Abstract of thesis entitled

An Evidence-based Guideline in Preventing Hypothermia for Adult Trauma Patients in Accident and Emergency Department

Submitted by

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Hypothermia is commonly found in injured victims who suffer from central nervous system injury, hypovolemic shock, exposure to environment, administration of anesthetic drugs and cold intravenous fluid. All these factors decrease the abilities of trauma victims to maintain normothermia and conserve body heat. Hypothermia in injured victim is a significant contributor to a well known cycle—triad of death and associated with increased mortality, morbidity and length of hospital stay. Hypothermia is one of the preventable complications in trauma patients. Therefore nurse plays a vital role to evaluate the methods of preventing hypothermia. However, there is no systematic review of effectiveness of different warming methods in local setting. The purpose of this dissertation is to develop an evidence-based guideline to prevent hypothermia in trauma patients by reviewing existing evidence, to assess the
feasibility and transferability of implementing the guideline and to develop its implementation and evaluation plan.

Five articles meeting the inclusion and exclusion criteria are identified after a systematic research of six electronic databases. Among these articles, four of them are randomized controlled trials while the remaining one is quasi-experimental design with prospective randomized assignment. The quality of these identified articles is evaluated with the methodology checklist for randomized controlled trials which is developed by Scottish Intercollegiate Guideline Network (SIGN). All studies of medium and high quality would be considered as sufficient evidence to support the proposed innovation in preventing hypothermia for trauma patients in Accident & Emergency Department.

After assessing the implementation potential, an evidence-based guideline in preventing hypothermia for adult trauma patients is established. The proposed innovation is necessary and beneficial for adult trauma patients to prevent hypothermia. The grade of recommendation in the guideline is rated based on the SIGN grading system from A to D.

Communication plans with stakeholders and 3-month pilot study on 20 patients are conducted before implementing the innovation into clinical setting. Evaluation is made to assess the effectiveness of the proposed guideline after the end of pilot study
and the end of implementation of guideline. The effectiveness of the proposed innovation is determined by change of core temperature as +1.1 °C/hr and at least 90% reduction in shivering and thermal discomfort which are reported in the reviewed articles. The guideline is considered as clinical effective when similar outcome is obtained.
An Evidence-based Guideline in Preventing Hypothermia for Adult Trauma Patients in Accident and Emergency Department

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Declaration

I declare that this thesis represents my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualifications.

Signed___________________________________

Wong Lai Hung

August 2013
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1. Introduction

1.1 Background

According to American Trauma Society, trauma is defined as injury caused by a physical force as consequence of falls, motor vehicles crashes, drowning, gunshots, stabbings, fire and burns, or blunt assaults (MTC, 2012). It is the fifth leading cause of death in all ages in Hong Kong and developed countries (DH, 2011) (CDC, 2008). It is also the commonest cause of death for persons aged from 18-44 years (McLarty, 2012). Hypothermia is commonly found in injured victims and occurs in about 57% trauma admission in Accident & Emergency Department (Stewart, 2003). The definition of hypothermia is core temperature below 36 °C in healthy subjects, or heat loss exceeds the heat production ability; but it is defined as temperature less than 36.5 °C in injured victims (Stewart, 2003; Kjellman, Glad-Mattsson, Sjoberg & Huss, 2011). Trauma patients are particularly prone to hypothermia for multiple reasons including exposure to environment or low ambient temperature, central nervous system injury, hypovolemic shock, administration of anaesthetic drugs and cold intravenous fluid which all decrease the abilities for these patients to maintain normothermia and conserve body heat (Ireland, Endacott, Cameron, Fitzgerald & Paul, 2011). According to Martin et al (2005), hypothermia in injured victim is associated with increased mortality and morbidity which impacts much greater than
the effects of cold alone, the significance of hypothermia has been well recognized in trauma setting. In general, hypothermia complicates trauma resuscitation by inhibiting fibrinogen synthesis and develops coagulopathy. Ineffective clotting causes increased volume loss and inadequate oxygen delivery; which leads to anaerobic metabolism and finally acidosis. Acidosis accelerates the breakdown of fibrinogen and intensifies the adverse effect of hypothermia which finally disturbs myocardial function (McLarty, 2012). Decreases in core temperature of 0.3 °C will increase 7% in oxygen consumption and decrease the ability to maintain cellular function (Moore, 2008). Moreover, there will be 6-7% drop in cerebral blood flow with further decrease in core temperature of 1°C and cause clouded consciousness and confusion (Tsuei & Kearney, 2004). Therefore, hypothermia is a significant contributor to a well known cycle—“triad of death” (Arthurs et al, 2006). Furthermore, hypothermia reduces wound infection resistance, contributes to pain by shivering and causes thermal discomfort in trauma patients (Kober et al, 2011).

1.2 Affirming the Need

As hypothermia is one of the preventable complications in trauma patients that contribute to morbidity and mortality, nurses play a vital role to evaluate the methods of preventing and reducing the rate of hypothermia (Cohen, Hayes, Tordella & Puente, 2002). Due to the exposure for assessment of injury and ambient temperature,
majority of heat loss occurred in Accident & Emergency Department by radiation, conduction and convection (Stewart, 2003). Preventing heat loss and maintaining normothermia are important nursing care in early phase of resuscitation as metabolic changes accompanied by injury cannot be corrected when patients are in hypothermic status (Cohen et al, 2002). According to the author’s hospital statistics, nearly 60% of the trauma victims admitted to Accident & Emergency Department are with temperature less than 36.5 °C; most of the patients complain thermal discomfort even though their core temperature are greater than 36.5°C. In most of the time, temperature measurement is overlooked during the admission of Accident & Emergency Department because it is considered as less important parameters when compared to blood pressure, heart rate and respirations (Stewart, 2003). Different methods such as warmed cotton blankets, warmed intravenous fluid are used to prevent hypothermia in local clinical setting. However, the incidence rate of hypothermia among trauma victims is still high. As those warmed cotton blankets and intravenous fluid are kept in a warm cabinet with temperature of 40°C and they are often cool down to room temperature soon by convection after applying to patients. Therefore temperature of warmed intravenous fluid and blankets cannot be maintained and blankets have to be replaced frequently in order to maintain temperatures effectively. Due to short time stay in the Accident & Emergency
Department and frequent transport to radiology or intra-hospital transport for trauma patients, there are limitations for these warming methods to maintain normothermia effectively during the entire process. Moreover, little literature is available to provide comprehensive evidence-based guideline and document the effectiveness of these warming methods to prevent heat loss during trauma resuscitation (Cohen et al, 2002). Furthermore, the severity of hypothermia and its associated complications is not often addressed in local clinical setting. Therefore, a systemic review on the effectiveness of active external warming methods and development of evidence-based guideline is needed in local setting.

1.3 Objective and Significance

The research question of this dissertation is:

In Accident & Emergency Department, what are the most effective active external warming methods in comparison to passive warming in preventing hypothermia for adult trauma patients?

Active external warming intervention refers to adding heat to body surface and producing body heat gain. This warming method includes electric heating blanket, water circulating blanket, air circulating blanket, forced-air inflatable blanket, conductive warmer etc. While passive warming refers to optimizing the environment and allowing endogenous heat production. This warming method includes radiant
heater to increase ambient temperature by, removal of all heat loss (i.e. wet clothing, cold environment), pre-warmed cotton blanket etc (Kjellman et al, 2011).

The objectives of this dissertation are:

1. To evaluate the effectiveness of active external warming in preventing hypothermia in trauma patients.
2. To standardize nursing management of preventing and reducing rate of hypothermia in trauma patients.
3. To review the existing evidence systematically and develop an evidence-based guideline for preventing hypothermia in trauma patients.
4. To assess the feasibility and transferability of implementing the proposed guideline in local Accident & Emergency Department.
5. To develop implementation strategies and evaluation plan for the proposed guideline in local Accident & Emergency Department.

Hypothermia is one of the preventable complications which associated with increased mortality and morbidity (Cohen et al, 2002). An effective clinical guideline can benefit patients, nurses and hospital. By implementing this guideline, the frequency of hypothermia episodes and complications associated with hypothermia in trauma victims will be reduced (Ireland et al, 2006). This also helps improve comfort level of patients such as reducing rate of shivering or thermal discomfort level
associated with hypothermia (Kober et al, 2001). Thus, length of hospital stay and intensive care unit stay will be ultimately decreased (Arthurs et al, 2006). Awareness of nurses towards recognition and management of hypothermia in trauma victims will also be raised (Ireland et al, 2006). Furthermore, it enhances decision making with the best evidence and reduces the variability of care among nurses which improves overall patient outcomes and quality of nursing care (McLarty, 2012).
2. Critical Appraisal

2.1 Search and Appraisal Strategies

2.1.1 Identification of studies

PICO model is used to formulate the clinical question and search relevant evidence to answer the question.

P (targeted patient population) is “Adult trauma patient with initial temperature not less than 35 °C”, I (intervention) is “active external warming intervention”, C (comparison) is “passive warming”, O (outcome) is “increase in core temperature as primary outcome, improve in thermal comfort and absence of shivering as secondary outcome at the time of discharge from Accident & Emergency Department”.

The following electronic databases, MEDLINE (OvidSP), CINAHL, British Nursing Index, Cochrane database, Pubmed & Embase were used for searching and identifying potential studies on 11th August 2012. Searching terms and keywords of “hypothermia”, “trauma OR burn” and “prewarm* OR Heating OR Warm*” were used. Identical searching terms were used for consistent searching strategies. The searching was limited to English or Chinese. The title, abstract and keywords of the searched citations were carefully screened for relevancy of the inclusion criteria. For those citations with insufficient information provided in the titles and abstracts, full body of those papers were reviewed to minimize the chance of forgoing relevant
articles. While for those potentially eligible papers, full body of papers were also reviewed to confirm the study eligibility. With relevant citations obtained, the selected papers were checked for duplication with the results of other databases. Reference list of identified studies were searched manually, studies that met the inclusion criteria were included in integrative review if there was no duplication with other identified studies. Details of the searching strategies and history in different databases are shown in the Appendix 1.

2.1.2 Inclusion Criteria

Studies are included if they are:

1. Traumatic injured victims including burn
2. Use active external warming method as intervention
3. Age of 18 or above
4. Initial temperature not less than 35 °C
5. Randomized controlled trial or Quasi-experimental study
6. Published in English

2.1.3 Exclusion Criteria

1. Invasive warming technique such as extracorporeal rewarming
2. Systematic review, qualitative studies, letters, editorials, news, comments, author’s opinion and articles
3. Animal studies

2.1.4 Data Extraction

Data was extracted from identified studies which include design of study, level of evidence, sample size, patient characteristics, interventions, comparison, outcome measures, length of follow up and effect size. It is recorded and displayed in Table of Evidence which shown in Appendix 2.

The outcome measures of this dissertation are core temperature difference between pre-intervention and post-intervention and development of hypothermia as primary outcome; while the secondary outcome are thermal comfort level and absence or presence of shivering.

2.1.5 Appraisal Strategies

The critical appraisal of quality of each identified studies was performed with the RCT methodological checklist: the Scottish Intercollegiate Guidelines Network (SIGN, 2008). The SIGN quality critique guideline consists of two parts which are internal validity and the overall assessment of the study. The table of methodological quality assessment on each individual study is shown in Appendix 3.
2.2 Results

2.2.1 Search Results

A total of 461 citations were retrieved by keyword search in 6 databases mentioned before, in which 15 potential relevant studies assembled after manually reviewing the title and abstract of the studies according to the inclusion criteria. Among those 15 citations, 5 studies were obtained without duplication and included in the systematic review. The reference lists of those 5 identified studies were reviewed, one eligible study was found but it has been included in the 5 studies already.

