What is a scoping report?
Scoping reports ascertain the quantity and quality of the published clinical and cost effectiveness evidence on health technologies under consideration by decision makers within NHSScotland. They also serve to clarify definitions related to the research question(s) on that topic. They are intended to provide an overview of the evidence base, including gaps and uncertainties, and inform decisions on the feasibility of producing an evidence review product on the topic. Scoping reports are undertaken in an approximately 1 month period. They are based upon a high level literature search and selection of the best evidence that Healthcare Improvement Scotland could identify within the time available. The reports are subject to peer review. Scoping reports do not make recommendations for NHSScotland. Further information on scoping reports is available at www.healthcareimprovementscotland.org.

Key definitions

Temporal artery thermometer (TAT): The TAT is a hand-held, battery-operated device which uses infrared detection technology to calculate skin temperature over the temporal artery (forehead) area, as a proxy for measuring core temperature. The device repeatedly samples the skin temperature of the forehead and the ambient temperature and uses equations of heat loss to arrive at an estimate.

Infrared in-ear thermometer (IRET): The IRET is a hand-held, battery-operated device with a probe which is inserted into the ear canal. The probe does not make contact with the tympanic membrane but detects infrared energy emitted from the membrane and combines this with readings from the ear canal to calculate a proxy for core temperature using heat loss equations.

Background
Measurement of core body temperature to detect or monitor fever or hypothermia is vital to guide patient assessment and management. Important patient groups include neonates, immune compromised patients and those receiving postoperative care. Specific clinical scenarios will present different temperature ranges over which accuracy is required and patient groups will have a range of needs with respect to how appropriate or acceptable invasive techniques may be.

When assessing any new diagnostic test, measurement against a standard is required. Measurement of pulmonary artery (PA) temperature using a thermistor within a catheter is regarded as the gold standard to which other methods of temperature assessment should be compared. Measurement of temperature at other internal body sites such as the oesophagus or bladder have been used as an alternative standard in diagnostic validation studies. Studies in infants and children commonly report measurement of rectal temperature as a standard for assessment of new technologies.

TAT is a non-invasive method of intermittent temperature assessment which became commercially available in 1999. Scanners may operate with or without skin contact depending on the type of device. The present report excludes non-contact devices and wireless TAT. It includes studies which used Exergen devices named as follows: TemporalScanner LXTA®, TAT-5000® or SensorTouch®. The technology is similar to that employed in IRET. As with IRET, it is unsuitable for use in clinical environments where the temperature of the patient is being externally manipulated, eg where an incubator is being used. Environmental and clinical issues of consideration for TAT include air flow across the face, diaphoresis (sweating) and the impact of vasopressor medications.
The following questions were scoped:

The first two were developed to determine the effectiveness of TAT in comparison with reference standards. The third explored the evidence base for TAT to potentially replace IRET in routine clinical practice, in line with the topic as referred.

1. What is the published evidence base for the clinical effectiveness of TAT in adults and in infants and children when compared with an appropriate gold standard?

2. What is the published evidence base for the clinical effectiveness of TAT in adults and in infants and children when compared with rectal temperature measurement?

3. What is the published evidence base for TATs compared with IRETs for temperature assessment in routine clinical practice, in terms of:
   a. clinical effectiveness
   b. cost effectiveness
   c. utility (including safety, ease of use and patient acceptability)

Evidence base

Table 1 Included evidence sources

<table>
<thead>
<tr>
<th>Publication type</th>
<th>Number of publications</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health technology assessment</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Systematic reviews and evidence summaries</td>
<td>3</td>
<td>4,14,16</td>
</tr>
<tr>
<td>Method comparison study*</td>
<td>22</td>
<td>5–10,12–13,15,17–29</td>
</tr>
</tbody>
</table>

*Method comparison studies use paired measurements taken either simultaneously or sequentially (in random order) and compare the results of the new method with the established method in association with pre-specified values for clinically acceptable difference. Measurements should be made within the physiological range of values for which the methods will be used. The majority of the method comparison studies were identified within the reviews.

