased health effects compared to the comparator, and the word 'dominated' is used to represent an intervention that is associated with an increase in costs and decreased health effects.
Uncertainty	A summary of the extent of uncertainty about the ICER. This can include the results of deterministic or probabilistic sensitivity analysis or stochastic analyses or trial data.

Cost-effectiveness criteria

NICE's report *Social value judgements: principles for the development of NICE guidance* sets out the principles that GDGs should consider when judging whether an intervention offers good value for money. In general, an intervention was considered to be cost effective if either of the following criteria applied (given that the estimate was considered plausible):

- the intervention dominated other relevant strategies (that is, it was both less costly in terms of resource use and more clinically effective compared with all the other relevant alternative strategies), or
- the intervention cost less than £20,000 per QALY gained compared with the next best strategy.

If the Committee recommended an intervention that was estimated to cost more than £20,000 per QALY gained, or did not recommend one that was estimated to cost less than £20,000 per QALY gained, the reasons for this decision are discussed explicitly in the 'evidence to recommendations' section of the relevant chapter, with reference to issues regarding the plausibility of the estimate or to the factors set out in *Social value judgements: principles for the development of NICE guidance*.

The net monetary benefit framework is a commonly used alternative to expressing the cost effectiveness of an intervention as the incremental cost per QALY gained. This method relies upon a rearrangement of the cost effectiveness decision rule by expressing both costs and health effects in monetary terms. The formula for calculating net monetary benefit is as follows:

$$NMB = \lambda \times \Delta E - \Delta C$$

This is to say – net monetary benefit is equal to the threshold ratio multiplied by difference in health effects, minus difference in costs. This framework ensures that interventions which are below the threshold ratio will always have a positive net monetary benefit, and when multiple interventions are compared, the most cost effective option will have the highest net monetary benefit.

2.4.2 Results of the economic literature review

1641 articles were identified by the initial search. 1632 papers were excluded based on title and abstract and 9 full papers were ordered. All 9 full papers were excluded. The economic modelling conducted for the original guideline (NICE Clinical Guidelines 65) was the only included study. Table 8 contains the economic evidence profile for this review question summarising the results of the studies included in the systematic review. Full economic evidence tables are contained in appendix M.

The flowchart summarising the number of studies included and excluded at each stage of the review process can be found in appendix K. Appendix L contains a list of excluded studies and the reason for their exclusion.

The National Collaborating Centre for Nursing and Supportive Care (2008) developed an original model to investigate the cost effectiveness of a range of warming methods identified in their clinical review. The structure was based on a decision tree and Markov model. The magnitude of surgery, anaesthesia type, ASA grade, age, duration of anaesthesia and effectiveness of warming determined the risk of a patient experiencing hypothermia during surgery. Experiencing hypothermia increased the subsequent risk of experiencing surgical site infection, blood transfusion, a morbid cardiac event, postoperative mechanical ventilation and pressure ulcer. The analysis found that warming fluids was cost effective compared to giving unwarmed fluids even when the risk of intraoperative hypothermia was low, the risk of cardiac complications was negligible and the anaesthesia duration was short. Forced air warming was cost effective compared to usual care even when the risk of perioperative hypothermia was low, the risk of cardiac complications was negligible, and the anaesthesia duration was short. An indirect comparison was used to determine the optimal strategy for preventing IPH. For surgery with an anaesthesia time of 60 minutes, forced air warming plus warmed fluids had the highest likelihood of being the optimal strategy for patients having intermediate or major surgery. In minor surgery, forced air warming plus warmed fluid was the optimal strategy for patients with a risk of cardiac complications that is typical for age 50. One of the limitations of the analysis was the need to estimate the effectiveness in terms of relative risk by imputing from data based on mean temperatures assuming a normal distribution because of the lack of data on the incidence of hypothermia in the clinical review. The study was directly applicable with minor limitations.

Although this analysis was judged to be methodologically sound in estimating the incremental health effects and resource usage associated with a case of perioperative hypothermia, it was determined that the comparators and sources of evidence used in the original analysis were outdated in light of results from the clinical literature review. Therefore, it was determined that values for net monetary benefit (NMB) associated with prevention of a case of hypothermia estimated using the original model would be used to inform a novel analysis based on the relative effectiveness and costs associated with forced air warming and resistive heating mattress according to the latest evidence.

2.4.3 Economic analysis

2.4.3.1 Introduction

The net monetary benefit (NMB) of each case of hypothermia avoided was available from the original guideline model. This figure used the standard willingness-to-pay of £20,000 per quality adjusted life year to calculate how much a healthcare provider would be prepared to pay for an additional case of hypothermia avoided by taking into account the probability of various adverse events occurring, the cost of that event and reduction in quality of life due to the event. The committee decided to consider cost effectiveness based on a simple analysis of this net monetary benefit combined with the relative effectiveness from the clinical review, rather than rebuilding the original guideline model for the following reasons:

- The simple analysis was sufficient for the narrow scope of the review protocols based on the key comparisons of forced air warming vs. resistive heating mattresses and blankets and preoperative warming vs. usual care.
- The net monetary benefits of avoiding hypothermia were large compared to the cost of warming. It was therefore highly likely that any intervention found to be more clinically effective would have also been more cost effective.
- It was therefore highly likely that the decision based on the simple analysis was no different than what would be reached through a more complex model.
- A network meta-analysis was not conducted for the clinical review, nor were comparisons with usual care included in review question 1, limiting any analysis to a series of pairwise analyses.

Therefore, a simple net benefit analysis was used to establish whether the incremental cost of warming is less than the net benefit of the cases of hypothermia avoided for the following comparisons:

1. Intraoperative forced air warming vs. intraoperative resistive heating mattress
2. Preoperative and intraoperative forced air warming vs. intraoperative forced air warming
3. Preoperative forced air warming vs. preoperative usual care (no intraoperative warming)
4. Intraoperative forced air warming vs. intraoperative resistive heating blanket

2.4.3.2 Methods

The cost effectiveness model developed for the original guideline was used to produce estimates of net monetary benefit per case of hypothermia averted for a variety of patient subgroups. This model used a decision tree structure in order to estimate resource usage associated with adverse health consequences as well as expected increase in hospital length of stay and post anaesthesia care unit (PACU) length of stay resulting from hypothermia. Health consequences considered were: infection, blood transfusion, morbid cardiac event, mechanical ventilation, and pressure ulcer. Although hypothermia was not associated with its own utility value *per se*, certain health consequences in the model was associated with their own QALY decrements, with differences in expected QALYs between hypothermic and non-hypothermic patients captured through differing probabilities of adverse health consequences. Costs and QALY decrements for each adverse consequence are shown in Table 4. The model also used a Markov structure in order to estimate the long-term impact of morbid cardiac events on expected lifetime QALY gains. For full details of model methodology, please refer to the original version of the full guideline.

Table 4: Adverse health consequences included in the original model

Adverse health consequence	Cost (£)	QALY loss
Surgical wound infection (minor surgery)	950	0.07
Surgical wound infection (major surgery)	3,858	0.07
Transfusion	244	-
Morbid cardiac event (ischemia)	2,024	-
Morbid cardiac event (cardiac arrest)	2,021	5.41 at age 20 3.54 at age 50 1.93 at age 70
Morbid cardiac event (myocardial infarction)	1,674	
Pressure ulcer	1,064	-
PACU length of stay per hour	44	-
Hospital length of stay per day	275	-

Costs of adverse events in the original guideline model were adjusted to 2016 prices and net monetary benefit was recalculated over 1,000 probabilistic iterations for patient subpopulations stratified by age (20, 50 and 70 years old) and magnitude of surgery (minor, intermediate and major). For each group the mean of the iterations was calculated, as reported in Table 5.

Table 5: Net monetary benefit per case of hypothermia averted

Age	20			50			70		
Magnitude of surgery	Minor	Intermediate	Major	Minor	Intermediate	Major	Minor	Intermediate	Major
Mean	£238	£732	£932	£1,513	£2,007	£2,207	£1,629	£2,123	£2,324
Lower 95% CI	£59	£191	£335	£441	£692	£857	£487	£742	£906
Upper 95% CI	£607	£1,856	£2,052	£3,698	£4,283	£4,539	£3,990	£4,638	£4,811

The novel economic analysis used values for net benefit per case of hypothermia prevented, cost of interventions, and relative effectiveness of interventions in order to produce estimates of incremental net monetary benefit for a series of pairwise comparisons of interventions. To achieve this, the model produced estimates of the relative effectiveness of preventing hypothermia via two methods. The first imputed data on core temperature at the end of surgery from the clinical review as this was specified as the critical outcome of interest in the review protocol. This involved assuming a normal distribution of mean temperature and calculating the proportion of that distribution under 36 degrees Celsius (the common definition of hypothermia) to represent the proportion of hypothermic patients in that arm. The second technique of establishing the relative effectiveness of preventing hypothermia involved extracting the data on the proportion of hypothermic patients from the studies where this was reported. Both techniques were important to decision-making because more studies tended to report mean core temperature at end of surgery than the proportion of hypothermic patients but the committee placed more importance on the direct reporting of hypothermic patients. There are 7 comparisons in the analysis, the results of which are reported in Table 6:

1. Forced air warming (intraoperative) vs. resistive heating mattress (intraoperative)

   a. The data on core temperature at the end of surgery from the clinical review (the critical outcome specified in the review protocol) was imputed assuming a normal distribution to estimate the number of patients hypothermic during surgery after pooling data on all arms of forced air warming and all arms of resistive heating mattress.
   b. As per (1a) above but excluding 2 studies on cardiac surgery (Calcaterra et al. 2009 and Hofer et al. 2005) because the committee determined these were outliers where patients underwent cardiac surgery and had much lower core temperature at end of surgery compared with other studies.
   c. Data only from studies in which the number of hypothermic patients were reported.
2. Forced air warming (preoperative and intraoperative) vs. forced air warming (intraoperative) from studies where the proportion of hypothermic patients was reported.
3. Preoperative warming (any active warming method) vs. usual care
   a. All studies that reported number of hypothermic patients
   b. Excluding Hirvonen et al. 2011 – this study investigated the effectiveness of a thermal suit but all other studies used forced air warming to warm preoperatively. Excluding this study effectively turned this comparison into forced air warming (preoperative) vs. usual care
4. Forced air warming (intraoperative) vs. resistive heating blanket – the difference in effectiveness between these two methods could only be derived using the imputation method because studies on the resistive heating blanket only reported core temperature at end of surgery, not the proportion of hypothermic patients. The two cardiac studies have been excluded from this comparison.

Table 6: Proportion of hypothermic patients in each arm

Comparison	% hypothermic intervention	% hypothermic comparator	Difference
1a. FAW (intra) vs. RHM (intra) - imputed	43%	49%	-6%
1b. FAW (intra) vs. RHM (intra) - imputed excluding cardiac surgery	32%	49%	-17%
1c. FAW (intra) vs. RHM (intra) - % hypothermic reported	38%	53%	-23%
2. FAW (pre+intra) vs. FAW (intra) - % hypothermic reported	9%	45%	-36%
3a. Preoperative warming vs. usual care - % hypothermic reported	24%	73%	-49%
3b. FAW (pre) vs. usual care - % hypothermic reported (excluded Hirvonen 2011)	28%	78%	-50%
4. FAW (intra) vs. resistive heating blanket – imputed excluding cardiac surgery	32%	49%	-17%

The cost of warming was established through the NHS Supply Chain, information provided by manufacturers and advice from the topic experts as per Table 7. There are 4 providers of forced air warming in the UK with similar pricing for their consumables. The 3M Bair Hugger was chosen as the most representative of the cost that would be incurred by most local areas in the UK. The resistive heating mattress (Inditherm) is provided for a monthly or annual fee on an ongoing basis with equipment maintained and replaced as needed (that is, no upfront equipment cost).

Table 7: Cost of warming

Forced air warming (intraoperative) - Bair Hugger			

Element	**Amount**	**Source**	
Cost standard Bair Hugger blankets	£5.62	NHS Supply Chain 13.07.2016	
Average cost non-standard Bair Hugger blankets	£20.23	NHS Supply Chain 13.07.2016	
Proportion standard blankets	84%	NHS Supply Chain 13.07.2016	
Proportion non-standard blankets	16%	NHS Supply Chain 13.07.2016	
Average weighted cost per blanket	£7.96		
Forced air warming (preoperative) - Bair Hugger			
Element	**Amount**	**Source**	
Preoperative and outpatient Bair Hugger blanket	£15.37	NHS Supply Chain 13.07.2016	
Forced air warming (pre+intra) - Bair Hugger			
Element	**Amount**	**Source**	
Intraoperative Bair Hugger blanket	£7.96	Weighted average above	
Preoperative Bair Hugger blanket	£15.37	NHS Supply Chain 13.07.2016	
Total	£23.33		
Resistive heating mattress - Inditherm			
Element	**Amount**	**Source**	
Full length mattress and controller p.a.	£900	Manufacturer 11.07.2016	
3/4 length mattress p.a.	£360	Manufacturer 11.07.2016	
1/2 length mattress p.a.	£360	Manufacturer 11.07.2016	
Number surgeries per year	1300	Expert advice	
Cost per surgery	£1.25		
Resistive heating blanket – HotDog			
Cost per surgery	£1.60	Manufacturer	
Usual care			
Assuming zero cost	£0	Assumption	

For each pairwise comparison of interventions and for each patient subpopulation (stratified by age and magnitude of surgery) incremental NMB per 1,000 patients was calculated. This was achieved by first calculating the difference in number of cases of hypothermia averted per 1,000 patients, which was then multiplied by the NMB per case of hypothermia averted for the relevant patient subpopulation. The difference in intervention costs per 1,000 patients was subtracted from this value to calculate overall NMB per 1,000 patients.

2.4.3.3 Uncertainty

2.4.3.3.1 SA1: Proportion of non-standard forced air warming blankets

It was assumed that the cheaper, standard blankets account for 86% of consumables used in forced air warming. That is, we have assumed that the non-standard blankets account for 14% of the procurement volume. Advice from the topic experts suggested that the use of non-standard blankets could be as high as 40%. A greater use of more expensive non-standard blankets reduces the cost effectiveness of forced air warming relative to other warming methods. Therefore, a one-way sensitivity analysis was conducted to test what impact this higher proportion would have on results. This effectively increases the cost per surgery for forced air warming to £11.47.

2.4.3.3.2 *SA2: Threshold used to define hypothermia when imputing data from core mean temperature*

Advice from the topic experts suggested that the 36 degrees Celsius threshold commonly used to define hypothermia is essentially arbitrary despite it being used in the majority of the literature. A one-way sensitivity analysis was conducted to see how results would be affected by increasing this threshold to 36.5 degrees Celcius. Note, this only impacts the strategies where the proportion of hypothermia has been imputed from core temperature at end of surgery (1a, 1b, 3). The threshold can only remain fixed at 36 degrees Celsius when data have been extracted from studies that reported the number of hypothermic patients directly.

2.4.3.3.3 *Probabilistic analysis*

The parameter uncertainty around mean relative risk and net monetary benefit per case of hypothermia avoided was tested by conducting a probabilistic sensitivity analysis. This is of most interest regarding strategy 1c. FAW (intra) vs. resistive heating mattress (intra), where the confidence interval around the relative risk of hypothermia crosses the line of no effect, despite the meta-analysis of core temperature at end of surgery finding a statistically significant difference favouring forced air warming. A simulation of 1000 hypothetical patients was run based on the confidence intervals obtained from the meta-analyses in the clinical review (for relative risk of hypothermia) and net monetary benefit simulations from the original guideline model. The probabilistic analysis only applies to the strategies based on the proportion of hypothermic patients from studies where this was reported (1c, 2, 3a, 3b). The parameter uncertainty around the proportion of hypothermic patients imputed from core temperature at end of surgery could not be established because it itself was derived from the distribution around core temperature at end of surgery.

2.4.3.4 Results

The deterministic results of the analysis are provided in Table 9. The net monetary benefit of avoiding hypothermia outweighed the incremental cost of all comparisons – i.e. in every comparison, the more effective treatment was also associated with higher NMB. Forced air warming was cost effective compared with the resistive heating mattress and this cost effectiveness increased based on the data from studies that reported the proportion of hypothermic patients. The addition of preoperative forced air warming to intraoperative forced air warming was cost effective compared with intraoperative forced air warming alone. Preoperative warming was cost effective compared with usual care and this conclusion strengthened when the studies on preoperative forced air warming only were used for this comparison. Forced air warming was cost effective compared with the resistive heating blanket to a similar degree as when it was compared against the resistive heating mattress (intraoperative).

Results show that, in all cases, more effective treatments are associated with higher NMB in older patients and in surgical procedures of a higher magnitude. This is due to a higher net monetary benefit per case of hypothermia averted in these patient subgroups – largely due to a higher rate of morbid cardiac events in older patients, and increased infection rates and length of hospital stay in patients undergoing an intermediate or major surgical procedure. The probabilistic results (Table 10) show that preoperative warming has at least a 96% probability of being cost effective. There was around 80% probability that intraoperative forced air warming was cost effective compared with the resistive heating mattress.

Increasing the cost of forced air warming in the first sensitivity analysis had minimal impact on the results (Table 11).

The second sensitivity analysis (Table 13), where the threshold for hypothermia was increased to 36.5 degrees Celsius, found that the cost effectiveness of forced air warming compared with the resistive heating mattress depended on whether or not the studies on cardiac patients were included. With the cardiac studies included, NMB values for all patient groups were negative, indicating that forced air warming was no longer cost effective compared to resistive heating mattress. This is because, at a 36.5 degrees Celcius threshold, both interventions result in a similar proportion of hypothermic patients (73.8% versus 73.6% for forced air warming and resistive heating mattress, respectively), whereas the treatment cost of forced air warming remained higher. Conversely, when the cardiac studies were excluded, forced air warming remained cost effective compared with the resistive heating mattress and the resistive heating blanket.

2.4.3.5 Limitations

It should be noted that the original model used '% of patients hypothermic' as the key clinical effectiveness parameter. This outcome was rarely reported in the studies that met the inclusion criteria in this update and had to be imputed from mean core temperature data at the end of surgery, assuming that mean core temperature was normally distributed among patients in the studies. The values obtained were generally consistent with the rest of the data in the clinical review where the proportion of hypothermic patients was reported but this method is not without its limitations.

The analysis assumes that the methods by which the net monetary benefit was calculated in the original guideline are valid and that the costs of adverse events have changed in line with inflation of broader healthcare costs.

As in the economic analysis for the original guideline, this analysis assumes that a case of hypothermia is not associated with a QALY decrement in itself, but is associated with an increased probability of adverse consequences, some of which result in a reduction in QALYs.

Incremental analysis could not be performed. Incremental analysis enables the identification of the strategy with the highest incremental cost-effectiveness ratio up to the cost-effectiveness threshold (that is, the strategy that maximises health gain at an acceptable opportunity cost). The calculation of overall net monetary benefit overcomes this limitation to a certain degree although the strategies are not compared to a common baseline.

2.4.3.6 Conclusion

As previously discussed, the net monetary benefit framework adopted by this analysis indicates that any intervention associated with a positive NMB is expected to be cost effective at a threshold of £20,000. Using this framework, the analysis found that preoperative warming was highly likely to be cost effective because the additional cost of the consumables required to prewarm was outweighed by the benefits of preventing hypothermia. Intraoperative forced air warming is likely to be cost effective compared with intraoperative resistive heating mattresses alone and intraoperative blankets alone.

Table 8: Economic evidence profile

Study	Applicability	Limitations	Other comments	Cost	Effect	Incremental cost	Incremental effect	ICER	Uncertainty
NICE CG65	Directly applicable	Minor limitations	Decision tree and Markov model						
United Kingdom			Pairwise comparisons		In QALYs:		In QALYs:	£/QALY:	% under £20,000 threshold:
			1. FAW (intra) vs. UC	1. -£700	1. 9.03	1. -£700	1. 9.03	1. FAW dominates	1. 99.6%
			2. WF (intra) vs. UC	2. -£7,800	2. 8.64	2. -£7,800	2. 8.64	2. WF dominates	2. 99.9%
			3. FAW (intra)+WF vs. FAW (intra)	3. £6,500	3. 2	3. £6,500	3. 2	3. £3,200	3. 82.1%
			4. FAW (intra) vs. EHP (intra)	4. Not available†	4. 1.48	4. Not available	4. 1.48	4. Not available	4. Not available
			5. FAW+WF (pre+intra) vs. UC	5. £21,400	5. 10.52	5. £21,400	5. 10.52	5. £2,030	5. 98.9%
			Indirect comparison vs. usual care						% optimal strategy:
			1. Usual care					1. -	1. –
			2. FAW (intra)					2. Dominates UC	2. 7%
			3. WF (intra)					3. Dominates UC	3. 34%
			4. FAW+WF (intra)					4. £195,200	4. 39%
			5. FAW+WF (pre+intra)					5. £189,000	5. 20%

Acronyms
ICER: incremental cost-effectiveness ratio; QALY: quality-adjusted life year; FAW: forced air warming; UC: usual care; WF: warmed fluids; EHP: electric heating pads
**The analysis was limited by the need to estimate the effectiveness in terms of relative risk by imputing from data based on mean temperatures assuming a normal distribution due to the lack of data on the incidence of hypothermia.†Authors could not establish the cost of electric heating pads*

Table 9: Net monetary benefit of warming per 1,000 patients – pairwise deterministic results (base case)

Age	20			50			70		
Magnitude of surgery	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**
1a. FAW (intra) vs. RHM (intra) - imputed	£6,947	£35,344	£46,878	£80,242	£108,638	£120,173	£86,957	£115,354	£126,888
1b. FAW (intra) vs. RHM (intra) - imputed excluding cardiac	£32,598	£114,321	£147,517	£243,535	£325,258	£358,454	£262,861	£344,584	£377,780
1c. FAW (intra) vs. RHM (intra) - % hypothermic reported	£48,992	£164,798	£211,838	£347,901	£463,707	£510,747	£375,288	£491,093	£538,134
2. FAW (pre+intra) vs. FAW (intra) - % hypothermic reported	£69,470	£245,849	£317,493	£524,723	£701,102	£772,747	£566,435	£742,813	£814,458
3a. Preoperative warming vs. usual care - % hypothermic reported	£101,033	£343,029	£441,328	£725,654	£967,650	£1,065,949	£782,883	£1,024,879	£1,123,178
3b. FAW (pre) vs. usual care - % hypothermic reported	£102,941	£348,901	£448,811	£737,795	£983,755	£1,083,665	£795,962	£1,041,923	£1,141,832
4. FAW (intra) vs. resistive heating blanket (intra) - imputed excluding cardiac	£39,065	£123,605	£157,945	£257,273	£341,813	£376,153	£277,265	£361,806	£396,146

FAW: forced air warming; RHM: resistive heating mattress; pre: preoperative warming; intra: intraoperative warming; pre+intra: preoperative and intraoperative warming

Table 10: Net monetary benefit of warming per 1,000 patients – pairwise probabilistic results (base case)

Age	**20**			**50**			**70**		
Magnitude of surgery	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**
1c. FAW (intra) vs. RHM (intra) - % hypothermic reported									
Expected net monetary benefit intervention vs. comparator	£38,893	£125,103	£163,634	£272,277	£362,073	£408,381	£299,778	£375,354	£399,860
Probability intervention is cost effective vs. comparator	79%	82%	83%	83%	83%	84%	83%	83%	83%
2. FAW (pre+intra) vs. FAW (intra) - % hypothermic reported									
Expected net monetary benefit intervention vs. comparator	£65,556	£231,676	£299,606	£488,198	£658,367	£689,721	£519,800	£677,853	£751,621
Probability intervention is cost effective vs. comparator	96%	99%	99%	99%	99%	99%	99%	99%	99%
3a. Preoperative warming vs. usual care - % hypothermic reported									
Expected net monetary benefit intervention vs. comparator	£96,887	£331,475	£421,262	£712,437	£915,890	£1,028,075	£737,737	£963,964	£1,062,246
Probability intervention is cost effective vs. comparator	99%	100%	100%	100%	100%	100%	100%	100%	100%
3b. FAW (pre) vs. usual care - % hypothermic reported									
Expected net monetary benefit intervention vs. comparator	£100,449	£345,113	£429,047	£712,047	£908,739	£1,019,998	£772,851	£990,192	£1,094,534
Probability intervention is cost effective vs. comparator	99%	100%	100%	100%	100%	100%	100%	100%	100%

FAW: forced air warming; RHM: resistive heating mattress; pre: preoperative warming; intra: intraoperative warming; pre+intra: preoperative and intraoperative warming
Strategies 1a, 1b, and 4 do not appear in this table because they were not included in the probabilistic analysis.

Table 11: SA1: Pairwise deterministic results per 1,000 patients with a higher cost of forced air warming

Age	20			50			70		
Magnitude of surgery	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**
1a. FAW (intra) vs. RHM (intra) - imputed	£3,440	£31,837	£43,371	£76,735	£105,131	£116,666	£83,450	£111,847	£123,381
1b. FAW (intra) vs. RHM (intra) - imputed excluding cardiac	£29,091	£110,814	£144,010	£240,028	£321,751	£354,947	£259,354	£341,077	£374,273
1c. FAW (intra) vs. RHM (intra) - % hypothermic reported	£45,485	£161,291	£208,331	£344,394	£460,200	£507,240	£371,781	£487,586	£534,627
2. FAW (pre+intra) vs. FAW (intra) - % hypothermic reported	£69,470	£245,849	£317,493	£524,723	£701,102	£772,747	£566,435	£742,813	£814,458
3a. Preoperative warming vs. usual care - % hypothermic reported	£101,033	£343,029	£441,328	£725,654	£967,650	£1,065,949	£782,883	£1,024,879	£1,123,178
3b. FAW (pre) vs. usual care - % hypothermic reported	£102,941	£348,901	£448,811	£737,795	£983,755	£1,083,665	£795,962	£1,041,923	£1,141,832
4. FAW (intra) vs. resistive heating blanket (intra) - imputed excluding cardiac	£39,065	£123,605	£157,945	£257,273	£341,813	£376,153	£277,265	£361,806	£396,146

FAW: forced air warming; RHM: resistive heating mattress; pre: preoperative warming; intra: intraoperative warming; pre+intra: preoperative and intraoperative warming

Table 12: SA1: Pairwise probabilistic results per 1,000 patients with a higher cost of forced air warming

Age	**20**			**50**			**70**		
Magnitude of surgery	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**
1c. FAW (intra) vs. RHM (intra) - % hypothermic reported									
Expected net monetary benefit intervention vs. comparator	£33,946	£126,509	£153,823	£254,461	£345,334	£366,168	£288,386	£365,351	£410,200
Probability intervention is cost effective vs. comparator	75%	81%	81%	82%	82%	82%	82%	82%	82%
2. FAW (pre+intra) vs. FAW (intra) - % hypothermic reported									
Expected net monetary benefit intervention vs. comparator	£67,014	£236,389	£301,954	£501,229	£668,876	£734,240	£534,600	£721,125	£758,582
Probability intervention is cost effective vs. comparator	96%	99%	99%	99%	99%	99%	99%	99%	99%
3a. Preoperative warming vs. usual care - % hypothermic reported									
Expected net monetary benefit intervention vs. comparator	£104,226	£320,768	£430,174	£697,689	£942,034	£1,043,648	£738,599	£958,576	£1,080,944
Probability intervention is cost effective vs. comparator	99%	100%	100%	100%	100%	100%	100%	100%	100%
3b. FAW (pre) vs. usual care - % hypothermic reported									
Expected net monetary benefit intervention vs. comparator	£100,614	£321,598	£424,857	£720,257	£915,665	£1,024,120	£756,315	£1,010,523	£1,101,214
Probability intervention is cost effective vs. comparator	98%	99%	99%	99%	99%	99%	99%	99%	99%

FAW: forced air warming; RHM: resistive heating mattress; pre: preoperative warming; intra: intraoperative warming; pre+intra: preoperative and intraoperative warming

Table 13: SA2: Pairwise deterministic results per 1,000 patients for increasing the threshold for hypothermia to 36.5 degree Celsius

Age	20			50			70		
Magnitude of surgery	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**	**Minor**	**Intermediate**	**Major**
1a. FAW (intra) vs. RHM (intra) - imputed	-£7,465	-£9,031	-£9,667	-£11,506	-£13,072	-£13,708	-£11,877	-£13,442	-£14,078
1b. FAW (intra) vs. RHM (intra) - imputed excluding cardiac	£11,302	£48,752	£63,964	£107,964	£145,413	£160,625	£116,820	£154,270	£169,482
4. FAW (intra) vs. resistive heating blanket (intra) - imputed excluding cardiac	£35,064	£111,287	£142,249	£231,805	£308,028	£338,990	£249,831	£326,054	£357,015

FAW: forced air warming; RHM: resistive heating mattress; pre: preoperative warming; intra: intraoperative warming;

Probabilistic results are not provided for SA2 because SA2 only applies to strategies where % hypothermic was imputed from core temperature at end of surgery and these strategies were not included in the probabilistic analysis.

2.5 Evidence statements

2.5.1 Clinical evidence statements

2.5.1.1 Intra-operative active warming

Core temperature at end of surgery

A total of 18 studies with 1029 participants contributed data for this outcome. There was no significant difference between forced air warming and other active warming devices with the exception of circulating water blankets, circulating water mattresses, radiant heating, resistive heating mattresses and electric blanket which were not as effective as forced air warming and warming pads which were more effective than forced air warming. The certainty in these findings ranged from very low to high.

After a sensitivity analysis excluding Hofer 2005 (population undergoing coronary artery bypass grafting) forced air warming was more effective than resistive heating blankets (6 studies, n= 256, certainty in this finding was high).

Surgical / wound infections

Two studies with 138 participants contributed data to this outcome. There was no significant difference between forced air warming and other active warming devices (circulating water garment, resistive heating blanket and warming pads) but the certainty in these finding was very low.

Core temperature at 30 minutes

Six studies with 344 participants contributed data for this outcome. There was no significant difference between forced-air warming and other active warming devices (circulating water mattress, resistive heating blanket, resistive heating mattress, radiant heating and electric heating pads) while forced air warming was more effective than electric blanket but the certainty in these findings ranged from low to moderate..

Core temperature at 60 minutes

Sixteen studies with 817 participants contributed data for this outcome. There was no significant difference between forced-air warming and other active warming devices (circulating water blanket, circulating water garment, circulating water mattress, resistive heating blanket, resistive heating mattress, radiant heating and electric heating pads) while forced air warming was more effective than electric blanket but the certainty in these findings ranged from very low to moderate,.

After a sensitivity analysis excluding Hofer 2005 (population undergoing coronary artery bypass grafting) there was no significant difference between forced air warming and resistive heating blankets (4 studies, n= 160) and the certainty in this finding was high.

Core temperature at 120 minutes

Eleven studies with 550 participants contributed data for this outcome. There was no significant difference between forced-air warming and other active warming devices (circulating water blanket, resistive heating blanket, resistive heating mattress) while forced air warming was more effective than both circulating water mattress and radiant heating. The Circulating water garment was more effective than forced air warming in this analysis. Overall the certainty in these findings ranged from very low to high.

After a sensitivity analysis excluding Hofer 2005 (population undergoing coronary artery bypass grafting) there was no significant difference between forced air warming and resistive heating blankets (3 studies, n= 136) and the certainty in this finding was high).

Number of patients suffering hypothermia

Twelve studies with 747 participants contributed data for this outcome. There was no significant difference between forced-air warming and other active warming devices (circulating water garment, circulating water mattress, radiant heating, resistive heating mattress, electric heating pads and warming pads) and the certainty in these findings ranged from very low to moderate.

Number of patients requiring a blood transfusion

Four studies with 388 participants contributed data for this outcome. there was no significant difference between forced-air warming and other active warming devices (circulating water mattress, resistive heating blanket, resistive heating mattress and warming pads) However there were more blood transfusion in the forced air warming group when compared to circulating water garments and the certainty in these findings ranged from very low to high.

Blood loss

Six studies with 352 participants contributed data for this outcome. There was no significant difference between forced-air warming and other active warming devices (circulating water mattress, resistive heating blanket and electric heating pads). However there was greater blood loss in the forced air warming group when compared to circulating water garments and the certainty in these findings ranged from very low to high.

Shivering

Six studies with 362 participants contributed data for this outcome. There was no significant difference between forced-air warming and other active warming devices (circulating water garment, radiant heating and electric heating pad). There were fewer cases of shivering in the forced air warming group when compared with circulating water mattress. Overall the certainty in these findings ranged from low to high.

Cardiac events

A single study with 46 participants contributed data to this outcome. There was no significant difference between forced air warming and circulating water mattress and the certainty in this finding was low

Adverse effects

Eleven studies study with 668 participants contributed data to this outcome. There was no significant difference between forced air warming and other active warming devices (resistive heating blanket, circulating water blanket, circulating water garment, circulating water mattress and radiant heating) though the majority of studies did not report any adverse effects. The certainty in these findings ranged from low to high.

Length of hospital stay

A single study with 50 participants contributed data to this outcome. The patients in the forced air warming group had longer hospital stays then those in the warming pads group. The certainty in this finding was high.

2.5.1.2 Preoperative active warming

Twelve studies including 1281 participants contributed data to the analysis. The quality of and certainty in the evidence for each outcome ranged from very low to moderate. Preoperative active warming was found to be significantly more effective than no preoperative active warming for critical outcomes (core temperature at end of surgery, 30 minutes, 60 minutes, 120 minutes, surgical & wound infections and hypothermia) There was no significant difference for the other outcomes reported (shivering, adverse effects, blood transfusion and cardiac complications)

2.5.2 Economic evidence statements

No economic studies were identified in the literature and the modelling conducted for the original guideline was the only included study.

Economic modelling conducted for the original guideline found that any method that is effective at warming is likely to be cost effective. Intraoperative forced air warming plus warmed fluids had the highest net monetary benefit and highest probability of being cost effective.

An economic analysis conducted for the update was based on the net monetary benefit per case of hypothermia avoided calculated by the original guideline model. The update analysis found that preoperative warming was highly likely to be cost effective because the additional cost of consumables was outweighed by the benefits of preventing hypothermia. Intraoperative forced air warming was likely to be cost effective compared with intraoperative resistive heating mattresses alone and intraoperative resistive heating blankets alone.

2.6 Evidence to recommendations

	Committee discussions
Relative value of different outcomes	The committee considered that core temperature at end of surgery and hypothermia were critical outcomes because these outcomes are the best indicators of the efficacy of the different warming devices. The number of people with hypothermia at any time was also considered critical as the complications such as cardiac events associated with it are severe for the patient and are resource intensive. Surgical or wound site infections are a critical outcome as they may not become apparent for several days and the patient may have been discharged from medical care plus they have a serious impact on the patient as they may require additional treatment and observation. There is concern that the risk of these may be increased with the current practice of forced air warming as this disrupts the laminar air flow in surgical theatres. Core temperature at different time-points (30, 60 and 120 minutes) during surgery is important as maintaining normothermia throughout the perioperative period will reduce the risk of infection at the surgical site and ensure that patients feel comfortably warm at all times. These outcomes are also useful as indicators of how effective the active warming devices are at maintaining normothermia during the surgery Likewise shivering was considered important as it may be a physiological reaction to the core temperature being too low. It is also distressing to the patient and may hamper post-surgical recovery and delay discharge from the recovery room with additional costs to the NHS.
Quality of evidence	The committee agreed that the quality of, and certainty in the evidence for the different outcomes was between very low and high. The committee had concerns over the generalisabilty of the evidence given that patients at higher risk of inadvertent perioperative hypothermia (ASA grade IV and V) were excluded from many of the included studies. The committee

	Committee discussions
	considered that it would have been unethical not provide the most effective method of active warming to these patients. The committee noted that the included studies were predominantly populated by people undergoing elective surgery and evidence on emergency surgery was sparse. The committee also noted however the wide range of surgical procedures in the included studies and were minded to not draft recommendations based on type of surgery and instead referred to type of anaesthesia used in the included studies which was predominantly general anaesthesia or neural blockade. The committee agreed that the certainty over the findings was reduced due to the fact that only a single study was included in many of the comparisons. The committee also noted that many of the studies were small in size and underpowered to detect rare events such as cardiac effects. This had the result of increasing the imprecision with resulting effects on the certainty around the evidence base. The committee considered that how the resistive heating mattress was used in the included studies (under-body mattress) differed from how it is used in clinical practice (under-body mattress with an over-body blanket). The committee agreed that this would lead to an underestimation of the effectiveness of this active warming method and reduce certainty in the review findings. The evidence for the comparisons of interest in the intraoperative period (forced air warming versus resistive heating) ranged from very low to high quality. The committee noted that the meta-analyses found that forced air warming was more effective than resistive heating mattresses but there was not a difference in effectiveness when forced air warming was compared to resistive heating blankets. The committee requested a sensitivity analysis on the comparison of core temperature at the end of surgery, as one of the included studies was in patients undergoing coronary artery bypass grafting surgery and this may be affecting the findings. Once this study was excluded, the meta-analysis found that forced air warming was more effective than resistive heating blanket at end of surgery but there was no difference at the different timepoints during surgery. For the review on active warming pre-operatively, the committee agreed that the certainty around the evidence ranged from very low to high. The committee also noted an additional limitation in their deliberations in that forced-air warming was the method used in the majority of the studies and only one study used resistive heating blankets.
Trade-off between benefits and harms	The committee deliberated on the benefits of active warming in both the pre-operative and intraoperative periods with a greater proportion of patients maintaining normothermia when active warming was used. The committee noted the lack of adverse effects (such as burns or hyperthermia) associated with the two methods of active warming of interest (forced air warming and resistive heating) to clinicians in the UK. The committee considered that the included studies may only have reported on adverse effects that were directly related to the devices used (such as burns) and may not have reported on adverse effects indirectly related (such as surgical or wound infections) and therefore there may be an under-reporting of the adverse effects in these studies.
Trade-off between net health benefits and resource use	The economic systematic review did not identify any relevant articles, although a previous analysis conducted for the original guideline was included in the health economic evidence review.

	Committee discussions
	The economic analysis conducted for the update was based on the net monetary benefit calculated by the original guideline model. This analysis found that preoperative warming was highly likely to be cost effective because the additional cost of the consumables required was outweighed by the benefits of preventing hypothermia. Intraoperative forced air warming was likely to be cost effective compared with intraoperative resistive heating mattresses alone and intraoperative resistive heating blankets alone. The committee discussed whether the comparison of intraoperative forced air warming vs. intraoperative resistive heating mattress should be included in the economic analysis when the meta-analysis in the clinical review found no statistically significant difference for the relative risk of hypothermia outcome based on 2 studies. The committee decided to retain this comparison because the clinical review found a statistically significant difference in core temperature at end of surgery. A probabilistic analysis was subsequently added to the economic analysis to quantify the uncertainty of this comparison and found there was an 80% probability that intraoperative forced air warming was cost effective compared with the intraoperative resistive heating mattress alone. The committee noted the economic analysis found that preoperative warming had a 98% probability of being cost effective. The economic analysis found that intraoperative forced air warming was cost effective compared with the intraoperative resistive heating blanket based on data where cardiac studies are excluded. This comparison could only be based on the relative risk of hypothermia imputed from data on core temperature at end of surgery because no studies included in the clinical review reported the proportion of hypothermic patients. This also meant the uncertainty of this comparison could not be quantified through probabilistic analysis. A one-way sensitivity analysis that increased the cost of forced air warming due to a greater use of non-standard blankets found that this input did not substantially change the results. A one-way sensitivity analysis that increased the threshold defining hypothermia to 36.5 degrees Celsius found that intraoperative forced air warming remained cost effective compared with the intraoperative resistive heating mattress and intraoperative resistive heating blanket based on effectiveness data excluding cardiac surgery studies. This sensitivity analysis applied to comparisons where effectiveness was imputed from core temperature at end of surgery only. There were a number of limitations with the economic analysis that the committee took into account when interpreting the conclusions. It was a relatively simple analysis based on the net monetary benefit from the original guideline. Therefore, it assumed that the methods used in the original guideline for this calculation were valid. The method of imputing the proportion of hypothermic patients from core temperature at end of surgery assuming a normal distribution was considered an estimate although it did yield similar results to the data on the proportion of hypothermic patients where this was reported. The probabilistic analysis took into account the parameter uncertainty around the effectiveness of reducing hypothermia only and not around the cost of warming or the net benefit of hypothermia avoided. The committee considered that resource impact of offering preoperative active warming to people having general anaesthesia or central neural blockade for surgery. This may mean that up to double the number of kits would need to be procured if, for example, the pre-operative active warming was delivered outside the theatre and another piece of kit used in theatre. The committee noted that NHS supply chain has negotiated with manufacturers to deliver forced air warming devices for free and that the consumable (coverings) are around £5 per single use. The committee

	Committee discussions
	considered that even a doubling of this initial outlay would be insignificant compared to the savings gained from cases of hypothermia avoided. Resistive heating mattresses and blankets are more costly but are re-usable so become more cost-effective with more use.
Other considerations	The committee noted the paucity of evidence on combinations of active warming methods used preoperatively and intraoperatively. The committee considered that combinations of devices would likely be more effective at maintaining normothermia than a single method but there was no evidence to support this. There is also a risk of hyperthermia when more than one method is used, this may be uncomfortable for patients in the preoperative phase. The committee noted that that people are able to move around preoperatively when undergoing active warming with either forced air warming or resistive heating blankets, though there are some constraints on movemement by the device's connecting wires or air tubes. This is a consideration if the pre-operative active warming is delivered on the ward as the patient would then need to be transported to the theatre for surgery. When discussing the equality impact assessment the committee noted that people with an intellectual disability, English as a second language or other issues affecting communication may not be able to indicate to clinical staff that they were uncomfortable with the active warming, or that they were feeling cold and needed extra warming. People with low literacy levels may not be able to follow the instructions on devices where the temperature is controlled by the patient. Overall the committee considered the demonstrated reduction in hypothermia rates outweighed the adverse effects of active warming and drafted a recommendation for the use of active warming in the preoperative period

2.7 Recommendations

1. Offer active warming for at least 30 minutes before induction of anaesthesia to all patients having general anaesthesia or central neural blockade for surgery, unless this will delay emergency surgery. [new 2016]

2. Pay particular attention to the comfort of patients with communication difficulties during the preoperative phase. [new 2016]

3. Warm patients intraoperatively from induction of anaesthesia, using a forced air warming device, if they are:

- **having anaesthesia for more than 30 minutes or**
- **having anaesthesia for less than 30 minutes and are at higher risk of inadvertent perioperative hypothermia (see recommendation 1.2.1)**

Consider a resistive heating mattress or resistive heating blanket if a forced air warming device is unsuitable. [new 2016]

2.8 Research recommendations

2.8.1 Combined methods of intraoperative active warming compared with a single method

What is the clinical and cost effectiveness of combined methods of intraoperative active warming compared with a single method in preventing inadvertent perioperative hypothermia?

Why this is important

A combination of active warming devices, such as forced air warming together with a resistive heating mattress, is usually used to warm patients during surgery. However, there is not enough evidence to show whether this is more clinically effective than a single active warming device, such forced air warming on its own. Large randomised controlled trials with at least 100 patients in each arm should be carried out to compare combined methods of intraoperative active warming (such as forced air warming together with a resistive heating mattress, or a resistive heating mattress together with a resistive heating blanket) with a single method of active warming (such as forced air warming). All intravenous fluids should be warmed to 37°C. Primary outcomes should be core temperature at the end of surgery and incidence of hypothermia. Patients should be stratified by anaesthesia duration and type of surgery. Adverse effects and numbers of patients with complications of hypothermia (for example, morbid cardiac events or wound infections) should be recorded**. [new 2016]**

PICO	**Population:** Adults undergoing surgery **Intervention:** combinations of active warming to devices; including forced air warming + resistive heating blanket and resistive heating mattress + resistive heating blanket **Comparison:** Single active warming device: forced air warming alone, resistive heating mattress alone or resistive heating blanket alone. **Outcomes:**

	Efficacy outcomes: Core temperature at the end of surgery Incidence of hypothermia Adverse events relating to hypothermia (including cardiac events, wound infection)
Current evidence base	There is currently a lack of evidence on the comparative clinical and cost effectiveness of combinations of active warming devices warming versus single active warming devices used in intraoperative warming. The committee report that combinations of active warming devices are used in clinical practice; evidence is required to assess the clinical and cost effectiveness of this approach.
Study design	RCT, observational studies.

Table 14: Criteria for selecting high-priority research recommendations

2.9 Review question 3

What is the best site and method for accurately measuring temperature in the different phases of perioperative care?

2.10 Clinical evidence review

A systematic search was conducted (see appendix D2) which identified 5002 articles. The titles and abstracts were screened and 80 articles were identified as potentially relevant. Full-text versions of these articles were obtained and reviewed against the criteria specified in the review protocol (appendix C2). Of these, 56 were excluded as they did not meet the criteria and 24 met the criteria and were included.

A review flowchart is provided in appendix E2, and the excluded studies (with reasons for exclusion) are shown in appendix F2.

2.10.1 Methods

One reviewer sifted the database (5002 abstracts); for quality assurance, a second reviewer assessed a random 20% sample. There was 96.6% agreement between the two reviewers. In cases of disagreement, the papers were ordered and assessed for inclusion.

The included studies differed with respect to the interventions, the reference method and site of temperature measurement and the perioperative period of temperature measurement.

- Interventions included the following sites of measurement: tympanic (IR and thermocouple), forehead, rectal, bladder, nasopharyngeal, oesophageal, pulmonary artery, oral/ sublingual and axillary.
- Reference methods of temperature measurement vary between studies; included pulmonary artery catheter, tympanic, oral and oesophageal.
- Of the 24 included studies in this review, 14 reported Bland Altman analysis of bias (mean difference between two methods of measurement); 12 of which reported the data in a way that could be analysed in this review. In 10 studies where Bland Altman was not reported and in the 2 studies where it was reported in a non-useable format, the mean difference of the sites of temperature measurement has been reported.
- Of the 12 studies reporting Bland Altman analyses, 4 studies report on the pre- operative period, 5 studies report on the intraoperative period (1 study reports pre and post CPB and 1 study reports results at 15, 45 and 75 minutes post anaesthesia), and 6 studies report results on the post- operative period. Within each of the 3 perioperative phases, the studies report at different time points, for example for the post- operative phase some report on admission to PACU and others report on discharge from PACU.
- 10 studies did not report Bland Altman analysis, in this instance the mean difference between sites of measurement was extracted. One study reported mean difference between sites of measurement in the preoperative phase, 9 studies reported outcomes in the intraoperative phase and 5 studies reported outcomes in the postoperative phase.

Analyses

Where reported, Bland Altman statistic of bias and limits of agreement (+/-2SD) was reported. If the Bland Altman statistic was not reported, mean difference in temperature was calculated and reported. Data was not meta-analysed due to the variation in the way that results were reported, and due to the number and different reference methods and comparisons reported by each study at varying time points.

All data are reported in this addendum: However, in committee meeting 1, the committee agreed post- hoc that the three reference methods that should be used to assess accuracy of core temperature measurement were pulmonary artery catheter, oesophagus and bladder.

Quality appraisal

The quality of the evidence for each outcome was assessed using GRADE methodology as follows;

- Risk of bias was assessed using the observational study checklist to identify any concerns over study methodology or reported of methodology.
- Inconsistency was not assessed as there was no pooling of data.
- Indirectness was assessed by divergence population, interventions and outcome from those specified in the review protocol.
- Imprecision was assessed using the 95% Confidence Interval (CI) around the point estimate of effect size. For all outcomes, 0.5 ºCelcius was used as the MID.

1

2 **Table 15: Summary of included studies**

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Barringer 2011	N=86 Procedures included orthopaedic (34%), general (26%), plastic (17%), gynaecological (15%), genitourinary (6%), other (3%)	Sublingual v axillary (both with SureTemp plus Electronic Thermometer Model 690, Welch Allyn, NY) v temporal (Exergen Temporal Scanner, model TAT-5000, Exergen Corp,MA).	Temperatures on admission to surgery and arrival in PACU. Bland Altman statistic to determine extent to which there was equivalence in temperatures between the 3 measurement sites.	57% received one or more preoperative warming measures with Bair Paws gown, warmed IV fluids and/or a warmed blanket
Bock 2005	N=26 Elective cardiac surgery	Tympanic (IRT 4000) v tympanic contact probe v pulmonary artery catheter	Temperatures recorded every 6 minutes. Bland Altman of IRT tympanic v tympanic contact probe/ pulmonary artery catheter	
Calonder 2010	N=23 Colorectal or gynaecological surgery	Oral v temporal v oesophageal probe	Temperature measured post-induction and at least 30 minutes later. Bland Altman plots of oral v oesophageal and temporal v oesophageal Bias estimates	
Cattaneo 2000	N=32 Male only Radical retropubic prostatectomy (n=16 spinal epidural and n=16 general anaesthetic)	Oral v temporal (infrared thermocouple) v axillary v rectal	Bland Altman (no numerical data reported), comparison of general and spinal anaesthesia; thermocouple probe at tympanic membrane as reference measurement. Differences between temperature measurements at time of admission to the recovery room.	
Erdling (2015)	N=52	Nasopharyngeal v oesophageal	Mean temperature	Part of a study assessing

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
	Elective colorectal surgery, general anaesthetic			prewarming v no prewarming
Erickson (1991)	N=60, major non-vascular abdominal surgery. General anaesthetic	Oral (IVAC TempPlus II predictive thermometer) v tympanic (FirstTemp infrared, Model 2000A, Intelligent Medical systems)	Offset (Farenheit) between tympanic and oral temperature at operating room entry, PACU entry and PACU exit.	No Bland Altman
Eshragi (2014)	N=105, people undergoing non-emergency cardiac surgery	Zero heat flux (ZHF) on forehead, ZHF on neck, , skin surface on forehead, pulmonary artery catheter	Mean difference between sites of measurement.	
Fallis	N=40, people undergoing scheduled open heart surgery	Oral v rectal v pulmonary artery (ref)	Mean difference between the 3 sites of measurement; results for postoperative only reported.	
Fanelli (2009)	N=56 Elective total hip replacement	Aural tympanic probe (Mon-a-therm, Covidien) v infrared tympanic thermometer First Temp Genius)	Final temperature	No Bland Altman; part of a study assessing FAW v resistive heating
Fetzer	N=222 Pre and post operative patients	Tympanic vs temporal artery	Bland altman	
Frommelt 2008	N=84, postoperative patients admitted to a surgical ward	Oral v tympanic v temporal	Bland Altman	Not reported whether sublingual or oral. Not reported whether correction factor used for IR tympanic measurement
Harasawa 1997	N=30 Coronary artery bypass graft	tympanic IR (Thermoscan Pro 1) v oesophagus (Mon-a-therm, Mallincrodt medical) v thermocouple tympanic (mon-a-therm)	Mean difference and limits of agreement between IR tympanic and CPB and between oesophagus and CPB (before, uring and after CPB).	

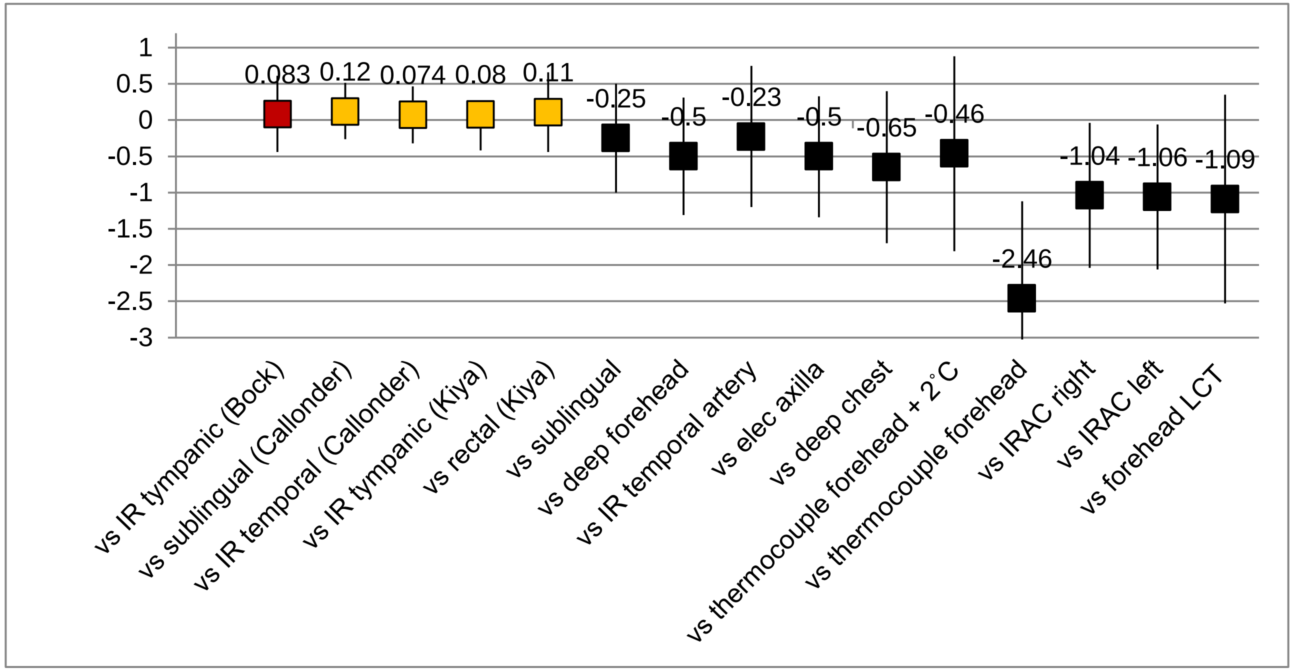
Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Harioka 2000	N=41 Abdominal and thoracic surgery lasting at least 3 hours	Deep forehead (Coretemp thermometer, Terumo, Japan) v rectal v tympanic v oesophageal (thermocouples) v pulmonary artery (thermistor)	Accuracy and precision, mean (SD) of different sites Bland Altman bias analysis	Cannot read Bland Altman analysis included in paper
Hecker 1996	N=205, sequential postoperative patients admitted to ICU	Forehead skin core temperature corrected LCT strips (Sharn) v axillary an oral thermistor probes v IR tympanic probe (First Temp Genius)	Bland Altman analysis	Unclear which site of measurement is reference
Heidenreich 1990	N=18, post- operative patients directly admitted from the operating room to ICU who had major surgical procedures.	Axillary electronic v axillary mercury v rectal mercury v pulmonary artery catheter	Mean difference between sites of measurement	
Hocker 2012	N=171, scheduled for surgery with duration<1 hr. General anaesthesia	Tympanic thermocouple (Tympanic temperature sensor YSI400, smiths medical Grasbrunn, Germany) v sublingual (Temp Plus II, Model 2080, Alaris Medical Systems)	Bland- Altman plots of preoperative, intraoperative and postoperative temperatures.	
Iden 2015	N=120 scheduled for elective gynaecological or trauma surgery. General anaesthesia.	Sublingual (SureTemp Plus, WelchAllyn) v nasopharyngeal probe (D-OS4, Exacon scientific) v zero heat flux (3M SpotOn)	Bland- Altman plots of zero heat flux vs sublingual/ nasopharyngeal at 15, 45 and 75 minutes postanaesthesia induction.	
Kiya 2007	N=18 Scheduled for elective non-abdominal and non-cardiac surgery under general anaesthesia and n=8 scheduled for cardiac	IR tympanic v rectal v oesophageal	Bland Altman between tympanic ad oesophageal and between rectal and oesophageal in the 2 groups of patients.	

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
	surgery			
Langham 2009	N=50 people arriving in PACU post operatively	Oral, axilla, temporal, forehead (skin surface/ liquid crystal), IR aural canal, deep forehead, bladder	Bland Altman of different sites vs bladder (control)	
Matsukawa 1995	N=30 women undergoing open lower abdominal surgery. Combined general anaesthesia and spinal epidural	IR tympanic (Quickthermo) v tympani c membrane (Mon-a-therm thermocouples, Mallinckrodt) v bladder (Mon-a-therm)	Bland Altman of IR tympanic v thermocouple tympanic and IR tympanic v bladder	
Ng (2006)	N=60 Patients undergoing total knee replacement, combined spinal and general anaesthetic	Infrared Tympanic (Thermoscan Pro 1) v rectal (no detail provided)	-First rectal and tympanic temperature and final temperature at both sites.	No Bland Altman reported. Part of a study comparing FAW to resistive heating.
Robinson 1998	N= 18 adults during cardiac surgery	Oesophagus v rectum v axilla (all Hi Lo Temp probes, Mallinckrodt) v tympanic (Genius) v tympanic (Core-check, IVAC) v pulmonary artery (Baxter Edwards Swan Ganz 7)	Comparison (mean difference) of readings compared to PA reading during open heart surgery ?Bland Altman?	
Russell 1996	N=20 people undergoing orthotic liver transplant	Pulmonary artery (Baxter catheter) v oesophageal (Mon-a-therm, Mallinckrodt) v urinary bladder (Mon-a-therm, Mallinckrodt)	Comparison of temperatures at 8 time points (incision, incision + 60 minutes, start of anhepatic phase, anhepatic + 30 minutes, reperfusion, reperfusion + 60 minutes, closure)	No Bland Altman
Winslow 2012	N=64 people undergoing elective major surgery	Sublingual (Welch Alleyn, SureTemp Plus 690 Oral) v temporal artery (Temporal scanner, model TAT 5000, Exergen) v bladder (Bardex Lubricath 400-Series and Lubri-	Mean temperatures at preoperative phase and on admission to PACU. Mean difference between temporal v other sites at preoperative stage, admission to PACU and discharge from	Part of a study comparing FAW to conductive warming system

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
		Sil catheters).	PACU. Bland Altman for oral v temporal and bladder v temporal	

2.10.2 Results: Bland Altman

Figure 1: Bland Altman results for temperature measurement sites compared to core reference sites of pulmonary artery catheter, oesophagus and bladder

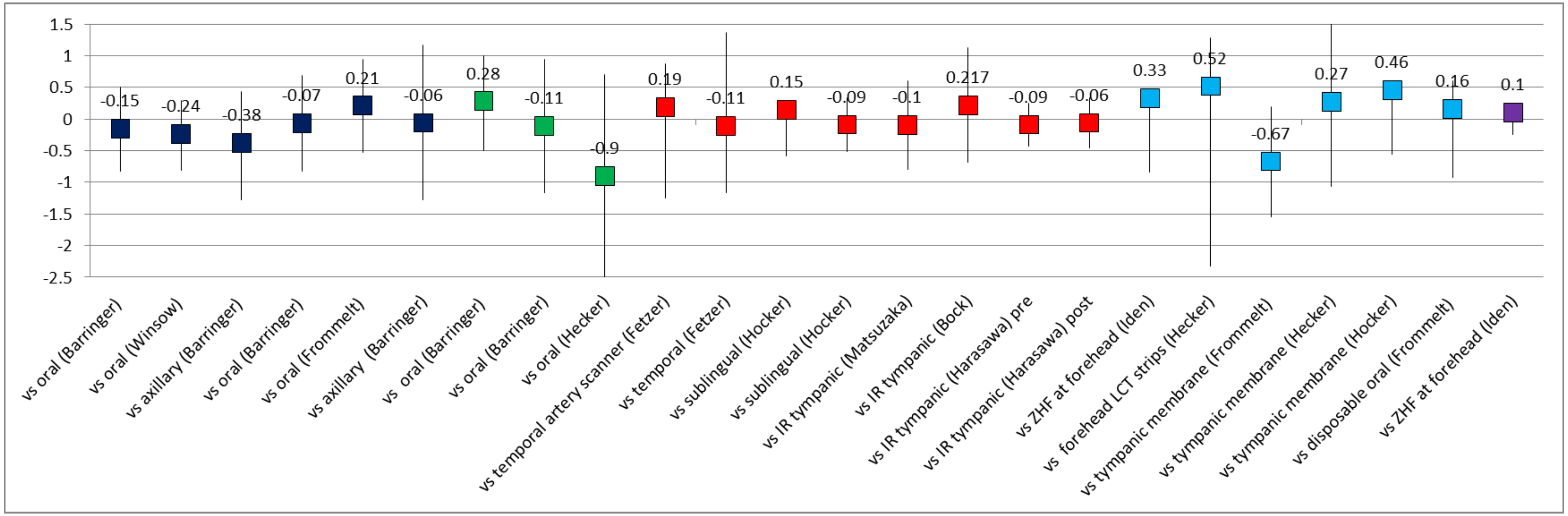


Key to graph: Coloured points represent bias, lines represent 2SD limits of agreement.

Colour code represents different reference mthods of measurement: red= pulmonary artery catheter reference; orange= oesophagus reference method; black= bladder reference method. Numbers indicate bias compared to reference method of temperature measurement. IR= infrared; IRAC= infrared aural canal.

Numbers represent bias for each method of measurement (ºC). A bias of 0.5ºC or less indicates good agreement between temperature measurement methods.

Figure 2: Bland Altman results for temperature measurement sites compared to other reference sites



Key to graph: Coloured points represent bias, lines represent 2SD limits of agreement.

Colour code represents different reference methods ofmeasurement: Dark blue= temporal artery scanner as reference; green= axillary site as reference; red= tympanic membrane as reference; light blue= sublingual site as reference; purple= nasopharyngeal as reference.

Numbers represent bias for each method of measurement (ºC). A bias of 0.5ºC or less indicates good agreement between temperature measurement methods.

2.11 Health economic evidence review

2.11.1 Methods

Evidence of cost effectiveness

The Committee is required to make decisions based on the best available evidence of both clinical and cost effectiveness. Guideline recommendations should be based on the expected costs of the different options in relation to their expected health.

Evidence on cost effectiveness related to the key clinical issues being addressed in the guideline update was sought. The health economist:

- undertook a systematic review of the published economic literature; and
- provided unit costs to assist the committee with their qualitative discussion on the impacts on resource use.

Economic literature search

A systematic literature search was undertaken to identify health economic evidence within published literature relevant to the review questions. The evidence was identified by conducting a broad search relating to devices and sites for measuring temperature in the NHS Economic Evaluation Database (NHS EED) and the Health Technology Assessment database (HTA). The search also included Medline and Embase databases using an economic filter. Studies published in languages other than English were not reviewed. The search was conducted on 10 March 2016. The health economic search strategies are detailed in appendix J.

The health economist also sought out relevant studies identified by the surveillance review or Committee members.

Economic literature review

The health economist:

- Identified potentially relevant studies for each review question from the economic search results by reviewing titles and abstracts. Full papers were then obtained.
- Reviewed full papers against prespecified inclusion and exclusion criteria to identify relevant studies.

Inclusion and Exclusion criteria

Full economic evaluations (studies comparing costs and health consequences of alternative courses of action: cost-utility, cost-effectiveness, cost-benefit and cost-consequence analyses) and comparative costing studies that address the review question in the relevant population were considered potentially includable as economic evidence.

Studies that only reported burden of disease or cost of illness were excluded. Literature reviews, abstracts, posters, letters, editorials, comment articles, unpublished studies and studies not in English were excluded.

For more details about the assessment of applicability and methodological quality see the economic evaluation checklist contained in *Appendix H* of *Developing NICE Guidelines: the manual 2014*.

In the absence of economic evidence

When no relevant economic studies were found from the economic literature review, and de novo modelling was not feasible or prioritised, the Committee made a qualitative judgement about cost-effectiveness by considering expected differences in resource use between options and relevant UK NHS unit costs, alongside the results of the clinical review of effectiveness evidence. The UK NHS costs reported in the guideline were those presented to the Committee and they were correct at the time recommendations were drafted; they may have been revised subsequently by the time of publication. However, we have no reason to believe they have been changed substantially.

2.11.2 Results of the economic literature review

552 papers were identified by the search. 4 full papers were ordered and all were excluded. The flowchart summarising the number of studies included and excluded at each stage of the review process can be found in appendix K. Appendix L contains a list of excluded studies and the reason for their exclusion.

2.11.3 Unit costs

The unit costs related to this review question are contained in Table 16.