2.2.2 Study Characteristics

Among five articles included in the systematic review, four of them are randomized controlled trials while the remaining was quasi-experimental design with prospective randomized assignment (Cohen et al, 2002). All five articles have reported ethical approval from ethical review board; and either written or oral consent was obtained from the subjects prior the studies.

All identified studies were conducted in western countries, one was conducted in the United States (Cohen et al, 2002), two were conducted in Austria (Scheck et al, 2004; Kober et al, 2001), and the remaining two were conducted in Sweden (Kjellman et al, 2011; Ludgren, Henriksson, Naredi & Bjornstig, 2011). No local
studies or studies with Asian ethnicity were identified. All samples in the identified studies were trauma patients including burn patients whose injury level ranged from minor to medium.

In the five articles, two were conducted in pre-hospital setting (Kober et al, 2001; Ludgren et al, 2011), one was conducted in Accident & Emergency Department setting (Cohen et al, 2002), one was conducted in the burn unit setting (Kjellman et al, 2011), while the remaining one was conducted in intra-hospital transfer setting (Scheck et al, 2004).

With regard to the nature of studies, one was multicenter studies (Ludgren et al, 2011) and the others did not specify whether they were carried at more than one site. One of the five articles disclosed the source of funding (Kober et al, 2001) while the others did not disclose any sources of funding.

2.2.3 Methodological Quality

Among five articles, two RCTs (Kober et al, 2001; Scheck, 2004) were methodologically strong with rating of 1++, two RCTs (Ludgren et al, 2011; Kjellman et al, 2011) were methodologically moderate with rating of 1+, the remaining quasi-experimental design with prospective randomized assignment (Cohen et al, 2002) was methodologically moderate with rating of 1+. As the study failed to provide detailed background information of the patients (type of injury, age, sex etc.)
and describe blinding of data collectors. These would impose bias and affect the study results.

All identified studies had stated their research questions clearly. All of them assigned subjects to treatment group randomly. However, only four of them used adequate method of concealment such as sealed envelope technique and computer generated code (Ludgren et al, 2011; Kober et al, 2001; Scheck et al, 2004; Cohen et al, 2002). The remaining one did not specify method of concealment which imposed bias to the results and affected the quality of results (Kjellman et al, 2011). Due to the nature of study, blinding of recruited subject was not possible in all articles, but blinding of data collector was possible and reported in 3 articles (Ludgren et al, 2011; Kober et al, 2001; Scheck, 2004). All of them were kept blind to the patient groups during the whole process. Moreover, the primary outcome was temperature difference between pre-treatment and post-treatment, it is an objective result that is unlikely to be affected by investigator bias or patient expectation. Therefore, whether the subjects and investigators were kept blind, would not impose bias and affect the quality of results.

Three articles reported that the treatment and control group had no statistical different prior trial (Ludgren et al, 2011; Kober et al, 2001; Scheck, 2004); one article (Kjellman et al, 2011) was within subject design which same patients were exposed to
both treatment and control group randomly; this ensured the study results were attributed only to the treatment under investigation and minimized the uncertainties from other confounding factors. The remaining one article (Cohen et al, 2002) reported that there was no statistical different in admission temperature but statistical different in the injury severity score and failed to provide background information such as age and sex of the patients; it would impose bias and add uncertainties from other confounding factors.

For relevant outcome measurements, all five articles described clearly about using reliable, standard and valid measurement instruments which was either thermostat probe or electronic thermometer to measure core temperature of patients.

No attrition rate was reported in three articles (Kober et al, 2001; Scheck et al, 2004; Kjellman et al, 2011), but 2 articles (Cohen et al, 2002; Ludgren et al, 2011) reported 1% (3 patients) and 6% (3 patients) attrition rate respectively due to inconsistent data record, decline from treatment and breach of protocol. Furthermore, the intention to treat analysis was not used in these two articles.

All five studies will be included and discussed in the summary and synthesis process. The overall quality assessment of each individual study is recorded in the summary table shown in Appendix 4.
2.3 Summary and Synthesis

After reviewing the five studies, they are summarized as patient characteristics, sample size of studies, intervention types, duration of intervention, outcome measures, time interval of data collection and effect size.

Patient Characteristics:

Patient characteristics were similar in five studies; all of them recruited patients with temperature not less than 35 °C (35-37.9°C Cohen et al, 2002; 35.1-35.5°C Kober et al, 2001; 36-37°C Scheck et al, 2004; 35.2°C Ludgren et al, 2011; 35-35.9°C, Kjellman et al, 2011) at the time of admission or scene of injury. All of the patients in the selected articles were from western countries, but it is not a big issue as heat loss or warming rate (skin barrier function) is not related to ethnicity of a population (Machado, Hadgraft & Lane, 2010). Although those countries are located in higher latitude than that of Hong Kong which have cooler temperate climate; trauma patients in a warmer climate such as Hong Kong have higher risk of endogenous hypothermia due to impaired thermoregulatory mechanism of the body which is unrelated to exposure to cold environment (Aitken, Hendrikz, Dulhunty & Rudd, 2009).

The patients in three articles were all minor to medium level trauma patients with abdominal trauma, fractures, contusion, hematoma and injury severity score from 6.7-10.2 (Cohen et al, 2002; Kober et al, 2001; Scheck et al, 2004). One of the studies
Kjellman et al, 2011) recruited burn patients with total burn surface area greater than 20% (ranged from 20% to 87%). The other article was patients with blunt trauma who were under cold stress (Ludgren et al, 2011). The age of the subjects were from 20 to 78 with mean age of 38-58 in the four articles except one of them failed to provide the age of subjects (Cohen et al, 2002).

Sample size of the studies:

The sample size of two studies were 100 (Kober et al, 2001) and 298(Cohen et al, 2001). The other two studies had sample sizes of 30 (Scheck et al, 2004) and 48 (Ludgren et al, 2011). One study was within subject design and had sample sizes of 10 (Kjellman et al, 2011).

Intervention types:

Two studies investigated the effect of carbon fiber heating blanket with temperature set to 42°C when compared to the control group which was same carbon fiber heating blanket without switching on the electricity (Kober et al, 2001; Scheck et al, 2004). The device was portable and easy to implement which contained batteries of 0.5 kg and could last for 30-40 minutes. One of the five articles investigated and compared the thermal efficiency among reflective blanket, prewarmed cotton blanket and forced-air inflatable blanket without specifying the control groups (Cohen et al, 2002). Another one article investigated the effect of using large chemical heat pad
applied to upper torso and passive warming blankets when compared to passive warming blankets only as control group (Ludgren et al, 2011). The remaining one compared the effect among temperature regulating water circulating mattress + infusion heater, temperature regulating air circulating mattress + infusion heater, and conventional heating which were radiator ceilings, bed warmers and infusion heater (Kjellman et al, 2011).

**Duration of intervention:**

The duration of warming devices applied was about one hour in both Kober et al (2001) and Scheck et al (2004). For the article (Ludgren et al, 2011), the warming duration was 35 +/- 26 minutes (mean +/- SD). The patients were subjected to 2 hours for each treatment in Kjellman et al (2011). Study by Cohen et al (2002) did not mention the exact duration of intervention applied, but just stated the use of different warming devices during the trauma resuscitation in Accident & Emergency Department.

**Outcome measures:**

The primary outcome measure was core temperature for all articles. Three articles used aural probe which was gently placed in aural canal and occluded with cotton as measuring tool for continuous core temperature measurement (Kober et al, 2001; Scheck et al, 2004; Ludgren et al, 2011). In Cohen et al (2002), electronic
thermometer either orally or rectally were used as measuring tool for core temperature measurement if urinary catheter thermistor was not feasible. In the article (Kjellman et al, 2011), an indwelling (bladder) thermistor was used as a tool to measure core temperature.

For the secondary outcomes, only Kober et al (2001) used shivering as secondary outcome. In Kober et al (2001) and Ludgren et al (2011), thermal discomfort was utilized as well. Likert scale (very cold, somewhat cold, comfortable and somewhat warm) and numerical rating scale (from 0--no sensation to 10--unbearable sensation) were utilized to measure thermal discomfort in the aforementioned two articles.

Primary outcome measure was used to assess the thermal efficiency of different treatments to prevent and reduce incidence of hypothermia; while secondary outcome measure was aimed to assess the complications associated with hypothermia.

**Time interval of data collection**

Different studies used different time interval for data collection. In Cohen et al (2002), data was recorded on arrival and every 15 minutes until the discharge of the Trauma Resuscitation Room in Accident & Emergency Department. Temperature at the injury scene, on entry into the ambulance (about 30 minutes later) and on arrival to hospital (after about 35 additional minutes) was recorded in Kober et al (2001). Thermal comfort was asked on the arrival of hospital and shivering was observed
during the whole process of treatment in Kober et al (2001). In Scheck et al (2004),
data was collected at the start of transport, before CT (about 20 minutes), during the
CT process (about 20 minutes), after CT, during transport to the CT and back at the
ICU (about 20 minutes). In Ludgren et al (2011), data was collected at injury scene
and every 30 minutes until on arrival of receiving hospital. Thermal comfort was
asked every 30 minutes until on arrival of receiving hospital. For the remaining article
(Kjellman et al, 2011), temperature was measured every 15 minutes until the end of
the intervention which was 2 hours for each heating methods.

Effect size:

Although all articles showed that there was an increase in core temperature,
Improved thermal comfort level and decrease in number of patients with shivering in
the intervention group; there were only 3 studies reported significant different (P
<0.01) between intervention group and controlled group (Kober et, 2001; Scheck et al,
2004; Kjellman et al, 2011). With the application of carbon-fiber heating blanket in
Kober et al (2001) and Scheck et al (2004), there was an increase in core temperature
of 1.2-1.5°C in comparison with the control group (passive warming). In Kjellamn et
al (2011), application of temperature regulating water circulating mattress increased
core temperature with 1.1-1.2°C when compared to conventional method and
temperature regulating air circulating mattress. Cohen et al (2002) showed no
statistically significant differences (P< 0.49) in temperature among the three groups. It stated that three modes of device conserved temperature equally to maintain temperature. As body temperature is in an inverse relationship with injury severity scores, patient with higher injury severity scores was more likely to be hypothermic (Cohen et al, 2002). The patients with application of reflective blanket had higher injury severity score which was statistically significant different among groups, this might minimize the effect size of reflective blanket and cause similar effect size among three treatment groups. In Ludgren et al (2011), there was no statistical difference between intervention group and control group in core temperature during the first 30 minutes. All recruited trauma patients were under cold stress at outdoor who were different from other samples in other four studies. The exposure to low environment temperature at outdoor might influence the intervention responses which took longer time to cause significant difference between groups.

One study (Kober et al, 2001) reported and compared shivering; only 2 % of patients were observed shivering in carbon-fiber heating group but 88% of patients in control group which were statistically significant ( P<0.001). Two studies mentioned and compared thermal comfort level, 90% of patients in the carbon-fiber heating group rated the level as Comfortable but 90% of patients in the control group rated Very Cold (P<0.01) (Kober et al, 2001). All patients in the chemical heating pad
group reported a reduction of cold discomfort while there were about 66% of patients in control group reported about it (P<0.05) (Ludgren et al, 2011).

