Preventing bath water scalds: a cost-effectiveness analysis of introducing bath thermostatic mixer valves in social housing

Ceri J Phillips, Ioan Humphreys, Denise Kendrick, Jane Stewart, Mike Hayes, Lesley Nish, David Stone, Carol Coupland, Elizabeth Towner

ABSTRACT

Aims To assess the cost-effectiveness of installing thermostatic mixer valves (TMVs) in reducing risks of bath water scalds and estimate the costs of avoiding bath water scalds.

Methods The evaluation was undertaken from the perspective of the UK public sector, and conducted in conjunction with a randomised control trial of TMVs installed in social housing in Glasgow. Installation costs were borne by the social housing organisation, while support materials were provided by the UK NHS. Effectiveness was represented by the number of families with at-risk bath water temperatures pre- and post-installation, and the number of bath scalds avoided as a result of installation. Differences in the number of families with at-risk temperatures between groups were derived from the RCT. Cost-effectiveness was assessed and a series of one-way sensitivity analyses were conducted.

Results Unit costs associated with installation were calculated to be £13.68, while costs associated with treating bath water scalds ranged from £25 226 to £71 902. The cost of an avoided bath water scald ranged from net savings to public purse of £1 41 saved for every £1 spent.

Conclusion It is very likely that installing TMVs as standard in social housing in new buildings and major refurbishments accompanied by educational information represents value for money.

Trial registration number ISRCTN:21179067.

INTRODUCTION

In April 2010 changes to the Building Regulations for England and Wales came into force, requiring that ‘the hot water supply to any fixed bath must incorporate measures to ensure that the temperature of the water that can be delivered to the bath does not exceed 48°C in new build houses and those where there is a change of use of the building.’ Thermostatic mixer valves (TMVs) are an engineering solution to this problem, but their cost-effectiveness in domestic settings has not been evaluated.

Scald injuries place a considerable burden on health services with the individual lifetime cost for treating a severe scald estimated to be as high as £250 000 and total annual health service costs in England and Wales to be over £61 million. Over 2600 bath water scalds occur each year in the UK.

Young children are at particular risk; more than 400 children under 5 years of age are admitted to hospital each year, and most hospital and paediatric burns centre admissions for bath water scalds occur in this age group, as do the most severe scalds. Social inequalities also exist, with admission rates for burns and scalds being over three times higher among children from disadvantaged areas compared with those from affluent areas.

Most bath hot water scalds occur from children falling or climbing unsupervised into baths, or turning on hot taps, or parents putting children into water that is too hot. In the UK, home water heater thermostats are frequently set at 60°C or above. At this temperature adults can suffer partial or full thickness burns after 5 and 5 seconds, respectively, with burns occurring in even shorter time periods in children. For these reasons, a bath hot water temperature no higher than 46°C–48°C is recommended.

Interventions to reduce scalds, such as tap water temperature testing and/or thermostat reduction do reduce water temperatures, but temperatures often remain above current recommended levels. Legislation to reduce thermostat settings has been more successful, with uncontrolled studies finding reductions in hospital admission rates, total body area burnt, the proportion needing skin grafts, and the proportion scarred. In general, it has been advocated that a combination of education and legislation is a more effective approach to prevention.

The economic literature in this area is sparse. Legislation to lower thermostat settings on domestic hot water heaters plus annual delivery of educational information to utility company customers has been estimated to generate cost savings of $CS51 per scald averted, but it has not been possible to find any published economic evaluations of TMVs in a domestic setting. This study therefore aims to assess the cost-effectiveness of installing TMVs and providing educational materials to families living in social housing, and to estimate the cost of avoiding a bath water scald as a result of adopting the strategy.