1 Table 16: Unit costs of temperature measurement devices

Type	Brand	Item	Cost per pack	Pack type	Units per pack	Cost per unit	Patient Temperature Management Framework	Source
General purpose	GE Healthcare	Temperature thermometer long for dinamap turbo long	159.16	Each	1	159.16	Yes	NHS Supply Chain
General purpose	Vital Signs	Reusable temperature probe	104.08	Each	1	104.08	Yes	NHS Supply Chain
General purpose	Level 1	Myocardial temp sensor 30mm long 22g	448.55	Case	20	22.43	Yes	NHS Supply Chain
General purpose	Level 1	Myocardial temperature sensor 8mm long 22g	448.55	Box	20	22.43	Yes	NHS Supply Chain
General purpose	3M	Spot on temperature sensor	223.82	Box	25	8.95	Yes	NHS Supply Chain
General purpose	Omron	Thermometer electronic device Flexible tip pen style thermometer with a fast 10 second rectal measurement				6.43	No	NHS Supply Chain
General purpose	Omron	Thermometer electronic device Rigid tip pen style thermometer with a fast 10 second rectal measurement				5.51	No	NHS Supply Chain
General purpose	MSR	Thermometer electronic device Electronic thermometer ECO Digital with flexible tip and 10 second measurement time				4.95	No	NHS Supply Chain
General purpose	Mon-a-Therm	Temperature probe general purpose 9ch packed clean	186.1	Box	50	3.72	Yes	NHS Supply Chain
General purpose	Temprecise	Temperature Probe general purpose 9fr 400 Series +/- 0.1c	185.89	Box	50	3.72	Yes	NHS Supply Chain
General purpose	MSR	Thermometer electronic device Digital childrens thermometer with flexible tip				3.58	No	NHS Supply Chain
General purpose	P3 Medical	Temperature probe general purpose 12fr	174.11	Box	50	3.48	Yes	NHS Supply Chain
General purpose	Deroyal industeries inc	General purpose probe 9fr soft	155.95	Case	50	3.12	Yes	NHS Supply Chain
General purpose	Deroyal industeries inc	General purpose probe 9 fr 400 series	155.95	Case	50	3.12	Yes	NHS Supply Chain
General purpose	Deroyal industeries inc	General purpose probe 12 fr 400 series	155.95	Case	50	3.12	Yes	NHS Supply Chain
General purpose	Deroyal industeries inc	General purpose probe 12 fr400 series single use sterile	155.95	Case	50	3.12	Yes	NHS Supply Chain
General purpose	MSR	Thermometer electronic device Digital thermometer with flexible tip and 10 second measurement time				2.98	No	NHS Supply Chain
General purpose	Timesco Rapid	Thermometer electronic device Flexible thermometer with a fast measurement. Reading display in Celsius				2.51	No	NHS Supply Chain
General purpose	MSR	Thermometer electronic device Electronic thermometer with flexible tip				2.4	No	NHS Supply Chain
General purpose	Level 1	General purpose probe 12fr	42.95	Case	20	2.15	Yes	NHS Supply Chain
General purpose	Level 1	General purpose probe - 9fr	42.85	Case	20	2.14	Yes	NHS Supply Chain
General purpose	MSR	Thermometer electronic device Electronic thermometer with rigid tip				1.91	No	NHS Supply Chain
General purpose	MSR	Thermometer electronic device Electronic thermometer with rigid tip				1.91	No	NHS Supply Chain
General purpose	Bridge (STERILE)	Temperature probe general purpose 9fr	91.76	Box	50	1.84	Yes	NHS Supply Chain
General purpose	Bridge (STERILE)	Temperature probe general purpose 12fr	91.76	Box	50	1.84	Yes	NHS Supply Chain
General purpose	GE Healthcare	Temperature probe general purpose disposable adult 12 fr	38.5	Box	25	1.54	Yes	NHS Supply Chain

Type	Brand	Item	Cost per pack	Pack type	Units per pack	Cost per unit	Patient Temperature Management Framework	Source
General purpose	GE Healthcare	Temperature probe general purpose disposable pediatric 9 fr	38.5	Box	25	1.54	Yes	NHS Supply Chain
General purpose	Clinitrend	Moving line temperature monitor	99.57	Box	100	1.00	Yes	NHS Supply Chain
General purpose	Omron	Thermometer Single Use Cover for Digital Device For digital thermometers - for use with thermometer FWH037				0.02	No	NHS Supply Chain
Infrared	Timesco	Thermometer temporal artery device Non contact infrared for hospital use reusable non invasive Thermofinder FS-700				49.2	No	NHS Supply Chain
Infrared	Rycom	Thermometer temporal artery device Infrared forehead thermometer non contact with carry case and batteries				28.7	No	NHS Supply Chain
Infrared	Bokang/Proact	Thermometer temporal artery device Non contact infrared for hospital use reusable non invasive				22.7	No	NHS Supply Chain
Nasopharyngeal	Deroyal industeries inc	Nasopharyngeal temperat probe 18 fr 1 inch tube twisted cord	155.95	Case	50	3.12	Yes	NHS Supply Chain
Nasopharyngeal	Deroyal industeries inc	Nasopharyngeal temperat probe 9 fr 1 inch tube flat cord	155.95	Case	50	3.12	Yes	NHS Supply Chain
Nasopharyngeal	Vital Signs	Nasal temerpature probe	84.57	Box	50	1.69	Yes	NHS Supply Chain
Oesophageal	GE Healthcare	Oesophageal stethoscope probe temperature re-useable rectal/oesophageal adult 14 fr (4.7 mm) 400 series	102.78	Each	1	102.78	Yes	NHS Supply Chain
Oesophageal	Mon-a-Therm	Oesophageal probe stethoscope with temperature sensor 9ch packed clean	174.3	Box	25	6.97	Yes	NHS Supply Chain
Oesophageal	Mon-a-Therm	Oesophageal probe stethoscope with temperature sensor 12ch packed clean	174.3	Box	25	6.97	Yes	NHS Supply Chain
Oesophageal	P3 Medical	Oesophageal probe stethoscope with temperature sensor 12fr	132.48	Box	25	5.30	Yes	NHS Supply Chain
Oesophageal	P3 Medical	Oesophageal probe stethoscope with temperature sensor 18fr	132.48	Box	25	5.30	Yes	NHS Supply Chain
Oesophageal	P3 Medical	Oesophageal probe stethoscope with temperature sensor 9fr	132.48	Box	50	2.65	Yes	NHS Supply Chain
Oesophageal	Level 1	Oesophageal stethoscope - 24fr	50.88	Case	20	2.54	Yes	NHS Supply Chain
Oesophageal	Level 1	Oesophageal stethoscope - 18fr	50.88	Case	20	2.54	Yes	NHS Supply Chain
Oesophageal	Level 1	Oesophageal stethoscope 12f	50.88	Case	20	2.54	Yes	NHS Supply Chain
Oesophageal	Level 1	Oesophageal stethoscope 24f	50.88	Case	20	2.54	Yes	NHS Supply Chain
Oesophageal	Level 1	Oesophageal stethoscope 18f	50.88	Case	20	2.54	Yes	NHS Supply Chain
Oesophageal	Level 1	Oesophageal stethoscope 24fr	50.53	Case	20	2.53	Yes	NHS Supply Chain
Oesophageal	Level 1	Oesophageal stethoscope - 9fr	42.85	Case	20	2.14	Yes	NHS Supply Chain
Oesophageal	GE Healthcare	Oesophageal stethoscope with temperature probe disposable 18 fr	52.29	Box	25	2.09	Yes	NHS Supply Chain
Oesophageal	GE Healthcare	Oesophageal stethoscope with temperature probe disposable 24 fr	52.29	Box	25	2.09	Yes	NHS Supply Chain
Oesophageal	Vital Signs	Oesphageal temp probe	101.48	Box	50	2.03	Yes	NHS Supply Chain
Oesophageal	Vital Signs	Oesphageal temp probe	101.48	Box	50	2.03	Yes	NHS Supply Chain
Oesophageal	GE Healthcare	Oesophageal stethoscope with temperature probe disposable 9 fr	50.53	Box	25	2.02	Yes	NHS Supply Chain

Type	Brand	Item	Cost per pack	Pack type	Units per pack	Cost per unit	Patient Temperature Management Framework	Source
Oesophageal	GE Healthcare	Oesophageal stethoscope with temperature probe disposable 12 fr	50.53	Box	25	2.02	Yes	NHS Supply Chain
Oesophageal	Vital Signs	12fr 400 series oesphageal stethoscope temperature probe	98.53	Box	50	1.97	Yes	NHS Supply Chain
Oesophageal	Vital Signs	9fr 400 series oesphageal stethoscope temperature probe	98.53	Box	50	1.97	Yes	NHS Supply Chain
Oral	Welch Allyn Suretemp Plus 690	Thermometer electronic device Electronic thermometer wall mount alarm 9ft cable oral probe				250.26	No	NHS Supply Chain
Oral	Welch Allyn Suretemp Plus 692	Thermometer electronic device Electronic thermometer wall mount alarm 4ft cable oral probe				207.53	No	NHS Supply Chain
Oral	Covidien FILAC 3000 AD	Thermometer electronic device Electronic thermometer for oral or axillary measurement with probe				192.27	No	NHS Supply Chain
Oral	Welch Allyn Suretemp Plus 692	Thermometer electronic device Electronic thermometer with oral probe				189.22	No	NHS Supply Chain
Oral	Covidien FILAC 3000 EZA	Thermometer electronic device Electronic oral thermometer with probe				183.11	No	NHS Supply Chain
Oral	Welch Allyn	Thermometer electronic device Oral temperature probe & well kit 9 ft cablefor the suretemp plus for the vsm 300 & spot lxi				76.91	No	NHS Supply Chain
Oral	Welch Allyn	Thermometer electronic device Oral/axillary probe well blue for the suretemp plus 690/692				18.31	No	NHS Supply Chain
Oral	Welch Allyn	Thermometer electronic device Oral temperature probe well (blue)				18.31	No	NHS Supply Chain
Oral	Omron	Thermometer electronic device Rigid style mini thermometer with a unique flat tip and large display for oral or axillary use				12.86	No	NHS Supply Chain
Oral	Omron	Thermometer electronic device Rigid style mini thermometer with a unique flat tip and large display for oral axillary or rectal use				8.57	No	NHS Supply Chain
Rectal	Welch Allyn Suretemp Plus 690	Thermometer electronic device Electronic thermometer wall mount 4 ft cable rectal probe				207.53	No	NHS Supply Chain
Rectal	Covidien FILAC 3000 EZA	Thermometer electronic device Electronic rectal thermometer with probe				183.11	No	NHS Supply Chain
Rectal	GE Healthcare	Temperature thermometer long rctal for dinamap turbo long rectal	159.16	Each	1	159.16	Yes	NHS Supply Chain
Rectal	Welch Allyn	Thermometer electronic device Temperature probe and well kit 4 ft cable rectal probe for the suretemp plus 690/692				76.91	No	NHS Supply Chain
Rectal	Deroyal industeries inc	General rectal temp probe 12fr soft with graduations	155.95	Case	50	3.12	Yes	NHS Supply Chain
Skin	GE Healthcare	Skin temperature probe re-useable adult/paediatric 9.5 mm diam. disk 400 series	104.08	Each	1	104.08	Yes	NHS Supply Chain

Type	Brand	Item	Cost per pack	Pack type	Units per pack	Cost per unit	Patient Temperature Management Framework	Source
Skin	Mon-a-Therm	Skin temperature probe sensor packed sterile	186.18	Box	50	3.72	Yes	NHS Supply Chain
Skin	P3 Medical	Skin - adult	162.64	Box	50	3.25	Yes	NHS Supply Chain
Skin	Deroyal industeries inc	Skin temperature probe	159.84	Case	50	3.20	Yes	NHS Supply Chain
Skin	Deroyal industeries inc	Single use sterile skin temperature probe	159.84	Case	50	3.20	Yes	NHS Supply Chain
Skin	Bridge (STERILE)	Skin temperature probe - paediatric	73.26	Box	25	2.93	Yes	NHS Supply Chain
Skin	Bridge (STERILE)	Skin temperature probe - infant	73.26	Box	25	2.93	Yes	NHS Supply Chain
Skin	Bridge (STERILE)	Skin temperature probe - adult	73.26	Box	25	2.93	Yes	NHS Supply Chain
Skin	Level 1	Temperature Probes and Sensors Skin temperature sensor - thermistor (400 series)				2.1	No	NHS Supply Chain
Skin	Level 1	Skin temperature sensor - thermistor (400 series)	41.94	Case	20	2.10	Yes	NHS Supply Chain
Skin	GE Healthcare	Skin temperature probe disposable skin	49.8	Box	25	1.99	Yes	NHS Supply Chain
Tympanic	Level 1	Adult tympanic sensor	108.63	Case	20	5.43	Yes	NHS Supply Chain
Tympanic	Level 1	Paediatric tympanic temp sensor	108.45	Case	20	5.42	Yes	NHS Supply Chain
Tympanic	ArcRoyal	Single use non-sterile tympanic temperature probe 400 series adult	257.51	Box	50	5.15	Yes	NHS Supply Chain
Tympanic	Deroyal industeries inc	Tympanic probe with foam ear plug single use non-sterile	223.16	Case	50	4.46	Yes	NHS Supply Chain
Tympanic	Deroyal industeries inc	Tympanic probe with foam ear plug	223.16	Case	50	4.46	Yes	NHS Supply Chain
Tympanic	Mon-a-Therm	Temperature probe general purpose 12ch packed clean	205.44	Box	50	4.11	Yes	NHS Supply Chain
Tympanic	Deroyal industeries inc	Tympanic probe without foam ear plug	205.24	Case	50	4.10	Yes	NHS Supply Chain
Tympanic	Vital Signs	Tympanic temperature probes	52.04	Box	25	2.08	Yes	NHS Supply Chain
Tympanic	Vital Signs	Probe temp tympanic adult 400 series	50.53	Box	25	2.02	Yes	NHS Supply Chain

2.12 Evidence statements

2.12.1 Clinical evidence statements

Bland Altman analysis: pre-operative phase

Axiliary temperature measured underestimated core temperature (measured using temporal artery scanner) in one study with 86 participants. There were conflicting results for oral temperature measurement as two studies (150 participants) showed an underestimation and a third study (86 participants) showed an overestimation. The certainty in each of these findings was moderate.

Temporal artery temperature measurement underestimated core temperature (measured using tympanic membrane) in two studies with 393 participants. The certainty in these findings from the individual studies was very low and moderate,

Mean difference data: pre-operative phase

One study with 60 people found that tympanic temperature measurement showed higher core temperature compared to oral site within 30 minutes of transport to operating room. The certainty in the finding was very low.

Bland Altman analysis: intraoperative phase

IR tympanic membrane temperature measurement overestimated core temperature measurement (measured using pulmonary artery catheter) in one study with 26 participants. The certainty in these findings was low.

IR tympanic membrane temperature measurement was assessed by 3 studies and indicated that temperature ranged from underestimation to overestimation compared to core temperature (using a tympanic thermocouple device). One study assessing sublingual temperature measurement to core temperature measurement (using tympanic thermocouple) indicated that there was an underestimation of temperature measurement. Certainty in the evidence was low and moderate.

Oral temperature measurement overestimated core temperature (measured using oesophageal site) in one study with 23 participants. The certainty in the evidence was moderate. IR temporal artery, IR tympanic membrane and rectal temperature measurements also overestimated core temperature (measured using oesophageal site). The certainty in the evidence ranged from low to high.

Zero Heat Flux (forehead) temperature measurement indicated an underestimation compared to core temperature (using sublingual temperature) in one study with 83 participants. The certainty in the evidence was moderate.

Zero Heat Flux (forehead) temperature measurement indicated an overestimation compared to core temperature (nasopharyngeal) in one study with 83 participants. The certainty in the evidence was high,

Mean difference data: intraoperative phase

Oral v compared to tympanic:

Low quality evidence from one study with 60 people identified that IR tympanic site of temperature may be higher compared to oral site. The certainty in the finding was low.

Tympanic probe v compared to IR tympanic:

Low quality evidence from one study with 56 people identified that there may be no difference between tympanic probe and IR tympanic temperature measurement in people receiving forced air warming and people receiving resistive heating. The certainty in the finding was low.

Rectal v compared to tympanic:

Low quality evidence from one study with 60 people identified that temperatures may be higher when measured at a rectal site than with IR tympanic site at first and final intraoperative measurements. The certainty in the finding was low.

Pulmonary artery catheter (PAC) compared to other site:

Two studies with 275 people suggested that there may be no difference between temperature at PAC and rectal sites. The certainty in the findings was moderate.

Forehead: Two studies with 146 people suggested that there is no difference between forehead temperature (measured with Zero Heat Flux or deep forehead CoreTemp) and PAC. The certainty in the findings was moderate.

One study with 105 people suggested that there might be no difference in temperature between ZHF neck and PAC sites. The certainty in the findings was moderate.

One study with 234 people suggested that there might be no difference between temperature measured by IR tympanic and PAC. The certainty in the findings was moderate,

Three studies with 79 people suggested that there might be no difference between temperature measured oesophageally and by PAC . The certainty in the findings was moderate. One study with 18 people suggested that there might be no difference between temperature measured at the axilla and PAC. The certainty in the findings was low.

One study with 105 people suggested that temperature measured by PAC is higher than skin surface temperature. The certainty in the findings was low.

One study with 20 people suggested that there might be no difference between temperature measured at bladder and PAC. The certainty in the findings was very low.

Oesophageal compared to nasopharynx:

One study with 43 people identified that there may be no difference between nasopharyngeal and oesophageal site of temperature measurement. The certainty in the findings was moderate,

Forehead compared to neck:

One study with 105 people suggested that there might be no difference between ZHF measurement at forehead or neck. The certainty in the findings was high.

Bland Altman analysis: post-operative phase

Oral temperature measurement overestimated core temperature (measured using oesophageal site) in one study with 23 participants. The certainty in the evidence was moderate. IR temporal artery, IR tympanic membrane and rectal temperature measurements also overestimated core temperature (measured using oesophageal site). The certainty in the evidence ranged from low to high.

Oral temperature underestimated core temperature (temporal artery) in one study and overestimated core temperature (temporal artery) in another study (170 participants in total). The certainty in the findings was low.

Axillary temperature measurement underestimated core temperature (temporal artery) on one study with 86 people. The certainty in the findings was low.

Oral temperature measurement underestimated core temperature (measured at axillary site) in one study with 291 participants. The certainty in the findings was very low.)

Temporal artery temperature indicated an underestimation compared to core temperature (measured at tympanic membrane site) in one study with 222 people. The certainty in the findings was very low.

Tympanic membrane temperature measurement underestimated (two studies) core temperature (measured at oral site) and one study overestimated core temperature (measured at oral site). The certainty in the findings was very low.

Disposable oral thermometers underestimated core temperature (measured at oral site). The certainty in the findings was low.

Forehead LCT strips temperature underestimated core temperature (oral site) in one study with 205 participants. The certainty in the finding was very low.

Electric oral temperature underestimated core temperature (bladder) in one study with 50 people. The certainty in the finding was low.

Deep forehead temperature underestimated core temperature (bladder) in one study with 50 participants. The certainty in the finding was moderate.

Temporal artery scanner temperature underestimated core temperature (bladder) in one study with 50 people. The certainty in the findings was low.

Electronic axilla temperature measurement underestimated core temperature (bladder) in one study with 50 people. The certainty in the findings was moderate.

Deep chest temperature measurement underestimated core temperature (bladder) in one study in 50 people. The certainty in the evidence was moderate.

Thermocouple forehead + twoºC correction temperature measurement underestimated core temperature (bladder) in one study with 50 people. The certainty in the findings was low.

Infrared aural canal (IRAC) (right ear) temperature underestimated core temperature (bladder) in one study with 50 people. The certainty in the findings was moderate,

IRAC (left ear) temperature measurement underestimated core temperature (bladder) in one study with 50 people. The certainty in the findings was moderate.

Thermocouple forehead temperature measurement underestimated core temperature (bladder) in one study with 50 people. The certainty in the finding was high.

Oesophageal temperature measurement underestimated core temperature (bladder) in one study with 50 people. The certainty in the findings was moderate.

IRAC in right vs left ear indicated an overestimation in one study with 50 people. The certainty in the findings was low.

Mean difference data: post-operative

One study with 105 people suggested that there may be no difference between ZHF measurement at forehead or neck. The certainty in the findings was high.

PAC compared to other site:

One study with 20 people indicated that there was no difference in temperature when measured by PAC and bladder. The certainty in the findings was moderate.

One study with 20 people indicated that temperature might be higher when measured by PAC compared to temperature measured at the oesophagus. The certainty in the findings was low.

One study with 18 people indicated that there might be no difference between PAC and electronic axillary temperatures or axillary temperature measured by mercury thermometer. The certainty in the findings was very low.

One study with 18 people indicated that there might be no difference between PAC and rectal temperature measured with a mercury thermometer. The certainty in the findings was low.

One study with 105 people indicated that there might be no difference between temperatures measured by PAC compared to forehead (ZHF). The certainty in the findings was low.

One study with 105 people indicated that there was no difference between temperatures measured using a PAC and ZHF placed at the neck. The certainty in the findings was low.One study with 105 people indicated that temperature measured using a PAC is higher than temperature measured at the skin surface (forehead). The certainty in the findings was very low.

Tympanic compared to other site:

One study with 32 people indicated that there was no difference between tympanic and forehead temperature measured with an Omni thermometer in people undergoing general or spinal anaesthetic. The certainty in the findings was moderate.

One study with 32 people indicated that there was no difference between tympanic and rectal temperature in people undergoing general or spinal anaesthetic. The certainty in the findings was moderate.

One study with 32 people indicated that tympanic temperature was higher than axillary temperature in people undergoing both general and spinal anaesthetic. The certainty in the findings was moderate.

One study with 32 people indicated that tympanic temperature might be higher than IR Temporal temperature in people undergoing both general and spinal anaesthesia. The certainty in the findings was low.

One study with 60 people indicated that tympanic temperature is higher than oral temperature at entry to PACU and exit from PACU. The certainty in the findings was low.

Forehead compared to neck ZHF:

One study with 105 people indicated that there was no difference between temperatures measured at the forehead. The certainty in the evidence was moderate.

2.12.2 Health economic evidence statements

No health economic studies were included

2.13 Evidence to recommendations

	Committee discussions
Relative value of different outcomes	For question 3, the most accurate site of temperature measurement, the committee discussed and decided that the Bland Altman data should be the principal driver of decision making; this is because it identifies the bias between measurements (unlike mean difference data which just identifies the difference between two measurements). Mean difference data was also taken into account for decision making, though to a lesser extent than Bland Altman data. No data on adverse events on different sites of measurement was identified.
Quality of evidence	. The quality of the evidence ranged from high to very low. The committee discussed the limitations of the evidence. 14 studies out of the 24 included in the review reported Bland Altman statistics; the remainder only reported mean difference data. The studies included in the review reported at multiple time points throughout the perioperative period, and there was variation in the way that each study reported their data (e.g. mean of repeated measurements, one measurement only at start and end of surgery amongst others). The committee highlighted that for most comparisons, only one study contributed towards the evidence base, and this introduces uncertainty into the evidence. The studies included in this review included the following sites and devices as reference methods of core temperature measurement: Axilla, bladder, nasopharyngeal, oesophagus, pulmonary artery catheter (PAC), sublingual, temporal artery scanner and tympanic membrane. The committee asked the topic experts which of these sites are considered “true” core temperature; the topic experts identified PAC, oesophagus and bladder as being the gold standard site of core temperature measurement for accurate assessment of temperature and identification of IPH. Therefore, the committee focussed on studies including comparisons using these three reference sites to form the basis of their decision making. The studies included different classes of temperature measurement device at each site. Within each class of device there were multiple manufacturers of the devices. This has implications for clinical practice as each device (within the same class) may operate differently: The topic experts highlighted that for infrared tympanic measurement, there is a correction factor for the device, in order that the measurement is as close as possible to the true core temperature. This correction factor can differ between devices and can also vary at different temperatures. This was considered by the committee to be of critical importance when considering the evidence. Overall, there is an incomplete picture of evidence; not all interventions were compared to each other across the different time points, different interventions were compared to multiple reference standards, and there is uncertainty around the correction factors used by manufacturers of different devices.
Trade-off between	

	Committee discussions
benefits and harms	The committee discussed the trade- off between using an invasive method of temperature monitoring to obtain the most accurate temperature measurement, thus ensuring adequate temperature monitoring and prevention/ minimising risk of of IPH and adverse effects associated with hypothermia, balanced against the fact that invasive core temperature monitoring is not appropriate for every person undergoing surgery. The need for accurate temperature measurement must be balanced against the most appropriate site of measurement for the individual patient. The topic experts identified that pulmonary artery catheter; oesophageal and bladder are considered the most accurate sites for core temperature measurement. However, pulmonary artery catheter temperature is not routinely used outside of cardiac surgery, and it is not always possible or appropriate to use other invasive sites of temperature measurement (for example, bladder may not be appropriate unless the person is routinely catheterised due to the risk of urinary sepsis). In people undergoing surgery, it is essential that an accurate core temperature reading is obtained even if the person cannot have invasive core temperature monitoring. In cases where invasive core temperature monitoring is not appropriate, the committee noted that an indirect method of core temperature measurement that is accurate to 0.5ºC of true core temperature should be used.
Trade-off between net health benefits and resource use	The committee considered the unit costs of temperature measurement devices and associated consumables. It was difficult to establish an accurate cost per use to compare the alternative methods of measurement because of the wide variety of costs offered by a wide variety of manufacturers. Because the devices are generally as accurate as each other, the cheapest option should usually be used.
Other considerations	When undertaking any method of core temperature measurement, whether direct or indirect, it should be ensured that the people using the equipment are adequately trained and follow the manufacturer’s guidelines.

2.14 Recommendations

4. Measure the patient's core temperature directly, using 1 of the following sites and basing the choice of site on its suitability for the patient, the type of surgery and the anaesthetic:

- **bladder.**
- **oesophagus**
- **pulmonary artery catheter [new 2016]**

5. If direct core temperature measurement is not suitable, assess core temperature indirectly, using a site or device that produces a measurement accurate to within 0.5ºC of the true core temperature. At the time of consultation these are:

- **deep forehead**
- **infrared temporal**

- **infrared tympanic**
- **rectal**
- **sublingual**
- **thermocouple forehead with a +2ºC correction factor. [new 2016]**

6. Do not use any site or device to indirectly assess core temperature in adults having surgery that has not been shown in research studies to produce a measurement accurate to within 0.5ºC of true core temperature. [new 2016]

3 References

3.1 Review question 1: Intraoperative active warming

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4 Glossary and abbreviations

Please refer to the NICE glossary.

Active warming: A process that transfers heat to the patient.

Circulating water mattress: An active patient warming device which conducts heat to the front and/or back of the body.

Electric warming mattress: An active patient warming device placed underneath the patient delivering warming at a low voltage (24V). A control unit is used to maintain the mattresses at the user-selected temperature. Surfaces are anti-static, latex-free polyurethane with fully welded seams.

Forced air warming: A temperature management unit where heated air is used to warm patients through convection. The warming unit draws ambient air through a filter and warms the air to a specified temperature. The warmed air is delivered through a hose to a blanket or gown.

Hyperthermia: An acute condition which occurs when the body produces or absorbs more heat than it can dissipate.

Hypothermia: For the purpose of this guideline, hypothermia is defined as a core temperature less than 36.0°C (96.8°F). Severity of hypothermia was defined as follows: mild hypothermia: core temperature 35.0°C to 35.9°C; moderate: 34.0°C to 34.9°C severe: ≤ 33.9°C.

Intraoperative phase: Defined as the period from time of anaesthetic intervention to entry into the operating room.

Normothermia: For the purpose of this guideline, normothermia is defined as a core temperature range of 36.5°C to 37.5°C.

Postoperative phase: 24 hours postoperatively, commencing from transfer to the recovery room and including the clinical area (e.g. ward, ICU)

Preoperative phase: Defined as the period from the time of preparation for surgery/administration of premedication to the time of first anaesthetic intervention.

Radiant warming: Electrically powered devices that are intended to assist in the maintenance of the thermal balance, principally by controlling the air temperature and humidity in an enclosure.

Resistive heating: The generation of heat by electric conductors carrying current.

Thermoregulation: The processes of heating and cooling that an organism uses to control its temperature

Thermoregulatory mechanisms: the anatomical system that controls the body temperature

Appendices

Appendix A: Standing Committee members and NICE teams

A.1 Core members

Name	Role
Susan Bewley	Chair
Gita Bhutani	Associate Director for Psychological Professions
Rachel Churchill	Chair in Evidence Synthesis
Simon Corbett	Cardiologist
John Graham	Vice Chair (Oncologist)
Nathan Griffiths	Consultant Nurse - Paediatric Emergency and Ambulatory Medicine
Gail Fortes Mayer	Commissioner
Manoj Mistry	Lay member
Mark Rodgers	Research Fellow - methodologist
Sietse Wieringa	General Practitioner

A.2 Topic expert Committee members

Name	Role
John Andrzejowski	Consultant Anaesthetist
Mark Harper	Consultant Anaesthetist
Mike Reed	Consultant Trauma and Orthopaedic Surgeon
Judith Tanner	Professor of Adult Nursing
Madeleine Wang	Lay member

A.3 NICE project team

Name	Role
Jeremy Wight	Clinical Adviser
Jessica Fielding	Public Involvement Adviser
Rupert Franklin	Guideline Commissioning Manager
Judy McBride	Senior Medical Editor
Bhash Naidoo	Technical Lead (Health Economics)
Sharon Summers-Ma	Guideline Lead
Nichole Taske	Technical Lead
Trudie Willingham	Guideline Co-ordinator

A.4 Clinical guidelines update team

Name	Role
Martin Allaby	Clinical Adviser
Emma Banks	Co-ordinator
Lee Berry	Project Manager
Sara Buckner	Technical Analyst
Emma Carter	Administrator
Paul Crosland	Health Economist
Jemma Deane	Information Specialist
Nicole Elliott	Associate Director (from July 2016)
Hugh McGuire	Technical Adviser
Susannah Moon	Programme Manager
Lorraine Taylor	Associate Director (until July 2016)

Appendix B: Declarations of interest

The standing committee and topic experts interests have been declared and collated and are available here.

Appendix C: Review protocol

C.1 Review question 1: Devices - intraoperative

Are warming devices/mechanisms effective in preventing perioperative inadvertent hypothermia in adults in the different phases of perioperative care, specifically comparing classes of active warming device?

Review Protocol	
Components	**Details**
Review question	Are warming devices/mechanisms effective in preventing perioperative inadvertent hypothermia in adults in the different phases of perioperative care, specifically comparing classes of active warming device?
Background/ objectives	The warming devices question was included in CG65 and is being updated to consider new evidence identified during the surveillance process relating to different types of active warming devices. The addition of the temperature monitoring for overheating was added following discussion with topic experts in this area. It was considered that this would be clinically useful as monitoring every 30 minutes in the first hour after induction of anaesthesia may not be current clinical practice and recommendations on this would be useful. Topic experts considered that monitoring of temperature every 30 minutes during the first hour of surgery, where warming devices are being used, may be unnecessary, as few patients are over 37.5ºC in the first hour.
Types of study to be included	<u>Include:</u> RCTs, systematic reviews/meta-analyses of RCTs <u>Exclude:</u> Any non-RCT study type
Language	English only
Status	Published articles, from 2006 onwards
Population	Adults undergoing surgery (except obstetrics and where hypothermia is induced for medical reasons). These exclusions are to ensure consistency with the original guideline parameters.
Intervention	• Active warming mechanisms, including but not limited to; - Forced air warming - Electric blanket - Radiant heater - Water mattress - Heating gel pads - Resistive heating blankets - Resistive heating mattress - Combinations of the above warming mechanisms

	In committee meeting 1, the committee decided to focus their deliberations on forced air warming and resistive heating as both of these methods are used in clincial practice in England and Wales, whereas the other active warming methods are no longer routinely used. As the review had been completed this post-hoc decision had no impact on study inclusion or exclusion.
Comparator	• Other warming devices/mechanisms • Usual care (may be included as a comparator for the network meta-analysis if there is sufficient data available to undertake the network) At committee meeting 1, the committee agreed that there were insufficient data reported on the outcome of interest (number of people with hypothermia) and that, while additional data on the number of people with hypothermia could be imputed from the mean core temparture, the small sample size of the majority of the included studies made this unreliable.
Outcomes	• Core temperature at the end of surgery • Temperature monitoring following induction of anaesthesia • Shivering/patient experience • Adverse effects of warming methods • Cardiac events • Surgical site infection • Pain • Increased blood loss, transfusion requirement • Longer time in recovery • Delayed healing • Longer hospital stay
Any other information or criteria for inclusion/exclusion	We will exclude studies that have not been carried out in countries similar to the UK in terms of access to the warming methods and procedures. The Committee will be sent the list of included and excluded studies prior to the Committee meeting, and the Committee will be requested to cross check whether any studies have been excluded inappropriately, and whether there are any relevant studies they have known of which haven't been picked up by the searches.
Analysis of subgroups or subsets	Site of operation, duration of operation Temperature monitoring following induction of anaesthesia
Data extraction and quality assessment	Sifting • Full double sifting will not be conducted due to the nature of this review question (straight-forward RCT intervention review). However in cases of uncertainty the technical analyst will discuss with a support technical analyst.

	Data extraction: • Information from included studies will be extracted into standardised evidence tables. Critical appraisal. • The following checklists will be used to assess the quality of each included study / systematic review o NICE RCT checklist. o NICE systematic reviews and meta-analyses checklist Quality assessment: • GRADE methodology will be used to assess the quality of evidence for each outcome as follows; o Risk of bias will be assessed using critical appraisal checklist o Inconsistency will be assessed using I^2 o Indirectness will be assessed using population, intervention and outcomes o Imprecision will be assessed using whether the Confidence intervals around point estimates cross the MIDs for each outcome. Reliability of quality assessment: • A full double-scoring quality assessment will not be conducted due to the nature of the review question (direct comparison intervention review) and the studies that are likely to be included (RCTs). Other quality assurance mechanisms will be in place as the following: o Internal QA by CGUT technical adviser on the quality assessment that is being conducted. o The Committee will be sent the evidence synthesis prior to the Committee meeting and the Committee will be requested to comment on the quality assessment, which will serve as another QA function.
Strategy for data synthesis	Where there is sufficient data a network meta-analysis for the core temperature outcomes will be undertaken, direct comparison meta-analysis will be used for the other outcomes where there is sufficient data. A fixed effects model will be used as it is expected that the studies will be homogenous in terms of population and we can assume a similar effect size across studies. A random effects model will be used as a sensitivity analysis if this assumption is not correct. COMET and published literature will be checked for appropriate minimal important differences (MID) for each outcome and if none are available Topic experts will be asked to provide MID's.

	STATA, R or RevMan will be used for all analyses and the results will be presented in GRADE profile, forest plot and summary evidence statement formats
Searches	• **Sources to be searched** o Clinical searches - Medline, Medline in Process, Embase, Cochrane CDSR, CENTRAL, DARE (legacy records), HTA and PubMed. o Economic searches - Medline, Medline in Process, Embase, PubMed, NHS EED (legacy records) and HTA, with economic evaluations and quality of life filters applied. • **Supplementary search techniques** o None identified • **Limits** o Studies reported in English o Study design – the RCT and SR filter will be applied o Animal studies will be excluded from the search results o Conference abstracts will be excluded from the search results in Embase o A 2006-Current date limit will be applied

C.2 Review question 2: Devices - preoperative

Review question:

Do active warming devices/ mechanisms delivered in the pre-operative phase, prevent inadvertent perioperative hypothermia in adults

Review protocol

Review Protocol	
Components	**Details**
Review question	Do active warming devices/ mechanisms delivered in the pre-operative phase, prevent inadvertent perioperative hypothermia in adults?
Background/ objectives	This question was included in CG65 and is being updated to consider new evidence identified during the surveillance process. GC feedback during the surveillance process and committee meeting 1 also indicated the clinical need for examining the effectiveness of active warming in the pre-operative phase in reducing the incidence of IPH.
Types of study to	Include:

be included	RCTs, systematic reviews/meta-analyses of RCTs Exclude: Any non-RCT study type
Language	English only
Status	Published articles, from 2006 onwards
Population	Adults undergoing surgery (excluding obstetrics and where hypothermia is induced for medical reasons). These exclusions are to ensure consistency with the original guideline parameters.
Intervention	• Active warming mechanisms, initiated up to 60 minutes prior to induction of anaesthesia limited to; - Forced air warming - Resistive heating blankets - Resistive heating mattress - Active self-warming/ heating blanket - Combinations of the above warming mechanisms The interventions have been limited to those listed above as these are the interventions currently in use and commonly available within the NHS. It was considered that the duration of preoperative warming should be at least 30 minutes; if the duration of warming is less than 30 minutes the evidence will be downgraded for indirectness.
Comparator	• Passive warming/ insulation (e.g. warmed cotton blankets, insulation covers) • Do nothing • Usual care
Outcomes	• Core temperature at the end of surgery o Where available, the last core temperature measurement in the operating room will be used. Where this is not available the first postoperative measurement will be used and the evidence will be downgraded for risk of bias (measurement bias). • Temperature from up to 60 minutes before induction of anaesthesia (based on definition of pre-operative of 60 minutes before induction of anaesthesia) o This will be extracted for multiple time points from 60 minutes before induction of anaesthesia and up to 120 minutes/ 2 hours after induction where reported, to identify whether there is a need to measure core temperature every 30 minutes. • Hypothermia o Hypothermia during the postoperative period will be extracted. Where this is not available, hypothermia at any point during the perioperative period will be extracted.

	• Shivering • Patient experience • Adverse effects of warming methods • Cardiac events • Surgical site/ wound infection • Pain • Amount of blood loss ○ Blood loss at any time during the intraoperative period will be extracted • Requirement for blood transfusion • Length of time in recovery • Delayed healing/ Time to healing • Length of hospital stay
Any other information or criteria for inclusion/exclusion	We will include studies carried out in OECD countries. The Committee will be sent the list of included and excluded studies prior to the Committee meeting, and the Committee will be requested to cross check whether any studies have been excluded inappropriately, and whether there are any relevant studies they have known of which haven't been picked up by the searches.
Analysis of subgroups or subsets	Sensitivity analysis will be carried out for studies with populations undergoing orthopaedic surgery or cardiac surgery, due to the specific differences in these populations in comparison to the general surgical population. If differences are found between the general surgical population and cardiac and orthopaedic populations, then the cardiac and orthopaedic population subgroups will be included and presented in the analysis. A sensitivity analysis will be carried out to assess whether the type of anaesthetic used (general, epidural or both) affects the important outcomes of core temperature during surgery, core temperature at end of surgery and hypothermia. For the outcomes of core temperature during surgery, the results reported by studies nearest to the time points of 30 minutes, 60 minutes and 120 minutes will be reported in subgroups. Stratification of results by age
Data extraction and quality assessment	Sifting • Full double sifting will not be conducted due to the nature of this review question (straight-forward RCT intervention review). However in cases of uncertainty the technical analyst will discuss

	with a support technical analyst. Data extraction: • Information from included studies will be extracted into standardised evidence tables. • Data reported by studies and presented numerically (e.g. mean, SD, Cis) in the paper will be extracted and included in a meta-analysis. • Only for the outcomes of core temperature at end of surgery and core temperature during surgery, data presented graphically in the papers will be imputed and included in the meta-analysis. This is because these outcomes are priority outcomes; thus the topic experts considered that it was vital that we included all available data in these outcomes. Where information is extracted from a graph, the quality of the evidence will be downgraded due to the imprecision introduced by imputing results. Critical appraisal. • Checklists in the Guidelines Manual (2014)will be used to assess the quality of each included study / systematic review • Core temperature monitoring is most accurate when undertaken with a rectal, bladder, oesophageal or tympanic thermometer. The quality of evidence for the outcome will be downgraded if any other temperature monitoring is used because it is not as accurate as the methods listed above. Quality assessment: • The quality of evidence for each outcome will be assessed as outlined in the Guidelines Manual (2014).; Reliability of quality assessment: • A full double-scoring quality assessment will not be conducted due to the nature of the review question (direct comparison intervention review) and the studies that are likely to be included (RCTs). Other quality assurance mechanisms will be in place as the following: o Internal QA by CGUT technical adviser on the quality assessment that is being conducted. o The Committee will be sent the evidence synthesis prior to the Committee meeting and the Committee will be requested to comment on the quality assessment, which will serve as another QA function.
Strategy for data synthesis	Pairwise meta-analysis will be used for all outcomes where there is sufficient data. A fixed effects model will be used as it is expected that the studies will be homogenous in terms of population and we can assume a similar effect size across studies. A random effects model will be used if this assumption is not correct.

	The previous guideline CG65 used an MID of 0.5 degrees Celcius change for core temperature at end of operation and core temperature during operation; for consistency this MID will be used in this update, this was agreed with the topic experts. COMET and published literature will be checked for other appropriate minimal important differences (MID) for each outcome and if none are available Topic experts will be asked to provide MID's. The GRADE default MIDs will be used if there are no other specific MIDs identified. STATA, R or RevMan will be used for all analyses and the results will be presented in GRADE profile, forest plot and summary evidence statement formats
Searches	• **Sources to be searched** o Clinical searches - Medline, Medline in Process, Embase, Cochrane CDSR, CENTRAL, DARE (legacy records), HTA and PubMed. o Economic searches - Medline, Medline in Process, Embase, PubMed, NHS EED (legacy records) and HTA, with economic evaluations and quality of life filters applied. • **Supplementary search techniques** o None identified • **Limits** o Studies reported in English o Study design – the RCT and SR filter will be applied o Animal studies will be excluded from the search results o Conference abstracts will be excluded from the search results in Embase o A 2006-Current date limit will be applied

C.3 Review question 3: Site of measurement

Review question:

What is the best site for accurately measuring temperature in the different phases of perioperative care?

Review protocol

Review Protocol	
Components	**Details**
Review question	What is the best site for accurately measuring temperature in the different phases of perioperative care?

Background/ objectives	This question was not systematically reviewed in CG65, the focus of the question is to consider the agreement of measurement at different sites with core temperature
Types of study to be included	Include: Cross-sectional studies. Published national and international clinical guidelines. Exclude: Qualitative studies, case series and case reports.
Language	English only
Status	Published articles, no date restriction
Population	Adults undergoing surgery (except obstetrics and where hypothermia is induced for medical reasons) in perioperative care. These exclusions are to ensure consistency with the original guideline parameters.
Site	Sites of temperature measurement used in perioperative care (including different technologies in relation to site); • Tympanic (to include direct and indirect measurement, and differing technologies such as thermocouple, infra-red) • Forehead (to include differing technologies such as temporal artery scanner, infra-red, strips, zeroflux) • • Rectal • Bladder • Nasopharyngeal • Oesophageal • Pulmonary artery • Oral/ sublingual • Axillary
Comparator	The temperature sites listed above will be compared to core temperature reported for each study.
Outcomes	• Mean difference between any two methods • Extent of variation in difference between any two methods • Adverse events
Any other information or criteria for inclusion/exclusion	This update will make recommendations on the site of monitoring, not on the individual manufacturer devices involved. We will exclude studies that have not been carried out in countries similar to the UK in terms of access to the devices and procedures.

	The Committee will be sent the list of included and excluded studies prior to the committee meeting, and the Committee will be requested to cross check whether any studies have been excluded inappropriately, and whether there are any relevant studies they have known of which haven't been picked up by the searches.
Analysis of subgroups or subsets	Subgroups will be considered for differing types of surgery, anaesthetic technique (general or regional anaesthetic) or differing BMI if there is sufficient data available.
Data extraction and quality assessment	Sifting • Full double sifting will not be conducted due to the nature of this review question (straight-forward agreement). However in cases of uncertainty the technical analyst will discuss with a support technical analyst. Data extraction: • Information from included studies will be extracted into standardised evidence tables. Quality assessment: • GRADE methodology will be used to assess the quality of evidence for each outcome as follows: o Risk of bias will be assessed using critical appraisal checklist o Inconsistency will be assessed using I^2 o Indirectness will be assessed using population, intervention and outcomes o Imprecision will be assessed using whether the Confidence intervals around point estimates cross the MIDs for each outcome. Reliability of quality assessment: • A full double-scoring quality assessment will not be conducted due to the nature of the review question (straight-agreement and DTA reviews) and the studies likely to be included (RCTs). Other quality assurance mechanisms will be in place as the following: o Internal QA by CGUT technical adviser on the quality assessment that is being conducted. o The Committee will be sent the evidence synthesis prior to the committee meeting and the Committee will be requested to comment on the quality assessment, which will serve as another QA function.
Strategy for data synthesis	Due to the nature of the review question, where possible, agreement to be assessed using Bland-Altman plots if sufficient data is available. COMET and published literature will be checked for appropriate

	minimal important differences (MID) for each outcome and if none are available the Topic experts will be asked to provide MID's.
Searches	• **Sources to be searched** o Clinical searches - Medline, Medline in Process, Embase, Cochrane CDSR, CENTRAL, DARE (legacy records), HTA and PubMed. o Economic searches - Medline, Medline in Process, Embase, PubMed, NHS EED (legacy records) and HTA, with economic evaluations and quality of life filters applied. • **Supplementary search techniques** o A scoping search for guidelines will be undertaken using a range of sources including Evidence Search (NICE Evidence Services), websites of national/international organisations, royal college/professional body websites, charity, community, voluntary and patient/service user websites. • **Limits** o Studies reported in English o Study design – the Observational filter will be applied o Animal studies will be excluded from the search results o Conference abstracts will be excluded from the search results in Embase o No date limit will be set

Appendix D: Search strategy

D.1 Review question 1 & 2: Devices

Databases that were searched, together with the number of articles retrieved from each database are shown in table 16. The Medline search strategy is shown in table 17. The same strategy was translated for the other databases listed.

Table 17: Clinical search summary

Database	Date searched	Number retrieved
Cochrane Central Register of Controlled Trials (CENTRAL)	7/03/2016	513
Cochrane Database of Systematic Reviews (CDSR)	7/03/2016	16
Database of Abstracts of Reviews of Effect (DARE) (legacy records)	7/03/2016	18
Embase (Ovid)	7/03/2016	884
Health Technology Assessment (HTA Database)	7/03/2016	5
MEDLINE (Ovid)	7/03/2016	1154
MEDLINE In-Process (Ovid)	7/03/2016	101
PubMed[a]	7/03/2016	976

Table 18: Clinical search terms

Line number/Search term/Number retrieved
1 Preoperative Care/ (53622) 2 exp Perioperative Care/ (129790) 3 exp Perioperative Period/ (62279) 4 exp Intraoperative Complications/ (43430) 5 Postoperative Complications/ (303380) 6 (preoperat* or pre-operat* or "pre operat*" or presurg* or pre-surg* or "pre surg*").tw. (221431) 7 (perioperat* or peri-operat* or "peri operat*" or perisurg* or peri-surg* or "peri surg*").tw. (61807) 8 (intraoperat* or intra-operat* or "intra operat*" or intrasurg* or intra-surg* or "intra surg*" or perian?esthe* or peroperative).tw. (99097) 9 (postoperat* or post-operat* or "post operat*" or postsurg* or post-surg* or "post surg*").tw. (419034) 10 ((before or prior or during or after) adj2 (surg* or operat*)).tw. (326899) 11 exp Anesthesia/ (172564) 12 Anesthesia Recovery Period/ (4503) 13 (an?esthe* or postan?esthe* or post-an?esthe* or "post an?esthe*").tw. (299100) 14 or/1-13 (1309319) 15 Hypothermia/ (12716) 16 hypotherm*.tw. (34149)

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[a] Limit search to publisher[sb] and last 3 days only. Tips on searching PubMed here

Line number/Search term/Number retrieved
17 ((low* or decrease* or decline* or reduce*) adj2 temperature*).tw. (45726)
18 (heat* adj4 (loss or lose or losing)).tw. (3180)
19 Piloerection/ (145)
20 piloerection*.tw. (344)
21 shiver*.tw. (3048)
22 or/15-21 (86019)
23 Body Temperature/ (43976)
24 exp Body Temperature Regulation/ (34203)
25 (normotherm* or thermoregulat* or thermogenes?s).tw. (20485)
26 (heat adj4 (preserv* or retention or retain* or balance)).tw. (1096)
27 ((temperature or thermal) adj4 (control* or regulat* or manage* or maintain* or core)).tw. (23617)
28 or/23-27 (97165)
29 14 or 22 or 28 (1454464)
30 (prewarm* or pre-warm* or "pre warm*" or rewarm* or re-warm* or "re warm*" or preheat* or pre-heat* or "pre heat*" or reheat* or re-heat* or "re heat*").tw. (5825)
31 ((warm* or heat*) adj4 (patient* or active or body or skin or cutaneous or device* or equipment or mechanism* or system* or intervention* or method* or technique* or resistiv* or radiant or convecti* or conductiv* or blanket* or garment* or mattress* or pad* or gown* or unit* or vest*)).tw. (19869)
32 Rewarming/ (1173)
33 Convection/ (741)
34 Hyperthermia, Induced/ (13694)
35 Heating/ (4763)
36 Hot Temperature/tu [Therapeutic Use] (2760)
37 or/30-36 (44655)
38 29 and 37 (14979)
39 (airwarm* or air-warm* or "air warm*" or forced-air).tw. (536)
40 (air adj2 (forced or warm*)).tw. (1023)
41 ((convecti* or conductiv* or electric* or resistiv* or water or thermal or carbon-fiber or carbon-fibre) adj4 (blanket* or garment* or mattress* or gown* or vest*)).tw. (903)
42 (inditherm or meditherm or medi-therm or heto or blanketrol or electroconcept or operatherm or smartcare or suntouch or k-thermia).tw. (48)
43 (electro adj2 concept).tw. (3)
44 (Bair adj2 (hugger or paws)).tw. (76)
45 ((warm or sun) adj2 touch).tw. (35)
46 (kr adj2 thermia).tw. (0)
47 or/39-46 (1946)
48 38 or 47 (16370)
49 Randomized Controlled Trial.pt. (407164)
50 Controlled Clinical Trial.pt. (90097)
51 Clinical Trial.pt. (496894)
52 exp Clinical Trials as Topic/ (287899)
53 Placebos/ (33035)
54 Random Allocation/ (85593)
55 Double-Blind Method/ (133208)
56 Single-Blind Method/ (21376)
57 Cross-Over Studies/ (37281)
58 ((random$ or control$ or clinical$) adj3 (trial$ or stud$)).tw. (800138)
59 (random$ adj3 allocat$).tw. (22481)
60 placebo$.tw. (160396)
61 ((singl$ or doubl$ or trebl$ or tripl$) adj (blind$ or mask$)).tw. (130356)

Line number/Search term/Number retrieved	
62	(crossover$ or (cross adj over$)).tw. (59847)
63	or/49-62 (1470067)
64	animals/ not humans/ (4159388)
65	63 not 64 (1368722)
66	Meta-Analysis.pt. (61700)
67	Meta-Analysis as Topic/ (14517)
68	Review.pt. (2011858)
69	exp Review Literature as Topic/ (8385)
70	(metaanaly$ or metanaly$ or (meta adj3 analy$)).tw. (72956)
71	(review$ or overview$).ti. (296233)
72	(systematic$ adj5 (review$ or overview$)).tw. (68410)
73	((quantitative$ or qualitative$) adj5 (review$ or overview$)).tw. (5000)
74	((studies or trial$) adj2 (review$ or overview$)).tw. (27387)
75	(integrat$ adj3 (research or review$ or literature)).tw. (6158)
76	(pool$ adj2 (analy$ or data)).tw. (16073)
77	(handsearch$ or (hand adj3 search$)).tw. (5821)
78	(manual$ adj3 search$).tw. (3498)
79	or/66-78 (2185631)
80	animals/ not humans/ (4159388)
81	79 not 80 (2046235)
82	65 or 81 (3157361)
83	48 and 82 (3553)
84	limit 83 to ed=20060101-20160331 (1467)
85	limit 84 to english language (1336)

D.2 Review question 3: Site of measurement

Databases that were searched, together with the number of articles retrieved from each database are shown in table 18. The Medline search strategy is shown in table 19. The same strategy was translated for the other databases listed.

Table 19: Clinical search summary

Database	Date searched	Number retrieved
Cochrane Central Register of Controlled Trials (CENTRAL)	09/03/16	1147
Cochrane Database of Systematic Reviews (CDSR)	09/03/16	13
Database of Abstracts of Reviews of Effect (DARE) (legacy records)	09/03/16	4

Database	Date searched	Number retrieved
Embase (Ovid)	09/03/16	2809
Health Technology Assessment (HTA Database)	09/03/16	1
MEDLINE (Ovid)	09/03/16	3176
MEDLINE In-Process (Ovid)	09/03/16	227
PubMed	09/03/16	301

1 **Table 20: Clinical search terms**

Line number/Search term/Number retrieved
1 Preoperative Care/ 2 exp Perioperative Care/ 3 exp Perioperative Period/ 4 exp Intraoperative Complications/ 5 Postoperative Complications/ 6 (preoperat* or pre-operat* or "pre operat*" or presurg* or pre-surg* or "pre surg*").tw. 7 (perioperat* or peri-operat* or "peri operat*" or perisurg* or peri-surg* or "peri surg*").tw. 8 (intraoperat* or intra-operat* or "intra operat*" or intrasurg* or intra-surg* or "intra surg*" or perian?esthe* or peroperative).tw. 9 (postoperat* or post-operat* or "post operat*" or postsurg* or post-surg* or "post surg*").tw. 10 ((before or prior or during or after) adj2 (surg* or operat*)).tw. 11 exp Anesthesia/ 12 Anesthesia Recovery Period/ 13 (an?esthe* or postan?esthe* or post-an?esthe* or "post an?esthe*").tw. 14 or/1-13 15 Hypothermia/ 16 hypotherm*.tw. 17 ((low* or decrease* or decline* or reduce*) adj2 temperature*).tw. 18 (heat* adj4 (loss or lose or losing)).tw. 19 Piloerection/ 20 piloerection*.tw. 21 shiver*.tw. 22 Body Temperature/ or skin temperature/ 23 exp Body Temperature Regulation/ 24 (normotherm* or thermoregulat* or thermogenes?s).tw. 25 (heat adj4 (preserv* or retention or retain* or balance)).tw. 26 ((temperature or thermal) adj4 (control* or regulat* or manage* or maintain* or core or bod* or skin* or measure* or monitor*)).tw. 27 or/15-26 28 Ear/ 29 Tympanic Membrane/ 30 (Ear or ears or eardrum or ear-drum or tympanic*).tw. 31 Forehead/ 32 (Forehead or fore-head or head).tw. 33 Temporal Arteries/ 34 Temporal arter*.tw. 35 Mouth/ 36 Mouth Mucosa/

Line number/Search term/Number retrieved

37 Sublingual Gland/

38 Tongue/

39 Nose/

40 Nasopharynx/

41 Esophagus/

42 (Oral or mouth or sublingual or hypoglossal or subglossal or tongue or nose or nasal or nasopharynx or rhinopharynx or esophag* or oesophag* or nasopharyngeal).tw.

43 Rectum/

44 (Rectum* or rectal* or anus or anal or bum or bottom).tw.

45 Urinary Bladder/

46 Bladder.tw.

47 Axilla/

48 (Axilla* or armpit* or arm-pit* or arm pit* or underarm* or under-arm* or under arm*).tw.

49 Pulmonary Artery/

50 Pulmonar* arter*.tw.

51 Thermometers/

52 Thermography/

53 Thermometry/

54 (Thermometer* or thermograph* or thermometr* or thermocouple*).tw.

55 ((Infrared or infra-red or infra red) adj2 (thermomet* or device* or monitor* or measure* or tool* or apparat*)).tw.

56 (Strip* adj2 (thermomet* or device* or monitor* or measure* or tool* or apparat*)).tw.

57 (Map* adj2 temperat*).tw.

58 Zeroflux.tw.

59 or/28-58

60 Monitoring, Intraoperative/

61 ((preoperat* or pre-operat* or "pre operat*" or presurg* or pre-surg* or "pre surg*" or perioperat* or peri-operat* or "peri operat*" or perisurg* or peri-surg* or "peri surg*" or intraoperat* or intra-operat* or "intra operat*" or intrasurg* or intra-surg* or "intra surg*" or perian?esthe* or peroperative or postoperat* or post-operat* or "post operat*" or postsurg* or post-surg* or "post surg*") adj2 (temperat* or monitor* or measure*)).tw.

62 ((Before or prior or during or after) adj2 (surg* or operat* or procedure*) adj2 (temperat* or monitor* or measure*)).tw.

63 or/60-62

64 14 and 27 and 59

65 27 and 63

66 64 or 65

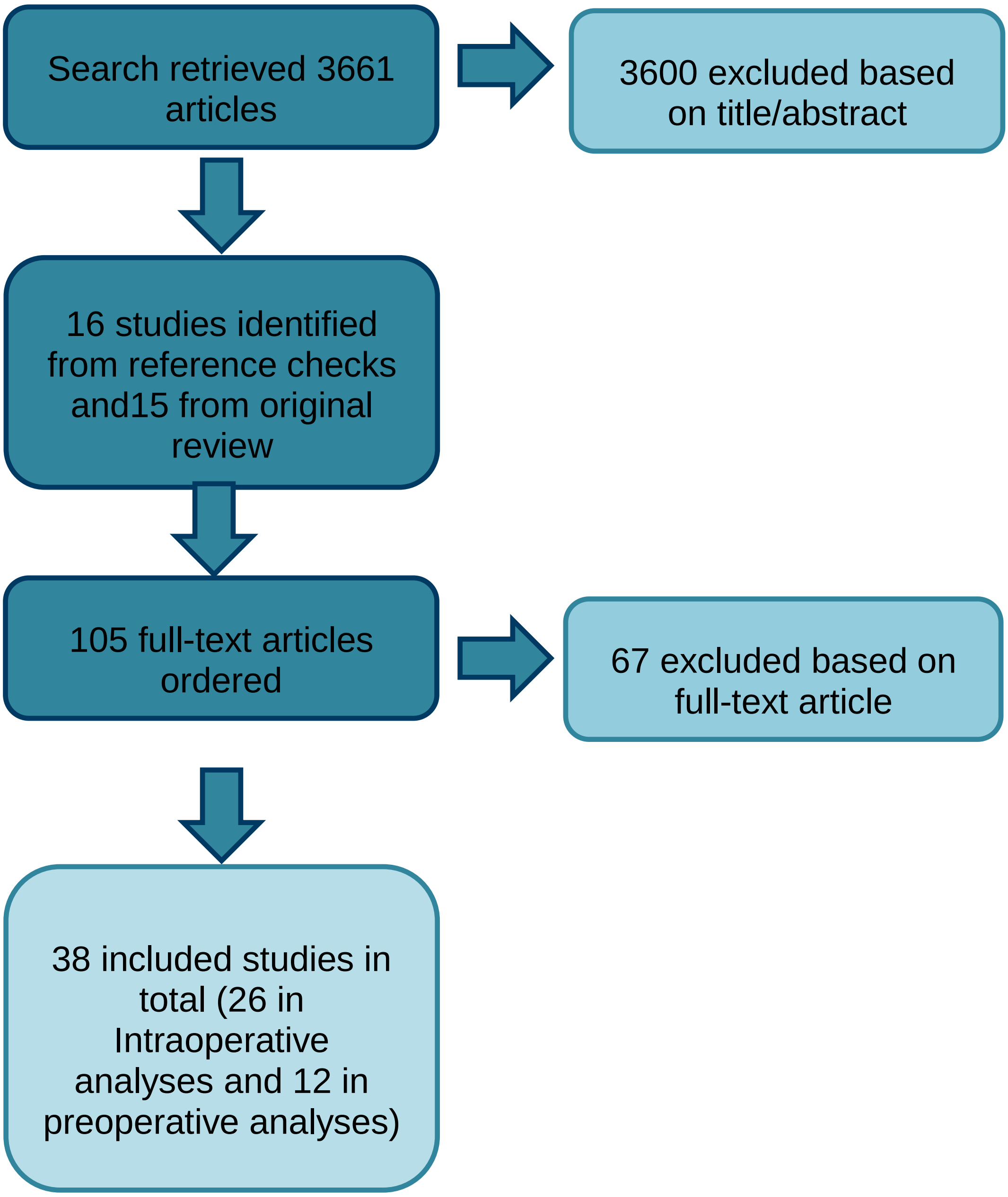
67 Animals/ not Humans/

68 66 not 67

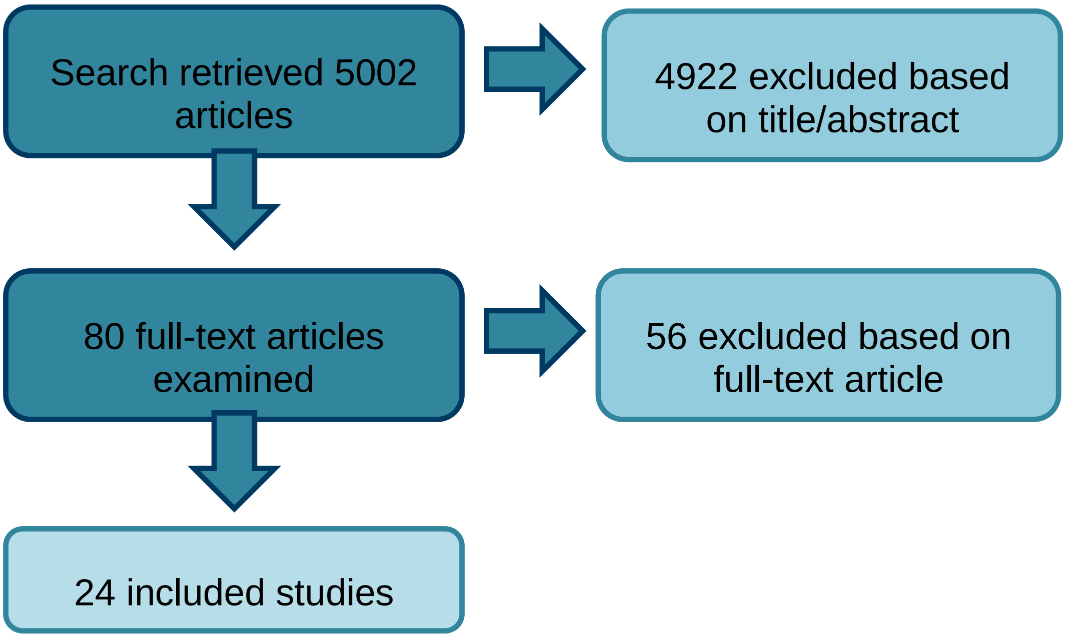
69 limit 68 to english language

Appendix E: Review flowchart

E.1 Review question 1 & 2: Devices



E.2 Review question 3: Site of measurement



Appendix F: Excluded studies

F.1 Review question 1 & 2: Devices

Reference	Reason for exclusion
Adriani MB., Moriber N. (2013) Preoperative forced-air warming combined with intraoperative warming versus intraoperative warming alone in the prevention of hypothermia during gynecologic surgery. AANA Journal 81: 446-451	Not randomised
Ahn HY., Eom MR. (2010) Rewarming intervention program for abdominal surgery patients. Journal of Korean Academy of Fundamentals of Nursing. 17: 220-230	Not in English
Becerra A., Cruz R., Suarez V., et al. (2013) Prevention of perioperative hypothermia in transurethral resection under spinal anesthesia. European Journal of Anaesthesiology 30: 19-20	Conference abstract
Benson, E. E., McMillan, D. E., Ong, B., The effects of active warming on patient temperature and pain after total knee arthroplasty, American Journal of Nursing, 112, 26-33; quiz 34, 42, 2012	Pre- and Intra-operative phase active warming and no active comparator
Bock M, Müller J, Bach A et al (1998) Effects of preinduction and intraoperative warming during major laparotomy. British Journal of Anaesthesia.80(2):159-63	Intervention did not meeting inclusion criteria
Bullock MR, Allen C, Malek A, (2013) Intraoperative temperature management Therapeutic hypothermia and temperature management 3, 46-51	Discussion paper, not an RCT
Bullock MR, Lundbye JB., Dietrich WD (2014) Intraoperative temperature management Therapeutic hypothermia and temperature management 4, 67-71	Discussion paper, not an RCT
Cobbe K-A., Di Staso R., Duff J., et al. (2012) Preventing inadvertent hypothermia: comparing two protocols for preoperative forced-air warming Journal of PeriAnesthesia Nursing 27: 18-24	Population were healthy volunteers
Crivits M., Reyntjens K., Wouters P., hert S. (2013) Comparison of two forced-air warming devices for the prevention of hypothermia during abdominal surgery in the Lloyd-Davies position. European Journal of Anaesthesiology 30: 21	Conference abstract
Darvall J., Vijaykumar R., Leslie K. (2016) Prewarming neurosurgical patients to minimize hypotension on induction of anaesthesia: a randomized trial. Canadian Journal of Anesthesia	No outcome data for intra- or post-operative period
de Brito Poveda V., Clark AM., Galvao CM. (2012) A systematic review on the effectiveness of prewarming to prevent perioperative hypothermia. Journal of Clinical Nursing 22; 906-918	Systematic review and references included in review
Degirmenci AK., Ozkardesler S., Terzi C., et al. (2015) Effect of standard normothermia protocol on surgical site infections: preliminary results of a randomised controlled trial. European Surgery 47:S262	Conference abstract
Engelen S., Himpe D., Borms S., et al. (2011) An evaluation of underbody forced-air and resistive heating during hypothermic, on-pump cardiac surgery. Anaesthesia 66: 104-110	Participants underwent Induced hypothermia for cardiac surgery
Fettes, S., Mulvaine, M., Van Doren, E., Effect of preoperative forced-air warming on postoperative temperature and postanesthesia care unit length of stay, AORN Journal, 97, 323-8, 2013	Data reported in insufficient detail to be included in analyses
Franke R., Brauer A., Emmert A., et al. (2015) Prevention of	Conference abstract