**Recommendations:**

Based on the findings of five selected articles, the follow recommendations for preventing hypothermia by using active external warming in trauma victims were provided:

Kober et al (2001) and Ludgren et al (2011) recommended that the time of implementing the innovation for trauma victims should be as soon as possible at the scene of injury to prevent further heat loss due to bleeding, wet clothes and cold exposure in the pre-hospital setting and continued as part of the nursing management plan on the arrival to Accident & Emergency Department (Ireland et al, 2006).

Regarding the types of heating blanket chosen for innovation, carbon-fiber resistive heating blanket is recommended as two studies of high quality (Kober et al ,2001; Scheck et al, 2004) have shown a statistical significant different between carbon-fiber resistive heating blanket and control group. It was highly effective and easy to implement without technical problem throughout the whole study (Scheck et al, 2004). As it is portable and easy to use, it can be implemented in Accident & Emergency Department where patients have short stay and require frequent transport to radiology and other departments.
Concerning the duration of innovation, 3 studies (Kober et al, 2001; Scheck et al, 2004; Ludgren et al, 2011) recommended one hour for trauma patient, while Kjellman et al (2011) recommended two hours for burn patients with greater than 20% total surface area involved. In order to prevent thermal burn or overheat, the innovation should be suspended if temperature is greater than 37.5°C as it is out of the normothermia range (36.5°C-37.5°C) (Sedlak, 1995).

For measurement tool of core temperature, three articles (Kober et al, 2001; Scheck et al, 2004; Ludgren et al, 2011) recommended the use of ear canal temperature as it has been shown to correlate with oesophageal temperature well which is considered as the most accurate non-invasive method to measure the core temperature of body (Ludgren et al, 2011).

Regarding the time interval for data collection, 15 minutes is recommended by Cohen et al (2002) and Kjellman et al (2011) to measure core temperature. Frequent and continuous temperature monitor are important to detect any declines in temperature and evaluate the effectiveness of interventions (Lawson, 1992).

In conclusion, the findings from those identified studies showed that the core temperature increased significantly with the application of carbon-fiber heating blankets and circulating water mattress; and the rate of hypothermia was effectively reduced during the treatment. Nurses have crucial roles to prevent hypothermia in the
early phase of resuscitation and advocate the effectiveness of evidence-based practice of using active external warming intervention. A total of four randomized controlled trials and one quasi-experimental design with prospective randomized assignment were reviewed in this paper. The quality of the identified studies were critiqued and recorded. Therefore, those five studies of medium and high quality will be utilized and contribute to the development of evidence-based guideline to prevent hypothermia for adult trauma patients in Accident & Emergency Department.
3. Translation and Application

From the integrative review in the previous chapter, there is a need for the development of evidence-based guideline to prevent hypothermia for adult trauma patients in Accident & Emergency Department. The findings of the integrative review showed that the core temperature increased significantly with the application of carbon-fiber heating blankets and circulating water mattress; and the rate of hypothermia was effectively reduced during the treatment. Implementation potential will be assessed in this chapter before implementing the guideline into target setting (Polit & Beck, 2008).

3.1 Implementation Potential

1. Target audience and setting

The target audience for the proposed guideline to prevent hypothermia is trauma patients aged 18 or above and initial temperature not less than 35 °C with trauma call activated. According to the trauma service policy in the target hospital, senior medical staff of Accident & Emergency Department (AED) will decide on activating Trauma Call based on the trauma team activation criteria when severely injured patient arrives.

The target setting is AED of a local public hospital in Hong Kong which is a major acute hospital providing comprehensive health care services of different
specialties except burn unit. It also serves as the only receiving unit for emergency patients transferred by the Government Flying Services in Hong Kong. As a major receiving hospital in outlying island disasters and growing network of major highway in Eastern Corridor are the main source of trauma victims in the target unit. There are also trauma victims transferred from other hospitals to have comprehensive health care services with related specialty. There are two resuscitation rooms in the target department and each has variety types of advanced medical equipment.

3.1.1 Transferability of the Findings

According to Polit and Beck (2008), the following factors will be discussed to assess the transferability of the reviewed articles to the innovation:

1. Similarities of targeted population and target setting

Among the five identified studies, the target audience was patient with minor to medium level trauma (fractures, contusion, abdominal trauma, heamatomas) or major burn (total burn surface area >20%). All recruited patients in the five studies had temperature not less than 35°C at time of admission and were all adults with mean age of 38-58.

Only one of the five reviewed studies was conducted in Accident & Emergency Department (Cohen et al, 2002). One was conducted in intra-hospital transfer setting (Scheck et al, 2004) as almost all trauma victims are arranged for Computed
Tomography (CT scan) in the proposed department, the time for trauma victims to stay in CT suite before transferring to operative theatre or intensive care unit (~20 minutes) is similar to the examined study. The other one was conducted in burn unit setting (Kjellman et al, 2011) yet the patients’ characteristics in the proposed setting are patients with major burn with BSA >15% which is similar to those in the examined article. The remaining two reviewed articles were conducted in pre-hospital setting (Kober et al, 2001; Lundgren et al, 2011). The time of transferring a trauma victim from scene of injury to the hospital were about one hour in 2 identified articles, but it only takes about 10 to 15 minutes in Hong Kong. Thus, the time of starting the proposed innovation for trauma victims in the target hospital (10-15 minutes delay when compared to the time at scene of injury) is similar to the examined study. Therefore, the five reviewed articles are transferable to the local setting.

2. Philosophy of care

   The philosophy of care is an important element to assess the transferability of the innovation. The philosophy of care in the target hospital is provision of holistic people-centered quality care through integration of quality nursing practice, management, education and research. Furthermore, patient’s comfort and well-being are always the prime concerns and core values of the target hospital (PYNEH, 2011). Nurse has an important role to identify and evaluate method that prevent or reduce
body heat-loss (Cohen et al, 2002) and should be accountable to make decision in delivering high quality holistic patient-centered care and promote patient comfort.

The proposed innovation aims to enhance the quality of nursing care to trauma victims which is in line with the philosophy of care of the target hospital. Therefore, the target AED is supportive to the innovation for higher quality patient care.

3. Number of patient benefit from the innovation

According to trauma statistics 2011 in the Hong Kong East Cluster, the total number of trauma victims were 450 with about 85% of them (385) fell into the target ranges of age. Among 385 trauma victims, 30% (105) of them required trauma call activation. These victims would benefit from the innovation.

4. Duration of implementing and evaluating the innovation

It will take about six months to implement and evaluate the proposed innovation. It includes one month to prepare the necessary equipment such as carbon-fiber heating blankets, digital thermometers and thermometer probes; one month to provide training program for nurses and health care assistants; three months to implement a pilot study of the innovation and one month for evaluation. Since the number of trauma victims is not predictable, therefore it takes longer period of time to implement the pilot study by recruiting sufficient number of trauma patients.
In conclusion, the findings from the reviewed articles can be transferable to implement the proposed innovation in the target setting in terms of the target audience, number of patient benefit, its philosophy and acceptable time frame to implement.

3.1.2 Feasibility of the Proposed Innovation

According to Polit and Beck (2008), the following factors will be discussed to assess the feasibility of an innovation:

1. Nurse’s autonomy over the innovation

   Nurse has a key role to identify hypothermia and maintain normothermia for trauma patients (Sedlak, 1995). Therefore, nurse in the target AED has autonomy to use different warming devices to promote patient’s comfort. If the innovation is considered to be ineffective or undesirable, nurse will have freedom to terminate its use.

2. Interference over current staff functions

   As the new innovation is an application of heating blanket over current convention practice with pre-warmed cotton blanket, nursing staff is already prepared and no additional manpower is necessary for the innovation. In order to evaluate the effectiveness of treatment, nurse has to measure and document the body temperature of trauma victims on admission, every 15 minutes and upon discharge from AED. Furthermore, health care assistant needs to perform standard cleaning procedure after
each use of heating blanket. Though frequent temperature measurements and cleaning of heating blankets will increase the workload of nurses and health care assistants, the benefit in maintaining normothermia will outweigh that.

3. Organizational climate and support from administration level

The nursing service division of the target hospital has established a working group on evidence-based nursing with members from all specialties which aims to foster the culture of evidence-based nursing practice and develop the evidence-based guideline to support the decision of clinical practice (PYNEH, 2012). The target department adopts evidence-based guideline currently and is one of the four pilot AEDs to run the nurse-led clinic. The Department Operations Manager, Ward Manager and Nurse Specialist of the target AED support clinical research and evidence-based practice to improve quality care by providing related workshops and tutorials to nurses. With adequate support from the administrative level and organizational stance, the implementation of innovation will be feasible.

4. Consensus among staffs and administrators

To make the innovation feasible, it is important to reach consensus among nurses and managerial staff. Improving quality care and patient safety are the consensus shared by both parties. Implementation of evidence-based guideline to prevent hypothermia for trauma victims will reduce the frequency of hypothermia and its
associated complications which reduce length of hospital stay, mortality and morbidity (Arthurs, et al., 2006) (Martin et al., 2005).

5. Possible friction within the organization and support from other department

Although the innovation is a simple nursing procedure which no specialized skill is required, the frontline staff may feel reluctant to the new practice. As trauma care is delivered in a complex and rapid way, it may not capture the attention of resuscitation team members to the new innovation under stressful environment. The compliance of trauma team doctors will be another possible friction to implement the innovation, as most of them expose trauma victims for assessment of injury which increase heat loss by radiation, conduction and convection. Adequate trainings and meetings will be offered to frontline nurses and health care assistants to consolidate their skills of proper use of heating blankets and create awareness towards hypothermia in trauma victims and its associated complications. Core group (8 nurses + 4 health care assistants) is formed to serve as changing agent who acts to collect feedbacks, difficulties and enquires from staff and provide channel to seek help if necessary. Informational meeting will be held with AED doctors and other trauma team doctors to address the needs of innovation. With effective communication among different parties, all potential frictions will be reduced.
6. Skills for the innovation

   It is a basic nursing skill to take accurate body temperature and simple procedure to use the heating blanket. With training session provided, nurses are confident to use the innovation without difficulty.

7. Equipment and facilities for the innovation

   Equipment and facilities for training such as projector, computer, lecture room, printer, pamphlets and two digital thermometers are all readily available. While, two carbon-fiber heating blankets and ten additional boxes of thermometer ear probe covers are required to purchase for the proposed innovation.

8. Staff training

   To ensure proper use of the innovation, all nurses in the target AED have to attend a 1-hour briefing and training program. The needs, objectives and recommendations of the clinical guideline to prevent hypothermia will be explained. There is a nursing discussion session on every Wednesday afternoon in the target AED which provides a platform for all nurses to share updated or interested clinical topics. Therefore this session can be used for staff training for the proposed innovation.

9. Evaluation of the innovation

   Patient’s satisfaction will be asked in pre and post treatment by completing the questionnaire. The temperature of trauma victims will be measured and documented
at the start and end of the innovation respectively. Feedbacks will be gathered regarding to staff’s attitude, awareness, workload, satisfaction, confidence and compliance to carry out the innovation.

Based on the information above, the proposed innovation is feasible to implement in the target setting.

3.1.3 Cost/ Benefit Ratio of the Innovation

The following factors will be discussed to assess the cost and benefits of the innovation before its implementation:

1. Risk of implementing the innovation

   The potential risk associated with the innovation includes thermal burn and hyperthermia. However, According to Sadove & Furgasen (1992), thermal burn that results from use of heating blanket is rare, and its associated risk can be minimized by frequent monitoring the patient’s temperature, skin condition and function of the blanket.

