

# BMJ Open Barriers to body temperature monitoring among prehospital personnel: a qualitative study using the modified nominal group technique

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## ABSTRACT

**Objectives** To identify and explore barriers that healthcare professionals working as prehospital care (PHC) providers at the University Hospital of North Norway experience with temperature monitoring and discover solutions to these problems.

**Study design** Qualitative study using the modified nominal group technique.

**Materials and methods** 14 experienced healthcare professionals working in air and ground emergency medical services were invited to the study. Initially, each participant was asked to suggest through email topics of importance regarding barriers to prehospital thermometry. Afterwards, they received a list of all disparate topics and were asked to individually rank them by importance. The top-ranked topics were discussed in a consensus meeting. The meeting was audio-recorded and a transcript was written and then analysed through an inductive thematic analysis.

**Results** 13 participants accepted the invitation. 63 suggestions were reduced to 24 disparate topics after removal of duplicates. Twelve highly ranked topics were discussed during the consensus meeting. Thematic analysis revealed 47 codes that were grouped together into six overarching themes, of which four described challenges to monitoring and two described potential solutions: equipment dissatisfaction, little focus on patient temperature, fear of iatrogenic complications, thermometry subordinated, more focus on temperature and simplification of thermometry.

**Conclusion** To increase the frequency of temperature measurement on correct indication, we suggest introducing PHC protocols that specify patients and conditions where an accurate temperature measurement should have high priority. Furthermore, there is a profound need for more suitable techniques for temperature monitoring in the prehospital setting.

## BACKGROUND

A stable human body temperature is essential to preserve proper organ function. Core temperature is strictly regulated through thermoregulation, and small deviations trigger physiological compensatory mechanisms.<sup>1</sup> Accidental hypothermia is defined as an involuntary drop in core temperature below

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Hypothermia is a well-studied topic, but as far as the authors know no previous studies have qualitatively assessed which challenges healthcare professionals in prehospital care (PHC) experience when measuring body temperature.
- ⇒ Topics of discussion were determined prior to the consensus meeting to avoid potential verbally dominating group members from affecting individual responses.
- ⇒ Several different personnel categories within PHC were included to ensure a rich variety of perspectives in the generation of topics.
- ⇒ Only one researcher coded and analysed the data, which introduces a risk of losing potential insight presented by another researcher.
- ⇒ One of the researchers worked within PHC prior to and during the study, which entails a risk of introducing researcher bias to the results.

35°C, and much emphasis has been placed on severe reduction of the core temperature.<sup>1</sup> However, several studies have reported that even less profound hypothermia independently increases mortality and morbidity in trauma patients,<sup>2–10</sup> although some authors conclude otherwise.<sup>11–12</sup> Hypothermia may cause coagulopathy with consecutively increased haemorrhage<sup>9–10–13–14</sup> and reduces the haemoglobin's ability to release oxygen to tissues, increasing oxygen debt.<sup>10</sup> Furthermore, hypothermia might have detrimental effects on cardiac, pulmonary, renal and neurological functions, with the potential for cardiac arrest and coma,<sup>9–10–15–16</sup> and is uncomfortable for the patient.<sup>17–18</sup> Studies from the more controlled perioperative setting have also demonstrated how hypothermia is associated with increased transfusion rates,<sup>13–14–19</sup> wound infections<sup>20–21</sup> and cardiovascular mortality, as well as delayed wound healing and prolonged hospital stay.<sup>18</sup> Finally, core temperature is important in several

treatment and patient triage algorithms and is critical for accurate triage of patients suffering from cardiac arrest or victims to avalanche or drowning.<sup>22</sup>

Hypothermia is a common finding in severely injured patients,<sup>2 3 7 23 24</sup> and these patients lose temperature both at the site of injury and during transport to the hospital.<sup>25</sup> Prehospital services have several ways of preventing hypothermia,<sup>26</sup> but in order to combat its many adverse effects the problem must be acknowledged by measuring an early and precise body temperature. For this reason, one might expect that temperature monitoring and actions to preserve normal body temperature have high priority in the treatment of emergency patients. However, measurement is often omitted in the early stages of patient treatment.<sup>2</sup> The lack of a universal standard for accurate prehospital body temperature measurement combined with the variety of methods available might contribute to this.<sup>10 27–29</sup> Regardless, the omission of temperature measurement and subsequent temperature conservation in patients with hypothermia reduces the overall quality of healthcare that the emergency medical services (EMS) can deliver.