DESIGN AND METHODS

The economic evaluation was undertaken from a UK public sector perspective and conducted alongside a randomised controlled trial (RCT) of TMVs. The trial was conducted in Scotland, where building regulations require TMVs to be installed in new build properties and major...
refurbishments. Participants comprised families with children under 5 years of age living in accommodation provided by the Glasgow Housing Association, the largest social housing provider in Europe. The costs of purchasing, fitting, replacing, and repairing TMVs were borne by the Housing Association, while educational materials were provided by the NHS. Data relating to the cost of TMVs, their installation and repair were obtained from the Glasgow Housing Association and from the City Building (Glasgow) Limited Liability Partnership, who installed the TMVs. Data relating to the educational materials were obtained from NHS staff responsible for study implementation. Estimated costs of treatment and care following a bath scald were obtained from an impact assessment for amending Part G of the Buildings Regulations 2000. A sensitivity analysis was carried out using cost estimates based on the findings of the Hot Water Burns Like Fire (HWBLF) campaign response to the Part G Building Regulations consultation headed by Labour MP Mary Creagh. Participants were randomised to a treatment arm; those in the intervention arm were offered:

- An educational leaflet mailed prior to TMV fitting.
- A TMV set at a maximum temperature of 45°C fitted by a qualified plumber from City Building (Glasgow) Limited Liability Partnership.
- A waterproof educational guide on how to use the TMV attached to the tap by the plumber at installation.

Control arm families were offered the intervention after collection of follow-up data. The effectiveness indicators for use in the cost-effectiveness analysis were the number of families with at-risk bath water temperatures (defined as >46°C) before installation and at follow-up, and the number of bath scalds avoided as a result of installation of the TMVs. The difference in the number of families with at-risk bath water temperature in the installation group relative to the control group was obtained from the results of the trial, while the number of bath scalds likely to be avoided following installation of TMVs was estimated from the baseline risk of a severe bath scald, adjusted for the difference in risk reduction between intervention and control arms in the RCT.

Based on estimated numbers of UK emergency department (ED) attendances from the Royal Society for the Prevention of Accidents (RoSPA) (2002 HASS/LASS figures and personal communication with RoSPA), and the number of hospital admissions reported by the Department of Trade and Industry (DTI) in 1999, it has been assumed that approximately 1107 children aged 0–4 years attend an ED each year with bath water scald injuries. Of these, 249 require specialist treatment or hospitalisation of at least 5 days, and 188 are inpatients for less than 5 days; therefore 670 attend EDs but are not admitted to hospital (classed here as minor injuries). Additionally, DTI data report that an estimated 2.5 children aged 0–4 years die each year from bath scalds. However, fatalities are not included in the analysis or costing detailed in this paper.

There are an estimated 3496 200 children aged 0–4 years in the UK. The target group for this analysis is children in this age group living in social housing. However, there are no published figures for the number of 0–4-year-olds in social housing in the UK. Therefore, we have used the percentage of children living in low income households (30%), which equates to 1 048 860 children, and divided this by the average number of dependent children per family in UK households (1.8) to derive the number of ‘at-risk’ households of 582 700.

Further, given that not every child who attends the ED with a bath scald lives in social housing, the level of risk was based on published rates for hospital admissions for thermal injuries in children in England, by quintiles of the Townsend deprivation score.

### Table 1 Costs associated with the installation of thermostatic mixer valves (TMVs)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit cost (£)</th>
<th>Source of information</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation; costs incurred by Housing Association</td>
<td>£5.41</td>
<td>Housing Association documents</td>
<td>Annualised capital charges calculated using 3.5% annual discount rate (assuming TMVs need replacing every 10 years)</td>
</tr>
<tr>
<td>Cost of installation: simple fit requiring removal of bath panel, based on 2 h of plumber’s time, as at 2008 prices</td>
<td>£103.02</td>
<td>City buildings (Glasgow) Limited Liability Partnership</td>
<td>Bath panel only removed to fit TMV</td>
</tr>
<tr>
<td>Cost of installation: complex fit requiring removal of bath, based on 4 h of plumber’s time, as at 2008 prices</td>
<td>£260.28</td>
<td>City buildings (Glasgow) Limited Liability Partnership</td>
<td>Bath needed to be disconnected to fit TMV</td>
</tr>
<tr>
<td>Cost of repair</td>
<td>£6.96</td>
<td>City buildings (Glasgow) Limited Liability Partnership</td>
<td>Assuming 11% require repair (findings from RCT)</td>
</tr>
<tr>
<td>Educational materials; cost incurred by NHS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of hanger</td>
<td>£1.21</td>
<td>Personal communication</td>
<td></td>
</tr>
<tr>
<td>Cost of leaflet</td>
<td>£0.10</td>
<td>Personal communication</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2 Estimated NHS costs by severity and calculation of unit cost of NHS treatment