2. Benefit of implementing the innovation

   By implementing the innovation, it reduces the hypothermia episodes and its associated complications in trauma victims such as increased mortality and morbidity, shivering, wound infection and thermal discomfort (Ireland et al, 2006) (Kober et al, 2001).
3. Risk of maintaining current practice

If the innovation is not implemented, the incidence rate of hypothermia and its associated complications will remain high in the target AED. Hypothermia in trauma victims is associated with increased morbidity, mortality and wound infection which all increase length of hospital stay and medical cost but decrease patient’s quality of life (Tsuei & Kearney, 2004)

4. Tangible cost of implementing the innovation

The set up cost of the innovation includes expenditure of nurses to attend 1-hour training session, two carbon-fiber heating blankets, digital thermometer ear probe covers, stationeries and printings or photocopies of the training material. The total expenses are sum up to an estimated as HKD $ 33,200. The details are summarized in appendix 5a.

The maintenance cost of the innovation includes annual cost of maintenance of the heating blankets, stationary expense, expenditure of newly recruited and current nurses to attend 1-hour training and refreshment session. The annual long run cost is estimated as HKD $ 17,500. The details are summarized in appendix 5b.

5. Tangible cost of not implementing the innovation

If the innovation is not implemented, the tangible cost will be hypothermia associated complications. Martin et al. (2005) reported that trauma associated
hypothermia increased ventilator use of 5 days, length of intensive care unit stay of 3.5 days, length of hospital stay of 5 days and subsequently the mortality rate of 11 folds. From the trauma statistics in the target hospital 2011, there were about 105 trauma patients met the criteria of the proposed innovation and in which about 60% (~60 patients) developed hypothermia on admission. These all turn into medical expenses of $3,909,000 per year which increase the burden of health care system and economic loss to the society. The details are summarized in Appendix 6.

6. Intangible cost of implementing the innovation

If the innovation is implemented, the possible intangible cost will include staff morale and the relationship between nurses and managerial staff. In view of the frontline staff, the innovation increases their workload and they are anticipated to be stressful towards the new practice. It takes time for staff to adapt the new practice before the innovation can be smoothly run. Comprehensive training for staff before implementation of innovation and being open-mind towards staff’s feedback can minimize the uncertainties towards innovation and improve staff job satisfaction when hypothermia episodes decrease.

7. Intangible cost of not implementing the innovation

The intangible cost includes patient’s satisfaction, quality of life, nurse’s job satisfaction and morale which all cannot be measured in monetary terms. If the
innovation is not implemented, trauma patients will suffer from hypothermia associated shivering, thermal discomfort, longer use of ventilators (day), longer ICU stay and hospitalization which all affect their satisfaction and quality of life. By implementing the evidenced-based guideline, nurse’s image is upheld and they are confident to make decision by using evidence which improve quality care and increase staff morale and job satisfaction.

In conclusion, the cost of implementing the innovation is much less than the cost of not implementing, and the benefit of the innovation outweighs its risk. Therefore it is worth to implement the innovation in the target department.

3.2 Evidence-based Guideline

After assessing the implementation potential of the innovation, an evidenced-based guideline is developed to prevent hypothermia for adult trauma patients. According to the Scottish Intercollegiate Guidelines Network (SIGN) 2011, the guideline is established based on the level of evidence and the grades of recommendations. The level of evidence is rated from 1++ to 4, while the grade of recommendations is graded by capital alphabets from A to D. The guideline is attached in Appendix 7.
4. Implementation Plan

After assessing the implementation potential and developing the evidence-based protocol in the previous chapter, it is crucial to design an implementation plan before implementing the innovation into clinical setting. This includes communication plan and pilot test.

4.1 Communication Plan

An effective and comprehensive communication plan is essential to disseminate information about the guideline in order to obtain approval and support from all stakeholders.

Stakeholders

According to Melnyk & Fineout-Overholt (2005), stakeholder is defined as someone who is affected by the proposed innovation or its anticipated results. Chief of Service (COS), Department Operations Manager (DOM) and Ward Manager (WM) are the key stakeholders of this guideline in the target setting. They are the administrators in the department who have authority to approve any new clinical changes and allocate resources to facilitate the implementation of the new evidence-based guideline. Doctors of AED, trauma team doctors (Surgeon, Neurosurgeon, Orthopaedics surgeon, Anesthetist, Intensive Care Unit doctor), all nurses (nurse specialist, advanced practice nurse, registered nurse, enrolled nurse) and health care
assistants in the target AED would be another stakeholders. Doctors often expose trauma patients to perform health assessment; it is essential to gain their cooperation and supports during prevention of hypothermia in trauma resuscitation. All frontline nurses are the new guideline users who are responsible for assessing and monitoring body temperature of trauma patients and have the autonomy to apply carbon-fiber heating blanket based on patients’ condition. Nurse specialist in the target AED is chosen as leader of this innovation program because she is in a position to advocate evidence-based practice in clinical setting and monitor quality and safety of patient care. Health care assistants are responsible for the cleaning of heating blankets after use.

**Communication Process**

The communication process includes 3 phases: initiating phase, guiding phase and sustaining phase.

1. Initiating phase

   It begins with the idea of making the proposed changes until gaining approval from administrators which takes about six weeks. In the first two weeks, the innovation proposer will have informal chat with nurse specialist, advanced practice nurses, registered/enrolled nurses and health care assistants of the department to gather their opinion about the existing management of hypothermia in trauma patients
and attitudes towards the proposed innovation. During the discussion, the incidence of hypothermia in trauma patients and evidence supporting the development of the proposed guideline will be addressed to gain recognition of the needs of solving the existing problems by using the proposed evidence-based guideline. After the discussion, staff showing positive attitude and supporting the changes will be invited to form core group in the department.

The innovation proposer will spend four weeks to prepare a formal proposal with the evidence of reviewed articles to support the change and have a meeting with two ward managers. The identified problem, affirming need for the proposed guideline, transferability, feasibility and cost-benefit ratio of the proposed innovation will have to be presented during the meeting. At this stage, the proposal is necessary to be convincing to gain approval from ward managers who will then pass it to COS and DOM for agreeing implementation eventually in the target setting.

2. Guiding phase

The guiding phase begins with the approval of the proposed innovation and ends when the innovation turns into practice which is estimated to take eight weeks in total. In the first four weeks, core group (8 nurses including nurse specialist and 4 health care assistants) is formed to serve as changing agent to collect feedbacks, enquiries and difficulties from frontline staff. Nurse specialist is invited to be the leader of the
core group who is responsible for formulating communication plan to communicate with different stakeholders, conducting pilot study and evaluating the effectiveness of the proposed guideline with other core group members. Informational meeting for AED doctors, other trauma team doctors and frontline nurses will be held to create a clear vision with realistic implementation strategies for the proposed guideline. The timeline for communication, pilot study and evaluation is shown in Appendix 8. In order to consolidate the skills of proper use of new heating blanket and enhance the awareness of the identified problem, a seminar will be held to highlight the difference between current and new guidelines and share the benefit of the new guideline such as reducing ICU stay, length of hospitalization, ventilator use (day) thermal discomfort and shivering in trauma victims. Apart from holding seminar, all updated information of the innovation will be disseminated to trauma team doctors, all AED doctors, nursing staff and health care assistants via internal email and daily nursing handover time.

In the remaining four weeks, the core group will initiate 2-hour “train the trainer” program with 10 nursing staff and 6 health care assistants recruited who act as role model and enhance the support to frontline staff by providing platform to seek help whenever necessary during the implementation of the guideline. The core group will also arrange training session for all nurses and its content is shown in Appendix 9.
Furthermore, the guideline is made to be easily accessible to all nurses by using pocket cards and posting enlarged guideline in 2 resuscitation rooms respectively. A branding logo such as chili pepper would be created to allow quick visual reminder of the guideline and remind staff to think “prevent hypothermia”.

3. Sustaining phase

The sustaining phase begins with the implementation of proposed guideline and continues when the innovation is still in progress. The core group and the innovation proposer should monitor the progress of innovation and make sure the availability and well-functioning of the equipment and other resources. Those equipment and resources include carbon-fiber heating blankets, thermometers, thermometer ear probes, and documentation forms. Regular nursing audit (Appendix 10) should be done to assess the compliance of nurses by the core group and the trainers. A pilot study will be conducted to assess the transferability and feasibility of the innovation in the target setting. The details of the pilot study will be discussed in section 4.2. It is estimated to take 12 weeks to conduct the pilot test and the guideline will be revised after feedback collection from all stakeholders. The patients’ outcome in the pilot study will be evaluated. With effective patients’ outcome, it is expected to obtain greater support for sustainment of the innovation.
4.2 Pilot Testing

Pilot study is a preliminary study that is conducted in small scale. It is essential to test the feasibility of implementing the innovation before conducting a full-scale study (Melnyk & Fineout-Overholt, 2005). The pilot testing team includes core group members with nurse specialist as team leader.

The objectives of pilot testing are to:

1. test the competency and compliance of frontline staff in using the proposed guideline
2. assess the feasibility of the proposed guideline
3. monitor the effectiveness of the proposed guideline, i.e. increased in core temperature
4. identify any barriers and difficulties during implementation of the guideline

Methodology

All frontline nurses and eligible trauma victims are the participants of the pilot study. The eligible trauma victims and target setting are same as that in the proposed guideline which shown in previous chapter 3.1. Patients are recruited by convenience sampling which is an easy accessible method with minimal time and resources required. The sample size for the pilot study is approximately 20. Since the number of trauma patients is unpredictable, the proposed time frame will be three months based
on the trauma statistics of the target cluster which involved 80 eligible patients in 2011.

Informed consent will be obtained from patients or from their relatives if he/she is unconscious before enrolling to the pilot study. Core temperature of trauma patients will be taken on arrival and every 15 minutes interval until the patient is discharged from the target AED. Shivering will be observed and thermal discomfort (conscious patients only) will be asked on patient’s arrival and discharge of AED. The “trauma resuscitation sheet” which is shown in Appendix 11, will be prepared by the core group to have better documentation of hypothermia management in trauma patients. Data is collected and analyzed for further evaluation of patient’s outcome.

**Evaluation**

The outcome can be evaluated by quiz, self-reported questionnaire (Appendix 12-13) and regular nursing audit (Appendix 10). All nurses will have to attend training workshop before the pilot study and their knowledge and attitudes towards the new guideline will be assessed with quiz and self-reported questionnaire for improvement and revision of the proposed guideline. Regular nursing audit will be done by the core group to assess the compliance and competency of frontline nurse in using the guideline. Furthermore, regular evaluation meetings will be held to discuss and recognize the difficulties encountered in the pilot study.
5. Evaluation Plan

An evaluation plan is used to assess the effectiveness of patient care and staff’s attitude towards the proposed guideline, identify possible adverse effect or problems encountered after the implementation of the innovation and make revision for future improvement. The evaluation provides important information for stakeholders to know whether the innovation meets its objectives and allot funding to sustain the innovation. The outcomes are evaluated in terms of patient, health care provider and system.

1. Patient outcomes

The primary outcome is incidence rate of hypothermia and its definition is core temperature below 36.5 °C in injured victims (Kjellman et al, 2011). The core temperature can be measured by tympanic thermometer. The secondary outcomes are shivering and thermal discomfort. Nurses will observe the occurrence of shivering and measure the number of related patients. Conscious trauma patients will be asked about the thermal discomfort by using a numerical rating scale with values from 0 to 10 (Pearsons, 2003; as cited in Ludgren et al, 2011), where 0 indicates no sensation of cold and 10 indicates unbearable sensation of cold. All the above data would be collected from the trauma resuscitation sheet (Appendix 11).
2. Health care provider outcomes

Regarding the health care provider outcomes, the level of knowledge of hypothermia among staff would be assessed by a quiz containing 15 questions (Appendix 12) which is prepared by core group members based on Ireland et al, 2006 & Smith, 2004. While the staff’s attitude and confidence level will be measured by using self-reported questionnaire (Appendix 13).

