Risk and protective factors for falls on one level in young children: multicentre case-control study

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ABSTRACT

**Background:** Childhood falls are an important global public health problem, but there is a lack of evidence about their prevention. Falls on one level result in considerable morbidity and they are costly to health services.

**Objective:** To estimate odds ratios for falls on one level in children aged 0-4 years for a range of safety behaviours, safety equipment use and home hazards.

**Design, setting and participants:** Multicentre case-control study at hospitals, minor injury units and general practices in and around 4 UK study centres. Participants included 582 children less than 5 years of age with a medically attended fall injury occurring at home and 2460 controls matched on age, sex, calendar time and study centre.

**Main outcome measure:** Fall on one level.

**Results:** Cases’ most common injuries were bangs on the head (52%), cuts or grazes not needing stitches (29%) or cuts or grazes needing stitches (17%). Comparing cases to community controls in the adjusted analyses, significant findings were observed for only 2 exposures. Injured children were significantly less likely to live in a household without furniture corner covers (adjusted odds ratio (AOR) 0.72, 95%CI 0.55, 0.95), or without rugs and carpets firmly fixed to the floor (AOR 0.76, 95% CI 0.59, 0.98).

**Conclusions:** We did not find any safety practices, use of safety equipment or home hazards associated with a reduced risk of fall on one level. Our findings do not provide evidence to support changes to current injury prevention practice.

INTRODUCTION

Unintentional falls are the leading cause of medically attended childhood injuries in most countries\(^1\)\(^2\) with the under-fives having higher rates of non-fatal falls than older children.\(^3\) Globally, falls are the 12th leading cause of disability-adjusted life years lost in this age group\(^1\) and incur high health service costs, accounting for over $1billion in the USA in 2005\(^4\).

The severity of injuries from falls varies according to the height of the fall, amongst other factors. Falls on one level (e.g. slips and trips) make a substantial contribution to
the overall burden of fall-related injuries. In England in 2012-13 they accounted for 23% of fall-related hospital admissions and in 2002 (the latest year for which data were collected) they accounted for 30% of fall-related emergency department (ED) attendances in the under-fives. Although fall injuries represent a considerable health burden, there is little evidence of modifiable risk factors or effective strategies to prevent childhood falls in the home, particularly falls on one level. This multicentre case-control study therefore investigates modifiable risk factors for falls on one level in children under five years in the home.

Our primary objective was to estimate odds ratios for medically attended falls on one level occurring in the home or garden in children under 5 years of age, for a range of exposures (safety behaviours, safety equipment use and hazards), adjusted for a range of potential confounding factors. The secondary objective was to investigate whether associations between exposures and falls on one level varied by socio-demographic factors previously found to be associated with differential effectiveness of home safety interventions (child age, gender, ethnicity, single parenthood, housing tenure, and unemployment).

**METHODS**

**Study design and setting**
The methods have been described in full in the published protocol. This was one of five multicentre matched case-control studies that employed identical methods to explore modifiable risk factors for poisonings, scalds, falls from furniture, falls on one level, and stair falls. These were conducted simultaneously within NHS hospitals in four areas of the UK: Nottingham and Derby; Bristol; Norwich and Great Yarmouth; Newcastle upon Tyne and Gateshead. Cases were recruited between 14 June 2010 and 15 November 2011. Control recruitment commenced at the same time as case recruitment and ended within 4 months of case recruitment.

Ethical approval was obtained from Nottingham Research Ethics Committee 1 (study reference number 09/H0407/14). Completion and return of a questionnaire was taken as informed consent.

**Participants**
Cases comprised children less than 5 years of age who attended an ED or minor injury unit (MIU) or were admitted to hospital with a fall on one level occurring in their home or garden. Children with intentional or suspected intentional injury, those living in residential care and those with fatal injuries were excluded. Parents/carers of potentially
eligible children were invited to participate during their medical attendance or by telephone or post within 72 hours of attendance. Non-responders were sent one reminder two weeks after the initial approach. Controls were children who had not sustained a medically attended fall on one level on the date of the case’s injury, matched on age (within 4 months), sex and calendar time (within 4 months of injury) to the case, and recruited from the case’s general practice (or a neighbouring practice). Children living in residential care and those previously participating as a case in the study were excluded. The 10 potentially eligible controls with dates of birth closest to that of their matched case were identified from the practice register and were sent postal study invitations. To increase power and make efficient use of recruited participants, control participants from cases with more than four controls, controls no longer matched to cases (eg, case had subsequently been excluded), and control participants participating in one of the other 4 ongoing case-control studies were matched on age, sex and study centre to cases which did not have four controls.