Findings

1. What is the published evidence base for the clinical effectiveness of TAT in adults and in infants and children when compared with an appropriate gold standard?

**Adults**

A systematic review with limited literature search identified three method comparison studies comparing TAT with PA temperature measurement in acute care.

In the first study, temperature measurements from the two methods were compared in 15 adults recovering from cardiopulmonary bypass surgery. In all, 89% of TAT measurements differed from the pulmonary artery catheter measurements by greater than the pre-specified acceptable 0.5°C. The study concluded that the accuracy of TAT was insufficient for clinical use in this patient group.

The second study, in 57 adults admitted to medical or surgical intensive care units (ICU) found that TAT had comparable accuracy to PA measurements and relatively good reliability in patients with normothermia.

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A third study, also conducted in adult ICU patients (n=60), reported that 20% of TAT measurements were outside the 0.5°C clinically acceptable difference compared with PA measurements. Most measurements were conducted in normothermic patients.
The systematic review also identified a study comparing TAT with bladder temperature measurement in 70 neurosurgical patients. The limits of agreement were around three times greater than the specified 0.5°C, and the sensitivity and specificity for detecting fever and hypothermia were insufficient to support TAT as a method for perioperative temperature monitoring.

A further method comparison study was identified which compared intraoperative oesophageal temperature with TAT in 23 patients undergoing colorectal or gynaecological surgery. Only two of 46 measurements were outside the pre-specified 0.4°C clinically acceptable limit of agreement.

A comparison of eight non-invasive methods of temperature monitoring, including TAT, in 50 patients following laparoscopic surgery, noted that none consistently provided measurements within 0.5°C of bladder temperature.

**Infants and children**

A poorly conducted HTA from Singapore identified one study which compared TAT with bladder temperature in 36 critically ill children. The study concluded that TAT forehead temperature measurements are inaccurate, highly variable, and do not reflect core temperatures.

This is in agreement with an earlier study which found that 31% of temperature values in 16 infants and children recovering from cardiac surgery differed by more than 0.5°C from bladder temperatures.

A manufacturer-funded pilot study in 80 mainly afebrile children (mean age 45 months) found good agreement between oesophageal and TAT temperatures.

**Summary**

In most studies, TAT was found to be insufficiently accurate when compared with an appropriate standard in both adult and paediatric inpatient settings. The invasive nature of the gold standard measure is likely to account for the lack of studies conducted in outpatient or community settings.

2. What is the published evidence base for the clinical effectiveness of TAT in adults and in infants and children when compared with rectal temperature measurement?

**Adults**

A Norwegian systematic review conducted in 2008 was unable to identify any prospective studies comparing TAT with rectal thermometry in adults in emergency wards, general wards or nursing homes.

The English language abstract of a study published in Norwegian concluded that the sensitivity of the infrared temporal thermometer for detecting rectally measured fever is too low to recommend its use in adult intensive care patients.

**Infants and children**

A review summarised three studies comparing TAT with rectal temperature measurement in infants. In one study, sensitivity of TAT to detect fever measured by rectal temperature was limited (66%) in 304 infants aged less than 1 year presenting to a paediatric emergency department.

Another study examined the use of TAT temperature cut off values for prediction of fever measured by rectal temperature in infants. It concluded that TAT is not sufficiently reliable at screening for fever measured by rectal thermometer in infants under 3 months but may be adequate to screen for fever measured by rectal thermometer in older infants and young children.

In the third study (n=200), the sensitivity and specificity of TAT for fever measured by rectal temperature was 83% and 86% respectively which represented insufficient diagnostic accuracy for use in this population of infants aged under 3 months.