3. System outcomes

In view of limited resources in the department, cost effectiveness of the innovation is the major system outcome. The cost of using the innovation and the benefit bring from it should be evaluated.

**Nature and Numbers of Clients Involved**

The characteristics of patients involved in evaluation are consistent to those eligible trauma patients recruited in pilot study which ensures the homogeneity of patient group. The patients are included for evaluation if they are adult (aged 18 or above) and initial temperature not less than 35 °C with trauma call activated.

Software called Java Applets for Power and Sample Size is used to calculate sample size (Lenth, 2006-9). It takes average of 0.55°C difference in means and standard deviation of 0.8 °C after 30-minute implementation according to the reviewed articles (+0.35°C in Kjellman et al, 2011, +0.6°C in Kober et al, 2001 &
+0.75°C in Scheck et al, 2004). The design of study will be a pre & post-test design. A two-tailed paired t-test is performed to calculate the sample size of the proposed innovation. With 80% power and level of significance of 0.05 to detect the difference in means of 0.55°C, the needed sample size will be 28 (Lenth, 2006-9). The attrition rate is 1-6% in the reviewed articles (Cohen et al, 2002 & Ludgren et al, 2011); it is more conservative to recruit more patients to minimize sampling error. Therefore, 30 eligible patients are required for the implementation of the proposed innovation.

**Timing and Frequency of Taking Measurement**

The time and frequency of outcome measures will be different among patients, staff and systems. The primary patient’s outcome measurement is core temperature during the trauma resuscitation in AED. Data will be collected at time of admission, every 15 minutes interval and until the time of discharge from AED (usually 30 minutes in the target setting). Due to short stay in AED (~30 minutes), shivering and thermal discomfort will be measured on patient’s arrival and discharge of AED. On the other hand, the outcome measurements for staff and system would be taken in intermediate term and long term. Staff’s knowledge in hypothermia will be evaluated immediately before the start of training workshop (11th-14th week) and the end of implementation of program (52nd week) respectively. The evaluation of staff’s attitude and confidence level towards the implementation of the evidence-based guideline will be performed
at the beginning (15th week) of the pilot study and the end (52nd week) of implementation respectively. Regarding the system outcome, the cost of implementing the innovation and allocation of resources will be evaluated in the monthly staff meeting. The total expenditure of the proposed innovation will be evaluated at the end of the implementation (52nd week) as long term.

**Data Analysis**

All data would be analyzed by using statistical software -- Statistical Package for Social Sciences. A two-tailed paired t-test would be performed to analyze the mean change of core temperature measured at pre and post intervention and to determine whether the level of thermal discomfort (mean scores) of trauma patients will be reduced after the implementation. Furthermore, a McNemar test will be performed to analyze the change of shivering episodes observed at pre and post intervention. Quiz and self-reported questionnaire (Appendix 12-13) are used to evaluate staff’s knowledge and attitude change (mean scores) after implementing the proposed guideline, two-tailed paired t-test will be performed to analyze the mean change in pre & post intervention.

**Basis for an Effective Innovation**

The innovation is determined as effective if all outcomes are achieved. The mean change of core temperature was reported as +1.1°C/hr in the reviewed articles.
(Kjellman et al, 2011, Kober et al, 2001 & Scheck et al, 2004). It is considered as effective if there is at least 0.55 °C core temperature increased after 30-minute implementation. According to the reviewed studies, there is at least 90% reduction in shivering (Kober et al, 2001) and thermal discomfort (Kober et, 2001 & Ludgren et al, 2011). Therefore the innovation is considered as beneficial if there is at least 90% reduction in shivering and thermal discomfort among trauma patients. Regarding the healthcare provider outcome, questionnaire with minimum response rate of 90% can probably represent the opinion and feeling of all staff (Taylor-Powel & Hermann, 2000). Therefore, the innovation is considered as effective if more than 90% response rate of the self-reported questionnaire and quiz, and there is a statistically significant (p value < 0.05) increase in mean score of knowledge and attitude. For system outcome, the innovation is considered as effective in cost if the total expenditure is within the budget limit.
Reference:


Lenth, R.V. (2006-9). Java Applets for Power and Sample Size. [Computer Software]


**Summary of searching strategies in different electronic databases on 11\textsuperscript{th} August, 2012**

<table>
<thead>
<tr>
<th></th>
<th>Medline (OvidSP)</th>
<th>CINAHL</th>
<th>Pubmed</th>
<th>EMBASE</th>
<th>Cochrane library</th>
<th>British Nursing Index</th>
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<td>1. Hypothermia</td>
<td>34770</td>
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<td>9819</td>
<td>38690</td>
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<td>2. Trauma OR Burn</td>
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<td>199414</td>
<td>245629</td>
<td>1188</td>
<td>1537</td>
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<td>3. Prewarm* OR Heating OR Warm*</td>
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<td>4297</td>
<td>12866</td>
<td>84840</td>
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<td>4. 1+2+3</td>
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<td>68</td>
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<td>5. Potential relevant articles after screening the title and abstracts</td>
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<td>6. Total number of articles reviewed without duplication</td>
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*Reference lists were reviewed (1 eligible article obtained but it has already included in 5 articles)*

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Tables of Evidence


<table>
<thead>
<tr>
<th>Study Type/ Level of evidence</th>
<th>Patient characteristics</th>
<th>Interventions</th>
<th>Comparisons</th>
<th>Outcome measures/ Length of follow up</th>
<th>Effect size</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quasi-experimental design with prospective randomized assignment (USA) 1+</td>
<td>Trauma patients with admission temperature not less than 35 °C with the mean injury severity score (6.7-10.2)</td>
<td>1. 3 cotton blankets warmed to 40 °C in a blanket warmer (n=101)</td>
<td>NA</td>
<td>Temperature (from admission to discharge from the trauma resuscitation unit)</td>
<td>1. Warmed cotton : ↑ 0.46°C P &lt; 0.49</td>
<td>- All blankets are found to be equally effective in maintaining core body temperature.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Reflective blanket and cap (n=98)</td>
<td></td>
<td></td>
<td>2. Reflective blanket and cap : ↑ 0.66 °C P&lt; 0.49</td>
<td>- Core temperature was monitored by urinary catheter thermistor, rectal/oral temperature taking mode was used by electronic thermometer if urinary catheter was not inserted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Forced-air inflatable blanket (n=99)</td>
<td></td>
<td></td>
<td>3. Forced-air inflatable blanket : ↑ 0.49 °C P&lt;0.49</td>
<td>- Potential confounding factors not addressed, i.e. age, gender, ethnicity of different groups</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study Type</th>
<th>Patient Characteristics</th>
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<th>Comparison</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Length of Follow up</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT (Austria) 1++</td>
<td>Patient with minor trauma --- fully conscious, limited bleeding, fractures or contusions</td>
<td>Carbon-fiber electric heating blanket (switch on) + wool blanket (provided by a 7-8 Ampere current passing through the carbon fiber, each battery last for 30-40 minutes, temperature is set to 42°C) (n=50)</td>
<td>Carbon-fiber electric heating blanket (switch off) + wool blanket (n=50)</td>
<td>1. Core temperature (ear canal temperature)</td>
<td>Intervention group: ↑ 0.8 °C/hr control group: ↓ 0.4 °C/hr Mean difference = ↑1.2 °C P&lt;0.001</td>
<td>from injury scene to on arrival of receiving hospital (~1 hour)</td>
<td>Average time for rescue: 1 to 1.5 hours</td>
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<td></td>
<td>Age older than 19 years (mean age -- intervention group: 57 Control group: 60)</td>
<td></td>
<td></td>
<td>2. Shivering</td>
<td>Intervention group: 1/50 (2%) Control group: 44/50 (88%) P&lt;0.001</td>
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<td>Intervention started at the scene of injury</td>
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<td></td>
<td>Initial temperature not less than 35°C</td>
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<td>3. Thermal comfort (likert scale)</td>
<td>Intervention group: 90% of patients felt “Comfortable” Control group: 96% of patients felt “Very Cold” P&lt;0.001</td>
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<td>4. Heart rate</td>
<td>Intervention group: ↓ 23 beats/min Control group: ↑ 1 beat/min P&lt;0.001</td>
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</table>

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<table>
<thead>
<tr>
<th>Study Type</th>
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<th>Comparison</th>
<th>Outcome measures</th>
<th>Length of follow up</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT (Austria) 1++</td>
<td>Critically ill trauma patients (abdominal trauma with additional minor injuries such as fractures, hematomas or contusions) Age of 20-50 (mean age-- intervention group: 38.7 Control group: 37 Initial temperature: 36.4°C</td>
<td>Carbon-fiber heating blanket set to 42 °C by passing a 7-8ampere current through the carbon-fiber, each battery last for 30-40 minutes (n=15)</td>
<td>Carbon-filter heating blanket (switched off) (n=15)</td>
<td>Core temperature (Ear canal temperature)</td>
<td>from start of transport to back to ICU (~1 hour)</td>
<td>Intervention group: normothermia during the whole procedure Control group: core temperature ↓0.5 °C/hr Mean difference=↑1.5°C/hr (P&lt;0.01)</td>
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<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT (Sweden) 1+</td>
<td>Trauma patients under cold stress (blunt trauma with GCS 15)</td>
<td>heat pad (42X 25X 2 cm) reaching 50°C within 2 minutes was applied on the anterior upper torso (leaving one layer of thin clothing between heat pad and skin) and with additional polyester blanket or woolen blanket or one rescue blanket (nylon outer with synthetic filling and cotton inner) (n=26)</td>
<td>polyester blanket or woolen blanket or one rescue blanket (nylon outer with synthetic filling and cotton inner) (n=26)</td>
<td>1. Ear canal temperature after 30 minutes</td>
<td>Intervention group: ↑ 0.8 °C Control group: : ↑ 0.9 °C (P&gt;0.05)</td>
<td>1.Type and number of blankets applied in passively warmed group were selected according to the EMS crew judgment 2.Polyester blanket =1 blanket, Woolen blanket =1.1 blanket, Rescue blanket = 1.5 blankets depending on their thermal insulation value</td>
</tr>
<tr>
<td></td>
<td>Age of (34-55) mean: intervention group: 43 control group: 45</td>
<td></td>
<td></td>
<td>2. Cold discomfort on arrival of receiving hospital</td>
<td>Intervention group: All 26 patients: ↓ cold discomfort ratings Control group: 15/22 patients: ↓ cold discomfort rating (P&lt;0.05)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study Type</th>
<th>Patient characteristics</th>
<th>Interventions</th>
<th>Comparison</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT (Sweden) 1++</td>
<td>Burn patients (total body surface area &gt;20%) mean:47%</td>
<td>1. Allon 2001 Thermowrap (a temperature regulating water-mattress) + fluid warmer</td>
<td>NA</td>
<td>Temperature measured every 15 minutes by using bladder thermistor</td>
<td>Mean ↑ 1.4 °C in 2 hr (0.6-2.6 °C) (P&lt;0.001)</td>
<td>Each intervention assessed for 2 hours each</td>
</tr>
<tr>
<td></td>
<td>10 patients randomly exposed to 3 interventions</td>
<td>2. Warm Cloud (a temperature regulating air-mattress) + fluid warmer</td>
<td></td>
<td></td>
<td>Mean ↑ 0.3 °C in 2 hr (-0.4-0.9°C) (P&lt;0.001)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age of (32-78) Mean age: 48</td>
<td>3. Conventional heating (Bair hugger + radiator ceiling + bed warmer + fluid warmer)</td>
<td></td>
<td></td>
<td>Mean ↑ 0.2 °C in 2 hr (-1.2-1.5°C) (P&lt;0.001)</td>
<td></td>
</tr>
</tbody>
</table>