Northern Norway is characterised by cold climate and a vast geographical area, which make for challenging work environments for the EMS. Patients in this region—many far from the nearest hospital—are susceptible to developing hypothermia, which makes optimal patient treatment demanding. Assessing potential hypothermia and preventing further progression are essential for many patients. Several studies have been conducted on hypothermia and its adverse effects, but as far as the authors know no previous studies have addressed which challenges the EMS personnel experience when measuring body temperature.<sup>1–13</sup> For this reason, we invited healthcare professionals working as prehospital care (PHC) providers to a consensus process about their attitudes and perceptions around temperature monitoring. The overall objective of the study was to identify barriers to prehospital temperature measurement that healthcare professionals working as PHC providers experience in their clinical work and to explore these barriers in search for potential solutions. We believe that increased knowledge and awareness of these obstacles may contribute to increasing the rate of accurate temperature measurement when indicated and thus contribute to increasing the quality of healthcare provided to patients in the prehospital setting.

## MATERIALS AND METHODS

### Study design

We used a modified nominal group technique (NGT) to define topics relevant for discussion and a subsequent thematic analysis. The NGT was originally developed by Delbecq and Van de Ven<sup>30</sup> and is closely related to focus group discussions. We modified the NGT in the sense that potential topics and rankings of said topics were gathered through email prior to the consensus meeting.

### Study participants

We invited a purposeful sample of 14 participants, of whom 13 accepted. All participants were healthcare professionals employed at the University Hospital of North Norway (UNN) EMS<sup>31</sup> and were known by the authors to possess opinions and clinical experience regarding the clinical challenges of prehospital thermometry. Inviting experienced employees was a deliberate choice to ensure a rich capture of themes, all the while recognising that a different sample, such as one composed of less experienced employees, in theory could have identified other relevant issues. Participants were invited by telephone and the inclusion of participants took approximately 1 week. The sample included fixed wing (FW) flight nurses, helicopter EMS (HEMS) physicians and ground ambulance (GA) paramedics. On invitation, a short brochure written by the research team, describing the importance of the topic and the reason for conducting the study, was shared with the participants. The participants were encouraged to avoid discussing the study with each other before the consensus meeting. This was to minimise the possibility of dominant group members affecting individual responses with their opinions, with the potential of losing valuable information.<sup>32</sup> The number of employees and the different categories of employees were deemed adequate to ensure both a rich variety of themes and an adequate representation of all personnel categories in the final group discussion.

### Consensus process

#### Phase 1: open suggestions

Participants were asked to list up to five challenges or objections to prehospital temperature measurement based on their own experience. They responded by email to the research team. Short explanatory comments could be included if necessary. All suggestions were sorted by the authors; duplicates were removed and a list of all disparate suggestions was compiled.

#### Phase 2: ranking of suggestions

A list of the different suggestions was emailed back to the participants and they were asked to individually rank the top 10 suggestions according to relevance and importance. At this point, the participants were informed that the 10 highest ranked suggestions overall would be discussed in detail in the upcoming group discussion. Ten was deemed a feasible number to cover during a 1-day consensus meeting.

An overall ranking was then calculated from the individually submitted rankings by awarding 10 points to the highest ranked suggestion, 9 points to rank 2 and so on. In addition, 2 points were awarded whenever a suggestion was included in a participant's top 10 list, similar to the methodology by Fevang *et al.*<sup>33</sup>

#### Phase 3: consensus meeting

During a 1-day consensus meeting the top 10 ranked suggestions from phase 2 were discussed sequentially

starting with the highest scoring priority. Two additional highly ranked suggestions—one from the FW nurses and one from the HEMS doctors—that did not reach the overall top 10 were included as well. This was because these groups were relatively under-represented during the ranking process.

The physical meeting took place in February 2019 at the University of Tromsø and lasted for 6 hours, including breaks. The authors acted as group moderator (KF) and secretary (RWS). Only participants and researchers were present. The meeting was audio-recorded and written notes were taken. The moderator let all participants take turns to initiate discussion on the various suggestions and they were allowed to make their points without interruption by the other participants before the rest could join the discussion of the topic. This facilitated active involvement of all participants to enhance the discussion.

#### Phase 4: final comments and participant checking

A written summary describing the themes and subthemes produced from the analysis of the consensus meeting discussion, with explanations, was emailed to the participants for participant checking and to gather final comments. Participants unable to attend the meeting also received this summary with the encouragement to provide supplementary comments. This was to ensure that we did not miss out on important insight from non-attending participants that potentially could help further development of the themes. Neither attending nor non-attending participants provided additional feedback on the written summary.

#### Analysis

One of the authors (RWS) transcribed the audio recording from the meeting *ad verbum*. Participants were anonymised before the transcript was reread for familiarisation, and memo notes about first impressions were made. An inductive thematic analysis of the research data was conducted based on the guide written by Braun and Clarke.<sup>34</sup> Inductive means that the themes were derived from the data, as opposed to a deductive approach where the analysis is driven by the researcher's pre-existing theories and ideas. The analytic process was approached with a realist framework, focusing on individual participants' actual experiences and their described realities from the field regarding problems with prehospital temperature measurement. Themes were identified and approached at a semantic level, meaning that the analysis was conducted based on the surface meaning of the data, as opposed to a latent level which attempts to discover underlying meanings.