<table>
<thead>
<tr>
<th>Severity of injury from impact assessment (2005—10 unit costs)¹</th>
<th>Equivalent from DTI report²</th>
<th>Cost per person</th>
<th>No. of 0—4-year-olds affected per year</th>
<th>Total cost by age/severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very serious with intensive care</td>
<td>Severe injuries (≥5 days as inpatients and/or transfer to specialist burns unit)</td>
<td>£80 516</td>
<td>147</td>
<td>£11 835 852</td>
</tr>
<tr>
<td>Serious</td>
<td>Severe injuries (&lt;5 days as inpatients)</td>
<td>£41 134</td>
<td>111</td>
<td>£4 565 874</td>
</tr>
<tr>
<td>Minor injuries</td>
<td>Attend emergency department, but discharged and do not require admission</td>
<td>£180</td>
<td>395</td>
<td>£71 100</td>
</tr>
</tbody>
</table>

Average NHS treatment cost: £25 226
These showed that admission rates per 10,000 children over the period 1992–97 were zero in the two most affluent quintiles, 4.9 in the middle quintile, and 16.0 and 29.9 in the two most deprived quintiles, respectively. Based on this, we estimated that approximately 59% of children admitted to hospital with thermal injuries would reside in the most disadvantaged areas, and assumed that these children would live in social housing. Therefore the estimated numbers of children aged 0–4 years in this target risk group having a bath water scald and attending an ED would be 653; the number of children aged 0–4 years requiring hospitalisation for ≥5 days or treatment at a specialist burns centre would be 147; the number of children aged 0–4 years requiring shorter period of hospitalisation would be 111; and the number of children aged 0–4 years requiring an ED attendance, but who were not admitted to hospital, would be 395.

A series of one-way sensitivity analyses tested the robustness of the findings to variations in underlying assumptions. Key parameters used in assessing the relative cost-effectiveness—rate of risk reduction, number of children aged 0–4 years suffering bath water scalds, percentage of children with very serious bath water scalds requiring treatment at a specialist burns centre or prolonged hospitalisation—were all adjusted by ±50%.

RESULTS

Determination of the costs of installing TMVs

The costs of purchasing, fitting, replacing, and repairing TMVs are shown in table 1, categorised according to which agency paid for the specific component of the service.

Costs to the NHS were obtained from the Department for Communities and Local Government Impact Assessment of amending Part G of the Building Regulations. These costs were derived from NHS data gathered between 2005 and 2009, categorised by injury severity. The reported unit costs of NHS treatment for children aged 0–14 years are £80,516 for very serious cases (£72,246 if no intensive care unit care provided), £41,154 for serious cases, and £180 for minor injuries. The average treatment cost, as shown in table 2, would therefore amount to £25,226.

Lifetime societal costs (including QALY losses, loss of human output, and further medical treatment) were not included in the impact assessment or in the baseline cost-effectiveness calculation, but were considered within the sensitivity analysis using data from the HWBLF campaign’s response to the Part G Building Regulations consultation, which estimated the wider societal treatment costs for a bath scald (using the incidence figures above) of £71,902.

Reduction of risk of bath water scalds

The baseline risk of a bath water scald was based on estimates that approximately 653 children aged 0–4 years attend EDs each year with scald injuries, 147 require specialist treatment or hospitalisation of at least 5 days, 111 are inpatients for less than 5 days, and 395 attend an ED and do not require admission (table 3).