Reference	Reason for exclusion
perioperative hypothermia in vats: a prospective randomised controlled trial comparing forced-air warming with conductive warming. Thoracic and Cardiovascular Surgeon p63	
Grocott H, Mathew J, Carver E et al. (2004) Methods for Preventing Hypothermia During Off-Pump Cardiac Surgery. Anesthesia and Analgesia 98: 298-302	Forced air warming not used in isolation but with usual care but comparator group did not receive usual care
Habicher M., Treskatsch S., Spies C., et al. (2012) Active patient warming can reduce postoperative complications after interventional aortic valve replacement. Applied Cardiopulmonary Pathophysiology 16: 329-32	Unclear when active warming was used
Hamada Y., Ouchi T., Kato T., et al. (2007) Upper type forced-air warming blanket with the temperature setting of 38ºC might be a better choice for maintaining normothermia. Anesthesia & Analgesia 110:S245-246	Conference abstract
Harper,C.M., Is a warming mattress as effective as forced-air warming in preventing peri-operative hypothermia, Anesthesiology, 107, A92-, 2007	Correspondence
Hendrickx HH, Trahey GE. (1991) Temperature regulation during surgery. Anaesthesia and Intensive Care. 9(4):399-400	Correspondence
Hofer CK., Ganter MT., Zollinger A. (2006) Evaluation of a modified ThermoWrap for the Allon warming system in patients undergoing elective off-pump coronary artery bypass grafting. Journal of Thoracic and Cardiovascular Surgery 131: 929-930	Correspondence
Horosz B., Malec-Milewska M. (2013) Inadvertent intraoperative hypothermia. Anaesthesiology Intensive Therapy 45: 38-43	Not an RCT, background paper
Horosz B., Malec-Milewska M. (2014) Methods to prevent intraoperative hypothermia. Anaesthesiology Intensive Therapy 46: 96-100	Not an RCT, background paper
Hovmann Rasmussen, Y., Leikersfeldt, G. and Drenck, N.-E. (1998), Forced-air surface warming versus oesophageal heat exchanger in the prevention of peroperative hypothermia. Acta Anaesthesiologica Scandinavica, 42: 348–52	Study compared forced air warming with a heat exchanger
Hsu KH., Chiang MC. (2014) A randomised trial of using thermal blanket to improve thermoregulation among preterm infants. Archives of Disease in Childhood 99: A195-A196	Population were not undergoing surgery
Hsu, Kai-Hsiang, Chiang, Ming-Chou, Lin, Shu-Wen, Lin, Jainn-Jim, Wang, Yu-Cheng, Lien, Reyin, (2015) Thermal Blanket to Improve Thermoregulation in Preterm Infants: A Randomized Controlled Trial, Pediatric Critical Care Medicine, 16, 637-43,	Population were not undergoing surgery
Hu Y., Xuan Y., Wang J., Zheng H. (2013) Effectiveness of forced air warming for the maintenance of perioiperative core temperature: a meta-analysis. DARE 985-991	DARE Abstract of a systematic review
Insler SR, Bakri MH, Nageeb F et al (2008) An evaluation of a full-access underbody forced-air warming system during near-normothermic, on-pump cardiac surgery. Anesthesia and Analgesia. 106(3):746-50	Study concerned with addition of forced air warming to standard active warming in intraoperative phase
Insler, S. R., Sessler, D. I.,(2006) Perioperative thermoregulation and temperature monitoring, Anesthesiology Clinics, 24, 823-37	Overview of thermoregulation
Jardeleza A., Fleig D., Davis N., Spreen-Parker R. (2011) The effectiveness and cost of passive warming in adult ambulatory	Study not concerned with active warming

Reference	Reason for exclusion
surgery patients. AORN 94: 363-369	
Jensen KO., Jensen JM., Sprengel K. (2015) Practicability of avoiding hypothermia in resusciatation room phase in severely injured patients. Journal of Medical Engineering & Technology 39: 223-225	Population were not undergoing surgery
Joachimssoun PO, Edstranfd H, Abow T (1987) Prevention of intraoperative hypothermia during abdominal surgery Acta Anaesthesiologica Scandinavica: 31: 330-7	Intra-operative phase and no active comparator
Johansson, T., Lisander, B. and Ivarsson, I. (1999), Mild hypothermia does not increase blood loss during total hip arthroplasty. Acta Anaesthesiologica Scandinavica, 43: 1005–1010.	Intra-operative phase and no active comparator
John M., Ford J., Harper M. (2014) Peri-operative warming devices: performance and clinical application. Anaesthesia 69: 623-638	Systematic review and references included in review
Johnson RJ., Fox MA., Grayson., et al. (2002) should we rely on nasophayngeal temperature during cardiopulmonary bypass? Perfusion 17: 145-151	Study interested in monitoring temperature
Joo, Y., Kim, H. J., Kim, J. T., Kim, H. S., Lee, S. C., Kim, C. S., Effect of active warming on shivering during spinal anesthesia, Korean Journal of Anesthesiology, 57, 176-80, 2009	Not in English
Kabbara,A., Goldlust,S.A., Smith,C.E., Hagen,J.F., Pinchak,A.C., Randomized prospective comparison of forced air warming using hospital blankets versus commercial blankets in surgical patients, Anesthesiology, 97, 338-344, 2002	Comparison of the use of brand or hospital blankets with forced-air warming
Kamada Y, Miyamoto N, Yamakage M, Tsujiguchi N, Namiki A. [Utility of an infrared ear thermometer as an intraoperative core temperature monitor]. Masui. 1999 Oct;48(10):1121-5	Not in English
Kastl, K. G., Wiesmiller, K. M., Lindemann, J., (2009) Dynamic infrared thermography of the nasal vestibules: a new method, Rhinology, 47, 89-92,	Population were healthy volunteers
Katyal, S., Tewari, A., Narula, N., (2002) Shivering: Anaesthetic considerations, Journal of Anaesthesiology Clinical Pharmacology, 18, 363-376,	Overview of thermoregulation
Kiessling, A. H., Isgro, F., Lehmann, A., Piper, S., Blome, M., Saggau, W., (2006) Evaluating a new method for maintaining body temperature during OPCAB and robotic procedures, Medical Science Monitor, 12, MT39-42,	Intra-operative phase and no active comparator
Kim, HJ., Kim NC., Park CW. (2008) The effects of warming methods on temperature, cardiac function and cytokines in plateletpheresis donors. Vox Sanguinis 95: 45-51	Population were not undergoing surgery
Kim, Y. S., Jeon, Y. S., Lee, J. A., Park, W. K., Koh, H. S., Joo, J. D., In, J. H., Seo, K. W., (2009) Intra-operative warming with a forced-air warmer in preventing hypothermia after tourniquet deflation in elderly patients, Journal of International Medical Research, 37, 1457-64,	Intra-operative phase and no active comparator
Kim HJ., Jeon GE., Choi JM., et al. (2008) The effects of temperature monitoring methods and thermal management methods during spinal surgery. Korean Journal of Anaesthesiology 54: 326-328	Not in English
Leaper D. (2006) Effects of local and systemic warming on postoperative infections. Surgical Infections 7:S-101-S103	Non- systematic review paper
Lee, J. H., Kim, H. J., Seo, H. J., Choi, Y. J., Ro, Y. J., Yang, H. S., The effects of the warming devices in patients undergoing tourniquet technique for total knee arthroplasty under the general anesthesia, European Journal of Anaesthesiology, 30, 18-9, 2013	Conference abstract

Reference	Reason for exclusion
Park OB., Choi H. (2010) The effect of pre-wa5rming for patients under abdominal surgery on body temperature, anxiety, pain, and thermal comfort. Journal of Korean Academy of Nursing 40: 317-25	Not in English
Perez-Protto S, Sessler DI, Reynolds LF, Bakri MH, Mascha E, Cywinski J, Parker B, Argalious M. Circulating-water garment or the combination of a circulating-water mattress and forced-air cover to maintain core temperature during major upper-abdominal surgery. Br J Anaesth. 2010 Oct;105(4):466-70	Study concerned with addition of forced air warming to standard active warming in intraoperative phase
Perl, T., Rhenius, A., Eich, C. B., Quintel, M., Heise, D., Brauer, A., (2012) Conductive warming and insulation reduces perioperative hypothermia, Central European Journal of Medicine, 7, 284-9	Intra-operative phase and no active comparator
Ping ST, Ling TL, Kamaruzaman E et al. (2015) Forced air warming during hysterectomy under combined epidural and general anaesthesia: Comparison of upper with lower body warming, International Medical Journal, 22, 295-8	Unclear if rescue heating in cases of hypothermia was used
Pu, Y., Cen, G., Sun, J., Gong, J., Zhang, Y., Zhang, M., Wu, X., Zhang, J., Qiu, Z., Fang, F., (2014) Warming with an underbody warming system reduces intraoperative hypothermia in patients undergoing laparoscopic gastrointestinal surgery: a randomized controlled study, International Journal of Nursing Studies, 51, 181-9	Intra-operative phase and no active comparator
Rathinam, S., Annam, V., Steyn, R., Raghuraman, G., A randomised controlled trial comparing Mediwrap heat retention and forced air warming for maintaining normothermia in thoracic surgery, Interactive Cardiovascular and Thoracic Surgery, 9, 15-9, 2009	Intra-operative phase and no active comparator
Rein, E. B., Filtvedt, M., Walloe, L., Raeder, J. C., Hypothermia during laparotomy can be prevented by locally applied warm water and pulsating negative pressure, British Journal of Anaesthesia, 98, 331-6, 2007	Comparison of pre-warming with intra-operative warming
Saad H., A;ladawy M. (2013) Temperature management in cardiac surgery. Global Cardiology Science and Practice	Overview of thermoregulation
Scott EM, Leaper DJ, Clark M, et al (2001) Effects of warming therapy on pressure ulcers--a randomized trial.AORN J. May;73(5):921-7, 929-33, 936-8	Intra-operative phase and no active comparator
Sessler DI. Temperature Monitoring and Perioperative Thermoregulation. Anesthesiology. 2008;109(2):318-38	Overview
Severens NMW., van Marken Lichenbelt WD., van Leeuwen GMJ., et al. (2007) Effect of forced-air heaters on perfusion and temperature distribution during and after open-heart surgery. European Journal of Cardio-thoracic Surgery 32: 888-895	Post-surgery warming
Sikka, R. S., Prielipp, R. C., (2014) Forced air warming devices in orthopaedics: a focused review of the literature, Journal of Bone & Joint Surgery - American Volume, 96, e200,	Non-systematic review
Tølløfsrud, S. G., Gundersen, Y. and Andersen, R. (1984), Peroperative Hypothermia. Acta Anaesthesiologica Scandinavica, 28: 511–5	Data reported in insufficient detail to be included in analyses
Tolstova I., Akselrod B., Bunatyan A. (2013) Air warming during DABG: simple method to prevent microcirculation disturbances. Applied Cardiopulmonary Pathophysiology 17: 200	Conference abstract
Torossian A. (2008) Thermal management during anaesthesia and thermoregulation standards for the prevention of inadvertent perioperative hypothermia. Best Practice & Research Clinical Anaesthesiology 22: 659-668	Overview of thermoregulation
Wagner K., Swanson E., Raymond CJ., et al. (2008) Comparison of	Comparison of two forced

Reference	Reason for exclusion
two convective warming systems during major abdominal and orthopaedic surgery. Canadian Journal of Anesthesia 55: 358-363	air warming systems
Wheeler D. (2006) Temperature regulation. Surgery. 12: 446-51	Overview of thermoregulation
Winkler, M., Akca, O., Birkenberg, B., Hetz, H., Scheck, T., Arkilic, C. F., Kabon, B., Marker, E., Grubl, A., Czepan, R., Greher, M., Goll, V., Gottsauner-Wolf, F., Kurz, A., Sessler, D. I., Aggressive warming reduces blood loss during hip arthroplasty, Anesthesia & Analgesia 91, 978-84, 2000	Study concerned with aggressive warming (36.5) versus 36.0
Wongprasartsuk P, Konstantatos A, McRae R. (1998) The effect of forced air warming on postoperative oxygen consumption and temperature in elective orthopaedic surgery. Anaesthesia and Intensive Care. 26(3):267-71.	Study with pre- and intraoperative warming compared with usual care
Yamakage M, Kawana S, Yamauchi M et al. (1995) Evaluation of a forced-air warming system during spinal anesthesia. Journal of Anesthesia 1995; 93-95	Study compared two form of Forced air warming with usual care in the intraoperative period
Yoo, H. S., Park, S. W., Yi, J. W., Kwon, M. I., Rhee, Y. G., (2009) The Effect of Forced-Air Warming During Arthroscopic Shoulder Surgery With General Anesthesia, Arthroscopy - Journal of Arthroscopic and Related Surgery, 25, 510-514,	Intra-operative phase and no active comparator

F.21 Review question 3: Site of measurement

Reference	Reason for exclusion
Akata, T., Kanna, T. (2004) Reliability of skin surgace temperature and its related therma measures as indices of peripheral perfusion in the clinical setting of the operating theatre. Anaesth Intensive Care 32: 519-529	Interventions not in protocol: fingertip and forearm skin temp v nasopharyngeal
Bone ME., Feneck RO. (1988) Bladder temperature as an estimate of body temperature during cardiopulmonary bypass. Anaesthesia 43: 181-185	Assessing temperature at cooling and rewarming periods of induced hypothermia during CPB
Bullock MR., Blitz A., Allen G., Malek A. (2013) Intraoperative temperature management. Therapeutic Hypothermia and Temperature Management 3: 46-51	Review/ discussion document
Bullock MR., Lundbye JB., Dalton DW. (2014) Intraoperative temperature management. Therapeutic Hypothermia and Temperature Management 4: 67-71	Review/ discussion document
Crocker BD., Okumura F., McCuaig DI., et al. (1980) Temperature monitoring during general anaesthesia. Br J Anaesth 52: 1223-1229	Different temperature measurements in different patients, retrospective
Cupitt JM., Badsha Z. (2002) Temperature measurement – which method is best? Anaesthesia 57: 619	Letter
Dressler, D. K., Smejkal, C., Ruffolo, M. L. (1983) A comparison of oral and rectal temperature measurement on patients receiving oxygen by mask. Nursing Research. 32 p.373-5	No relevant data reported on outcomes of interest, unable to include in analysis.
Earp, J. K., Finlayson, D. C (1992) Urinary bladder/pulmonary artery temperature ratio of less than 1 and shivering in cardiac surgical patients. .American Journal of Critical Care. 1 p.43-52	Does not provide data for different temperature measurement, graphical presentation only for shivering vs no shivering

Reference	Reason for exclusion
Ferrara-Love R. (1991) A comparison of tympanic and pulmonary artery measures of core temperatures. Journal of Post Anesthesia Nursing 6: 161-164	Not during surgery
Goon S., Seagrave M., Vernon J., et al. (2007) Maintaining body temperature during surgery. Aneasthesia 62: 198-199	Abstract
Gobolos L., Philipp A., Ugocsai P., et al. (2014) Reliability of different body temperature measurement sites during aortic surgery. Perfusion 29: 75-81	Retrospective
Grocott HP., Newman MF. (1998) Temoerature measurement during cardiac surgery. Can J Anaesth 45: 1133-1134	Abstract
Harper CM. (2009) The need for an accurate noninvasive thermometer. Anesth Analg 109: 288	Letter
Hendrickx HH., Trahey GE. (1981) Temperature regulation during surgery. Anaesth Intensive Care 9: 399-400	Letter
Hopf HW. (2015) Perioperative temperature management: time for a new standard of care? Anaesthesiology 122: 229-230	Editorial
Janicki PK, Higgins MS, Janssen J, et al. (2001) Comparison of two different temperature maintenance strategies during open abdominal surgery: upper body forced air warming versus whole body water garment. Anaesthesiology 95: 868-74	Only reports data in graph format, not data reported.
Johnson, J., Desai, J. B., Ponte, J.(1997) Fingertip temperature during cardiopulmonary bypass. Perfusion. 12 p.120-6	Only reports data from rewarming period of CPB
Khan TA., Vohra HA., Paul S., et al. (2006) Axillary and tympanic membrane temperature measurements and unreliable early after cardiopulmonary bypass. Eur J Anesth 23: 551-554	Not during surgery
Lfeituri, M. A., Bober, J., Studena, A.(1999) Comparison of body temperature changes during cholecystectomy performed via laparotomy or laparoscopy. Anesteziologie a Neodkladna Pece 10 p.33-36	comparison of temperature in people undergoing cholecystectomy laparotomy v laparoscopy, not comparison of temperature measurement sites
Matsukawa T., Kashimoto S., Ozaki M., et al. (1996) Temperatures measured by a deep body thermometer (Coretemp) compared with tissue temperatures measured at various depths using needles placed into the sole of the foot. Eur J Anaesth 13; 340-345	Not relevant temperature measurements
Matsukawa T., Ozaki M., Hanagata K., et al. (1996) A comparison of four infrared tympanic thermometers with tympanic membrane temperatures measured by thermocouples. Can J Anaesth 43: 1224-1228	In volunteers, not surgery
Moran JL., Peter JV., Solomon PJ., et al. (2007) Tympanic temperature measurements: are they reliable in the critically ill? A clinical study of measures of agreement. Crit Care Med 35: 155-164	In ICU, not surgery
Nishimura, C., Kanemaru, K., Otagiri, T. (1990) Characteristic changes between core and peripheral surface temperature related with postanesthetic shivering following surgical operations. Journal of Anesthesia. 4 p.350-7	Measured core temperature rectally or oesophageally and on forehead and dorsum of foot; pooled results for rectum and oesophagus and for forehead and dorsum of foot. Dorsum of foot not

Reference	Reason for exclusion
	included intervention. No results of use.
Nussmeier NA. (2005) Management of temperature during and after cardiac surgery. Tex Heart Inst J 32: 472-476	Review paper
Parris M., Ward M. (2006) A complication of temperature monitoring. Anaesthesia 61: 472-476	Letter
Saad H., Aladawy M. (2013) Temperature management in cardiac surgery. Global Cardiology Science and Practice. 2013	Review paper
Sessler D. (1999) Temperature monitoring and management during neuraxial anesthesia. Anesth Analg 88: 243-245	Review paper
Stirrat CR., Seaber AV., Urbaniak JR., et al. (1978) Temperature monitoring in digital replantation. Journal of Hand Surgery 3: 342-347	Not core temperature
Suleman M-I., Doufas AG., Akca O., et al. (2002) Insufficiency in anew temporal-artery thermometer for adult and pediatric patients. Anesth Analg 95: 67-71	Included paediatric patients, not analysed separately.
Summers S. (1991) Axillary, tympanic, and esophageal temperature measurement: descriptive comparisons in post anesthesia patients. Journal of Post Anesthesia Nursing 6: 420-425	Not an RCT
Tabor MW., Blaho DM., Schriver WR. (1981) Tympanic memebrane perforation: complication of tympanic thermometry during general anaesthesia. Oral Surg Oral Med Oral Pathol 51: 581-583	Case report
Wheeler D. (2006) Temperature regulation. Surgery 24: 446-451	Review paper
Whitby JD, Dunkin LJ. (1968) Temperature differences in the oesophagus. Preliminary study. Br J Anaesth 40: 991-995	No comparison between sites
Whitby JD, Dunkin LJ. (1969) Temperature differences in the oesophagus. The effects of intubation and ventilation. Br J Anaesth 41: 615-618	No comparison between sites
White, N., Baird, S., Anderson, D. L.(1994) A comparison of tympanic thermometer readings to pulmonary artery catheter core temperature recordings. Applied Nursing Research.7 p.165-9	Comparison between 2 different tympanic machines (of the same make), comparing temperatures measured in L v R ears; no relevant comparator

1

Appendix G: Evidence tables

G.1 Review question 1: Devices - Intraoperative

Brandt 2010

<table>
<tr><th>Bibliographic reference</th><th>Brandt S, Oguz R, Hu H et al. (2010) Resistive-polymer versus forced-air warming: comparable efficacy in orthopedic patients. Anesthesia and analgesia 110: 834-8</th></tr>
<tr><td>**Study type**</td><td>RCT (open-label; computer-generated randomization; group assignment using sequentially numbered, opaque envelopes)</td></tr>
<tr><td>**Aim**</td><td>To compare the efficacy of a widely distributed forced air warming system with the resistive polymer (RP) system in a prospective, randomized clinical study of orthopaedic patients</td></tr>
<tr><td>**Patient characteristics**</td><td>Inclusion:
All patients undergoing elective orthopaedic surgery

Exclusion:
Severe peripheral artery disease in the warmed extremity

Demographic characteristics:
<table>
<tr><th></th><th>Forced air warming
N=40</th><th>Resistive heating blankets
N=40</th></tr>
<tr><td>Age in years – mean (SD)</td><td>39 (16)</td><td>37 (13)</td></tr>
<tr><td>Gender – male/female</td><td>16/24</td><td>31/9</td></tr>
</table></td></tr>
<tr><td>**Number of Patients**</td><td>N=80</td></tr>
<tr><td>**Interventions and comparisons**</td><td>Forced-air warming with a Bair Hugger upper body warming cover (model #522), connected to a model #750 warming unit set to “high” (43°C)

Resistive heating blanket. Conductive warming: electric current warms a resistive polymer blanket
2 Hot Dog warming blankets (model: Multi-Position Blanket) and the Hot Dog controller unit set to “high” (43°C).
Each blanket is approximately half the size of a typical upper body FA blanket. For upper body warming, straps connected the 2 Hot Dog blankets, resulting in 1 normal-size upper body blanket.
Mean duration of surgery = 90mins</td></tr>
</table>

<table>
<tr><th>Bibliographic reference</th><th>Brandt S, Oguz R, Hu H et al. (2010) Resistive-polymer versus forced-air warming: comparable efficacy in orthopedic patients. Anesthesia and analgesia 110: 834-8</th></tr>
<tr><td></td><td>Mean operating room temperature at start and end of surgery did not differ significantly between groups (around 19-20 ºC). However, environmental temperature at 1 meter distance to warming device (after 30 minutes) was significantly higher with FA warming than RP warming:
Environmental temperature - Forced air warming – mean temp ºC (SD): 24.4 (5.2) vs Resistive heating blanket - mean temp ºC (SD): 22.6 (1.9)</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>Austria</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Forced air warming
N=40</th><th>Resistive heating blanket
N=40</th></tr>
<tr><td>Core temp at end of surgery ºC – mean (SD)</td><td>36.4 (0.5)</td><td>36.2 ± 0.4</td></tr>
<tr><td>Number hypothermic</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Core temp during surgery ºC</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Adverse effects of active warming – n/N</td><td>0/40</td><td>0/40</td></tr>
<tr><td>Blood loss (mL) – mean (SD)</td><td>54 (54)</td><td>38 (44)</td></tr>
<tr><td>Thermal comfort (VAS 0-100) – mean (SD)</td><td>51 (6)</td><td>56 (11)</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site / wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Research Fund of the Department of Anaesthesiology and Pain Therapy, Bern University Hospital, Switzerland. Thermocouples were donated by Mallinckrodt Anesthesiology Products, Inc., St. Louis, MO, and the Hot Dog system was donated by Augustine Biomedical Products, Eden Prairie, MN.</td></tr>
<tr><td>Comments</td><td>No concerns over risk of bias</td></tr>
</table>

(a) Values estimated from line graph; SD's / confidence intervals not presented for interval measurements taken during surgery.

1 Calcaterra 2009

Bibliographic reference	**Calcaterra D., Ricci M., Lombardi P., et al. (2009) Reduction of postoperative hypothermia with a new warming device: a prospective randomized study in off-pump coronary artery surgery. Journal of Cardiovascular Surgery 50: 813-817**
Study type	RCT (investigator-blinded)
Aim	To demonstrate the effectiveness of a warming pads system in controlled core body temperature in those undergoing off-pump coronary artery bypass graft
Patient characteristics	Intraoperative General anaesthesia Inclusion; off-pump coronary artery bypass graft Exclusion; History of bleeding problems, anti-platelet drugs within 76hrs prior to surgery, pregnancy, conversion to on-pump surgery, intra-aortic balloon pump placement
Number of Patients	N=50
Interventions and comparisons	Forced air warming (Bair Hugger); Set to 38ºC N=25 Warming pads (Kimberley Clark), throughout procedure, removed at the end of surgery Set to 37ºC N=25 Operating room temperature 36ºC for both groups
Length of follow up	Not applicable
Location	USA
Results	

Patient characteristics:

	Forced air warming N=25	Warming pads N=25
Age in years– mean (SD)	61.7 (10.4)	62.7 (9.9)
Gender – male/female	16/9	14/11

Results:

	Forced air warming N = 25	Warming pads N = 25
Core temp at end of surgery ºC – mean (SD)	34.7 (0.9)	36.1 (0.4)
Number hypothermic* (<35 ºC) - n/N	5/25	0/25

<table>
<tr><th>Bibliographic reference</th><th>Calcaterra D., Ricci M., Lombardi P., et al. (2009) Reduction of postoperative hypothermia with a new warming device: a prospective randomized study in off-pump coronary artery surgery. Journal of Cardiovascular Surgery 50: 813-817</th></tr>
<tr><td></td><td>
<table>
<tr><td>Core temp during surgery ºC</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Adverse effects of active warming – n/N</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss (mL) – mean (SD)</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection – n/N</td><td>1/25</td><td>0/25</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion – n/N</td><td>12/25</td><td>13/25</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days) – mean (SD)</td><td>7.2 (2.3)</td><td>6 .0 (1.2)</td></tr>
</table>
*Reported as ‘during the operation’</td></tr>
<tr><td>Source of funding</td><td>Grant from Kimberly-Clark Inc</td></tr>
<tr><td>Comments</td><td>No concerns over risk of bias</td></tr>
</table>

Egan 2011

Bibliographic reference	**Egan C, Bernstein E, Reddy D et al. (2011) A randomized comparison of intraoperative Perfectemp and forced air warming during open abdominal surgery. Anesthesia and Analgesia 113: 1076-81**
Study type	RCT (open-label, random blocked computer-generated codes, opaque envelopes)
Aim	To consider intraoperative temperatures with underbody resistive warming and upper body forced air warming
Patient characteristics	Intraoperative General anaesthesia Inclusion; - major open abdominal surgery (liver, pancreas, gynaecological, colorectal), 2 centres, operating time ≥2hrs - BMI <36kg/m2, age 18 to 75yrs, ASA I to III, June to September 2010

<table>
<tr><th>Bibliographic reference</th><th>Egan C, Bernstein E, Reddy D et al. (2011) A randomized comparison of intraoperative Perfectemp and forced air warming during open abdominal surgery. Anesthesia and Analgesia 113: 1076-81</th></tr>
<tr><td></td><td>Exclusion;
- major open abdominal surgery (liver, pancreas, gynaecological, colorectal), 2 centres, operating time ≥2hrs
<table>
<tr><th></th><th>FA warming
N=34</th><th>Resistive warming
N=36</th></tr>
<tr><td>Age – mean (SD)</td><td>51 (13)</td><td>51 (15),</td></tr>
<tr><td>Gender – male/female</td><td>10/24</td><td>15/19</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N=70</td></tr>
<tr><td>Interventions and comparisons</td><td>Forced air warming (Bair Hugger, Arizant Medical Inc, Eden Prairie, USA), upper body; activated as soon as practical induction of anaesthesia; Set to 43ºC N=34

Resistive heating (PerfecTemp, LMA, San Diego, USA), underbody, entire torso; about 15mins before entering operating room; Set to 40ºC N=36
Rescue warming with forced air if <35ºC

Operating room temperature maintained near 20ºC
Warming discontinued if core temp >37ºC</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>USA</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Forced air warming n = 34</th><th>Resistive heating mattress n = 36</th></tr>
<tr><td>Core temp at end of surgery ºC – mean (95% CI)</td><td>36.6 (36.4 to 36.8)</td><td>36.3 (36.0 to 36.5)</td></tr>
<tr><td>Number hypothermic at end of surgery - n/N</td><td>4/34</td><td>15/36</td></tr>
<tr><td>Core temp during surgery ºC – mean (SD): [a]
- 30 mins
- 60 mins
- 90 mins</td><td>
36.06 (0.59) (n=30)
35.95 (0.59) (n=30)
36.00 (0.59) (n=31)</td><td>
35.85 (0.53) (n=33)
35.90 (0.55) (n=32)
36.13 (0.57) (n=29)</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Bibliographic reference</th><th>Egan C, Bernstein E, Reddy D et al. (2011) A randomized comparison of intraoperative Perfectemp and forced air warming during open abdominal surgery. Anesthesia and Analgesia 113: 1076-81</th></tr>
<tr><td></td><td>
<table>
<tr><td>- 120 mins</td><td>36.08 (0.61) (n=25)</td><td>36.20 (0.65) (n=26)</td></tr>
<tr><td>Adverse effects of active warming – n/N</td><td>0/34</td><td>0/36</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days) – mean (SD)</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>LMA, Inc</td></tr>
<tr><td>Comments</td><td>Some concern over methodology with regard to use of rescue warming / target temp and so we are unable to use reported data on Core temp at end of surgery as some patients were switched to the other active warming if < 35 ºC as rescue warming was initiated. Also if temp reached 37 ºC then active warming devices were adjusted to maintain temp at 37 ºC.
Core temp during surgery was reported on a per protocol basis</td></tr>
</table>

(a) Values estimated from point graph

Fanelli 2009

Bibliographic reference	Fanelli A, Danelli G, Ghisi D et al. (2009) The efficacy of a resistive heating under patient blanket versus a forced air warming system: a randomized controlled trial. International Anesthesia Research Society 108: 199-201
Study type	RCT (open-label, randomisation via sealed envelope assignment based on computer generated list)
Aim	To compare temperature changes during patient warming with resistive heating blanket or forced air warming
Patient characteristics	Intraoperative Spinal block Inclusion;

<table>
<tr><td>**Bibliographic reference**</td><td>**Fanelli A, Danelli G, Ghisi D et al. (2009) The efficacy of a resistive heating under patient blanket versus a forced air warming system: a randomized controlled trial. International Anesthesia Research Society 108: 199-201**</td></tr>
<tr><td></td><td>
- major orthopaedic surgery (elective total hip replacement)
- aged 18-80yrs
- ASA physical status I-III
- anaesthesia duration >1 hr

Exclusion;
- neurological defects, history of head injury, thyroid disease, disturbance of autonomic function, severe cardiovascular and respiratory disease, perioperative temp ≥37.5ºC, current infection, use of steroids and vasoactive drugs
<table>
<tr><th></th><th>Forced Air warming
N=28</th><th>Resistive heating blanket
N=28</th></tr>
<tr><td>Age – mean (SD)</td><td>66 (13)</td><td>70 (10),</td></tr>
<tr><td>Gender – male/female</td><td>11/17</td><td>12/16</td></tr>
</table>
</td></tr>
<tr><td>**Number of Patients**</td><td>N=56</td></tr>
<tr><td>**Interventions and comparisons**</td><td>Forced air warming (Warm Touch, Covidien), applied to patient’s chest, abdomen and both arms, 27% of body surface; Set to 43ºC

Resistive heating blanket (DM-Warm 12, Diemme International, Italy), in direct contact with patient’s back, one arm and one leg, 31.5% of body surface; Set to 40.7ºC

No preoperative warming in either group , all IV fluids warmed
Operating room temperature, controlled laminar air flow temperature set at 21ºC
Duration of surgery; forced air warming 88±31mins, resistive heating 90±24mins, p=0.33</td></tr>
<tr><td>**Length of follow up**</td><td>Not applicable</td></tr>
<tr><td>**Location**</td><td>Italy</td></tr>
<tr><td>**Results**</td><td>
<table>
<tr><th></th><th>Forced air warming
N=28</th><th>Resistive heating blanket N=28</th></tr>
<tr><td>Core temp at end of surgery ºC – mean</td><td>35.5 (0.7)</td><td>35.3 (0.7)</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	**Fanelli A, Danelli G, Ghisi D et al. (2009) The efficacy of a resistive heating under patient blanket versus a forced air warming system: a randomized controlled trial. International Anesthesia Research Society 108: 199-201**

(SD)		
Number hypothermic – n/N	Not reported	Not reported
Core temp during surgery ºC[a] - mean (SD) - 30 mins - 60 mins - 90 mins - 120 mins	 35.89 (35.67 to 36.14) 35.58 (35.34 to 35.84) 35.43 (35.16 to 35.70) 35.28 (35.02 to 35.57)	 35.86 (35.64 to 36.09) 35.59 (35.36 to 35.83) 35.29 (35.01 to 35.58) 35.21 (34.91 to 35.52)
Adverse effects of active warming* - n/N	0/28	0/28
Blood loss (mL)/24 hours – mean (SD)	378 (183)	364 (141)
Thermal comfort	Not reported	Not reported
Shivering	Not reported	Not reported
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

*Reported as ‘burns’

Source of funding	Supported by the University of Parma, Italy
Comments	To detect a difference of 0.3ºC in final tympanic core temperature, assuming SD of 0.4ºC, significance 0.05, sample size needed for each group was 28 Infrared temperature used in all analyses

(a) Values estimated from point graph

Hasegawa 2012

Bibliographic reference	**Hasegawa K, Negishi C, Nakagawa F et al (2012) Core temperature during major abdominal surgery in patients warmed with new circulating water garment, forced air warming, or carbon fibre resistive heating system. Journal of Anesthesia 26: 168-73**

Bibliographic reference	**Hasegawa K, Negishi C, Nakagawa F et al (2012) Core temperature during major abdominal surgery in patients warmed with new circulating water garment, forced air warming, or carbon fibre resistive heating system. Journal of Anesthesia 26: 168-73**
Study type	RCT (open-label, computer generated randomisation)
Aim	To consider the efficacy of the combination of circulating water garment and mattress to forced air warming and carbon fibre resistive heating during major abdominal surgery
Patient characteristics	Intraoperative General + continuous epidural anaesthesia Inclusion; Elective major abdominal surgery, general anaesthesia combined with epidural analgesia, ASA I or II, aged 20 to 80yrs Exclusion; Preoperative fever, current infection, thyroid disease, dysautonomia
Number of Patients	N=36
Interventions and comparisons	Forced air warming (Bair Hugger, Arizant Healthcare, UK), lower body, covering approx. 15 to 20% of the skin surface; Set to high Circulating water garment, leg wraps (Rapr-Round Body Wraps, Gaymar Industries, New York) and a full length water circulating mattress (Gaymar), covering approx. 30% of the skin surface; Set to 42 ºC Carbon fibre resistive heating blanket (SmartCare, Geratherm Medical AG, Germany), covering approx. 15 to 20% of the skin surface Set to 42 ºC All warmers started at induction of general anaesthesia and maintained throughout surgery. All fluids warmed during surgery to 35-37 ºC
Length of follow up	Not applicable
Location	Japan
Results	

Patient characteristics:

	Forced air warming N=12	Resistive heating N=12	Circulating water garment N = 12
Age – mean (SD)	63 (13)	64 (10)	59 (10)
Gender – male/female	8/4	6/6	7/5

Bibliographic reference	**Hasegawa K, Negishi C, Nakagawa F et al (2012) Core temperature during major abdominal surgery in patients warmed with new circulating water garment, forced air warming, or carbon fibre resistive heating system. Journal of Anesthesia 26: 168-73**

	Forced-air warming N=12	Resistive heating blanket N = 12	Circulating water heating pads N=12
Core temp at end of surgery ºC	36.2 (0.9)	36.0 (0.6)	36.9 (0.7)
Number hypothermic at end of surgery	Not reported	Not reported	Not reported
Core temp during surgery °C – mean (SD) [a]			
• 30 minutes	35.95 (NE)	35.90 (0.47)	36.04 (NE)
• 60 minutes	35.76 (0.44)	35.75 (0.45)	35.98 (0.42)
• 90 minutes	35.70 (0.47)	35.75 (0.46)	36.12 (0.49)
• 120 minutes	35.80 (NE)	35.76 (0.54)	36.35 (0.54)
Adverse effects of active warming	0/12	0/12	0/12
Blood loss	Not reported	Not reported	Not reported
Thermal comfort	Not reported	Not reported	Not reported
Shivering	Not reported	Not reported	Not reported
Cardiac events	Not reported	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported	Not reported
Pain	Not reported	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported	Not reported
Length of time in recovery	Not reported	Not reported	Not reported
Delayed healing	Not reported	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported	Not reported

Source of funding	Not reported
Comments	To detect a clinically important difference of 1.0ºC in core temperature among the groups, SD of 0.7 ºC, power of 0.7, significance 0.05, sample size needed for each group was 12 No concerns over risk of bias

(a) Values estimated from graph

Hofer 2005

Bibliographic reference	**Hofer CK, Worn M, Tavakoli R, et al. (2005) Influence of body core temperature on blood loss and transfusion requirements during off-pump coronary artery bypass grafting: A comparison of 3 warming systems, Journal of Thoracic and Cardiovascular Surgery, 129, 838-843**
Study type	RCT (open-label, computer generated randomisation list)
Aim	To evaluate the efficacy of the intraoperative warming systems on maintaining normothermia, effects on perioperative bleeding, transfusion requirements, and costs
Patient characteristics	Intraoperative General anaesthesia Inclusion; - Elective multiple OPCABG (off-pump technique for coronary artery bypass grafting) - Preserved left ventricular function, absence of platelet glycoprotein inhibitor therapy, exclusion of pre-existing coagulation disorders, preoperative haematocrit ≥30% - Preoperative normothermia Baseline characteristics <table><tr><td></td><td>Forced air warming N=29</td><td>Resistive heating blanket N=30</td><td>Circulating water garment N = 29</td></tr><tr><td>Age – mean (SD)</td><td>66.3 (10.9)</td><td>64.4 (10.7)</td><td>65.6 (11.8)</td></tr><tr><td>Gender – male/female</td><td>25/4</td><td>24/6</td><td>23/6</td></tr></table>
Number of Patients	N=90 (2 excluded after randomisation due to conversion to cardiopulmonary bypass during the operation)
Interventions and comparisons	Forced air warming (Warm-Touch system, Mallinckrodt Inc, St Louis, USA); Set to 42ºC Resistive heating electric carbon blankets (Thermamed SmartCare OP system, Medeqco, Bad Oeynhausen, Germany) Set to 42ºC Disposable circulating-water garment (Allon 2001 system, MTRE Advanced Technologies Ltd, OrAkiva Industrial Park, Israel) Set to 36.7ºC body core temperature Operating room temperature maintained at 22.2ºC±0.9ºC Intraoperative fluid warmer used for transfusions for all patients

<table>
<tr><th>Bibliographic reference</th><th>Hofer CK, Worn M, Tavakoli R, et al. (2005) Influence of body core temperature on blood loss and transfusion requirements during off-pump coronary artery bypass grafting: A comparison of 3 warming systems, Journal of Thoracic and Cardiovascular Surgery, 129, 838-843</th></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>Switzerland</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Forced air warming, N=29</th><th>Resistive heating blanket, N=30</th><th>Circulating-water garment, N=29</th></tr>
<tr><td>Core temp at end of surgery ºC – mean (SD)</td><td>34.7 (0.9)</td><td>35.6 (0.8)</td><td>36.5 (0.4)</td></tr>
<tr><td>Number hypothermic at end of surgery</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Core temp during surgery ºC – mean (SD)</td><td></td><td></td><td></td></tr>
<tr><td>• 30 minutes</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>• 60 minutes</td><td>35.2 (0.5)</td><td>35.4 (0.5)</td><td>36.0 (0.6)</td></tr>
<tr><td>• 90 minutes</td><td>35.0 (0.7)</td><td>35.3 (0.6)</td><td>36.1 (0.5)</td></tr>
<tr><td>• 120 minutes</td><td>34.8 (0.6)</td><td>35.2 (0.8)</td><td>36.2 (0.5)</td></tr>
<tr><td>Adverse effects of active warming* – n/N</td><td>0/29</td><td>0/30</td><td>0/29</td></tr>
<tr><td>Blood loss - perioperative (mL) - mean (SD)</td><td>2683 (1049)</td><td>2300 (788)</td><td>1497 (497)</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection – n/N</td><td>1/29</td><td>1/30</td><td>0/29</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>14/29</td><td>12/30</td><td>6/29</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
</table>
*Reported as ‘burns or decubitus’</td></tr>
<tr><td>Source of funding</td><td>No financial support from manufacturers or pharmaceutical industry, material support from Soma Pharma AG, Switzerland for the Thermamed and by Homedica AG Switzerland/MTRE Advanced Technologies Ltd, Israel for the Allon 2001</td></tr>
<tr><td>Comments</td><td>No concerns over risk of bias
Core temperature measured rectally.</td></tr>
</table>

[1] <Insert Note here>

Hynson 1992

<table>
<tr><th>Bibliographic reference</th><th>Hynson J, Sessler D. (1992) Intraoperative warming therapies: a comparison of three devices. Journal of Clinical Anesthesia, 4: 194-9.</th></tr>
<tr><td>Study type</td><td>RCT (open-label; prospective controlled trial; randomisation by alternation)</td></tr>
<tr><td>Aim</td><td>To compare the effectiveness of three commonly used intraoperative warming devices (circulating water blanket, heated humidifier, forced air warming)</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion:
- Patients undergoing kidney transplantation for end-stage renal disease

Exclusion:
- Obesity (≥150% of ideal bodyweight)
- Peripheral vascular disease
- Limb amputation
- Preoperative infection or fever

Demographic characteristics
<table>
<tr><th></th><th>Forced-air warming N=5</th><th>Circulating water blanket N=5</th><th>Heated humidifier N=5</th><th>Control N=5</th></tr>
<tr><td>Age – mean (SD)</td><td>45 (13)</td><td>39 (9)</td><td>37 (7)</td><td>48 (16)</td></tr>
<tr><td>Gender – male/female</td><td>3/2</td><td>2/3</td><td>0/5</td><td>2/5</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N=20</td></tr>
<tr><td>Interventions and comparisons</td><td>Forced air warmer (Bair Hugger) - lower body blanket covering legs to mid-thigh; set to 43 ºC after induction of anaesthesia

Circulating water blanket (Blanketrol 200HL, blanket #164) – full length, prewarmed to 40 ºC

Heated humidifier (Saratoga SCT) – servo-controlled inspired gas warmer and humidifier initiated after intubation; temperature set to 40 ºC (mean airway temperature was 38.6 ºC ±1.3 ºC)</td></tr>
</table>

Bibliographic reference	**Hynson J, Sessler D. (1992) Intraoperative warming therapies: a comparison of three devices. Journal of Clinical Anesthesia, 4: 194-9.**
	Control - no external warming or humidification. Intravenous fluids were warmed (37 ºC) for all patients; ambient room temperature was maintained near 20ºC. No passive heat and moisture exchangers were used in the breathing circuit. No significant differences between groups in tympanic membrane temperature at baseline (induction of anaesthesia)
Length of follow up	Not applicable
Location	USA (single centre)
Results	Results:

	Forced-air warming N=5	Circulating water blanket N=5	Heated humidifier N=5	Control N=5
Core temp at end of surgery ºC – mean change (SD)	-0.50 (0.40)	-1.20 (0.40)	Not reported	Not reported
Number hypothermic at end of surgery*	Not reported	Not reported	Not reported	Not reported
Core temp during surgery ºC reported as change – mean (SD) • 30 mins • 60 mins • 120 mins	Not reported -0.84 (0.36) -0.75 (0.36)	Not reported -0.87 (0.36) -1.14 (0.31)	Not reported	Not reported
Adverse effects of active warming	Not reported	Not reported	Not reported	Not reported
Blood loss	Not reported	Not reported	Not reported	Not reported
Thermal comfort	Not reported	Not reported	Not reported	Not reported
Shivering	Not reported	Not reported	Not reported	Not reported
Cardiac events	Not reported	Not reported	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported	Not reported	Not reported
Pain	Not reported	Not reported	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported	Not reported	Not reported
Length of time in recovery	Not reported	Not reported	Not reported	Not reported

Bibliographic reference	**Hynson J, Sessler D. (1992) Intraoperative warming therapies: a comparison of three devices. Journal of Clinical Anesthesia, 4: 194-9.**
	Delayed healing: Not reported / Not reported / Not reported / Not reported Length of hospital stay (days): Not reported / Not reported / Not reported / Not reported
Source of funding	Mon-a-Therm Inc. donated thermometers and thermocouples; Datex Capnomac anaesthesia monitor loaned by Datex Medical Instrumentation Inc.
Comments	Poor allocation concealment – patients assigned consecutively to the four groups (5 patients per group). Change in core temperature data taken from original guideline

Delayed healing	Not reported	Not reported	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported	Not reported	Not reported

(a) Values estimated from point graph; unclear if SDs are standard deviations of change.

Ihn 2008

Bibliographic reference	**Ihn CH., Joo JD., Chung HS., et al. (2008) Comparison of three warming devices for the prevention of core hypothermia and post-anaesthesia shivering. The Journal of International Medical Research 36: 923-931**
Study type	RCT (open-label)
Aim	To evaluate the efficacy in preventing a decrease in temperature during anaesthesia and post anaesthesia of forced air warming with a surgical access blanket compared forced air warming and with a circulating water mattress
Patient characteristics	Intraoperative General anaesthesia Inclusion; - total abdominal hysterectomy, ASA I or II Exclusion; - pre-operative fever, thyroid disease, seizure disorders, peripheral vascular disease, taking beta blockers Baseline characteristics

	Forced air warming N=30	Forced air warming with surgical access N=30	Circulating water mattress N = 30
Age – mean (SD)	59 (10)	63 (13)	64 (10)
Gender – male/female	0/30	0/30	0/30

Bibliographic reference	**Ihn CH., Joo JD., Chung HS., et al. (2008) Comparison of three warming devices for the prevention of core hypothermia and post-anaesthesia shivering. The Journal of International Medical Research 36: 923-931**
Number of Patients	N=90
Interventions and comparisons	Forced air warming with surgical access (Bair Hugger, no.570 blanket, no. 505 blower, Arizant Healthcare, Eden Prairie, USA), lower body, covering approx. 15 to 20% of the skin surface; Set to 43 ºC N=30 After induction of anaesthesia Forced air warming with upper body blanket (Bair Hugger, no.522 blanket, no. 505 blower, Arizant Healthcare, Eden Prairie, USA), covering approx. 30% of the skin surface; Set to 42 ºC N=30 After induction of anaesthesia Circulating water mattress (Cincinnati Subzero Products, Cincinnati, USA); Set to 41 ºC N=30 At induction of anaesthesia - All fluids warmed during surgery Operating room temperature 21 to 22ºC
Length of follow up	Not applicable
Location	Korea
Results	

	Forced-air warming with upper body blanket N=30	Forced air warming with surgical access blanket N=30	Circulating water mattress N=30
Core temp at end of surgery ºC	Not reported	Not reported	Not reported
Number hypothermic at end of surgery	Not reported	Not reported	Not reported
Core temperature during surgery* ºC – mean (SD) • 30 minutes • 60 minutes • 90 minutes • 120 minutes	 36.18 (NE) 35.84 (NE) 35.74 (NE) 35.61 (0.20)	 36.2 (NE) 35.98 (NE) 35.96 (NE) 35.98 (0.13)	 35.92 (NE) 35.53 (NE) 35.39 (NE) 35.25 (0.16)
Adverse effects of active warming	Not reported	Not reported	Not reported
Blood loss	Not reported	Not reported	Not reported
Thermal comfort	Not reported	Not reported	Not reported

Bibliographic reference	**Ihn CH., Joo JD., Chung HS., et al. (2008) Comparison of three warming devices for the prevention of core hypothermia and post-anaesthesia shivering. The Journal of International Medical Research 36: 923-931**

Shivering – n/N	6/30	5/30	14/30
Cardiac events	Not reported	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported	Not reported
Pain	Not reported	Not reported	Not reported
Requirement for blood transfusion – n/N	0/30	0/30	0/30
Length of time in recovery	Not reported	Not reported	Not reported
Delayed healing	Not reported	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported	Not reported

*****data extracted from graph , NE = not estimable from graph

Source of funding	Catholic Medical Center Research Foundation, Catholic University of Korea
Comments	Randomisation and allocation concealment procedures not described.

(a) Values estimated from point graph

Janicki 2001

Bibliographic reference	**Janicki PK, Higgins MS, Janssen J, et al. (2001) Comparison of two different temperature maintenance strategies during open abdominal surgery: upper body forced air warming versus whole body water garment. Anaesthesiology 95: 868-74**
Study type	RCT (open-label)
Aim	To compare perioperative temperature maintenance strategy using the new water garment with current methods to determine whether it provides most consistent maintenance of normothermia in those undergoing major abdominal surgery with general anaesthesia
Patient characterisas fartics	Intraoperative General anaesthesia Inclusion; - ASA class II to IV, open abdominal surgery – procedures with general anaesthesia lasting >120mins (from the time of incision) Exclusion; - Pregnancy, current fever, recent septic, burn injury, lumtiple traumatic injuries, abdominal procedures involving rectal manipulation, surgery in the lithotomy position Baseline characteristics

	Forced air warming	Circulating water

<table>
<tr><td>Bibliographic reference</td><td>Janicki PK, Higgins MS, Janssen J, et al. (2001) Comparison of two different temperature maintenance strategies during open abdominal surgery: upper body forced air warming versus whole body water garment. Anaesthesiology 95: 868-74</td></tr>
<tr><td></td><td><table>
<tr><td></td><td>N=28</td><td>garment
N = 25</td></tr>
<tr><td>Age – mean (SD)</td><td>52.9 (15)</td><td>56.1 (11.7)</td></tr>
<tr><td>Gender – male/female</td><td>16/12</td><td>13/12</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N=60 (7 excluded after randomisation due to shorter operation time or unplanned extension of surgery)</td></tr>
<tr><td>Interventions and comparisons</td><td>Forced air warming (Bair Hugger blanket model 552, Augustine, MN), upper body, 20 to 40% of body surface; Set to 43ºC

Circulating-water garment (Allon, MTRE Advanced Technologies, Or-Akiva, Israel), whole body garment, covered 70 to 80% of body surface; lower and upper extremities, upper anterior, lateral proportions of the chest, entire back Set to 36.8ºC Temperature is not constant normal oscillates between 34 and 18.5ºC (upper cut off 41ºC)

Warming started after induction of anaesthesia
All intravenous fluids warmed
Duration of surgery (mins); forced air warming (299±86) vs water garment (361±141)
Ambient operating room temperature (ºC); forced air warming (20.4±1.4) vs water garment (20.4±1.5)</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>USA</td></tr>
<tr><td>Results</td><td><table>
<tr><td></td><td>Forced air warming, N=28</td><td>Water garment, N=25</td></tr>
<tr><td>Core temp at end of surgery ºC – mean (SD)</td><td>36.4 (0.8)</td><td>36.9 (0.3)</td></tr>
<tr><td>Number hypothermic - n/N</td><td>6/28</td><td>0/25</td></tr>
<tr><td>Core temp during surgery, ºC – mean (SD)
• 30 minutes
• 60 minutes
• 120 minutes</td><td>
Not reported
35.9 (0.7)
Not reported</td><td>
Not reported
36.5 (0.3)
Not reported</td></tr>
<tr><td>Adverse effects of active warming** - n/N</td><td>0/28</td><td>0/25</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Bibliographic reference</th><th>Janicki PK, Higgins MS, Janssen J, et al. (2001) Comparison of two different temperature maintenance strategies during open abdominal surgery: upper body forced air warming versus whole body water garment. Anaesthesiology 95: 868-74</th></tr>
<tr><td></td><td>
<table>
<tr><td>Shivering – n/N</td><td>4/18</td><td>1/19</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr>
</table>
* reported as rectal or oesophageal temp <35.5ºC at surgical closing
**reported as ‘burns, redness’
</td></tr>
<tr><td>Source of funding</td><td>Not reported</td></tr>
<tr><td>Comments</td><td>No concerns over risk of bias
Clinically relevant difference 0.5ºC between groups, minimum sample size 44 needed, α 0.05</td></tr>
</table>

Janicki 2002

Bibliographic reference	**Janicki PK, Stoica C, Chapman WC, et al. (2002) Water warming garment versus forced air warming system in prevention of intraoperative hypothermia during liver transplantation: a randomized controlled trial. BMC Anesthesiology 2: 7**
Study type	RCT (open-label, computer generated randomisation list, concealed by keeping it with a nurse not taking direct part in perioperative care)
Aim	To compare perioperative maintenance of temperature using water warming garment or upper and lower body forced air warming in patient undergoing orthotopic liver transplantation (OTL)
Patient characteristics	Intraoperative General anaesthesia Inclusion; - 18 to 65years, OLT

Bibliographic reference	**Janicki PK, Stoica C, Chapman WC, et al. (2002) Water warming garment versus forced air warming system in prevention of intraoperative hypothermia during liver transplantation: a randomized controlled trial. BMC Anesthesiology 2: 7**
	Baseline characteristics
Number of Patients	N=24
Interventions and comparisons	Forced air warming (Bair Hugger Warming Unit Model 505, Augustine Medical) Set to 43 ºC Applied after the induction of anaesthesia, upper and lower body warming blankets, cover approx. 50 to 60% of total body surface Water warming garment Set to 36.8ºC Patient placed in the garment before induction of anaesthesia continued unitl transfer from operating room table at the end of surgery, covers 70 to 80% of total body surface Operating room temperature at 20ºC for 30mins before and throughout surgery All intraoperative fluids warmed in both groups Time difference between applying warming techniques, 48±16mins Length of operation (hrs); forced air warming (mean 7.3± SD 2.1) vs water garment 6.9±1.9, No significant difference between the groups
Length of follow up	Not applicable
Location	USA
Results	

Baseline characteristics

	Forced air warming N=12	Circulating water garment N = 12
Age – mean (SD)	49.8 (8)	51.1 (5)
Gender – male/female	7/5	6/6

Results

	Forced air warming, N=12	Water garment, N=12
Core temp at end of surgery ºC – mean (SD)	36.07 (0.4)	36.8 (0.1)
Number hypothermic at end of surgery	Not reported	Not reported
Core temperature during surgery, ºC – mean (SD) • 30 minutes • 60 minutes • 120 minutes	Not reported 36.1 (0.4) Not reported	Not reported 36.7 (0.2) Not reported
Adverse effects of active warming	Not reported	Not reported

Bibliographic reference	**Janicki PK, Stoica C, Chapman WC, et al. (2002) Water warming garment versus forced air warming system in prevention of intraoperative hypothermia during liver transplantation: a randomized controlled trial. BMC Anesthesiology 2: 7**
	Blood loss | Not reported | Not reported Thermal comfort | Not reported | Not reported Shivering | Not reported | Not reported Cardiac events | Not reported | Not reported Surgical site/ wound infection | Not reported | Not reported Pain | Not reported | Not reported Requirement for blood transfusion | Not reported | Not reported Length of time in recovery | Not reported | Not reported Delayed healing | Not reported | Not reported Length of hospital stay (days) | Not reported | Not reported
Source of funding	Unrestricted grant from MTRE Advanced Technologies Ltd, Or-Akiva, Israel
Comments	No concerns over risk of bias Null hypothesis – that there is no difference between the groups for the primary outcome, sample size of 24 needed to detect a clinically relevant 0.5ºC difference between the groups, α 0.05

1

2 **John 2015**

Bibliographic reference	**John M, Crook D, Dasari K et al. (2015) Comparison of resistive heating and forced-air warming to prevent inadvertent perioperative hypothermia. British Journal of Anaesthesia. 2016 116 p.249-54**
Study type	RCT, single blind.
Aim	To compare the efficacy of carbon- polymer mattress (posterior forced air warming) with FAW banket (anterior FAW) in preventing IPH patients undergoing non- emergency surgery
Patient characteristics	General anaesthetic Intraoperative warming only Initially undertook a pilot study with n=40. Then recruited a further 120 patients. Mixed surgery; included gynaecological, general, maxillofacial, ENT, vascular, breast, urology, orthopaedics. Inclusion;

<table>
<tr><td>Bibliographic reference</td><td>John M, Crook D, Dasari K et al. (2015) Comparison of resistive heating and forced-air warming to prevent inadvertent perioperative hypothermia. British Journal of Anaesthesia. 2016 116 p.249-54</td></tr>
<tr><td></td><td>Patients undergoing elective surgery under general anaesthesia.

Exclusion
Patients less than 18 years of age or presenting as an emergency.

<table>
<tr><td>Variable</td><td>Forced air warming N=78</td><td>Resistive heating mattress N = 81</td></tr>
<tr><td>Age – mean (range)</td><td>54 (21-89)</td><td>55 (18-93)</td></tr>
<tr><td>Gender – male/female</td><td>23/55</td><td>17/64</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N=160</td></tr>
<tr><td>Interventions and comparisons</td><td>Forced air-warming (Bair Hugger 750, Actamed, UK) Set to maximal setting (43ºC). Warming started immediately after surgical draping.

Resistive heating mattress Inditherm;(inspiration healthcare, Rotherham, UK). Set to maximal setting of 40ºC. Warming started as soon as patient positioned on the operating table.

General anaesthesia induced i.v and maintained with inhaled volatile agents in all patients. All patients received warmed fluids, operating theatre temperature maintained between 20-22ºC.
Warming continued until the end of the operation.
Pre induction and recovery room temperature obtained from all patients using a temporal artery thermometer.
After induction of anaesthesia, temperature measured with oesophageal core temperature, immediately after induction and every 15 mins for 1^{st} hour, then every 30 minutes thereafter until the end of surgery.</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>UK</td></tr>
<tr><td>Results</td><td>Primary outcome;
<table>
<tr><td></td><td>Forced air warming n = 78</td><td>Resistive heating mattress n = 81</td></tr>
<tr><td>Core temp at end of surgery ºC – mean (SD)</td><td>36.1 (0.5)</td><td>35.9 (0.6)</td></tr>
<tr><td>Number hypothermic at any time - n/N</td><td>44/78</td><td>50/81</td></tr>
<tr><td>Core temp during surgery ºC</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**John M, Crook D, Dasari K et al. (2015) Comparison of resistive heating and forced-air warming to prevent inadvertent perioperative hypothermia. British Journal of Anaesthesia. 2016 116 p.249-54**

Blood loss (L) – median (IQR)	0.1 (0-0.2[0-1])	0.1 (0.05-0.3[0-1.1])
Thermal comfort	Not reported	Not reported
Shivering	Not reported	Not reported
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion – n/N	0/78	2/81
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

Source of funding	No funding declared
Comments	No concerns over risk of bias Calculated that a total sample of 120 patients required to show non-inferiority. Randomised via computer generated codes. 1 person excluded from resistive heating group due to excessive surgical bleeding (>5 L of blood) Blood loss volumes were estimations Unable to blind treatment groups Type of FAW blanket not standardised.

Kadam 2009

Bibliographic reference	**Kadam VR, Moyes D, Moran JL. (2009) Relative efficiency of two warming devices during laparoscopic cholecystectomy, Anaesthesia & Intensive Care, 37, 464-8**
Study type	RCT
Aim	To evaluate the efficacy of radiant warming compared to forced air warming during elective laparoscopic cholecystectomy.
Patient characteristics	Intraoperative General anaesthesia Inclusion; Patients aged 18-75 years, presenting for elective laparoscopic cholecystectomy, where surgical procedure expected to take>60 minutes.

Bibliographic reference	**Kadam VR, Moyes D, Moran JL. (2009) Relative efficiency of two warming devices during laparoscopic cholecystectomy, Anaesthesia & Intensive Care, 37, 464-8**
	Exclusion Patients requiring emergency or open cholecystectomy and who were on antipyretic medication, history of malignant hyperthermia or preoperative temperature of either >37.5ºC or <35.5 ºC Demographics (mean, SD), no significant differences in baseline demographics;

Variable	Forced air warming n = 15	Radiant warming n = 14
Age- mean (SD)	40.9 (15.0)	39.0(10.1)
Gender – male/female	7/7	9/6

Number of Patients	N=30 1 patient from group 2 withdrew
Interventions and comparisons	Forced air warming: Warm-touch (Tyco healthcare, Mallinckrodt medical, USA). N=15 Wrap placed on upper body and fixed in position with tape. warm touch set at 46 ºC Radiant warming: Sun touch radiant warmer model PW820 AEA (Fisher & Paykel, NZ). N=14 Warming started after induction of anaesthesia.. Device was placed 40cm above the head. Skin temperature sensor placed on patients forehead. Warmer set to 41 ºC as per manufacturers recommendations for adults. The warmer reduces its power once the set skin temperature is reached. IV fluids warmed in all groups. Oesophageal probe used to measure core temperature, measured before commencement of surgery, at T15 and thereafter measured every 15 minutes until the end of the procedure. Ambient temperature Forced air warming 20.7 (1.9) vs radiant warming 19.9 (1.7) Surgical time – Forced air warming 90 (60-180) vs radiant warming 90 (90-150)
Length of follow up	Not applicable
Location	Australia
Results	Primary outcome; Postoperative complications:

	Forced air warming N = 15	Radiant warming N = 14
Core temp at end of surgery ºC	Not reported	Not reported

<table>
<tr><th>Bibliographic reference</th><th>Kadam VR, Moyes D, Moran JL. (2009) Relative efficiency of two warming devices during laparoscopic cholecystectomy, Anaesthesia & Intensive Care, 37, 464-8</th></tr>
<tr><td></td><td>
<table>
<tr><td>Number hypothermic (post-operatively)</td><td>2/13</td><td>3/10</td></tr>
<tr><td>Core temp during surgery ºC – mean (SD)
• 30 mins
• 60 mins
• 90 mins
• 120 mins</td><td>
Not reported
Not reported
36.2 (0.44)
Not reported</td><td>
Not reported
Not reported
35.9 (0.29)
Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td></td></tr>
<tr><td>Comments</td><td>Perioperative hypothermia was considered a temperature below 36 ºC; temperature measure on immediate arrival into the emergency room.
Randomisation performed via closed opaque envelope system and numbered cards (1 or 2) indicating which group the patient was assigned to.
Not clear when warming started in Group 1</td></tr>
</table>

Kim 2014

Bibliographic reference	Kim HY, Lee KC, Lee MJ et al. (2014) Comparison of the efficacy of a forced-air warming system and circulating-water mattress on core temperature and post-anaesthesia shivering in elderly patients undergoing total knee arthroplasty under spinal anesthesia. Korean Journal of Anesthesiology 66(5): 352-7
Study type	RCT (open-label, randomisation method not reported)

Bibliographic reference	**Kim HY, Lee KC, Lee MJ et al. (2014) Comparison of the efficacy of a forced-air warming system and circulating-water mattress on core temperature and post-anaesthesia shivering in elderly patients undergoing total knee arthroplasty under spinal anesthesia. Korean Journal of Anesthesiology 66(5): 352-7**
Aim	To evaluate the efficacy of a forced air-warming system versus a circulating-water mattress in preventing a decrease in core temperature and post-anaesthesia shivering in elderly patients during spinal anaesthesia for total knee arthroplasty
Patient characteristics	Intraoperative Spinal anaesthesia Inclusion: - Patients with American Society of Anaesthesiologists physical status of I-III - Aged 65 years and above - Scheduled for elective total knee arthroplasty under spinal anaesthesia Exclusion: - History of head injury - Thyroid disease - Severe cardiovascular and respiratory disease - Core temperature of ≥37.5 ºC - Any contraindications to regional anaesthesia Baseline characteristics: <table><tr><th></th><th>Forced-air warming (n=23)</th><th>Circulating-water mattress (n=23)</th></tr><tr><td>Age – mean (SD)</td><td>75.8 (4)</td><td>73.1 (3.9)</td></tr><tr><td>Gender – male/female</td><td>8/15</td><td>7/16</td></tr></table>
Number of Patients	N=46; 23* in forced air warming arm; 23 in circulating-water mattress arm *Sample size and power calculations revealed that 23 patients in each group would be required to indicate a 0.5 ºC difference in core temperature between both groups with a SD of 0.6 ºC.
Interventions and comparisons	Forced-air warming system (Bair Hugger warming unit-Model 505, Arizant Healthcare, Eden Prairie, USA) The blanket was applied after the induction of anaesthesia; the blanket was attached with tape at the level of the umbilicus; the blower was set at a high level (43 ºC).

Bibliographic reference	**Kim HY, Lee KC, Lee MJ et al. (2014) Comparison of the efficacy of a forced-air warming system and circulating-water mattress on core temperature and post-anaesthesia shivering in elderly patients undergoing total knee arthroplasty under spinal anesthesia. Korean Journal of Anesthesiology 66(5): 352-7**
	Circulating-water mattress (Blanketrol II, Cincinnati Sub-Zero, Cincinnati, USA) Circulating-water mattress was placed on the operating table and warming started 10 minutes before patients were transferred to the operating table The temperature of the circulating-water mattress was set at maximum (41ºC) An infrared tympanic thermometer (Instant Thermometer HM3, Braun) was used to measure the temperature of patients in both groups First tympanic temperature was measured immediately after transfer to the operating table After performing spinal anaesthesia, a rectal thermistor temperature probe was inserted 10-12cm above the anal sphincter and temperature was monitored continuously until the end of anaesthesia. First rectal temperature was recorded every 5 minutes after initial equilibration. During the perioperative period, the ambient temperature was maintained at 21 to 23ºC in the operating room and at 24-26 ºC in the recovering room. All intravenous fluids were warmed to 37 ºC with an infusion warmer.
Length of follow up	Not applicable
Location	Korea
Results	

	Forced-air warming (n=23)	Circulating-water mattress (n=23)
Core temp at end of surgery ºC	Not reported	Not reported
Number hypothermic at end of surgery*	Not reported	Not reported
Core temp during surgery ºC – mean (SD) [a] • 30 mins • 60 mins • 120 mins	 36.47 (0.39) 36.50 (0.38) 36.63 (0.37)	 36.50 (0.33) 36.56 (0.32) 36.63 (0.33)
Adverse effects of active warming	Not reported	Not reported
Blood loss	Not reported	Not reported
Verbal Analogue Scale (VAS) for thermal comfort, mean (SD)	5.0 (0.5)	4.0 (0.7)
Shivering	3/23	10/23
Cardiac events* - n/N	0/23	2/23
Surgical site/ wound infection	Not reported	Not reported

<table>
<tr><td>Bibliographic reference</td><td>Kim HY, Lee KC, Lee MJ et al. (2014) Comparison of the efficacy of a forced-air warming system and circulating-water mattress on core temperature and post-anaesthesia shivering in elderly patients undergoing total knee arthroplasty under spinal anesthesia. Korean Journal of Anesthesiology 66(5): 352-7</td></tr>
<tr><td></td><td>
<table>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr>
</table>

*Reported as ‘Bradycardia’</td></tr>
<tr><td>Source of funding</td><td>Konkuk University</td></tr>
<tr><td>Comments</td><td>No concerns over risk of bias</td></tr>
</table>

(a) Values estimated from point graph

Kurz (1993)

<table>
<tr><td>Bibliographic reference</td><td>Kurz A, Kurz M, Poeschl G, Faryniak B, Redl G, Hackl W. (1993) Forced-air warming maintains intraoperative normothermia better than circulating-water mattresses. Anesthesia and Analgesia, 77: 89-95.</td></tr>
<tr><td>Study type</td><td>RCT (open-label)</td></tr>
<tr><td>Aim</td><td>To compared forced-air warming with circulating water-mattresses in (a) adults undergoing long operations requiring large incisions; (b) adults with approximately 25% of body surface area available for warming; (c) infants undergoing maxillofacial surgery, and (d) young children undergoing orthopaedic surgery.</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion:
- adults undergoing major maxillofacial surgery (N=16)
- adults undergoing hip arthroplasty with approx.. 25% body surface area available for warming (N=53)
- infants undergoing minor maxillofacial surgery for cleft palate / lip repair (N=20)
- young children undergoing pelvic or femoral osteotomies (N=10)

Exclusion:
History of fever, thyroid disease, dysautonomia, Raynaud’s syndrome, or malignant hyperthermia.