Initially an open coding was performed, by going thoroughly through the transcript and labelling all sentences and paragraphs thought to be relevant into codes. Next, a process of categorisation was done; similar codes were grouped together under describing names and initial codes regarded as irrelevant were discarded. Subsequently, codes were sorted into more general themes. These themes went through multiple modifications

ensuring that all relevant data were represented, before eventually being finalised. Subthemes were generated for comprehensive themes where appropriate. NVivo qualitative data analysis software (V.12, QSR International) was used during the analysis, and the Consolidated criteria for Reporting Qualitative research checklist<sup>35</sup> was applied to ensure a thorough process.

Written, informed consent was obtained for participation and audio recording from all participants.

#### Patient and public involvement

None was involved.

## RESULTS

Out of 14 invited employees, 13 accepted the invitation. The four HEMS doctors were all certified specialists in anaesthesiology, aged 44–58, and all were male and had worked in the HEMS between 6 and 22 years. The four FW nurses were aged 42–65, both female and male, had between 7 and 30 years of experience within the service, and were certified nurse specialists in either anaesthesia or critical care. The five GA personnel were paramedics, aged 24–51, both female and male, and had worked between 6 and 22 years in the service. All 13 participated in phases 1 and 2. The first phase generated 63 suggestions, which were reduced to 24 disparate suggestions after removing duplicates (table 1). The top 10 overall suggestions included in the consensus meeting are shown in table 2, and the top 5 suggestions for the individual occupations are shown in table 3. Table 3 also displays the two additional suggestions included in the consensus meeting, labelled with asterisks. Two flight nurses (2 out of 2 women), three anaesthesiologists and two paramedics (0 out of 2 women) participated in the consensus meeting. The remaining participants were unable to attend due to busy time schedules (5 out of 13) or illness (1 out of 13).

During analysis, 47 codes were grouped together into 6 overarching themes, with a total of 12 subthemes (figure 1). The research question explores two elements: challenges to prehospital thermometry and suggestions for solutions. Four of the resulting themes relate to challenges and two relate to solutions.

#### Challenges and objections

##### Theme 1: equipment dissatisfaction

Lack of adequate equipment for thermometry was emphasised as a prominent issue. Quick and simple methods such as axillary, tympanic and oral measurements were deemed unreliable, thought to often give falsely too low values.

And that is a feeling I have had several times. I have been sitting there, wondering why I am spending valuable time on getting that temperature measurement. I know that it won't be correct. (Participant 13)

**Table 1** All disparate suggestions from the participants

Challenge or objection	
1	Axillary thermometer is inaccurate and difficult to establish properly, especially in a moving vehicle.
2	Thermometry is forgotten or omitted due to lack of time and/or it being subordinated by other measures.
3	Administration's accentuation of the costs of disposable equipment makes measuring demotivating.
4	Undressing patients for rectal measurement exposes them to cold.
5	Moving patients between vehicles may expose them to cold weather.
6	Rectal measurement is considered contraindicated in patients with pelvic fractures*.
7	Rectal measurement is considered unhygienic.
8	Personnel experience high threshold for establishing a rectal probe.
9	Body temperature is rarely requested on patient handover at the emergency department.
10	Temperature measurement may be omitted in favour of a subjective evaluation.
11	Little focus on hypothermia in the professional environment when hypothermia is not the primary issue.
12	Lack of sufficient heat-preserving equipment in the EMS†.
13	Motor restlessness and non-cooperative patients due to hypothermia might complicate measurements.
14	Negligence of the potential importance of temperature measurement in seemingly healthy patients.
15	Rectal temperature is often perceived as unnecessary, intimate and/or unworthy for the patient.
16	Establishing a rectal probe is time-consuming.
17	Increasing the temperature in the ambulance is time-consuming.
18	Patient and personnel might perceive the ambient temperature differently‡.
19	Available equipment for measuring is considered unreliable and/or inconvenient.
20	Recognising the necessity of a temperature measurement is sometimes difficult.
21	Proper fixation of the probe for continuous monitoring is sometimes difficult.
22	Difficulties establishing the equipment for measurement§.
23	Difficulties choosing the most suitable area of measurement.
24	Equipment for measuring ear temperature is perceived as inaccurate.

All disparate suggestions from the participants after removal of duplicates. The symbols show explanatory comments given by the participants where necessary.

\*Rectal measurement requires movement of the pelvic area or the lower extremities.

†Active heating blankets are only available in the HEMS. Wool blankets are described as potentially inadequate.

‡Different clothing between patient and personnel and/or increased body temperature in personnel due to labour.

§When the patient is strapped to the stretcher, heavily dressed and wrapped in blankets, it is difficult to properly establish a rectal or axillary probe. Equipment for ear temperature in the field is described as too large.