Measurement exposures and confounding variables

Parents completed questionnaires asking about home hazards, safety equipment use, safety behaviours and potential confounders. Questionnaires were developed by the research team in conjunction with a lay research advisor, and were age-specific (0-12 months, 13-36 months, and 37-59 months), containing measures of child behaviour and temperament, and health related quality of life, to reflect appropriate developmental levels. They were piloted on parents of children attending EDs within participating hospitals and control questionnaires were piloted on parents attending local children’s centres. To increase response rates respondents were sent a £5 shopping voucher on receipt of completed questionnaires. Questions referred to the 24 hours preceding injury, or for controls the 24 hours prior to questionnaire completion for use of (response options: yes/no):

- Baby walkers (ages 0-36 months)
- Playpens or travel cots (ages 0-36 months)
- Stationary activity centres (ages 0-36 months)
- Safety gates anywhere in house
- Furniture corner covers
- Rugs or carpets being firmly fixed to floor

Questions referred to the seven days prior to injury or questionnaire completion (response options: every/ most/some days/never/not applicable, grouped into at least some days vs. never with analyses excluding not applicable responses) for:

- Electric wires or cables trailing across floors
• Tripping hazards on floors
• Allowing un supervised play in the garden
• Locking back doors to prevent access to the garden
• The use of safety gates to prevent access to garden

Questions asked about teaching children safety rules\textsuperscript{13} about (response options: yes/no):

• Slippery floors
• Running in the house

Responses to eight of the questions which could be verified by observation were validated during home visits to a sample of 162 case-control study participants who had expressed interest in taking part in further research (see Table 2)\textsuperscript{14}. Participants were asked to take part in a home safety study and not informed that the purpose of the home visit was to validate their previously completed questionnaire.

Questions on potential confounders asked about:

• family size and structure, ethnic group, overcrowding, housing tenure, receipt of state-provided means-tested benefits, maternal age, time cared for outside the home, place of out-of-home care, area-level deprivation (Index of Multiple Deprivation (IMD) score\textsuperscript{15}) and straight line distance from home address to hospital\textsuperscript{16};

• validated measures of child behaviour and temperament (the activity and high intensity pleasure subscales of the Infant, Early Child and Child Behaviour Questionnaires; IBQ, ECBQ and CBQ)\textsuperscript{17-21}, parenting daily hassles (parenting tasks subscale)\textsuperscript{22 23}, parental mental health scale (HADS)\textsuperscript{24}, child health related quality of life inventory (PedsQL)\textsuperscript{25 26} and general health visual analogue scale (VAS)\textsuperscript{27}.

**Study size**

Based on data on the prevalence of exposures from previous studies\textsuperscript{28 29}, ranging from 36% (using a baby walker) to 76% (not using a stationary playcentre), 496 cases and 1984 matched controls were required to provide 80\% power, with a 5\% significance level and a correlation between exposures in cases and controls of 0.1\textsuperscript{30}, to detect an odds ratio of 1.43 (equivalent to an odds ratio of 0.70 expressed as a protective association).
**Statistical methods**

Conditional logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals for each exposure variable, adjusted for deprivation and distance from hospital, plus confounding variables. The choice of confounders to include in multivariable models for each exposure was based on directed acyclic graphs (DAGs). The confounders adjusted for in each model are specified in Table 3.

Response options for questions pertaining to the frequency of safety behaviours were grouped into at least some days vs. never with analyses excluding not applicable responses.

The linearity of relationships between continuous confounders and case/control status was tested by adding higher-order terms to regression models, with categorisation where there was nonlinearity. Interaction terms were added to regression models to explore differential effects by child age, gender, ethnic group, single parenthood, non-owner occupied housing and unemployment, with significance assessed with likelihood ratio tests (P<0.01). Where significant interactions were found stratified ORs are presented.

For the PedsQL, mean scale scores were computed by summing items and dividing by number of items answered. Means were not computed where ≥50% items were missing. For the HADS, single missing item values for each subscale were imputed using the mean of the remaining 6 items. Subscale scores were not computed when more than one item was missing. The same approach was used for missing values of PDH, since we were unable to find guidance on this. The main analyses were complete case analyses including single imputed values for HADS and PDH. For the IBQ, ECBQ and CBQ missing values were scored as the total score divided by the total number of questions answered. Sensitivity analyses imputed missing data for all exposures and confounders. Twenty multiply imputed datasets were imputed and combined using Rubin’s rules.

For exposure variables validated by home visits, sensitivity, specificity, positive and negative predictive values (with 95% exact confidence intervals) were calculated assuming observed values were the “true” values, see Figure 1. The values were calculated for cases and controls separately in order to to assess differential reporting between the two groups.
RESULTS
In total, 582 cases, 2460 controls (including 706 extra matched controls) participated. The process of recruitment is shown in Figure 1. The recruitment rate was 24% for both cases and controls. Study participants and non-participants were similar in terms of age group (0-12 months, 12% vs 12%; 13-36 months, 62% vs 63%; ≥37 months 25% vs 25%), and sex (male 62% vs 61%).
Figure 2: Selection of cases and controls and flow of participants through study
The mean number of controls recruited per case was 4.23. The median time from date of injury to date of questionnaire completion for cases was 10 days (interquartile range 6-20). Most cases (80%) sustained single injuries, most commonly bangs on the head (52%), cuts or grazes not needing stitches (29%) or cuts or grazes needing stitches (17%). 47% of cases were seen but did not require treatment, 46% received treatment in ED, 4% were discharged with outpatient or general practice follow up, and 3% were admitted to hospital.