Five additional studies were identified which included comparison of TAT with rectal temperature measurement in children. A range of age groups and clinical settings was examined, and the limits of clinically acceptable agreement ranged from 0.4 to 1.0°C. Most of the studies concluded or suggested that TAT was not sufficiently accurate to be used for the detection of fever measured by rectal temperature in the clinical setting although there were some suggestions that it may be used as a screening tool.
Summary

Most studies where comparison was made with rectal temperature concluded that TAT was not sufficiently accurate for detection of fever measured by rectal temperature.

3. **What is the published evidence base for the clinical effectiveness, cost effectiveness and utility (including safety, ease of use and patient acceptability) of TATs compared with IRETs for temperature assessment in routine clinical practice?**

Table 2 summarises the findings of six studies which compared TAT and IRET alongside reference standards.

### Table 2 TAT versus IRET versus reference standard

<table>
<thead>
<tr>
<th>Study/population</th>
<th>Reference standard</th>
<th>TAT</th>
<th>IRET</th>
<th>Conclusions from study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenes et al.(^{17})</td>
<td>Rectal temperature</td>
<td>Sensitivity to detect rectal fever: 0.66</td>
<td>Sensitivity to detect rectal fever: 0.49</td>
<td>TAT is more accurate than the tympanic thermometer in infants, and it is better tolerated by infants than rectal thermometry.</td>
</tr>
<tr>
<td>304 infants under 1 year, emergency care</td>
<td></td>
<td>Sensitivity to detect high rectal fever: 0.94</td>
<td>Sensitivity to detect high rectal fever: 0.76</td>
<td></td>
</tr>
<tr>
<td>Lawson et al.(^{7})</td>
<td>Pulmonary artery temperature</td>
<td>20% of readings with difference of ±0.5°C from standard</td>
<td>49% of readings with difference of ±0.5°C from standard</td>
<td>Temporal artery measurements were more accurate and precise than ear measurements.</td>
</tr>
<tr>
<td>60 adults with cardiopulmonary disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frommelt et al.(^{26})</td>
<td>Oral temperature</td>
<td>6% of readings with difference of ±2°F</td>
<td>18% of readings with difference of ±2°F</td>
<td>TAT had less variation from reference temperatures than IRET.</td>
</tr>
<tr>
<td>84 adult postoperative patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kirk et al.(^{27})</td>
<td>Brain temperature* (*Brain temperature is not a standard for core temperature)</td>
<td>Range in difference from brain temperature: -0.7 to 1.5°C</td>
<td>Range in difference from brain temperature: -0.8 to 2.5°C</td>
<td>TAT is closer to brain temperature than IRET at temperatures within the normal to febrile range.</td>
</tr>
<tr>
<td>20 patients aged 17-76 with severe traumatic brain injury</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fountain et al.(^{28})</td>
<td>Oral temperature</td>
<td>8% of readings with difference of ±2°F</td>
<td>7% of readings with difference of ±2°F</td>
<td>Both TAT and IRET have significant and clinical differences from electronic oral temperatures.</td>
</tr>
<tr>
<td>60 adult oncology inpatients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nimah et al.(^{12})</td>
<td>Bladder temperature</td>
<td>0.56 ± 1.81°F Less than bladder temperature</td>
<td>0.03 ± 1.43 °F Less than bladder temperature</td>
<td>IRET measurements more accurately reflect core (bladder) temperatures than TAT in febrile and nonfebrile periods in children.</td>
</tr>
<tr>
<td>36 critically ill children aged under 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A method comparison study which compared TAT and IRET with each other without the use of a separate standard was also identified. It compared temperature measurements taken using TAT and IRET in adult peri-anaesthesia patients (n=222). Statistical analysis showed that the two measurements are related and vary together, but are not equivalent and, therefore, cannot be substituted for each other. If TAT is to be used in place of the IRET, it must be used consistently, and TAT and IRET values should not be directly compared.

**Utility**

One study measured the tolerability of temperature measurement devices in infants, and found that TAT and IRET were similarly associated with lower discomfort scores than rectal thermometry. No peer-reviewed published evidence on safety, including cross-contamination risk, was identified. An evaluation of TAT use in an adult acute care setting in the United States noted poor use of measurement technique and poor knowledge of correct cleaning procedures.