Patient age in years – mean (SD):
<table>
<tr><td></td><td>Forced-air warming</td><td>Circulating water blanket</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Bibliographic reference</th><th>Kurz A, Kurz M, Poeschl G, Faryniak B, Redl G, Hackl W. (1993) Forced-air warming maintains intraoperative normothermia better than circulating-water mattresses. Anesthesia and Analgesia, 77: 89-95.</th></tr>
<tr><td></td><td>
<table>
<tr><td>Adult – maxillofacial surgery</td><td>56yrs (8)
n=8</td><td>60 (4)
n=8</td></tr>
<tr><td>Adult – orthopaedic surgery</td><td>50 (22)
n=25</td><td>54 (18)
n=28</td></tr>
<tr><td>Paediatric – maxillofacial surgery</td><td>5 (3)
n=10</td><td>4 (3)
n=10</td></tr>
<tr><td>Paediatric – orthopaedic surgery</td><td>2.9 (0.6)
n=5</td><td>2.8 (1.0)
n=5</td></tr>
</table>
Gender not reported.
No difference between treatment groups in height or weight for any type of surgery.
</td></tr>
<tr><td>Number of Patients</td><td>N_1=16; N_2 = 53; N_3 =20; N_4 = 10</td></tr>
<tr><td>Interventions and comparisons</td><td>
Forced-air warming (Bair Hugger, model 500) – temperature set to ‘high’, 40 ºC; applied directly to skin surface. Temperature was decreased in patients whose core temperatures exceeded 36.5-37.0ºC.
- Adult maxillofacial patients – lower-body covers placed over legs (approx. 36% body surface area); surgery lasted ≥12hrs in all patients; temperature decreased from ‘high’ to ‘medium’ in all patients after approx. 7 hours following induction of anaesthesia when rectal temperature exceeded 36.5 ºC
- Adult orthopaedic patients – upper body covers over one arm, shoulders and top portion of chest (approx.. 25% body surface area); surgery lasted ≥3 hours in all patients
- Infant maxillofacial – disposable, tube-shaped paediatric covers positioned around lateral aspects with warm air supply at the feet; temperature decreased from ‘high’ to ‘medium’ in all patients 112 ±13 mins after induction of anaesthesia, when core temperatures reached 37 ºC
- Paediatric orthopaedic – disposable, tube-shaped paediatric covers positioned around lateral aspects with warm air supply at the head; temperature decreased from ‘high’ to ‘medium’ in 4 of 5 patients 128 ±9 mins after induction of anaesthesia, when core temperatures reached 37 ºC

○ Circulating-water mattress – full length (Aquatic module, Hamilton Inc.) – measured temperature of 40 ºC. Single cotton sheet separated adult patients from the water mattress.
- Adult maxillofacial patients –Approx. 35% body surface area contact;
- Adult orthopaedic patients –Approx. 25-30% body surface area contact;
- Infant maxillofacial –not described
- Paediatric orthopaedic – not described.
</td></tr>
</table>

Bibliographic reference	**Kurz A, Kurz M, Poeschl G, Faryniak B, Redl G, Hackl W. (1993) Forced-air warming maintains intraoperative normothermia better than circulating-water mattresses. Anesthesia and Analgesia, 77: 89-95.**
	Active warming with assigned device started immediately after induction of anaesthesia. Operating room temperature was maintained around 21 ºC. IV fluids were heated to 37 ºC for all adult patients but not heated for paediatric patients. Inspired gases were not actively warmed and heat and moisture exchangers were avoided.
Length of follow up	Not applicable
Location	Austria
Results	Results:

	Forced-air warming (n=8)	Circulating-water mattress (n=8)
Core temp at end of surgery ºC	Not reported	Not reported
Number hypothermic at en	Not reported	Not reported
Core temperature during surgery, ºC – mean (SD)		
• 30 mins	Not reported	Not reported
• 60 mins	36.1 (0.1)	36.4 (0.2)
• 120 mins	36.2 (NE)	36.2 (NE)
Adverse effects of active warming	Not reported	Not reported
Blood loss	Not reported	Not reported
Thermal comfort	Not reported	Not reported
Shivering	Not reported	Not reported
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

- Adult maxillofacial patients: measured with rectal probe inserted 10cm

NE – not estimable from graph; NR – not reported

Bibliographic reference	**Kurz A, Kurz M, Poeschl G, Faryniak B, Redl G, Hackl W. (1993) Forced-air warming maintains intraoperative normothermia better than circulating-water mattresses. Anesthesia and Analgesia, 77: 89-95.**
	- Infant maxillofacial: measured with rectal probe inserted 5cm (table A below) Statistically significant difference between groups after 75 mins of anaesthesia: mean core temperature higher in patients warmed with forced-air - Paediatric orthopaedic – measured via distal third of oesophagus (table B below) NR – not reported Statistically significant difference between groups after 90 mins of anaesthesia: mean core temperature higher in patients warmed with forced-air
Source of funding	Supported by Augustine Medical Inc. (manufacturers of Bair Hugger forced-air warming device)
Comments	Adult and paediatric patients having each type of surgery were randomly assigned to the two treatment groups. Randomisation and group allocation procedures not described. Adult data used in all analyses

- Infant maxillofacial: measured with rectal probe inserted 5cm

Time from induction of anaesthesia	**Forced-air warming (n=10)**	**Circulating-water mattress (n=10)**
30 mins	36.3 (0.3)	36.4 (0.2)
60 mins	36.4 (1.8)	36.35 (0.3)
90 mins	36.75 (0.16)	36.33 (0.4)
120 mins	37.2 (0.2)	36.3 (0.5)

- Paediatric orthopaedic – measured via distal third of oesophagus

Time from induction of anaesthesia	**Forced-air warming (n=5)**	**Circulating-water mattress (n=5)**
30 mins	36.15 (NR)	36.25 (NR)
60 mins	35.97 (NR)	36.10 (NR)
90 mins	36.25 (NR)	35.86 (NR)
120 mins	36.82 (NR)	35.74 (NR)

(a) Values estimated from point graphs

Lee 2004

Bibliographic reference	**Lee L, Leslie K, Kayak E et al. (2004) Intraoperative patient warming using radiant warming or forced-air warming during long operations. Anaesthesia & Intensive Care 32: 358-61**

Bibliographic reference	**Lee L, Leslie K, Kayak E et al. (2004) Intraoperative patient warming using radiant warming or forced-air warming during long operations. Anaesthesia & Intensive Care 32: 358-61**
Study type	RCT (single-blind (patients), using random number tables)
Aim	To evaluate radiant warming compared with forced air warming in patients having operations more than 2hours
Patient characteristics	Intraoperative General / spinal/ other anaesthesia Inclusion; - 18 to 80years, elective or emergency non-cardiac surgical patients with duration of anaesthesia anticipated to be >2hours Exclusion; - Not expected to be extubated at the end of surgery, deliberate induction of core hypothermia, intention to use a major regional blockade, intention to use tourniquets in the upper limbs - Core temperature ≥37.5ºC Baseline characteristics:
Number of Patients	N=60 (N=1 recruited in error, data removed from the analysis)
Interventions and comparisons	Forced air warming (Bair Hugger, Augustine Medical); Warming immediately after induction of anaesthesia and ceased if core temperature reached 36.5ºC Mean ambient temperature in the operating room, ºC, 21.5±1.1, compared with the intervention, p=0.30 Radiant warming, directed at the palm of the hand (Suntouch, Fisher and Paykel). Warming immediately after induction of anaesthesia and ceased if core temperature reached 36.5ºC Mean ambient temperature in the operating room, ºC, 22.1±1.0 Duration of surgery (min); radiant warming (median 130, range 45 to 248), forced air warming (median 133, range 52 to 620)
Length of follow up	Not applicable
Location	Australia
Results	Results;

Baseline characteristics (Patient characteristics):

	Forced-air warming n=29	Circulating-water mattress n=30
Age – mean (SD)	56 (15)	53 (27)
Gender – male/female	19/10	13/17

Bibliographic reference	**Lee L, Leslie K, Kayak E et al. (2004) Intraoperative patient warming using radiant warming or forced-air warming during long operations. Anaesthesia & Intensive Care 32: 358-61**

	Forced air warming, N=29	Radiant warming, N=30
Core temp at end of surgery ºC – mean (SD)	36.4 (0.6)	36.0 (0.5)
Number hypothermic during surgery – n/N	8/29	11/30
Core temperature over time, ºC – mean (95% CIs)		
• 30 mins	36.03 (35.85 to 36.20)	35.89 (35.71 to 36.07)
• 60 mins	36.05 (35.91 to 36.25)	35.92 (35.72 to 36.05)
• 90 mins	36.15 (35.96 to 36.34)	35.94 (35.74 to 36.10)
• 120 mins	36.25 (36.07 to 36.44)	35.95 (35.73 to 36.11)
Adverse effects of active warming - n/N	0/29	0/30
Blood loss	Not reported	Not reported
Thermal comfort (0 – 100) – mean (SD)	49 (5)	48 (14)
Shivering – n/N	1/29	2/30
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

Source of funding	Grant from Fisher and Paykel
Comments	Sample size 28 in each group to detect clinically important difference of 0.3ºC in final core temperature, α0.05, SD 0.4ºC Data on number hypothermic taken from original guideline

(a) Values estimated from point graph

Leung 2007

Bibliographic reference	**Leung KK, Lai A, Wu A. (2007) A randomised controlled trial of the electric heating pad vs forced-air warming for preventing hypothermia during laparotomy. Anaesthesia 62: 605-608**

Bibliographic reference	**Leung KK, Lai A, Wu A. (2007) A randomised controlled trial of the electric heating pad vs forced-air warming for preventing hypothermia during laparotomy. Anaesthesia 62: 605-608**
Study type	RCT (open-label, computer generated randomisation list)
Aim	To compare upper body forced-air warming and the electric heating pad, during laparotomy
Patient characteristics	Intraoperative General Inclusion; - 18 to 80years, ASA physical status I to III - elective laparotomy Exclusion; - Pregnancy, core temperature ≥37.5ºC Baseline characteristics: <table><tr><td></td><td>Forced-air warming N = 30</td><td>Electric heating pad N = 30</td></tr><tr><td>Age – mean (SD)</td><td>66.1 (10)</td><td>64.1 (12)</td></tr><tr><td>Gender – male/female</td><td>19/11</td><td>20/10</td></tr></table>
Number of Patients	N=60
Interventions and comparisons	Forced air warming (Bair Hugger, model 500, Augustine Medical, USA); Set to 43ºC. Covering anterior chest, both arms Electric heating pad (Opermtherm 202, KanMed, Sweden); 104x45cm pad Operating room temperature maintained at 20±1ºC Fluid warmer used for transfusions for all patients Warming started after induction of general anaesthesia and continued to the end of surgery Warming was stopped at any time when nasopharyngeal temperature >37ºC Duration of anaesthesia (mins); forced air warming, mean 293 (SD113); heating pad (279 (150) Duration of surgery (mins); forced air warming, mean 271 (SD113); heating pad (258 (148)
Length of follow up	Not applicable
Location	China
Results	Results;

Bibliographic reference	**Leung KK, Lai A, Wu A. (2007) A randomised controlled trial of the electric heating pad vs forced-air warming for preventing hypothermia during laparotomy. Anaesthesia 62: 605-608**

	Forced air warming, N=30	Electric heating pad, N=30
Core temp at end of surgery ºC	36.2 (0.4)	35.2 (1.0)
Number hypothermic (final measurement) – n/N	15/30	19/30
Core temperature during surgery ºC	Not reported	Not reported
Adverse effects of active warming	Not reported	Not reported
Blood loss – mean (SD)	617.1 (521.0)	509.6 (497.3)
Thermal comfort (VAS 0 – 100) – mean)SD)	5.05 (0.8)	4.96 (0.2)
Shivering – n/N	2/30	2/30
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

Source of funding	Not reported
Comments	Assuming clinically important difference of 0.3ºC in final core temperature, 28 required in each group, α0.05,

(a) Values estimated from point graph

Matsuzaki 2003

Bibliographic reference	**Matsuzaki Y, Matsukawa T, Ohki K, et al. (2003) Warming by resistive heating maintains perioperative normothermia as well as forced air heating. British Journal of Anaesthesia 90: 689-91**
Study type	RCT (open-label, randomisation via computer generated codes, kept in opaque envelopes until after induction of anaesthesia)
Aim	To compare core body temperature using circulating water mattress, forced air warmers or resistive heating during laparoscopic cholecystectomy
Patient characteristics	Intraoperative General anaesthesia

Bibliographic reference	**Matsuzaki Y, Matsukawa T, Ohki K, et al. (2003) Warming by resistive heating maintains perioperative normothermia as well as forced air heating. British Journal of Anaesthesia 90: 689-91**
	Inclusion; - 20 to 80 years, ASA I or II Exclusion; - Preoperative fever, current infection, thyroid disease, disturbance of autonomic function Baseline characteristics:
Number of Patients	N=24
Interventions and comparisons	Forced air warming, upper body cover (WarmTouch, Tyco-Mallinckrodt Anaesthesiology Products, St Louis, USA) Set to medium Started after induction of general anaesthesia Circulating water mattress, full length (Blanketroll, CSZ, Cincinnati, USA) Set to 38ºC Started after induction of general anaesthesia Carbon-fibre resistive heating blanket, covered both arms, chest and both legs (SmartCare OP System, Thermamed, Bad Oeynhausen, Germany) Set to 38ºC Started after induction of general anaesthesia Operating room temperature kept near 22ºC All intraoperative fluids warmed Initial core temperatures were near 36.6ºC to 36.9ºC, NS difference between the groups Operating time: Forced air warming 98 (13) Circulating water mattress 101 (20) Resistive heating blanket 106 (24)
Length of follow up	Not applicable
Location	Japan
Results	Results;

Baseline characteristics:

	Forced-air warming N = 8	Resistive heating blanket N = 8	Circulating-water mattress N = 8
Age – mean (range)	59 (41 – 73)	48 (312 - 71)	57 (36 – 77)
Gender – male/female	4/4	6/2	5/3

Results;

	Forced air warming,	Circulating water mattress	Resistive heating blanket

Bibliographic reference	**Matsuzaki Y, Matsukawa T, Ohki K, et al. (2003) Warming by resistive heating maintains perioperative normothermia as well as forced air heating. British Journal of Anaesthesia 90: 689-91**			
		N=8	N=8	N=8
	Core temp at end of surgery ºC – mean (SD)	36.8 (0.4)	36.2 (0.4)	36.7 (0.5)
	Number hypothermic at end of surgery	Not reported	Not reported	Not reported
	Core temperature during surgery - ºC	Not reported	Not reported	Not reported
	Adverse effects of active warming – n/N	0/8	0/8	0/8
	Blood loss	Not reported	Not reported	Not reported
	Thermal comfort	Not reported	Not reported	Not reported
	Shivering	Not reported	Not reported	Not reported
	Cardiac events	Not reported	Not reported	Not reported
	Surgical site/ wound infection	Not reported	Not reported	Not reported
	Pain	Not reported	Not reported	Not reported
	Requirement for blood transfusion	Not reported	Not reported	Not reported
	Length of time in recovery	Not reported	Not reported	Not reported
	Delayed healing	Not reported	Not reported	Not reported
	Length of hospital stay (days)	Not reported	Not reported	Not reported
Source of funding	Not reported			
Comments	No concerns over risk of bias			

1 *(a) Values estimated from point graph*

2

3 Negishi 2003

Bibliographic reference	**Negishi C, Hasegawa K, Mukai S, et al. (2003) Resistive-heating and forced-air warming are comparably effective. Anesthesia & Analgesia 96: 1683-7**
Study type	RCT (open-label, randomisation on computer-generated codes, maintained in sequentially numbered opaque envelopes until just before the induction of anaesthesia)
Aim	To evaluate the efficacy of resistive heating, by comparing core temperature changes during major abdominal surgery
Patient characteristics	Intraoperative General anaesthesia

Bibliographic reference

Negishi C, Hasegawa K, Mukai S, et al. (2003) Resistive-heating and forced-air warming are comparably effective. Anesthesia & Analgesia 96: 1683-7

Inclusion;

- Elective open abdominal surgery, 20 to 80years, ASA physical status I or II

Exclusion;

- Current infection, thyroid disease, dysautonomia

Baseline characteristics:

	Forced-air warming N = 8	Resistive heating blanket N = 8	Circulating-water mattress N = 8
Age – mean (SD)	62 (12)	66 (11)	59 (9)
Gender – male/female	5/3	5/3	5/3

Number of Patients

N=24

Interventions and comparisons

Forced air warming (Bair Hugger, Augustine Medical Inc, MN), lower body Temperature set to ‘high’

Circulating water mattress (Meditherm, Gaymar Industries, NY), full length; Set to 42ºC 5mm pad between mattress and patient to reduce the risk of burns

Resistive heating blanket (SmartCare OP, Thermamed GmbH, Bad Oeynhausen, Germany), full length; Set to 42ºC Covered one arm, the chest, both legs

All warmers started just before the induction of general anaesthesia and maintained throughout surgery

Duration of surgery; average 240mins; water mattress, 208±51; forced air warming, 248±96; resistive heating blanket, 253±69

Length of follow up

Not applicable

Location

USA

Results

	Forced air warming N=8	Circulating water mattress N=8	Resistive heating blanket N=8
Core temp at end of surgery ºC	36.2 (1.0)	34.9 (0.9)	36.0 (0.6)
Number hypothermic at end of surgery	Not reported	Not reported	Not reported
Core temperature during surgery ºC – mean			

<table>
<tr><th>Bibliographic reference</th><th>Negishi C, Hasegawa K, Mukai S, et al. (2003) Resistive-heating and forced-air warming are comparably effective. Anesthesia & Analgesia 96: 1683-7</th></tr>
<tr><td></td><td>
<table>
<tr><td>change (SD)</td><td></td><td></td><td></td></tr>
<tr><td>• 30 mins</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>• 60 mins</td><td>-1.1 (0.6)</td><td>-1.4 (0.4)</td><td>-0.9 (0.3)</td></tr>
<tr><td>• 90 mins</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>• 120 mins</td><td>-1.0 (0.6)</td><td>-1.9 (0.5)</td><td>-0.8 (0.2)</td></tr>
<tr><td>Adverse effects of active warming – n/N</td><td>0/8</td><td>0/8</td><td>0/8</td></tr>
<tr><td>Blood loss (mL x kg^{-1}) – mean (SD)</td><td>12 (16)</td><td>12 (9)</td><td>7 (8)</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Supported by Thermamed GmbH, National Institutes of Health Grant, the Joseph Drown Foundation, the Commonwealth of Kentucky Research Challenge Trust Fund</td></tr>
<tr><td>Comments</td><td>None</td></tr>
</table>

(a) Values estimated from point graph

Ng 2006

Bibliographic reference	**Ng V, Lai A, Ho V. (2006) Comparison of forced-air warming and electric heating pad for maintenance of body temperature during total knee replacement. Anaesthesia 61: 110-1104**
Study type	RCT (open-label, drawing lots)
Aim	To compare forced air warming and the electric heating pad during total knee replacement
Patient characteristics	Intraoperative Combined spinal epidural

Bibliographic reference	**Ng V, Lai A, Ho V. (2006) Comparison of forced-air warming and electric heating pad for maintenance of body temperature during total knee replacement. Anaesthesia 61: 110-1104**
	Inclusion; - Elective total knee replacement, 18 to 80years, ASA physical status I to III, combined spinal epidural anaesthesia Exclusion; - Pregnancy, history of head injury, core temperature ≥37.5ºC, contra-indication to neuraxial blockade Baseline characteristics:
Number of Patients	N=60
Interventions and comparisons	Forced air warming (Bair Hugger, Augustine Medical, model 500/OR, MN), to cover anterior chest, both arms; Set to 43ºC Electric heating pad (Operatherm 202, KanMed, Bromma, Sweden), 104x45cm Set to 39ºC Operating room temperature maintained at 20ºC±1ºC Intraoperative fluid warmer used for transfusions for all patients Warming started 10mins before patients were transferred to the operating table Duration of anaesthesia (mins); forced air warming 125.3 (15.1) vs heating pad 126.2 (17.2) Duration of surgery (mins); forced air warming 89.3 (12.6) vs heating pad 90.9 (13.8)
Length of follow up	Not applicable
Location	China
Results	Results;

Baseline characteristics:

	Forced-air warming N = 30	Electric heating pad N = 30
Age – mean (SD)	67.3 (9.1)	67.4 (7.4)
Gender – male/female	9/21	8/22

Results;

	Forced air warming N=30	Electric heating pad N=30
Core temp –final tympanic ºC – mean (SD)	36.3 (0.5)	36.1 (0.7)
Number hypothermic at end of surgery – n/N	0/30	0/30

<table>
<tr><td>Bibliographic reference</td><td>Ng V, Lai A, Ho V. (2006) Comparison of forced-air warming and electric heating pad for maintenance of body temperature during total knee replacement. Anaesthesia 61: 110-1104</td></tr>
<tr><td></td><td>
<table>
<tr><td>Core temp during surgery °C – mean (SD)
• 30 mins
• 60 mins
• 120 mins</td><td>36.55 (0.77)
35.67 (0.87)
Not reported</td><td>36.7 (0.42)
46.84 (0.52)
Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss (mL) – mean (SD)</td><td>100.0 (41.5)</td><td>103.3 (34.6)</td></tr>
<tr><td>Thermal comfort – mean (SD)</td><td>8.3 (1.8)</td><td>8.4 (1.9)</td></tr>
<tr><td>Shivering</td><td>2/30</td><td>1/30</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Not reported</td></tr>
<tr><td>Comments</td><td>Clinically important difference of 0.3°C in final core temperature, power analysis 28 patients needed in each group
Rectal temperature used in all analyses</td></tr>
</table>

(a) Values estimated from point graph

Ruetzler 2011

Bibliographic reference	**Ruetzler K, Kovaci B, Guloglu E et al. (2011) Forced-air and a novel patient-warming system (vitalHEAT vH^2) comparably maintain normothermia during open abdominal surgery. Anesthesia and analgesia 112(3): 608-14**
Study type	RCT (open-label, randomisation based on computer generated codes maintained in sequentially numbered opaque envelopes.
Aim	To test the hypothesis that intraoperative distal oesophageal (core) temperatures are not >0.5 °C lower during elective open abdominal surgery under general anaesthesia in patients warmed with the warm-water sleeve on 1 arm than with an upper-body forced-air cover.

Bibliographic reference	**Ruetzler K, Kovaci B, Guloglu E et al. (2011) Forced-air and a novel patient-warming system (vitalHEAT vH^2) comparably maintain normothermia during open abdominal surgery. Anesthesia and analgesia 112(3): 608-14**
Patient characteristics	Intraoperative General anaesthetic Inclusion: - Body mass index 20 to 36kg/m^2 - Age 18 to 75 years - ASA physical status 1 to 3 Exclusion: - Patients requiring bilateral vascular catheters distal to the elbow - Serious skin lesions on the hands or arms - History of vascular conditions including Reynaud's syndrome - Preoperative fever - Contraindication to sevoflurane endotracheal anaesthesia - Pre-existing neuropathy Baseline characteristics:
Number of Patients	N=71; 37 in circulating water sleeve and 34 in forced air group
Interventions and comparisons	Forced-air warming - Bair Hugger upper body forced air cover was positioned over the upper body and exposed arms, set to high which is ~43 ºC, Warmer activated as soon as practical, usually after prepping and draping Circulating-water sleeve (vitalHeat) - Hand and forearm without an IV or arterial catheter was inserted into the warming sleeve, Warming activated as soon as practical after induction of anaesthesia, Cotton blankets were used to avoid any contact between the heating elements and the side of the body, In the initial patients, the heater was set to 42 ºC with 10mmHg vacuum, Protocol modified after 1 warm-water sleeve patient received second-degree

Baseline characteristics:

	Forced air warming (n=34)	Circulating water garment (sleeve) (n=37)
Age in years	50.3 (15.2)	48 (15.5)
Gender – male//female	18/16	23/14

Bibliographic reference	**Ruetzler K, Kovaci B, Guloglu E et al. (2011) Forced-air and a novel patient-warming system (vitalHEAT vH^2) comparably maintain normothermia during open abdominal surgery. Anesthesia and analgesia 112(3): 608-14**
	burns after a 10-hour surgery and another patient experienced several small blisters – the temperature for the remaining patients were set to 41 ºC In both groups, ambient temperature was maintained near 20ºC. A thermometer incorporated into a stethoscope was positioned in the distal oesophagus. Temperature measurements from 15 minutes after intubation until the end of the case were used for analysis.
Length of follow up	Not applicable
Location	Austria
Results	

	Forced air warming n=34	Circulating water garment (sleeve) n=37
Core temp at end of surgery ºC	Not reported	Not reported
Number hypothermic (≤ 35.0) at any time – n/N	4/34	3/37
Core temperature during surgery ºC - mean (SE)		
• 30 mins	Not reported	Not reported
• 60 mins	35.87 (0.085), n=34	35.96 (0.081), n=37
• 120 mins	36.09 (0.086), n=32	36.06 (0.084), n=31
• 180 mins	36.37 (0.087), n=29	36.16 (0.087), n=26
• 240 mins	36.46 (0.094), n=20	36.25 (0.094), n=18
Adverse effects of active warming* – n/N	0/34	2/37
Blood loss	Not reported	Not reported
Thermal comfort	Not reported	Not reported
Shivering	Not reported	Not reported
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported

Bibliographic reference	**Ruetzler K, Kovaci B, Guloglu E et al. (2011) Forced-air and a novel patient-warming system (vitalHEAT vH^2) comparably maintain normothermia during open abdominal surgery. Anesthesia and analgesia 112(3): 608-14**
	Delayed healing – Not reported – Not reported Length of hospital stay (days) – Not reported – Not reported *reported as 'burns'
Source of funding	Supported by Dynatherm Medical
Comments	No concerns over risk of bias

Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

*reported as 'burns'

1

2 **Russell 1995**

Bibliographic reference	**Russell SH, Freeman JW. (1995) Prevention of hypothermia during orthotopic liver transplantation: comparison of three different intraoperative warming methods. British Journal of Anaesthesia 74: 415-418**
Study type	RCT (open-label, system of sealed envelopes)
Aim	To compare an electric under mattress, warm air under mattress and forced air warming during orthotopic liver transplantation
Patient characteristics	Intraoperative General anaesthetic Inclusion; - Orthotopic liver transplantation, May 1992 to August 1993 Exclusion; - Fulminant liver disease, previous upper abdominal surgery Baseline characteristics:
Number of Patients	N=60

Baseline characteristics:

	Forced air warming (under blanket) N = 20	Forced air warming (over blanket) N = 20	Electric blanket N = 20(n=37)
Age – mean (range)	46.8 (18 to 65)	44.7 (20 to 66)	45.9 (19 to 68)
Gender – male//female	10/10	9/11	10/10

Bibliographic reference	**Russell SH, Freeman JW. (1995) Prevention of hypothermia during orthotopic liver transplantation: comparison of three different intraoperative warming methods. British Journal of Anaesthesia 74: 415-418**
Interventions and comparisons	Electric under blanket (JAW Medical), modified to facilitate surgery by cutting a hole in the abdomen, covered both legs, one arm, sides of the abdomen and thorax; Set to 39ºC, cut-out at 41ºC Forced air under blanket (Howarth); Set to 40ºC, alarms if exceeds 41.5ºC Forced air over blanket (MallinkrodtHowarth); Set to high, 42 to 48ºC, automatically resets to medium 36 to 41.5ºC after 45mins Operating room temperature maintained at 21±1ºC Intraoperative fluid warmer used for transfusions for all fluids Duration of operation (mins); electric under blanket (mean 324, SD 49), forced air under blanket (348, 54), forced air over blanket (315, 58)
Length of follow up	Not applicable
Location	UK
Results	Results;

	Forced air warming (under blanket) N = 20	Forced air warming (over blanket) N = 20	Electric under blanket N = 20
Core temp at end of surgery ºC – mean (SD)	35.5 (0.23)	36.8 (0.3)	34.9 (0.4)
Number hypothermic at end of surgery*	Not reported	Not reported	Not reported
Core temp during surgery (Anhepatic phase) ºC – mean (SD)			
• 30 mins	35.4 (0.36)	35.9 (0.29)	35.3 (0.42)
• 60 mins	35.2 (0.4)	35.8 (0.33)	35.1 (0.32)
• 120 mins	Not reported	Not reported	Not reported
Adverse effects of active warming	0/20	0/20	0/20
Blood loss	Not reported	Not reported	Not reported
Thermal comfort	Not reported	Not reported	Not reported
Shivering	Not reported	Not reported	Not reported
Cardiac events	Not reported	Not reported	Not reported

Bibliographic reference	**Russell SH, Freeman JW. (1995) Prevention of hypothermia during orthotopic liver transplantation: comparison of three different intraoperative warming methods. British Journal of Anaesthesia 74: 415-418**			
	Surgical site/ wound infection	Not reported	Not reported	Not reported
	Pain	Not reported	Not reported	Not reported
	Requirement for blood transfusion	Not reported	Not reported	Not reported
	Length of time in recovery	Not reported	Not reported	Not reported
	Delayed healing	Not reported	Not reported	Not reported
	Length of hospital stay (days)	Not reported	Not reported	Not reported
Source of funding	Mallinkrodt Medical UK provided the Warm Touch warming units and blankets			
Comments	No concerns over risk of bias FAW arms pooled			

1

2 **Suraseranivongse 2009**

Bibliographic reference	**Suraseranivongse S, Pongraweewan O, Kongmuang B et al. (2009) A custom-made forced-air warming mattress for heat loss prevention during vascular surgery: Clinical evaluation, Asian Biomedicine, 3, 299-307**
Study type	RCT
Aim	To invent a custom made FAW mattress with 3 appendages covering both arms and to compare it efficacy with the circulating water mattress in prevention of heat loss during vascular surgery
Patient characteristics	General anaesthetic or general anaesthetic + regional Intraoperative warming Inclusion; Patients undergoing aortic surgery and revascularisation of lower extremities. ASA I-III Age range 31-88 years Duration of surgery at least 3 hours Exclusion Patient with preoperative fever, thyroid disease, dysautonomia or evidence of current infection Baseline characteristics

Bibliographic reference	**Suraseranivongse S, Pongraweewan O, Kongmuang B et al. (2009) A custom-made forced-air warming mattress for heat loss prevention during vascular surgery: Clinical evaluation, Asian Biomedicine, 3, 299-307**

	Forced air warming N = 22	Circulating water mattress N = 22
Age – mean (SD)	69.32 (14.32)	68.68 (12.99)
Gender – male/female	13/9	16/6

Number of Patients	44
Interventions and comparisons	Forced air warming mattress (FWM), n=22 Warming with a full length custom made, reusable forced air warming mattress (covered arms and chest). Heated forced air from a Warm Touch 5900 (Tyco-Mallinckrodt Anaesthesiology product, USA). Set to 43ºC. Circulating water mattress (CWM), n=22 Warming with a full length circulating water mattress set to 38ºC with 2 surgical sheets on top to prevent heat- burn (Gaymar, Meditherm Hyper/Hypothermia, USA) Measurement started after induction of anaesthesia and continued at 30 minute intervals. Mean skin temperature calculated from temperatures recorded at chest, arm and thigh. Core temperature monitored using a mid-oesophageal thermistor. Rescue procedure: FAW device if core temperature <35ºC
Length of follow up	Not applicable
Location	Thailand
Results	

	Forced air warming (n=22)	Circulating water mattress (n=22)
Core temp at end of surgery ºC	Not reported	Not reported
Number hypothermic at end of surgery (< 35 ºC) – n/N	6/22	11/22
Core temperature during surgery ºC	Not usable	Not usable
Adverse effects of active warming* - n/N	0/22	4/22
Blood loss – Median (IQR)	275 (188 – 1400)	360 (150 – 938)
Thermal comfort	Not reported	Not reported
Shivering	Not reported	Not reported
Cardiac events	Not reported	Not reported

Bibliographic reference	**Suraseranivongse S, Pongraweewan O, Kongmuang B et al. (2009) A custom-made forced-air warming mattress for heat loss prevention during vascular surgery: Clinical evaluation, Asian Biomedicine, 3, 299-307**
	<table><tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr><tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr><tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr><tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr><tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr><tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr></table>*reported as ‘burns’
Source of funding	Siriraj Research Development Fund : financial support
Comments	Block randomisation based on random number table kept in sequential number opaque envelopes, opened by investigator after final enrolment of the patient. Stratified by type of surgery (aortic vs revascularisation of lower extremities) and type of anaesthesia (general or general + epidural). Blinding of investigator not possible. Analysis based on different temperature of 0.6ºC between FWM and CWM from a previous study in abdominal operation, SD of 1 a=0.05, power=80% and sample size estimation of 22 per group Each group treated by ITT analysis. Unable to use temperature at different time-points as rescue warming used if core temp < 35

Tanaka 2013

Bibliographic reference	**Tanaka N, Ohno Y, Hori M et al. (2013) A randomised controlled trial of the resistive heating blanket versus the convective warming system for preventing hypothermia during major abdominal surgery, Journal of Perioperative Practice, 23, 82-6**
Study type	RCT, non- inferiority trial
Aim	To compare resistive heating with upper body convective warming in patients undergoing major abdominal surgery.
Patient characteristics	Epidural and general anaesthetic Intraoperative Inclusion; Expected operating time of at least 3 hours. BMI 20-36, age 20-80 years, ASA physical status I-III, surgery performed in supine position

Bibliographic reference	**Tanaka N, Ohno Y, Hori M et al. (2013) A randomised controlled trial of the resistive heating blanket versus the convective warming system for preventing hypothermia during major abdominal surgery, Journal of Perioperative Practice, 23, 82-6**
	Exclusion Evidence of current infection, preoperative core temperature of ≥37.5ºC, history of malignant hyperthermia, thyroid disease, dysautonomia, use of vasoactive drugs. Baseline characteristics
Number of Patients	70 (6 were excluded)
Interventions and comparisons	Forced air warming (FAW); Bair Hugger, Arizant healthcare, USA). Output set to 43ºC Resistive heating blanket (SmartCare: Geratherm Medical, Germany) Set to 42ºC All patients positioned supine. Cotton blanket folded into 2 layers and the intervention placed between the 2 layers. The blanket was applied to patients anterior chest and arms. The systems was started after the induction of anaesthesia and their use continued unti the end of surgery. Operating room temperature set to 22-24ºC and relative humidity of 40% Core temperature measured by oesophageal probe. Measurements started after induction of anaesthesia and continued at 15 minute intervals throughout surgery. No premedication or prewarming
Length of follow up	NA
Location	Japan
Results	

Baseline characteristics

	Forced air warming N = 33	Resistive heating blanket N = 31
Age – mean (SD)	55.52 (13.23)	60.85 (13.35)
Gender – male/female	7/26	10/21

Results

	Forced air warming N = 33	Resistive heating blanket N = 31
Core temp at end of surgery ºC – mean (SD)	36.3 (0.38)	36.23 (0.44)
Number hypothermic at end of surgery	Not reported	Not reported
Core temperature during surgery - ºC (mean, SD) • 30 mins	Not reported	Not reported

<table>
<tr><th>Bibliographic reference</th><th>Tanaka N, Ohno Y, Hori M et al. (2013) A randomised controlled trial of the resistive heating blanket versus the convective warming system for preventing hypothermia during major abdominal surgery, Journal of Perioperative Practice, 23, 82-6</th></tr>
<tr><td></td><td>
<table>
<tr><td>• 60 mins
• 120 mins
• 180 mins</td><td>35.87 (0.32)
35.93 (0.35)
36.13 (0.32)</td><td>35.93 (0.38)
35.93 (0.42)
36.05 (0.43)</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss – mean (SD)</td><td>869.3 (613.7)</td><td>1084.9 (728.8)</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Not reported</td></tr>
<tr><td>Comments</td><td>Randomisation code produced by a statistician, block sixes of 4. Stratified by operative site, with equal allocation ratio. Opaque, sealed envelopes provided to each trial site. To enrol a patient an independent nurse opened the next consecutively numbered envelope.
Calculated a sample size of 62 patients would yield a power of 90% to establish whether RH was inferior to CW, with expected SD for intraoperative core temperature of 0.6ºC, a non-inferiority margin of 0.5ºC.
6 patients were excluded: RH=2, CW=4. Reasons provided for withdrawal and were adequate</td></tr>
</table>

Torrie 2005

Bibliographic reference	Torrie JJ, Yip P, Robinson E. (2005) Comparison of forced-air warming and radiant heating during transurethral prostatic resection under spinal anaesthesia. Anaesthesia and Intensive Care 33: 733-8
Study type	RCT (open-label, randomisation via random number tables, concealed in opaque envelopes)
Aim	To compare a radiant warming device with forced air warming in patients undergoing transurethral resection of the prostate under spinal anaesthesia
Patient characteristics	Intraoperative

Bibliographic reference	**Torrie JJ, Yip P, Robinson E. (2005) Comparison of forced-air warming and radiant heating during transurethral prostatic resection under spinal anaesthesia. Anaesthesia and Intensive Care 33: 733-8**
	Spinal anaesthesia Inclusion; September 2002 to April 2004 - Elective TURP, subarchnoid block Exclusion; - <55years or >90years, thyroid dysfunction, <50kg or >120kg, ASA physical status >III - Indwelling urinary catheter or urinary tract infection, core temperature ≥37.5ºC Baseline characteristics
Number of Patients	N=60 (4 of those initially randomised data not included)
Intervention and comparison	Forced air warming (Bair Hugger, Augustine Medical, MN, USA), upper body; Set to 43ºC Radiant warming device (Suntouch, Fisher and Paykel, Auckland, New Zealand), directed on the patient's face Set to 41ºC Operating room mean temperature; forced air warming (22.0±1.1ºC), radiant warming (21.9±1.1ºC) Intravenous and irrigation fluids warmed for all patients Anaesthesia duration (mins); forced air warming 50 (20 to 100), radiant heating 56 (20 to 110)
Length of follow up	NA
Location	New Zealand
Results	Primary outcomes; body core temperature (recorded via rectally) Other outcomes; hypothermia, thermal comfort, shivering

Baseline characteristics

	Forced air warming N = 32	Radiant heating N = 28
Age – mean (SD)	73 (9)	72 (7)
Gender – male/female	32/0	28/0

	Forced air warming, N=32	Radiant heating, N=28
Core temp at end of surgery ºC – mean (SD)	36.4 (0.6)	36.1 (0.5)

<table>
<tr><th>Bibliographic reference</th><th>Torrie JJ, Yip P, Robinson E. (2005) Comparison of forced-air warming and radiant heating during transurethral prostatic resection under spinal anaesthesia. Anaesthesia and Intensive Care 33: 733-8</th></tr>
<tr><td></td><td>
<table>
<tr><td>Number hypothermic at end of surgery*</td><td>10/31</td><td>12/26</td></tr>
<tr><td>Core temp during surgery ºC – mean (SD)
• 30 mins
• 60 mins
• 120 mins</td><td>Not reported
36.3 (0.5)
Not reported</td><td>Not reported
36.3 (0.5)
Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>3/30</td><td>1/26</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Not reported</td></tr>
<tr><td>Comments</td><td>Clinically important difference 0.3ºC in rectal temperature, 28 needed in each group</td></tr>
</table>

Trentman 2009

Bibliographic reference	**Trentman TL, Weinmeister KP, Hentz JG et al. (2009) Randomized non-inferiority trial of the vitalHEAT temperature management system vs the Bair Hugger warmer during total knee arthroplasty, Canadian journal of anaesthesia = Journal canadien d'anesthésie, 56, 914-20**
Study type	RCT
Aim	To test the hypothesis that the vH$^{2\text{TM}}$ system not inferior to a FAW system during total knee arthroplasty surgery.
Patient characteristics	General anaesthetic Intraoperative Inclusion;

Bibliographic reference	**Trentman TL, Weinmeister KP, Hentz JG et al. (2009) Randomized non-inferiority trial of the vitalHEAT temperature management system vs the Bair Hugger warmer during total knee arthroplasty, Canadian journal of anaesthesia = Journal canadien d'anesthésie, 56, 914-20**
	ASA I-III ≤18 years old Scheduled for unilateral TKA Duration of surgery expected to be 2-3 hrs under planned general endotracheal anaesthetic. Exclusion Skin abrasions, trauma, allergic skin conditions of the upper extremities, history of peripheral vascular disease, malignant hyperthermia, MRSA. Patients were excluded after randomisation if they received a laryngeal mask airway device instead of an endotracheal tube, or people who specifically requested regional anaesthesia. Demographics (mean, SD) <table><tr><td></td><td>Forced air warming N N =25</td><td>Circulating water garment N=30</td></tr><tr><td>Age – mean (SD)</td><td>67.0 (9.4)</td><td>68.9 (11.4</td></tr><tr><td>Gender – male/female</td><td>12/13</td><td>12/18</td></tr></table>
Number of Patients	55
Interventions and comparisons	Forced air warming (FAW), Bair Hugger,(n=30, 5 excluded, reasons provided) When patient transferred to the operating room table, the Bair Hugger upper body blanket was applied to the patient's body. And covered with one cotton blanket. Bair Hugger set at 43ºC and the patients head was covered with a clear head drape which is an integral part of the FAW system. circulating water garment, (CWG),vH^{2TM} system (n=36, 6 excluded, reasons provided) When patient transferred to the operating room, before the induction of anaesthesia, the vH^{2TM} warming sleeve was applied to one of the patients hands/forearms and secured. The vH^{2TM} system was activated to a ≤42ºC fluid temperature at the skin surface. A clear plastic drape was placed over the patients head and neck in a manner similar to the placement of the Bair hugger head wrap. Cotton blanket placed over patients arms and upper chest. Core temperature measured with oesophageal probe. Temperature measured every 15 minutes during operation.
Length of follow up	Not applicable
Location	USA

<table>
<tr><th>Bibliographic reference</th><th>Trentman TL, Weinmeister KP, Hentz JG et al. (2009) Randomized non-inferiority trial of the vitalHEAT temperature management system vs the Bair Hugger warmer during total knee arthroplasty, Canadian journal of anaesthesia = Journal canadien d'anesthésie, 56, 914-20</th></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Forced air warming N = 25</th><th>Circulating water garment n = 30</th></tr>
<tr><td>Core temp at end of surgery ºC –n/N</td><td>36.73 (0.29)</td><td>36.38 (0.38)</td></tr>
<tr><td>Number hypothermic at end of surgery*</td><td>14/25</td><td>19/30</td></tr>
<tr><td>Core temperature during surgery ºC – mean (SD)</td><td></td><td></td></tr>
<tr><td>• 30 mins</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>• 60 mins</td><td>36.28 (0.32), 25</td><td>36.0 (0.52), 29</td></tr>
<tr><td>• 120 mins</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>0/25</td><td>0/30</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Financially supported by Dynatherm Medical, USA.</td></tr>
<tr><td>Comments</td><td>Randomisation in 1:1 ratio, randomisation schedule created by statistician by using computerised random number generator. Allocation concealment concealed by storing schedule on a randomisation website. Patient and clinical staff did not know the allocation until after the patient signed the informed consent to participate.
Non-inferiority margin defined as -0.5ºC, based on clinical judgement. Sample of 25 patient per group planned to achieve 80% power if the population difference between mean temperatures was 0.0ºC and the SD was 0.7 ºC.
For measures other than sublingual temperature in PACU, the full set and per protocol set were the same.</td></tr>
</table>

Wong 2004

<table>
<tr><td>Bibliographic reference</td><td>Wong A, Walker S, Bradley M. (2004) Comparison of a radiant patient warming device with forced air warming during laparoscopic cholecystectomy. Anaesthesia and Intensive Care 32: 93-99</td></tr>
<tr><td>Study type</td><td>RCT (random number tables)</td></tr>
<tr><td>Aim</td><td>To assess the efficacy of a new radiant warming device in maintaining intraoperative normothermia, with forced air warming as a control</td></tr>
<tr><td>Patient characteristics</td><td>Intraoperative
General anaesthetic

Inclusion;
- Laprascopic cholecystectomy, female, 20 to 60years, weight between 50 to 110kg
Exclusion;
- Pre-existing hyperpyrexia, history of malignant hyperthermia, currently taking antipyretic medication

Demographic characteristics:
<table>
<tr><th></th><th>Forced air warming N=21</th><th>Radiant heating N=21</th></tr>
<tr><td>Age in years – mean (SD)</td><td>40.5 (9.8)</td><td>38.1 (11.6)</td></tr>
<tr><td>Gender – male/female</td><td>0/21</td><td>0/21</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N=42</td></tr>
<tr><td>Interventions and comparisons</td><td>Forced air warming device (Bair Hugger, model 522, Augustine Medical, USA), covered arms, upper body and head; Set to 43ºC

Radiant warming device (SunTouch, model PW820, Fisher & Paykel Healthcare, NZ), positioned directly over the patient’s face, warmer skin temperature sensor attached to the forehead; Set to 41ºC

Mean operating room temperature; radiant warming 21.6±1.1ºC, forced air warming 22.2±1.2ºC
Duration of surgery (mins); radiant warming 66 (18), forced air warming 64 (17),</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>New Zealand</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Forced air warming N=21</th><th>Radiant heating N=21</th></tr>
</table></td></tr>
</table>

Bibliographic reference	**Wong A, Walker S, Bradley M. (2004) Comparison of a radiant patient warming device with forced air warming during laparoscopic cholecystectomy. Anaesthesia and Intensive Care 32: 93-99**		
	Core temp at end of surgery ºC	36.2 (0.4)	36.0 (0.4)
	Number hypothermic at end of surgery	Not reported	Not reported
	Core temp during surgery ºC	Not reported	Not reported
	Adverse effects of active warming	Not reported	Not reported
	Blood loss	Not reported	Not reported
	Thermal comfort	Not reported	Not reported
	Shivering	Not reported	Not reported
	Cardiac events	Not reported	Not reported
	Surgical site/ wound infection	Not reported	Not reported
	Pain	Not reported	Not reported
	Requirement for blood transfusion	Not reported	Not reported
	Length of time in recovery	Not reported	Not reported
	Delayed healing	Not reported	Not reported
	Length of hospital stay (days)	Not reported	Not reported
Source of funding	Fisher and Paykel Healthcare provided the Bair Hugger and SunTouch warming units and all temperature monitoring equipment		
Comments	Sample size of 20 needed in each group, assumed variance of 0.116 between start and end temperature in the 2 groups, significance 0.05, detectable difference of 0.1ºC		

G.2 Review question 2: Devices – Preoperative

Andrzejowski 2008

Bibliographic reference	**Andrzejowski J, Hoyle J, Eapen G et al (2008) Effect of prewarming on post-induction core temperature and the incidence of inadvertent perioperative hypothermia in patients undergoing general anaesthesia. British Journal of Anaesthesia 101: 627-31**
Study type	RCT (open-label, computer generated randomisation)
Aim	To consider the efficacy of prewarming with forced air warming
Patient characteristics	Preoperative + intraoperative

Bibliographic reference

Andrzejowski J, Hoyle J, Eapen G et al (2008) Effect of prewarming on post-induction core temperature and the incidence of inadvertent perioperative hypothermia in patients undergoing general anaesthesia. British Journal of Anaesthesia 101: 627-31

General anaesthesia

Inclusion;

- Elective spinal surgery, ASA I and II

	FAW preoperative and intraoperative N=31	FAW intraoperative only N=37
Age – mean (range)	54 (19 – 80)	57 (26 – 87)
Gender – male/female	20/11	25/12

Number of Patients

N=68

Interventions and comparisons

Forced air warming (Bair Paws, Arizant Healthcare, UK), full body blanket for cervical spine surgery, surgical access blanket access for lumbar surgery; N=31 Set to 38ºC Pre-warming approx. 60mins before induction

All received routine forced air warming intra-operatively
Operating room temperature, pre-warmed mean 20.7ºC (SD 1.5), non-pre-warmed 20.9ºC (1.2),

Length of follow up

Not applicable

Location

UK

Results

Core temp at end of surgery ºC	Not reported	Not reported
Number hypothermic at end of surgery*	10/31	21/37
Core temp during surgery ºC - mean change (SD)		
• 20 mins-0.4	-0.5 (0.5), N=31	-0.8 (0.6), N=37
• 40 mins	-0.5 (0.5), N=31	-0.8 (0.6), N=36
• 60 mins	-0.4 (0.6), N=31	-0.7 (0.7), N=35
• 80 mins	-0.4 (0.6), N=27	-0.7 (0.7), N=30
• 100 mins	-0.3 (0.6), N=22	-0.6 (0.8), N=23
• 120 mins	-0.3 (0.6), N=16	-0.4 (0.8), N=17
• 140 mins	-0.4 (0.5), N=13	-0.4 (0.7), N=12

Bibliographic reference	**Andrzejowski J, Hoyle J, Eapen G et al (2008) Effect of prewarming on post-induction core temperature and the incidence of inadvertent perioperative hypothermia in patients undergoing general anaesthesia. British Journal of Anaesthesia 101: 627-31**

Adverse effects of active warming	Not reported	Not reported
Blood loss	Not reported	Not reported
Thermal comfort	Not reported	Not reported
Shivering	2/31	3/37
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

Source of funding	Arizant Healthcare UK provided the Bair Paws system and disposables for this trial
Comments	No concerns over risk of bias To detect a difference of 0.2ºC in mean core temperature, power of 0.8, significance 0.05, sample size needed for each group was 35

[2] *<Insert Note here>*

De Witte 2010

Bibliographic reference	**De Witte JL, Demeyer C, Vandemaele E. (2010) Resistive-heating or forced-air warming for the prevention of redistribution hypothermia. Anesthesia and Analgesia 110: 829-33**
Study type	RCT
Aim	To compare the efficacy of resistive heating or forced air warming vs no pre- warming, applied before induction of anaesthesia for prevention of hypothermia.
Patient characteristics	Pre- and intraoperative warming, general anaesthetic. Inclusion; Adult patients scheduled for elective laparoscopic colorectal surgery, normal BMI (18-28)

<table>
<tr><th>Bibliographic reference</th><th>De Witte JL, Demeyer C, Vandemaele E. (2010) Resistive-heating or forced-air warming for the prevention of redistribution hypothermia. Anesthesia and Analgesia 110: 829-33</th></tr>
<tr><td></td><td>Exclusion
History of alcohol or drug abuse, older than 80 years, evidence of current infection, pregnancy thyroid disease, intake of calcium channel blocker within 24 hours, antiemetic, opioid, antihistamine, neuroleptic or anticholinergic medication or the use of cannabinoids or corticosteroids.

Demographics; (
<table>
<tr><th></th><th>Preoperative and intra-operative forced air warming</th><th>Preoperative resistive heating blanket and intra-operative forced air warming</th><th>Intra-operative forced air warming only</th></tr>
<tr><td>Age years - mean, SD)</td><td>66 (12)</td><td>64 (10)</td><td>59 (10)</td></tr>
<tr><td>Gender – male/female</td><td>33.3</td><td>33.3</td><td>37.5</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N=27</td></tr>
<tr><td>Interventions and comparisons</td><td>Forced air prewarming (n=9) Arizant Healthcare (Eden Prairie, MN) Model 110 Perioperative blanket and temperature management unit, calibrated at 42ºC.

Resistive heating prewarming (n=9) Geratherm “presurgical” whole body cover applied for exactly 30 minutes before induction of anaesthesia. Control unit set at 42ºC.

No pre-warming (n=9)

Start of prewarming considered as time 0. Time 0 was 07.30am +/- 5 minutes in all patients. The devices for prewarming were removed after 31 minutes.
Intraoperative temperature management started at time 31; FAW in all patients, set to 42ºC. IV fluids warmed to 42ºC. Ambient temperature was kept near 20ºC.
Tympanic temperature measured at end of prewarming, then oesophageal temperature measured intraoperatively.
Duration of anaesthesia ranged from 90-260 minutes</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>Belgium</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Preoperative and intraoperative forced air warming</th><th>Preoperative resistive heating blanket and</th><th>Intraoperative forced air warming only N = 8</th></tr>
</table></td></tr>
</table>

Bibliographic reference	**De Witte JL, Demeyer C, Vandemaele E. (2010) Resistive-heating or forced-air warming for the prevention of redistribution hypothermia. Anesthesia and Analgesia 110: 829-33**

	N = 9	intraoperative forced air warming N = 9	
Core temp at end of surgery ºC – mean (SD)	35.5 (0.8)	35.6 (0.5)	35.4 (1.0)
Number hypothermic at end of surgery	0/9	0/9	Not reported
Core temp during surgery ºC	Not reported	Not reported	Not reported
Adverse effects of active warming	Not reported	Not reported	Not reported
Blood loss (mL/kg) – mean (SD)	2 (3)	1 (1)	1 (1)
Thermal comfort	Not reported	Not reported	Not reported
Shivering	Not reported	Not reported	Not reported
Cardiac events	Not reported	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported	Not reported
Pain	Not reported	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported	Not reported
Length of time in recovery	Not reported	Not reported	Not reported
Delayed healing	Not reported	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported	Not reported

Source of funding	OLV research unit VZW. Geratherm provided by NWS BVBA and Arizant donated the perioperative blankets.
Comments	Randomisation drawing lots (numbered, opaque and sealed envelope, destroyed after opening) Null hypothesis was that there is no difference in intraoperative oesophageal temperature between the active treatment groups and the control group Study adequately powered to find 0.7ºC difference between groups. Blood loss converted from reported mL/Kg for use in meta-analysis For the meta-analysis both groups that used preoperative and intraoperative warming were combined and compared with intraoperative warming only group

1 **Erdling 2015**

Bibliographic reference	**Erdling A, Johansson A. (2015) Core Temperature – the intraoperative difference between esophageal versus naopharyngeal temperatures and the impact of prewarming, age and weight: a randomised clinical trial. AANA Journal 83(2): 99-105**
Study type	RCT (open-label, randomly assigned by sealed envelope technique)
Aim	To determine the intraoperative temperatures with 2 different measurement techniques (oesophagus vs nasopharynx). This was evaluated in 2 groups with and without an extended warming period.
Patient characteristics	Pre and intraoperative General and spinal anaesthesia Inclusion: - Adult and of either gender - ASA physical status 1 and 2 who were to undergo elective open colorectal surgery under general anaesthesia combined with regional analgesia for an anticipated anaesthesia time of at least 210 minutes. Exclusion: - Those who did not give informed consent or understand the information - Patients with known nasal or oesophageal anomalies - Patients with thyroid dysfunction and known ischemic peripheral vessel disease Baseline characteristics: <table><tr><td></td><td>Forced air warming preoperative- and intraoperative N =21</td><td>Forced air warming intraoperative N = 22</td></tr><tr><td>Age - mean (SD)</td><td>70 (15)</td><td>72 (11)</td></tr><tr><td>Gender – male/female)</td><td>12/14</td><td>11/15</td></tr></table>
Number of Patients	N=52; 26 in each arm of the study; 21 and 22 from each group analysed since 9 patients were excluded due to shorter surgery
Interventions and comparisons	1. Pre- and intraoperative warmed* (group A) • Prewarming (extended warming) in this group started after epidural catheter insertion but before epidural anaesthesia test dose was given and this warming was continued during 210 minutes of surgery. 2. Intraoperative warmed* (group B) • Warming intraoperatively started after surgical preparation was completed using the same warming equipment and continued similarly.

Bibliographic reference	**Erdling A, Johansson A. (2015) Core Temperature – the intraoperative difference between esophageal versus naopharyngeal temperatures and the impact of prewarming, age and weight: a randomised clinical trial. AANA Journal 83(2): 99-105**
	*The warming procedure started in the operating room where all anaesthesia and surgical preparations took place. Warming was performed for both groups using a forced-air device (Warm Touch, Nellcor or Gaymar, Smiths Medical), set to 43ºC, covering both arms, head and thorax. All fluids given intravenously were warmed to 39ºC in both groups. To minimise diurnal variation in body temperature, all studies started at 7.30am. In all patients, both oesophageal and nasopharyngeal thermometers were used to collect core temperatures.
Length of follow up	Not applicable
Location	Southern Sweden
Results	
Source of funding	Not reported
Comments	

	FAW preoperative and intraoperative N =21	FAW intraoperative only N=22
Core temp at end of surgery ºC – mean (SD)	36.65 (0.63)	36.02 (0.60)
Number hypothermic at end of surgery*	Not reported	Not reported
Core temp during surgery ºC	Not reported	Not reported
Adverse effects of active warming	Not reported	Not reported
Blood loss	Not reported	Not reported
Thermal comfort	Not reported	Not reported
Shivering	Not reported	Not reported
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

Fossum 2001

<table>
<tr><td>Bibliographic reference</td><td>Fossum S, Hays J, Henson MM. (2001) A comparison study on the effects of prewarming patients in the outpatient surgery setting. Journal of Perianesthesia Nursing 16(3):187-94.</td></tr>
<tr><td>Study type</td><td>RCT</td></tr>
<tr><td>Aim</td><td>To determine if there was a difference in arrival temperatures to the PACU between surgical patients who had been warmed preoperatively and those who had not been warmed preoperatively</td></tr>
<tr><td>Patient characteristics</td><td>General anaesthesia
Inclusion; not extracted in original guideline

Baseline characteristics
<table>
<tr><td></td><td>Both groups</td></tr>
<tr><td>Age – range</td><td>45.23 years</td></tr>
<tr><td>Gender – male/female</td><td>57/43</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N= 100</td></tr>
<tr><td>Interventions and comparisons</td><td>Forced-air warming (Bair Hugger® model # 505) with a single-layer cotton blanket placed over n = 50 Duration: 45 mins (in the preoperative holding area) FAW was set at medium operating temperature of 38 ± 3°C

Warmed single cotton blanket n = 50 Duration: 45 mins (in the preoperative holding area) Warmed at 66°</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>USA</td></tr>
<tr><td>Results</td><td>
<table>
<tr><td></td><td>Preoperative active warming = = 50</td><td>Usual care N = 50</td></tr>
<tr><td>Core temp at end of surgery ºC</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Number hypothermic– n/N</td><td>22/50</td><td>36/50</td></tr>
<tr><td>Core temp during surgery ºC</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Fossum S, Hays J, Henson MM. (2001) A comparison study on the effects of prewarming patients in the outpatient surgery setting. Journal of Perianesthesia Nursing 16(3):187-94.**
Source of funding	Augustine medical-equipment & financial support
Comments	No concerns over risk of bias

Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

1 Hirvonen 2011

Bibliographic reference	**Hirvonen EA, Niskanen M. (2011) Thermal suits as an alternative way to keep patients warm peri-operatively: a randomised trial. European Journal of Anaesthesiology. 28(5):376-81**
Study type	Randomised control trial with computer-generated random numbers allocated in envelopes numbered consecutively
Aim	To compare temperature changes in patients undergoing transurethral resection of the prostate under spinal anaesthesia using a thermal suit throughout the procedure or using conventional methods of warming during surgery and recovery.
Patient characteristics	Preoperative only <u>Inclusion:</u> Patients undergoing transurethral resection of the prostate <u>Exclusion:</u> Serious co-morbidities such as ASA class IV, Use of neuroleptics Mental statues with inability to give informed consent Contra-indications to spinal anaesthesia Demographic characteristics:

	Pre-warming N = 20	Usual care N = 20
Age in years – mean (SD)	68.2 (8.8)	69.4 (9.0)
Gender – male/female	20/0	20/0

Bibliographic reference	**Hirvonen EA, Niskanen M. (2011) Thermal suits as an alternative way to keep patients warm peri-operatively: a randomised trial. European Journal of Anaesthesiology. 28(5):376-81**
Number of Patients	N=40
Interventions and comparisons	Thermal suit – T-Balance (Kuopio, Finland) – three-layer laminate reusable suit Forced air warming – Bair Hugger (Arizant Healthcare, Minnesota USA) Forced air warming was used in both group if core temp reach 35 ºC in intraoperative phase
Length of follow up	Not applicable
Location	Finland
Results	See table below
Source of funding	Foundation of the Kuopio University Hospital and Telespro Finland Ltd
Comments	NICE technical team did not include core temperature at end of surgery in meta-analysis as patient were offered extra blankets or forced air warming during surgery or recovery if they were hypothermic

	Pre-warming N = 19	Usual care N = 20
Core temp at end of surgery ºC – mean (SD)	36.0 (0.4)	36.0 (0.4)
Number hypothermic at end of surgery* - n/N	1/19	7/20
Core temp during surgery ºC	Not reported	Not reported
Adverse effects of active warming	Not reported	Not reported
Blood loss	Not reported	Not reported
Thermal comfort	Not reported	Not reported
Shivering	1/20	14/20
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

*reported as number needing forced air warming during surgery or recovery

1 **Horn 2012**

Bibliographic reference	**Horn EP, Bein B, Böhm R et al (2012), The effect of short time periods of pre-operative warming in the prevention of peri-operative hypothermia. Anaesthesia, 67: 612–7**
Study type	RCT
Aim	to evaluate if 10, 20 or 30 min of forced-air pre-warming compared with passive insulation may be long enough to reduce the incidence of postoperative hypothermia and shivering.
Patient characteristics	General anaesthesia Preoperative warming only <u>Inclusion:</u> Adults undergoing elective surgery under general anaesthesia: laparoscopic cholecystectomy; inguinal hernia repair; breast surgery; minor orthopaedic surgery; and ENT surgery with expected duration > 30 min, but < 90 min. <u>Exclusion:</u> < 18 years old, classified as ASA physical status 3 or higher or planned for combined general / regional anaesthesia. Demographic characteristics:

	Preoperative Forced air warming 30 N = 50	Preoperative Forced air warming 20 N =43	Preoperative Forced air warming 10 N =52	Usual care N = 55
Age in years – mean (SD)	54 (11)	52 (13)	55 (16)	49 (12)
Gender – male/female	15/35	16/27	16/36	17/38

Number of Patients	N=200
Interventions and comparisons	Forced air warming groups: Forced-air cover (Level 1 Snuggle Warm Upper Body Blanket; Smiths Medical, Rockland, MA, USA) was positioned over the whole body of the patients laying in their beds, covered by a cotton blanket. A Level 1 Equator warmer (Smiths Medical) was set to 'high level' (44 ºC) Usual care In all groups, patients were covered with cotton blankets intra- and postoperatively. However, active warming of the upper body was started if core temperature decreased below 36 ºC (Snuggle Warm Upper Body Blanket). If the patient felt overheated the warmer was lowered to 40 ºC. Pre-, intra- and postoperative ambient temperatures were maintained near 23 ºC.

<table>
<tr><th>Bibliographic reference</th><th>Horn EP, Bein B, Böhm R et al (2012), The effect of short time periods of pre-operative warming in the prevention of peri-operative hypothermia. Anaesthesia, 67: 612–7</th></tr>
<tr><td></td><td>All fluids were warmed to 39 ºC; however, no active fluid warming device was used.