As shown in Table 1 cases were similar in age to controls (median age 2.08 vs. 2.16 years), but were more likely to have a mother who had her first child under the age of 20 (16.5% vs 10.8%), live in a household with no adults in paid work (19.1% vs. 12.4%), live in a household receiving state benefits (44.3% vs. 37.0%) and live in non-owner occupied housing (42.5% vs. 32.7%).

Table 1. Characteristics of cases and controls (percentage, unless stated otherwise) [missing values].

| Characteristics                                      | Cases n=582 | Controls n=2460 |
|-----------------------------------------------------|-------------|-----------------|
| Study centre                                        |             |                 |
| Nottingham                                          | 192 (33.0)  | 765 (31.1)      |
| Bristol                                             | 180 (30.9)  | 817 (33.2)      |
| Norwich                                             | 137 (23.5)  | 614 (25.0)      |
| Newcastle                                           | 73 (12.5)   | 264 (10.7)      |
| Median age in years (IQR)*                          |             |                 |
| Age group:                                          |             |                 |
| 0-12 months                                         | 73 (12.5)   | 206 (8.4)       |
| 13-36 months                                        | 355 (61.0)  | 1,591 (64.7)    |
| 37-62 months                                        | 154 (26.5)  | 663 (26.9)      |
| Male                                                | 355 (61.0)  | 1,507 (61.3)    |
| Ethnic Origin: White                                | 512 (89.8)  | 2,232 (91.9)    |
| Number of children aged 0-4 years in family         |             |                 |
| 0                                                   | 2 (0.4)     | 20 (0.8)        |
| 1                                                   | 365 (63.9)  | 1,438 (59.3)    |
| 2                                                   | 180 (31.5)  | 867 (35.7)      |
| ≥3                                                  | 24 (4.2)    | 101 (4.2)       |
| First child                                         | 244 (44.5)  | 959 (42.5)      |
| Maternal age ≤ 19 at birth of first child**          | 86 (16.5)   | 244 (10.8)      |
| Single adult household                              | 80 (14.0)   | 263 (10.9)      |
| Median weekly hours out of home child care (IQR)     | 10 (0; 20.0)| 15 (2.5; 24.0)  |
| Adults in paid work                                 |             |                 |
| ≥ 2                                                 | [12]        | [33]            |
| 1                                                   | 263 (46.1)  | 1,381 (56.9)    |
| 0                                                   | 198 (34.7)  | 745 (30.7)      |
| Receives state benefits                             | 109 (19.1)  | 301 (12.4)      |
| Overcrowding >1 person per room                      | 252 (44.3)  | 893 (37.0)      |
| Non owner occupier                                  | 71 (12.4)   | 252 (10.4)      |
| Household has no car                                 | 51 (9.3)    | 173 (7.4)       |
|                                                      | 242 (42.5)  | 792 (32.7)      |
The sensitivity, specificity and predictive values for exposures validated by home observations are shown in Table 2. Specificities for all 8 items of nursery or safety equipment were high (> 70%) in both cases and controls. Sensitivity was high for only four items in cases and three in controls. Negative predictive values were high for all eight exposures in cases and seven in controls. Positive predictive values were high for only three exposures (all related to safety gates) in both cases and controls. There were only two items (safety gates at top and bottom of stairs) with high values for both specificity and sensitivity.
Table 2. Sensitivity, specificity and predictive values for self-reported exposures compared to observed exposures for cases and controls