EMS, emergency medical services; HEMS, hospital emergency medical service.

This was explained as an important reason for omitting a measurement. Rectal probes were considered reliable, but in many situations inconvenient and difficult to establish properly, particularly when patients are already secured to the stretcher under clothes and duvet. This was also true for the axillary thermometer.

Placing a rectal probe is time consuming. If the patient is packed within a duvet, you have to remove and perhaps cut their clothes open, position them sufficiently, and attempt to properly apply the probe, all in the cramped space. This takes time, and during this process, monitoring cables might tangle, ECG-electrodes may be pulled off, and suddenly, your only iv access is gone as well. It is very cumbersome. (Participant 13)

Seat belts limiting personnel movement and cramped space, especially inside the helicopter, further

complicated this issue. Furthermore, unbuckling while in motion violates the health, safety and environment (HSE) regulations.

Our patients are strapped to the stretcher for safety reasons. We cannot begin unbuckling them during transportation, and hence it's a problem if we don't establish a probe before we start transportation. (Participant 9)

Discomfort was also an issue. Placing a rectal temperature probe was considered embarrassing and uncomfortable for both patients and personnel, especially with conscious patients. It was regarded as an invasion of privacy, especially if the indication of a temperature measurement was unclear. Regardless, all participants agreed that this threshold should be—and in most situations was—exceeded and that an accurate temperature measurement was conducted when indication was clear.



**Table 2** Top 10 overall highest ranked suggestions

Rank	Challenge/objection
1	Thermometry is forgotten or omitted due to lack of time and/or it being subordinated by other measures.
2	Difficulties establishing the equipment for measurement.
3	Undressing patients for rectal measurement exposes them to cold.
4	Temperature measurement may be omitted in favour of a subjective evaluation.
5	Available equipment for measuring is considered unreliable and/or inconvenient.
6	Personnel experience high threshold for establishing a rectal probe.
7	Axillary thermometer is inaccurate and difficult to establish properly, especially in a moving vehicle.
8	Negligence of the potential importance of temperature measurement in seemingly healthy patients.
9	Little focus on hypothermia in the professional environment when hypothermia is not the primary issue.
10	Motor restlessness and non-cooperative patients due to hypothermia might complicate measurements.

The overall top 10 ranked challenges with, and objections to, prehospital temperature measurement, as ranked by the participants. For the individually submitted rankings, 10 points were awarded to the highest ranked suggestion, 9 points to rank 2 and so on. In addition, 2 points were awarded whenever a suggestion was included in a participant's top 10 list.

Of course, it is uncomfortable. However, in situations where it really matters, where a temperature measurement is important, there should not be a threshold regarding removing the patient's clothes. Even though it might be an uncomfortable setting, it is an important parameter. It is a reliable measurement. (Participant 1)

Discomfort with an oesophageal probe was also brought up during the discussion. All participants agreed that this technique was only practically feasible in sedated patients because of the displeasure associated with the procedure. However, this was also difficult to establish correctly,

and blind introduction of the probe entailed a risk of the probe curling back into the pharynx, measuring the pharyngeal temperature. A correctly established probe, which was considered reliable by the participants, may also initially give misleading readings if the stomach and oesophagus are filled with cold liquids.

The participants considered it probable that lack of reliable equipment could be a useful reason for not measuring patient temperature. In some situations, a subjective assessment of the patient's temperature (eg, feeling the skin temperature with one's hand or asking the patient if they were cold) could easily replace actual

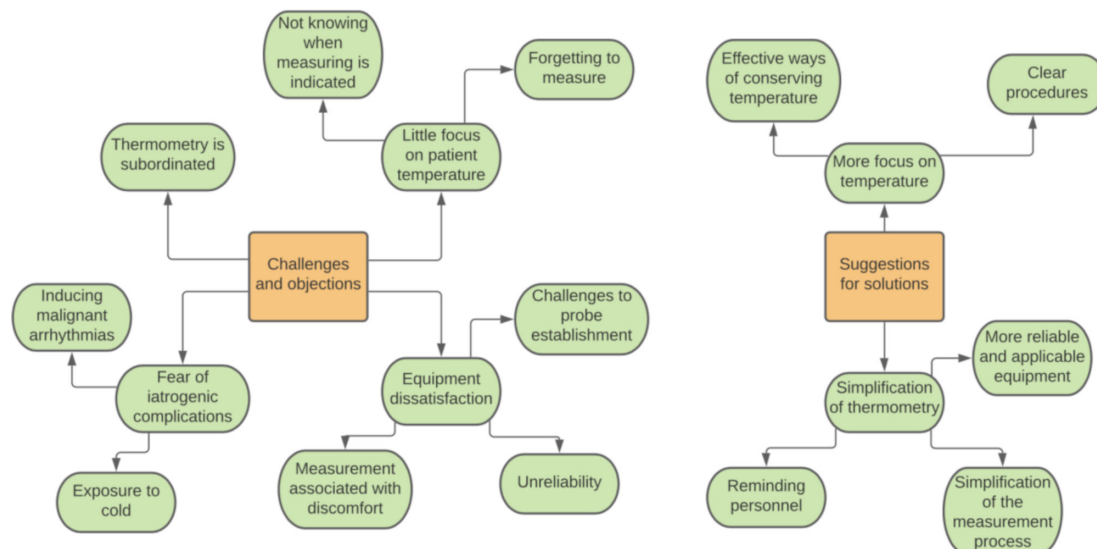
**Table 3** Top 5 suggestions for each occupational group