As described above, the estimated number of ‘at-risk’ social housing households in the UK was 582,700. The risk of a child in this target risk group having a bath water scald was estimated as 1 in 892 (653/582,700); the risk of a child requiring hospitalisation for ≥5 days or treatment at a specialist burns centre was estimated as 1 in 3964 (147/582,700); the risk of a child aged 0–4 years requiring a shorter period of hospitalisation was estimated as 1 in 5250 (111/582,700); and the risk of a child aged 0–4 years requiring an ED attendance was estimated as 1 in 1475 (395/582,700) (table 4).

The percentage of families in the intervention arm pre-TMV installation with bath water temperature considered to be at-risk (ie, >46°C) was 100%; this reduced to 19% at follow-up, a reduction in risk of 0.81. The percentage of families in the control arm with bath water temperature considered to be at-risk (ie, >46°C) was 100% at baseline and 87% at follow-up, a reduction in risk of 0.13. The difference in scald risk reduction between groups was therefore 0.68 (0.81 – 0.13) (table 5).

### Table 3

<table>
<thead>
<tr>
<th>Estimated number per year</th>
<th>Estimated number of children living in social housing each year</th>
<th>Source of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe injuries (≥5 days as inpatients and/or transfer to specialist burns unit)</td>
<td>249</td>
<td>147</td>
</tr>
<tr>
<td>Severe injuries (&lt;5 days as inpatients)</td>
<td>188</td>
<td>111</td>
</tr>
<tr>
<td>Minor injuries (attend ED, but discharged and do not require admission)</td>
<td>670</td>
<td>395</td>
</tr>
<tr>
<td>Total injuries (ED + inpatient)</td>
<td>1107</td>
<td>653</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Severity of injury</th>
<th>Estimated number per year</th>
<th>Estimated number of affected households in social housing in the UK</th>
<th>Risk within population</th>
<th>% Risk within population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe injuries (≥5 days as inpatients and/or transfer to specialist burns unit)</td>
<td>147</td>
<td>582,700</td>
<td>1 in 3964</td>
<td>0.025%</td>
</tr>
<tr>
<td>Severe injuries (&lt;5 days as inpatients)</td>
<td>111</td>
<td>582,700</td>
<td>1 in 5250</td>
<td>0.019%</td>
</tr>
<tr>
<td>Minor injuries (attend emergency department, but discharged and do not require admission)</td>
<td>395</td>
<td>582,700</td>
<td>1 in 1475</td>
<td>0.068%</td>
</tr>
<tr>
<td>Total injuries</td>
<td>653</td>
<td>582,700</td>
<td>1 in 892</td>
<td>0.112%</td>
</tr>
</tbody>
</table>
A 68% reduction in scald risk would reduce the risk of children aged 0–4 years requiring hospitalisation for ≥5 days or treatment at a specialist burns centre following a bath water scald to 1 in 12,398, the risk of a child aged 0–4 years requiring shorter periods of hospitalisation to 1 in 16,186, and the risk of a child aged 0–4 years requiring an ED attendance to 1 in 4625; and would reduce the risk of total ED attendances/admissions to 1 in 2788 (see table 6).

Cost-effectiveness of installing TMVs
In order to assess the relative cost-effectiveness of TMVs, the perspective employed in the baseline analysis was that of the UK public sector and was based on the assumption that the costs of TMV installation are incurred as an integral part of refurbishment or rebuild of the housing stock. The cost of the intervention to the Housing Association consisted of the cost of purchasing and repairing TMVs (based on 11% needing repair) or unit had the greatest impact on the cost per scald averted. More days hospitalisation or transfer to a specialist burns hospital or unit; percentage of children aged 0–4 years having bath water scald requiring at least 5 days hospitalisation or transfer to a specialist hospital or unit; percentage of children aged 0–4 years with a bath water scald requiring at least 5 days hospitalisation or transfer to a specialist hospital or unit (based on wider societal treatment costs of £71,902); estimated number of affected households in social housing in the UK; maximum cost of purchasing and installation of TMVs and educational materials from a wider societal perspective; changes in the base-case minimum cost of installation and treatment costs with wider societal treatment costs of £71,902; and finally, the estimated number of children admitted to hospital with thermal injuries residing in the most disadvantaged areas (59%). Each of these parameters in the assessment of relative cost-effectiveness was adjusted by ±30% and the results are shown in table 8. The cost of the intervention of £13.68 has been used as the base-case for the purpose of the sensitivity analysis.