**SECTION 1: INTERNAL VALIDITY**

<table>
<thead>
<tr>
<th>In a well conducted RCT study…</th>
<th>In this study this criterion is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 The study addresses an appropriate and clearly focused question.</td>
<td>Well covered, the purpose of study was clearly stated.</td>
</tr>
<tr>
<td>1.2 The assignment of subjects to treatment groups is randomised</td>
<td>Adequately addressed, randomization was done by trauma nurse researcher who was not involved in patient care. Patients were allocated into 3 groups by sealed packets which indicate group assignment of the patient.</td>
</tr>
<tr>
<td>1.3 An adequate concealment method is used</td>
<td>Adequately addressed, sealed packets were used as concealment method so that the nurse researcher did not know which protocol would be followed before patients enter the study.</td>
</tr>
<tr>
<td>1.4 Subjects and investigators are kept ‘blind’ about treatment allocation</td>
<td>Not applicable, blinding of patients and health care providers in the study is not possible due to the nature of study. However, blinding of data collector was not reported.</td>
</tr>
<tr>
<td>1.5 The treatment and control groups are similar at the start of the trial</td>
<td>Adequately addressed, the groups had no statistical different in the admission temperature, but statistical different in the injury severity score. Other initial background information such as age of patients was not addressed.</td>
</tr>
<tr>
<td>1.6 The only difference between groups is the treatment under investigation</td>
<td>Adequately covered, injury severity score of different groups were listed.</td>
</tr>
<tr>
<td>1.7 All relevant outcomes are measured in a standard, valid and reliable way</td>
<td>Poorly addressed, different temperature taking modes (rectal or oral) were used in different patients, but same temperature taking mode was used in the same patient.</td>
</tr>
<tr>
<td>1.8 What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed?</td>
<td>3 patients were dropped from the database because data were inconsistently recorded</td>
</tr>
</tbody>
</table>
1.9 All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis) | Well covered, Intention to treat analysis was not used.

1.10 Where the study is carried out at more than one site, results are comparable for all sites | Not addressed.

### SECTION 2: OVERALL ASSESSMENT OF THE STUDY

2.1 How well was the study done to minimise bias? *Code ++, +, or −* |

1+, the study is properly performed in all steps except failure to provide detailed background information of the patients (type of injury, age, sex etc.) and describe blinding of data collectors. This will impose bias and affect the study results.

2.2 Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, are you certain that the overall effect is due to the study intervention? |

No, given the above bias, the study result could not solely attribute to the interventions.

2.3 Are the results of this study directly applicable to the patient group targeted by this guideline? |

Yes, the patient group in the study is similar to my proposed guideline except the age range of patients was unknown.
Methodology Checklist 2: Controlled Trials


SECTION 1: INTERNAL VALIDITY

<table>
<thead>
<tr>
<th>In a well conducted RCT study…</th>
<th>In this study this criterion is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 The study addresses an appropriate and clearly focused question.</td>
<td>Well covered, the purpose of the study was clearly stated.</td>
</tr>
<tr>
<td>1.2 The assignment of subjects to treatment groups is randomised</td>
<td>Well Covered, the randomization was based on computer-generated codes that sealed in numbered opaque envelopes.</td>
</tr>
<tr>
<td>1.3 An adequate concealment method is used</td>
<td>Well covered, sealed envelopes were used as concealment method.</td>
</tr>
<tr>
<td>1.4 Subjects and investigators are kept ‘blind’ about treatment allocation</td>
<td>Well covered, the investigator and patients were not kept blind due to the nature of the study. The other investigator who recoded all measurements during the intervention was blinded to randomization.</td>
</tr>
<tr>
<td>1.5 The treatment and control groups are similar at the start of the trial</td>
<td>Well covered, both groups had no statistical difference in demographic and morphometric characteristics before the study.</td>
</tr>
<tr>
<td>1.6 The only difference between groups is the treatment under investigation</td>
<td>Well covered.</td>
</tr>
<tr>
<td>1.7 All relevant outcomes are measured in a standard, valid and reliable way</td>
<td>Adequately addressed, core temperature thermal comfort were measured in a standard, valid and reliable way.</td>
</tr>
</tbody>
</table>
| 1.8 What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed? | Intervention: 0  
Control: 0 |
| 1.9 All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis) | Well covered, intention-to-treat analyses were used throughout the study. |
| 1.10 Where the study is carried out at more than one site, results are comparable for all sites | Not addressed. |
### SECTION 2: OVERALL ASSESSMENT OF THE STUDY

<table>
<thead>
<tr>
<th></th>
<th>How well was the study done to minimise bias? <em>Code ++, +, or –</em></th>
<th>1++, the study is properly performed in all steps except failure to address the measurement tool of shivering and thermal comfort.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, are you certain that the overall effect is due to the study intervention?</td>
<td>Yes, this study is of high methodology quality.</td>
</tr>
<tr>
<td>2.3</td>
<td>Are the results of this study directly applicable to the patient group targeted by this guideline?</td>
<td>Yes, the patient group in the study is similar to my proposed guideline.</td>
</tr>
</tbody>
</table>
**Methodology Checklist 2: Controlled Trials**

### SIGN


### SECTION 1: INTERNAL VALIDITY

**In a well conducted RCT study…**

<table>
<thead>
<tr>
<th></th>
<th><strong>In this study this criterion is:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The study addresses an appropriate and clearly focused question.</td>
</tr>
<tr>
<td>1.2</td>
<td>The assignment of subjects to treatment groups is randomised</td>
</tr>
<tr>
<td>1.3</td>
<td>An adequate concealment method is used</td>
</tr>
<tr>
<td>1.4</td>
<td>Subjects and investigators are kept ‘blind’ about treatment allocation</td>
</tr>
<tr>
<td>1.5</td>
<td>The treatment and control groups are similar at the start of the trial</td>
</tr>
<tr>
<td>1.6</td>
<td>The only difference between groups is the treatment under investigation</td>
</tr>
<tr>
<td>1.7</td>
<td>All relevant outcomes are measured in a standard, valid and reliable way</td>
</tr>
<tr>
<td>1.8</td>
<td>What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed?</td>
</tr>
<tr>
<td>1.9</td>
<td>All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis)</td>
</tr>
<tr>
<td>1.10</td>
<td>Where the study is carried out at more than one site, results are comparable for all sites</td>
</tr>
</tbody>
</table>

### SECTION 2: OVERALL ASSESSMENT OF THE STUDY

<table>
<thead>
<tr>
<th></th>
<th><strong>Code ++, +, or –</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>How well was the study done to minimise bias?</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2</td>
<td>Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, are you certain that the overall effect is due to the study intervention?</td>
<td>Yes, this study is of high methodology quality.</td>
</tr>
<tr>
<td>2.3</td>
<td>Are the results of this study directly applicable to the patient group targeted by this guideline?</td>
<td>Yes, the patient group in the study is similar to my proposed guideline.</td>
</tr>
</tbody>
</table>
**Methodology Checklist 2: Controlled Trials**


### Section 1: Internal validity

<table>
<thead>
<tr>
<th>In a well conducted RCT study…</th>
<th>In this study this criterion is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 The study addresses an appropriate and clearly focused question.</td>
<td>Well covered, the purpose of study was clearly stated.</td>
</tr>
<tr>
<td>1.2 The assignment of subjects to treatment groups is randomised</td>
<td>Well covered, sequentially numbered and sealed envelopes containing randomized study protocols were used to randomly assign patients into 2 groups.</td>
</tr>
<tr>
<td>1.3 An adequate concealment method is used</td>
<td>Adequately addressed, sealed envelopes were used as concealment method so that the emergency medical services personnel did not know which protocol would be followed before patients enter the study.</td>
</tr>
<tr>
<td>1.4 Subjects and investigators are kept ‘blind’ about treatment allocation</td>
<td>Not applicable, blinding of patients and health care providers in the study is not possible due to the nature of study. However, blinding of data collector was not reported.</td>
</tr>
<tr>
<td>1.5 The treatment and control groups are similar at the start of the trial</td>
<td>Well covered, both groups had no statistical difference in patient characteristic and confounding factors</td>
</tr>
<tr>
<td>1.6 The only difference between groups is the treatment under investigation</td>
<td>Not reported, although the type and number of blankets applied in each case were selected according to emergency medical service crew judgment without regulations by investigator, there was no significant differences between groups ( p&lt;0.05). On the other hand, injury severity score of different groups were not addressed.</td>
</tr>
<tr>
<td>1.7 All relevant outcomes are measured in a standard, valid and reliable way</td>
<td>Well covered, core temperature, cold discomfort and vital signs were measured in a standard, valid and reliable ways</td>
</tr>
<tr>
<td>1.8 What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed?</td>
<td>3 patients were dropped out before the end of the study. One patient wanted to end the study prior to arrival of hospital; the other two were excluded due to breach of protocol.</td>
</tr>
<tr>
<td>1.9 All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis)</td>
<td>Well covered, Intention to treat analysis was not used.</td>
</tr>
</tbody>
</table>
Where the study is carried out at more than one site, results are comparable for all sites. Well covered, fourteen road ambulance units and one helicopter unit in northern parts of Sweden were selected for the study.

### Section 2: OVERALL ASSESSMENT OF THE STUDY

<table>
<thead>
<tr>
<th>2.1</th>
<th>How well was the study done to minimise bias? <em>Code ++, +, or −</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1+, the study is properly performed in all steps except failure to provide adequate concealment method used in randomly assignment of subjects and describe blinding of data collectors. This will impose bias and affect the study results</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.2</th>
<th>Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, are you certain that the overall effect is due to the study intervention?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No, given the above bias, the study result could not solely attribute to the interventions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.3</th>
<th>Are the results of this study directly applicable to the patient group targeted by this guideline?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes, the patient group in the study is similar to my proposed guideline except the patients in this study were under cold stressed.</td>
</tr>
</tbody>
</table>

**Methodology Checklist 2: Controlled Trials**

**Section 1: Internal validity**

<table>
<thead>
<tr>
<th>In a well conducted RCT study…</th>
<th>In this study this criterion is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 The study addresses an appropriate and clearly focused question.</td>
<td>Well covered, the purpose of study was clearly stated.</td>
</tr>
<tr>
<td>1.2 The assignment of subjects to treatment groups is randomised</td>
<td>Adequately addressed, patients were randomized to be exposed to 3 interventions (started with one and the other two followed randomly). Randomization method was not described.</td>
</tr>
<tr>
<td>1.3 An adequate concealment method is used</td>
<td>Not addressed.</td>
</tr>
<tr>
<td>1.4 Subjects and investigators are kept ‘blind’ about treatment allocation</td>
<td>Not applicable, blinding of patients and health care providers in the study is not possible due to the nature of study. However, blinding of data collector was not addressed.</td>
</tr>
<tr>
<td>1.5 The treatment and control groups are similar at the start of the trial</td>
<td>Not applicable. As the study is within subject design, same patients were exposed to both treatment and control group randomly.</td>
</tr>
<tr>
<td>1.6 The only difference between groups is the treatment under investigation</td>
<td>Not applicable. As the study is within subject design, same patients were exposed to both treatment and control group randomly.</td>
</tr>
<tr>
<td>1.7 All relevant outcomes are measured in a standard, valid and reliable way</td>
<td>Well covered, core temperature was measured in a standard, valid and reliable way</td>
</tr>
<tr>
<td>1.8 What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed?</td>
<td>0</td>
</tr>
<tr>
<td>1.9 All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1.10 Where the study is carried out at more than one site, results are comparable for all sites</td>
<td>Not addressed.</td>
</tr>
</tbody>
</table>