	Rank	Challenge/objection
GA	1	Axillary thermometer is inaccurate and difficult to establish properly, especially in a moving vehicle.
	2	Undressing patients for rectal measurement exposes them to cold.
	3	Difficulties establishing the equipment for measurement.
	4	Thermometry is forgotten or omitted due to lack of time and/or it being subordinated by other measures.
	5	Personnel experience high threshold for establishing a rectal probe.
FW	1	Thermometry is forgotten or omitted due to lack of time and/or it being subordinated by other measures.
	2	Negligence of the potential importance of temperature measurement in seemingly healthy patients.
	3	Temperature measurement may be omitted in favour of a subjective evaluation.
	4	Difficulties establishing the equipment for measurement.
	5*	Patient and personnel might perceive the ambient temperature differently.
HEMS	1	Available equipment for measuring is considered unreliable and/or inconvenient.
	2	Thermometry is forgotten or omitted due to lack of time and/or it being subordinated by other measures.
	3*	Equipment for measuring ear temperature is perceived as inaccurate.
	4	Difficulties establishing the equipment for measurement.
	5	Temperature measurement may be omitted in favour of a subjective evaluation.

The top 5 suggestions within each participant group.

\*Highly ranked suggestions not included in the overall top 10.

FW, fixed wing (ambulance); GA, ground ambulance; HEMS, helicopter emergency medical service.



**Figure 1** Overview of themes and subthemes from the inductive thematic analysis, split into challenges and objections, and suggestions for solutions, respectively. The main categories are displayed in orange, while related themes and subthemes are shown in green.

measurement. In other situations, a measurement would have no consequence because actions to preserve body temperature had already been taken, or a temperature measurement would not be relevant for the respective patient's presenting condition.

Regardless, we provide these patients with basic temperature conserving interventions including active heating blankets, and we increase the cabin temperature. In most cases, an extreme deviation in temperature would be necessary for me to prioritize further interventions. (Participant 7)

The participants emphasised the importance of being aware of equipment limitations. Uncritical use could lead to overtriage due to falsely low measurements, which in turn could lead to unnecessary use of resources—in worst case initiating the establishment of extracorporeal membrane oxygenation in unresponsive patients. Lastly, the assumption that the patients would have a new rectal probe placed after admission also led to omitting temperature measurement in some situations.

### Theme 2: little focus on patient temperature

According to the participants, body temperature was seemingly not considered very important in the professional environment. Unawareness of its importance could result in the temperature not being monitored. This was especially relevant in complex patients where hypothermia did not present itself as an obvious issue.

I don't see the point of doing a temperature measurement in a situation where I don't understand why it is important or necessary, or what I should do with the result. (Participant 9)

Sometimes, thermometry was simply forgotten. This was partly explained by the abovementioned reasons.

However, another important reason was that patients and PHC providers sometimes experienced ambient temperature differently. This was relevant in situations where the personnel had worked hard physically. When warm and sweaty, it was simple to forget that the patient might be immobilised and cold. This discrepancy was especially relevant in the FW service because the cabin heating outlet was placed close to the nurse's position. However, the nurses were aware of this issue and regularly removed unnecessary personal clothing if they felt warm. This was more difficult in the HEMS, where the crew normally is dressed for outdoor work even during flight, sometimes also including survival suits. Furthermore, neither the HEMS nor the FW services had cabin thermometers showing the ambient temperature, which the participants meant could serve as a reminder to check patient temperature.

### Theme 3: fear of iatrogenic complications

Fear of causing additional harm was brought up as an issue. Undressing the patient to measure the temperature would often conflict with temperature conservation measures. The participants emphasised the importance of considering whether exposing the patient to establish a temperature probe was worth it or if it should be omitted to avoid heat loss. The possibility of inducing arrhythmias was also mentioned in patients with severe hypothermia, especially those with a core temperature of 30°C or below. Establishing an oesophageal probe in these patients may provoke malignant arrhythmias, and this potential complication made the personnel reluctant to use rectal probes as well.

