Title

Modifiable Risk Factors for Scald Injury in Children Under 5 Years of Age: A Multi-centre Case–Control Study

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Abstract

Objective: To determine the relationship between a range of modifiable risk factors and medically attended scalds in children under the age of 5 years.

Methods: Multicentre matched case-control study in acute hospitals, minor injury units and GP practices in four study centres in England. Cases comprised 338 children under 5 presenting with a scald, and 1438 control participants matched on age, sex, date of event and study centre. Parents/caregivers completed questionnaires on safety practices, safety equipment use, home hazards and potential confounders. Odds ratios were estimated using conditional logistic regression.

Results: Parents of cases were significantly more likely than parents of controls to have left hot drinks within reach of their child (adjusted odds ratio (AOR) 2.33, 95%CI 1.63, 3.31; population attributable fraction (PAF) 31%). They were more likely not to have taught children rules about climbing on kitchen objects (AOR 1.66, 95%CI 1.12, 2.47; PAF 20%); what to do or not do when parents are cooking (AOR 1.95, 95%CI 1.33, 2.85; PAF 26%); and about hot things in the kitchen (AOR 1.89, 95%CI 1.30, 2.75; PAF 26%).

Conclusions: Some scald injuries may be prevented by parents keeping hot drinks out of reach of children and by teaching children rules about not climbing on objects in the kitchen, what to do or not do whilst parents are cooking using the top of the cooker and about hot objects in the kitchen. Further studies, providing a more sophisticated exploration of the immediate antecedents of scalds are required to quantify associations between other hazards and behaviours and scalds in young children

KEYWORDS injury prevention, scalds, children

Introduction

Globally, scald injuries are an important public health issue and cause considerable morbidity and mortality [1-3]. They can be the most distressing and painful injuries a child can receive and may result in long-term physical and psychological effects. Paediatric scald injuries also have significant economic implications for families and health services[1].

It is noteworthy that the majority of scalds in childhood occur at home [1, 4-6] and are most commonly caused by hot liquids from kettles, cups and baths [2, 5-8]. Children under the age of 5 years are most at risk of sustaining a scald in the home[9, 10] and the burden of paediatric scalds falls most heavily on those from the most disadvantaged groups[4, 5, 11, 12] Preventing scalds requires understanding of modifiable risk factors for scalds. Several small case control studies have been conducted which demonstrate increased risks of thermal injuries associated with composite burn and scald hazard scores[3, 13] , with drinking hot drinks from their original containers rather than vacuum flasks[14] and with having cooking equipment within reach of children.[15] However, these studies were not restricted to scald injuries, some had small sample sizes and limited power, used hospital controls, explored only a limited number of exposures or used composite exposure measures which precluded assessment of risk associated with single items within the composite measure, included exposures not relevant to the UK or failed to adjust for a range of confounding factors. We therefore undertook this study to determine the relationship between a wide range of modifiable risk factors and medically attended scalds in children under the age of 5 years, and to inform development of prevention programmes designed to address this important public health problem.

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Methods

The published protocol for this study fully describes the methods[16]. Approval was given by Nottingham Research Ethics Committee 1. Informed consent from parents of cases and controls was implied when parents returned the completed study questionnaire.

This multi-centre case-control study of scald injuries was one of five concurrent case-control studies, each for a different injury mechanism (3 types of falls (furniture, flat and stairways), poisonings and scalds). Cases were recruited from Emergency Departments (EDs), minor injury units (MIU) and inpatient wards in English National Health Service (NHS) hospitals in Nottingham, Bristol, Newcastle upon Tyne, Norwich, Gateshead, Derby, Lincoln and Great Yarmouth.

Cases were recruited between 14th June 2010 and 15th November 2011. Recruitment of controls started with the recruitment of the first case and continued until the 7th December 2011.

Participants

Cases were children 0-4 years with a scald injury occurring at home, seeking medical attention at an ED, MIU or admitted to hospital. Those with fatal or intentional injuries and those living in children's homes were excluded.