| Exposure                                      | Sensitivity (95%CI) | Specificity (95%CI) | PPV (95%CI) | NPV (95%CI) | X² (p) |
|-----------------------------------------------|---------------------|---------------------|-------------|-------------|--------|
| Has stair gate at top of stairs¹              |                     |                     |             |             |        |
| cases                                         | 87.2 (72.6, 95.7)   | 75.7 (58.8, 88.2)   | 79.1 (64.0, 90.0) | 84.8 (68.1, 94.9) | 0.14 (0.71) |
| controls                                      | 93.2 (81.3, 98.6)   | 71.4 (51.3, 86.8)   | 83.7 (70.3, 92.7) | 87.0 (66.4, 97.2) |        |
| Has stair gate at bottom of stairs³           |                     |                     |             |             |        |
| cases                                         | 89.3 (71.8, 97.7)   | 85.4 (72.2, 93.9)   | 78.1 (60.0, 90.7) | 93.2 (81.3, 98.6) | 0.00 (0.95) |
| controls                                      | 93.5 (78.6, 99.2)   | 78.9 (62.7, 90.4)   | 78.4 (61.8, 90.2) | 93.8 (79.2, 99.2) |        |
| Has other safety gates in the house⁴          |                     |                     |             |             |        |
| cases                                         | 45.0 (23.1, 68.5)   | 98.2 (90.6, 100)    | 90.0 (55.5, 99.7) | 83.6 (72.5, 91.5) | 1.49 (0.22) |
| controls                                      | 40.5 (24.8, 57.9)   | 91.9 (78.1, 98.3)   | 83.3 (58.6, 96.4) | 60.7 (46.8, 73.5) |        |
| Use of corner covers on any furniture³        |                     |                     |             |             |        |
| cases                                         | 66.7 (29.9, 92.5)   | 91.7 (82.7, 96.9)   | 50.0 (21.1, 78.9) | 95.7 (87.8, 99.1) | 0.23 (0.63) |
| controls                                      | 75.0 (34.9, 96.8)   | 79.5 (68.4, 88.0)   | 28.6 (11.3, 52.2) | 96.7 (88.5, 99.6) |        |
| Use of baby walker²                           |                     |                     |             |             |        |
| cases                                         | 50.0 (6.8, 93.2)    | 74.1 (60.3, 85.0)   | 12.5 (1.6, 38.3) | 95.2 (83.8, 99.4) | 0.24 (0.62) |
| controls                                      | 60.0 (26.2, 87.8)   | 78.3 (65.8, 87.9)   | 31.6 (12.6, 56.6) | 92.2 (81.1, 97.8) |        |
| Use of stationary play centre²                |                     |                     |             |             |        |
| cases                                         | 83.3 (35.9, 99.6)   | 88.2 (76.1, 95.6)   | 45.5 (16.7, 76.6) | 97.8 (88.5, 99.9) | 3.36 (0.07) |
| controls                                      | 44.4 (13.7, 78.8)   | 77.0 (64.5, 86.8)   | 22.2 (6.4, 47.6) | 90.4 (79.0, 96.8) |        |
| Use of play pen²                              |                     |                     |             |             |        |
| cases                                         | 100 (15.8, 100)     | 96.4 (87.7, 99.6)   | 50.0 (6.8, 93.2) | 100 (93.4, 100) | 0.53 (0.47) |
| controls                                      | 66.7 (9.4, 99.2)    | 95.5 (87.3, 99.1)   | 40.0 (5.3, 85.3) | 98.4 (91.6, 100) |        |
| Use of travel cot instead of a playpen²       |                     |                     |             |             |        |
| case                                          | 57.1 (18.4, 90.1)   | 92.2 (81.1, 97.8)   | 50.0 (15.7, 84.3) | 94.0 (83.5, 98.7) | 0.17 (0.68) |
| controls                                      | 33.3 (0.8, 90.6)    | 94.0 (85.4, 98.3)   | 20.0 (0.5, 71.6) | 96.9 (89.3, 99.6) |        |

PPV = positive predictive value, NPV= negative predictive value.

¹ Only people with stairs were asked these questions in the Study A questionnaire so this analysis was only carried out on people who had stairs (cases: n=77; controls: n=74)

² These practices were only asked for children in the two younger age groups (cases: n=59; controls: n=70)

³ All participants were asked this question (cases: n=81; controls: n=81)

Table 3 shows the frequency of exposures and ORs for the complete case and multiple imputation analyses, adjusted for confounding variables as listed. Significant findings were observed for only 2 exposures. Injured children were significantly less likely to live in a household without furniture corner covers (adjusted odds ratio (AOR) 0.72, 95%CI 0.55, 0.95), or without rugs and carpets firmly fixed to the floor (AOR 0.76, 95% CI 0.59, 0.98). There was a difference of more than 10% between odds ratios from complete case (CC) and multiple imputation (MI) analysis for only two exposures (did not use safety gate to prevent access to garden AOR(MI) 0.78, 95%CI 0.50,1.21; AOR(CC) 1.01, 95%CI 0.58,1.74; not taught rules about running in house AOR(MI) 0.82, 95%CI 0.64,1.06; AOR(CC) 0.73, 95%CI 0.54,1.00).
Table 3. Frequency of exposures in cases and controls and adjusted odds ratios from complete case and multiple imputation analyses