**Section 2: OVERALL ASSESSMENT OF THE STUDY**

<table>
<thead>
<tr>
<th>How well was the study done to minimise bias?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code ++, +, or –</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>2.3</td>
</tr>
</tbody>
</table>
## Appendix 4

### Summary of SIGN Critical Appraisal for the Retrieved RCTs

<table>
<thead>
<tr>
<th>Section 1: Internal Validity</th>
<th>Randomized controlled trials</th>
<th>Cohen et al., 2002</th>
<th>Kober et al., 2001</th>
<th>Scheck et al., 2004</th>
<th>Lundgren et al., 2011</th>
<th>Kjellman et al., 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 The study addresses an appropriate and clearly focused question.</td>
<td>Well covered</td>
<td>Well Covered</td>
<td>Well covered</td>
<td>Well covered</td>
<td>Well Covered</td>
<td></td>
</tr>
<tr>
<td>1.2 The assignment of subjects to treatment groups is randomised</td>
<td>Adequately addressed</td>
<td>Well covered</td>
<td>Well covered</td>
<td>Well covered</td>
<td>Adequately addressed</td>
<td></td>
</tr>
<tr>
<td>1.3 An adequate concealment method is used</td>
<td>Adequately addressed</td>
<td>Well covered</td>
<td>Well covered</td>
<td>Adequately addressed</td>
<td>Not addressed</td>
<td></td>
</tr>
<tr>
<td>1.4 Subjects and investigators are kept ‘blind’ about treatment allocation</td>
<td>Not applicable</td>
<td>Well covered</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>1.5 The treatment and control groups are similar at the start of the trial</td>
<td>Adequately addressed</td>
<td>Well covered</td>
<td>Well covered</td>
<td>Not reported</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>1.6 The only difference between groups is the treatment under investigation</td>
<td>Adequately addressed</td>
<td>Well covered</td>
<td>Not reported</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>1.7 All relevant outcomes are measured in a standard, valid and reliable way</td>
<td>Poorly addressed</td>
<td>Adequately addressed</td>
<td>Well covered</td>
<td>Well covered</td>
<td>Well covered</td>
<td></td>
</tr>
<tr>
<td>1.8 What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed?</td>
<td>3 patients (1%) dropped out</td>
<td>No drop out in both groups</td>
<td>No drop out in both groups</td>
<td>3 patients (6%) dropped out</td>
<td>No drop out</td>
<td></td>
</tr>
<tr>
<td>1.9 All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis)</td>
<td>Well covered</td>
<td>Well Covered</td>
<td>Not addressed</td>
<td>Well covered</td>
<td>Not addressed</td>
<td></td>
</tr>
<tr>
<td>1.10 Where the study is carried out at more than one site, results are comparable for all sites</td>
<td>Not addressed</td>
<td>Not addressed</td>
<td>Not addressed</td>
<td>Well covered</td>
<td>Not addressed</td>
<td></td>
</tr>
</tbody>
</table>

### Section 2: Overall assessment of the study

<table>
<thead>
<tr>
<th>Code ++, +, or −</th>
<th>(+)</th>
<th>(++)</th>
<th>(++)</th>
<th>(+)</th>
<th>(+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 How well was the study done to minimise bias?</td>
<td>(+)</td>
<td>(++)</td>
<td>(++)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
</tbody>
</table>
Appendix 5a

Estimated cost of setting up innovation

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit cost (HK$)</th>
<th>Quantity</th>
<th>Amount (HK$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff training</td>
<td>$200/hour X 1 hour</td>
<td>66 staff</td>
<td>$13,200</td>
</tr>
<tr>
<td>Heating blanket</td>
<td>$7500</td>
<td>2</td>
<td>$15,000</td>
</tr>
<tr>
<td>Digital thermometer</td>
<td>Readily available</td>
<td>4</td>
<td>---</td>
</tr>
<tr>
<td>Thermometer ear probe,</td>
<td></td>
<td></td>
<td>$5,000</td>
</tr>
<tr>
<td>Photocopies, stationary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total set up cost of innovation</td>
<td></td>
<td></td>
<td>$33,200</td>
</tr>
</tbody>
</table>

Appendix 5b

Estimated annual maintenance cost of the innovation

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit cost (HK$)</th>
<th>Quantity</th>
<th>Amount (HK$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training/refreshment cost for newly recruited and current staff</td>
<td>$200/hour X 1hour</td>
<td>~70 staff</td>
<td>$14,000</td>
</tr>
<tr>
<td>Heating blanket</td>
<td>$1,000</td>
<td>2</td>
<td>$2,000</td>
</tr>
<tr>
<td>Thermometer ear probe covers</td>
<td></td>
<td></td>
<td>$1,500</td>
</tr>
<tr>
<td>Photocopies, stationary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total maintenance cost of innovation per year</td>
<td></td>
<td></td>
<td>$17,500</td>
</tr>
</tbody>
</table>
## Appendix 6

### Estimated cost of not implementing the innovation per year

<table>
<thead>
<tr>
<th>Items</th>
<th>Item description</th>
<th>Amount (HK $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of ICU LOS</td>
<td>Mean: 3.5 days</td>
<td>$2,919,000</td>
</tr>
<tr>
<td></td>
<td>Estimated eligible patients: 60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost: $13,900 per bed/ day *</td>
<td></td>
</tr>
<tr>
<td>Reduction of hospital LOS</td>
<td>Mean: 5 days</td>
<td>$990,000</td>
</tr>
<tr>
<td></td>
<td>Estimated eligible patients: 60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost: $3,300 per bed/day **</td>
<td></td>
</tr>
<tr>
<td>Total estimated cost of not implementing the innovation</td>
<td></td>
<td>$3,909,000</td>
</tr>
</tbody>
</table>

*Maintenance fee of ICU bed per day in public hospital (HA, 2012)

**Maintenance fee of general inpatient bed per day in public hospital (HA, 2012)

### Estimated benefits (cost saving) of the innovation per year:

=>Total estimated cost of not implementing the innovation/ year (cost saving if implementing the innovation) - Total set up cost of innovation/ year

= $3,909,000 - $33,200

=$3,875,800/ year
Appendix 7

An Evidence-based Guideline

An evidence-based guideline in preventing hypothermia for adult trauma patients in Accident and Emergency Department

Introduction

Hypothermia is commonly found in injured victims and occurs in about 57% of the trauma admission in Accident and Emergency Department (Stewart, 2003). It is defined as temperature less than 36.5°C in injured victims (Stewart, 2003 & Kjellman et al, 2011). Hypothermia in trauma victim is associated with increased mortality, morbidity, shivering, wound infection rate, thermal discomfort and thus the cost of medical expense (Martin et al, 2005 & Kober et al, 2001). As hypothermia is one of the preventable complications in trauma victims, nurse plays a vital role to prevent hypothermia episodes (Cohen et al, 2002). There is an urgency to develop an evidence-based guideline in preventing hypothermia for adult trauma patients.

The guideline is developed for nurses to work in Accident and Emergency Department of the local public hospital which based on the evidence of the reviewed articles to prevent or reduce the hypothermia episodes for adult trauma patients. The level of evidence of all reviewed articles is rated based on the Scottish Intercollegiate Guidelines Network (SIGN) 2011. According to the Grade of Recommendations
(SIGN, 2008), the recommendations developed in the guideline are graded from A to D. Nurse should terminate the use of heating blanket if any undesirable outcome is noted and document with reasons.

**Objectives**

The objectives of this evidence-based guideline are:

1. To prevent and reduce hypothermia episodes in adult trauma patients
2. To standardize nursing management in preventing and reducing rate of hypothermia for trauma patients
3. To assist nurses in making evidence-based decision towards the use of active external warming devices
4. To promote the use of evidence-based guideline in the target setting

**Intended User**

This guideline is intended to support the decision making of nurses in Accident and Emergency Department to care trauma patient with hypothermia.

**Target Group**

The evidence-based guideline target adult trauma patients who are aged 18 or above and require trauma call activation as candidate.

Patients are eligible if they meet the following criteria:

1. Adult (aged 18 or above)
2. Trauma patient (require trauma call activation)

3. Initial temperature not less than 35 °C
## Rating Scheme for the Strength of the Evidences

Level of evidence of reviewed articles was rated based on SIGN (2011):

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Evidence Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1++</td>
<td>High quality meta-analyses, systematic reviews of RCTs, or RCTs with very low risk of bias.</td>
</tr>
<tr>
<td>1+</td>
<td>Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with low risk of bias.</td>
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<tr>
<td>1-</td>
<td>Meta analyses, systematic review of RCTs, or RCTs with a high risk of bias.</td>
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<tr>
<td>2++</td>
<td>High quality case control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal.</td>
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<tr>
<td>2+</td>
<td>Well-conducted case control or cohort studies with a low risk of confounding bias and a moderate probability that the relationship is causal.</td>
</tr>
<tr>
<td>2-</td>
<td>Case control or cohort studies with high risk of confounding bias and a significant risk that the relationship is not causal.</td>
</tr>
<tr>
<td>3</td>
<td>Non-analytic studies, e.g. case reports, case series.</td>
</tr>
<tr>
<td>4</td>
<td>Expert opinion.</td>
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</tbody>
</table>
## Grade of Recommendations

The recommendations are graded based on SIGN (2008)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>At least one meta analysis, systematic review, or RCT rated as 1++, and directly applicable to the target population; or a systematic review of RCTs or a body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and demonstrating overall consistency of results.</td>
</tr>
<tr>
<td>B</td>
<td>A body of evidence including studies rated as 2++, directly applicable to the target population, and demonstrating overall consistency of results; or extrapolated evidence from studies rated as 1++ or 1+.</td>
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<tr>
<td>C</td>
<td>A body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results; or extrapolated evidence from studies rated as 2++.</td>
</tr>
<tr>
<td>D</td>
<td>Evidence level 3 or 4; or extrapolated evidence from studies rated as 2+.</td>
</tr>
<tr>
<td>D(GTP)</td>
<td>Recommended best practice based on the clinical experience of the guideline development group.</td>
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</tbody>
</table>
Recommendations

Recommendation 1

Heating blanket should be initiated as soon as possible for those eligible trauma victims at the scene of injury or on arrival of the Accident and Emergency Department. (Grade of recommendation: A)

The time of implementing the heating blanket for trauma victims should be as soon as possible when their body temperature are less than 36.5 °C (Kober et al, 2001; Ludgren et al, 2011& Cohen et al, 2002) (1++, 1+, 1+) to prevent heat loss due to due to bleeding, wet clothes and cold exposure in pre-hospital and continue as part of nursing care plan on arrival to Accident and Emergency Department.