Duration of surgery; Usual care = min 65 (35–95 [30–165]) Pre-warming 10 = 60 (30–90 [30–140]) Prewarming 20 = 60 (40–95 [30–155]) Prewarming 30 = 65 (35–100 [30–165])</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>Germany</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Pre-warming 30 mins
N = 50</th><th>Pre-warming 20 mins
N =43</th><th>Pre-warming 10 mins
N =52</th><th>Usual care
N = 55</th></tr>
<tr><td>Core temp at end of surgery ºC</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Number hypothermic at end of surgery* - n/N</td><td>3/50</td><td>3/43</td><td>7/52</td><td>38/55</td></tr>
<tr><td>Core temp during surgery ºC</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering – n/N</td><td>1/50</td><td>3/43</td><td>3/52</td><td>10/55</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
</table>
*reported as number hypothermic (< 36 ºC) at entry to PACU
** observer rated as shivering in PACU</td></tr>
<tr><td>Source of funding</td><td>No funding reported</td></tr>
<tr><td>Comments</td><td>No concerns over risk of bias</td></tr>
</table>

Bibliographic reference	**Horn EP, Bein B, Böhm R et al (2012), The effect of short time periods of pre-operative warming in the prevention of peri-operative hypothermia. Anaesthesia, 67: 612–7**
	Outcome data from Prewarming 30 mins group were used in all analyses Data on core temperature not extracted form graph as rescue warming was used

1 Horn 2016

Bibliographic reference	**Horn EP, Bein B, Broch O et al. (2015) Warming before and after epidural block before general anaesthesia for major abdominal surgery prevents perioperative hypothermia: A randomised controlled trial, European Journal of Anaesthesiology. 33(5):334-40**
Study type	RCT
Aim	To evaluate the effects of active skin surface warming before and/or after initiation of EDA during general anaesthesia as a procedure to prevent perioperative hypothermia.
Patient characteristics	Epidural and general anaesthesia Pre and intraoperative warming Inclusion; Major abdominal surgery, with expected duration of surgery at least 120 mins Exclusion Under 18 years of age, ASA IV or higher. Demographics
Number of Patients	99
Interventions and comparisons	No prewarming (intraoperative only), n=32 Prewarming after epidural + intraoperative, n=33 Received 15 mins FAW after insertion of epidural catheter and application of the test dose, but before injection of 6-8mL of ropivicaine.

Demographics (Patient characteristics):

	Forced air warming preoperative (pre and post epidural) and intraoperative N = 34	Forced air warming preoperative (post epidural) and intraoperative N = 33	Forced air warming intraoperative alone N = 32
Age – mean (SD)	66 (13)	67 (12)	66 (13)
Gender – male/female	17/17	9/24	13/19

Bibliographic reference	**Horn EP, Bein B, Broch O et al. (2015) Warming before and after epidural block before general anaesthesia for major abdominal surgery prevents perioperative hypothermia: A randomised controlled trial, European Journal of Anaesthesiology. 33(5):334-40**
	Prewarming before and after epidural + intraoperative, n=34 Received FAW 15 minutes before insertion of epidural catheter and then for 15 minutes after insertion and administration of the test dose, but before injection of 6-8mL of ropivicaine. Prewarming with FAW was with a Level 1 Snuggle Warmer Upper Body Blanket (Smiths Medical, Rockland, USA) positioned over whole body. A level 1 Equator warmer (Smiths medical, USA) was set to 44ºC. Patients were asked every 5 minutes during the prewarming about their thermal comfort. I f they felt overheated, the warmer was lowered to 40ºC. Intraoperative warming to upper body using a Level 1 Equator warmer set to 44ºC Preoperative, intraoperative and postoperative ambient temperature was maintained near 23ºC. Core temperature continuously monitored at the tympanic membrane using a tympanic temperature sensor. Core temperature was measured at baseline, 15 minutes after the start of warming, after positioning of the epidural catheter, 15 minutes after the 2nd period of warming (if applicable) at the beginning of surgery then once every hour and on arrival at ICU. Mean skin temperature calculated from measurements at chest, arm, thigh and calf at same time points.
Length of follow up	Not applicable
Location	Germany
Results	

	Forced air warming preoperative (30 mins) and intraoperative N = 34	Forced air warming preoperative (15 mins) and intraoperative N = 33	Forced air warming intraoperative alone N = 32
Core temp at end of surgery ºC – mean (SD)	37.5 (0.5)	36.6 (0.4)	35.7 (0.6)
Number hypothermic at end of surgery - n/N	0/34	2/33	23/32
Core temp during surgery ºC – mean (SD) • 30 mins • 60 mins • 120 mins	Not reported 36.7 (0.8) 36.9 (0.4)	Not reported Not estimable Not estimable	Not reported 36.0 (0.4) 35.9 (0.5)
Adverse effects of active warming	Not reported	Not reported	Not reported
Blood loss	Not reported	Not reported	Not reported

<table>
<tr><th>Bibliographic reference</th><th>Horn EP, Bein B, Broch O et al. (2015) Warming before and after epidural block before general anaesthesia for major abdominal surgery prevents perioperative hypothermia: A randomised controlled trial, European Journal of Anaesthesiology. 33(5):334-40</th></tr>
<tr><td></td><td>
<table>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering – n/N</td><td>0/34</td><td>0/33</td><td>2/32</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
</table>
*reported as postoperative hypothermia
</td></tr>
<tr><td>Source of funding</td><td>No funding received</td></tr>
<tr><td>Comments</td><td>Randomisation performed by an uninvolved nurse by rolling a dice; 1-4= no warming group; 2 or 5 allocated to warming after epidural group; 3 or 6 allocated to warming before and after EDA.
Sample size calculation based on treatment effect of 0.5ºC on the postoperative core temperature. Sample size of 99 patients divided into 3 groups estimated to provide 80% power.
No exclusions from the analysis.
Outcome data form the pre-and post epidural group (30 mins pre warming) was used in all analyses</td></tr>
</table>

Kim 2006

Bibliographic reference	Kim JY, Shinn H, Oh YJ et al. (2006) The effect of skin surface warming during anesthesia preparation on preventing redistribution hypothermia in the early operative period of off-pump coronary artery bypass surgery, European Journal of Cardio-Thoracic Surgery, 29, 343-7
Study type	RCT
Aim	For the meta-analysis both groups that used preoperative and intraoperative FAW werr combined and compared with intraoperative FAW only group
Patient characteristics	General anaesthetic an epidural Pre and intraoperative

Bibliographic reference	**Kim JY, Shinn H, Oh YJ et al. (2006) The effect of skin surface warming during anesthesia preparation on preventing redistribution hypothermia in the early operative period of off-pump coronary artery bypass surgery, European Journal of Cardio-Thoracic Surgery, 29, 343-7**
	Inclusion; Patients undergoing OPCAB Exclusion Clinically significant peripheral vascular disease, history of fever within a week before surgery, and skin lesion or hypersensitivity to skin contact devices. Demographics; the two groups were comparable in patient characteristics. No differences between groups.

	Preoperative forced air warming and circulating water mattress N = 20	circulating water mattress alone N = 20
Age - mean, SD)	64.1 (8.1)	61.3 (10.8)
Gender – male/female	15/5	15/5

Number of Patients	40
Interventions and comparisons	All patients had a warming mattress with circulating water at 38ºC applied prior to arrival in operating room. Circulating water mattress n=20 Patients covered with 2 cotton blankets in addition to water mattress. Forced air warming + circulating water mattress, n=20 Patients warmed with a Bair Hugger forced air heater (model 200 blower, full body cover, Augustine medical, Eden Prairie, USA), with blower set at medium (40ºC). Patients covered from trunk to legs, but arms exposed for monitoring. Prewarming time was not set to prevent delay in induction. FAW was discontinued immediately after anaesthetic induction, patients were subsequently exposed to the ambient environment. After induction, heat and moisture exchange filters were used in all patients.
Length of follow up	Not applicable
Location	Republic of Korea
Results	

	Preoperative forced air warming and	Intraoperative circulating water

Bibliographic reference	**Kim JY, Shinn H, Oh YJ et al. (2006) The effect of skin surface warming during anesthesia preparation on preventing redistribution hypothermia in the early operative period of off-pump coronary artery bypass surgery, European Journal of Cardio-Thoracic Surgery, 29, 343-7**

	Intraoperative circulating water mattress N = 20	mattress alone N = 20
Core temp at end of surgery °C	Not reported	Not reported
Number hypothermic at 90 mins – n/N	1/20	7/20
Core temperature during surgery °C - mean (SD)		
• 30 minutes	36.3 (0.4)	36.0 (0.5)
• 60 minutes	35.8 (0.4)	35.5 (0.6)
• 90 minutes	35.6 (0.5)	35.2 (0.6)
Adverse effects of active warming	Not reported	Not reported
Blood loss	Not reported	Not reported
Thermal comfort	Not reported	Not reported
Shivering	Not reported	Not reported
Cardiac events	Not reported	Not reported
Surgical site/ wound infection	Not reported	Not reported
Pain	Not reported	Not reported
Requirement for blood transfusion	Not reported	Not reported
Length of time in recovery	Not reported	Not reported
Delayed healing	Not reported	Not reported
Length of hospital stay (days)	Not reported	Not reported

Source of funding	Not reported
Comments	No concerns over risk of bias Randomisation using a sealed envelope system. Core temperature measured with pulmonary artery catheter

Melling 2001

Bibliographic reference	**Melling AC, Baqar A, Scott EM, Leaper DJ. (2001) Effects of preoperative warming on the incidence of wound infection after clean surgery: a randomised controlled trial. The Lancet 358: 876-80**
Study type	RCT (open-label, randomisation in blocks of 90, allocation in concealed opaque envelopes)

Bibliographic reference	**Melling AC, Baqar A, Scott EM, Leaper DJ. (2001) Effects of preoperative warming on the incidence of wound infection after clean surgery: a randomised controlled trial. The Lancet 358: 876-80**
Aim	To assess the use of a local warming device and a warm air blanket for the reduction of infection after clean wound surgery
Patient characteristics	Preoperative only Type of anaesthetic not reported Inclusion; April 1999 to May 2000 Elective hernia repair, varicose vein surgery, or beast surgery that would result in a scar <3cm in length and >18years Exclusion; Pregnant, long-term steroids, radiotherapy or chemotherapy in the last 4weeks and Infection at the time of surgery Types of surgery; - breast; standard 60 (43%); forced air warming 57 (41%), local radiant heat 58 (42%) - hernia; standard 47 (34%); forced air warming 54 (39%), local radiant heat 54 (39%) - varicose veins; standard 32 (23%); forced air warming 28 (20%), local radiant heat 26 (19%) (table below) Clean surgery defined as uninfected, where no inflammation is encountered and the respiratory. Alimentary and GU tracts are not opened
Number of Patients	N=421 randomised (417 completed trial)
Interventions and comparisons	Forced air warming Minimum 30mins preoperative warming – left in situ until just before surgery Radiant heat dressing; local warming to the planned wound area Minimum 30mins preoperative warming – left in situ until just before surgery Standard care - No prewarming

	Preoperative forced air warming N = 139	Preoperative radiant heat dressing N = 138	Standard care N = 139
Age - mean, SD)	49.7 (13.7)	50 (14.1)	50.4 (15.3)
Gender - male/female	64/75	55/83	55/84

<table>
<tr><th>Bibliographic reference</th><th>Melling AC, Baqar A, Scott EM, Leaper DJ. (2001) Effects of preoperative warming on the incidence of wound infection after clean surgery: a randomised controlled trial. The Lancet 358: 876-80</th></tr>
<tr><td></td><td>Length of surgery (mins); Standard care, mean 48mins (17 to 52), forced air warming 49.3mins (15 to 63), local radiant heat 49.5mins (19)

Longer warming periods with local radiant heat (44.94) compared with forced air warming (38.73), p=0.005</td></tr>
<tr><td>**Length of follow up**</td><td>Reviewed at 2 and 6 weeks postoperatively, observer unaware of allocation</td></tr>
<tr><td>**Location**</td><td>UK</td></tr>
<tr><td>**Results**</td><td>
<table>
<tr><th></th><th>Preoperative forced air warming N = 133</th><th>Preoperative radiant heat dressing N = 125</th><th>Usual care N = 136</th></tr>
<tr><td>Core temp at end of surgery ºC</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Number hypothermic at end of surgery*</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Core temp during surgery ºC</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>8/133</td><td>5/125</td><td>19/136</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>**Source of funding**</td><td>Action Research and the Smith & Nephew Foundation
Augustine Medical Inc provided consumables</td></tr>
<tr><td>**Comments**</td><td>ITT analysis, 90% power estimated a sample size of 402 (1334 in each group), at 5% level
Outcome data on forced air warming preoperatively use in all analyses</td></tr>
</table>

Perl 2014

<table>
<tr><th>Bibliographic reference</th><th>Perl T, Peichl L, Reyntjens K, Deblaere I, Zaballos J, Brauer A. (2014) Efficacy of a novel prewarming system in the prevention of perioperative hypothermia. A prospective, randomized, multicentre study.</th></tr>
<tr><td>**Study type**</td><td>RCT (multicentre) – computer-generated randomisation and allocation</td></tr>
<tr><td>**Aim**</td><td>To determine the efficacy of two novel prewarming methods in attaining higher core temperatures at the end of surgery and reducing the incidence of perioperative hypothermia.</td></tr>
<tr><td>**Patient characteristics**</td><td>Inclusion:
- 18-70 years
- ASA physical status I – III
- BMI between 20-30 kg/m^2
- Undergoing elective surgery scheduled to last between 30 and 120 mins

Exclusion:
- Preoperative core temperature <35 ºC or >38 ºC
- Known pregnancy
- History of thyroid gland disease

Baseline characteristics
<table>
<tr><th></th><th>Active prewarming group (C)
N=18</th><th>Passive prewarming group (B)
N=20</th><th>Control group (A)
N=30</th></tr>
<tr><td>Age – mean (SD)</td><td>43 (16)</td><td>45 (17)</td><td>52 (15)</td></tr>
<tr><td>Gender – male/female</td><td>13/5</td><td>18/2</td><td>22/8</td></tr>
</table></td></tr>
<tr><td>**Number of Patients**</td><td>N=68 (n=90 randomised but 22 subsequently excluded on basis of exclusion criteria listed above)</td></tr>
<tr><td>**Interventions and comparisons**</td><td>Control (Group A) – covered preoperatively according to local hospital standard with duvet on the ward Duration of surgery (mins) – mean (SD): 60 (26)

Passive pre-warming (Group B) – covered up preoperatively in the holding area with a Mistral-Air Premium Warming Suit - Light gown covering patient from neck to feet, with soft inner surface and reflective outer surface to reduce radiant heat loss from body surface
- Duration of pre-warming (mins) – mean (SD): 35 (14)
- Duration from pre-warming to induction of anaesthesia (mins) – mean (SD): 13 (5)</td></tr>
</table>

<table>
<tr><th>Bibliographic reference</th><th>Perl T, Peichl L, Reyntjens K, Deblaere I, Zaballos J, Brauer A. (2014) Efficacy of a novel prewarming system in the prevention of perioperative hypothermia. A prospective, randomized, multicentre study.</th></tr>
<tr><td></td><td>
- Duration of surgery (mins) – mean (SD):62 (26)

Active pre-warming (Group C) - covered in the holding area with a Mistral-Air Premium Warming Suit actively warmed with forced air (using Mistral Air warming unit) for 30-60 minutes prior to induction of anaesthesia.
- Duration of pre-warming (mins) – mean (SD): 44 (13)
- Duration from pre-warming to induction of anaesthesia (mins) – mean (SD): 20 (12)
- Duration of surgery (mins) – mean (SD):69 (24)

OR temperature maintained around 19-21ºC for all groups
All intraoperative IIV fluids were warmed to 37 ºC

Intraoperative warming: all patients actively warmed immediately after induction of anaesthesia using a forced-air upper or lower body blanket (Mistral Air).
- For groups B and C the pre-warming suit used for insulation or pre-warming was intraoperatively attached to the forced-air blower and used as an upper or lower body forced-air warming blanket.
</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>Germany, Belgium & The Netherlands</td></tr>
<tr><td>Results</td><td>Results:

<table>
<tr><th></th><th>Pre- and intra-operative warming
N=18</th><th>Passive prewarming group (B)
N=20</th><th>Intra-operative alone
N=30</th></tr>
<tr><td>Core temp at end of surgery ºC – mean (SD)</td><td>36.9 (0.4)*</td><td>36.4 (0.4)</td><td>36.3 (0.5)</td></tr>
<tr><td>Number hypothermic any time – n/N</td><td>1/18</td><td>Not reported</td><td>12/30</td></tr>
<tr><td>Core temp during surgery ºC – mean (SD)</td><td></td><td></td><td></td></tr>
<tr><td>• 30 mins</td><td>36.66 (0.45)*</td><td>36.10 (0.35)</td><td>36.10 (0.45)</td></tr>
<tr><td>• 60 mins</td><td>36.80 (0.47)*</td><td>36.20 (0.40)</td><td>36.25 (0.34)</td></tr>
<tr><td>• 90 mins</td><td>37.03 (0.23)</td><td>36.45 (0.45)</td><td>36.30 (0.40</td></tr>
<tr><td>• 120 mins</td><td>37.24 (0.15)</td><td>36.45 (0.12)</td><td>36.60 (0.35)</td></tr>
<tr><td>Adverse effects of active warming* - n/N</td><td>0/18</td><td>0/20</td><td>0/30</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Bibliographic reference</th><th>Perl T, Peichl L, Reyntjens K, Deblaere I, Zaballos J, Brauer A. (2014) Efficacy of a novel prewarming system in the prevention of perioperative hypothermia. A prospective, randomized, multicentre study.</th></tr>
<tr><td></td><td>
<table>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering – n/N</td><td>0/18</td><td>4/20</td><td>5/30</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td><td>Not reported</td></tr>
</table>
*reported as ‘skin lesions or burns’</td></tr>
<tr><td>Source of funding</td><td>Authors in receipt of consulting fees from The 37Company, the Netherlands (manufacturers of Mistral-Air Premium Warming Suit and Mistral-Air Warming unit).</td></tr>
<tr><td>Comments</td><td>Study was underpowered: required 23 patients per group to detect a clinically important difference of 0.5 ºC (±0.5 ºC) at end of surgery. High rate of exclusions in groups B and C due to patients exceeding BMI / age limits or surgery <30 mins duration.

Pre-warming duration was not standardised, although all patients received >10 mins (which is a duration considered effective)</td></tr>
</table>

(a) Values estimated from point graph

Shin 2015

Bibliographic reference	**Shin KM, Ahn JH, Kim IS, et al. (2015) The efficacy of pre-warming on reducing intraprocedural hypothermia in endovascular coiling of cerebral aneurysms. BMC Anesthesiology. 15(1):8.**
Study type	RCT
Aim	to evaluate the efficacy of skin surface warming using a forced air warming blanket for 30 minutes prior to induction of anaesthesia to prevent the decrease in core temperature
Patient characteristics	Preoperative only Inclusion: aged 20 to 80 years and undergoing elective or emergency endovascular coiling to treat cerebral aneurysms with

<table>
<tr><th>Bibliographic reference</th><th>Shin KM, Ahn JH, Kim IS, et al. (2015) The efficacy of pre-warming on reducing intraprocedural hypothermia in endovascular coiling of cerebral aneurysms. BMC Anesthesiology. 15(1):8.</th></tr>
<tr><td></td><td>general anaesthesia in the INR suite.
Exclusion:
a history of current infection, the intake of antipyretics within 24 hours before induction of anaesthesia, a body mass index (BMI) exceeding 35 kg/m2, preoperative body temperature of more than 37.2°C before transfer to the INR suite, and patients with severe neurosurgical conditions whose treatment should not be delayed, did not give consent for the pre-warming

Demographic characteristics:
<table>
<tr><th></th><th>Pre-warming
N = 36</th><th>Usual care
N = 36</th></tr>
<tr><td>Age in years – mean (SD)</td><td>56 (15)</td><td>60 (13)</td></tr>
<tr><td>Gender – male/female</td><td>10/26</td><td>14/22</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N = 72</td></tr>
<tr><td>Interventions and comparisons</td><td>Prewarming: patients were warmed for 30 minutes with a forced air warming blanket (3M™ Bair Hugger™ Full Body Blanket Model 300, Arizant Healthcare Inc., A 3 M Company, Eden Prairie, MN, USA) which covered the entire body except the head and neck – set to medium (38°C) Pre-warming was started before entering the INR suite and maintained until induction of anaesthesia

No prewarming:. Patients were covered only with two layers of cotton blanket that were not warmed before transfer to the INR suite and this was continued during the positioning.

Rescue warming: Forced air warming (Bair Hugger) was operated if the core temperature of patients decreased below 35.5°C during procedure. The temperature output of the blower was set at high level (43°C).</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>South Korea</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Pre-warming
N = 36</th><th>Usual care
N = 36</th></tr>
<tr><td>Core temp at end of surgery ºC</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Number hypothermic at 120 mins* - n/N</td><td>16/36</td><td>32/36</td></tr>
<tr><td>Core temp during surgery ºC – mean (SD)
• 30 mins</td><td>
Not reported</td><td>
Not reported</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Bibliographic reference</th><th>Shin KM, Ahn JH, Kim IS, et al. (2015) The efficacy of pre-warming on reducing intraprocedural hypothermia in endovascular coiling of cerebral aneurysms. BMC Anesthesiology. 15(1):8.</th></tr>
<tr><td></td><td>
<table>
<tr><td>• 60 mins
• 120 mins</td><td>36.2 (0.3)
35.9 (0.3)</td><td>35.8 (0.4)
35.5 (0.3)</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering – n/N</td><td>3/30</td><td>6/27</td></tr>
<tr><td>Cardiac events</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Surgical site/ wound infection</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Pain</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Requirement for blood transfusion</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of time in recovery</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Delayed healing</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Length of hospital stay (days)</td><td>Not reported</td><td>Not reported</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>3 M for providing the Bair Hugger temperature management unit and disposables</td></tr>
<tr><td>Comments</td><td>No concerns over risk of bias
Outcome data for core temperature over time was not included in analysis as rescue warming was used</td></tr>
</table>

Wong 2007

Bibliographic reference	Wong PF, Kumar S, Bohra D, et al. (2007) Randomized clinical trial of perioperative systemic warming in major elective surgery. Br J Surg 94:421-426
Study type	RCT (computer generated random number, sealed in opaque envelopes)
Aim	To examine the effects of additional perioperative systemic warming on postoperative morbidity
Patient characteristics	Pre + intraoperative vs intraoperative only General anaesthesia Inclusion; Major open surgery requiring bowel resection with or without anastomosis, October 2002 to December 2003 Exclusion; laparoscopic procedures, use of corticosteroids or other immunosuppressive drugs in the last 4weeks, recent fever infection or both

<table>
<tr><th>Bibliographic reference</th><th>Wong PF, Kumar S, Bohra D, et al. (2007) Randomized clinical trial of perioperative systemic warming in major elective surgery. Br J Surg 94:421-426</th></tr>
<tr><td></td><td>Demographic characteristics:
<table>
<tr><th></th><th>Pre-warming
N = 47</th><th>No prewarming
N = 56</th></tr>
<tr><td>Age – median (range)</td><td>68.0 (24 – 88)</td><td>60.5 (20 – 84)</td></tr>
<tr><td>Gender – male/female</td><td>24/23</td><td>29/27</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>N=103</td></tr>
<tr><td>Interventions and comparisons</td><td>Prewarming - Warming mattress (Inditherm, Rotherham, UK); Set to 40ºC, 2hrs before, during and up to 2hrs after surgery

No prewarming - Warming mattress switched off

Both groups had systemic warming during all major surgery by forced air warming (Bair Hugger, Arizant Healthcare, Minnesota, USA); Set to 40ºC

Baseline demographics balanced for age, sex, ASA grade I/II/II and core temperature on admission.</td></tr>
<tr><td>Length of follow up</td><td>Not applicable</td></tr>
<tr><td>Location</td><td>UK</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th></th><th>Pre – and intra-operative N = 47</th><th>Intra-operative alone N = 56</th></tr>
<tr><td>Core temp at end of surgery ºC – median (range)</td><td>36.3 (34.3-38.1)</td><td>36.2 (34.3-37.9)</td></tr>
<tr><td>Number hypothermic at end of surgery*</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Core temp during surgery ºC</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Adverse effects of active warming</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Blood loss</td><td>200 (5-1000)</td><td>400 (50-2300)</td></tr>
<tr><td>Thermal comfort</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Shivering</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cardiac events</td><td>0/47</td><td>2/56</td></tr>
<tr><td>Surgical site/ wound infection</td><td>6/47</td><td>15/56</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Wong PF, Kumar S, Bohra D, et al. (2007) Randomized clinical trial of perioperative systemic warming in major elective surgery. Br J Surg 94:421-426**		
	Pain	Not reported	Not reported
	Requirement for blood transfusion	11/47	19/56
	Length of time in recovery	Not reported	Not reported
	Delayed healing	Not reported	Not reported
	Length of hospital stay (days)	11.0 (5-119)	(5-40)
Source of funding	Not reported		
Comments	No concerns over risk of bias Power calculations, each arm required 50 participants for 80% power with 0.05 to detect a 25% reduction in complications after systemic warming ITT analysis		

G.3 Review question 3: Site of measurement

Bibliographic reference	**Barringer LB, Evans CW, Ingram LL, et al. (2011) Agreement between temporal artery, oral, and axillary temperature measurements in the perioperative period. Journal of PeriAnesthesia Nursing 26: 143-150**
Study type	Cross-sectional, repeated measures comparison
Aim	To examine agreement in temperature readings preoperatively and postoperatively between temporal artery and electronic oral/axillary thermometers
Patient characteristics	Inclusion; - Adults, undergoing elective surgery in a community hospital Exclusion; - Patients on vasopresser or vasodilator medications Baseline; age range 18 to 86years (mean 52.6±16.6 (SD)), 65% female, 35% male Surgery details; - orthopaedic (34%), general (26%), plastic (17%), gynaecological (15%), GU (6%), other (3%) - surgical time 2 to 345minutes - N=51 (57%) received one or more preoperative warming measures

Bibliographic reference	**Barringer LB, Evans CW, Ingram LL, et al. (2011) Agreement between temporal artery, oral, and axillary temperature measurements in the perioperative period. Journal of PeriAnesthesia Nursing 26: 143-150**
	- N=72 (82%) received one or more intraoperative warming measures
Number of Patients	N=86
Intervention	Oral and axillary temperature; - SureTemp Plus Electronic Thermometer Model 690 (Welch Allyn, Skaneateles Falls, NY) - Measureable temperature range of 26.7ºC to 43.3ºC, accuracy of ±0.1ºC Oral; - Probe in posterior sublingual pocket, held maintaining contact between probe and mucosa until the device bleeped Axillary; - Axillary mode indicator flashing, probe in highest area of the axilla, arm placed at the subject’s side and hled firmly until the device bleeped Temporal; - Exergen Temporal Scanner, Temporal Artery Thermometer Model TAT-5000 (Exergen Corp, Watertown, MA) - Measureable temperature range of 34.5ºC to 43ºC, accuracy of ±0.1ºC - Swiping the probed across the forehead and down across the temporal artery, then continuing to sweep behind the ear while depressing the scanner 8 nurses trained to use each of the thermometers according to manufacturer recommendations, techniques were observed before beginning data collection The order of using the thermometers was randomised to prevent systematic bias
Comparison	
Length of follow up	N/A
Location	USA
Outcomes measures and effect size	(results given in ºF, calculated into ºC by reviewer) Preoperative; - Mean temperatures recorded by the 3 thermometers differed significantly (p<0.000), oral mean temperature 36.7 ºC, axillary 36.4 ºC, temporal artery 36.8ºC

Bibliographic reference	**Barringer LB, Evans CW, Ingram LL, et al. (2011) Agreement between temporal artery, oral, and axillary temperature measurements in the perioperative period. Journal of PeriAnesthesia Nursing 26: 143-150**
	Post-operative not included in this update, data not extracted **Bland Altman: figures in ºF** **Preoperative:** oral v TA: -0.27 (-1.46, 0.91) [TA higher than oral] Preoperative axillary v TA: -0.7 (-2.3, 0.8) Preoperative oral v axillary: 0.5 (-0.9, 1.8) **Post operative:** Oral v TA: -0.12 (-1.49, 1.24) Axilla v TA: -0.1 (-2.3, 2.1) Oral v axilla: -0.2 (-2.1, 1.7)
Source of funding	Not reported
Comments	Bland-Altman analysis used to evaluate the comparability (computes the difference between the scores on two instruments for each subject, calculates the mean difference for the sample, plots where each case’s difference score falls in relation to the mean difference and shows the interval between which 95% of the difference scores fall. A smaller mean difference with a smaller 95% interval indicates greater agreement between the two instruments). Power analysis based on 0.05 level of significance, 0.80 power, an estimated large effect size, sample size of 77 needed

[3] *<Insert Note here>*

Bibliographic reference	**Bock M, Hohlfeld U, von Engeln K, et al. (2005) The accuracy of a new infrared ear thermometer in patients undergoing cardiac surgery. Can J Anesth 52: 1083-1087**
Study type	Cross-sectional
Aim	To determine whether infrared ear thermometry is an accurate and feasible method for thermometry in cardiac surgery
Patient characteristics	Inclusion;

Bibliographic reference	**Bock M, Hohlfeld U, von Engeln K, et al. (2005) The accuracy of a new infrared ear thermometer in patients undergoing cardiac surgery. Can J Anesth 52: 1083-1087**
	- Adults, undergoing coronary artery bypass graft surgery in a university hospital, 18 to 85years, ASA II and III Exclusion; - Acute or chronic infection of the external auditory canal, middle ear, mastoid, those with congenital or acquired anomaly of the auditory canal, defect of the tympanum, impacted cerumen - Significant microangiopathia, cerebral circulatory disease, migraine headaches Baseline; median age 67.5years, range 48 to 81years Surgery details; - median surgical time 153min (range 97 to 263)
Number of Patients	N=26
Intervention	Tympanic temperature; - Tympanic membrane probe, Mon-a-therm Tympanic (Tyco, HennefSieg, Germany) - IRT 4000, infrared, Exac-Temp sensot (Braun, GmbH) Pulmonary artery; - Swan Ganz catheter (Baxter Healthcare, Deerfield, Il, USA) Measurements taken at 6min intervals, simultaneous recordings from the 3 measures Ambient temperature and humidity recorded at 12min intervals, ranged from 18.2 to 27.7ºC – which is within the range for the IRT (10 to 40ºC) Devices validated post-operatively in a 40ºC warm water bath using a reference thermometer
Comparison	
Length of follow up	N/A
Location	Italy
Outcomes measures and effect size	729 measurements, 22 excluded due to artefact (results given in ºF, calculated into ºC by reviewer) Preoperative;

Bibliographic reference	**Bock M, Hohlfeld U, von Engeln K, et al. (2005) The accuracy of a new infrared ear thermometer in patients undergoing cardiac surgery. Can J Anesth 52: 1083-1087**
	- Mean temperatures recorded by the 3 thermometers differed significantly (p<0.000), oral mean temperature 36.7 ºC, axillary 36.4 ºC, temporal artery 36.8ºC Bland Altman: IR ear thermometer v pulmonary artery catheter: 0.083 (-0.44, 0.61) IR ear thermometer v tympanic memebrane probe: 0.217 (-0.69, 1.13)
Source of funding	Braun GmbH
Comments	Bland-Altman analysis, paired sets of 2 individual thermometry methods compared to the mean value of these data, mean value of the difference in methods was defined systemic error (bias). Bias >0.4ºC, 95%CI >±1.0ºC was considered clinically significant

Bibliographic reference	**Cattaneo CG., Frank S., Hesel TW., et al. (2000) The accuracy and precision of body temperature monitoring methods during regional and general anesthesia. Anesth Analg 90: 938-945**
Study type	Cross-sectional
Aim	To determine the relative accuracy and precision of various temperature monitoring sites and methods during spinal anaesthesia and general anaesthesia
Patient characteristics	Inclusion; - Adults, undergoing radical retropubic prostactomy surgery, ASA II and III Exclusion; - no history of significant cardiovascular or pulmonary disease Baseline; age range 18 to 86years (mean 52.6±16.6 (SD)), 100% male Surgery details; - orthopaedic (34%), general (26%), plastic (17%), gynaecological (15%), GU (6%), other (3%) - surgical time 2 to 345minutes - N=51 (57%) received one or more preoperative warming measures - N=72 (82%) received one or more intraoperative warming measures
Number of Patients	N=32, N=16 spinal anaesthesia, N=16 general anaesthesia
Intervention	Oral and axillary temperature;

Bibliographic reference	**Cattaneo CG., Frank S., Hesel TW., et al. (2000) The accuracy and precision of body temperature monitoring methods during regional and general anesthesia. Anesth Analg 90: 938-945**
	- SureTemp Plus Electronic Thermometer Model 690 (Welch Allyn, Skaneateles Falls, NY) - Measureable temperature range of 26.7ºC to 43.3ºC, accuracy of ±0.1ºC Oral; - Probe in posterior sublingual pocket, held maintaining contact between probe and mucosa until the device bleeped Axillary; - Axillary mode indicator flashing, probe in highest area of the axilla, arm placed at the subject's side and hled firmly until the device bleeped Temporal; - Exergen Temporal Scanner, Temporal Artery Thermometer Model TAT-5000 (Exergen Corp, Watertown, MA) - Measureable temperature range of 34.5ºC to 43ºC, accuracy of ±0.1ºC - Swiping the probed across the forehead and down across the temporal artery, then continuing to sweep behind the ear while depressing the scanner 8 nurses trained to use each of the thermometers according to manufacturer recommendations, techniques were observed before beginning data collection The order of using the thermometers was randomised to prevent systematic bias
Comparison	
Length of follow up	N/A
Location	USA
Outcomes measures and effect size	(results given in ºF, calculated into ºC by reviewer) Preoperative; - Mean temperatures recorded by the 3 thermometers differed significantly (p<0.000), oral mean temperature 36.7 ºC, axillary 36.4 ºC, temporal artery 36.8ºC Bland Altman figures displayed, but no figures reported, therefore could not be reported in analysis. Differences between temperature measurement at time of admission to recovery room (ºC), mean (SD) General anaesthetic

<table>
<tr><th>Bibliographic reference</th><th>Cattaneo CG., Frank S., Hesel TW., et al. (2000) The accuracy and precision of body temperature monitoring methods during regional and general anesthesia. Anesth Analg 90: 938-945</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td>Omni forehead</td><td>Sharn forehead</td><td>Rectal</td><td>Axilla</td><td>Isothermex forehead</td><td>Infrared</td><td></td></tr>
<tr><td>Isothermex tympanic</td><td>-0.1 (0.2)</td><td>-1.4 (0.2)</td><td>0.1 (0.1)</td><td>-2.1 (0.3)</td><td>-2.4 (0.1)</td><td>-0.5 (0.2)</td><td></td></tr>
<tr><td colspan="8">Spinal</td></tr>
<tr><td>Isothermex tympanic</td><td>-0.3 (0.2)</td><td>-1.6 (0.2)</td><td>0.4 (0.1)</td><td>-1.8 (0.3)</td><td>-3.3 (0.2)</td><td>-0.6 (0.2)</td><td></td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Anesthesia Patient Safety Foundation, Abbott Laboratories</td></tr>
<tr><td>Comments</td><td>Bland-Altman analysis used to evaluate the comparability (computes the difference between the scores on two instruments for each subject, calculates the mean difference for the sample, plots where each case’s difference score falls in relation to the mean difference and shows the interval between which 95% of the difference scores fall. A smaller mean difference with a smaller 95% interval indicates greater agreement between the two instruments).
Sample size chosen to achieve power analysis based on 0.05 level of significance, 0.80 power</td></tr>
</table>

Bibliographic reference	**Calonder EM, Sendelbach S, Hodges JS, et al. (2010) Temperature measurement in patients undergoing colorectal surgery and gynecology surgery: a comparison of esophageal core, temporal artery, and oral methods. Journal of PeriAnesthesia Nursing 25: 71-78**
Study type	Cross sectional study, sequence of measurement methods randomly assigned for each participant at each measurement and concealed in an envelope that was opened in the operating room
Aim	To determine the difference, if any, between core temperature as measured by an oesophageal thermometer and oral and temporal thermometers in patients undergoing colorectal or gynaecological surgery
Patient characteristics	Inclusion; - Adults, scheduled for elective colorectal or gynaecological surgery in a 2-week period in August 2008 - Oesophageal temperature probe Exclusion; - Surgical time scheduled for <2hours, nasal thermometer - Vulnerable patients (decisional impairment, minors, elderly with dementia) Baseline; age mean 55.7 (SD 13.4, range 32 to 81), 74% female, 26% male, 92% Caucasian Surgery details;

Bibliographic reference	**Calonder EM, Sendelbach S, Hodges JS, et al. (2010) Temperature measurement in patients undergoing colorectal surgery and gynecology surgery: a comparison of esophageal core, temporal artery, and oral methods. Journal of PeriAnesthesia Nursing 25: 71-78**
	- colorectal (35%), gynaecology (65%) - length of surgery mean 3.3hrs (SD 1.2, range 2.1 to 5.8)
Number of Patients	N=23
Intervention	3 temperatures taken within 2minutes once the patient was anaesthetised, draped and positioned; second set of temperatures taken ≥30minutes after the first set One experienced postanaesthesia recovery nurse collected all of the data Oesophageal core temperature; - ES400-18 Level 1 Acoustascope Esophageal Stethoscope with temperature sensor and the Thermisor (equivalent to the YSI 400 series) – used to measure core temperature (SMITHS Medical, Dublin) - Equipment tested on a yearly preventative maintenance schedule - Oesophageal probe floated down after ET tube placement, distal oesophageal temperature, placement verified
Comparison	Oral; - SureTemp Plus Electronic Thermometer Model 678 (Welch Allyn, Skaneateles Falls, NY) - Purchased new for this study, calibration by clinical engineering department as per manufacturer recommendations completed before and after completing the study - Taken in the left or right posterior sublingual (buccal) pocket Temporal; - TAT 5000 (Exergen Watertown, MA) - Purchased new for this study, calibration by clinical engineering department as per manufacturer recommendations completed before and after completing the study - Taken by manufacturer recommendations, sliding the probe midline across the forehead to the hair but not down the side of the face
Length of follow up	

Bibliographic reference	**Calonder EM, Sendelbach S, Hodges JS, et al. (2010) Temperature measurement in patients undergoing colorectal surgery and gynecology surgery: a comparison of esophageal core, temporal artery, and oral methods. Journal of PeriAnesthesia Nursing 25: 71-78**
Location	USA

Outcomes measures and effect size

2 measurements per site per participant

Results;

Temperature measurement by site;

Site	Time 1			Time 2		
	Mean (SD)	Min	Max	Mean (SD)	Min	Max
Oesophageal	36.30 (0.38)	35.2	36.9	36.16 (0.41)	35.4	37.1
Oral	36.43 (0.34)	35.7	37.1	36.28 (0.41)	35.7	37.3
Temporal artery	36.33 (0.42)	35.3	36.9	36.28 (0.41)	35.6	37.1

Oral vs oesophageal;

Bland-Altman, difference in temperatures plotted against the mean of the 2 measurement methods (average oral and oesophageal) for each set of measurements;

- Mean difference (bias) 0.124, estimated limits of agreement -0.264 to 0.512
- 2 of 46 (4.4%) outside the limits of agreement

Temporal artery vs oesophageal;

- Mean difference (bias) 0.074, estimated limits of agreement -0.319 to 0.467
- 2 of 46 (4.4%) outside the limits of agreement

Estimated bias of alternative measurement compared with oesophageal (ANOVA models);

Site	Bias	SE	P value
Oral vs oesophageal	0.124	0.032	0.0008
Oral vs oesophageal (without 3 outliers)	0.102	0.031	0.0036
Temporal artery vs oesophageal	0.074	0.031	0.0330
Temporal artery vs oesophageal (without 3 outliers)	0.058	0.031	0.719

On average oral was high relative to oesophageal by 0.12ºC, 95% CI 0.061 to 0.187, p=0.0008 (within the 0.4ºC

Bibliographic reference	**Calonder EM, Sendelbach S, Hodges JS, et al. (2010) Temperature measurement in patients undergoing colorectal surgery and gynecology surgery: a comparison of esophageal core, temporal artery, and oral methods. Journal of PeriAnesthesia Nursing 25: 71-78**
	clinically acceptable standard) On average temporal was high relative to oesophageal by 0.074ºC, 95% CI 0.010 to 0.133, p=0.03 (within the 0.4ºC clinically acceptable standard)
Source of funding	Minnesota Nurses Association Foundation, the American Society of PeriAnesthesia Nurses
Comments	Difference of 0.4ºC established as a clinically relevant based on previous studies, estimated that a sample size of 23 participants each with 2 measures per thermometry site to give 80% power to detect 0.4 ºC difference for each measure compared with oesophageal, α of 0.05, SD of 0.65 ºC Analysis; scatterplots, Bland-Altman plots

<table>
<tr><th>Bibliographic reference</th><th>Erdling 2015</th></tr>
<tr><td>Study type</td><td>RCT</td></tr>
<tr><td>Aim</td><td>To determine the intraoperative temperatures with 2 different measurement techniques, evaluated in 2 groups with and without an extended warming period.</td></tr>
<tr><td>Patient characteristics</td><td>Patients on a waiting list for colorectal surgery; ASA I and II; to undergo general anaesthesia combined with epidural anaesthesia, for anticipated anaesthesia time of >210 minutes.
Patients were randomly assigned to pre and intraoperative warmed or intraoperative warmed only (n=26 in each group).
<table>
<tr><td>Charateristics</td><td>All (n=52)</td></tr>
<tr><td>Female</td><td>29 (55.8%)</td></tr>
<tr><td>Male</td><td>23 (44.2%)</td></tr>
<tr><td>Age (mean, SD)</td><td>70 (13), range 32-92</td></tr>
<tr><td>BMI (mean, SD, range)</td><td>26 (5), range 16-34</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>52 included, 43 included in assessment of outcomes</td></tr>
<tr><td>Intervention</td><td>Oesophageal (using level 1 disposable general purpose temperature probes, Smiths Medical ASD Inc)
Following intubation, temperature probe immediately in distal oesophagus at individualy adjusted distance of 40 +/-</td></tr>
</table>

<table>
<tr><th>Bibliographic reference</th><th>Erdling 2015</th></tr>
<tr><td></td><td>4cm from the nostrils using the Mekjavic-Rempel formula</td></tr>
<tr><td>Comparison</td><td>Nasopharynx (using level 1 disposable general purpose temperature probes, Smiths Medical ASD Inc)
Prior to insertion of epidural catheter, probe placed 6-8 cm beyond one of the nostrils using individual nose- to- ear distance, and confirming that the probe was not visible in the mouth</td></tr>
<tr><td>Length of follow up</td><td>Measurements at start of anaesthesia, start of surery, 30, 90, 120, 150, 210, 270, 330, 390, 450 and 510 minutes after the start of surgery.</td></tr>
<tr><td>Location</td><td>Sweden</td></tr>
<tr><td>Outcomes measures and effect size</td><td><table>
<tr><td>Temperatures at 210 minutes</td><td>Prewarmed group (n=21)</td><td>Not prewarmed group (n=22)</td></tr>
<tr><td>Oesophageal (mean, SD)</td><td>36.46 (0.59)</td><td>35.81 (0.66)</td></tr>
<tr><td>Nasopharyngeal (mean, SD)</td><td>36.65 (0.63)</td><td>36.02 (0.60)</td></tr>
<tr><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Source of funding</td><td></td></tr>
<tr><td>Comments</td><td>Study reported nasopharyngeal and oesophageal temeratures from baseline throughout study at 30 minute intervals; this data is only plotted in a graph without values so not reported here.</td></tr>
</table>

Bibliographic reference	Erickson 1991
Study type	Prospective cohort
Aim	To compare tympanic an oral temperature measurement during the perioperative period in adults having major abdominal surgery; equivalence and stability of temperature measurement
Patient characteristics	People having major non-vascular abdominal surgery under general anaesthesia. 25-80 years old (mean 51.6, SD 14.6); 11 men, 49 women; 33 had upper GI surgery and 27 had lower abdominal gynaecologic procedures. Perioperative period ranged from 2.7 – 8.2 hours, Mean 4.6 (SD 1.1 hours)
Number of Patients	60; 235 paired measurements for oral, 300 measurements for tympanic.
Intervention	Tympanic (First Temp infrared thermometer, Model 2000A, Intelligent Medical Systems) Probe tip placed in opening of ear canal, measurements taken in triplicate
Comparison	Oral Measured in posterior sublingual pocket using IVAC TempPlus II predictive thermometer (Model 2080A, IVAC

<table>
<tr><th>Bibliographic reference</th><th>Erickson 1991</th></tr>
<tr><td></td><td>corporation)</td></tr>
<tr><td>Length of follow up</td><td>Within 30 minutes before transport to OR, on entry to OR, on entry to PACU following surgery and before exit from PACU. Tympanic also measured in OR, after preparation of surgical site</td></tr>
<tr><td>Location</td><td>USA</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Temperature (all values in degrees Fahrenheit)
<table>
<tr><th>Time</th><th>Tympanic (mean, SD) range (n=60)</th><th>Oral (mean, SD) range</th><th>Tympanic – oral correlation</th><th>Tympanic – oral offset (mean, SD) range</th></tr>
<tr><td>Before transport to OR</td><td>99.7 (0.6), 98.3-100.7</td><td>98.4 (0.7), 96.6-99.5</td><td>0.78</td><td>1.2 (0.4), 0.4-2.4</td></tr>
<tr><td>OR entry</td><td>99.8 (0.7), 98.4-101.0</td><td>98.6 (0.7), 97.0-100.3
96.4 (1.2), 92.2-98.9</td><td>0.77</td><td>1.1 (0.5), -0.1-2.3</td></tr>
<tr><td>PACU entry</td><td>99.0 (0.8), 97.0-100.5</td><td>97.5 (1.0), 95.5-99.4</td><td>0.85</td><td>1.3 (0.6), 0.0-3.1</td></tr>
<tr><td>PACU exit</td><td></td><td></td><td>0.85</td><td>1.5 (0.5), 0.6-2.5</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td></td></tr>
<tr><td>Comments</td><td>Part of a larger study on thermal coverings on body temperature during the perioperative period.</td></tr>
</table>

Bibliographic reference	Eshragi (2014)
Study type	Prospective observational
Aim	To test the hypothesis that zero heat flux temperatures are sufficiently accurate for routine clinical use.
Patient characteristics	People having non-emergency cardiac surgery Mean age (S) 67 (9); 64% male; Mean duration in operating room 279 (75) minutes.. All subjects monitored for 4 hours in ICU
Number of Patients	105
Intervention	Zero heat flux (SpotOn prototype, 3M) positioned on the skin of the forehead, another was positioned on lateral neck contralateral to the site of internal jugular vein cannulation for the pulmonary artery catheter. Skin surface temperature measured at forehead with self adhesive skin probe (Covidien, Dublin)

<table>
<tr><th>Bibliographic reference</th><th>Eshragi (2014)</th></tr>
<tr><td>Comparison</td><td>Pulmonary artery (</td></tr>
<tr><td>Length of follow up</td><td>Temperatures recorded at 1 minute intervals, excuding period of CPB and for the 1^{st} 4 postoperative hours.</td></tr>
<tr><td>Location</td><td>USA</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Bland Altman:
<table>
<tr><td>Comparison</td><td>Mean (SD), ºC</td><td>95% limits of agreement (ºC)</td></tr>
<tr><td colspan="3">Operating room</td></tr>
<tr><td>Forehead- PA</td><td>-0.08 (0.45)</td><td>-0.96, 0.80</td></tr>
<tr><td>Neck- PA</td><td>-0.15 (0.43)</td><td>-0.99, 0.69</td></tr>
<tr><td>Skin – PA</td><td>-3.1 (1.62)</td><td>-6.27, 0.07</td></tr>
<tr><td>Neck- forehead</td><td>0.07 (0.48)</td><td>-0.88, 1.02</td></tr>
<tr><td colspan="3">Cardiac intensive care unit</td></tr>
<tr><td>Forehead- PA</td><td>-0.32 (0.38)</td><td>-1.06, 0.42</td></tr>
<tr><td>Neck- PA</td><td>-0.40 (0.43)</td><td>-1.24, 0.44</td></tr>
<tr><td>Skin – PA</td><td>-3.2 (1.14)</td><td>-5.44, -0.96</td></tr>
<tr><td>Neck- forehead</td><td>0.07 (0.52)</td><td>-0.95, 1.10</td></tr>
<tr><td>overall</td><td></td><td></td></tr>
<tr><td>Forehead- PA</td><td>-0.23 (0.42)</td><td>-1.06, 0.60</td></tr>
<tr><td>Neck- PA</td><td>-0.30 (0.45)</td><td>-1.18, 0.58</td></tr>
<tr><td>Skin – PA</td><td>-3.2 (1.35)</td><td>-5.84, -0.56</td></tr>
<tr><td>Neck- forehead</td><td>0.07 (0.51)</td><td>-0.92, 1.06</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Supported by 3M</td></tr>
<tr><td>Comments</td><td>Bias differences of more than 0.5ºC were considered to be potentially clinically important.
Initial 10 minutes of zero heat flux discarded to allow for instrument and tissue equilibration..
Analysis restricted to intraoperative period only. CPB period excluded.
2 patients exclude from analysis because of sensor failure.</td></tr>
</table>

Bibliographic reference	Fallis (1994)

<table>
<tr><th>Bibliographic reference</th><th>Fallis (1994)</th></tr>
<tr><td>Study type</td><td>Repeated measures quasi experimental</td></tr>
<tr><td>Aim</td><td></td></tr>
<tr><td>Patient characteristics</td><td>Patients over 18 years undergoing scheduled open heart surgery in which warm or cold cardioplegic solution was used.
24 men and 9 women, mean age 63.4 yrs (range 31- 77 years)</td></tr>
<tr><td>Number of Patients</td><td>40</td></tr>
<tr><td>Intervention</td><td>Oral
Rectal</td></tr>
<tr><td>Comparison</td><td>Pulmonary artery</td></tr>
<tr><td>Length of follow up</td><td>After 30 minute stabilisation period, , temperatures taken on 5 occasions for each subject., 2 x evening before surgery and 3 x after intubation at 1,4 and 8 hours after surgery.</td></tr>
<tr><td>Location</td><td>Canada</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th>Time</th><th>Rectal – PA (ETT in place n=33)
Mean difference (SD)</th><th>Rectal – oral (n=33)
Mean difference (SD)</th><th>Oral – PA (ETT in place n=33).
Mean difference (SD)</th></tr>
<tr><td>1 hour post op</td><td>0.08 (0.37)</td><td>0.22 (0.39)</td><td>-0.14 (0.30)</td></tr>
<tr><td>4 hours post op</td><td>0.16 (0.30)</td><td>0.19 (0.35)</td><td>-0.02 (0.27)</td></tr>
<tr><td>8 hours post op</td><td>0.34 (0.22) (p=<0.05)</td><td>0.21 (0.29)</td><td>0.14 (0.21)</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Canadian council of cardiovascular nurses, Heart and Stroke foundation</td></tr>
<tr><td>Comments</td><td>Data eliminated from 7 people
Sample size of 32 required for power of 90% for significance of 0.2ºC</td></tr>
</table>

Bibliographic reference	**Fanelli (2009)**
Study type	
Aim	To compare temperature in people undergoing arming with resistive heating v faW
Patient characteristics	People undergoing hip replacement
Number of Patients	56
Intervention	Infrared tympanic thermometer (First Temp Genius, Sherwood medical)
Comparison	Tympanic temperature probe (mon-a-therm, Covidien)
Length of follow up	
Location	Italy
Outcomes measures and effect size	Mean (SD) / FAW group / Resistive blanket group Final tympanic temperature (aural probe), ºC / 35.3 (0.5) / 35.1 (0.6) Final IR tympanic temperature, ºC / 35.5 (0.7) / 35.3 (0.7)
Source of funding	Not reported
Comments	

Mean (SD)	FAW group	Resistive blanket group
Final tympanic temperature (aural probe), ºC	35.3 (0.5)	35.1 (0.6)
Final IR tympanic temperature, ºC	35.5 (0.7)	35.3 (0.7)

1

Bibliographic reference	**Fetzer 2008**
Study type	Prospective correlational
Aim	To determine whether Temporal artery thermometer can serve as a substitute for tympanic membrane thermometer in PACU
Patient characteristics	At least 18 years of age, pre and post- operative adult patients. N=82 males, 139 female; mean age (SD): 50.4 (15.4)
Number of Patients	222
Intervention	Temporal artery
Comparison	Tympanic membrane
Length of follow up	Unclear at what point measurements taken
Location	USA
Outcomes measures and effect size	

	Tympanic membrane (ºC) (SD)	Temporal artery (ºC) (SD)	Significance

<table>
<tr><th>Bibliographic reference</th><th>Fetzer 2008</th></tr>
<tr><td></td><td>
<table>
<tr><td>Preoperative (n=54)</td><td>36.9 (0.50)</td><td>36.7 (0.40)</td><td>P=0.013</td></tr>
<tr><td>Postoperative (n=157)</td><td>36.4 (0.64)</td><td>36.5 (0.54)</td><td>P=0.032</td></tr>
<tr><td>Unknown (n=11)</td><td>36.7 (0.65)</td><td>36.8 (0.63)</td><td>Ns</td></tr>
<tr><td>Total sample (n=222)</td><td>36.53 (0.65)</td><td>36.57 (0.52)</td><td>ns</td></tr>
</table>
Bland Altman:
<table>
<tr><th></th><th>Mean difference (SD) [TA – TM/2]</th><th>95% CI</th></tr>
<tr><td>Preoperative (n=54)</td><td>-0.19 (0.54)</td><td>-1.25, 0.87</td></tr>
<tr><td>Postoperative (n=157)</td><td>-0.11 (0.65)</td><td>-1.16, 1.37</td></tr>
<tr><td>Total sample (n=222)</td><td>-0.04 (0.64)</td><td>-1.29, 1.21</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>NR</td></tr>
<tr><td>Comments</td><td>All 5 PACU nurses trained in data collection, but significant differences amongst data collectors. Post hoc analysis indicated one collector responsible for wide variation in mean temperature differences</td></tr>
</table>

Bibliographic reference	Frommelt (2008)
Study type	Prospective observational
Aim	To compare different methods for temperature monitoring
Patient characteristics	Postoperative patients admitted to a surgical unit within 4-6 hours. Aged at least 18 year and less than 85 years. 22 male, 62 female; mean age (SD) 52.5 (14.4)
Number of Patients	84
Intervention	Tympanic temperature- Genius 2090 (IVAC corporation) Oral disposable- 3M TempaDOTs (Model #5122,3M healthcare)
Comparison	Oral electronic- Vital signs monitor 300 (Welch Allen) – reference standard
Length of follow up	Temperatures measured once during hospitalisation with each implement during a scheduled assessment time..

Bibliographic reference	**Frommelt (2008)**
	Less than 1 minute elapsing between temperature measurements for each subject.
Location	USA
Outcomes measures and effect size	<table><tr><td>Device</td><td>Temperature (ºF)</td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>Range</td><td>Average</td><td>Bias (Difference score)</td><td>precision</td><td>Random mean SD</td></tr><tr><td>Oral electronic (reference standard)</td><td>94.6 (100.0)</td><td>97.9 (0.7)</td><td></td><td></td><td></td></tr><tr><td>Tympanic</td><td>91.0 (99.9)</td><td>96.7 (1.2)</td><td>-1.21</td><td>0.79</td><td>1.44</td></tr><tr><td>Disposable oral</td><td>94.0 (99.8)</td><td>97.7 (1.9)</td><td>-0.28</td><td>0.69</td><td>0.74</td></tr><tr><td>Temporal artery</td><td>94.6 (100.4)</td><td>98.3 (1.0)</td><td>0.37</td><td>0.67</td><td>0.76</td></tr></table>
Source of funding	
Comments	Order of temperature measurement was assigned randomly by computer generated randomisation scheme. Order of temperature device testing was not significant (p=0.02) Types of surgery include hysterectomy, radical retropubic prostatectomy, transurethral resection of the prostate, vaginal hysterectomy, breast reduction, nephrectomy, bladder suspension, cholecystectomy, ovarian cyst, other.

1

2

Bibliographic reference	**Harasawa (1997)**
Study type	Prospective observational
Aim	Evaluate the performance of IR emission detection thermometer during coronary artery revascularisation, in which mild hypothermic CPB was used.
Patient characteristics	People undergoing coronary artery bypass graft surgery Mean age 60 years.
Number of Patients	30
Intervention	IR tympanic (Thermoscan Pro-1)

<table>
<tr><th>Bibliographic reference</th><th>Harasawa (1997)</th></tr>
<tr><td></td><td>Tympanic- using thermocouple (in 16/30 patients), (mon-a-therm, mallinckrodt)</td></tr>
<tr><td>Comparison</td><td>Oesophageal (mon-a-therm, mallinckrodt)</td></tr>
<tr><td>Length of follow up</td><td>Pre, during and after CPB</td></tr>
<tr><td>Location</td><td>Japan</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Bland Altman: paper reported mean difference+/- 2SD. Upper and lower limits calculated by analyst.
IRED tympanic v oesophagus
<table>
<tr><th></th><th>IR tympanic v oesophageal mean bias (SD)</th><th>IR tympanic v thermocouple tympanic</th></tr>
<tr><td>Before CPB</td><td>-0.36 (0.66) [-1.02, 0.3]</td><td>-0.09 (0.34) [-0.43, 0.25]</td></tr>
<tr><td>After CPB</td><td>-0.30 (0.75) [-1.05, 0.45]</td><td>-0.06 (0.40) [-0.46, 0.34]</td></tr>
</table></td></tr>
<tr><td>Source of funding</td><td>Not reported.</td></tr>
<tr><td>Comments</td><td>Bland Altman plots did not display figures. Bias apparently not reported.</td></tr>
</table>

Bibliographic reference	Harioka (2000)
Study type	
Aim	To evaluate the accuracy and precision of “deep forehead” temperature with rectal, oesophageal and tympanic membrane temperature compared with blood temperature
Patient characteristics	ASA physical status I or II undergoing abdominal or thoracic surgery under general anaesthesia scheduled to last at least 3 hours. None were obese, taking medication or had a history of problems with the tympanic membrane. Age 66 (10) years (mean, SD). 451 temperature sets recorded. Blood temperatures ranged from 33.3-37.7ºC
Number of Patients	41
Intervention	Deep forehead- measured using Coretemp. Sensor fixed securely with tape, 20 minutes before anaesthesia induction. Rectal, tympanic membrane, distal oesophagus measured using isposable thermocouples and Model 6500 digital thermometers. (mon-a-therm, Mallinckrodt).

Bibliographic reference	**Harioka (2000)**
	Tympanic temperatures measured at right membrane. Probe inserted until atients felt the thermocouple touch the tympanic membrane. Oesophageal probe positioned at point with maxima heart sounds.
Comparison	Blood temperature – pulmonary artery catheter (Baxter inc.) inserted before induction.
Length of follow up	Temperatures recorded at 20 minute intervals after induction of anaesthesia
Location	Japan
Outcomes measures and effect size	
Source of funding	
Comments	Determined accuracy and precision of 0.5 degrees celcius to be clinically acceptable. Reported Bland Altman analysis, but figures not legible in paper.

Measure	Forehead	Rectal	Tympanic	Oesophageal
R^2	0.85	0.85	0.93	0.95
Slope	0.84	1.02	0.96	0.97
Mean (ºC) – mean difference between reference and test	0.0	0.3	0.0	0.1
SD (ºC)	0.3	0.3	0.2	0.2

1

Bibliographic reference	**Hecker (1996)**
Study type	Prospective observational
Aim	To compare skin core temperature corrected liquid crystal thermography, axillary electronic and infrared tympanic membrane temperatures with oral thermometry
Patient characteristics	Sequential postoperative patients admitted to PACU. 88 men, 117 women; mean age 45.2 (SD 19.6);
Number of Patients	205
Intervention	Forehead skin core-temperature-corrected LCT strips (Sharn Inc, Tampa) Axillary and oral thermistor tipped electronic probes (oral probe, IVAC), Infrared sensitive electronic tympanic probe (First Temp Genius Model 3000A, Intelligent Medical Systems Inc)
Comparison	

Bibliographic reference	**Hecker (1996)**
Length of follow up	Immediately upon arrival in PACU, simultaneous measurement with different methods of temperature measurement.
Location	USA
Outcomes measures and effect size	Bland Altman: mean (SD) reported. 2SD calculated by analyst. Values are ºC. Infrared tympanic v Oral thermometer: 0.27 (0.67) Axilla v oral: -0.90 (0.80) Forehead v oral: -0.52 (0.90)
Source of funding	Not reported
Comments	

1

Bibliographic reference	**Heidenreich (1990)**
Study type	
Aim	To determine the validity of the axillary site for temperature measurement in the postoperative patient.
Patient characteristics	Post- operative patients, directly admitted from the operating room to ICU, who had major surgical procedures. 11 men, 7 women; mean age 66.3 yrs (range 53-86). Operation time ranged from 130-565 minutes, mean 292 minutes.
Number of Patients	18
Intervention	Axillary electronic (Filac, Cheeseborough-Ponds)- left in place until digital display indicated it had registered. Axillary mercury (Tem-Con mercury in glass thermometers)- left in situ for 5 minutes, removed and replaced for another 5 minuts; temperature then read. Rectal mercury (Tem-Con mercury in glass thermometers) – in situ for 5 minutes, removed and replaced for another 5 minutes; temperature then read.
Comparison	Core temperature- pulmonary catheter with thermistor
Length of follow up	Immediately upon arrival in ICU Length of time from arrival in ICU to temperature assessment ranged from 0-185 minutes, mean 18 minutes.

<table>
<tr><th>Bibliographic reference</th><th>Heidenreich (1990)</th></tr>
<tr><td>Location</td><td>USA</td></tr>
<tr><td>Outcomes measures and effect size</td><td><table>
<tr><td>Site</td><td>Mean (SD)</td><td>range</td></tr>
<tr><td>Pulmonary artery</td><td>36.0 (1.3)</td><td>33.4, 38.7</td></tr>
<tr><td>Electronic axillary</td><td>35.4 (1.1)</td><td>32.4, 37.2</td></tr>
<tr><td>5 minute mercury axillary</td><td>35.7 (1.5)</td><td>32.0, 38.8</td></tr>
<tr><td>10 minute mercury axillary</td><td>35.8 (1.4)</td><td>33.0, 38.8</td></tr>
<tr><td>Rectal mercury</td><td>36.5 (1.4)</td><td>34.0, 39.7</td></tr>
</table></td></tr>
<tr><td>Source of funding</td><td>Not reported</td></tr>
<tr><td>Comments</td><td>2 patients had delays of more than 15 minutes in having temperature assessed in ICU.</td></tr>
</table>

Bibliographic reference	Hocker (2012)
Study type	Prospective
Aim	To evaluate the performance of perioperative sublingual and tympanic temperature measurement in awake and anaesthetised patients.
Patient characteristics	Aged 18-75, scheduled for surgery less than 1 hour under general anaesthesia. ASA status I or II. Mean (S) age 52.9 (13.8); female n=118, male n=53; type of surgery (abdominal n=101: orthopaedic n=17; gynae n=45: ENT n=8
Number of Patients	171
Intervention	Sublingual- measured by inserting the probe (Temp Plus II, Model 2080, Alaris medical systems) into posterior sublingual pocket. Measured by study nurse blinded to results of tympanic membrane measurements.
Comparison	Tympanic- thermocouple inserted into ear to contact tympanic membrane (Tympanic temperature sensor YSI 400, Smiths medical) left to equilibrate for at least 5 minutes
Length of follow up	Temperatures measured preoperative – on arrival in OR; intraoperatively- 30 minutes after start of surgery and postoperatively- immediately after arrival in PACU.
Location	Germany

<table>
<tr><th>Bibliographic reference</th><th>Hocker (2012)</th></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th>Measurement time/ patient condition</th><th>Sublingual (ºC)</th><th>Tympanic (ºC)</th><th>P</th></tr>
<tr><td>Preoperative/ awake</td><td>36.5 (0.3)</td><td>36.3 (0.3)</td><td><0.0001</td></tr>
<tr><td>Intraoperative/ intubated</td><td>36.4 (0.3)</td><td>36.3 (0.3)</td><td><0.0001</td></tr>
<tr><td>Postoperative/ Awake</td><td>36.2 (0.4)</td><td>36.1 (0.4)</td><td><0.0001</td></tr>
</table>

Bland Altman bias (SD):
Preoperative: -0.15 (0.24)
Intraoperative: -0.09 (0.21)
Postoperative: -0.09 (0.23)</td></tr>
<tr><td>Source of funding</td><td>none</td></tr>
<tr><td>Comments</td><td></td></tr>
</table>

Bibliographic reference	Iden (2015)
Study type	Propspective observational
Aim	To evaluate a new temperature sensor (3M Spot on) using the zero heat flux method attached to the forehead, and compare it to sublingual and nasopharyngeal sensors
Patient characteristics	Men and women undergoing elective trauma or gynaecological surgery under general anaesthesia. Female n=55, male n=28; female (age: mean, SD) 47.7 (14.1); male (age):55.0 (16.8)
Number of Patients	120 enrolled, data from 83 patients finally analysed.
Intervention	(3M Spot on) using the zero heat flux, forehead
Comparison	Sublingual- SureTemp plus, WelchAlleyn Inc. monitored in posterior sublingual pocket Nasopharyngeal- Adult temperature probe, D-OS4 exacon scientific A/S. sensor placed just posterior to the soft palate.
Length of follow up	Measured at 15, 45 and 75 minutes post induction of anaesthesia.
Location	Germany

<table>
<tr><th>Bibliographic reference</th><th>Iden (2015)</th></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><td>time</td><td>ZHF v nasopharyngeal
Bland Altman measurement Bias (SD) [95% limits of agreement]</td><td>ZHF v sublingual
Bland Altman measurement Bias (SD) [95% limits of agreement]</td></tr>
<tr><td>15 minute</td><td>0.07 (0.22) [-0.38, 0.51]</td><td>-0.37 (0.30) [-0.95, 0.22]</td></tr>
<tr><td>45 minutes</td><td>0.05 (0.22) [-0.39, 0.48]</td><td>-0.36 (0.30) [-0.95, 0.23]</td></tr>
<tr><td>75 minutes</td><td>0.10 (0.18) [-0.25, 0.46]</td><td>-0.33 (0.27) [-0.84, 0.19]</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>3M</td></tr>
<tr><td>Comments</td><td>37 patients excluded; 19 patients, the sublingual temperature could not be obtained at 45 minutes of surgery due to calibration failure. For 12 patients, surgery time was less than 60 minutes; 4 had signal errors with the SpotOn sensor, 2 patients opted for spinal epidural.