**Cost effectiveness**

No published economic evaluations were identified on the cost effectiveness of TAT versus IRET.

**Table 3 Procurement prices for IRET and TAT**

<table>
<thead>
<tr>
<th>Technology</th>
<th>General Cost (£) range per item</th>
<th>National contract/NHS supply chain/board Cost (£) range per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tympanic IRET thermometer</td>
<td>10–216</td>
<td>120–170</td>
</tr>
<tr>
<td>Tympanic IRET thermometer probe covers</td>
<td>0.04–0.15</td>
<td>0.04–0.06</td>
</tr>
<tr>
<td>TAT thermometer</td>
<td>300–431</td>
<td>430</td>
</tr>
<tr>
<td>TAT thermometer probe covers</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>TAT alcohol wipe</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

a. IRET – Covidien dominant market share in NHSScotland (90%); typically provide IRET thermometer free of charge (with lifetime unlimited guarantee) then charge for the probe covers.


c. TAT – Exergen is the sole supplier of these products to NHSScotland (GE Healthcare UK are the only UK agent).

d. Manufacturer list price £97.00 per box of 1,000 covers. The manufacturer notes, however, that considerable savings on this price can be negotiated, presumably dependent upon contract and volume.
Summary
Evidence from a range of adult and paediatric patient groups suggests that TAT is insufficiently accurate for clinical use in inpatient settings when compared with an appropriate gold standard. Where comparison was made with rectal temperature, most studies concluded that TAT was not sufficiently accurate for detection of fever measured by rectal temperature.

Six studies comparing both TAT and IRET with various reference standards in a range of patient groups have reported inconsistent results, with four studies favouring TAT. From the published literature, it is not possible to reach firm conclusions on the relative benefits and costs of TAT compared with IRET due to the degree of heterogeneity in the reference standards and patient groups, and the lack of information on safety and cost effectiveness.

Further work for Healthcare Improvement Scotland
This brief examination of the published literature indicates the complexity of comparisons for non-invasive assessment of core temperature. Extrapolation of the findings from one clinical setting to another is not straightforward. In particular, the accuracy and utility of a device in normothermic patients cannot be translated into clinical situations where hyperthermia or hypothermia is likely to be encountered.

While there is sufficient published clinical evidence to develop an evidence note, or series of evidence notes, comparing TAT with IRET or other relevant comparator(s) for specific patient groups of interest to NHSScotland, no evidence on cost effectiveness was identified.

A number of centres in NHSScotland are assessing TATs and non-contact infrared technologies. There could be an opportunity for SHTG to work in partnership with the services involved to help define robust clinical questions which clearly specify the intervention comparisons, the clinical situation and patient group, and the thresholds of accuracy required to deliver appropriate patient management and consider infection risk as an outcome.

Equality and diversity
Healthcare Improvement Scotland is committed to equality and diversity in respect of the nine equality groups defined by age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion, sex, and sexual orientation. As a scoping report summarises information and does not provide recommendations a full EQIA assessment is not deemed necessary.

The scoping report process has been assessed and no adverse impact across any of these groups is expected. The completed equality and diversity checklist is available on www.healthcareimprovementscotland.org

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References

14. Norwegian Knowledge Centre for the Health Service. The diagnostic accuracy of infrared tympanic, oral, axillary and temporal thermometry, compared with rectal readings when identifying fever in adult hospitalized patients: 3-page executive summary [online]. 2009 [cited 2012 Nov 21]; Available from: http://www.kunnskapsenteret.no/Publikasjoner/Diagnostikk+n%C3%B8yaktighet+av+%C3%B8re-%2C+munnhule-%2C+armhule-%2C+og+pannetermometer+sammenliknet+med+reaktaltermometer+for+%C3%A5+identifisere+feber+hos+voksne+pasienter+innlagt+i+sykehus+eller+sykehjem.6875.cms?language=english&threepage=1
References continued