It was considered important to avoid patient exposure to cold environment due to possible loss of body heat with its following complications. However, this was in many situations challenging. Even though the personnel

actively attempted to keep high temperatures inside the patient compartments, heat immediately escaped when doors were opened, especially during winter and on helicopters which have big, sliding doors. Both the HEMS and FW environments are particularly exposed to cold temperatures due to thin fuselages and high altitudes. FW nurses attempted to counter this issue with frequent use of blankets.

#### Theme 4: thermometry is subordinated

It was emphasised that a critically ill patient with problems related to airways, breathing or circulation (ABC) demands other priorities before measuring body temperature, which for this reason sometimes was delayed, omitted or even forgotten. This was especially relevant for short missions with limited time for necessary prehospital diagnostics and treatments. It also applied to situations requiring focused ABC interventions followed by immediate transportation, where HSE measures limited access to the patient:

In regard to forgetting, we have to remember that it's called ABCDE. Exposure is at the bottom of the list, which means that we should always prioritize airways, breathing, circulation before we address the temperature. Obviously, there are patients where we might forget to conduct a temperature measurement due to having full focus on the basics. (Participant 5)

#### Suggestions for solutions

##### Theme 5: more focus on temperature

More focus on body temperature within the organisation was emphasised as important to ensure more frequent temperature measurements, especially when it was clearly indicated. Increasing personnel enthusiasm was also believed to be important, by increasing awareness, especially in situations where it might not be obvious that the patient is at risk of hypothermia:

I would like more training and understanding as to why a temperature measurement could be important. If I understand why it could be important to measure temperature on a patient who seemingly have no deviations in temperature, it might be easier to do. (Participant 9)

Developing clear guidelines was also suggested, for example, by listing conditions and situations where thermometry should be considered because it has potential consequences for the patient. Such guidelines should also explain why measuring is relevant in a listed patient category.

I believe the threshold for measuring would be lower if we had a list of "yes-patients" regarding temperature measurement. It would be easier to get at it if we know that our patient is within the target group where a temperature measurement is important, and that it will be valuable for those taking over after us. (Participant 9)

#### Theme 6: simplification of thermometry

Simplification of techniques and reliable methods could also increase the frequency of measurement. Rectal and oesophageal probes are both available and reliable, although in many situations considered not applicable. The mini digital thermometer used in the HEMS instead of the larger multimonitor was one example of more applicable equipment. Simplifying the workflow also felt important, with reference to intubated HEMS patients, where thermometry has been included in the preanaesthesia induction checklist and the probe is placed in the intubation kit. A similar level of simplicity was requested for non-intubated patients. Lastly, several participants suggested that introducing cabin thermometers in the vehicles would help to remind them about temperature management.

#### DISCUSSION

We have discovered several challenges and objections suggesting that prehospital thermometry still is an unsolved issue. The participants described lack of reliable equipment for temperature monitoring that was feasible in prehospital environments and stated that body temperature monitoring is not given high priority in the service. Fear of causing iatrogenic complications was also important and temperature measurement was often subordinated by other measures and even forgotten in time-critical situations. Some possible solutions were suggested: to increase focus on monitoring and conservation of patient temperature and to facilitate the procedure as much as possible.

The suggested solutions may not be surprising, given that the prehospital practitioners describe a procedure that is cumbersome and time-consuming, often unreliable and often not requested by the in-hospital teams on patient handover. One must keep in mind that this notion may have influenced participants' suggestions for solutions. Personnel dissatisfaction with the available equipment has also been described by others and is a major unsolved problem in PHC.<sup>29</sup> Apart from this, the prehospital setting with challenging climate, tight spaces and inconvenient locations limits the feasibility of most existing methods for temperature monitoring. The discussion about a high threshold for using the rectal temperature probe further illustrates the issue. It is irrelevant that rectal temperature is reliable prehospitally if the personnel are reluctant to use it. However, it must be emphasised that thermometry is not equally important in all patients, and this issue mainly appeared as a problem when the indication for a reliable measurement was unclear.

Regardless, many patients benefit from a precise temperature measurement and might suffer due to the technical limitations accompanying the equipment currently in use. Therefore, developing more reliable and suitable equipment for prehospital measurement is of utmost importance. We also support participants'



suggestions of personnel education and developing protocols specifying patients and conditions where an accurate temperature measurement is important. A precise measurement should be prioritised in patients where deviations from normal core temperature have clear clinical implications for diagnostics or treatment. A consensus-based protocol, specifying that, for example, critically ill patients and patients in general anaesthesia and multitrauma always should be monitored, may increase the frequency of temperature monitoring when the indication is strong. This could reduce the risk of deliberate use of potentially unreliable techniques, such as axillary or tympanic probes, or in the worst case to refrain from measuring at all.<sup>28 29</sup>

Active patient temperature conservation was discussed during the group meeting. This might easily be forgotten in stressful clinical situations. More focus on temperature monitoring as well as protocols on temperature conservation would serve as reminders to always keep the doors shut and frequently apply duvets, hypothermia bags and even external heaters for selected groups of patients.