0.5ºC used for accuracy and precision considered clinically significant. Sample of 77 patients adequate to detect difference of 0.15ºC and SD 0.333</td></tr>
</table>

Bibliographic reference	Kiya (2007)
Study type	Observational comparative
Aim	To determine the usefulness of an earphone-type infrared tympanic thermometer (IRT) for core temperature monitoring during surgery.
Patient characteristics	Group 1: 18 people AS I and II, 18-67 years (mean = 46.2), scheduled for elective surgery (noncardiac and non abdominal) under general anaesthesia. Median duration of operation 186 (range 50-650 minutes) Group 2: 8 people ASA II or III who had been scheduled for cardiac surgery with CPB. – temperature monitored during cooling and rewarming phases of CPB (excluded from this analysis)
Number of Patients	18 + 8 = 26
Intervention	Earphone type IR tympanic inserted into left or right ear. Rectal Thermistor probes inserted 8cm into rectum (CTM-210, Terumo, Tokyo)
Comparison	Oesophageal Thermistor probes inserted approx. 30 cm into oesophagus. (CTM-210, Terumo, Tokyo)

Bibliographic reference	**Kiya (2007)**
Length of follow up	Temperatures monitored and recorded at 1 min intervals
Location	Japan
Outcomes measures and effect size	Bland Altman: Group 1: IRT v oesophagus: +0.08 (2SD 0.34) Rectal v oesophagus: +0.11 (2SD 0.55) Group 2: IRT v oesophagus: +0.72 (2SD 2.2) Rectal v oesophagus: +0.43 (2SD 3.4)
Source of funding	
Comments	Patients warmed with Bair Hugger FAW during surgery.

Bibliographic reference	**Langham 2009**
Study type	Prospective observational
Aim	To quantify the change in core temperature occurring during emergence and transport to evaluate the accuracy and precision of 8 non-invasive thermometers in the PACU.
Patient characteristics	People having laparoscopic surgery, ASA I & II, aged over 18 years
Number of Patients	50
Intervention	Oesophagus – oesophageal stethoscope with thermistor (Mon-a-therm, EST) Temporal artery thermometer- Temporal scanner, TAT-5000 Infrared aural canal thermometer- FirstTemp Genius 3000A Skin-surface thermocouple (mon-a-therm 6130) Liquid crystal display strip (crystalline moving line, Sharna)

Bibliographic reference	**Langham 2009**
	Electronic thermometer (IVAC TempPlus II)
Comparison	Bladder (Foley catheter with thermistor (Mon-a-therm, Mallinkrodt)
Length of follow up	PACU arrival and 30 and 60 minutes thereafter
Location	USA
Outcomes measures and effect size	
Source of funding	Crystaline Moving thermometers received from Sharn, Tampa, Florida. No other funding reported.
Comments	

Comparison (compared to bladder (reference)	Mean (SD)	95% limits of agreement
Electric oral	-0.25 (0.38)	-1.00, 0.50
Deep FH	-0.50 (0.41)	-1.31, 0.31
TA	-0.23 (0.50)	-1.20, 0.75
Elec Axilla	-0.50 (0.42)	-1.34, 0.33
Deep chest	-0.65 (0.53)	-1.70, 0.40
TC FH2	-0.46 (0.68)	-1.81, 0.88
IRAC right	-1.04 (0.51)	-2.04, -0.04
IRAC left	-1.06 (0.51)	-2.06, -0.06
TC FH	-2.46 (0.68)	-3.81, -1.12
Between 2 references		
Bladder – oesophageal	-0.06 (0.26)	-0.56, 0.45
IRAC right – IRAC left	0.02 (0.40)	-0.76, 0.81

Bibliographic reference	**Matsukawa 1995**
Study type	Prospective observational

Bibliographic reference	**Matsukawa 1995**
Aim	To test the hypothesis that new IR aural canal thermometer sufficiently accurate and precise for routine intraoperative use.
Patient characteristics	Women undergoing open lower abdominal surgery. Age (mean, SD)= 49 (15); surgery lasted 3.3 (1.6) hours
Number of Patients	30
Intervention	IR aural canal thermometer (Quickthermo, Tanabe pharmaceutical)- in right ear canal
Comparison	Thermocouples in aural canal Left tympanic membrane, using Mon-a-therm (Mallinckrodt). Inserted until patient felt thermocouple touch tympanic membrane Thermocouples in bladder using Mon-a-therm (Mallinckrodt)
Length of follow up	Values from each site recorded at 30 minute intervals throughout anaesthesia
Location	Japan
Outcomes measures and effect size	Correlation Between IR and aural thermocouple: 0.66 Between IR and bladder: 0.35 Difference: IR and aural thermocouple: -0.1 (2SD 0.7)ºC NR for IR v bladder.
Source of funding	Tanabe pharmaceutical provided the Quickthermo thermometer.
Comments	Did not report bias for IR v bladder.

Bibliographic reference	**Ng 2006**
Study type	RCT
Aim	To compare the efficacy of FAW and electric heating pad.
Patient characteristics	People undergoing Total knee replacement.Age 18-80 years, ASA physical status I-III. Cobined spinal- epidural anaesthesia.
Number of Patients	60
Intervention	Tympanic- Thermoscan Pro 1, Braun.
Comparison	Rectal- thermistor temperature probe (not reported which manufacturer.
Length of follow up	Unclear – appears that temperature only monitored during operation for rectal temperature, not reported for tympanic temperature.
Location	Hong Kong
Outcomes measures and effect size	First temperature recording, mean (SD) (ºC): (see table below) Final temperature recording, mean (SD) (ºC): (see table below)
Source of funding	NR
Comments	Part of a study comparing FAW vs electric heating pad. Doesn't report rectal and tympanic temperatures for whole cohort, only separate groups.

First temperature recording, mean (SD) (ºC):

	Forced air (n=30)	Heating pad (n=30)
Rectal	36.8 (0.4)	36.9 (0.3)
Tympanic	36.6 (0.4)	36.6 (0.5)

Final temperature recording, mean (SD) (ºC):

	Forced air (n=30)	Heating pad (n=30)
Rectal	36.8 (0.4)	36.9 (0.4)
Tympanic	36.3 (0.5)	36.1 (0.7)

1

2

Bibliographic reference	**Robinson 1998**
Study type	Prospective observational
Aim	Measurements of rapid changes in temperature at different sites to establish best site to measure temperature and

<table>
<tr><th>Bibliographic reference</th><th>Robinson 1998</th></tr>
<tr><td></td><td>compare two brands of commercial tympanic thermometer.</td></tr>
<tr><td>Patient characteristics</td><td>People undergoing elective cardiac surgery</td></tr>
<tr><td>Number of Patients</td><td>18</td></tr>
<tr><td>Intervention</td><td>tympanic (Core-check, IVAC), tympanic (Genius, intelligent medical systems); rectum, axilla, Oesophagus (Hi Lo temp probes, Mallinckrodt)</td></tr>
<tr><td>Comparison</td><td>Pulmonary artery (Baxter Swan Ganz 7 catheters</td></tr>
<tr><td>Length of follow up</td><td>Intraoperative temperature measurement: measured every 5-10 minutes for oesophagus, rectum, and PA (when not on CPB)</td></tr>
<tr><td>Location</td><td>Canada</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><td>Variable</td><td>N</td><td>Mean difference (ºC) SD</td></tr>
<tr><td>PA- oesophagus</td><td>234</td><td>0.0 (0.5)</td></tr>
<tr><td>PA-IVAC (tympanic)</td><td>234</td><td>-0.3 (0.5)</td></tr>
<tr><td>PA- Genius (tympanic)</td><td>234</td><td>-0.4 (0.5)</td></tr>
<tr><td>PA- Rectal</td><td>234</td><td>-0.4 (1.0)</td></tr>
<tr><td>PA- Axilla</td><td>234</td><td>0.2 (1.0)</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Part funded by ALARIS medical systems</td></tr>
<tr><td>Comments</td><td>Difference of 0.5ºC considered to be clinically significant.
Tympanic- Genius was in tympanic mode calibrated to read 0.3ºC higher than rectal an 1.0ºC higher than oral.
IVAC only gives readings in an equivalence mode.
Temperatures recorded during CPB not used in calculations as absence of pulmonary blood flow would interfere with accuracy of PA readings.
All sets of readings where PA <25ºC were eliminate from calculations as measurement with IVAC range from 25-43.3ºC.
Data on cooling and rewarming appear to have been analysed separately.</td></tr>
</table>

Bibliographic reference	Russell 1996
Study type	Prospective observational
Aim	To compare urinary bladder and oesophageal temperatures with pulmonary artery core temperature.

<table>
<tr><th>Bibliographic reference</th><th>Russell 1996</th></tr>
<tr><td>Patient characteristics</td><td>People undergoing orthotic liver transplant</td></tr>
<tr><td>Number of Patients</td><td>20</td></tr>
<tr><td>Intervention</td><td>Urinary bladder- Mon-a-therm thermistor tipped urinary catheter passed into bladder

Oesophagus- Mon-a-therm, Mallinckrodt placed in lower 1/3 of the oesophagus at site of maximum heart sounds</td></tr>
<tr><td>Comparison</td><td>Pulmonary artery- Baxter pulmonary artery catheter inserted via internal jugular or subclavian vein.</td></tr>
<tr><td>Length of follow up</td><td>Temperature measured continuously from all 3 sites; recorded at 8 time points.</td></tr>
<tr><td>Location</td><td>UK</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th>Time point</th><th>Pulmonary artery ºC (mean, SD)</th><th>Bladder ºC (mean, SD)</th><th>Oesophagus ºC (mean, SD)</th></tr>
<tr><td>1. Incision</td><td>35.6 (0.6)</td><td>35.8 (0.6)</td><td>35.7 (0.6)</td></tr>
<tr><td>2. Incision+60 minutes</td><td>35.5 (0.5)</td><td>35.6 (0.5)</td><td>35.5 (0.5)</td></tr>
<tr><td>3.start of anhepatic phase</td><td>35.3 (0.5)</td><td>35.3 (0.6)</td><td>35.2 (0.6)</td></tr>
<tr><td>4.anhepatic+ 30 minutes</td><td>35.0 (0.6)</td><td>35.1 (0.6)</td><td>34.8 (0.7)</td></tr>
<tr><td>5. reperfusion</td><td>34.6 (0.6)</td><td>34.8 (0.7)</td><td>34.0 (0.7)</td></tr>
<tr><td>6. reperfusion+ 30 minutes</td><td>34.9 (0.6)</td><td>34.9 (0.6)</td><td>34.2 (1.0)</td></tr>
<tr><td>7. reperfusion + 60 minutes</td><td>35.2 (0.7)</td><td>35.2 (0.7)</td><td>34.9 (1.0)</td></tr>
<tr><td>8.closure</td><td>35.7 (0.7)</td><td>35.7 (0.7)</td><td>35.2 (0.9)</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>NR</td></tr>
<tr><td>Comments</td><td>No patient demographics.</td></tr>
</table>

Bibliographic reference	Winslow 2012
Study type	Prospective observational
Aim	To compare oral, temporal artery and bladder temperatures.

Bibliographic reference	**Winslow 2012**
Patient characteristics	Hospitalised people, undergoing elective surgery (colon resection, breast reconstruction, gastric bypass, Whipple procedure, abdominal aortic aneurism repair, aortic femoral bypass). 18 years or older. Surgery expected to last an hour or more. 43 women, 21 men. Mean age 57 (SD 17) years, surgery duration averaging 176 minutes. Most common surgery was colon resection (52%)
Number of Patients	109. 45 were excluded therefore data analysed for 64 people.
Intervention	Oral (pre-operative)- Electronic oral thermometer- Welch Allyn SUreTemp Plus 690 Oral (Welch Allyn) Bladder (intra and post- operative)- Bardex Lubricath 400 series foley catheter and lubrisil (C.R Bard, inc)
Comparison	Temporal artery (pre and post- operative)- Temporal scanner Modell TAT 5000 (Exergen)
Length of follow up	Preoperatively, one hour after induction of anaesthesia, within 15 minutes of arrival in PACU, on discharge from PACU
Location	USA
Outcomes measures and effect size	Bland Altman data Oral v temporal pre-operative: bias -0.43 (-1.46, 0.51) Bladder v temporal artery: bias -0.76 (-3.04, 1.52) Patient temperatures (ºF)
Source of funding	NR
Comments	

Patient temperatures (ºF)

	Oral/ bladder, mean (SD)	Temporal, mean (SD)
Pre- op	97.9 (0.30) ORAL	98.4 (0.60)
PACU admission	97.1 (1.34) BLADDER	97.9 (0.84)
PACU discharge	97.9 (1.02)	98.0 (0.63)

Appendix H: GRADE profiles

H.1 Review question 1: Devices - Intraoperative

Table 21: Devices – Intraoperative – Core temperature at end of surgery

Quality assessment						Number of patients		Effect		
Number of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Forced air warming**	**Other warming**	**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
Circulating water blanket										
1	randomised trials	no serious risk of bias[1]	No serious inconsistency[2]	no serious indirectness[3]	serious[4]	5	5	-	MD 0.7 higher (0.2 to 1.2 higher)	MODERATE
Circulating water garment										
5	randomised trials	no serious risk of bias[1]	very serious[5]	no serious indirectness[3]	very serious[6]	102	103	-	MD 0.67 lower (1.41 lower to 0.07 higher)	VERY LOW
Circulating water mattress										
2	randomised trials	no serious risk of bias[1]	serious[7]	no serious indirectness[3]	serious[4]	16	16	-	MD 0.82 higher (0.18 to 1.45 higher)	LOW
Radiant heating										
3	randomised trials	no serious risk of bias [1]	no serious inconsistency[8]	no serious indirectness[3]	no serious imprecision[9]	82	79	-	MD 0.29 higher (0.14 to 0.44 higher)	HIGH
Warming pads										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	serious[4]	25	25	-	MD 1.4 lower (1.79 to 1.01 lower)	MODERATE
Resistive heating blanket										

Quality assessment						Number of patients		Effect		
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Forced air warming	Other warming	Relative (95% CI)	Absolute (95% CI)	Quality
7	randomised trials	no serious risk of bias[1]	very serious[5]	no serious indirectness[3]	no serious imprecision[9]	158	157	-	MD 0.01 higher (0.25 lower to 0.27 higher)	LOW
6	randomised trials	no serious risk of bias[1]	No serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[9]	129	127	-	MD 0.14 higher (0.02 lower to 0.27 higher)	HIGH
Resistive heating mattress										
2	randomised trials	no serious risk of bias[1]	no serious inconsistency[8]	serious [10]	no serious imprecision[9]	112	117	-	MD 0.22 higher (0.07 to 0.27 higher)	MODERATE
Electric heating pads										
2	randomised trials	no serious risk of bias[1]	very serious[5]	no serious indirectness[3]	very serious[6]	60	60	-	MD 0.44 higher (0.64 lower to 1.51 higher)	VERY LOW
Electric blanket										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[9]	40	20	-	MD 1.3 higher (1.1 to 1.5 higher)	HIGH

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's cross one MID (0.5 degrees C)
[5] Severe heterogeneity (Isq > 70%)
[6] 95% CI's cross two MID's (0.5 degrees C)
[7] Moderate heterogeneity (Isq > 40%)
[8] No heterogeneity (Isq ≤ 40%)
[9] 95% CI's do not cross MID's (0.5 degrees C)
[10] The resistive heating mattress only included the mattress not the over-blanket as used in clinical practice so this understated the effectiveness of resistive heating mattress for this outcome

Table 22: Devices – Intraoperative – Core temperature at 30 mins

Quality assessment	Number of patients	Effect	Quality

Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Forced air warming	Other warming	Relative (95% CI)	Absolute (95% CI)	
Circulating water mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[4]	23	23	-	MD 0.03 lower (0.24 lower to 0.18 higher)	HIGH
Resistive heating blanket										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[22]	no serious indirectness[3]	no serious imprecision[4]	28	28	-	MD 0.03 higher (0.31 lower to 0.37 higher)	HIGH
Resistive heating mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	serious[5]	no serious imprecision[4]	30	33	-	MD 0.21 higher (0.07 lower to 0.49 higher)	MODERATE
Radiant heating										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[4]	29	30	-	MD 0.14 higher (0.11 lower to 0.39 higher)	HIGH
Electric heating pads										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[4]	30	30	-	MD 0.19 lower (0.5 lower to 0.12 higher)	HIGH
Electric blanket										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[4]	40	20	-	MD 0.4 higher (0.19 to 0.61 higher)	HIGH

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's do not cross MID's (0.5 degrees C)
[5] The resistive heating mattress only included the mattress not the over-blanket as used in clinical practice so this understated the effectiveness of resistive heating mattress for this outcome

1 **Table 23: Devices – Intraoperative – Core temperature at 60 mins**

Quality assessment						Number of patients		Effect		
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Forced air warming	Other warming	Relative (95% CI)	Absolute (95% CI)	Quality
Circulating water blanket										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[4]	5	5	-	MD 0.03 lower (0.48 lower to 0.42 higher)	HIGH
Circulating water garment										
6	randomised trials	no serious risk of bias[1]	very serious[5]	no serious indirectness[3]	serious[6]	130	138	-	MD 0.33 lower (0.68 lower to 0.01 higher)	VERY LOW
Circulating water mattress										
3	randomised trials	no serious risk of bias[1]	very serious[5]	no serious indirectness[3]	no serious imprecision[4]	39	39	-	MD 0.08 lower (0.36 lower to 0.19 higher)	LOW
Resistive heating blanket										
5	randomised trials	no serious risk of bias[1]	no serious inconsistency[7]	no serious indirectness[3]	no serious imprecision[4]	110	109	-	MD 0.08 lower (0.2 lower to 0.05 higher)	HIGH
4	randomised trials	no serious risk of bias[1]	no serious inconsistency[7]	no serious indirectness[3]	no serious imprecision[4]	81	79	-	MD 0.06 lower [0.19 lower to 0.08]	HIGH
Resistive heating mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	serious[8]	no serious imprecision[4]	30	32	-	MD 0.05 higher (0.23 lower to 0.33 higher)	MODERATE
Radiant heating										
2	randomised trials	no serious risk of bias[1]	no serious inconsistency[7]	no serious indirectness[3]	no serious imprecision[4]	61	48	-	MD 0.11 higher (0.07 lower to 0.3 higher)	HIGH
Electric heating pads										
1	randomised	no serious	no serious	no serious	no serious	30	30	-	MD 0.27 lower	HIGH

Quality assessment						Number of patients		Effect		
Number of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Forced air warming**	**Other warming**	**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
	trials	risk of bias[1]	inconsistency[2]	indirectness[3]	imprecision[4]				(0.63 lower to 0.09 higher)	
Electric blanket										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	serious[6]	40	20	-	MD 0.4 higher (0.22 to 0.58 higher)	MODERATE

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's do not cross MID's (0.5 degrees C)
[5] Severe heterogeneity (Isq > 70%)
[6] 95% CI's cross one MID (0.5 degrees C)
[7] No heterogeneity (Isq ≤ 40%)
[8] The resistive heating mattress only included the mattress not the over-blanket as used in clinical practice so this understated the effectiveness of resistive heating mattress for this outcome

Table 24: Devices – Intraoperative – Core temperature at 120 mins

Quality assessment						Number of patients		Effect		
Number of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Forced air warming**	**Other warming**	**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
Circulating water blanket										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	serious[4]	5	5	-	MD 0.39 lower (0.81 lower to 0.03 higher)	MODERATE
Circulating water garment										
2	randomised trials	no serious risk of bias[1]	very serious[5]	no serious indirectness[3]	serious[4]	61	60	-	MD 0.56 lower (0.74 to 0.37 lower)	VERY LOW
Circulating water mattress										
3	randomised trials	no serious risk of bias[1]	very serious[5]	no serious indirectness	serious[4]	91	61	-	MD 0.48 higher (0.4 to 0.55	VERY LOW

Quality assessment						Number of patients		Effect		Quality
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Forced air warming	Other warming	Relative (95% CI)	Absolute (95% CI)	
				[3]					higher)	
Resistive heating blanket										
4	randomised trials	no serious risk of bias[1]	no serious inconsistency[6]	no serious indirectness[3]	no serious imprecision[7]	98	97	-	MD 0.08 lower (0.22 lower to 0.07 higher)	HIGH
3	randomised trials	no serious risk of bias[1]	no serious inconsistency[6]	no serious indirectness[3]	no serious imprecision[7]	69	67	-	MD 0.01 lower (0.17 lower to 0.14 higher)	HIGH
Resistive heating mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	serious [8]	no serious imprecision[7]	25	25	-	MD 0.12 lower (0.47 lower to 0.23 higher)	MODERATE
Radiant heating										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	serious[4]	29	30	-	MD 0.3 higher (0.03 to 0.57 higher)	MODERATE

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's cross one MID (0.5 degrees C)
[5] Severe heterogeneity (Isq > 70%)
[6] No heterogeneity (Isq ≤ 40%)
[7] 95% CI's do not cross MID's (0.5 degrees C)
[8] The resistive heating mattress only included the mattress not the over-blanket as used in clinical practice so this understated the effectiveness of resistive heating mattress for this outcome

Table 25: Devices – Intraoperative – Hypothermia

Quality assessment						Number of patients		Effect		Quality
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Forced air warming	Other warming	Relative (95% CI)	Absolute (95% CI)	
Circulating water garment										

Quality assessment						**Number of patients**		**Effect**		
Number of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Forced air warming**	**Other warming**	**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
3	randomised trials	no serious risk of bias[1]	serious[2]	no serious indirectness[3]	serious[4]	22/77 (28.6%)	22/86 (25.6%)	RR 1.31 (0.48 to 3.59)	79 more per 1000 (from 133 fewer to 663 more)	LOW
Circulating water mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	serious[4]	6/22 (27.3%)	11/22 (50%)	RR 0.55 (0.25 to 1.21)	225 fewer per 1000 (from 375 fewer to 105 more)	MODERATE
Radiant heating										
3	randomised trials	no serious risk of bias[1]	no serious inconsistency[6]	no serious indirectness[3]	serious[4]	20/75 (26.7%)	26/66 (39.4%)	RR 0.69 (0.43 to 1.11)	122 fewer per 1000 (from 225 fewer to 43 more)	MODERATE
Resistive heating mattress										
2	randomised trials	no serious risk of bias[1]	very serious[7]	serious[9]	serious[4]	48/112 (42.9%)	65/117 (55.6%)	RR 0.56 (0.17 to 1.85)	244 fewer per 1000 (from 461 fewer to 472 more)	VERY LOW
Electric heating pads										
2	randomised trials	no serious risk of bias[1]	no serious inconsistency[8]	no serious indirectness[3]	serious[4]	15/60 (25%)	19/60 (31.7%)	RR 0.79 (0.5 to 1.24)	67 fewer per 1000 (from 158 fewer to 76 more)	MODERATE
Warming pads										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	serious[4]	5/25 (20%)	0/25 (0%)	RR 11 (0.64 to 188.95)	-	MODERATE

[1] No concerns over risk of bias
[2] Moderate heterogeneity (Isq > 40%)
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI cross line of no effect (RR = 1)
[5] Single study analysis
[6] No heterogeneity (Isq ≤ 40%)
[7] Severe heterogeneity (Isq > 70%)

[8] Data only sourced from one of the 2 included studies
[9] The resistive heating mattress only included the mattress not the over-blanket as used in clinical practice so this understated the effectiveness of resistive heating mattress for this outcome

Table 26: Devices – Intraoperative – Blood transfusion

Quality assessment						Number of patients		Effect		
Number of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Forced air warming**	**Other warming**	**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
Resistive heating mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[7]	very serious[4]	0/78 (0%)	2/81 (2.5%)	RR 0.21 (0.01 to 4.26)	20 fewer per 1000 (from 24 fewer to 80 more)	LOW
Warming pads										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[4]	12/25 (48%)	13/25 (52%)	RR 0.92 (0.53 to 1.61)	42 fewer per 1000 (from 244 fewer to 317 more)	HIGH
Circulating water garment										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	serious[5]	14/29 (48.3%)	6/30 (20%)	RR 2.41 (1.08 to 5.42)	282 more per 1000 (from 16 more to 884 more)	MODERATE
Resistive heating blanket										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	very serious[4]	14/29 (48.3%)	12/30 (40%)	RR 1.21 (0.68 to 2.15)	84 more per 1000 (from 128 fewer to 460 more)	LOW
Circulating water mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[6]	0/60 (0%)	0/30 (0%)	not pooled	not pooled	HIGH

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's cross both default MID's (RR 0.8 and 1.25)

[5] 95% CI's cross one default MID (RR = 1.25)
[6] No events reported
[0] The resistive heating mattress only included the mattress not the over-blanket as used in clinical practice but this was not expected to affect this outcome

Table 27: Devices – Intraoperative – Blood loss

Quality assessment						Number of patients		Effect		
Number of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**			**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
Circulating water garments										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[4]	29	29	-	MD 1186 higher (763.53 to 1608.47 higher)	HIGH
Resistive heating blanket										
4	randomised trials	no serious risk of bias[1]	no serious inconsistency[5]	no serious indirectness[3]	no serious imprecision[4]	98	97	-	MD 29.35 higher (168.18 lower to 226.88 higher)	HIGH
Electric heating pads										
2	randomised trials	no serious risk of bias[1]	no serious inconsistency[5]	no serious indirectness[3]	no serious imprecision[4]	60	60	-	MD 2.68 lower (21.96 lower to 16.6 higher)	HIGH
Circulating water mattress										
1	randomised trials	no serious risk of bias[1]	very serious[6]	no serious indirectness[3]	very serious[7]	8	8	-	MD 84.0 higher (677.32 lower to 845.32 higher)	VERY LOW

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] Confidence intervals around point estimate do not cross MID of 500 mL (agreed with committee)
[5] No heterogeneity (Isq ≤ 40%)
[6] Confidence intervals around point estimate cross both MID 500 mL (agreed with committee)
[5] Severe heterogeneity (Isq > 70%)

Table 28: Devices – Intraoperative – Shivering

Quality assessment	Number of patients	Effect	Quality

Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			Relative (95% CI)	Absolute (95% CI)	
Circulating water mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[4]	11/60 (18.3%)	14/30 (46.7%)	RR 0.39 (0.2 to 0.76)	285 fewer per 1000 (from 112 fewer to 373 fewer)	HIGH
Circulating water garment										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	very serious[5]	4/18 (22.2%)	1/19 (5.3%)	RR 4.22 (0.52 to 34.28)	169 more per 1000 (from 25 fewer to 1000 more)	LOW
Radiant heating										
2	randomised trials	no serious risk of bias[1]	no serious inconsistency[6]	no serious indirectness[3]	very serious[5]	4/59 (6.8%)	3/56 (5.4%)	RR 1.22 (0.25 to 6.08)	12 more per 1000 (from 40 fewer to 272 more)	LOW
Electric heating pads										
2	randomised trials	no serious risk of bias[1]	no serious inconsistency[6]	no serious indirectness[3]	very serious[5]	4/60 (6.7%)	3/60 (5%)	RR 1.31 (0.3 to 5.74)	15 more per 1000 (from 35 fewer to 237 more)	LOW

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's do not cross default MIDs (RR 0.8 and 1.25)
[5] 95% CI's cross both default MID's (RR 0.8 and 1.25)
[6] No heterogeneity (Isq ≤ 40%)

Table 29: Devices – Intraoperative – Cardiac events

Quality assessment						Number of patients		Effect		Quality
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			Relative (95% CI)	Absolute (95% CI)	
Circulating water mattress										
1	randomised trials	no serious risk of bias[1]	serious[2]	no serious indirectness	very serious[4]	0/23 (0%)	2/23 (8.7%)	OR 0.18 (0.01 to	70 fewer per 1000 (from 86	VERY LOW

Quality assessment						Number of patients		Effect		Quality
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			Relative (95% CI)	Absolute (95% CI)	
				3				4.03)	fewer to 190 more)	

[1] No concerns over risk of bias
[2] Data only sourced from one of the included studies
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's cross both default MID's (RR 0.8 and 1.25)

Table 30: Devices – Intraoperative – Surgical / wound infection

Quality assessment						Number of patients		Effect		Quality
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			Relative (95% CI)	Absolute (95% CI)	
Circulating water garments										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	very serious[4]	1/29 (3.4%)	0/29 (0%)	RR 3 (0.13 to 70.74)	-	LOW
Resistive heating blanket										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[22]	no serious indirectness[3]	very serious[4]	1/29 (3.4%)	1/30 (3.3%)	RR 1.03 (0.07 to 15.77)	1 more per 1000 (from 31 fewer to 492 more)	LOW
warming pads										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	very serious[4]	1/25 (4%)	0/25 (0%)	RR 3 (0.13 to 70.3)	-	LOW

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's

Table 31: Devices – Intraoperative – Adverse effects

Quality assessment						Number of patients		Effect		
Number of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Forced air warming**	**Other warming**	**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
Resistive heating blanket										
6	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[2]	0/125 (0%)	0/126 (0%)	not pooled	not pooled	HIGH
Resistive heating mattress										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[6]	no serious imprecision[2]	0/34 (0%)	0/36 (0%)	not pooled	not pooled	HIGH
Circulating water blankets										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[2]	0/29 (0%)	0/29 (0%)	not pooled	not pooled	HIGH
Circulating water garment										
4	randomised trials	no serious risk of bias[1]	no serious inconsistency[4]	no serious indirectness[3]	very serious[5]	0/99 (0%)	2/104 (1.9%)	OR 0.21 (0.01 to 4.44)	15 fewer per 1000 (from 19 fewer to 61 more)	LOW
Radiant heating										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[2]	0/29 (0%)	0/30 (0%)	not pooled	not pooled	HIGH
Circulating water mattress										
3	randomised trials	no serious risk of bias[1]	no serious inconsistency[4]	no serious indirectness[3]	very serious[5]	0/38 (0%)	4/38 (10.5%)	OR 0.09 (0 to 1.81)	95 fewer per 1000 (from 105 fewer to 70 more)	LOW

[1] No concerns over risk of bias
[2] No events reported
[3] Population, intervention and outcome as specified in the review protocol
[4] Data only sourced from one of the included studies
[5] 95% CI's cross both default MID's (RR 0.8 and 1.25)
[6] The resistive heating mattress only included the mattress not the over-blanket as used in clinical practice but this was not expected to affect this outcome

Table 32: Devices – Intraoperative – Length of hospital stay

Quality assessment						Number of patients		Effect		Quality
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			Relative (95% CI)	Absolute (95% CI)	Quality
Warming pads										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	serious[4]	25	25	-	MD 1.2 higher (0.18 to 2.22 higher)	HIGH

[1] No concerns over risk of bias
[2] Single study analysis
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's around the point estinate cross default MID of 1.15 (50% of larger SD)

H.2 Review question 2: Devices - Preoperative

Table 33: Devices – Preoperative

Quality assessment						Number of patients		Effect		Quality
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			Relative (95% CI)	Absolute (95% CI)	Quality
Core temp - end of surgery - With intraoperative										
4	randomised trials	no serious risk of bias[1]	very serious[2]	no serious indirectness[3]	serious[4]	81	95	-	MD 0.84 higher (0.12 to 1.57 higher)	VERY LOW
Core temp- 30 mins - With intraoperative										
2	randomised trials	no serious risk of bias[1]	serious[5]	no serious indirectness[3]	no serious imprecision[4]	38	50	-	MD 0.43 higher (0.18 to 0.69 higher)	MODERATE
Core temp- 60 mins - With intraoperative										
4	randomised trials	no serious risk of bias[1]	no serious inconsistency[5]	no serious indirectness[3]	serious[4]	103	117	-	MD 0.47 higher (0.28 to 0.65 higher)	MODERATE
Core temp- 120 mins - With intraoperative										

Quality assessment						Number of patients		Effect		Quality
Number of studies	**Design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**			**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
3	randomised trials	no serious risk of bias[1]	very serious[2]	no serious indirectness[3]	no serious imprecision[4]	68	79	-	MD 0.64 higher (0.27 to 1.01 higher)	LOW
Hypothermia - With intraoperative										
4	randomised trials	no serious risk of bias[1]	very serious[2]	no serious indirectness[3]	no serious imprecision[4]	12/103 (11.7%)	51/119 (42.9%)	RR 0.2 (0.05 to 0.8)	343 fewer per 1000 (from 86 fewer to 407 fewer)	LOW
Hypothermia - Without intraoperative										
4	randomised trials	no serious risk of bias[1]	serious[5]	no serious indirectness[3]	no serious imprecision[4]	42/155 (27.1%)	113/161 (70.2%)	RR 0.33 (0.15 to 0.7)	470 fewer per 1000 (from 211 fewer to 597 fewer)	MODERATE
Shivering - With intraoperative										
3	randomised trials	no serious risk of bias[1]	no serious inconsistency[6]	no serious indirectness[3]	serious[7]	2/83 (2.4%)	10/99 (10.1%)	RR 0.42 (0.11 to 1.57)	59 fewer per 1000 (from 90 fewer to 58 more)	MODERATE
Shivering - Without intraoperative										
3	randomised trials	no serious risk of bias[1]	no serious inconsistency[6]	no serious indirectness[3]	no serious imprecision[4]	5/100 (5%)	30/102 (29.4%)	RR 0.18 (0.05 to 0.64)	241 fewer per 1000 (from 106 fewer to 279 fewer)	HIGH
Adverse effects - With intraoperative										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no serious imprecision[8]	0/18 (0%)	0/30 (0%)	not pooled	not pooled	MODERATE
Blood transfusion - With intraoperative										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	very serious[10]	11/47 (23.4%)	19/66 (28.8%)	RR 0.81 (0.43 to 1.54)	55 fewer per 1000 (from 164 fewer to 155 more)	LOW
Surgical infections - With intraoperative										

Quality assessment						Number of patients		Effect		Quality
Number of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			Relative (95% CI)	Absolute (95% CI)	
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	very serious[10]	6/47 (12.8%)	15/66 (22.7%)	RR 0.56 (0.24 to 1.34)	100 fewer per 1000 (from 173 fewer to 77 more)	LOW
Surgical infections - Without intraoperative										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	no imprecision[11]	13/258 (5.0%)	19/136 (14.0%)	RR 0.36 (0.18 to 0.71)	89 fewer per 1000 (from 41 fewer to 115 fewer)	LOW
Cardiac complications - With intraoperative										
1	randomised trials	no serious risk of bias[1]	no serious inconsistency[2]	no serious indirectness[3]	very serious[10]	0/47 (0%)	2/66 (3%)	RR 0.28 (0.01 to 5.68)	22 fewer per 1000 (from 30 fewer to 142 more)	LOW

[1] No concerns over risk of bias
[2] Severe heterogeneity (I-sq > 70%)
[3] Population, intervention and outcome as specified in the review protocol
[4] 95% CI's cross one MID (0.5 degrees C)
[5] Moderate heterogeneity (I-sq > 40%)
[6] No heterogeneity (I-sq < 40%)
[7] TBC
[8] No events reported
[9] Single study analysis
[10] 95% CI's cross both default MID's (RR 0.8 and 1.25)
[11] 95% CI's do not cross default MID's (RR 0.8 and 1.25)

H.3 Review question 3: Site of measurement

Table 34: Preoperative – Bland Altman and mean difference: temperature difference between sites

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Treatment (T)	Comparator (C)*	Bias/ Mean difference (95% CI)	

Quality assessment							**No of patients**		**Effect estimate**	**Quality**
Outcome: Bland Altman: Temporal artery scanner as reference v oral										
2	Observational	none	No serious	No serious [a]	Serious [b]	none	150	150	[BA] range -0.24 to -0.15ºC (range of CI= -0.81, 0.51ºC)	Moderate
Outcome: Bland Altman: Temporal artery scanner as reference v axillary										
1	Observational	none	No serious	No serious [a]	Serious [b]	none	86	86	[BA] -0.39 ºC (-1.28, 0.44 ºC)	Moderate
Outcome: Bland Altman: Temporal artery scanner as reference v oral										
1	Observational	none	No serious	No serious [a]	Serious [b]	none	86	86	[BA] 0.28 ºC (-0.5, 1.0 ºC)	Moderate
Outcome: Bland Altman: Tympanic membrane as reference v temporal artery scanner										
1	Observational	Serious [d]	No serious	No serious [a]	Very serious [c]	none	222	222	[BA] 0.19 ºC (-1.25, 0.87 ºC)	Very low
Outcome: Bland Altman: Tympanic membrane as reference v sublingual										
1	Observational	Serious [e]	No serious	No serious [a]	Serious [b]	none	171	171	[BA] 0.15 ºC (0.59, 0.29 ºC)	Moderate
Outcome: Mean Difference :Tympanic membrane IR as reference v oral										
1	Observational	Serious [g]	Serious [f]	No serious [a]	No serious	none	60	60	MD 0.67ºC (-0.33, 0.16ºC)	Low

[BA] – Bland Altman analysis. individuals served as their own controls, therefore equal numbers in treatment and control group.*
a Could not be assessed as data not meta-analysed
b Serious imprecision as 95%CI extend beyond 0.5ºC in one direction
c very serious imprecision as 95%CI extend beyond 0.5ºC in both directions
d Fetzer (2008) unclear at what points temperature measured.
e population of Hocker (2012) had general anaesthetic lasting less than 1 hour.
f Erickson (1991) was part of a larger study whose primary outcome was temperature difference between people undergoing warming during the perioperative period.
g Erickson (1991) reported 235 paired measurements for oral and 300 measurements for tympanic IR.

Table 35: Intraoperative – for continuous outcomes – Bland Altman and mean difference: temperature difference between sites

Quality assessment							**No of patients**		**Effect estimate**	**Quality**
No of studies	**Design**	**Risk of bias**	**Indirectness**	**Inconsistency**	**Imprecision**	**Other considerations**	**Treatment (T)**	**Comparator* (C)**	**Bias/ Mean difference (95% CI)**	

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Treatment (T)	Comparator* (C)	Bias/ Mean difference (95% CI)	
Outcome: Bland Altman: pulmonary artery catheter as reference v IR tympanic										
1	observational	Serious [a]	none	None [d]	Serious [b]	none	26	26	[BA] 0.083ºC (-0.44, 0.61)	Low
Outcome: Bland Altman: tympanic thermocouple as reference v IR tympanic										
3	observational	Serious [c]	none	None [d]	Serious [b]	none	86	86	[BA] range -0.1 to 0.217 ºC (range of CI -0.8, 1.13 ºC).	Low
Outcome: Bland Altman: tympanic thermocouple as reference v sublingual										
1	observational	none	none	None [d]	Serious [b]	none	171	171	[BA] -0.09 ºC (-0.51, 0.33 ºC)	Moderate
Outcome: Bland Altman: oesophageal temperature as reference v oral										
1	observational	none	none	None [d]	Serious [b]	none	23	23	[BA] 0.12 ºC (0.264, 0.512ºC)	Moderate
Outcome: Bland Altman: oesophageal temperature as reference v IR temporal artery										
1	observational	none	none	None [d]	none	none	23	23	[BA] 0.074ºC (-0.319, 0.467 ºC)	High
Outcome: Bland Altman: oesophageal temperature as reference v IR tympanic membrane										
1	observational	serious [e]	none	None [d]	None	none	18	18	[BA] 0.08ºC (-0.42, 0.26 ºC)	Moderate
Outcome: Bland Altman: oesophageal temperature as reference v rectal										
1	observational	serious [e]	none	None [d]	Serious [b]	none	18	18	[BA] 0.11 ºC (-0.44, 0.66)	Low
Outcome: Bland Altman: sublingual temperature as reference v Zero Heat Flux (ZHF) forehead										
1	observational	none	none	None [d]	Serious [b]	none	83	83	[BA] 0.33 ºC (-0.84, 0.19)	Moderate
Outcome: Bland Altman: nasopharyngeal temperature as reference v Zero Heat Flux (ZHF) forehead										
1	observational	none	none	None [d]	None	none	83	83	[BA] 0.10 ºC (-0.25, 0.46)	High
Outcome: Mean difference: oral v tympanic										

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Treatment (T)	Comparator* (C)	Bias/ Mean difference (95% CI)	
1	observational	serious [f, g]	none	None [d]	Serious [b]	none	60	60	MD 0.61 ºC (-0.06, 1.28 ºC)	Low
Outcome: Mean difference: tympanic probe v IR tympanic										
1	RCT	none	Serious [h]	None [d]	Serious [b]	none	28	28	FAW: MD-0.20 ºC [-0.52, 0.12] Resistive heating: MD -0.20 (-0.54, 0.14)	Low
Outcome: Mean difference: tympanic v rectal (first and final measurements in OR)										
1	observational	none	Serious [h]	None [d]	Serious [b]	none	30	30	First: 0.25 ºC (0.10, 0.39 ºC) Final: 0.62 ºC (0.44, 0.80 ºC)	Low
Outcome: Mean difference: PA v rectal										
2	observational	none	None[e]	None [d]	Serious [b]	none	59	59	MD range -0.4 to 0.3 ºC (SD range 0.3 to 1.0)	Moderate
Outcome: Mean difference: PA v forehead (ZHF)										
2	observational	none	none	None [d]	none	none	146	146	MD range -0.8 to 0.0ºC (SD range 0.3 to 0.45)	High
Outcome: Mean difference: PA v neck (ZHF)										
1	observational	none	none	None [d]	none	none	105	105	MD -0.15 ºC (SD 0.43 ºC)	High
Outcome: Mean difference: PA v IR tympanic										
1	observational	Serious [e, i]	none	None [d]	Serious [b]	none	18	18	MD range -0.4 to -0.3 (SD range 0.5)	Low
Outcome: Mean difference: PA v oesophageal										
3	observational	Serious [e]	none	None [d]	none	none	79	79	MD 0.1°C [SD 0.2], 0ºC[SD 0.5], -0.10ºC [95%CI -0.47, 0.27]	Moderate
Outcome: Mean difference: PA v axilla										
1	observ	Serious	none	None [d]	Serious [b]	none	18	18	MD 0.2 ºC [SD 1.0]	Low

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Treatment (T)	Comparator* (C)	Bias/ Mean difference (95% CI)	
	ational	[e]								
Outcome: Mean difference: PA v skin										
1	observational	none	none	None [d]	very serious [j]	none	105	105	MD -3.1 ºC [SD 1.62]	Low
Outcome: Mean difference: PA v bladder										
1	observational	very serious [k]	none	None [d]	Serious [b]	none	20		MD -0.20 ºC [95%CI -0.57, 0.17]	Very low
Outcome: Mean difference: Oesophageal v nasopharynx										
1	observational	serious [l]	none	None [d]	none	none	43		MD -0.20 ºC [95%CI -0.46, 0.06]	Moderate
Outcome: Mean difference: forehead (ZHF) v neck (ZHF)										
1	observational	none	none	None [d]	none	none	105		MD 0.07 ºC [SD 0.48]	High

[BA] – Bland Altman analysis. individuals served as their own controls, therefore equal numbers in treatment and control group (Fanelli (2009) and Ng (2006) RCTs so does not apply to these studies.*

a. *Bock (2005) included people with ASA grade II & III*
b. *Serious imprecision as 95%CI extend beyond 0.5ºC in one direction*
c. *Matsukawa (1995) population of women only.*
d. *Could not be assessed as data not meta-analysed*
e. *very small study: Kiya (2007)n=<20; Robinson (1998) n=18; Russell (1996) n=20*
f. *Erickson (1991) was part of a larger study whose primary outcome was temperature difference between people undergoing warming during the perioperative period.*
g. *Erickson (1991) reported 235 paired measurements for oral and 300 measurements for tympanic IR.*
h. *Fanelli (2009) was an RCT assessing the use of FAW v resistive heating – temperature at different sites not a primary outcome: Ng (2006) study was primarily assessing FAW v electric heating pad; site of temperature measurement not primary outcome.*
i. *Robinson (1998) IVAC readings <25ºC excluded from analysis as outside range of thermometer.*
j. *very serious imprecision as 95% CI extend beyond 0.50 in both directions.*
k. *Russel l (1996); no patient demographics reported, very small study n=20.*
l. *Erdling (2015) primary focus of study was prewarming vs no prewarming. Site of temperature measurement no primary outcome*

Table 36: Postoperative: Bland Altman and mean difference: temperature difference between sites

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Treatment (T)	Comparator (C)	Bias/ Mean difference (95% CI)	

Quality assessment							No of patients		Effect estimate	Quality
No of studies	**Design**	**Risk of bias**	**Indirectness**	**Inconsistency**	**Imprecision**	**Other considerations**	**Treatment (T)**	**Comparator (C)**	**Bias/ Mean difference (95% CI)**	
Outcome: Bland- Altman: temporal artery as reference v oral										
2	observational	none	none	None[b]	Very serious[a]	none	170		[BA] -0.12 ºC (-1.49, 1.24) And, 0.21 ºC (-0.53, 0.95 ºC)	Low
Outcome: Bland- Altman: temporal artery as reference v axilla										
1	observational	none	none	None[b]	Very serious[a]	None	86		[BA] -0.1ºC(-2.3, 2.1)	Low
Outcome: Bland- Altman Axillary temperature as reference v oral										
2	observational	Serious[c]	none	None[b]	Very serious[a]	none	291		[BA] -0.9 to -0.2 ºC (range for CI of mean difference: -2.5, 1.7)	Very low
Outcome: Bland- Altman: Tympanic membrane as reference v temporal artery										
1	observationa	Serious[d]	none	None[b]	Very serious[a]	none	222		[BA] -0.11ºC (-1.16, 1.37)	Very low
Outcome: Bland- Altman: Oral temperature as reference v tympanic membrane										
3	observationa	Serious[c,e]	none	None[b]	Very serious[a]	none	460		[BA] bias ranging from -0.67ºC to 0.27ºC (range for CI of mean difference: -1.67, 1.07ºC).	Very low
Outcome: Bland- Altman: Oral temperature as reference v disposable oral thermometers										
1	Observational	none	none	None[b]	Very serious[a]	none	84		[BA] -0.16ºC (-0.93,0.61ºF).	Low
Outcome: Bland- Altman: Oral temperature as reference v forehead LCT strips										
1	observational	Serious[c]	none	None[b]	Very serious[a]	none	205		[BA] - 0.52ºC (-2.32, 1.28ºC)	Very low
Outcome: Bland- Altman: Bladder temperature as reference velectronic oral										

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Treatment (T)	Comparator (C)	Bias/ Mean difference (95% CI)	
1	observational	none	none	None[b]	Very serious[a]	none	50		[BA] -0.25 ºC (-1.0, 0.50)	Low
Outcome: Bland- Altman: Bladder temperature as reference v deep forehead										
1	observational	none	none	None[b]	Serious[g]	none	50		[BA] -0.50 ºC (-1.31, 0.31)	Moderate
Outcome: Bland- Altman: Bladder temperature as reference v temporal artery scanner										
1	observational	none	none	None[b]	Very serious[a]	none	50		[BA] -0.23 ºC (-1.20, 0.75)	Low
Outcome: Bland- Altman: Bladder temperature as reference v electronic axilla										
1	observational	none	none	None[b]	Serious[g]	none	50		[BA] -0.50 ºC (-1.34, 0.33)	Moderate
Outcome: Bland- Altman: Bladder temperature as reference v deep chest										
1	observational	none	none	None[b]	Serious[g]	none	50		[BA] -0.65 ºC (-1.70, 0.40)	Moderate
Outcome: Bland- Altman: Bladder temperature as reference v thermocouple forehead + 2ºC correction										
1	observational	none	none	None[b]	Very serious[a]	none	50		[BA] -0.46 ºC (-1.81, 0.88)	Low
Outcome: Bland- Altman: Bladder temperature as reference v infrared aural canal (IRAC)- right										
1	observational	none	none	None[b]	Serious[g]	none	50		[BA] -1.04 ºC (-2.04, -0.04)	Moderate
Outcome: Bland- Altman: Bladder temperature as reference v IRAC – left										
1	observational	none	none	None[b]	Serious[g]	none	50		[BA] -1.06ºC (-2.06, -0.06)	Moderate
Outcome: Bland- Altman: Bladder temperature as reference v thermocouple forehead										
1	observational	none	none	None[b]	none	none	50		[BA] -2.46ºC (-3.81, -1.12)	High
Outcome: Bland- Altman: Bladder temperature as reference v oesophagus										
1	observational	none	none	None[b]	Serious[g]	none	50		[BA] -0.06ºC (-0.56, 0.45)	Moderate
Outcome: Bland- Altman: IRAC right v IRAC left										

Quality assessment							No of patients		Effect estimate	Quality
No of studies	**Design**	**Risk of bias**	**Indirectness**	**Inconsistency**	**Imprecision**	**Other considerations**	**Treatment (T)**	**Comparator (C)**	**Bias/ Mean difference (95% CI)**	
1	observational	none	none	None[b]	Very serious[a]	none	50		[BA] 0.02ºC (-0.76, 0.81)	Low
Outcome: Mean Difference: PA v bladder										
1	Observational	Serious [f]	none	None[b]	none	none	20		MD 0 ºC [95%CI -0.43, 0.43 ºC]).	Moderate
Outcome: Mean Difference: PA v oesophagus										
1	Observational	Serious [f]	none	None[b]	Serious [g]	none	20		MD -0.50 ºC [95%CI -1.00, 0.00 ºC]	Low
Outcome: Mean Difference: PA v electronic or mercury axillary										
1	Observational	Serious [h]	none	None[b]	Very serious [a]	none	18		Electronic: MD -0.60 ºC [95%CI -1.39, 0.19 ºC] Mercury: MD -0.20 ºC [95%CI -1.08, 0.68 ºC]).	Very low
Outcome: Mean Difference: PAC v rectal										
1	Observational	Serious [h]	none	None[b]	Serious [g]	none	18		MD 0.50 ºC [95%CI -0.38, 1.38 ºC].	Low
Outcome: Mean Difference: PAC v forehead (ZHF)										
1	Observational	Serious [i]	none	None[b]	Serious [g]	none	105		MD -0.32 ºC [SD 0.38] 95%CI -1.06, 0.42 ºC).	Low
Outcome: Mean Difference: PAC v neck (ZHF)										
1	Observational	Serious [i]	none	None[b]	Serious [g]	none	105		MD -0.4 ºC [SD 0.43] 95%CI -1.24, 0.44 ºC).	Low
Outcome: Mean Difference: PAC v skin surface (forehead)										
1	Observational	Serious [i]	none	None[b]	Very serious [a]	none	105		MD -3.2 ºC [SD 1.14], 95%CI -5.44, -0.96 ºC).	Very low

Quality assessment							**No of patients**		**Effect estimate**	**Quality**
No of studies	**Design**	**Risk of bias**	**Indirectness**	**Inconsistency**	**Imprecision**	**Other considerations**	**Treatment (T)**	**Comparator (C)**	**Bias/ Mean difference (95% CI)**	
Outcome: Mean Difference: tympanic v forehead (Omni thermometer)										
1	Observational	Serious [j]	none	None[b]	none	none	32		General anaesthetic: MD -0.1 ºC [SD0.2] Spinal anaesthetic: MD -0. 3 ºC [0.2] respectively).	Moderate
Outcome: Mean Difference: tympanic and rectal										
1	Observational	Serious [j]	none	None[b]	none	none	32		General anaesthetic: MD 0.1 ºC [SD 0.1] Spinal anaesthetic: MD 0.4 [0.1] respectively).	Moderate
Outcome: Mean Difference: tympanic v axillary										
1	Observational	Serious [j]	none	None[b]	none	none	32		General anaesthetic: MD -2.1 ºC [SD 0.3] Spinal anaesthetic: MD -1.8 ºC [SD 0.3] respectively).	Moderate
Outcome: Mean Difference: tympanic v IR Temporal										
1	Observational	Serious [j]	none	None[b]	Serious [g]	none	32		MD -0.5 ºC [SD 0.2] and MD -0.6 ºC [SD 0.2] respectively).	Low
Outcome: Mean Difference: tympanic v oral										
1	Observational	Serious [j, k]	none	None[b]	Serious [g]	none	60		Entry to PACU: MD 1.3 ºC [SD0.6] Exit from PACU: MD 1.5 ºC [SD0.5].	Low
Outcome: Mean Difference: forehead (ZHF) v neck ZHF)										
1	Observational	Serious [i]	none	None[b]	none	none	105		MD 0.07 ºC [SD 0.52], 95%CI -0.95, 1.10 ºC).	Moderate

[BA] – Bland Altman analysis. individuals served as their own controls, therefore equal numbers in treatment and control group (Fanelli (2009) and Ng (2006) RCTs so does not apply to these studies.*

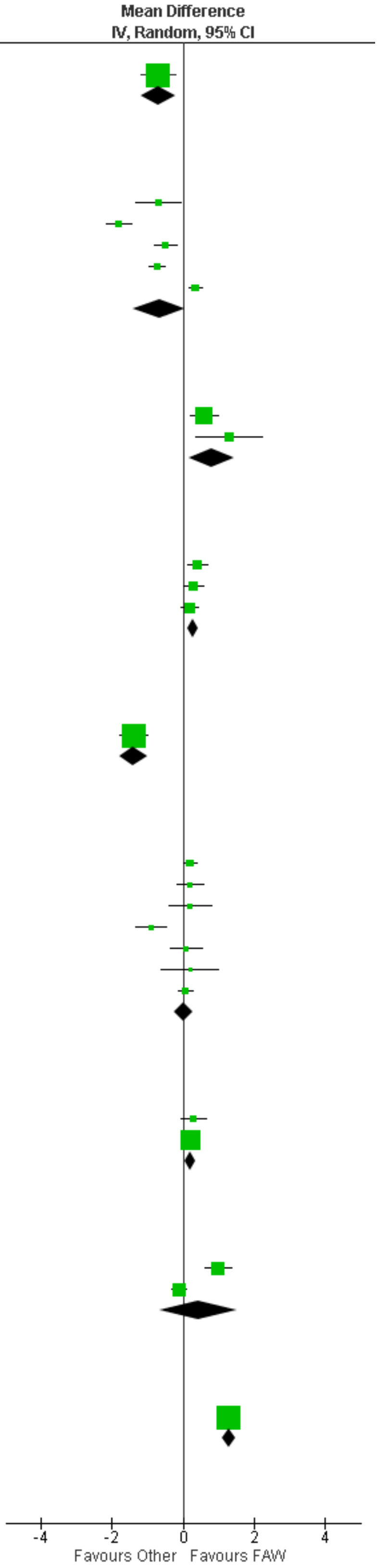
a. Very serious imprecision as CI crosses 0.5 threshold in both directions
b. Could not be assessed as data not meta-analysed
c. Hecker (1996) had a lack of baseline demographics.
d. Fetzer (2008) unclear at what point and how many temperature measurements taken.
e. Hocker (2012) included people only having surgery of less than 1 hour duration
f. Russell (1996) no patient demographics, small study n=20.
g. Serious imprecision as CI crosses 0.5 threshold in one direction
h. Heidenreich (1990)small study (n=18); interventions included mercury thermometers – not current practice?
i. Eshragi (2014) did not include the first 4 postoperative measurements in the analysis.
j. Erickson (1991) was part of a larger study whose primary outcome was temperature difference between people undergoing warming during the perioperative period.
k. Erickson (1991) reported 235 paired measurements for oral and 300 measurements for tympanic IR.