| Exposures                                                                 | Cases n=582 (%) | Controls n=2,460 (%) | Adjusted OR (95% CI) | Confounders adjusted for† |
|----------------------------------------------------------------------------|-----------------|----------------------|----------------------|---------------------------|
| Used safety gates*                                                         |                 |                      |                      |                           |
| YES                                                                       | 412 (75.5)      | 1779 (77.3)          | 1.00                 |                           |
| NO                                                                        | 134 (24.5)      | 524 (22.7)           | 1.12 (0.83; 1.49)    | HADS, hours of out-of-home child care, PDH, first child |
|                                                                           | [36]            | [157]                |                      |                           |
| Used furniture corner covers*                                             |                 |                      |                      |                           |
| YES                                                                       | 135 (23.4)      | 458 (18.8)           | 1.00                 |                           |
| NO                                                                        | 443 (76.6)      | 1982 (81.2)          | 0.72 (0.54; 0.94)    | HADS, hours of out-of-home child care, PDH, first child, uses safety gate |
|                                                                           | [4]             | [20]                 |                      |                           |
| Had rugs/carpets firmly fixed to the floor*                               |                 |                      |                      |                           |
| YES                                                                       | 420 (73.6)      | 1634 (66.9)          | 1.00                 |                           |
| NO                                                                        | 151 (26.4)      | 808 (33.1)           | 0.77 (0.59; 0.99)    | HADS, hours of out-of-home child care, PDH, first child, uses safety gate |
|                                                                           | [11]            | [18]                 |                      |                           |
| Electric cables or wires were trailing across floor **                     |                 |                      |                      |                           |
| NO                                                                        | 464 (84.4)      | 1906 (80.1)          | 1.00                 |                           |
| YES                                                                       | 86 (15.6)       | 475 (19.9)           | 0.75 (0.55; 1.02)    | HADS, hours of out-of-home child care, PDH, first child, uses safety gate |
|                                                                           | [14]            | [16]                 |                      |                           |
| Items on the floor which could be tripped over**                          |                 |                      |                      |                           |
| NO                                                                        | 184 (33.2)      | 725 (29.9)           | 1.00                 |                           |
| YES                                                                       | 371 (66.8)      | 1698 (70.1)          | 1.07 (0.82; 1.38)    | HADS, hours of out-of-home child care, PDH, first child, uses safety gate |
|                                                                           | [14]            | [16][63]             |                      |                           |
| Back door was locked to prevent access to garden**                        |                 |                      |                      |                           |
| NO                                                                        | 304 (61.2)      | 1327 (60.9)          | 1.00                 |                           |
| YES                                                                       | 193 (38.8)      | 851 (39.1)           | 0.97 (0.75; 1.27)    | HADS, hours of out-of-home child care, PDH, first child, uses safety gate |
|                                                                           | [17]            | [23][259]            |                      |                           |
| Used safety gate to prevent access to garden**                            |                 |                      |                      |                           |
| NO                                                                        | 42 (10.3)       | 111 (6.4)            | 1.00                 |                           |
| YES                                                                       | 364 (89.7)      | 1631 (93.7)          | 1.01 (0.58; 1.74)    | HADS, hours of out-of-home child care, PDH, first child, uses safety gate |
|                                                                           | [16][682]       | [36][682]            |                      |                           |
| Child played in garden without adult present**                            |                 |                      |                      |                           |
| NO                                                                        | 367 (70.4)      | 1456 (65.4)          | 1.00                 |                           |
| YES                                                                       | 154 (29.6)      | 770 (34.6)           | 0.89 (0.68; 1.17)    | HADS, hours of out-of-home child care, PDH, first child, uses safety gate |
|                                                                           | [13][48]        | [27][207]            |                      |                           |
| Had taught child rules about slippery floors                              |                 |                      |                      |                           |
| NO                                                                        | 336 (60.7)      | 1484 (62.0)          | 1.00                 |                           |
| YES                                                                       | 218 (39.3)      | 910 (38.0)           | 1.13 (0.83; 1.52)    | HADS, PDH, first child uses safety gate |
|                                                                           | [28]            | [66]                 |                      |                           |
| Had taught child rules about running in the house                         |                 |                      |                      |                           |
| NO                                                                        | 352 (64.0)      | 1454 (60.8)          | 1.00                 |                           |
| YES                                                                       | 198 (36.0)      | 939 (39.2)           | 0.73 (0.54; 1.00)    | HADS, PDH, first child uses safety gate |
|                                                                           | [32]            | [67]                 |                      |                           |
| Safety practices measured only in children aged 0-36 months | Cases n=428 (%) | Controls n=1797 (%) | Adjusted OR (95% CI) | Confounders adjusted for<sup>i</sup> |
|-----------------------------------------------------------|-----------------|---------------------|----------------------|----------------------------------|
| Used baby walker*                                         |                 |                     |                      |                                  |
| NO                                                       | 306 (72.3)      | 1243 (70.1)         | 1.00                 | HADS, hours of out-of-home child care, PDH, first child, uses safety gate, playpen/travel cot, activity centre |
| YES                                                      | 117 (27.7)      | 530 (29.9)          | 0.83 (0.59; 1.16)    |                                  |
| Used playpen or travel cot*                               |                 |                     |                      |                                  |
| YES                                                      | 75 (17.9)       | 252 (14.2)          | 1.00                 | HADS, hours of out-of-home child care, PDH, first child, uses safety gate, baby walker, activity centre |
| NO                                                       | 345 (82.1)      | 1521 (85.8)         | 0.90 (0.61; 1.33)    |                                  |
| Used stationary activity centre*                          |                 |                     |                      |                                  |
| YES                                                      | 71 (16.9)       | 381 (21.5)          | 1.00                 | HADS, hours of out-of-home child care, PDH, first child, uses safety gate, baby walker, playpen/travel cot |
| NO                                                       | 350 (83.1)      | 1391 (78.5)         | 1.37 (0.95; 1.97)    |                                  |