Controls were children 0-4 years who did not seek medical attention for a scald injury on the same date of the case's injury. Controls were recruited from the same General Practice (GP) in which the case was registered, or a neighbouring practice. The aim was to recruit an average of 4 control children matched to each case, by gender, by age (within 4 months of cases child's age and by seasonality, (within 4 months of case injury date). On occasions fewer or more than 4 controls were recruited to a case. To maximise use of data and increase power, cases with more than 4 controls had excess controls re-matched to cases with less than 4. Other strategies used to increase power were 1) if a case was subsequently found to be ineligible their controls were re-matched to cases and 2) controls matched to cases with injury mechanisms other than scalds in the other ongoing

case-control studies were re-matched to cases in the scald study using matching criteria previously described. Controls were only used once as a re-matched participant. The numbers of each of these types of controls are given in figure 1.

Recruitment strategies

Potentially eligible cases were invited to take part either during their medical attendance or by telephone or postal invite within 72 hours of attendance. General Practitioners (GPs) used their practice register to match and send a postal invite to 10 control individuals. All participants were asked to complete one age appropriate paper questionnaire. One reminder was sent after two weeks and a £5 gift voucher was sent upon return of a completed questionnaire.

Definition and measurement of outcomes, exposures and confounding variables.

A scald injury resulting in hospital admission or attendance at ED or MIU was the outcome of interest. Exposures were categorised into safety equipment use, safety behaviours and home hazards. Exposures were assessed either for the 24 hours or the week prior to the scald for cases and for the 24 hours or the week prior to questionnaire completion for controls using age specific questionnaires (0-12 months, 13-36 months, and ≥37 months) which included, whenever possible, previously validated questions. In addition, home observations were undertaken in a sample of 162 cases and controls to validate self-reported exposures.[17] Exposures which are known to potentially impact on injuries, but which are not modifiable were considered confounding variables. These included socio-demographic and economic characteristics, out of home childcare and validated measures previously shown to impact on child injury.

Exposures

Boxes 1-4 below detail exposures and potential confounders assessed in the study

Box 1. a) Home hazards and b) use of safety and other potentially risk reduction equipment and home hazards

a) Home hazards

1. Used a baby walker in the last 24 hours (children aged 0 to 36 months only)

b) Use of safety and other potentially risk reducing equipment

1. Safety gates or stairgates anywhere in the house
2. Kettles with curly or short cables
3. Play pens or travel cots (children aged 0 to 36 months only)
4. Stationary activity centres (children aged 0 to 36 months only)

Box 1 Exposures: Home hazards and use of safety and other potentially risk reduction equipment

Box 2. Safety Behaviours	
1. Not drinking hot drinks while holding a child	9. Using cold water first when running a bath
2. Not passing hot drinks over a child	10. Measuring bath water temperature
3. Keeping hot drinks out of reach of children	11. Not leaving child without an adult in the bath or bathroom
4. Storing kettles at back of work tops	12. Not having children running baths
5. Use of back rings on cooker	13. Taught child safety rules about hot things in the kitchen e.g. kettle
6. Turning saucepan handles away from edge of cooker	14. Taught child safety rules about what to do or not do when parents are cooking using the top of the cooker
7. Not using tablecloths	15. Taught child safety rules about things in the kitchen that he/she is not supposed to climb on
8. Hot tap water/thermostat temperature known to be below 54○C	16. Taught child safety rules about what to do or not do in the bathtub

Box 2 Safety Behaviours

Box 3. Potential confounders - Sociodemographic	
1. Age of child	7. Single parenthood
2. Gender of child	8. Adult unemployment in the household
3. Ethnic group	9. Overcrowding
4. Family size	10. Deprivation (measured using the Index of Multiple Deprivation)(18)
5. Housing tenure	11. Distance of residence from hospital
6. Receipt of state-provided means-tested benefits	12. Use of out-of-home childcare