Lastly, it is important to remember that the argument that simple measurement methods are considered unreliable is, however, only relevant in diagnosing hypothermia. It is unlikely that modern equipment will show a higher temperature than what is present, and thus an increased temperature should be trusted to confirm a fever and a normal temperature excludes hypothermia. Still, the PHC environment awaits reliable and feasible techniques and equipment with such a level of simplicity that the personnel will not hesitate to measure temperature.

### Strengths and limitations

The study design, with collection of individually suggested topics before the participants met, reduced the potential influence of dominating personalities in the selection of topics.<sup>31</sup> Several measures were also taken to minimise the impact of the researcher's own beliefs and thereby contamination of the results with subjectivity. Most of the communication prior to the meeting was done by the first author, a medical student with limited PHC experience. Furthermore, the topics for the group discussion were defined by the participants. The discussion was also driven solely by the participants, and the researchers actively avoided sharing their own ideas. Reflexivity was an important part of the methodological approach, especially since the group moderator also worked as an anaesthesiologist at the UNN HEMS. Furthermore, we believe that a semantic, instead of a latent, analysis reduced the risk of bias, as an attempt to discover underlying ideas likely could be more prone to researcher bias. Participant checking was done after the analysis to ensure that the researchers' interpretations did not introduce bias. Direct participant quotes have also been included to support the analysis.

The ad verbum transcription of the consensus meeting was written, coded and analysed by a researcher who was present at the meeting, which we believe gave us a better

foundation to contextualise and tie verbal comments to non-verbal behaviour, compared with paid external assistance with the transcription. Inconsistencies and incorrect transcription would have been a large source of bias contaminating analytic process, which we attempted to avoid. Furthermore, having a fully transcribed data set, compared with relying solely on memory and notes taken during the meeting, also reduced the risk of omitting anything important due to oversight. The data were however coded and analysed by just one researcher. This introduced a theoretical risk of losing insight presented by another researcher, but we attempted to reduce this risk by frequent discussions within the research group.

To ensure a rich capture of themes, we invited experienced individuals. This selection may have influenced the topics that were discussed in the consensus meeting. Theoretically, less experienced participants or a random sample of employees might have revealed other topics, but we believe that our purposeful sampling gave a satisfying capture, with a feasible number of participants. Unfortunately, regardless of several reschedules, we were unable to gather more than seven participants for the consensus meeting. Even though all participants were invited to provide additional comments to the written summary, valuable information and insight from non-attending participants may have been lost, especially since no participants provided additional comments.

Participants were recruited from just one PHC centre in Northern Norway, and potentially important insights from other centres are therefore not included. Regardless, cold environmental temperature and patient hypothermia are not specific to our region and we therefore believe that our results may be applied to other environments.

### CONCLUSION

This study supports introduction of PHC protocols for temperature measurement that specify which patients and conditions a precise measurement should have high priority. More focus on temperature in the professional environment, including personnel education, may be beneficial. Current equipment for temperature monitoring has a limited functionality outside the hospital and there is a profound need for developing suitable techniques and equipment.

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**Contributors** RWS and KF conceived the study. KF recruited the participants, while RWS collected and analysed the data prior to the consensus meeting. Both participated in the meeting. RWS analysed the data and drafted the manuscript. Both authors have revised and approved the final version. KF is the guarantor for the study.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.



**Patient consent for publication** Not required.

**Ethics approval** This study involves human participants but did not include health-related data and thus did not need approval from the regional ethical committee. The study did not need approval from the UiT data protection authorities as participants consented to participate voluntarily and anonymously and no sensitive information was collected.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon reasonable request. The transcript of the group discussion is in Norwegian language and is available upon reasonable request.