[missing values] {not applicable responses} Percentages may not add up to 100% due to rounding. * in the last 24 hours ** at least some days in the last week. <sup>i</sup>All adjusted models adjusted for index of Multiple Deprivation and distance from hospital in addition to listed confounders. CBQ = Child behaviour questionnaire, PDH = Parenting daily hassles scale. HADS= Hospital anxiety and depression scale.
There was a significant interaction (p=0.002) between the number of adults in the household and rugs or carpets not being firmly fixed to the floor (See Table 4). In one-parent households, having rugs or carpets not firmly fixed to the floor significantly increased the odds of a fall on one level (AOR 2.54, 95%CI 1.16, 5.54) but in households with more than one adult, the odds of a fall were significantly reduced (AOR 0.69, 95%CI 0.52, 0.90). One of the AORs for the interaction analyses differed between analyses using the multiply imputed and complete case data by more than 10%.

Table 4. Comparison between complete case analysis and analysis using multiple imputation where significant interactions were found in the complete case analysis

| Exposure                                      | Adjusted OR (95% CI) by number of adults living with child | Test for interaction |
|-----------------------------------------------|------------------------------------------------------------|----------------------|
| Did not have rugs/carpets firmly fixed to the floor * |                                                            |                      |
| One adult                                     | 2.54 (1.16, 5.54)                                          |                      |
| More than one adult                           | 0.69 (0.52, 0.90)                                          | P=0.002              |

Adjusted for confounders as in Table 3.

* in the last 24 hours.

DISCUSSION

Falls on one level result in considerable morbidity and health service use in the under-fives, but our study did not find safety practices, use of safety equipment or home hazards which reduced the odds of a medically attended fall on one level. Conversely, we found not using furniture covers and not having rugs or carpets firmly fixed to the floor were associated with decreased odds of a fall on one level. Validation of exposures showed high (>70%) sensitivity and specificity for only 2 of the 8 items measured on home visits (safety gates at top and bottom of stairs).

This study has a number of strengths. It is the first case-control study exploring a wide range of modifiable risk factors for falls on one level in young children. We recruited more than the required sample size, adjusted for a wide range of confounding variables, and findings in the multiple imputation analyses were very similar to those in the complete case analysis. Home observations found most exposures were reported with similar accuracy in cases and controls.

Our results should be interpreted in the context of the limitations of this study. Although participation rates were the same for cases and controls, they were low. This raises the possibility of selection bias if participation was associated with exposures or with case/control status. Participants and non-participants were similar in age and sex, but
we were unable to measure exposures in non-participants, so the extent to which selection bias may have occurred is unknown. Exposures were self-reported, so recall and social desirability bias may have also have occurred. The results of our validation study indicate that some exposures were likely to have been misclassified, which may have resulted in odds ratios tending towards unity. The prevalence of some exposures amongst controls differed from that used in our sample size calculation (five were lower, four were higher), so our study may have been underpowered to detect associations between some exposures and falls on one level. This particularly applies to using safety gates anywhere in the house and across kitchen doors to prevent garden access, having trailing cable on floors and use of baby walkers and playpens. Conversely, the large number of statistical tests undertaken may have resulted in type 1 error which may explain the small number of significant associations we found. Our study did not differentiate cases by whether the fall occurred in the house or in the garden although we did collect data on exposures relevant to both the house and garden. In addition we did not collect data on the type of floor coverings within homes or in gardens because our study would have been underpowered to detect differences between cases and controls for such exposures. Larger studies would be required to study falls in houses and gardens separately and to explore the risks associated with different types of floor covering.