Box 3: Potential Confounders – Sociodemographic factors

Box 4. Potential confounders - Child and parent measures for health and behaviour
1. Child behaviour (infant, early child and child behaviour questionnaires)[19-21] (Measured over two weeks prior to injury or questionnaire completion)
2. Child health status (VAS[18]; PedsQL[19, 20]) *VAS 24 hours before completion Peds QL (Measured over two weeks prior to injury or questionnaire completion)*
3. Long-term health conditions *(conditions the child has had for at least 3 months or is expected to last for at least the next 3 months)*
4. Parental mental health (Hospital Anxiety and Depression Scale)[21] *(measured for period of 1 week prior to injury before injury or questionnaire completion)*
5. Parenting daily hassles[22, 23] (Measured for 6 months prior to injury for parents of cases or questionnaire completion for control parents)
6. Parental perception of child's ability to reach hot liquids (a series of questions on climbing, reaching, turning on taps, ability to open safety gates)

Box 4: Potential Confounders – Child and parent measures for health and behaviour

The child's Index of Multiple Deprivation score (IMD) was identified using their home postcode[24]. The straight line distance from the case's or matched control's home address to the hospital attended by the case was calculated using the hospital's postcode and the postcode of the home address of the case or matched control[25].

Directed acyclic graphs (DAGs)[6, 7, 26] were generated in order to select confounders to be used in the multivariable models for each exposure. DAGs allow for the assessment of whether controlling for confounders is sufficient or appropriate by the use of epidemiological models in which assumed relationships between exposures, outcomes and confounders are made explicit.

Study Size

To detect an odds ratio of 1.59 (equivalent to an odds ratio of 0.63 expressed as a protective association), 259 cases and 1,036 controls were required, based on the exposure prevalence estimated from the first 428 controls recruited to the study. This took account of missing data on exposures and requiring the largest sample size from drinking hot drinks whilst holding child (27%) and not using kettles with curly/short flexes (22%).

Statistical methods:

Descriptive statistics for the exposures and confounding variables were calculated by case/control status. Categorical variables were described using frequencies and percentages, whilst continuous variables were described (depending on their distributions) by means (and standard deviations) or median (and interquartile ranges). Sensitivity, specificity and predictive value for self-reported and observed exposures were calculated. The X^2 test for homogeneity was used to assess accuracy of reporting between cases and controls.

Conditional logistic regression was used to estimate odds ratios and 95% confidence intervals for each exposure variable for the analysis of cases and matched controls. Adjustments were made for the confounding variables that were identified from DAGs as well as deprivation scores and distance

from hospital. Exploration of differential effects by socio-demographic factors was undertaken by adding interaction terms to the regression models, with a likelihood ratio test significance level of $p<0.01$. Where a significant interaction was found, odds ratios were estimated stratified by the socio-demographic factor. Population attributable fractions (PAF) were calculated for exposures with statistically significantly raised adjusted odds ratios[27].

The main analyses were complete case analyses. An additional analysis used multiple imputation to replace missing values. The multiple imputation model included all exposure variables and potential confounding variables and case/control participant status. Twenty multiply imputed datasets were imputed and Rubin's rules were used to combine results.

Results

In total 338 cases and 1,438 controls (of whom 340 were extra matched control participants) took part in this study (see figure 1). 32% of cases and 29% of controls agreed to participate. The sex and age group of participating and non-participating cases were similar (male, 55% vs 58% respectively; 0-12 months, 29% vs 26%; 13-36 months, 62% vs 61%; ≥37 months 9% vs 14%, respectively).

The mean number of controls per case was 4.25. The median number of days between the date of injury to questionnaire completion for cases was 11 (interquartile range, 6-21).

All cases had sustained a scald and no other additional injury. 31% received treatment at ED, 24% were seen and examined but did not require treatment, and 18% were admitted to hospital. The remainder were discharged either with outpatient follow up (18%) or GP/practice nurse follow up (10%).

The socio-demographic characteristics of cases and control participants are shown in Table 1. Cases were slightly younger than controls (median age 1.47 vs 1.56 years), less likely to be of white ethnic

origin (82% vs 91%), more likely to receive state benefits (46% vs 35%), and more likely to live in rented accommodation (50% vs 37%), an overcrowded household (15% vs 9%) or a household with only one child under 5 years of age (68% vs 62%). Cases lived in neighbourhoods with higher deprivation scores (median, 20.6 vs 15.7), and had fewer hours of out-of-home child care per week (median, 5.5 vs 12). Fewer parents of cases than parents of controls thought their children very likely to reach hot drinks in at least 1 of 8 scenarios (79% vs 83%).