Appendix I: Forest plots

I.1 Review Question 1: Devices - Intraoperative

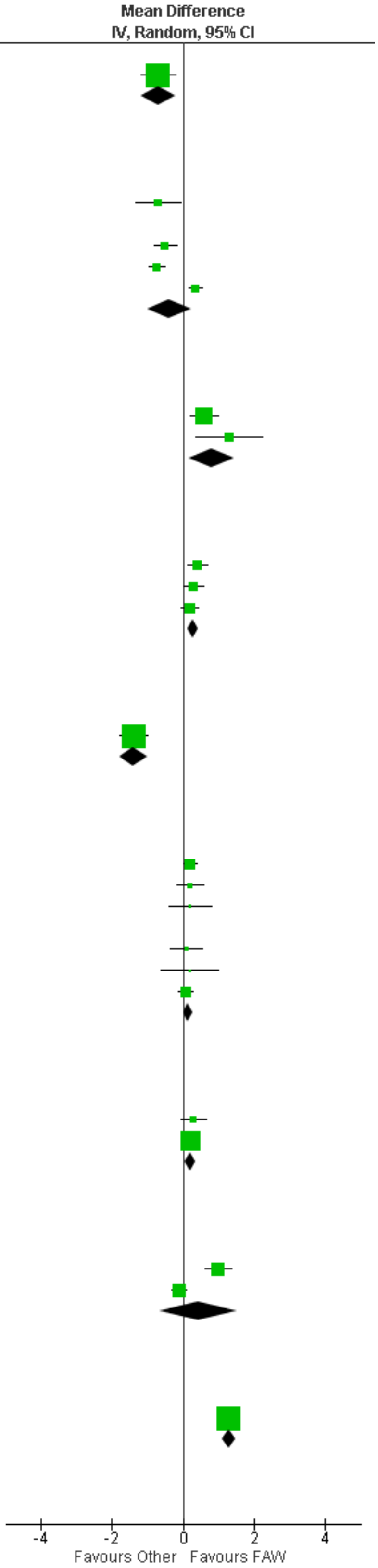
Core temperature at end of surgery

	Forced air-warming			Other active warming				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.1.1 Circulating water blanket								
Hynson 1992	0.5	0.4	5	1.2	0.4	5	100.0%	-0.70 [-1.20, -0.20]
Subtotal (95% CI)			**5**			**5**	**100.0%**	**-0.70 [-1.20, -0.20]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.77 (P = 0.006)								
1.1.2 Circulating water garment								
Hasegawa 2012	36.2	0.9	12	36.9	0.7	12	18.2%	-0.70 [-1.35, -0.05]
Hofer 2005	34.7	0.9	29	36.5	0.4	29	20.1%	-1.80 [-2.16, -1.44]
Janicki 2001	36.4	0.8	28	36.9	0.3	25	20.3%	-0.50 [-0.82, -0.18]
Janicki 2002	36.07	0.4	12	36.8	0.1	12	20.7%	-0.73 [-0.96, -0.50]
Trentman 2009	36.73	0.29	21	36.38	0.38	25	20.8%	0.35 [0.16, 0.54]
Subtotal (95% CI)			**102**			**103**	**100.0%**	**-0.67 [-1.41, 0.07]**
Heterogeneity: Tau² = 0.68; Chi² = 124.91, df = 4 (P < 0.00001); I² = 97%								
Test for overall effect: Z = 1.77 (P = 0.08)								
1.1.3 Circulating water mattesss								
Matsuzaki 2003	36.8	0.4	8	36.2	0.4	8	69.0%	0.60 [0.21, 0.99]
Negishi 2003	36.2	1	8	34.9	0.9	8	31.0%	1.30 [0.37, 2.23]
Subtotal (95% CI)			**16**			**16**	**100.0%**	**0.82 [0.18, 1.45]**
Heterogeneity: Tau² = 0.11; Chi² = 1.84, df = 1 (P = 0.17); I² = 46%								
Test for overall effect: Z = 2.52 (P = 0.01)								
1.1.4 Radiant heating								
Lee 2004	36.4	0.6	29	36	0.5	30	29.5%	0.40 [0.12, 0.68]
Torrie 2005	36.4	0.6	32	36.1	0.5	28	30.3%	0.30 [0.02, 0.58]
Wong 2004	36.2	0.4	21	36	0.4	21	40.2%	0.20 [-0.04, 0.44]
Subtotal (95% CI)			**82**			**79**	**100.0%**	**0.29 [0.14, 0.44]**
Heterogeneity: Tau² = 0.00; Chi² = 1.12, df = 2 (P = 0.57); I² = 0%								
Test for overall effect: Z = 3.70 (P = 0.0002)								
1.1.5 Warming pads								
Calcaterra 2009	34.7	0.9	25	36.1	0.4	25	100.0%	-1.40 [-1.79, -1.01]
Subtotal (95% CI)			**25**			**25**	**100.0%**	**-1.40 [-1.79, -1.01]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 7.11 (P < 0.00001)								
1.1.6 Resistive heating blanket								
Brandt 2010	36.4	0.5	40	36.2	0.4	40	20.0%	0.20 [0.00, 0.40]
Fanelli 2009	35.5	0.7	28	35.3	0.7	28	15.6%	0.20 [-0.17, 0.57]
Hasegawa 2012	36.2	0.9	12	36	0.6	12	10.0%	0.20 [-0.41, 0.81]
Hofer 2005	34.7	0.9	29	35.6	0.8	30	13.8%	-0.90 [-1.34, -0.46]
Matsuzaki 2003	36.8	0.4	8	36.7	0.5	8	13.6%	0.10 [-0.34, 0.54]
Negishi 2003	36.2	1	8	36	0.6	8	7.0%	0.20 [-0.61, 1.01]
Tanaka 2013	36.3	0.38	33	36.23	0.44	31	20.0%	0.07 [-0.13, 0.27]
Subtotal (95% CI)			**158**			**157**	**100.0%**	**0.01 [-0.25, 0.27]**
Heterogeneity: Tau² = 0.08; Chi² = 21.52, df = 6 (P = 0.001); I² = 72%								
Test for overall effect: Z = 0.06 (P = 0.95)								
1.1.7 Resistive heating mattress								
Egan 2011	36.6	0.5732	34	36.3	0.8867	36	19.5%	0.30 [-0.05, 0.65]
John 2015	36.1	0.5	78	35.9	0.6	81	80.5%	0.20 [0.03, 0.37]
Subtotal (95% CI)			**112**			**117**	**100.0%**	**0.22 [0.07, 0.37]**
Heterogeneity: Tau² = 0.00; Chi² = 0.26, df = 1 (P = 0.61); I² = 0%								
Test for overall effect: Z = 2.80 (P = 0.005)								
1.1.8 Electric heating pads								
Leung 2007	36.2	0.4	30	35.2	1	30	48.8%	1.00 [0.61, 1.39]
Ng 2006	36.8	0.4	30	36.9	0.4	30	51.2%	-0.10 [-0.30, 0.10]
Subtotal (95% CI)			**60**			**60**	**100.0%**	**0.44 [-0.64, 1.51]**
Heterogeneity: Tau² = 0.58; Chi² = 24.53, df = 1 (P < 0.00001); I² = 96%								
Test for overall effect: Z = 0.80 (P = 0.43)								
1.1.9 Electric blanket								
Russell 1995	36.2	0.3	40	34.9	0.4	20	100.0%	1.30 [1.10, 1.50]
Subtotal (95% CI)			**40**			**20**	**100.0%**	**1.30 [1.10, 1.50]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 12.84 (P < 0.00001)								
Test for subgroup differences: Chi² = 202.76, df = 8 (P < 0.00001), I² = 96.1%								



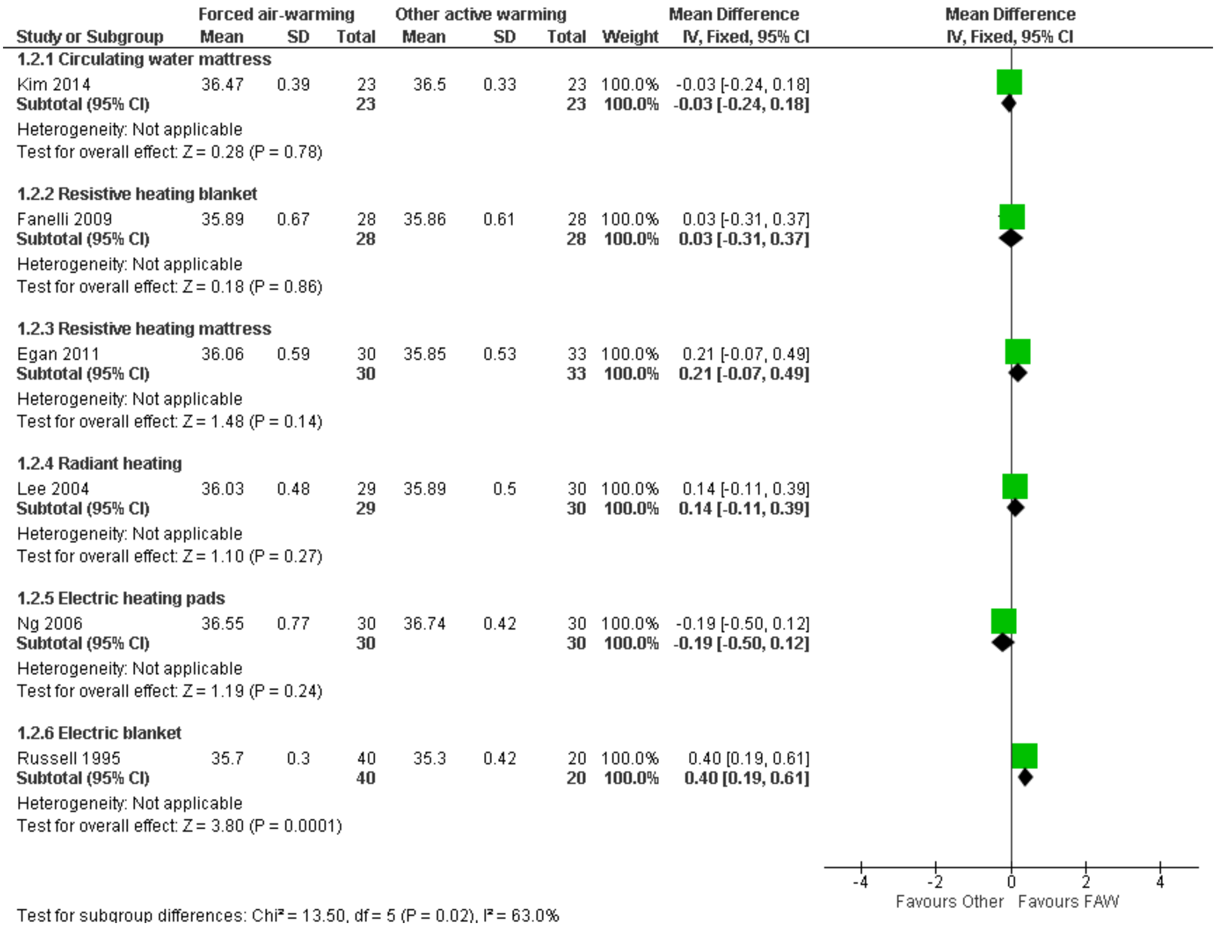
Sensitivity analysis – excluding Hofer 2005

	Forced air-warming			Other active warming				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.1.1 Circulating water blanket								
Hynson 1992	0.5	0.4	5	1.2	0.4	5	100.0%	-0.70 [-1.20, -0.20]
Subtotal (95% CI)			**5**			**5**	**100.0%**	**-0.70 [-1.20, -0.20]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.77 (P = 0.006)								
1.1.2 Circulating water garment								
Hasegawa 2012	36.2	0.9	12	36.9	0.7	12	21.3%	-0.70 [-1.35, -0.05]
Hofer 2005	34.7	0.9	29	36.5	0.4	29	0.0%	-1.80 [-2.16, -1.44]
Janicki 2001	36.4	0.8	28	36.9	0.3	25	25.6%	-0.50 [-0.82, -0.18]
Janicki 2002	36.07	0.4	12	36.8	0.1	12	26.4%	-0.73 [-0.96, -0.50]
Trentman 2009	36.73	0.29	21	36.38	0.38	25	26.7%	0.35 [0.16, 0.54]
Subtotal (95% CI)			**73**			**74**	**100.0%**	**-0.38 [-1.00, 0.25]**
Heterogeneity: Tau² = 0.37; Chi² = 56.43, df = 3 (P < 0.00001); I² = 95%								
Test for overall effect: Z = 1.17 (P = 0.24)								
1.1.3 Circulating water mattesss								
Matsuzaki 2003	36.8	0.4	8	36.2	0.4	8	69.0%	0.60 [0.21, 0.99]
Negishi 2003	36.2	1	8	34.9	0.9	8	31.0%	1.30 [0.37, 2.23]
Subtotal (95% CI)			**16**			**16**	**100.0%**	**0.82 [0.18, 1.45]**
Heterogeneity: Tau² = 0.11; Chi² = 1.84, df = 1 (P = 0.17); I² = 46%								
Test for overall effect: Z = 2.52 (P = 0.01)								
1.1.4 Radiant heating								
Lee 2004	36.4	0.6	29	36	0.5	30	29.5%	0.40 [0.12, 0.68]
Torrie 2005	36.4	0.6	32	36.1	0.5	28	30.3%	0.30 [0.02, 0.58]
Wong 2004	36.2	0.4	21	36	0.4	21	40.2%	0.20 [-0.04, 0.44]
Subtotal (95% CI)			**82**			**79**	**100.0%**	**0.29 [0.14, 0.44]**
Heterogeneity: Tau² = 0.00; Chi² = 1.12, df = 2 (P = 0.57); I² = 0%								
Test for overall effect: Z = 3.70 (P = 0.0002)								
1.1.5 Warming pads								
Calcaterra 2009	34.7	0.9	25	36.1	0.4	25	100.0%	-1.40 [-1.79, -1.01]
Subtotal (95% CI)			**25**			**25**	**100.0%**	**-1.40 [-1.79, -1.01]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 7.11 (P < 0.00001)								
1.1.6 Resistive heating blanket								
Brandt 2010	36.4	0.5	40	36.2	0.4	40	38.1%	0.20 [0.00, 0.40]
Fanelli 2009	35.5	0.7	28	35.3	0.7	28	11.2%	0.20 [-0.17, 0.57]
Hasegawa 2012	36.2	0.9	12	36	0.6	12	4.0%	0.20 [-0.41, 0.81]
Hofer 2005	34.7	0.9	29	35.6	0.8	30		Not estimable
Matsuzaki 2003	36.8	0.4	8	36.7	0.5	8	7.6%	0.10 [-0.34, 0.54]
Negishi 2003	36.2	1	8	36	0.6	8	2.3%	0.20 [-0.61, 1.01]
Tanaka 2013	36.3	0.38	33	36.23	0.44	31	36.8%	0.07 [-0.13, 0.27]
Subtotal (95% CI)			**129**			**127**	**100.0%**	**0.14 [0.02, 0.27]**
Heterogeneity: Tau² = 0.00; Chi² = 1.00, df = 5 (P = 0.96); I² = 0%								
Test for overall effect: Z = 2.31 (P = 0.02)								
1.1.7 Resistive heating mattress								
Egan 2011	36.6	0.5732	34	36.3	0.8867	36	19.5%	0.30 [-0.05, 0.65]
John 2015	36.1	0.5	78	35.9	0.6	81	80.5%	0.20 [0.03, 0.37]
Subtotal (95% CI)			**112**			**117**	**100.0%**	**0.22 [0.07, 0.37]**
Heterogeneity: Tau² = 0.00; Chi² = 0.26, df = 1 (P = 0.61); I² = 0%								
Test for overall effect: Z = 2.80 (P = 0.005)								
1.1.8 Electric heating pads								
Leung 2007	36.2	0.4	30	35.2	1	30	48.8%	1.00 [0.61, 1.39]
Ng 2006	36.8	0.4	30	36.9	0.4	30	51.2%	-0.10 [-0.30, 0.10]
Subtotal (95% CI)			**60**			**60**	**100.0%**	**0.44 [-0.64, 1.51]**
Heterogeneity: Tau² = 0.58; Chi² = 24.53, df = 1 (P < 0.00001); I² = 96%								
Test for overall effect: Z = 0.80 (P = 0.43)								
1.1.9 Electric blanket								
Russell 1995	36.2	0.3	40	34.9	0.4	20	100.0%	1.30 [1.10, 1.50]
Subtotal (95% CI)			**40**			**20**	**100.0%**	**1.30 [1.10, 1.50]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 12.84 (P < 0.00001)								



Test for subgroup differences: Chi² = 201.57, df = 8 (P < 0.00001), I² = 96.0%

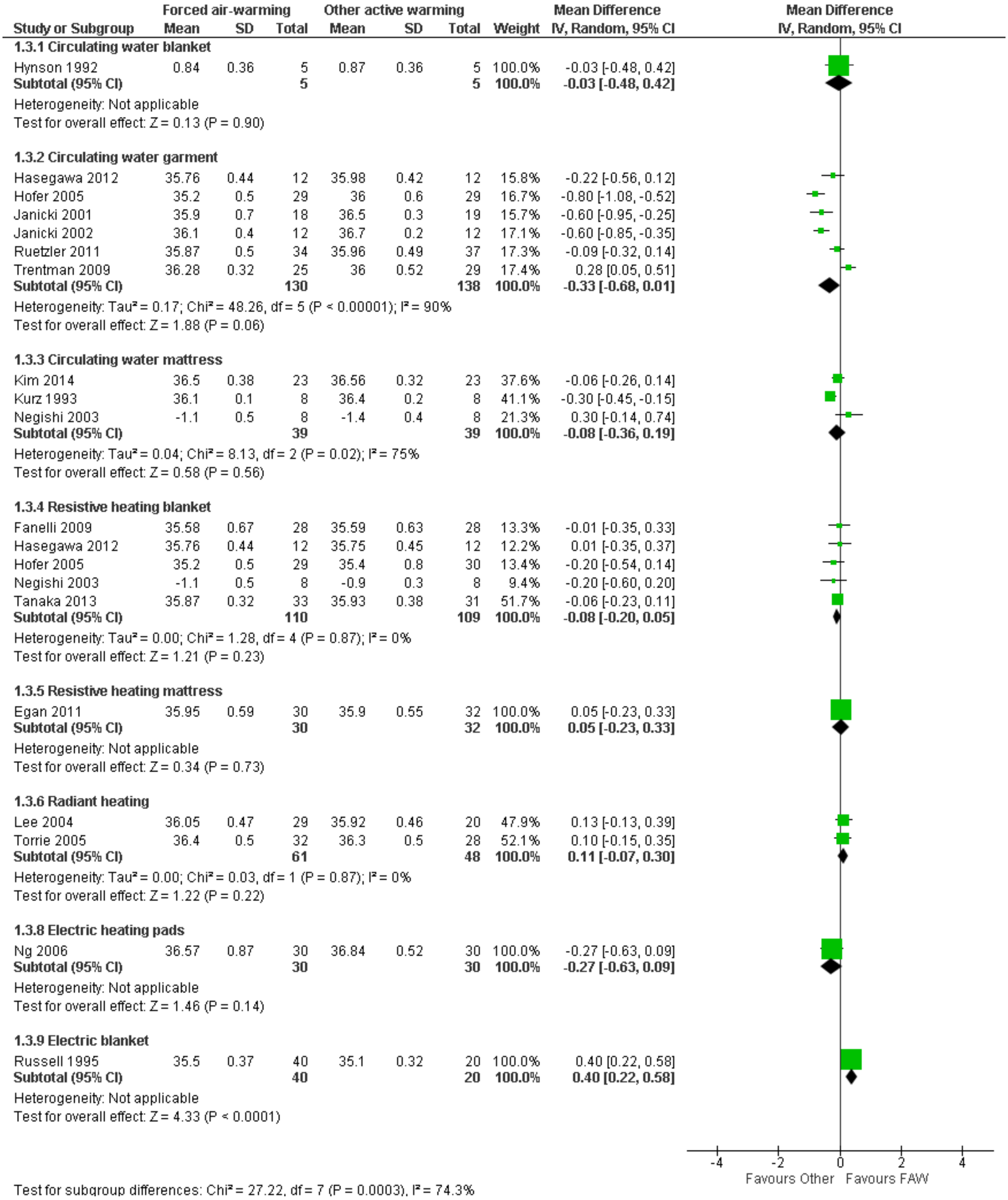
Core temperature at 30 mins



	Forced air-warming			Other active warming				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Fixed, 95% CI**
1.2.1 Circulating water mattress								
Kim 2014	36.47	0.39	23	36.5	0.33	23	100.0%	-0.03 [-0.24, 0.18]
Subtotal (95% CI)			**23**			**23**	**100.0%**	**-0.03 [-0.24, 0.18]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.28 (P = 0.78)								
1.2.2 Resistive heating blanket								
Fanelli 2009	35.89	0.67	28	35.86	0.61	28	100.0%	0.03 [-0.31, 0.37]
Subtotal (95% CI)			**28**			**28**	**100.0%**	**0.03 [-0.31, 0.37]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.18 (P = 0.86)								
1.2.3 Resistive heating mattress								
Egan 2011	36.06	0.59	30	35.85	0.53	33	100.0%	0.21 [-0.07, 0.49]
Subtotal (95% CI)			**30**			**33**	**100.0%**	**0.21 [-0.07, 0.49]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.48 (P = 0.14)								
1.2.4 Radiant heating								
Lee 2004	36.03	0.48	29	35.89	0.5	30	100.0%	0.14 [-0.11, 0.39]
Subtotal (95% CI)			**29**			**30**	**100.0%**	**0.14 [-0.11, 0.39]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.10 (P = 0.27)								
1.2.5 Electric heating pads								
Ng 2006	36.55	0.77	30	36.74	0.42	30	100.0%	-0.19 [-0.50, 0.12]
Subtotal (95% CI)			**30**			**30**	**100.0%**	**-0.19 [-0.50, 0.12]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.19 (P = 0.24)								
1.2.6 Electric blanket								
Russell 1995	35.7	0.3	40	35.3	0.42	20	100.0%	0.40 [0.19, 0.61]
Subtotal (95% CI)			**40**			**20**	**100.0%**	**0.40 [0.19, 0.61]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.80 (P = 0.0001)								

Test for subgroup differences: Chi² = 13.50, df = 5 (P = 0.02), I² = 63.0%

Core temperature at 60 mins



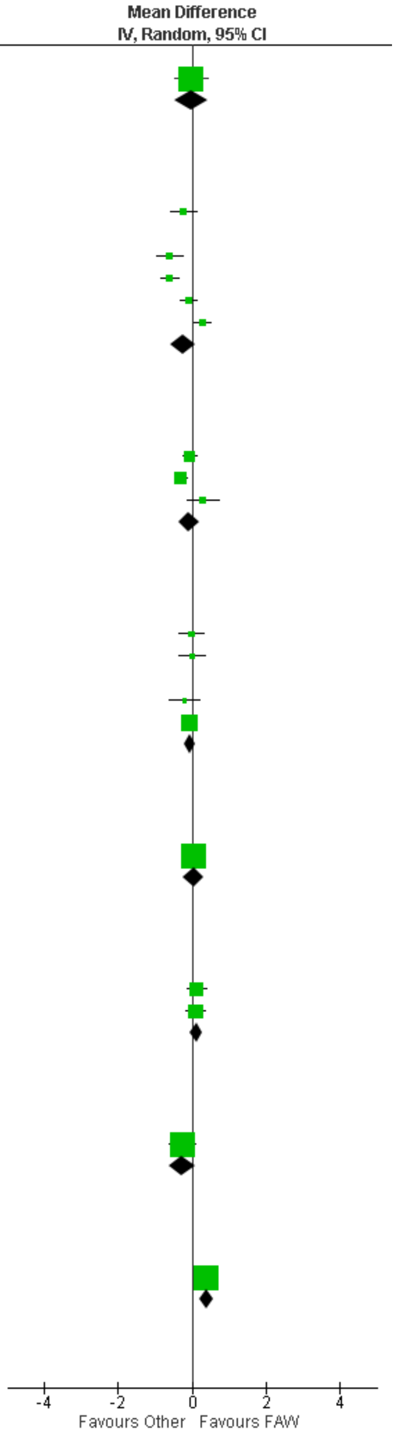
	Forced air-warming			Other active warming				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.3.1 Circulating water blanket								
Hynson 1992	0.84	0.36	5	0.87	0.36	5	100.0%	-0.03 [-0.48, 0.42]
Subtotal (95% CI)			**5**			**5**	**100.0%**	**-0.03 [-0.48, 0.42]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.13 (P = 0.90)								
1.3.2 Circulating water garment								
Hasegawa 2012	35.76	0.44	12	35.98	0.42	12	15.8%	-0.22 [-0.56, 0.12]
Hofer 2005	35.2	0.5	29	36	0.6	29	16.7%	-0.80 [-1.08, -0.52]
Janicki 2001	35.9	0.7	18	36.5	0.3	19	15.7%	-0.60 [-0.95, -0.25]
Janicki 2002	36.1	0.4	12	36.7	0.2	12	17.1%	-0.60 [-0.85, -0.35]
Ruetzler 2011	35.87	0.5	34	35.96	0.49	37	17.3%	-0.09 [-0.32, 0.14]
Trentman 2009	36.28	0.32	25	36	0.52	29	17.4%	0.28 [0.05, 0.51]
Subtotal (95% CI)			**130**			**138**	**100.0%**	**-0.33 [-0.68, 0.01]**
Heterogeneity: Tau² = 0.17; Chi² = 48.26, df = 5 (P < 0.00001); I² = 90%								
Test for overall effect: Z = 1.88 (P = 0.06)								
1.3.3 Circulating water mattress								
Kim 2014	36.5	0.38	23	36.56	0.32	23	37.6%	-0.06 [-0.26, 0.14]
Kurz 1993	36.1	0.1	8	36.4	0.2	8	41.1%	-0.30 [-0.45, -0.15]
Negishi 2003	-1.1	0.5	8	-1.4	0.4	8	21.3%	0.30 [-0.14, 0.74]
Subtotal (95% CI)			**39**			**39**	**100.0%**	**-0.08 [-0.36, 0.19]**
Heterogeneity: Tau² = 0.04; Chi² = 8.13, df = 2 (P = 0.02); I² = 75%								
Test for overall effect: Z = 0.58 (P = 0.56)								
1.3.4 Resistive heating blanket								
Fanelli 2009	35.58	0.67	28	35.59	0.63	28	13.3%	-0.01 [-0.35, 0.33]
Hasegawa 2012	35.76	0.44	12	35.75	0.45	12	12.2%	0.01 [-0.35, 0.37]
Hofer 2005	35.2	0.5	29	35.4	0.8	30	13.4%	-0.20 [-0.54, 0.14]
Negishi 2003	-1.1	0.5	8	-0.9	0.3	8	9.4%	-0.20 [-0.60, 0.20]
Tanaka 2013	35.87	0.32	33	35.93	0.38	31	51.7%	-0.06 [-0.23, 0.11]
Subtotal (95% CI)			**110**			**109**	**100.0%**	**-0.08 [-0.20, 0.05]**
Heterogeneity: Tau² = 0.00; Chi² = 1.28, df = 4 (P = 0.87); I² = 0%								
Test for overall effect: Z = 1.21 (P = 0.23)								
1.3.5 Resistive heating mattress								
Egan 2011	35.95	0.59	30	35.9	0.55	32	100.0%	0.05 [-0.23, 0.33]
Subtotal (95% CI)			**30**			**32**	**100.0%**	**0.05 [-0.23, 0.33]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.34 (P = 0.73)								
1.3.6 Radiant heating								
Lee 2004	36.05	0.47	29	35.92	0.46	20	47.9%	0.13 [-0.13, 0.39]
Torrie 2005	36.4	0.5	32	36.3	0.5	28	52.1%	0.10 [-0.15, 0.35]
Subtotal (95% CI)			**61**			**48**	**100.0%**	**0.11 [-0.07, 0.30]**
Heterogeneity: Tau² = 0.00; Chi² = 0.03, df = 1 (P = 0.87); I² = 0%								
Test for overall effect: Z = 1.22 (P = 0.22)								
1.3.8 Electric heating pads								
Ng 2006	36.57	0.87	30	36.84	0.52	30	100.0%	-0.27 [-0.63, 0.09]
Subtotal (95% CI)			**30**			**30**	**100.0%**	**-0.27 [-0.63, 0.09]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.46 (P = 0.14)								
1.3.9 Electric blanket								
Russell 1995	35.5	0.37	40	35.1	0.32	20	100.0%	0.40 [0.22, 0.58]
Subtotal (95% CI)			**40**			**20**	**100.0%**	**0.40 [0.22, 0.58]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 4.33 (P < 0.0001)								

Test for subgroup differences: Chi² = 27.22, df = 7 (P = 0.0003), I² = 74.3%

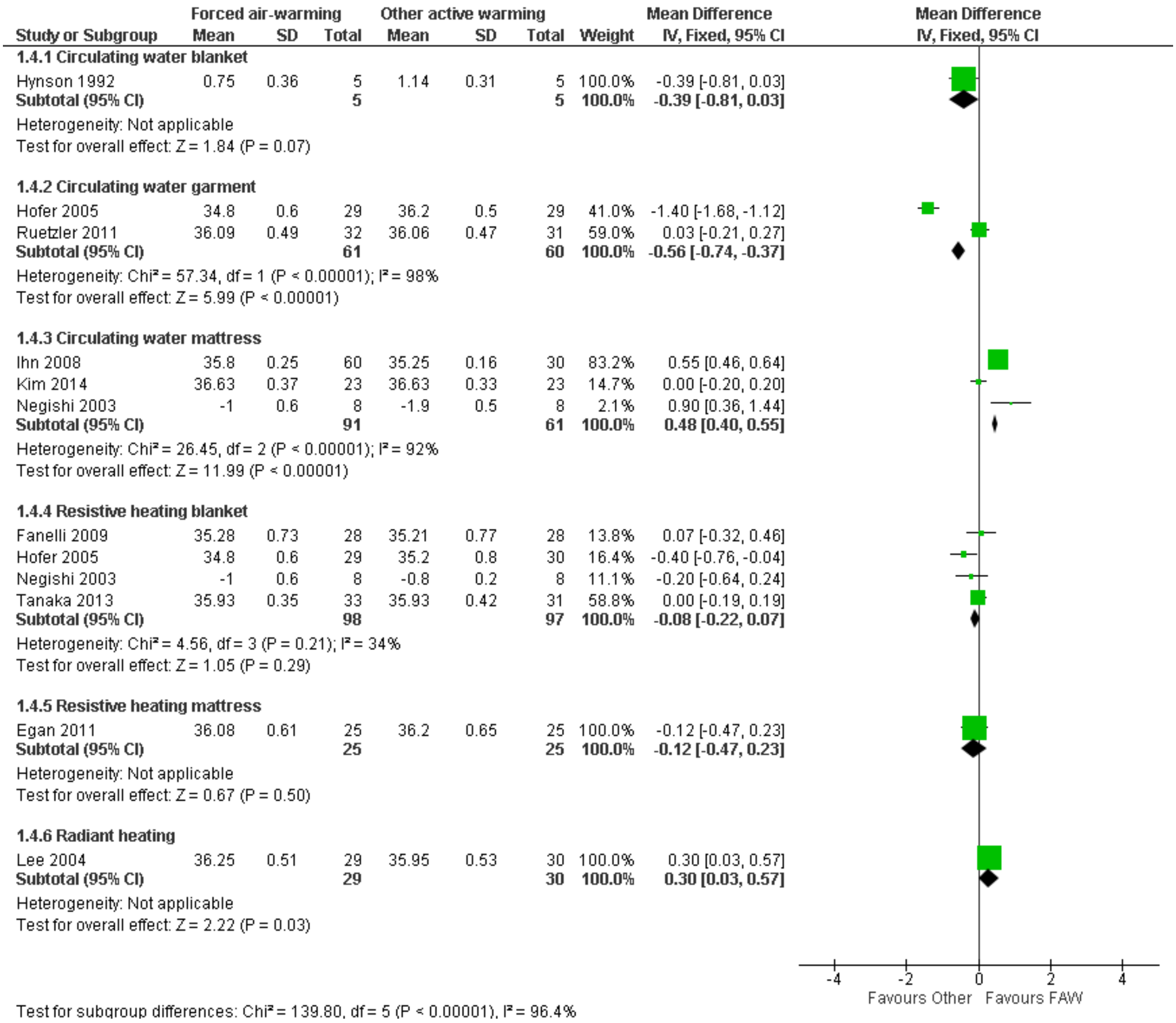
Sensitivity analysis – excluding Hofer 2005

	Forced air-warming			Other active warming				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.3.1 Circulating water blanket								
Hynson 1992	0.84	0.36	5	0.87	0.36	5	100.0%	-0.03 [-0.48, 0.42]
Subtotal (95% CI)			**5**			**5**	**100.0%**	**-0.03 [-0.48, 0.42]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.13 (P = 0.90)								
1.3.2 Circulating water garment								
Hasegawa 2012	35.76	0.44	12	35.98	0.42	12	18.8%	-0.22 [-0.56, 0.12]
Hofer 2005	35.2	0.5	29	36	0.6	29		Not estimable
Janicki 2001	35.9	0.7	18	36.5	0.3	19	18.7%	-0.60 [-0.95, -0.25]
Janicki 2002	36.1	0.4	12	36.7	0.2	12	20.6%	-0.60 [-0.85, -0.35]
Ruetzler 2011	35.87	0.5	34	35.96	0.49	37	20.9%	-0.09 [-0.32, 0.14]
Trentman 2009	36.28	0.32	25	36	0.52	29	21.0%	0.28 [0.05, 0.51]
Subtotal (95% CI)			**101**			**109**	**100.0%**	**-0.24 [-0.58, 0.11]**
Heterogeneity: Tau² = 0.14; Chi² = 32.50, df = 4 (P < 0.00001); I² = 88%								
Test for overall effect: Z = 1.34 (P = 0.18)								
1.3.3 Circulating water mattress								
Kim 2014	36.5	0.38	23	36.56	0.32	23	37.6%	-0.06 [-0.26, 0.14]
Kurz 1993	36.1	0.1	8	36.4	0.2	8	41.1%	-0.30 [-0.45, -0.15]
Negishi 2003	-1.1	0.5	8	-1.4	0.4	8	21.3%	0.30 [-0.14, 0.74]
Subtotal (95% CI)			**39**			**39**	**100.0%**	**-0.08 [-0.36, 0.19]**
Heterogeneity: Tau² = 0.04; Chi² = 8.13, df = 2 (P = 0.02); I² = 75%								
Test for overall effect: Z = 0.58 (P = 0.56)								
1.3.4 Resistive heating blanket								
Fanelli 2009	35.58	0.67	28	35.59	0.63	28	15.3%	-0.01 [-0.35, 0.33]
Hasegawa 2012	35.76	0.44	12	35.75	0.45	12	14.0%	0.01 [-0.35, 0.37]
Hofer 2005	35.2	0.5	29	35.4	0.8	30		Not estimable
Negishi 2003	-1.1	0.5	8	-0.9	0.3	8	10.9%	-0.20 [-0.60, 0.20]
Tanaka 2013	35.87	0.32	33	35.93	0.38	31	59.7%	-0.06 [-0.23, 0.11]
Subtotal (95% CI)			**81**			**79**	**100.0%**	**-0.06 [-0.19, 0.08]**
Heterogeneity: Tau² = 0.00; Chi² = 0.69, df = 3 (P = 0.88); I² = 0%								
Test for overall effect: Z = 0.85 (P = 0.40)								
1.3.5 Resistive heating mattress								
Egan 2011	35.95	0.59	30	35.9	0.55	32	100.0%	0.05 [-0.23, 0.33]
Subtotal (95% CI)			**30**			**32**	**100.0%**	**0.05 [-0.23, 0.33]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.34 (P = 0.73)								
1.3.6 Radiant heating								
Lee 2004	36.05	0.47	29	35.92	0.46	20	47.9%	0.13 [-0.13, 0.39]
Torrie 2005	36.4	0.5	32	36.3	0.5	28	52.1%	0.10 [-0.15, 0.35]
Subtotal (95% CI)			**61**			**48**	**100.0%**	**0.11 [-0.07, 0.30]**
Heterogeneity: Tau² = 0.00; Chi² = 0.03, df = 1 (P = 0.87); I² = 0%								
Test for overall effect: Z = 1.22 (P = 0.22)								
1.3.8 Electric heating pads								
Ng 2006	36.57	0.87	30	36.84	0.52	30	100.0%	-0.27 [-0.63, 0.09]
Subtotal (95% CI)			**30**			**30**	**100.0%**	**-0.27 [-0.63, 0.09]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.46 (P = 0.14)								
1.3.9 Electric blanket								
Russell 1995	35.5	0.37	40	35.1	0.32	20	100.0%	0.40 [0.22, 0.58]
Subtotal (95% CI)			**40**			**20**	**100.0%**	**0.40 [0.22, 0.58]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 4.33 (P < 0.0001)								

Test for subgroup differences: Chi² = 23.93, df = 7 (P = 0.001), I² = 70.8%



Core temperature at 120 mins

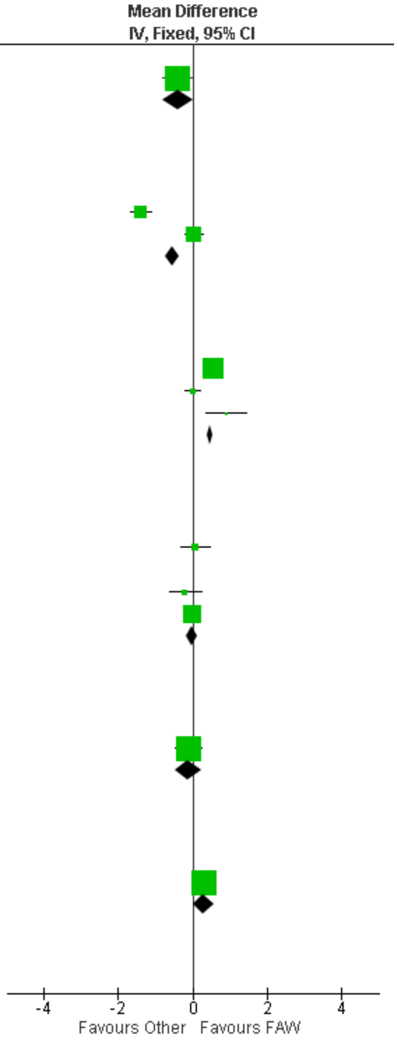


Study or Subgroup	Forced air-warming Mean	SD	Total	Other active warming Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
1.4.1 Circulating water blanket								
Hynson 1992	0.75	0.36	5	1.14	0.31	5	100.0%	-0.39 [-0.81, 0.03]
Subtotal (95% CI)			**5**			**5**	**100.0%**	**-0.39 [-0.81, 0.03]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.84 (P = 0.07)								
1.4.2 Circulating water garment								
Hofer 2005	34.8	0.6	29	36.2	0.5	29	41.0%	-1.40 [-1.68, -1.12]
Ruetzler 2011	36.09	0.49	32	36.06	0.47	31	59.0%	0.03 [-0.21, 0.27]
Subtotal (95% CI)			**61**			**60**	**100.0%**	**-0.56 [-0.74, -0.37]**
Heterogeneity: Chi² = 57.34, df = 1 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 5.99 (P < 0.00001)								
1.4.3 Circulating water mattress								
Ihn 2008	35.8	0.25	60	35.25	0.16	30	83.2%	0.55 [0.46, 0.64]
Kim 2014	36.63	0.37	23	36.63	0.33	23	14.7%	0.00 [-0.20, 0.20]
Negishi 2003	-1	0.6	8	-1.9	0.5	8	2.1%	0.90 [0.36, 1.44]
Subtotal (95% CI)			**91**			**61**	**100.0%**	**0.48 [0.40, 0.55]**
Heterogeneity: Chi² = 26.45, df = 2 (P < 0.00001); I² = 92%								
Test for overall effect: Z = 11.99 (P < 0.00001)								
1.4.4 Resistive heating blanket								
Fanelli 2009	35.28	0.73	28	35.21	0.77	28	13.8%	0.07 [-0.32, 0.46]
Hofer 2005	34.8	0.6	29	35.2	0.8	30	16.4%	-0.40 [-0.76, -0.04]
Negishi 2003	-1	0.6	8	-0.8	0.2	8	11.1%	-0.20 [-0.64, 0.24]
Tanaka 2013	35.93	0.35	33	35.93	0.42	31	58.8%	0.00 [-0.19, 0.19]
Subtotal (95% CI)			**98**			**97**	**100.0%**	**-0.08 [-0.22, 0.07]**
Heterogeneity: Chi² = 4.56, df = 3 (P = 0.21); I² = 34%								
Test for overall effect: Z = 1.05 (P = 0.29)								
1.4.5 Resistive heating mattress								
Egan 2011	36.08	0.61	25	36.2	0.65	25	100.0%	-0.12 [-0.47, 0.23]
Subtotal (95% CI)			**25**			**25**	**100.0%**	**-0.12 [-0.47, 0.23]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.67 (P = 0.50)								
1.4.6 Radiant heating								
Lee 2004	36.25	0.51	29	35.95	0.53	30	100.0%	0.30 [0.03, 0.57]
Subtotal (95% CI)			**29**			**30**	**100.0%**	**0.30 [0.03, 0.57]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.22 (P = 0.03)								

Test for subgroup differences: Chi² = 139.80, df = 5 (P < 0.00001), I² = 96.4%

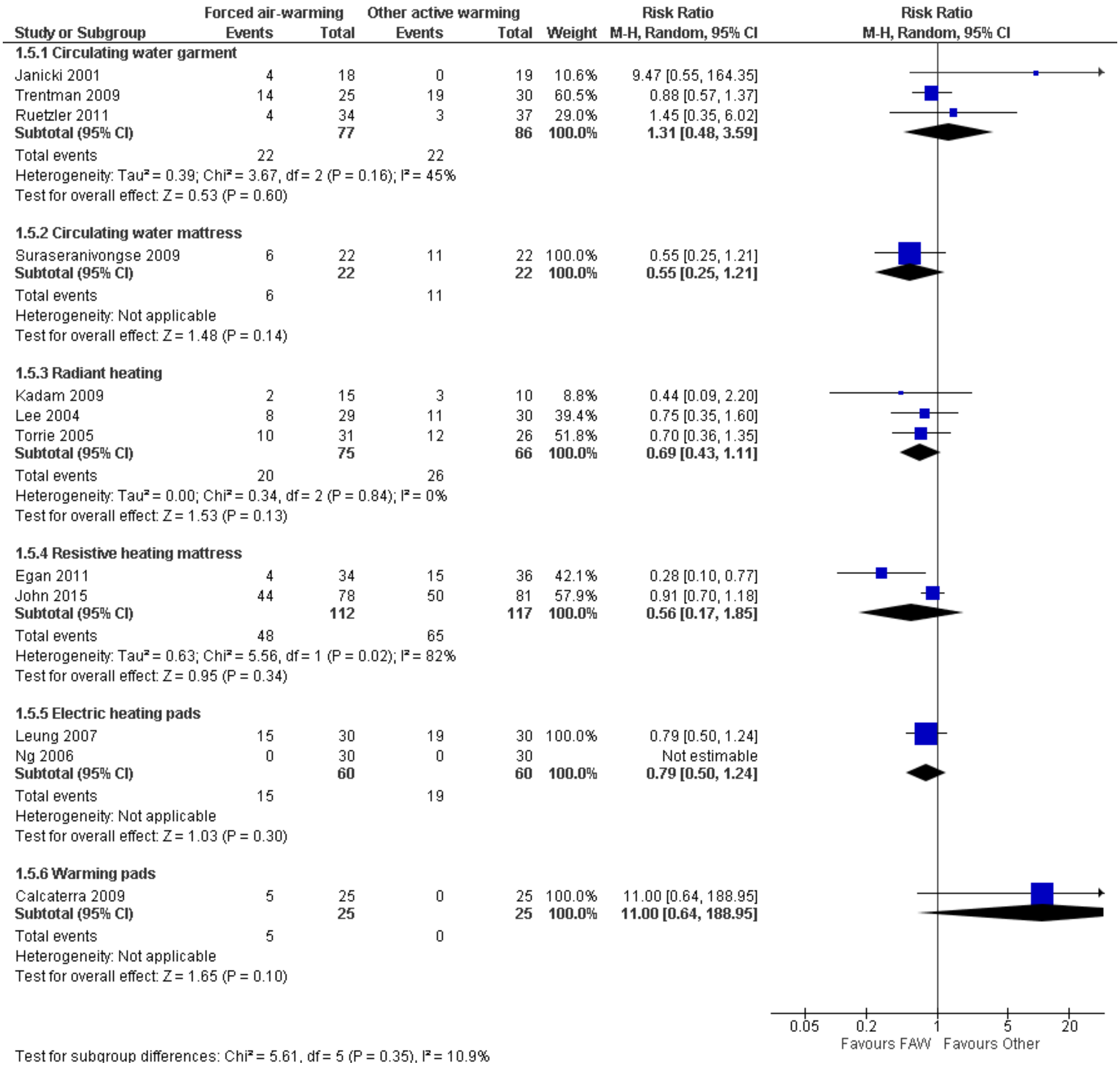
Sensitivity analysis – excluded Hofer 2005

	Forced air-warming			Other active warming				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Fixed, 95% CI**
1.4.1 Circulating water blanket								
Hynson 1992	0.75	0.36	5	1.14	0.31	5	100.0%	-0.39 [-0.81, 0.03]
Subtotal (95% CI)			**5**			**5**	**100.0%**	**-0.39 [-0.81, 0.03]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.84 (P = 0.07)								
1.4.2 Circulating water garment								
Hofer 2005	34.8	0.6	29	36.2	0.5	29	41.0%	-1.40 [-1.68, -1.12]
Ruetzler 2011	36.09	0.49	32	36.06	0.47	31	59.0%	0.03 [-0.21, 0.27]
Subtotal (95% CI)			**61**			**60**	**100.0%**	**-0.56 [-0.74, -0.37]**
Heterogeneity: Chi² = 57.34, df = 1 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 5.99 (P < 0.00001)								
1.4.3 Circulating water mattress								
Ihn 2008	35.8	0.25	60	35.25	0.16	30	83.2%	0.55 [0.46, 0.64]
Kim 2014	36.63	0.37	23	36.63	0.33	23	14.7%	0.00 [-0.20, 0.20]
Negishi 2003	-1	0.6	8	-1.9	0.5	8	2.1%	0.90 [0.36, 1.44]
Subtotal (95% CI)			**91**			**61**	**100.0%**	**0.48 [0.40, 0.55]**
Heterogeneity: Chi² = 26.45, df = 2 (P < 0.00001); I² = 92%								
Test for overall effect: Z = 11.99 (P < 0.00001)								
1.4.4 Resistive heating blanket								
Fanelli 2009	35.28	0.73	28	35.21	0.77	28	16.4%	0.07 [-0.32, 0.46]
Hofer 2005	34.8	0.6	29	35.2	0.8	30	0.0%	-0.40 [-0.76, -0.04]
Negishi 2003	-1	0.6	8	-0.8	0.2	8	13.2%	-0.20 [-0.64, 0.24]
Tanaka 2013	35.93	0.35	33	35.93	0.42	31	70.3%	0.00 [-0.19, 0.19]
Subtotal (95% CI)			**69**			**67**	**100.0%**	**-0.01 [-0.17, 0.14]**
Heterogeneity: Chi² = 0.89, df = 2 (P = 0.64); I² = 0%								
Test for overall effect: Z = 0.18 (P = 0.85)								
1.4.5 Resistive heating mattress								
Egan 2011	36.08	0.61	25	36.2	0.65	25	100.0%	-0.12 [-0.47, 0.23]
Subtotal (95% CI)			**25**			**25**	**100.0%**	**-0.12 [-0.47, 0.23]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.67 (P = 0.50)								
1.4.6 Radiant heating								
Lee 2004	36.25	0.51	29	35.95	0.53	30	100.0%	0.30 [0.03, 0.57]
Subtotal (95% CI)			**29**			**30**	**100.0%**	**0.30 [0.03, 0.57]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.22 (P = 0.03)								



Test for subgroup differences: Chi² = 131.79, df = 5 (P < 0.00001), I² = 96.2%

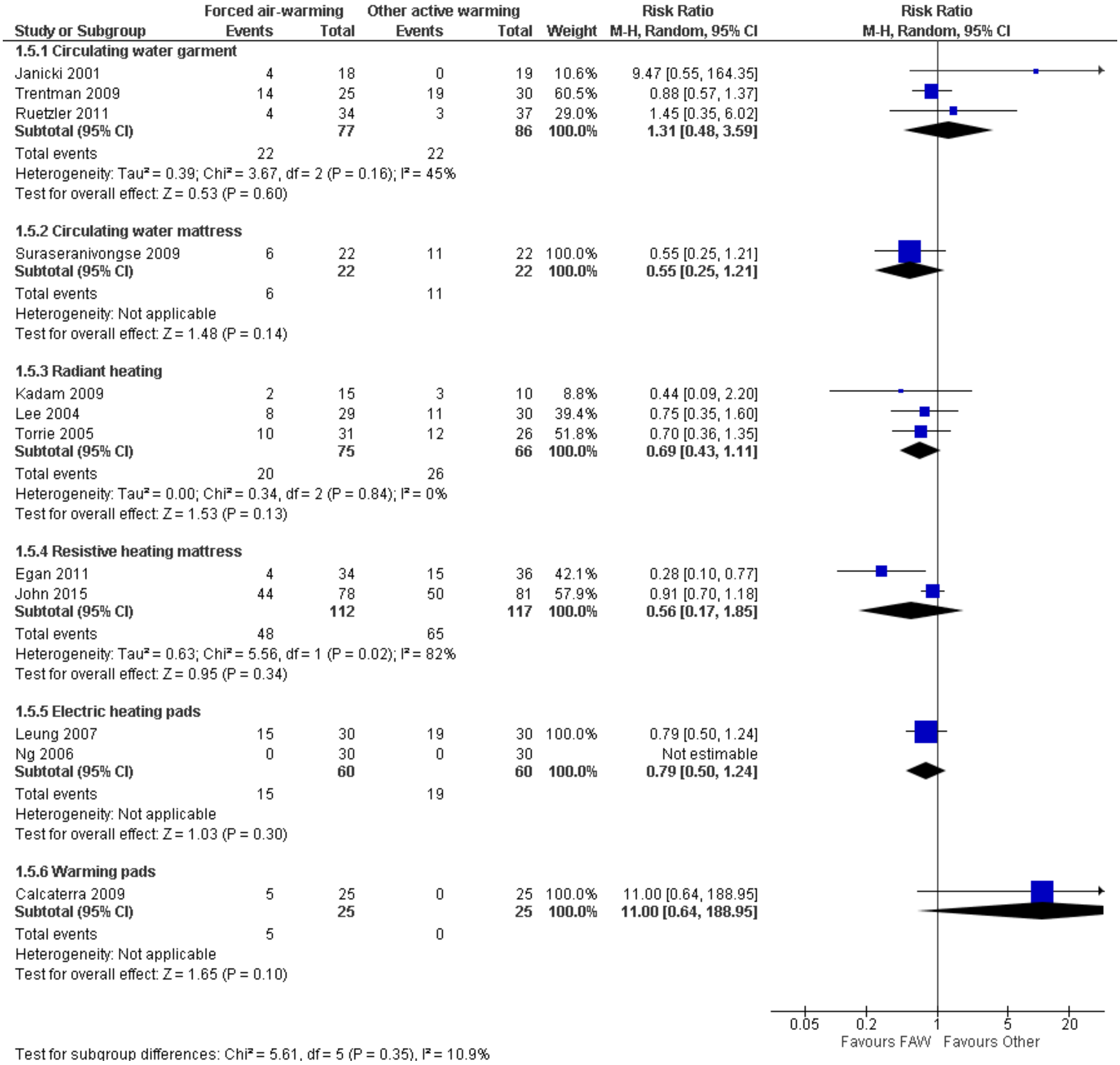
Hypothermia



Study or Subgroup	Forced air-warming Events	Forced air-warming Total	Other active warming Events	Other active warming Total	Weight	Risk Ratio M-H, Random, 95% CI
1.5.1 Circulating water garment						
Janicki 2001	4	18	0	19	10.6%	9.47 [0.55, 164.35]
Trentman 2009	14	25	19	30	60.5%	0.88 [0.57, 1.37]
Ruetzler 2011	4	34	3	37	29.0%	1.45 [0.35, 6.02]
Subtotal (95% CI)		**77**		**86**	**100.0%**	**1.31 [0.48, 3.59]**
Total events	22		22			
Heterogeneity: Tau² = 0.39; Chi² = 3.67, df = 2 (P = 0.16); I² = 45%						
Test for overall effect: Z = 0.53 (P = 0.60)						
1.5.2 Circulating water mattress						
Suraseranivongse 2009	6	22	11	22	100.0%	0.55 [0.25, 1.21]
Subtotal (95% CI)		**22**		**22**	**100.0%**	**0.55 [0.25, 1.21]**
Total events	6		11			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.48 (P = 0.14)						
1.5.3 Radiant heating						
Kadam 2009	2	15	3	10	8.8%	0.44 [0.09, 2.20]
Lee 2004	8	29	11	30	39.4%	0.75 [0.35, 1.60]
Torrie 2005	10	31	12	26	51.8%	0.70 [0.36, 1.35]
Subtotal (95% CI)		**75**		**66**	**100.0%**	**0.69 [0.43, 1.11]**
Total events	20		26			
Heterogeneity: Tau² = 0.00; Chi² = 0.34, df = 2 (P = 0.84); I² = 0%						
Test for overall effect: Z = 1.53 (P = 0.13)						
1.5.4 Resistive heating mattress						
Egan 2011	4	34	15	36	42.1%	0.28 [0.10, 0.77]
John 2015	44	78	50	81	57.9%	0.91 [0.70, 1.18]
Subtotal (95% CI)		**112**		**117**	**100.0%**	**0.56 [0.17, 1.85]**
Total events	48		65			
Heterogeneity: Tau² = 0.63; Chi² = 5.56, df = 1 (P = 0.02); I² = 82%						
Test for overall effect: Z = 0.95 (P = 0.34)						
1.5.5 Electric heating pads						
Leung 2007	15	30	19	30	100.0%	0.79 [0.50, 1.24]
Ng 2006	0	30	0	30		Not estimable
Subtotal (95% CI)		**60**		**60**	**100.0%**	**0.79 [0.50, 1.24]**
Total events	15		19			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.03 (P = 0.30)						
1.5.6 Warming pads						
Calcaterra 2009	5	25	0	25	100.0%	11.00 [0.64, 188.95]
Subtotal (95% CI)		**25**		**25**	**100.0%**	**11.00 [0.64, 188.95]**
Total events	5		0			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.65 (P = 0.10)						

Test for subgroup differences: Chi² = 5.61, df = 5 (P = 0.35), I² = 10.9%

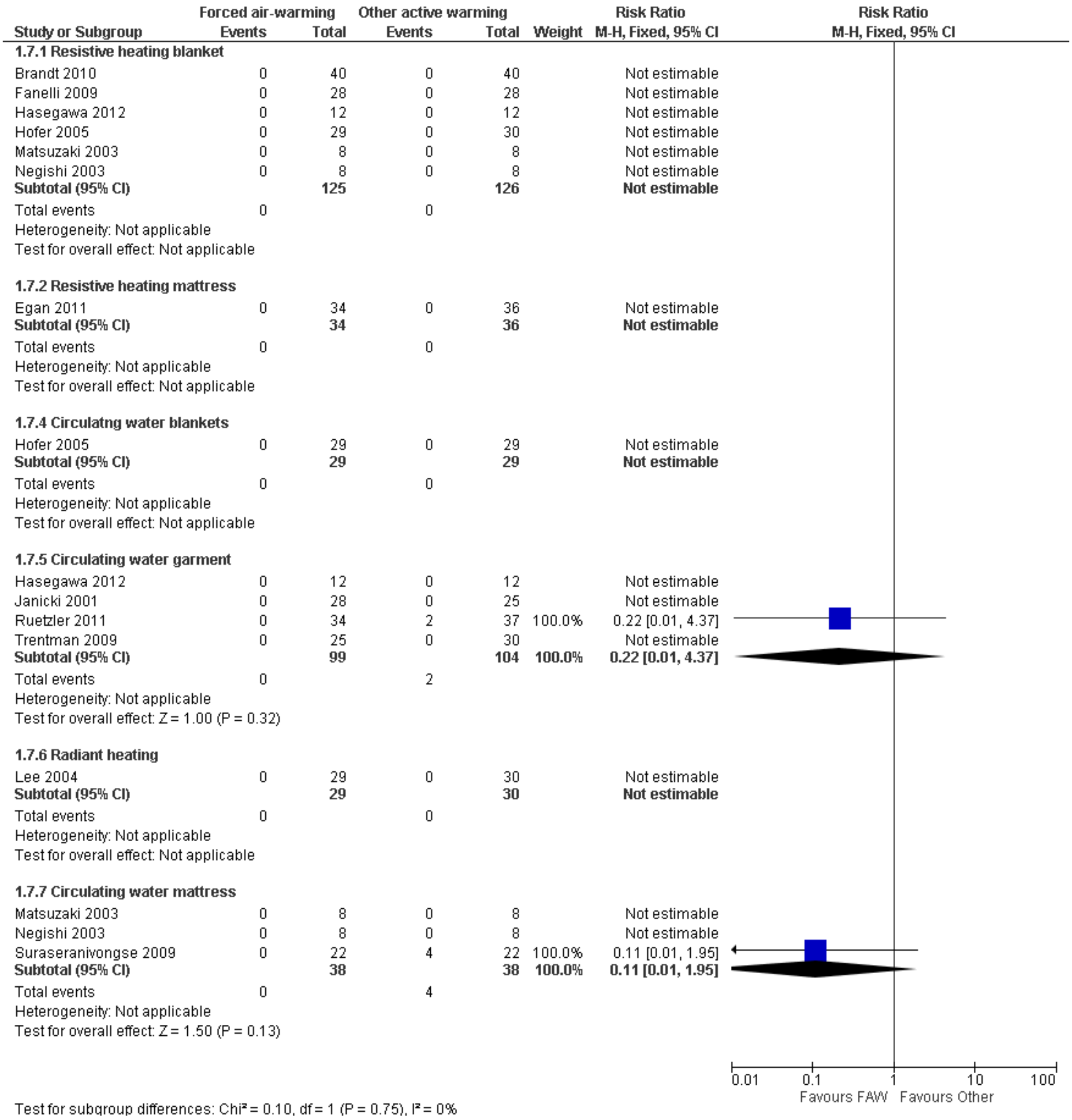
Shivering



	Forced air-warming		Other active warming			Risk Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Random, 95% CI**
1.5.1 Circulating water garment						
Janicki 2001	4	18	0	19	10.6%	9.47 [0.55, 164.35]
Trentman 2009	14	25	19	30	60.5%	0.88 [0.57, 1.37]
Ruetzler 2011	4	34	3	37	29.0%	1.45 [0.35, 6.02]
Subtotal (95% CI)		**77**		**86**	**100.0%**	**1.31 [0.48, 3.59]**
Total events	22		22			
Heterogeneity: Tau² = 0.39; Chi² = 3.67, df = 2 (P = 0.16); I² = 45%						
Test for overall effect: Z = 0.53 (P = 0.60)						
1.5.2 Circulating water mattress						
Suraseranivongse 2009	6	22	11	22	100.0%	0.55 [0.25, 1.21]
Subtotal (95% CI)		**22**		**22**	**100.0%**	**0.55 [0.25, 1.21]**
Total events	6		11			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.48 (P = 0.14)						
1.5.3 Radiant heating						
Kadam 2009	2	15	3	10	8.8%	0.44 [0.09, 2.20]
Lee 2004	8	29	11	30	39.4%	0.75 [0.35, 1.60]
Torrie 2005	10	31	12	26	51.8%	0.70 [0.36, 1.35]
Subtotal (95% CI)		**75**		**66**	**100.0%**	**0.69 [0.43, 1.11]**
Total events	20		26			
Heterogeneity: Tau² = 0.00; Chi² = 0.34, df = 2 (P = 0.84); I² = 0%						
Test for overall effect: Z = 1.53 (P = 0.13)						
1.5.4 Resistive heating mattress						
Egan 2011	4	34	15	36	42.1%	0.28 [0.10, 0.77]
John 2015	44	78	50	81	57.9%	0.91 [0.70, 1.18]
Subtotal (95% CI)		**112**		**117**	**100.0%**	**0.56 [0.17, 1.85]**
Total events	48		65			
Heterogeneity: Tau² = 0.63; Chi² = 5.56, df = 1 (P = 0.02); I² = 82%						
Test for overall effect: Z = 0.95 (P = 0.34)						
1.5.5 Electric heating pads						
Leung 2007	15	30	19	30	100.0%	0.79 [0.50, 1.24]
Ng 2006	0	30	0	30		Not estimable
Subtotal (95% CI)		**60**		**60**	**100.0%**	**0.79 [0.50, 1.24]**
Total events	15		19			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.03 (P = 0.30)						
1.5.6 Warming pads						
Calcaterra 2009	5	25	0	25	100.0%	11.00 [0.64, 188.95]
Subtotal (95% CI)		**25**		**25**	**100.0%**	**11.00 [0.64, 188.95]**
Total events	5		0			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.65 (P = 0.10)						

Test for subgroup differences: Chi² = 5.61, df = 5 (P = 0.35), I² = 10.9%

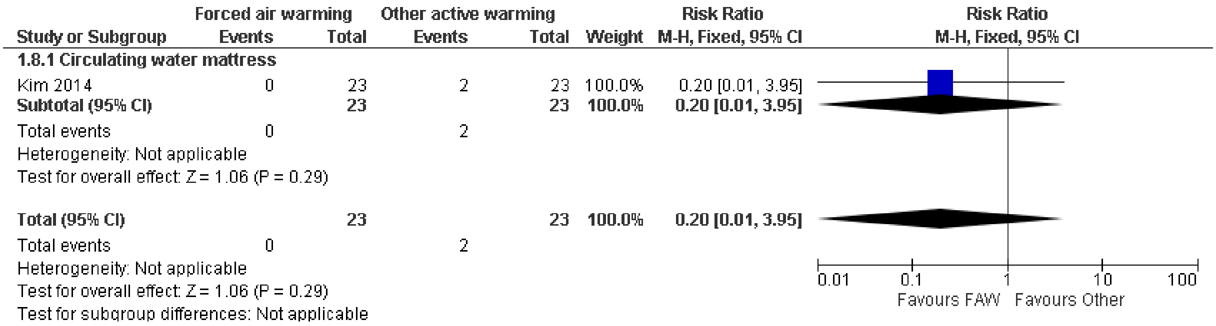
Adverse effects



	Forced air-warming		Other active warming			Risk Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95% CI**
1.7.1 Resistive heating blanket						
Brandt 2010	0	40	0	40		Not estimable
Fanelli 2009	0	28	0	28		Not estimable
Hasegawa 2012	0	12	0	12		Not estimable
Hofer 2005	0	29	0	30		Not estimable
Matsuzaki 2003	0	8	0	8		Not estimable
Negishi 2003	0	8	0	8		Not estimable
Subtotal (95% CI)		**125**		**126**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
1.7.2 Resistive heating mattress						
Egan 2011	0	34	0	36		Not estimable
Subtotal (95% CI)		**34**		**36**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
1.7.4 Circulatng water blankets						
Hofer 2005	0	29	0	29		Not estimable
Subtotal (95% CI)		**29**		**29**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
1.7.5 Circulating water garment						
Hasegawa 2012	0	12	0	12		Not estimable
Janicki 2001	0	28	0	25		Not estimable
Ruetzler 2011	0	34	2	37	100.0%	0.22 [0.01, 4.37]
Trentman 2009	0	25	0	30		Not estimable
Subtotal (95% CI)		**99**		**104**	**100.0%**	**0.22 [0.01, 4.37]**
Total events	0		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.00 (P = 0.32)						
1.7.6 Radiant heating						
Lee 2004	0	29	0	30		Not estimable
Subtotal (95% CI)		**29**		**30**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
1.7.7 Circulating water mattress						
Matsuzaki 2003	0	8	0	8		Not estimable
Negishi 2003	0	8	0	8		Not estimable
Suraseranivongse 2009	0	22	4	22	100.0%	0.11 [0.01, 1.95]
Subtotal (95% CI)		**38**		**38**	**100.0%**	**0.11 [0.01, 1.95]**
Total events	0		4			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.50 (P = 0.13)						

Test for subgroup differences: Chi² = 0.10, df = 1 (P = 0.75), I² = 0%

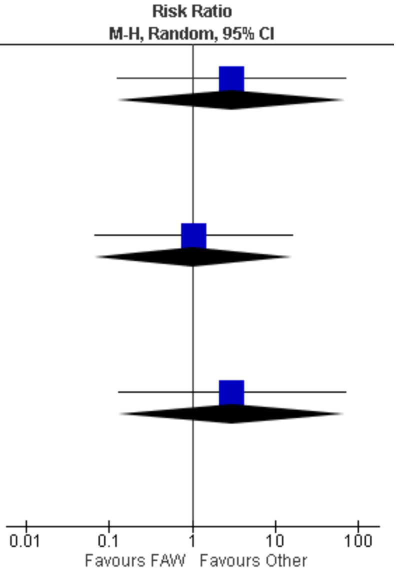
Cardiac events



	Forced air warming		Other active warming			Risk Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95% CI**
1.8.1 Circulating water mattress						
Kim 2014	0	23	2	23	100.0%	0.20 [0.01, 3.95]
Subtotal (95% CI)		**23**		**23**	**100.0%**	**0.20 [0.01, 3.95]**
Total events	0		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.06 (P = 0.29)						
Total (95% CI)		**23**		**23**	**100.0%**	**0.20 [0.01, 3.95]**
Total events	0		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.06 (P = 0.29)						
Test for subgroup differences: Not applicable						

Surgical / wound infections

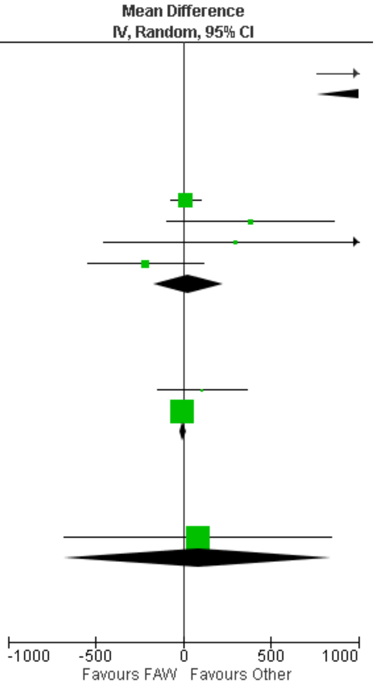
	Forced air-warming		Other active warming			Risk Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Random, 95% CI**
1.9.1 Circulating water garments						
Hofer 2005	1	29	0	29	100.0%	3.00 [0.13, 70.74]
Subtotal (95% CI)		**29**		**29**	**100.0%**	**3.00 [0.13, 70.74]**
Total events	1		0			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.68 (P = 0.50)						
1.9.2 Resistive heating blanket						
Hofer 2005	1	29	1	30	100.0%	1.03 [0.07, 15.77]
Subtotal (95% CI)		**29**		**30**	**100.0%**	**1.03 [0.07, 15.77]**
Total events	1		1			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.02 (P = 0.98)						
1.9.3 warming pads						
Calcaterra 2009	1	25	0	25	100.0%	3.00 [0.13, 70.30]
Subtotal (95% CI)		**25**		**25**	**100.0%**	**3.00 [0.13, 70.30]**
Total events	1		0			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.68 (P = 0.49)						



Test for subgroup differences: Chi² = 0.35, df = 2 (P = 0.84), I² = 0%

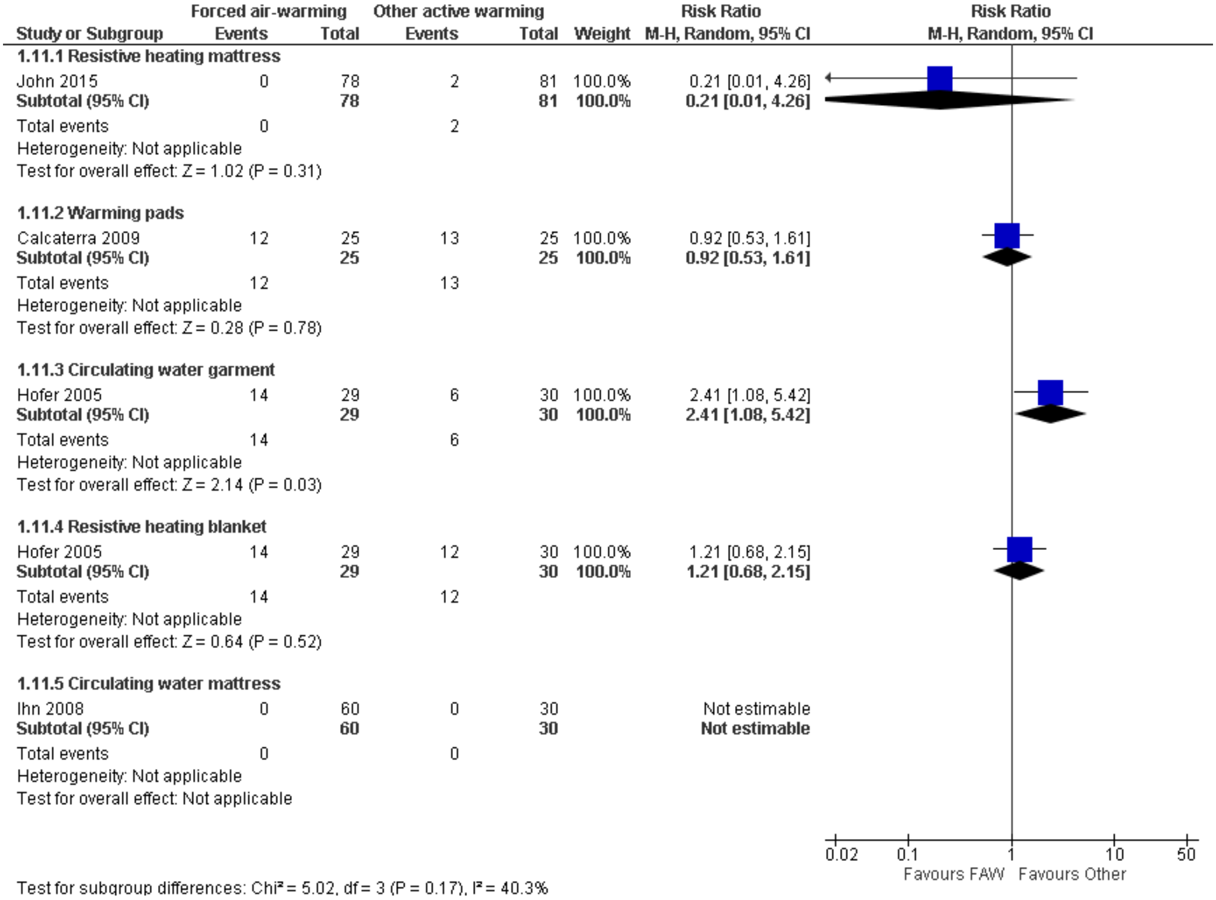
Blood loss

	Forced air-warming			Other active warming				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.10.1 Circulating water garments								
Hofer 2005	2,683	1,049	29	1,497	497	29	100.0%	1186.00 [763.53, 1608.47]
Subtotal (95% CI)			**29**			**29**	**100.0%**	**1186.00 [763.53, 1608.47]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 5.50 (P < 0.00001)								
1.10.2 Resistive heating blanket								
Fanelli 2009	378	183	28	364	141	28	57.3%	14.00 [-71.57, 99.57]
Hofer 2005	2,683	1,049	29	2,300	788	30	13.6%	383.00 [-91.63, 857.63]
Negishi 2003	708	994	8	406	464	8	6.1%	302.00 [-458.14, 1062.14]
Tanaka 2013	869.26	613.71	33	1,084.91	728.82	31	22.9%	-215.65 [-546.81, 115.51]
Subtotal (95% CI)			**98**			**97**	**100.0%**	**29.35 [-168.18, 226.88]**
Heterogeneity: Tau² = 15804.62; Chi² = 4.72, df = 3 (P = 0.19); I² = 36%								
Test for overall effect: Z = 0.29 (P = 0.77)								
1.10.3 Electric heating pads								
Leung 2007	617.1	521	30	509.6	497.3	30	0.6%	107.50 [-150.23, 365.23]
Ng 2006	100	41.5	30	103.3	34.6	30	99.4%	-3.30 [-22.63, 16.03]
Subtotal (95% CI)			**60**			**60**	**100.0%**	**-2.68 [-21.96, 16.60]**
Heterogeneity: Tau² = 0.00; Chi² = 0.71, df = 1 (P = 0.40); I² = 0%								
Test for overall effect: Z = 0.27 (P = 0.79)								
1.10.4 Circulating water mattress								
Negishi 2003	708	994	8	624	468	8	100.0%	84.00 [-677.32, 845.32]
Subtotal (95% CI)			**8**			**8**	**100.0%**	**84.00 [-677.32, 845.32]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 0.22 (P = 0.83)								