Cases appeared to be slightly more socio-economically disadvantaged than controls, which is a well-known known risk factor for child injury and is hypothesised to increase the risk of injury through a range of structural and behavioural mechanisms. Cases would therefore be expected to have a higher prevalence of exposures than controls, but the two significant associations we did find were in the opposite direction to this. Our findings of reduced odds of a fall in households without furniture covers or without firmly fixing rugs and carpets to the floor may possibly be explained by type 1 error or residual confounding, such as differences in supervisory practices. Previous research suggests parents adapt their supervision according to their perceptions of injury risk. Parents in households with hazards which increase the risk of fall-related injuries (e.g. not having rugs or carpets firmly fixed to the floor or not using furniture covers) may supervise children differently from parents in households without those hazards. Several studies suggest parental supervision is associated with reduced injury risk, and if supervision is effective at preventing falls, this may explain our findings of a protective association for these exposures. We were unable to measure parental supervision within our study as validated self-completion tools did not exist at that time.
Many falls on one level occur to young children whilst learning to walk or during play and although our study limitations may explain our negative findings, it is also possible that the exposures we measured do not protect against falls on one level in this age group.

**Comparisons with previous research**

One small Australian case-control study recruited infants aged 6-12 months with head or face trauma attending EDs and compared them to age matched community controls. In contrast to our findings, they found infants using baby walkers most days and those starting using walkers before 8 months of age had a 2-3 fold higher odds of a head injury than those who used walkers less frequently or started use at an older age. Differences in the findings of the two studies may relate to inclusion of multiple mechanisms of falls or design changes to baby walkers after the introduction of new European standards in 2005.

**Implications for research and practice**

Further research is required to identify modifiable risk factors for falls on one level in young children, including those our study was underpowered to detect and type of flooring. As we did not find a reduced risk of falls on one level with any safety practices or items of safety equipment, exploring the effect of parental supervision on falls risk would be useful. Self-controlled case series incorporating time varying measures of supervision, safety practices, safety equipment use and hazards may be helpful. Development of valid measures of parental reported supervision, which were not subject to recall bias between parents of injured and uninjured children, would greatly assist in this process. Our findings do not provide evidence to change the advice currently given to parents about reducing the risk of falls on one level in young children.

| What is already known on this subject |
|--------------------------------------|
| - Childhood falls are an important global public health problem, but there is a lack of evidence about their prevention. |
| - Falls on one level result in considerable morbidity and are costly to health services. |

| What this study adds |
|----------------------|
| - None of the safety practices or home hazards measured in this study was found to reduce the odds of having a medically attended fall on one level in children aged under 5 years. |
| - There is a need to explore other possible risk factors for falls in young children, including the role of parental supervision. |
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REFERENCES

1. Peden M, Oyegbite K, Ozanne-Smith J, et al. World report on child injury prevention. Geneva: WHO, 2008.
2. Centers for Disease Control and Prevention. National Estimates of the 10 Leading Causes of Nonfatal Injuries Treated in Hospital Emergency Departments, United States 2011 National Center for Injury Prevention and Control.
3. Ballesteros MF, Schieber RA, Gilchrist J, et al. Differential ranking of causes of fatal versus non-fatal injuries among US children. Inj Prev 2003;9(2):173-76.
4. Centers for Disease Control and Prevention. WISQARS Cost of Injury Reports.
5. Information Centre for Health and Social Care. Hospital Episode Statistics, Admitted Patient Care, England - 2012-13, 2013.
6. Department of Trade and Industry. UK Home & Leisure Accident Surveillance System, http://www.hassandlass.org.uk/reports/2002data.pdf
7. National Institute for Health and Care Excellence. Preventing unintentional injuries among under-15s in the home (PH30), 2010.
8. Young B, Wynn PM, He Z, et al. Preventing childhood falls within the home: Overview of systematic reviews and a systematic review of primary studies. Accident Analysis & Prevention 2013;60(0):158-71.
9. Kendrick D, Coupland C, Mulvaney C, et al. Home safety education and provision of safety equipment for injury prevention. Cochrane Database Systematic Review 2007;Issue 1(Art. No.:CD005014):DOI: 10.1002/14651858.CD005014.pub2.
10. Kendrick D, Maula A, Stewart J, et al. Keeping children safe at home: protocol for three matched case control studies of modifiable risk factors for falls. Injury Prevention 2012;18(3):e3.
11. Edwards PJ, Roberts I, Clarke MJ, et al. Methods to increase response to postal and electronic questionnaires. Cochrane Database of Systematic Reviews 2009;3.
12. McColl E, Jacoby A, Thomas L, et al. Design and Use of Questionnaires: a review of best practice applicable to surveys of health service staff and patients. Health Technology Assessment, 2001;5(31):1-256.
13. Morrongiello BA, Midgett C, Shields R. Don't run with scissors: young children's knowledge of home safety rules. *J Pediatr Psychol* 2001;26(2):105-15.

14. Watson MC, Benford P, Coupland CA, et al. Validation of a home safety questionnaire used in a series of case control studies. *Inj Prev Published Online First: 3 March 2014 doi:10.1136/injuryprev-2013-041006 2014*.

15. Department for Communities and Local Government. English Indices of Deprivation 2010. https://www.gov.uk/government/publications/english-indices-of-deprivation-2010 [accessed 3/2/14].