Table 2 shows the sensitivity, specificity and predictive values for scald exposures validated by home observations. Four questions relating to safety gates were combined into one exposure (used safety gates anywhere in the house) which was used in the case-control study analysis. Sensitivities were high (over 70%) for five exposures in cases and controls. Specificities were high for four exposures in cases and controls. . Positive predictive values were high for five exposures in cases and controls. Negative predictive values were high for three exposures in cases and controls. Sensitivity and specificity were both high in cases and controls for safety gate across the kitchen doorway, safety gate at top of stairs and safety gate at bottom of stairs. There were no significant differences in the accuracy of reporting between cases and controls.

Table 3 shows the frequency of exposures and ORs for the complete case and multiple imputation analyses, adjusted for the confounding variables as listed in the table. Parents of cases were significantly more likely not to have taught their child rules about climbing on objects in the kitchen (AOR 1.66, 95%CI 1.12 to, 2.47, population attributable fraction (PAF) 20%); what to do or not do when parents are cooking using the top of the cooker (AOR 1.95, 95%CI 1.33 to, 2.85, PAF 26%); and what to do or not do with hot things in the kitchen (AOR 1.89, 95%CI 1.30 to, 2.75, PAF 26%). They were also significantly more likely than parents of controls to have left hot drinks within reach of their child (AOR 2.33, 95%CI 1.63 to, 3.31, PAF 31%).

Cases were significantly less likely to have climbed or played on furniture (AOR 0.62, 95%CI 0.40, 0.96) or to have been left in the bath without an adult (AOR 0.47, 95%CI 0.30, 0.75). Seventeen of the odds ratios from complete case and multiple imputation analyses differed by more than 10% and statistical significance (P<0.05) differed for seven exposures which were significant in the MI analysis but not the complete case analysis, and for one exposure (climbed or played on furniture) which was no longer significant in the MI analysis.

There were three exposures where there was a significant interaction with one of the socio-demographic variables (see Table 4). In households with two or more adults in paid work cases were significantly more likely than controls to have not been taught rules about what to do or not do when in the bathtub (AOR 2.81, 95%CI 1.43, 5.53), but there was no association in households with none or one adult in paid work. In single adult households parents of cases were less likely than parents of controls to have a hot water temperature of 54 ^{0}C or above, or not know the water temperature (AOR 0.42, 95%CI 0.07, 2.72), whereas in households with more than one adult, they were more likely to have a hot water temperature of 54 ^{o} C or above, or not know the water temperature (AOR 1.47, 95%CI 0.85, 2.56). Among parents living in rented accommodation, compared to controls, case parents living in rented accommodation were significantly more likely to never check their child's bath water temperature using a thermometer or other gadget (AOR 1.84, 95%CI 1.03, 3.28) but there was no association in parents living in private accommodation. For five odds ratios there was a difference of more than 10% between the multiple imputation and complete case interaction analyses.

Discussion

Key findings

The results show a number of modifiable risk factors were associated with risk of medically attended scald injuries; in particular leaving hot drinks in reach of children and not teaching children safety rules to prevent scalds.

There were some counter-intuitive findings, mainly relating to the potential for hot bathwater scalds; parents of case children reported being less likely to leave a child alone in the bath and if living in a single adult household less likely to report an unsafe hot water temperature or not knowing the temperature of their water. Cases reported their children climbed or played on furniture less often than controls.

Comparison with other studies

There are several case-control studies with which we can compare our findings. A Greek study of young children compared ED attenders with a burn injury (61% were scalds) to those attending without an injury, matched on age and gender[13]. They used a composite measure burn avoidance index (direction of handles of cooking utensils on the cooker while cooking; use of front/rear hot plates during cooking; keeping hot objects, foods and liquids in places inaccessible to children and avoidance of tablecloths on kitchen tables). A one unit increase in burn avoidance index was associated with a 40% reduction in the odds of a burn (OR 0.6, 95%CI 0.5, 0.8)[13]. A study from Iraq of children aged 0-5 years admitted to a burns centre (79% suffered scalds), matched on age and sex to non-injury admissions, used a composite burns hazard score (use of kerosene cookers, kerosene heaters, samovars for tea, home generators, non-electric heaters for bath water, knowledge of boiler temperature, storing petrol at home and possession of fire extinguishers and smoke alarms) and found a one unit increase in a score increased the odds of a burn by 32% (OR 1.32, 95%CI 1.02, 1.71).[3] A Dutch study of children aged 0-4 years attending the ED with a burn injury (62% scalds),