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#### REFERENCES

- Brown DJA, Brugger H, Boyd J, *et al.* Accidental hypothermia. *N Engl J Med* 2012;367:1930–8.
- Balvers K, Van der Horst M, Graumans M, *et al.* Hypothermia as a predictor for mortality in trauma patients at admittance to the intensive care unit. *J Emerg Trauma Shock* 2016;9:97–102.
- Rutherford EJ, Fusco MA, Nunn CR, *et al.* Hypothermia in critically ill trauma patients. *Injury* 1998;29:605–8.
- Shafi S, Elliott AC, Gentilello L. Is hypothermia simply a marker of shock and injury severity or an independent risk factor for mortality in trauma patients? analysis of a large national trauma registry. *J Trauma* 2005;59:1081–5.
- Reynolds BR, Forsythe RM, Harbrecht BG, *et al.* Hypothermia in massive transfusion: have we been paying enough attention to it? *J Trauma Acute Care Surg* 2012;73:486–91.
- Rubiano AM, Sanchez AI, Estebanez G, *et al.* The effect of admission spontaneous hypothermia on patients with severe traumatic brain injury. *Injury* 2013;44:1219–25.
- Ireland S, Endacott R, Cameron P, *et al.* The incidence and significance of accidental hypothermia in major trauma—a prospective observational study. *Resuscitation* 2011;82:300–6.
- Martin RS, Kilgo PD, Miller PR, *et al.* Injury-associated hypothermia: an analysis of the 2004 National Trauma Data Bank. *Shock* 2005;24:114–8.
- Wang HE, Callaway CW, Peitzman AB, *et al.* Admission hypothermia and outcome after major trauma. *Crit Care Med* 2005;33:1296–301.
- Eddy VA, Morris JA, Cullinane DC. Hypothermia, coagulopathy, and acidosis. *Surg Clin North Am* 2000;80:845–54.
- Beilman GJ, Blondet JJ, Nelson TR, *et al.* Early hypothermia in severely injured trauma patients is a significant risk factor for multiple organ dysfunction syndrome but not mortality. *Ann Surg* 2009;249:845–50.
- Mommsen P, Andruszkow H, Frömke C, *et al.* Effects of accidental hypothermia on posttraumatic complications and outcome in multiple trauma patients. *Injury* 2013;44:86–90.
- Schmied H, Kurz A, Sessler DI, *et al.* Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. *Lancet* 1996;347:289–92.
- Hofer CK, Worn M, Tavakoli R, *et al.* Influence of body core temperature on blood loss and transfusion requirements during off-pump coronary artery bypass grafting: a comparison of 3 warming systems. *J Thorac Cardiovasc Surg* 2005;129:838–43.
- Kirkpatrick AW, Chun R, Brown R, *et al.* Hypothermia and the trauma patient. *Can J Surg* 1999;42:333–43.
- Frank SM, Fleisher LA, Breslow MJ, *et al.* Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events. A randomized clinical trial. *JAMA* 1997;277:1127–34.
- Diaz M, Becker DE. Thermoregulation: physiological and clinical considerations during sedation and general anesthesia. *Anesth Prog* 2010;57:quiz 3–4:25–32.
- Sessler DI. Temperature monitoring and perioperative thermoregulation. *Anesthesiology* 2008;109:318–38.
- Winkler M, Akça O, Birkenberg B, *et al.* Aggressive warming reduces blood loss during hip arthroplasty. *Anesth Analg* 2000;91:978–84.
- Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. study of wound infection and temperature group. *N Engl J Med* 1996;334:1209–15.
- Melling AC, Ali B, Scott EM, *et al.* Effects of preoperative warming on the incidence of wound infection after clean surgery: a randomised controlled trial. *Lancet* 2001;358:876–80.
- Monsieurs KG, Nolan JP, Bossaert LL, *et al.* European resuscitation Council guidelines for resuscitation 2015: section 1. executive summary. *Resuscitation* 2015;95:1–80.
- Tsuei BJ, Kearney PA. Hypothermia in the trauma patient. *Injury* 2004;35:7–15.
- Weuster M, Brück A, Lippross S, *et al.* Epidemiology of accidental hypothermia in polytrauma patients: an analysis of 15,230 patients of the TraumaRegister DGU. *J Trauma Acute Care Surg* 2016;81:905–12.
- Kober A, Scheck T, Fülesdi B, *et al.* Effectiveness of resistive heating compared with passive warming in treating hypothermia associated with minor trauma: a randomized trial. *Mayo Clin Proc* 2001;76:369–75.
- Karlsen AM, Thomassen O, Vikenes BH, *et al.* Equipment to prevent, diagnose, and treat hypothermia: a survey of Norwegian pre-hospital services. *Scand J Trauma Resusc Emerg Med* 2013;21:63.
- Moran DS, Mendal L. Core temperature measurement: methods and current insights. *Sports Med* 2002;32:879–85.
- Niven DJ, Gaudet JE, Laupland KB, *et al.* Accuracy of peripheral thermometers for estimating temperature: a systematic review and meta-analysis. *Ann Intern Med* 2015;163:768–77.
- Podsiadlo P, Darocha T, Kosiński S, *et al.* Body temperature measurement in ambulance: a challenge of 21-st century? *BMC Emerg Med* 2019;19:44.
- Delbecq AL, Van de Ven AH. A group process model for problem identification and program planning. *J Appl Behav Sci* 1971;7:466–92.
- Palinkas LA, Horwitz SM, Green CA, *et al.* Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Adm Policy Ment Health* 2015;42:533–44.
- Dunnette MD, Campbell J, Jaastad K. The effect of group participation on brainstorming effectiveness for 2 industrial samples. *J Appl Psychol* 1963;47:30–7.
- Fevang E, Lockey D, Thompson J, *et al.* The top five research priorities in physician-provided pre-hospital critical care: a consensus report from a European research collaboration. *Scand J Trauma Resusc Emerg Med* 2011;19:57.
- Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006;3:77–101.
- Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care* 2007;19:349–57.