16. Department for Education. Education and skills in your area. Postcode distances. http://www.education.gov.uk/cgi-bin/inyourarea/distance.pl [accessed 3/2/2014].

17. Gartstein MA, Rothbart MK. Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development* 2003;26(1):64-86.

18. Morrongiello BA, Lasenby-Lessard J. Psychological determinants of risk taking by children: an integrative model and implications for interventions. *Inj Prev* 2007;13(1):20-25.

19. Plumert JM, Schwobel DC. Social and Temperamental Influences on Children's Overestimation of Their Physical Abilities: Links to Accidental Injuries. *Journal of Experimental Child Psychology* 1997;67(3):317-37.

20. Putnam SP, Gartstein MA, Rothbart MK. Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behavior and Development* 2006;29(3):386-401.

21. Putnam SP, Rothbart MK. Development of Short and Very Short Forms of the Children’s Behavior Questionnaire. *Journal of Personality Assessment* 2006;87(1):102-12.

22. Crnic K, Booth C. Mothers’ and fathers’ perceptions of daily hassles of parenting across early childhood. *Journal of Marriage and the Family* 1991;53:1043-50.

23. Crnic K, Greenberg M. Minor parenting stresses with young children. *Child Development* 1990;61:1628-37.

24. Bjelland I, Dahl AA, Haug TT, et al. The validity of the Hospital Anxiety and Depression Scale: An updated literature review. *Journal of Psychosomatic Research* 2002;52(2):69-77.

25. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. *Medical Care* 2001;39(8):800-12.

26. Varni JW, Seid M, Rode CA. The PedsQL: measurement model for the pediatric quality of life inventory. *Medical Care* 1999;37(2):126-39.

27. Brunner HI, Maker D, Grundland B, et al. Preference-Based Measurement of Health-Related Quality of Life (HRQL) in Children with Chronic Musculoskeletal Disorders (MSKDs). *Medical Decision Making* 2003;23(4):314-22.

28. Clamp M, Kendrick D. A randomised controlled trial of general practitioner safety advice for families with children under 5 years. *BMJ* 1998;316(7144):1576-9.

29. Watson M, Kendrick D, Coupland C, et al. Providing child safety equipment to prevent injuries: randomised controlled trial. *BMJ* 2005;330(7484):178-81.

30. Dupont WD. Power calculations for matched case-control studies. Biometrics 1988;44:1157-1168.

31. Greenland S, Brumback B. An overview of relations among causal modelling methods. *Int J Epidemiol* 2002;31(5):1030-37.

32. Greenland S, Pearl J, Robins JM. Causal Diagrams for Epidemiologic Research. *Epidemiology* 1999;10(1):37-48.

33. Shrier I, Platt R. Reducing bias through directed acyclic graphs. *BMC Med Res Methodol* 2008;8(1):1-15.

34. GL Assessment. The Hospital Anxiety and Depression Scale. Frequently asked questions. How should missing data be treated?http://www.gl-assessment.co.uk/products/hospital-anxiety-and-depression-scale/hospital-anxiety-and-depression-scale-faqs [accessed 8/10/13].
35. Rothbart M. Frequently Asked Questions. http://www.bowdoin.edu/~sputnam/rothbart-temperament-questionnaires/faq/. [accessed 15/09/2012].
36. Rubin DB. *Multiple Imputation for Nonresponse in Surveys*. New York: John Wiley & Sons, 1987.
37. Laflamme L, Hasselberg M, Burrows S. 20 Years of Research on Socioeconomic Inequality and Children’s Unintentional Injuries Understanding the Cause-Specific Evidence at Hand. *Int. J. Pediatr* 2010.
38. Morrongiello BA. Caregiver Supervision and Child-Injury Risk: I. Issues in Defining and Measuring Supervision; II. Findings and Directions for Future Research. *J Pediatr Psychol* 2005;30(7):536-52.
39. Schnitzer PG, Dowd MD, Kruse RL, et al. Supervision and risk of unintentional injury in young children. *Inj Prev* 2014.
40. Morrongiello BA, Corbett M, Brison RJ. Identifying predictors of medically-attended injuries to young children: do child or parent behavioural attributes matter? *Inj Prev* 2009;15(4):220-25.
41. Damashek A, Kuhn J. Toddlers’ Unintentional Injuries: The Role of Maternal-Reported Paternal and Maternal Supervision. *J Pediatr Psychol* 2013;38(3):265-75.
42. Elkington J, Blogg S, Kelly J, et al. Head injuries in infants: A closer look at baby-walkers, stairs and nursery furniture. *New South Wales Public Health Bulletin* 1999;10(7):82-83.
43. British Standards Institution. *Child use and care articles. Baby walking frames. Safety requirements and test methods*. UK: BSI, 2005.