matched with controls on age, found storing hot drinks in original containers rather than vacuum flasks increased the risk of a burn (OR 2.0, 90% CI 1.2,3.1)[14]. A study in Bangladesh of children aged 0-12 years admitted to burns units and controls matched on age, sex and area of residence found significantly more cases had cooking equipment within reach of children than controls (P<0.001, OR not reported).

As these comparison studies included burns, although the majority were scalds, there is a possibility that varying case definitions may account for differences from the results reported here. Few of the exposures measured were common across countries, probably reflecting different cooking and water heating practices in each country. Findings from this study that families left drinks in reach of children had increased odds of a scald are in keeping with the Greek study[13]. However, use of a composite measure in the Greek study prevents a direct comparison. It is important to note that to create effective interventions for preventing scald injuries, it is essential to consider a range of factors including socioeconomic, ethnic, and cultural.[28] For example, cultural practices relating to how different liquids are heated in food and drink preparation can have an influence on the severity of scald injuries sustained because injuries caused by milk or other liquids with a higher fat content cause more serious burns than those via hot water alone. Whilst interventions to reduce the risk of all scalds are needed knowledge of cultural practices that put some children at greater risk of the most severe scalds need to be incorporated into interventions for these groups. [28, 29].

Strengths and limitations

To our knowledge, this is the largest case control study examining associations between a range of modifiable risk factors and scald injuries in children aged 0-4 years. It was undertaken within the NHS and recruited children living in a variety of socio-economic and geographical areas. Our analyses adjusted for a wide range of confounders and took account of missing data by multiple imputation, with findings broadly similar to those from the complete case analysis. We also validated self-reported exposures with home observations where possible.

Our study found significant associations between only a small number of exposures and scalds. This may have been due to lack of power where the prevalence of exposures amongst controls was lower than the prevalences used in our sample size calculation (10 exposures). However, this cannot explain negative findings where the prevalence of exposures s amongst controls were similar to, or higher than those used in our sample size calculation (11 exposures). Misclassification of exposures can bias odds ratios towards the null, but is unlikely to explain at least some of our negative findings as home observations showed little evidence of differential reporting accuracy between cases and controls. However, many exposures (such as self-reported behaviours) are not possible to validate by home observations, so we cannot exclude the possibility that some recall or social desirability bias may have occurred. As our participation rates were low (32% for cases and 29% for controls), selection bias may have occurred. More cases than controls lived in socioeconomically disadvantaged and potentially more hazardous circumstances, but this would tend to overestimate odds ratios rather than explain our negative findings. It is possible that residual confounding could lead to masking of associations between exposures and scalds. For example, if parents of cases supervised children more effectively than parents of controls, this could ameliorate risks associated with exposures, leading odds ratios to tend towards the null. Further research is required to confirm our negative findings. Case cross-over designs which measure the presence of hazards, child interactions with hazards and caregiver supervision[30] may provide a more sophisticated understanding of the immediate antecedents of scald injuries may be useful for this purpose.

We found two factors which might be expected to increase the risk of scalds were associated with reduced odds of scalds (children climbing or playing on furniture and children being left alone in the bath). Although under-reporting of risk factors did not appear to be differential between cases and controls for the exposures we were able to validate with home observations, it is possible that parents of cases under-reported these two factors because of social desirability or recall bias.

However, more case than control parents reported many other risk factors which might also be viewed as “undesirable”, so this may not explain our findings. It is also possible that some significant findings could represent type 1 error due to the large number of statistical tests undertaken in our analyses.