Sensitivity analyses indicated that the cost of purchasing and installing the TMV and the cost of treating a scald requiring at least 5 days hospitalisation or transfer to a specialist burns unit; percentage of children aged 0–4 years having bath water scald requiring at least 5 days hospitalisation or transfer to a specialist burns hospital or unit; percentage of children aged 0–4 years with a bath water scald requiring at least 5 days hospitalisation or transfer to a specialist hospital or unit (based on wider societal treatment costs of £71,902); estimated number of affected households in social housing in the UK; maximum cost of purchasing and installation of TMVs and educational materials from a wider societal perspective; changes in the base-case minimum cost of installation and treatment costs with wider societal treatment costs of £71,902; and finally, the estimated number of children admitted to hospital with thermal injuries residing in the most disadvantaged areas (59%). Each of these parameters in the assessment of relative cost-effectiveness was adjusted by ±30% and the results are shown in table 8. The cost of the intervention of £13.68 has been used as the base-case for the purpose of the sensitivity analysis.

Sensitivity analysis
The sensitivity analysis took into consideration the following changes: to the base-case minimum cost of installation; the percentage risk reduction from use of TMVs; number of children aged 0–4 years having bath water scalds per annum; percentage of children aged 0–4 years with bath water scald requiring at least 5 days hospitalisation or transfer to a specialist burns hospital or unit; percentage of children aged 0–4 years with a bath water scald requiring at least 5 days hospitalisation or transfer to a specialist burns hospital or unit (based on wider societal treatment costs of £71,902); estimated number of affected households in social housing in the UK; maximum cost of purchasing and installation of TMVs and educational materials from a wider societal perspective; changes in the base-case minimum cost of installation and treatment costs with wider societal treatment costs of £71,902; and finally, the estimated number of children admitted to hospital with thermal injuries residing in the most disadvantaged areas (59%). Each of these parameters in the assessment of relative cost-effectiveness was adjusted by ±30% and the results are shown in table 8. The cost of the intervention of £13.68 has been used as the base-case for the purpose of the sensitivity analysis.

Sensitivity analyses indicated that the cost of purchasing and installing the TMV and the cost of treating a scald requiring live or more days hospitalisation or transfer to a specialist burns hospital or unit had the greatest impact on the cost per scald averted.

**DISCUSSION**

**Principal findings**

This economic analysis has demonstrated that the installation of TMVs in social housing with children under the age of 5 years, when undertaken as part of new build or major

---

### Table 5 Thermostatic mixer valve pre- and post-installation risk

<table>
<thead>
<tr>
<th>Comparison</th>
<th>£/family reduction in at-risk families</th>
<th>£/percentage reduction in at-risk families</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Follow-up</td>
<td>19%</td>
<td>87%</td>
</tr>
<tr>
<td>Reduction in risk</td>
<td>81%</td>
<td>13%</td>
</tr>
<tr>
<td>% Risk difference between groups</td>
<td>68% reduction</td>
<td>(0.81–0.13)</td>
</tr>
<tr>
<td><strong>Total cost of installing a TMV</strong></td>
<td><strong>£13.68</strong></td>
<td><strong>£13.68</strong></td>
</tr>
</tbody>
</table>

*Table 5: Thermostatic mixer valve pre- and post-installation risk.*

---

### Table 6 Reduction in child risk post-thermostatic mixer valve (TMV) installation (based on TMVs reducing risk by 68%) (HASS/LASS® and D11 (1999)@)