Recommendation 2

Carbon-fiber resistive heating blanket should be used as warming device among the other heating blankets. (Grade of recommendation: A)

Carbon-fiber resistive heating blanket has been shown statistical significant difference in body temperature when compared to the control group in two high quality studies. (Kober et al, 2001 & Scheck et al, 2004) (1++, 1++) It is highly effective and easy to implement without any technical problems throughout the whole study (Scheck et al, 2004). Due to its portable property and easy manipulation, it is
suggested to implement in Accident & Emergency Department where patients have short stay and require frequent transport to radiology and other departments.

**Recommendation 3**

The heating blanket should be implemented for at least one hour or until the patient becomes normothermic. *(Grade of recommendation: A)*

Two high quality studies and one moderate quality study suggested that the duration of the implementation should be at least one hour for trauma patients. *(Kober et al, 2001; Scheck et al, 2004 & Ludgren et al, 2011) (1++, 1++, 1+)*

The other moderate quality study recommended two hours for burn patients with total surface area involved greater than 20%. *(Kjellman et al, 2011) (1+)* In order to prevent thermal burn or overheat, the innovation should be suspended if temperature is greater than 37.5 °C as it is out of the normothermic range *(36.5 °C- 37.5°C)* *(Sedlak, 1995).*

**Recommendation 4**

The carbon-fiber resistive heating blanket should be set to 42°C. *(Grade of Recommendation: A)*

Two high quality studies showed that the carbon-fiber resistive heating blanket should be set to 42 °C. *(Kober et al, 2001 & Scheck et al, 2004) (1++, 1++) This*
temperature can keep the core temperature stable and ensure normothermia in trauma victims during whole process.

**Recommendation 5**

**Ear canal temperature (Tympanic temperature) should be used as measurement method of core temperature. (Grade of recommendation: A)**

The use of ear canal temperature has been shown to correlate with oesophageal temperature well which is considered as the most accurate non-invasive method to measure core temperature. (Ludgren et al, 2011) (1+) Three articles including two high quality and one moderate quality studies suggested the use of ear canal temperature as measuring method for core temperature. (Kober et al, 2001; Scheck et al, 2004; Ludgren et al, 2011) (1++, 1++, 1+) This method is non-invasive and rapid to measure core temperature with reading displayed within one to two seconds and avoid over-exposure of the patient when compared to others.

**Recommendation 6**

**The core temperature should be monitored at the start of implementation and then every 15 minutes. (Grade of recommendation: A)**

Core temperature of trauma victims should be always kept at the rage of 36.5- 37.5 °C. Frequent and continuous temperature is important to detect any declines in temperature and evaluate the effectiveness of interventions (Lawson, 1992). Two
moderate quality studies showed that the time interval for temperature measurement should be about 15 minutes. (Cohen et al, 2002 & Kjellman et al, 2011) (1+, 1+)
## Timeline for implementation and evaluation plan

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Appendix 9

Training session on evidenced-based guideline in preventing hypothermia in trauma patients

Venue: Meeting Room of AED
Date: Every Wednesday
Time: 1430-1530
Speakers: Nurse Specialist (AED) and other 11 core group members
Language: Chinese with English handout
Target Participants: Nurses
Enquiry: Nurse Specialist (Tel: 31234567)
Email: ns123@ha.org.hk

Content
1. Knowledge in identifying hypothermia of different level
2. Affirming needs for the evidenced-based guideline
3. Introduction of guideline
4. Proper use of the new carbon-fiber heating blanket
5. Proper cleaning of the carbon-fiber heating blanket
6. Accurate technique in measuring core temperature
7. Instrument to measure core temperature
8. Duration of the innovation
9. Frequency of temperature monitoring
10. Maintenance of equipment
Appendix 10

Audit form on assessing the competence and compliance of using the evidence-based guideline in preventing hypothermia for trauma patients

Please “tick” the appropriate column.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>Temperature measurement within 5 minutes of arrival on AED</td>
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<td>Shivering observed within 5 minutes of arrival on AED</td>
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<td>Thermal discomfort asked within 5 minutes of arrival on AED</td>
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<tr>
<td>Application of carbon-fiber heating blanket to the eligible patients within 5 minutes of arrival on AED</td>
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<tr>
<td>Use the right way of temperature measurement</td>
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<tr>
<td>Correct use of device of temperature measurement</td>
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<tr>
<td>Temperature measurement at every 15 minutes until discharge of patient</td>
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<tr>
<td>Monitor any thermal burn every 15 minutes until discharge of patient</td>
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<tr>
<td>Shivering observed on discharge of patient</td>
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<td>Thermal discomfort asked on discharge of patient</td>
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<tr>
<td>Document all data in trauma resuscitation form</td>
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</tbody>
</table>
Appendix 11

**Trauma Resuscitation Sheet—data collection and evaluation of evidence-based guideline in preventing hypothermia in trauma patients**

**Patient Characteristic**
- Gender: M / F
- Age: ______
- Type of injury: Fracture / Contusion / Bleeding / Burn / Injury / Amputated / Others
- Part of body involved: Head / Face / Neck / Thorax / Pelvis / Upper limbs / Lower limbs
- Intoxication: Yes / No  If yes, type: ____________
- Scene of injury: Outdoors / Indoors
- Time before arrival to hospital: ________________
- Trauma call initiated: Yes / No

**Admission Data**
- Blood pressure: ________ mmHg
- Heart rate: ________ beats/ min
- Core temperature: ________ °C  ( Hypothermia / Normothermia / Hyperthermia )
- Respiration rate: ________ /min
- Shivering: Yes / No
- Thermal discomfort: 0 = “no sensation of cold”; 10= “unbearable sensation of cold”
  
  0  1  2  3  4  5  6  7  8  9  10

  Temperature in resuscitation room: ________ °C
- Use of carbon-fiber heating blanket: Yes / No  If No, why? Reasons:__________

**Data during ongoing resuscitation**

<table>
<thead>
<tr>
<th>Minutes</th>
<th>15</th>
<th>30</th>
<th>45</th>
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<tbody>
<tr>
<td>Shivering (Yes/No)</td>
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<tr>
<td>Skin condition--thermal burn (Yes/No)</td>
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<tr>
<td>Termination of heating blanket (Yes/No)</td>
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<tr>
<td>Temperature of heating blanket set</td>
<td>°C</td>
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<td>Sedation used (Yes/No) If yes, type:</td>
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<td>Opioids used (Yes/No) If yes, type:</td>
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</tbody>
</table>
**Discharge data**

Blood pressure: _________ mmHg
Heart rate: _________ beats/ min
Core temperature: _______ °C  (Hypothermia / Normothermia / Hyperthermia)
Respiration rate: _______ /min
Shivering: Yes / No
Thermal discomfort: 0 = “no sensation of cold”; 10 = “unbearable sensation of cold”

Temperature in resuscitation room: _______ °C
Termination of carbon-fiber heating blanket: Yes / No
If Yes, why? Reasons: _______________________

**Evaluation:**

Screening for eligibility

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Yes</th>
<th>No</th>
</tr>
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<tbody>
<tr>
<td>Age 18 or above</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Temperature ≥35 °C</td>
<td>☐</td>
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<tr>
<td>Trauma call initiated</td>
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<td>Entry of guideline</td>
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Appendix 12

Quiz on testing the staff’s knowledge of hypothermia in trauma patients
(pre-training workshop)

Do you think the following statements describing trauma patients with hypothermia correct? Please tick the appropriate column.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The definition of normothermia in trauma patient is 36°C.</td>
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<tr>
<td>2. Impaired tissue oxygen delivery is adverse effects of hypothermia in trauma.</td>
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<td>3. Cold IV fluids and blood products increase heat loss.</td>
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<tr>
<td>4. Burn patient is not risk factor for hypothermia.</td>
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<td>5. Hypothermia decreased blood viscosity of trauma patient.</td>
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<td>6. Hypothermia increase wound infection rate in trauma patient.</td>
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<td>7. Spinal cord injury is risk factors for hypothermia.</td>
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<td>9. Coagulopathy and metabolic acidosis are not the complication of hypothermia.</td>
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<td>10. Environment exposure is the major source heat loss for adult in pre-hospital.</td>
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<td>11. Alcohol increase heat production.</td>
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<td>12. Patients at extreme age are at risk of hypothermia.</td>
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<td>13. Oxygen consumption is reduced during rewarming.</td>
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<td>14. Head injury is not a risk factor for hypothermia in trauma.</td>
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<td>15. Covering the head is effective to prevent hypothermia in trauma patients.</td>
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**Quiz on testing the staff’s knowledge of hypothermia in trauma patients**  
*(post-pilot study/ post-implementation of the guideline)*

Do you think the following statements describing trauma patients with hypothermia correct? Please tick the appropriate column.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The definition of normothermia in trauma patient is 36°C.</td>
<td></td>
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<tr>
<td>2. Impaired tissue oxygen delivery is adverse effects of hypothermia in trauma.</td>
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<tr>
<td>3. Cold IV fluids and blood products increase heat loss.</td>
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<tr>
<td>4. Burn patient is not risk factor for hypothermia.</td>
<td></td>
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<tr>
<td>5. Hypothermia decreased blood viscosity of trauma patient.</td>
<td></td>
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<tr>
<td>6. Hypothermia increase wound infection rate in trauma patient.</td>
<td></td>
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<tr>
<td>7. Spinal cord injury is risk factors for hypothermia.</td>
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<tr>
<td>9. Coagulopathy and metabolic acidosis are not the complication of hypothermia.</td>
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<tr>
<td>10. Environment exposure is the major source heat loss for adult in pre-hospital.</td>
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<tr>
<td>11. Alcohol increase heat production.</td>
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<tr>
<td>12. Patients at extreme age are at risk of hypothermia.</td>
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<tr>
<td>13. Oxygen consumption is reduced during rewarming.</td>
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<tr>
<td>14. Head injury is not a risk factor for hypothermia in trauma.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Covering the head is effective to prevent hypothermia in trauma patients.</td>
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<td></td>
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</tbody>
</table>


**Questionnaire on assessing the attitude and confidence level among health care providers (Pre-pilot study)**

Dear Colleagues,

You are invited to complete the following questionnaire on the attitude and confidence level before the implementation of the guideline. The aim of this questionnaire is to collect baseline data and test the effectiveness of the guideline after its implementation. Please “tick” the appropriate column. Likert scale is used (1= Strongly disagree; 2= Disagree; 3= Agree; 4= Strongly agree)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitude</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>I understand the importance of treating hypothermia in trauma patients.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>The implementation of guideline enhances my awareness of hypothermia in trauma patients.</td>
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<td></td>
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<tr>
<td>I feel supportive in efforts to prevent hypothermia.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Confidence level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am able to use the equipment.</td>
<td></td>
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<tr>
<td>I feel well prepared to carry out the guideline.</td>
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<tr>
<td>I am competent and knowledgeable to care trauma patients with hypothermia.</td>
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Any other comment(s)?

_________________________________________________________________________________  
_________________________________________________________________________________  
_________________________________________________________________________________  
_________________________________________________________________________________  
_________________________________________________________________________________  

Adopted from : questionnaire on assessing nurses’ attitude and confidence level towards new evidence-based practice in the target department

Thank You!
**Questionnaire on assessing the attitude and confidence level among health care providers (Post-pilot study/post-implementation of guideline)**

Dear Colleagues,

You are invited to complete the following questionnaire on the attitude and confidence level after the implementation of the guideline. The aim of this questionnaire is to review the effectiveness of the guideline. Please “tick” the appropriate column. Likert scale is used (1= Strongly disagree; 2= Disagree; 3= Agree; 4= Strongly agree)

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________________________________________________________________________

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Adopted from : questionnaire on assessing nurses’ attitude and confidence level towards new evidence-based practice in the target department

Thank You!

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