We found that teaching children several safety rules were associated with a reduced odds of a scald. Previous research suggests parents predominantly try to prevent injuries by supervision or changing the home environment for children under the age of two years, but move to predominantly teaching and rule-based strategies when children are between 2 and 4 years of age.[31, 32] However, there is evidence that teaching safety rules can increase the risk of injury,[32, 33]and that for teaching to be effective, it needs to increase children's understanding of the safety issue to reduce the extent to which they interact with hazards.[33] It is therefore important that parents do not rely solely on teaching safety rules, and use these in conjunction with environmental measures.

Conclusion

Some scald injuries may be prevented by parents keeping hot drinks out of reach of children and by teaching children rules about not climbing on objects in the kitchen, what to do or not do whilst parents are cooking using the top of the cooker and about hot objects in the kitchen. Further studies, providing a more sophisticated exploration of the immediate antecedents of scalds are required to quantify associations between other hazards and behaviours and scalds in young children.

Author contribution

Prof Kendrick had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Kendrick, Stewart, Coupland, Watson.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Stewart, Benford, Wynn , Watson, Coupland, Kendrick.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Benford, Wynn, Coupland, Kendrick.

Obtained funding: Kendrick, Watson, Coupland,

Administrative, technical, or material support: Hindmarch, Deave, Majsak Newman.

Study supervision: Stewart, Kendrick, Watson

Approval of final manuscript: all authors

Conflicts of interest

None

Funding statement

This article presents independent research funded by grant RP-PG- 0407-10231 from the National Institute for Health Research through its Program Grants for the Applied Research Program. The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Disclaimer

The views expressed in this article are those of the authors and not necessarily those of the National Health Service, the National Institute for Health Research, or the Department of Health**.**

Acknowledgements

We thank the parents who participated in the study. We also thank the principal investigators, liaison health visitors, research nurses, and other staff from the emergency departments and minor injury units who assisted with recruiting participants from the Nottingham University Hospitals National Health Service Trust, Derby Hospitals National Health Service Foundation Trust, Norfolk and Norwich University Hospitals National Health Service Foundation Trust, James Paget University Hospitals National Health Service Foundation Trust, University Hospitals Bristol National Health Service Foundation Trust, North Bristol Healthcare Trust, Newcastle upon Tyne Hospitals National Health Service Foundation Trust, Gateshead National Health Service Foundation Trust, and Northumbria Healthcare National Health Service Foundation Trust.

We acknowledge the support provided for recruitment by the primary care research networks for East Midlands and South Yorkshire, Leicestershire, Northamptonshire and Rutland, East of England, Northern and Yorkshire and from South West and Trent, Norfolk & Suffolk, and Northumberland Tyne and Wear and Western Comprehensive Local Research Networks. We thank Joanne Ablewhite, PhD, Clare Timblin, BA, Philip Miller, PhD, and Ben Young, MSc, University of Nottingham; Lisa McDaid, MSc, Clare Ferns, and Nathalie Horncastle, Norfolk and Norwich University Hospitals National Health Service Foundation Trust; Trudy Goodenough, PhD, Pilar Munoz, and Benita Laird-Hopkins, BSc, University of the West of England; Adrian Hawkins, BSc, Emma Davison, BA, and Laura Simms, BA, Great North Children's Hospital, Newcastle upon Tyne; and Bryony Kay, BSc, Bristol Royal Hospital for Children, who helped with recruitment, and data collection and prepared data for analysis.

We acknowledge the following principal investigators who contributed to obtaining funding ,study design, project management in their centres, interpretation of analyses, and comments on paper drafts: Richard Reading , MD, Norfolk and Norwich University Hospitals NHS Foundation Trust, Elizabeth Towner, PhD, University of the West of England, Elaine McColl, PhD, Newcastle University, Alex J. Sutton, PhD, and Nicola Cooper, PhD, University of Leicester, and Frank Coffey, MMedSci, Nottingham University Hospitals National Health Service Trust. All previously listed individuals received salaries for their contribution as this was part of their work.

We are also grateful to Rose Clacy, lay research adviser, who attended project management meetings, helped draft and pilot study documentation, advised on recruitment strategies, and commented on drafts of the paper. Ms Clacy did not receive a salary but did receive payment for her time and expenses.

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