Test for subgroup differences: Chi² = 30.48, df = 3 (P < 0.00001), I² = 90.2%

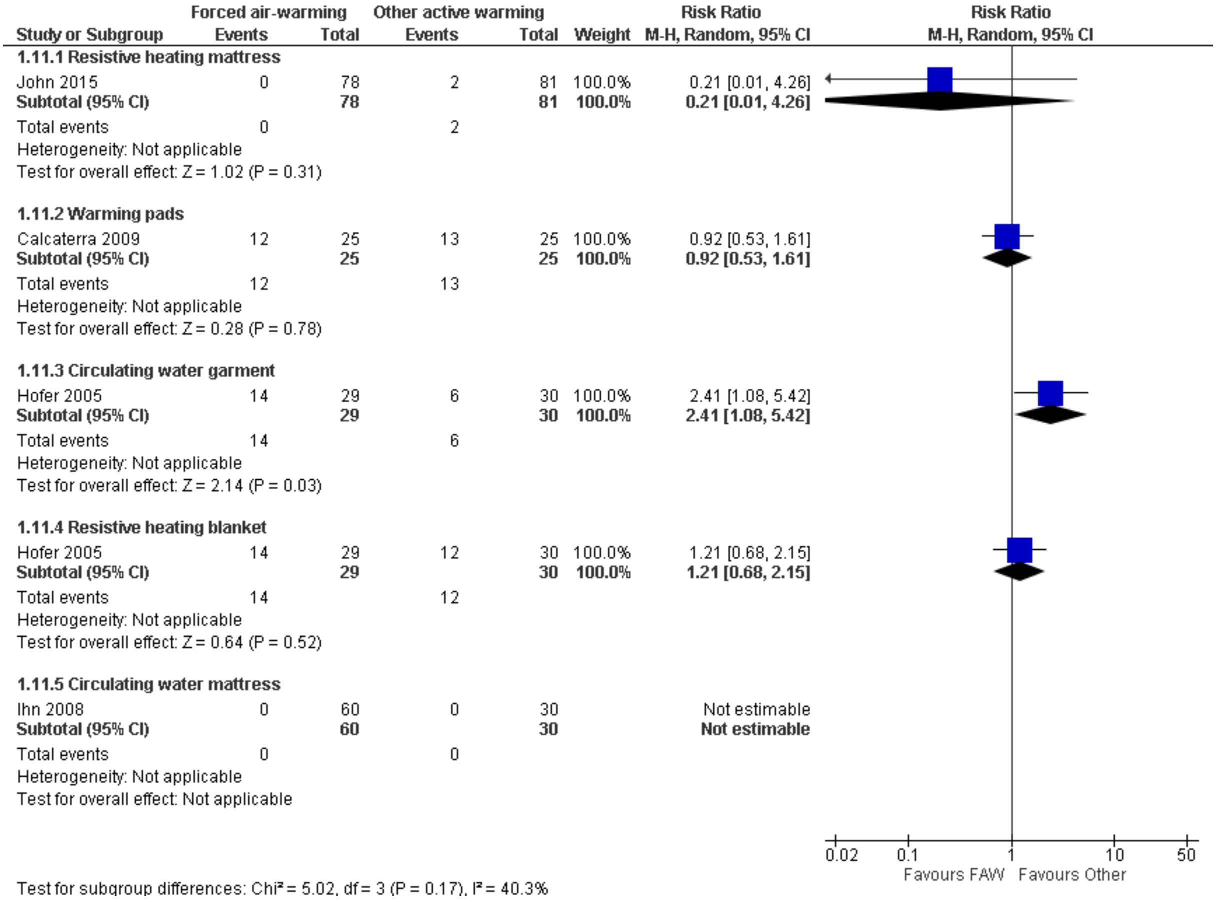
Blood transfusion



	Forced air-warming		Other active warming			Risk Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Random, 95% CI**
1.11.1 Resistive heating mattress						
John 2015	0	78	2	81	100.0%	0.21 [0.01, 4.26]
Subtotal (95% CI)		**78**		**81**	**100.0%**	**0.21 [0.01, 4.26]**
Total events	0		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.02 (P = 0.31)						
1.11.2 Warming pads						
Calcaterra 2009	12	25	13	25	100.0%	0.92 [0.53, 1.61]
Subtotal (95% CI)		**25**		**25**	**100.0%**	**0.92 [0.53, 1.61]**
Total events	12		13			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.28 (P = 0.78)						
1.11.3 Circulating water garment						
Hofer 2005	14	29	6	30	100.0%	2.41 [1.08, 5.42]
Subtotal (95% CI)		**29**		**30**	**100.0%**	**2.41 [1.08, 5.42]**
Total events	14		6			
Heterogeneity: Not applicable						
Test for overall effect: Z = 2.14 (P = 0.03)						
1.11.4 Resistive heating blanket						
Hofer 2005	14	29	12	30	100.0%	1.21 [0.68, 2.15]
Subtotal (95% CI)		**29**		**30**	**100.0%**	**1.21 [0.68, 2.15]**
Total events	14		12			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.64 (P = 0.52)						
1.11.5 Circulating water mattress						
Ihn 2008	0	60	0	30		Not estimable
Subtotal (95% CI)		**60**		**30**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						

Test for subgroup differences: Chi² = 5.02, df = 3 (P = 0.17), I² = 40.3%

Length of hospital stay

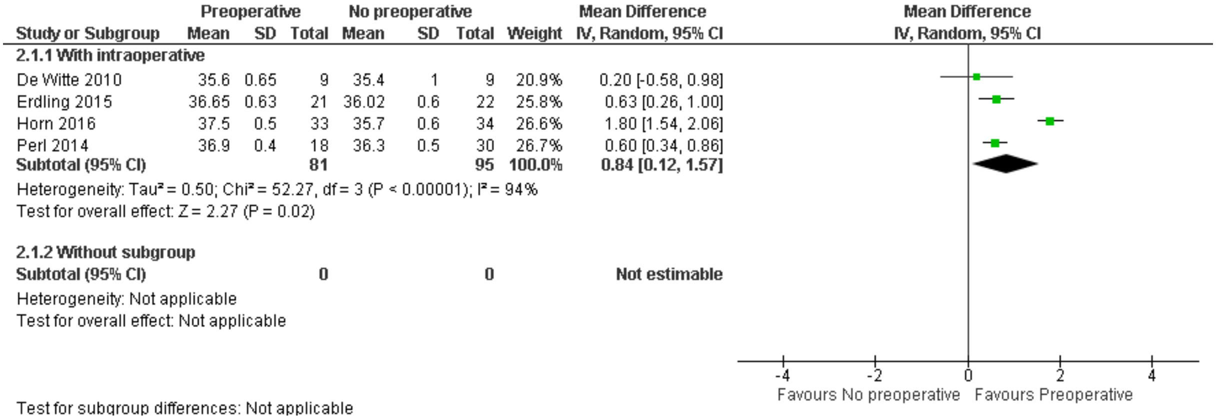


Study or Subgroup	Forced air-warming Events	Forced air-warming Total	Other active warming Events	Other active warming Total	Weight	Risk Ratio M-H, Random, 95% CI
1.11.1 Resistive heating mattress						
John 2015	0	78	2	81	100.0%	0.21 [0.01, 4.26]
Subtotal (95% CI)		**78**		**81**	**100.0%**	**0.21 [0.01, 4.26]**
Total events	0		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.02 (P = 0.31)						
1.11.2 Warming pads						
Calcaterra 2009	12	25	13	25	100.0%	0.92 [0.53, 1.61]
Subtotal (95% CI)		**25**		**25**	**100.0%**	**0.92 [0.53, 1.61]**
Total events	12		13			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.28 (P = 0.78)						
1.11.3 Circulating water garment						
Hofer 2005	14	29	6	30	100.0%	2.41 [1.08, 5.42]
Subtotal (95% CI)		**29**		**30**	**100.0%**	**2.41 [1.08, 5.42]**
Total events	14		6			
Heterogeneity: Not applicable						
Test for overall effect: Z = 2.14 (P = 0.03)						
1.11.4 Resistive heating blanket						
Hofer 2005	14	29	12	30	100.0%	1.21 [0.68, 2.15]
Subtotal (95% CI)		**29**		**30**	**100.0%**	**1.21 [0.68, 2.15]**
Total events	14		12			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.64 (P = 0.52)						
1.11.5 Circulating water mattress						
Ihn 2008	0	60	0	30		Not estimable
Subtotal (95% CI)		**60**		**30**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						

Test for subgroup differences: Chi² = 5.02, df = 3 (P = 0.17), I² = 40.3%

I.2 Review question 2: Devices – Preoperative

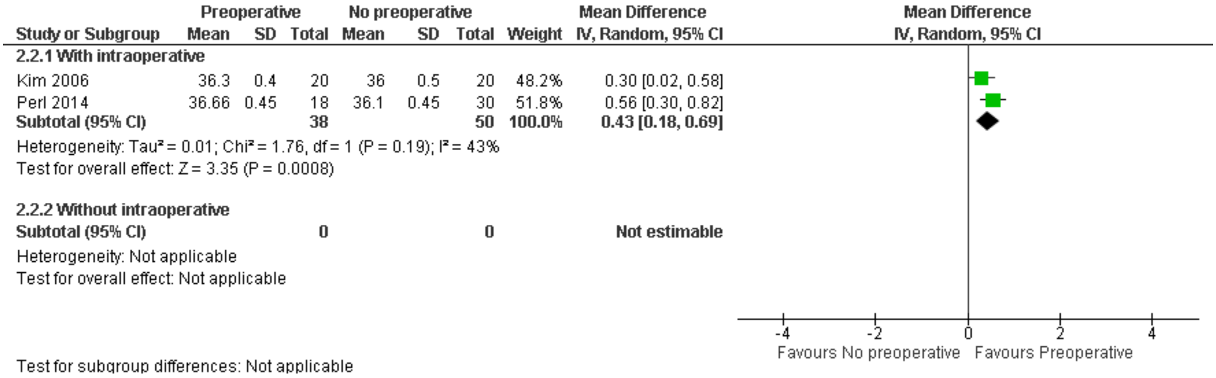
Core temperature at end of surgery



Study or Subgroup	Preoperative Mean	Preoperative SD	Preoperative Total	No preoperative Mean	No preoperative SD	No preoperative Total	Weight	Mean Difference IV, Random, 95% CI
2.1.1 With intraoperative								
De Witte 2010	35.6	0.65	9	35.4	1	9	20.9%	0.20 [-0.58, 0.98]
Erdling 2015	36.65	0.63	21	36.02	0.6	22	25.8%	0.63 [0.26, 1.00]
Horn 2016	37.5	0.5	33	35.7	0.6	34	26.6%	1.80 [1.54, 2.06]
Perl 2014	36.9	0.4	18	36.3	0.5	30	26.7%	0.60 [0.34, 0.86]
Subtotal (95% CI)			**81**			**95**	**100.0%**	**0.84 [0.12, 1.57]**
Heterogeneity: Tau² = 0.50; Chi² = 52.27, df = 3 (P < 0.00001); I² = 94%								
Test for overall effect: Z = 2.27 (P = 0.02)								
2.1.2 Without subgroup								
Subtotal (95% CI)			**0**			**0**		**Not estimable**
Heterogeneity: Not applicable								
Test for overall effect: Not applicable								

Test for subgroup differences: Not applicable

Core temperature at 30 mins



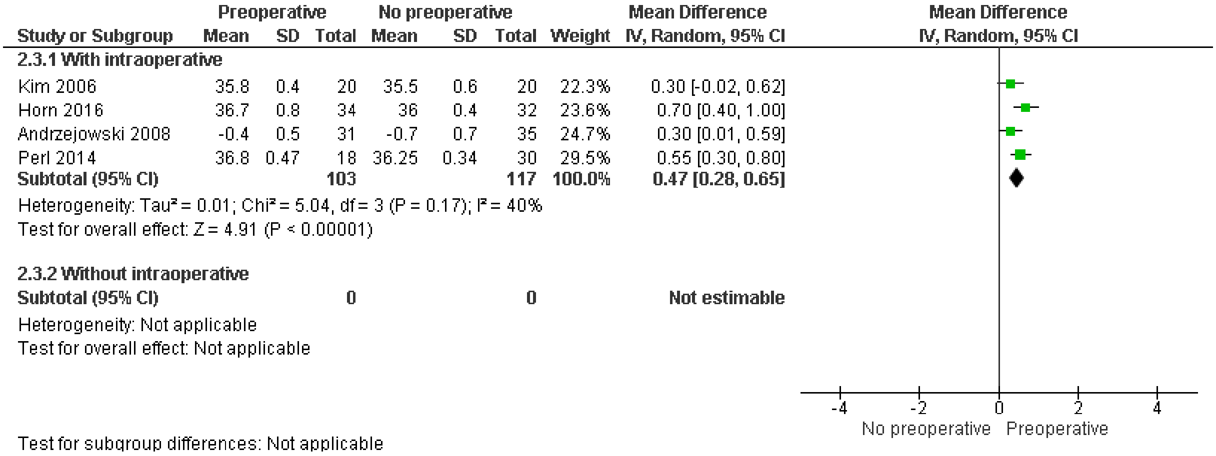
Study or Subgroup	Preoperative Mean	Preoperative SD	Preoperative Total	No preoperative Mean	No preoperative SD	No preoperative Total	Weight	Mean Difference IV, Random, 95% CI
2.2.1 With intraoperative								
Kim 2006	36.3	0.4	20	36	0.5	20	48.2%	0.30 [0.02, 0.58]
Perl 2014	36.66	0.45	18	36.1	0.45	30	51.8%	0.56 [0.30, 0.82]
Subtotal (95% CI)			**38**			**50**	**100.0%**	**0.43 [0.18, 0.69]**
2.2.2 Without intraoperative								
Subtotal (95% CI)			**0**			**0**		**Not estimable**

2.2.1: Heterogeneity: Tau² = 0.01; Chi² = 1.76, df = 1 (P = 0.19); I² = 43%
Test for overall effect: Z = 3.35 (P = 0.0008)

2.2.2: Heterogeneity: Not applicable
Test for overall effect: Not applicable

Test for subgroup differences: Not applicable

Core temperature at 60 mins



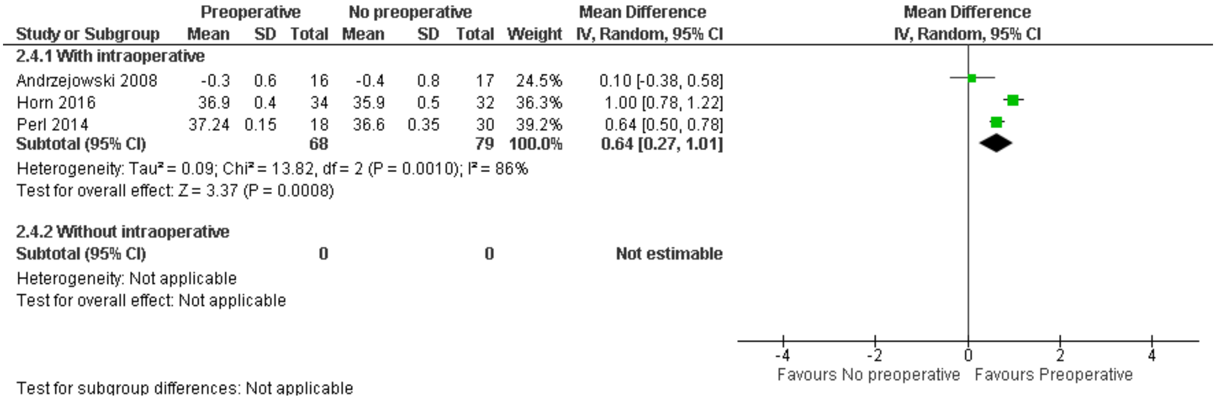
Study or Subgroup	Preoperative Mean	Preoperative SD	Preoperative Total	No preoperative Mean	No preoperative SD	No preoperative Total	Weight	Mean Difference IV, Random, 95% CI
2.3.1 With intraoperative								
Kim 2006	35.8	0.4	20	35.5	0.6	20	22.3%	0.30 [-0.02, 0.62]
Horn 2016	36.7	0.8	34	36	0.4	32	23.6%	0.70 [0.40, 1.00]
Andrzejowski 2008	-0.4	0.5	31	-0.7	0.7	35	24.7%	0.30 [0.01, 0.59]
Perl 2014	36.8	0.47	18	36.25	0.34	30	29.5%	0.55 [0.30, 0.80]
Subtotal (95% CI)			**103**			**117**	**100.0%**	**0.47 [0.28, 0.65]**
2.3.2 Without intraoperative								
Subtotal (95% CI)			**0**			**0**		**Not estimable**

2.3.1: Heterogeneity: Tau² = 0.01; Chi² = 5.04, df = 3 (P = 0.17); I² = 40%
Test for overall effect: Z = 4.91 (P < 0.00001)

2.3.2: Heterogeneity: Not applicable
Test for overall effect: Not applicable

Test for subgroup differences: Not applicable

Core temperature at 120 mins



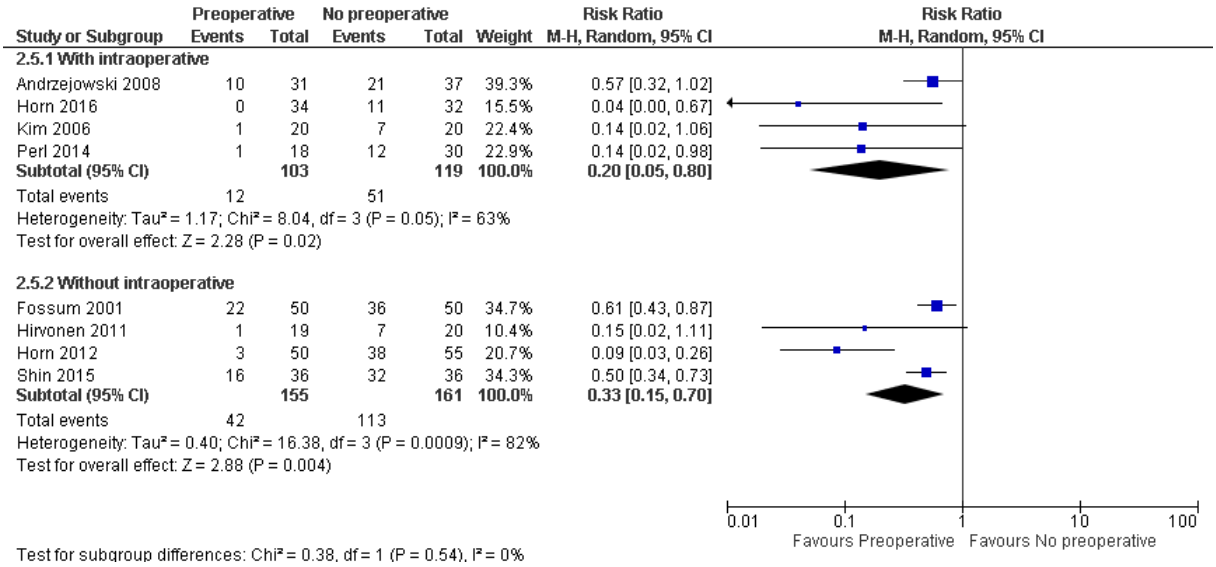
Study or Subgroup	Preoperative Mean	Preoperative SD	Preoperative Total	No preoperative Mean	No preoperative SD	No preoperative Total	Weight	Mean Difference IV, Random, 95% CI
2.4.1 With intraoperative								
Andrzejowski 2008	-0.3	0.6	16	-0.4	0.8	17	24.5%	0.10 [-0.38, 0.58]
Horn 2016	36.9	0.4	34	35.9	0.5	32	36.3%	1.00 [0.78, 1.22]
Perl 2014	37.24	0.15	18	36.6	0.35	30	39.2%	0.64 [0.50, 0.78]
Subtotal (95% CI)			**68**			**79**	**100.0%**	**0.64 [0.27, 1.01]**
2.4.2 Without intraoperative								
Subtotal (95% CI)			**0**			**0**		**Not estimable**

2.4.1: Heterogeneity: Tau² = 0.09; Chi² = 13.82, df = 2 (P = 0.0010); I² = 86%
Test for overall effect: Z = 3.37 (P = 0.0008)

2.4.2: Heterogeneity: Not applicable
Test for overall effect: Not applicable

Test for subgroup differences: Not applicable

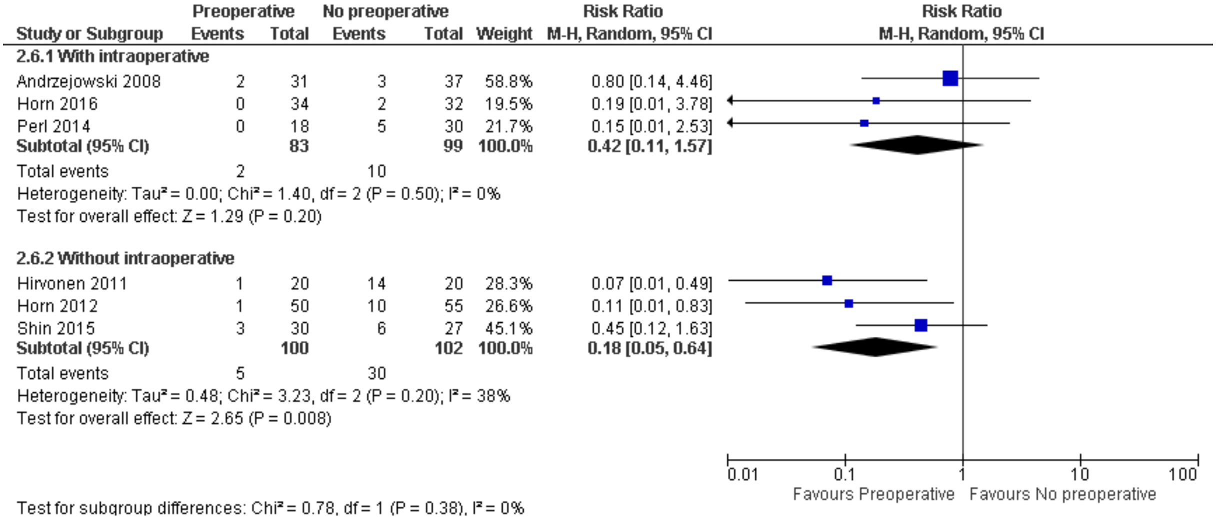
Hypothermia



Study or Subgroup	Preoperative Events	Preoperative Total	No preoperative Events	No preoperative Total	Weight	Risk Ratio M-H, Random, 95% CI
2.5.1 With intraoperative						
Andrzejowski 2008	10	31	21	37	39.3%	0.57 [0.32, 1.02]
Horn 2016	0	34	11	32	15.5%	0.04 [0.00, 0.67]
Kim 2006	1	20	7	20	22.4%	0.14 [0.02, 1.06]
Perl 2014	1	18	12	30	22.9%	0.14 [0.02, 0.98]
Subtotal (95% CI)		**103**		**119**	**100.0%**	**0.20 [0.05, 0.80]**
Total events	12		51			
Heterogeneity: Tau² = 1.17; Chi² = 8.04, df = 3 (P = 0.05); I² = 63%						
Test for overall effect: Z = 2.28 (P = 0.02)						
2.5.2 Without intraoperative						
Fossum 2001	22	50	36	50	34.7%	0.61 [0.43, 0.87]
Hirvonen 2011	1	19	7	20	10.4%	0.15 [0.02, 1.11]
Horn 2012	3	50	38	55	20.7%	0.09 [0.03, 0.26]
Shin 2015	16	36	32	36	34.3%	0.50 [0.34, 0.73]
Subtotal (95% CI)		**155**		**161**	**100.0%**	**0.33 [0.15, 0.70]**
Total events	42		113			
Heterogeneity: Tau² = 0.40; Chi² = 16.38, df = 3 (P = 0.0009); I² = 82%						
Test for overall effect: Z = 2.88 (P = 0.004)						

Test for subgroup differences: Chi² = 0.38, df = 1 (P = 0.54), I² = 0%

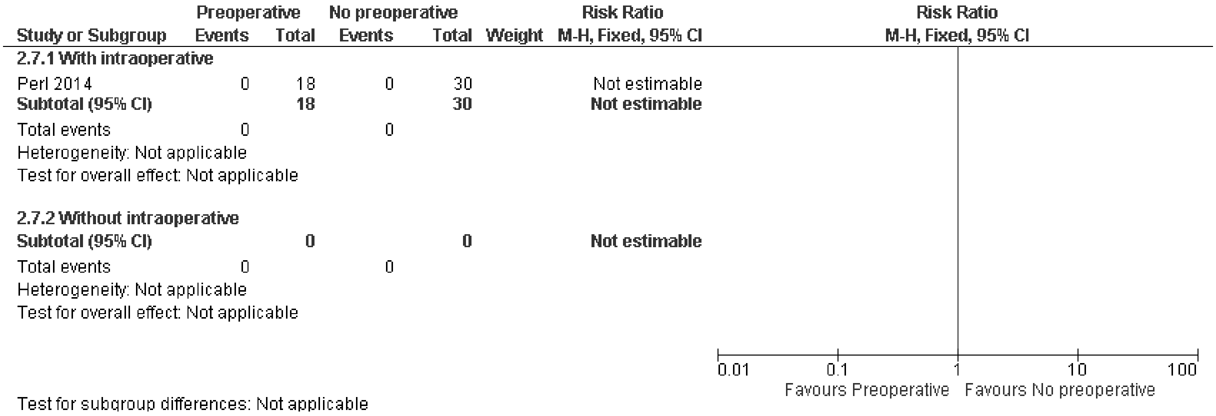
Shivering



Study or Subgroup	Preoperative Events	Preoperative Total	No preoperative Events	No preoperative Total	Weight	Risk Ratio M-H, Random, 95% CI
2.6.1 With intraoperative						
Andrzejowski 2008	2	31	3	37	58.8%	0.80 [0.14, 4.46]
Horn 2016	0	34	2	32	19.5%	0.19 [0.01, 3.78]
Perl 2014	0	18	5	30	21.7%	0.15 [0.01, 2.53]
Subtotal (95% CI)		**83**		**99**	**100.0%**	**0.42 [0.11, 1.57]**
Total events	2		10			
Heterogeneity: Tau² = 0.00; Chi² = 1.40, df = 2 (P = 0.50); I² = 0%						
Test for overall effect: Z = 1.29 (P = 0.20)						
2.6.2 Without intraoperative						
Hirvonen 2011	1	20	14	20	28.3%	0.07 [0.01, 0.49]
Horn 2012	1	50	10	55	26.6%	0.11 [0.01, 0.83]
Shin 2015	3	30	6	27	45.1%	0.45 [0.12, 1.63]
Subtotal (95% CI)		**100**		**102**	**100.0%**	**0.18 [0.05, 0.64]**
Total events	5		30			
Heterogeneity: Tau² = 0.48; Chi² = 3.23, df = 2 (P = 0.20); I² = 38%						
Test for overall effect: Z = 2.65 (P = 0.008)						

Test for subgroup differences: Chi² = 0.78, df = 1 (P = 0.38), I² = 0%

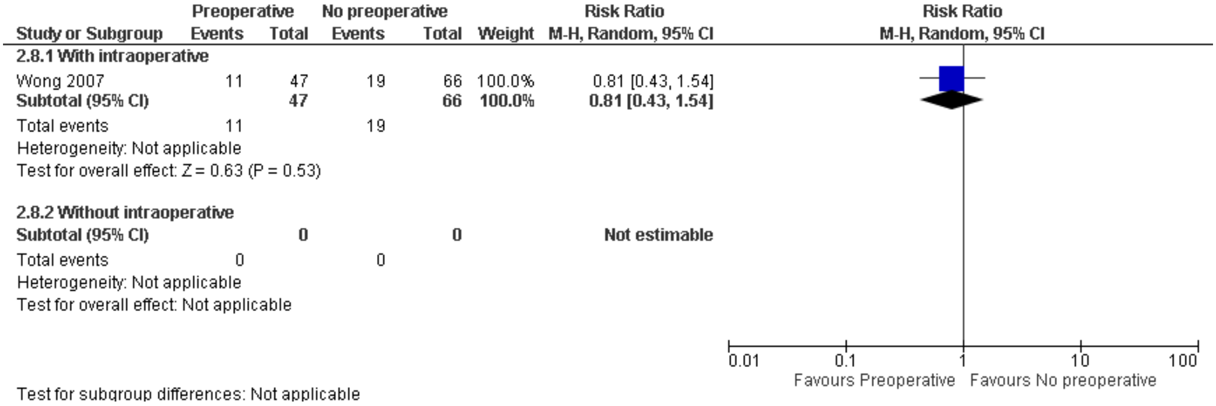
Adverse effects



Study or Subgroup	Preoperative Events	Preoperative Total	No preoperative Events	No preoperative Total	Weight	Risk Ratio M-H, Fixed, 95% CI
2.7.1 With intraoperative						
Perl 2014	0	18	0	30		Not estimable
Subtotal (95% CI)		**18**		**30**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						
2.7.2 Without intraoperative						
Subtotal (95% CI)		**0**		**0**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						

Test for subgroup differences: Not applicable

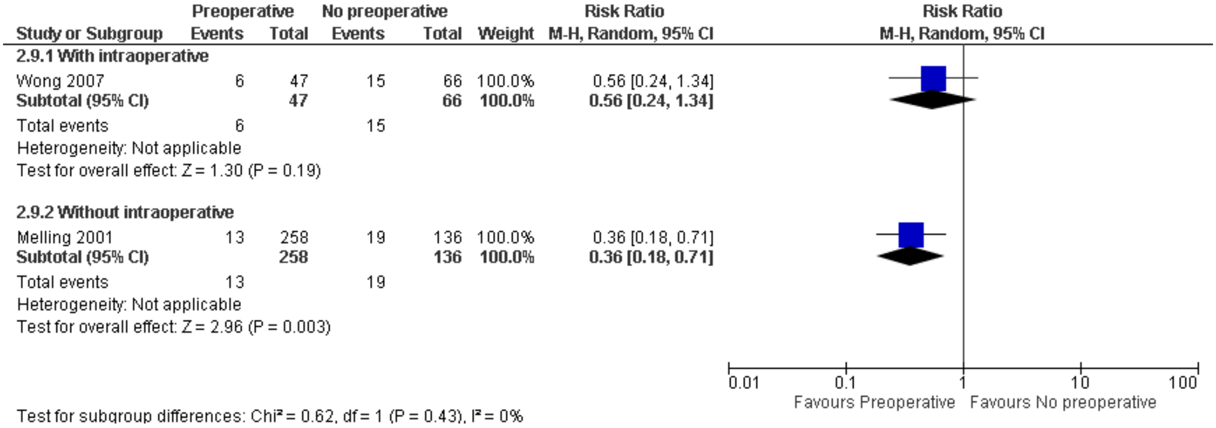
Blood transfusion



	Preoperative		No preoperative			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
2.8.1 With intraoperative						
Wong 2007	11	47	19	66	100.0%	0.81 [0.43, 1.54]
Subtotal (95% CI)		**47**		**66**	**100.0%**	**0.81 [0.43, 1.54]**
Total events	11		19			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.63 (P = 0.53)						
2.8.2 Without intraoperative						
Subtotal (95% CI)		**0**		**0**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						

Test for subgroup differences: Not applicable

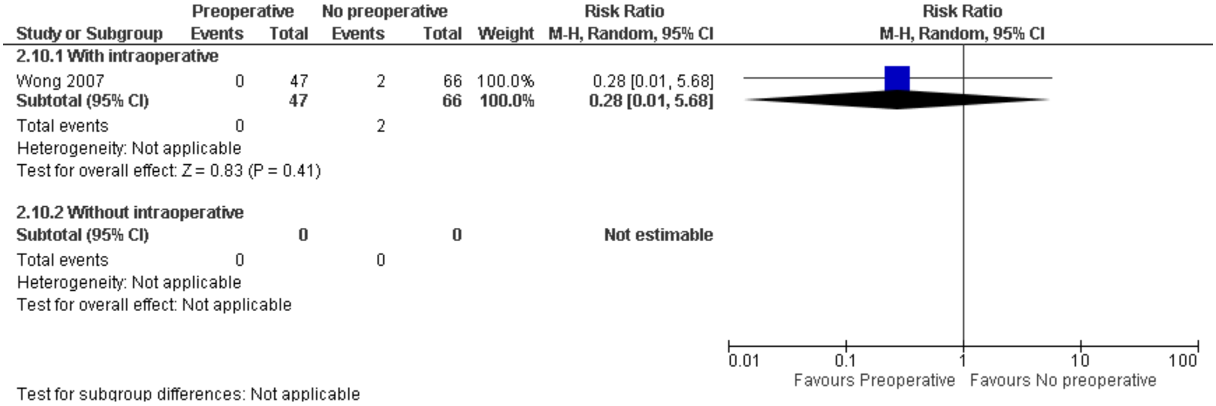
Surgical infections



	Preoperative		No preoperative			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
2.9.1 With intraoperative						
Wong 2007	6	47	15	66	100.0%	0.56 [0.24, 1.34]
Subtotal (95% CI)		**47**		**66**	**100.0%**	**0.56 [0.24, 1.34]**
Total events	6		15			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.30 (P = 0.19)						
2.9.2 Without intraoperative						
Melling 2001	13	258	19	136	100.0%	0.36 [0.18, 0.71]
Subtotal (95% CI)		**258**		**136**	**100.0%**	**0.36 [0.18, 0.71]**
Total events	13		19			
Heterogeneity: Not applicable						
Test for overall effect: Z = 2.96 (P = 0.003)						

Test for subgroup differences: Chi² = 0.62, df = 1 (P = 0.43), I² = 0%

Cardiac complications



	Preoperative		No preoperative			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
2.10.1 With intraoperative						
Wong 2007	0	47	2	66	100.0%	0.28 [0.01, 5.68]
Subtotal (95% CI)		**47**		**66**	**100.0%**	**0.28 [0.01, 5.68]**
Total events	0		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.83 (P = 0.41)						
2.10.2 Without intraoperative						
Subtotal (95% CI)		**0**		**0**		**Not estimable**
Total events	0		0			
Heterogeneity: Not applicable						
Test for overall effect: Not applicable						

Test for subgroup differences: Not applicable

I.3 Review question 3: Site of measurement

No forest plots for this review

Appendix J: Economic search strategy

Databases that were searched, together with the number of articles retrieved from each database are shown in the tables below. The same strategy was translated for the other databases listed.

J.1 Review question 1 and 2: Intraoperative and preoperative warming devices

Table 37: Economic search summary

Databases	Date searched	Version/files	No. retrieved
Embase (Ovid)	9/03/2016	Embase 1974 to 2016 Week 10	461
Health Technology Assessment (HTA Database)	9/03/2016	Issue 1 of 4, January 2016	5
MEDLINE (Ovid)	9/03/2016	Ovid MEDLINE(R) 1946 to February Week 4 2016	268
MEDLINE In-Process (Ovid)	9/03/2016	Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations March 08, 2016	78
PubMedb	9/03/2016	-	981
NHS Economic Evaluation Database (NHS EED) (legacy database)	9/03/2016	Issue 2 of 4, April 2015	1

Table 38: Economic search strategy

Database: Medline
Strategy used:
1 Preoperative Care/ (53622)
2 exp Perioperative Care/ (129790)
3 exp Perioperative Period/ (62279)
4 exp Intraoperative Complications/ (43430)
5 Postoperative Complications/ (303380)
6 (preoperat* or pre-operat* or "pre operat*" or presurg* or pre-surg* or "pre surg*").tw. (221431)
7 (perioperat* or peri-operat* or "peri operat*" or perisurg* or peri-surg* or "peri surg*").tw. (61807)
8 (intraoperat* or intra-operat* or "intra operat*" or intrasurg* or intra-surg* or "intra surg*" or perian?esthe* or peroperative).tw. (99097)
9 (postoperat* or post-operat* or "post operat*" or postsurg* or post-surg* or "post surg*").tw. (419034)
10 ((before or prior or during or after) adj2 (surg* or operat*)).tw. (326899)
11 exp Anesthesia/ (172564)
12 Anesthesia Recovery Period/ (4503)
13 (an?esthe* or postan?esthe* or post-an?esthe* or "post an?esthe*").tw. (299100)
14 or/1-13 (1309319)
15 Hypothermia/ (12716)
16 hypotherm*.tw. (34149)

Database: Medline

17 ((low* or decrease* or decline* or reduce*) adj2 temperature*).tw. (45726)
18 (heat* adj4 (loss or lose or losing)).tw. (3180)
19 Piloerection/ (145)
20 piloerection*.tw. (344)
21 shiver*.tw. (3048)
22 or/15-21 (86019)
23 Body Temperature/ (43976)
24 exp Body Temperature Regulation/ (34203)
25 (normotherm* or thermoregulat* or thermogenes?s).tw. (20485)
26 (heat adj4 (preserv* or retention or retain* or balance)).tw. (1096)
27 ((temperature or thermal) adj4 (control* or regulat* or manage* or maintain* or core)).tw. (23617)
28 or/23-27 (97165)
29 14 or 22 or 28 (1454464)
30 (prewarm* or pre-warm* or "pre warm*" or rewarm* or re-warm* or "re warm*" or preheat* or pre-heat* or "pre heat*" or reheat* or re-heat* or "re heat*").tw. (5825)
31 ((warm* or heat*) adj4 (patient* or active or body or skin or cutaneous or device* or equipment or mechanism* or system* or intervention* or method* or technique* or resistiv* or radiant or convecti* or conductiv* or blanket* or garment* or mattress* or pad* or gown* or unit* or vest*)).tw. (19869)
32 Rewarming/ (1173)
33 Convection/ (741)
34 Hyperthermia, Induced/ (13694)
35 Heating/ (4763)
36 Hot Temperature/tu [Therapeutic Use] (2760)
37 or/30-36 (44655)
38 29 and 37 (14979)
39 (airwarm* or air-warm* or "air warm*" or forced-air).tw. (536)
40 (air adj2 (forced or warm*)).tw. (1023)
41 ((convecti* or conductiv* or electric* or resistiv* or water or thermal or carbon-fiber or carbon-fibre) adj4 (blanket* or garment* or mattress* or gown* or vest*)).tw. (903)
42 (inditherm or meditherm or medi-therm or heto or blanketrol or electroconcept or operatherm or smartcare or suntouch or k-thermia).tw. (48)
43 (electro adj2 concept).tw. (3)
44 (Bair adj2 (hugger or paws)).tw. (76)
45 ((warm or sun) adj2 touch).tw. (35)
46 (kr adj2 thermia).tw. (0)
47 or/39-46 (1946)
48 38 or 47 (16370)
49 Economics/ (26646)
50 exp "Costs and Cost Analysis"/ (194395)
51 Economics, Dental/ (1876)
52 exp Economics, Hospital/ (21114)
53 exp Economics, Medical/ (13825)
54 Economics, Nursing/ (3933)
55 Economics, Pharmaceutical/ (2604)
56 Budgets/ (10338)
57 exp Models, Economic/ (11328)
58 Markov Chains/ (10873)
59 Monte Carlo Method/ (22024)
60 Decision Trees/ (9351)
61 econom$.tw. (171582)

Database: Medline

62 cba.tw. (8950)
63 cea.tw. (17159)
64 cua.tw. (821)
65 markov$.tw. (12870)
66 (monte adj carlo).tw. (22855)
67 (decision adj3 (tree$ or analys$)).tw. (9201)
68 (cost or costs or costing$ or costly or costed).tw. (335455)
69 (price$ or pricing$).tw. (25003)
70 budget$.tw. (18593)
71 expenditure$.tw. (37527)
72 (value adj3 (money or monetary)).tw. (1462)
73 (pharmacoeconomic$ or (pharmaco adj economic$)).tw. (2947)
74 or/49-73 (706985)
75 "Quality of Life"/ (133238)
76 quality of life.tw. (154754)
77 "Value of Life"/ (5474)
78 Quality-Adjusted Life Years/ (8058)
79 quality adjusted life.tw. (6781)
80 (qaly$ or qald$ or qale$ or qtime$).tw. (5567)
81 disability adjusted life.tw. (1467)
82 daly$.tw. (1413)
83 Health Status Indicators/ (20955)
84 (sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).tw. (16714)
85 (sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six).tw. (1057)
86 (sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve).tw. (3072)
87 (sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).tw. (22)
88 (sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty).tw. (341)
89 (euroqol or euro qol or eq5d or eq 5d).tw. (4604)
90 (qol or hql or hqol or hrqol).tw. (28076)
91 (hye or hyes).tw. (54)
92 health$ year$ equivalent$.tw. (38)
93 utilit$.tw. (122516)
94 (hui or hui1 or hui2 or hui3).tw. (929)
95 disutili$.tw. (238)
96 rosser.tw. (71)
97 quality of wellbeing.tw. (6)
98 quality of well-being.tw. (336)
99 qwb.tw. (177)
100 willingness to pay.tw. (2558)
101 standard gamble$.tw. (675)
102 time trade off.tw. (790)
103 time tradeoff.tw. (213)
104 tto.tw. (649)
105 or/75-104 (350815)
106 74 or 105 (1009915)
107 48 and 106 (781)
108 animals/ not humans/ (4159388)

Database: Medline	
109	107 not 108 (598)
110	limit 109 to ed=20060101-20160331 (303)
111	limit 110 to english language (268)

J.2 Review question 3: site of measurement

Table 39: Economic search summary

Economics	Date searched	Version/files	No. retrieved
MEDLINE (Ovid)	10/03/16	1946 to March Week 1 2016	168
MEDLINE in Process (Ovid)	10/03/16	March 09, 2016	12
Embase (Ovid)	10/03/16	1974 to 2016 Week 10	169
EconLit (Ovid)	10/03/16	1886 to February 2016	1
NHS Economic Evaluation Database (NHS EED) (legacy database)	10/03/16	Issue 2 of 4, April 2015	0
Health Technology Assessment (HTA Database)	09/03/16	Issue 1 of 4, January 2016	1
PubMed	09/03/16	n/a	301

Table 40: Economic search strategy

Database: Medline & Medline in Process

Search Strategy:

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1 Preoperative Care/ (53723)
2 exp Perioperative Care/ (130025)
3 exp Perioperative Period/ (62502)
4 exp Intraoperative Complications/ (43516)
5 Postoperative Complications/ (303940)
6 (preoperat* or pre-operat* or "pre operat*" or presurg* or pre-surg* or "pre surg*").tw. (221965)
7 (perioperat* or peri-operat* or "peri operat*" or perisurg* or peri-surg* or "peri surg*").tw. (62028)
8 (intraoperat* or intra-operat* or "intra operat*" or intrasurg* or intra-surg* or "intra surg*" or perian?esthe* or peroperative).tw. (99368)
9 (postoperat* or post-operat* or "post operat*" or postsurg* or post-surg* or "post surg*").tw. (420041)
10 ((before or prior or during or after) adj2 (surg* or operat*)).tw. (327614)
11 exp Anesthesia/ (172805)
12 Anesthesia Recovery Period/ (4516)
13 (an?esthe* or postan?esthe* or post-an?esthe* or "post an?esthe*").tw. (299693)
14 or/1-13 (1312015)
15 Hypothermia/ (12736)
16 hypotherm*.tw. (34234)
17 ((low* or decrease* or decline* or reduce*) adj2 temperature*).tw. (45847)
18 (heat* adj4 (loss or lose or losing)).tw. (3188)
19 Piloerection/ (145)
20 piloerection*.tw. (344)
21 shiver*.tw. (3054)
22 Body Temperature/ or skin temperature/ (51189)
23 exp Body Temperature Regulation/ (34268)
24 (normotherm* or thermoregulat* or thermogenes?s).tw. (20540)
25 (heat adj4 (preserv* or retention or retain* or balance)).tw. (1100)
26 ((temperature or thermal) adj4 (control* or regulat* or manage* or maintain* or core or bod* or skin* or measure* or monitor*)).tw. (60309)

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27 or/15-26 (185656)
28 Ear/ (9321)
29 Tympanic Membrane/ (6678)
30 (Ear or ears or eardrum or ear-drum or tympanic*).tw. (84748)
31 Forehead/ (2974)
32 (Forehead or fore-head or head).tw. (227207)
33 Temporal Arteries/ (2884)
34 Temporal arter*.tw. (4772)
35 Mouth/ (18583)
36 Mouth Mucosa/ (23888)
37 Sublingual Gland/ (1335)
38 Tongue/ (16186)
39 Nose/ (21006)
40 Nasopharynx/ (7847)
41 Esophagus/ (39685)
42 (Oral or mouth or sublingual or hypoglossal or subglossal or tongue or nose or nasal or nasopharynx or rhinopharynx or esophag* or oesophag* or nasopharyngeal).tw. (731381)
43 Rectum/ (35296)
44 (Rectum* or rectal* or anus or anal or bum or bottom).tw. (132766)
45 Urinary Bladder/ (45622)
46 Bladder.tw. (117106)
47 Axilla/ (10969)
48 (Axilla* or armpit* or arm-pit* or arm pit* or underarm* or under-arm* or under arm*).tw. (28096)
49 Pulmonary Artery/ (41048)
50 Pulmonar* arter*.tw. (60168)
51 Thermometers/ (3378)
52 Thermography/ (6749)
53 Thermometry/ (226)
54 (Thermometer* or thermograph* or thermometr* or thermocouple*).tw. (10202)
55 ((Infrared or infra-red or infra red) adj2 (thermomet* or device* or monitor* or measure* or tool* or apparat*)).tw. (2009)
56 (Strip* adj2 (thermomet* or device* or monitor* or measure* or tool* or apparat*)).tw. (583)
57 (Map* adj2 temperat*).tw. (485)
58 Zeroflux.tw. (0)
59 or/28-58 (1422903)
60 Monitoring, Intraoperative/ (16132)
61 ((preoperat* or pre-operat* or "pre operat*" or presurg* or pre-surg* or "pre surg*" or perioperat* or peri-operat* or "peri operat*" or perisurg* or peri-surg* or "peri surg*" or intraoperat* or intra-operat* or "intra operat*" or intrasurg* or intra-surg* or "intra surg*" or perian?esthe* or peroperative or postoperat* or post-operat* or "post operat*" or postsurg* or post-surg* or "post surg*") adj2 (temperat* or monitor* or measure*)).tw. (16808)
62 ((Before or prior or during or after) adj2 (surg* or operat* or procedure*) adj2 (temperat* or monitor* or measure*)).tw. (4474)
63 or/60-62 (34316)
64 14 and 27 and 59 (4181)
65 27 and 63 (1835)
66 64 or 65 (5476)
67 Animals/ not Humans/ (4168833)
68 66 not 67 (3980)
69 limit 68 to english language (3183)
70 Economics/ (26656)

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71 exp "Costs and Cost Analysis"/ (194910)
72 Economics, Dental/ (1876)
73 exp Economics, Hospital/ (21177)
74 exp Economics, Medical/ (13837)
75 Economics, Nursing/ (3933)
76 Economics, Pharmaceutical/ (2606)
77 Budgets/ (10364)
78 exp Models, Economic/ (11372)
79 Markov Chains/ (10929)
80 Monte Carlo Method/ (22116)
81 Decision Trees/ (9372)
82 econom$.tw. (172167)
83 cba.tw. (8959)
84 cea.tw. (17200)
85 cua.tw. (821)
86 markov$.tw. (12953)
87 (monte adj carlo).tw. (22957)
88 (decision adj3 (tree$ or analys$)).tw. (9244)
89 (cost or costs or costing$ or costly or costed).tw. (336793)
90 (price$ or pricing$).tw. (25090)
91 budget$.tw. (18656)
92 expenditure$.tw. (37695)
93 (value adj3 (money or monetary)).tw. (1477)
94 (pharmacoeconomic$ or (pharmaco adj economic$)).tw. (2951)
95 or/70-94 (709361)
96 "Quality of Life"/ (133837)
97 quality of life.tw. (155470)
98 "Value of Life"/ (5483)
99 Quality-Adjusted Life Years/ (8096)
100 quality adjusted life.tw. (6819)
101 (qaly$ or qald$ or qale$ or qtime$).tw. (5600)
102 disability adjusted life.tw. (1478)
103 daly$.tw. (1421)
104 Health Status Indicators/ (21004)
105 (sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).tw. (16781)
106 (sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six).tw. (1059)
107 (sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve).tw. (3094)
108 (sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).tw. (22)
109 (sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty).tw. (342)
110 (euroqol or euro qol or eq5d or eq 5d).tw. (4637)
111 (qol or hql or hqol or hrqol).tw. (28233)
112 (hye or hyes).tw. (54)
113 health$ year$ equivalent$.tw. (38)
114 utilit$.tw. (123225)
115 (hui or hui1 or hui2 or hui3).tw. (937)
116 disutili$.tw. (241)
117 rosser.tw. (71)

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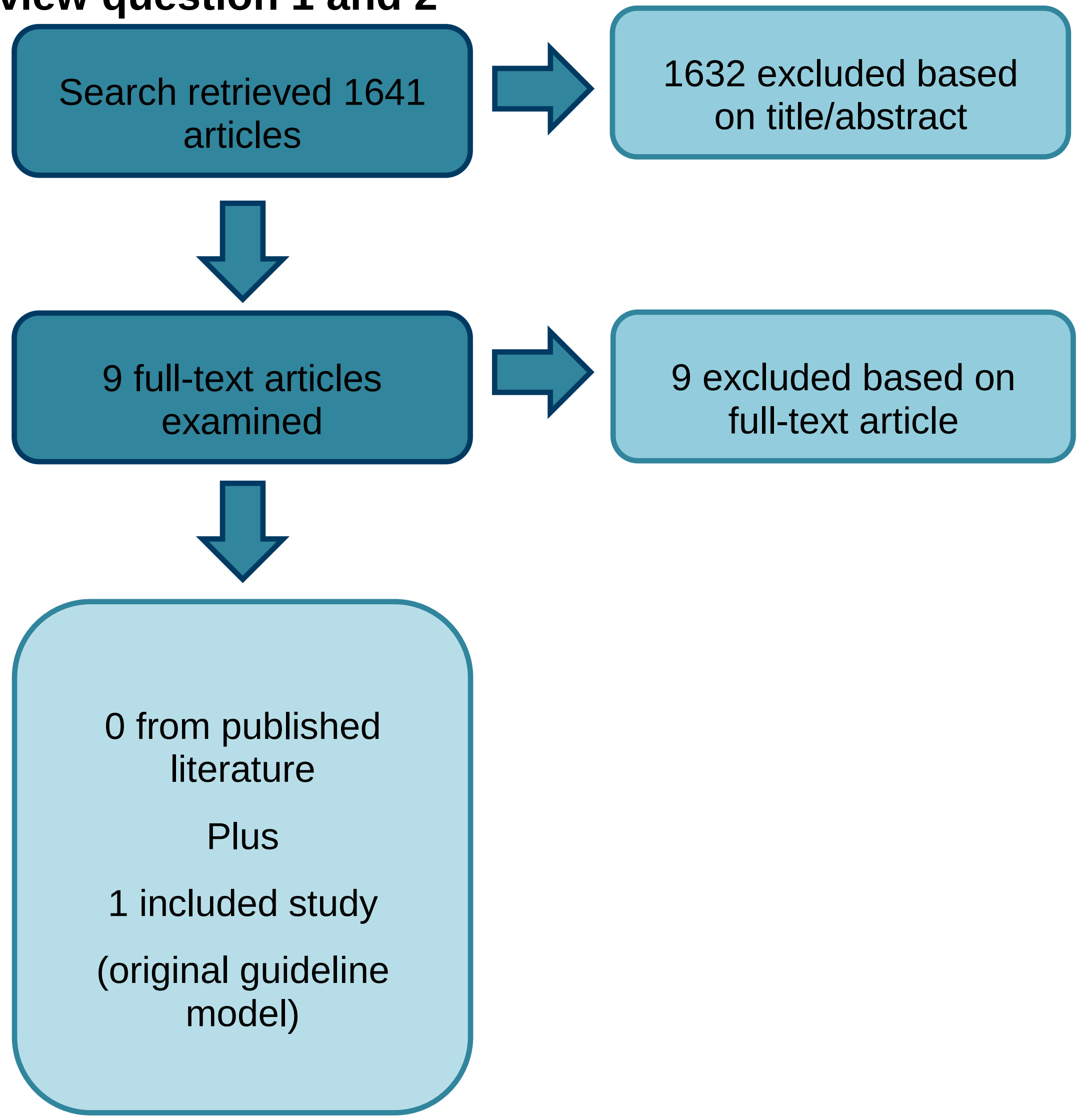
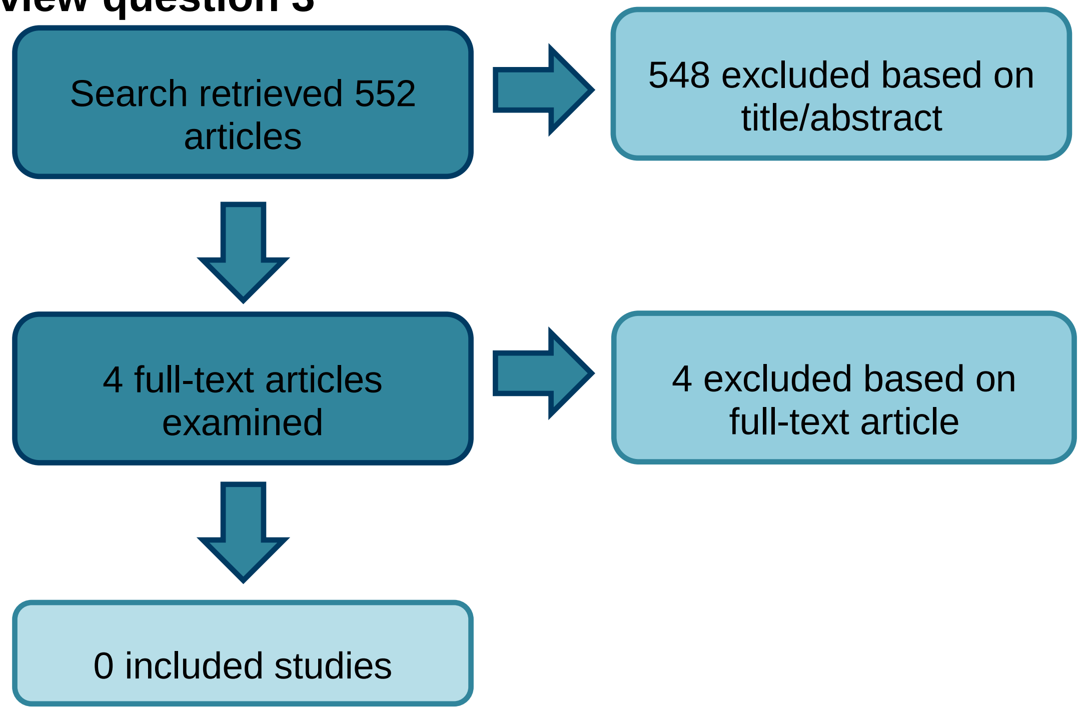
118 quality of wellbeing.tw. (6)
119 quality of well-being.tw. (337)
120 qwb.tw. (178)
121 willingness to pay.tw. (2571)
122 standard gamble$.tw. (677)
123 time trade off.tw. (791)
124 time tradeoff.tw. (213)
125 tto.tw. (650)
126 or/96-125 (352481)
127 95 or 126 (1013725)
128 69 and 127 (168)

Appendix K: Economic review flowchart

K.1 Review question 1 and 2



K.2 Review question 3



Appendix L: Economic excluded studies

L.1 Review question 1 and 2

Table 41: Excluded economic studies

Study	Reason for Exclusion
Berry, D., Wick, C., Magons, P., A clinical evaluation of the cost and time effectiveness of the ASPAN Hypothermia Guideline, Journal of PeriAnesthesia Nursing, 23, 24-35, 2008	Selectively excluded on the basis that it is superseded by the original guideline modelling which is more relevant to the UK healthcare setting
Cadth,, Forced air warming units for adults undergoing surgery: clinical evidence (Structured abstract), Health Technology Assessment Database, 2013	No economic analysis
Cadth,, Heating standards for clinical interventions: clinical evidence (Structured abstract), Health Technology Assessment Database, 2013	No economic analysis
Galvao, C. M., Marck, P. B., Sawada, N. O., Clark, A. M., A systematic review of the effectiveness of cutaneous warming systems to prevent hypothermia, Journal of Clinical Nursing, 18, 627-36, 2009	Systematic review, no economic studies included
Jardeleza, A., Fleig, D., Davis, N., Spreen-Parker, R., The effectiveness and cost of passive warming in adult ambulatory surgery patients, AORN Journal, 94, 363-9, 2011	Irrelevant intervention (passive warming)
Scott, E. M., Buckland, R., A systematic review of intraoperative warming to prevent postoperative complications, AORN Journal, 83, 1090-104, 1107-13, 2006	Systematic review, 1 economic study included, excluded from this review because the 1998 study is outside the specified date range
Shao, L., Zheng, H., Jia, F. J., Wang, H. Q., Liu, L., Sun, Q., An, M. Y., Zhang, X. H., Wen, H., Methods of patient warming during abdominal surgery, PLoS ONE [Electronic Resource], 7, e39622, 2012	No economic analysis
Torossian, A., Thermal management during anaesthesia and thermoregulation standards for the prevention of inadvertent perioperative hypothermia, Best Practice and Research: Clinical Anaesthesiology, 22, 659-668, 2008	Narrative review only
Wu, X., The safe and efficient use of forced-air warming systems, AORN Journal, 97, 302-8, 2013	Narrative review

L.2 Review question 3

Table 42: Excluded economic studies

Study	Reason for Exclusion
Hannenberg, A. A., Sessler, D. I., Improving perioperative temperature management, Anesthesia and Analgesia, 107, 1454-1457, 2008	Narrative review
Putzu, Marta, Casati, Andrea, Berti, Marco, Pagliarini, Giovanni, Fanelli, Guido, Clinical complications, monitoring and management of perioperative mild hypothermia: anesthesiological features, Acta Bio-Medica de l Ateneo ParmenseActa Biomed Ateneo Parmense, 78, 163-9, 2007	Narrative review
Shafer, Steven L., Dexter, Franklin, Brull, Sorin J., Deadly heat: economics of continuous temperature monitoring during general anesthesia, Anesthesia & AnalgesiaAnesth Analg, 119, 1235-7, 2014	Editorial
Torossian, Alexander, Thermal management during anaesthesia and thermoregulation standards for the prevention of inadvertent perioperative hypothermia, Best Practice & Research Clinical AnaesthesiologyBest Pract Res Clin Anaesthesiol, 22, 659-68, 2008	Narrative review

Appendix M: Full economic evidence tables

These are the full evidence tables for all included economic studies.

Table 43: Full economic evidence tables

Bibliographic reference	**National Collaborating Centre for Nursing and Supportive Care (2008). The management of inadvertent perioperative hypothermia in adults (NICE Clinical Guideline 65)**	
Overview	**Comparisons**	Direct comparisons: • Forced air warming (intraoperative) vs. usual care • Warmed fluids vs. unwarmed fluids • Forced air warming (intraoperatively) and warmed fluids vs. forced air warming and unwarmed fluids (intraoperatively) • Forced air warming (intraoperatively) vs. electric heated pad (intraoperatively) • Forced air warming (intraoperatively) vs. warmed cotton blankets (intraoperatively) • Forced air warming (intraoperatively) vs. thermal insulation (intraoperatively) • Circulating water mattress (intraoperatively) vs. usual care • Forced air warming (pre and intraoperatively) and warmed fluids vs. usual care • Thermal insulation (pre and intraoperatively) vs. usual care • Forced air warming (preoperatively) vs. warmed cotton blankets (preoperatively) Indirect comparison vs. usual care: • Forced air warming (intraoperative) • Warmed fluids (intraoperative) • Forced air warming and warmed fluids (intraoperative) • Forced air warming and warmed fluids (preoperative and intraoperative)
	Base-line cohort characteristics	Variation of risk factors; • Magnitude of surgery – minor, intermediate or major • Type of anaesthesia – general/regional or both combined • ASA grade - I, II or >II • Age – 20, 50 or 70

Bibliographic reference	**National Collaborating Centre for Nursing and Supportive Care (2008). The management of inadvertent perioperative hypothermia in adults (NICE Clinical Guideline 65)**

	• Duration of anaesthesia – 30, 60 or 120 minutes
Type of Analysis	Cost-utility analysis
Structure	Decision tree and Markov model
Cycle length	Yearly
Time horizon	Lifetime
Perspective	NHS and PSS
Country	UK
Currency unit	£
Cost year	2006
Discounting	3.5%
Other comments	Nil

Results

Pairwise comparisons, 50 year old patient, ASA I, minor surgery, 60 minutes anaesthesia (base case)

Comparison	**Cases of IPH prevented**	**Cost saving from prevented consequences**	**QALY gain from prevented consequences**	**Incremental cost of warming**	**Incremental cost per QALY**	**Incremental net benefit at £20,000/QALY**	**% under £20,000 threshold**
FAW (intra) vs. usual care	121	£17,200	8.03	£16,500	FAW dominates usual care	£161,000	99.6%
Warmed fluids (intra) vs. usual care	130	£18,600	8.64	£10,800	Warmed fluids dominates usual care	£180,700	99.9%
FAW (intra)+ warmed fluids vs. FAW (intra)	31	£4,300	2.00	£10,800	£3,200	£33,900	82.1%
FAW (intra) vs. EHP (intra)	22	£3,200	1.48	Not available	Not available	Not available	Not available
FAW+ warmed fluids (pre and intra) vs. usual care	157	£22,500	10.52	£43,900	£2,030	£189,000	98.9%

Bibliographic reference	**National Collaborating Centre for Nursing and Supportive Care (2008). The management of inadvertent perioperative hypothermia in adults (NICE Clinical Guideline 65)**

Indirect comparison, 50 year old patient, ASA I, minor surgery, 60 minutes anaesthesia

Intervention	**Incidence of hypothermia**	**Cost of consequences**	**QALY loss of consequences**	**Cost of strategy**	**Cost per QALY compared to usual care**	**Net benefit at £20,000 compared to usual care**	**% optimal strategy**
Usual care	237	£103,863	227.19	£0	-	-	-
FAW (intra)	116	£86,665	219.15	£16,500	Dominates usual care	£161,000	7%
Warmed fluids (intra)	107	£85,286	218.54	£10,800	Dominates usual care	£180,700	34%
FAW+ warmed fluids (intra)	86	£82,300	217.14	£27,300	£600	£195,200	39%
FAW+ warmed fluids (pre and intra)	80	£81,300	216.67	£43,900	£2,000	£189,000	20%

Data sources

Base-line data	• Surgical site infection: Health Protection Agency report on Surgical Site Infection Surveillance Service 2006 (3%) • Pressure ulcer: report on the incidence of pressure sores across a NHS Trust hospital (1994). 0% for minor surgery; 1.8% for major and intermediate surgery (10.9% sensitivity analysis) • Blood transfusion: Based on the number of red blood cell units transfused in England, the proportion of all units that were used by surgery and the number of operations carried out from Health Episode Statistics (2000-01). 0% for minor surgery; 12% intermediate and major surgery (31% sensitivity analysis) • Unplanned postoperative mechanical ventilation: prospective cohort study (1996). 0.27% all patients regardless of magnitude of surgery. • Morbid cardiac events: prospective cohort study (2011). 2.4% for 50 year old patients; 4.5% for 70 year old patients; 0% for 20 year old patients • Length of hospital stay: 1 day for intermediate surgery; 4 days for major surgery; 0.25 days for minor surgery
Effectiveness data	Increase in risk of adverse events due to hypothermia from the clinical evidence review: • Length of stay: increase of 19% from the clinical evidence review

Bibliographic reference	**National Collaborating Centre for Nursing and Supportive Care (2008). The management of inadvertent perioperative hypothermia in adults (NICE Clinical Guideline 65)**	
		• Surgical site infection: relative risk 4.0 • Blood transfusion: 1 base case; 1.19 in sensitivity analysis • Morbid cardiac event: 2.20 • Mechanical ventilation: 1.58 • Pressure ulcer: 1 base case; 1.87 in sensitivity analysis
	Cost data	Cost of adverse events • Surgical site infection: extra length of hospital stay from surveillance of 12 categories of surgery in 140 English hospitals between October 1997 and June 2001. Cost of extra days in hospital from published study (2001). 2.8 days for minor surgery; £3,858 for intermediate and major surgery; £950 for minor surgery • Blood transfusion: study on the annual cost of blood transfusions in the UK (2003). £243.89 • Mechanical ventilation: additional hours from a study from the clinical review and cost from the NHS Reference costs 2006. £1,144 • Length of stay: from NHS reference costs. £275 per bed day for ICU. • Morbid cardiac event: Additional length of stay from Hospital Episode Statistics and National Schedule of Reference Costs. £1,674 for myocardial infarction; £2,023 for ischaemic heart disease; £2,201 day for cardiac arrest • Pressure ulcers: from a UK costing study. £1,064 Cost of warming • Forced air warming: NHS Supply Chain -
	Utility data	• Surgical site infection: case-control study of orthopaedic surgery patients (2002), mean difference of -0.07 • Blood transfusion: no QALY loss • Mechanical ventilation: no QALY loss • Length of stay: no QALY loss • Morbid cardiac event: 24% reduction from a statins HTA for cardiac arrest or myocardial infarction; no utility reduction for ischaemia. Discounted lifetime QALY loss due to an MI or cardiac arrest: 5.41 for 20 years old; 3.54 for 50 years old; 1.93 for 70 years old • Pressure ulcers: no QALY loss

Bibliographic reference	**National Collaborating Centre for Nursing and Supportive Care (2008). The management of inadvertent perioperative hypothermia in adults (NICE Clinical Guideline 65)**
Uncertainty	Pairwise comparisons • Reduce anaesthesia duration to 30 minutes: warmed fluids (intra) vs. usual care highest net benefit £238,100, 99.7% probability warmed fluids (intra) under £20k threshold • Increasing magnitude of surgery to intermediate and duration of anaesthesia to 120 minutes: forced air warming (intra) vs. thermal insulation (intra) highest net benefit £1,538 with 99.3% under £20k threshold Indirect comparison • Increase magnitude of surgery to intermediate: Highest net benefit changes to forced air warming and warmed fluids (pre and intra) £660,000 with a 35% probability it is the optimal strategy. • Increase magnitude of surgery to major surgery: Highest net benefit changes to forced air warming and warmed fluids (pre and intra) £625,900 with 35% probability it is the optimal strategy • Increase age to 70 years: Highest net benefit remains forced air warming and warmed fluids (intra) £210,500 with a 41% optimal strategy
Applicability	**Directly Applicable**
Limitations	**Minor Limitations** The analysis was limited by the need to estimate the effectiveness in terms of relative risk by imputing from data based on mean temperatures assuming a normal distribution due to the lack of data on the incidence of hypothermia.
Conflicts	Please see declarations of interest in original guideline