<table>
<thead>
<tr>
<th>Severity of injury</th>
<th>Estimated number per year</th>
<th>Estimated number of affected households in social housing in the UK</th>
<th>Risk within population</th>
<th>% Risk within population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe injuries (≥5 days as inpatients and/or transfer to specialist burns unit)</td>
<td>47</td>
<td>582,700</td>
<td>1 in 12,398</td>
<td>0.008%</td>
</tr>
<tr>
<td>Severe injuries (&lt;5 days as inpatients)</td>
<td>36</td>
<td>582,700</td>
<td>1 in 16,186</td>
<td>0.006%</td>
</tr>
<tr>
<td>Minor injuries (attend emergency department, but discharged and do not require admission)</td>
<td>126</td>
<td>582,700</td>
<td>1 in 4625</td>
<td>0.022%</td>
</tr>
<tr>
<td><strong>Total injuries</strong></td>
<td><strong>209</strong></td>
<td><strong>582,700</strong></td>
<td><strong>1 in 2788</strong></td>
<td><strong>0.036%</strong></td>
</tr>
</tbody>
</table>

*Table 6: Reduction in child risk post-thermostatic mixer valve (TMV) installation (based on TMVs reducing risk by 68%) (HASS/LASS® and D11 (1999)@).*
refurbishment with installation of a new bath, is likely to produce cost savings for the public purse. This finding was robust to adjusting all parameters used in the analyses by a factor of 0.50, except when the risk reduction is lowered to 0.48, the estimated number of children scalded reduces to 457, or when TMVs are fitted as a stand-alone installation in existing bathrooms. These parameters then produce positive costs (table 8).

Strengths and limitations of the study

To our knowledge this is the first economic evaluation of TMVs in a domestic setting. Our finding of a 68% reduction in water temperatures to the recommended levels in a domestic setting. Our...
Comparisons with existing literature
We have not been able to find any published economic evaluations of installing TMVs with which to compare our estimates. The 2004 Cochrane Review by Turner et al.18 does highlight studies that report drops in scald incidence, however they draw attention to methodological issues that weaken the results of several of these studies. And most, if not all of the studies tend to be designed around literature dissemination and none of the RCTs actually used a TMV and/or direct action against water temperature. Therefore, we have no comparative proportional reduction estimates to use in this paper. A recent cost-effectiveness analysis of legislation to set thermostats on new domestic water heaters to a maximum 49°C and annual educational information sent to utility company customers found the intervention resulted in a saving of $C531 per scald averted.17 This intervention was much cheaper than installing TMVs, and as the legislation applied to the entire population, not just those living in social housing, the potential impact may be greater. However, findings from our RCT indicated that most families would not be happy with kitchen hot water at the same temperature as their bath hot water.18 This suggests that similar legislation to lower new boiler thermostats may not be acceptable to the UK population.

Implications for policy and research
It is very likely that installing TMVs in social housing new builds and major refurbishments with installation of new baths accompanied by educational information represents value for money (as measured by cost/QALY). Current building regulations for England and Wales mandate TMVs in new builds and major refurbishments with installation of new baths accompanying educational information sent to utility company customers. However, not just those living in social housing, the potential impact may be greater. Social housing providers should therefore consider fitting TMVs when baths are replaced, as well as complying with existing building regulations.

Further work is required to estimate the long-term cost of bath water scalds to children, families, and society, and to quantify their impact on quality of life. The impact of amendments to the building regulations for England and Wales requires evaluation, especially in terms of their effect on inequalities in childhood bath water scalds.

Acknowledgements
Thanks are extended to Elizabeth Orton.

Funding
National Institute for Health Research, Accidental Injury Prevention Research Initiative (001/0009). The final study design, data collection, analysis, interpretation of results, and paper writing was the sole responsibility of the authors. The views and opinions expressed in this paper do not necessarily reflect those of the funding body. This is an independent report commissioned and funded by the Policy Research Program in the Department of Health. The views expressed are not necessarily those of the Department.

Competing interests
None.

Patient consent
Obtained.

Ethics approval
The trial protocol was reviewed by Nottingham Research Ethics Committee. As the trial did not involve NHS staff or patients and hence did not fall within the remit for NHS ethics committee approval, the committee was able to provide a review, but not approval. The trial received NHS organisational approval from Nottinghamshire County Primary Care Trust (PCT) (formerly Broxtowe and Hucknall PCT) as some research staff working on the trial were employed by the PCT.

Provenance and peer review
Not commissioned; externally peer reviewed.

REFERENCES