

**Poison prevention practices and medically attended poisoning in young children: multicentre
case-control study**

Denise Kendrick¹; Gosia Majsak-Newman²; Penny Benford¹; Carol Coupland¹, Clare Timblin¹ Mike Hayes³, Trudy Goodenough⁴, Adrian Hawkins⁵ and Richard Reading²

¹School of Medicine, Division of Primary Care, Tower Building, University Park, Nottingham NG7 2RD, UK.

²Norfolk and Norwich University Hospital, Norwich Norfolk and Norwich University Hospitals NHS Foundation Trust, Colney Lane, Norwich NR4 7TJ, UK.

³Child Accident Prevention Trust, PO Box 3588, Barnet, EN5 9QU, UK.

⁴Centre for Child & Adolescent Health, Health and Applied Sciences, University of the West of England, Bristol, Oakfield House, Oakfield Grove, Bristol BS8 2BN, UK.

⁵Great North Children's Hospital, Newcastle upon Tyne Hospitals NHS Foundation Trust, Research Unit Level 2, New Victoria Wing, Royal Victoria Infirmary, Queen Victoria Road, Newcastle upon Tyne, UK

Correspondence to: Professor Denise Kendrick. E mail: denise.kendrick@nottingham.ac.uk Tel:

0115 8466914 Fax: 0115 8466904

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What is already known on this topic

- Poisonings are common in children aged 0-4 years, placing a substantial burden on health services.
- Previous case-control studies provide inconsistent evidence about modifiable risk factors for unintentional poisonings in 0-4 year olds. .

What this study adds

- Not storing medicines out of reach or locked away and not putting medicines and household products away immediately after use increased the odds of secondary care attended poisonings in 0-4 year olds.
- If associations are causal, implementing these poison prevention practices could each prevent between 11% and 20% of poisonings.

Abstract

Introduction

Childhood poisonings are common, placing a substantial burden on health services. Case-control studies have found inconsistent evidence about modifiable risk factors for poisonings amongst 0-4 year olds. This study quantifies associations between poison prevention practices and medically attended poisonings in 0-4 year olds.

Methods

Multicentre case-control study conducted at hospitals, minor injury units and family practices from four study centres in England between 2010 and 2013. Participants comprised 567 children presenting with unintentional poisoning occurring at home, and 2320 community control participants matched on age, sex, date of event and study centre. Parents/caregivers provided data on safety practices, safety equipment use, home hazards and potential confounders, by means of self-completion questionnaires. Data were analysed using conditional logistic regression.

Results

Compared with community controls, parents of poisoned children were significantly more likely not to store medicines out of reach (adjusted odds ratio (AOR) 1.59; 95%CI, 1.21, 2.09; population attributable fraction (PAF) 15%), not to store medicines safely (locked or out of reach (AOR 1.83; 95%CI 1.38, 2.42; PAF 16%) and not to have put all medicines (AOR 2.11; 95%CI 1.54, 2.90; PAF 20%) or household products (AOR 1.79, 95%CI 1.29, 2.48; PAF 11%) away immediately after use.

Conclusions

Not storing medicines out of reach or locked away and not putting medicines and household products away immediately after use increased the odds of secondary care attended poisonings in 0-4 year olds. If associations are causal, implementing these poison prevention practices could each prevent between 11% and 20% of poisonings.

Introduction

Childhood poisonings are a global problem resulting in considerable health service use. In the USA between 2000 and 2006, unintentional poisonings were the eighth leading cause of non-fatal injuries in 0-4 year olds.[1] In the UK there are an estimated 26,000 emergency department (ED) attendances each year[2] and there were more than 5200 hospital admissions in 2012-13 in 0-4 year olds.[3] In Australia in 2009-10, one fifth of all unintentional medicinal poisonings and a tenth of all unintentional poisonings from other substances occurred in 0-4 year olds.[4] Childhood poisoning costs the UK National Health Service (NHS) an estimated £2 million every year[5] and in the USA in 2010, total lifetime medical costs for unintentional poisonings in 0-4 year olds attending ED were estimated at \$66 million.[6]

A small number of case-control studies have explored risk factors for unintentional poisoning in 0-4 year olds; several found significant associations with a limited number of poison prevention practices,[7-9] whilst others have not.[10 ,11] This study therefore aimed to quantify associations between poison prevention practices and medically attended poisonings amongst 0-4 year olds.

Methods

The methods are described in the published protocol.[12] Ethical approval was granted by Nottinghamshire Research Ethics Committee 1 (09/H0407/14). Parental consent to participate was assumed by return of completed study questionnaires.

Study design and setting

This is one of five case-control studies (the others being falls from furniture, falls on one level, stair falls and burns), [13-15] conducted simultaneously within EDs, in-patient wards and minor injury units (MIUs) (services external to acute hospitals, treating a limited range of non-serious injuries) in four areas of England: Nottingham, Derby and Lincoln; Bristol;

Norwich, Cromer and Great Yarmouth; and Newcastle upon Tyne and Gateshead. Cases were recruited between 14 June 2010 and 14 February 2013. Control recruitment commenced at the same time as case recruitment and ended within 4 months of case recruitment.

Participants

Cases were children aged 0-4 years with poisoning or suspected poisoning (hereafter referred to as poisoning) occurring at home attending an ED or MIU or admitted to hospital. Cases were identified by clinical staff during or following attendance/admission, using diagnoses recorded in medical records. Eligibility queries were discussed and agreed between researchers at the four study centres. Study questionnaires recorded whether children had swallowed medicinal or household products. Information on suspected poisonings (where it was unclear if a child had ingested a substance) was ascertained from parents' free-text descriptions of poisoning events and from recruitment logs completed by clinical staff. Children with intentional or fatal injuries or living in residential care were excluded. Parents/guardians of potentially eligible cases were approached during their medical attendance or by telephone or post within 72 hours of attendance.

Community controls were aged 0-4 years without a medically attended poisoning on the date of the case's poisoning, recruited from the case's family practice (or neighbouring practice) and not living in residential care. We aimed to recruit an average of four controls per case, individually matched on age (within 4 months of age of case), sex and date of event (within four months of case poisoning). Ten controls were identified from the practice register for each case and invited to participate by post. Where more than 10 met inclusion criteria, the 10 with dates of birth closest to that of the case were chosen. Where fewer than four controls were recruited per case, we used controls from cases with more than four controls, controls that were no longer matched to cases (e.g. the case had subsequently been excluded) and controls from the other ongoing case-control studies as extra

controls. These were matched on age (within 4 months of case of age), sex, date of event (within 4 months of case's poisoning) and study centre and were only used once as extra controls. We also used an additional group of cases with other injuries (children admitted to hospital or attending ED) from the other ongoing case-control studies as unmatched hospital controls. Detailed information about inclusion and exclusion of cases and controls who had already been recruited to one of the case-control studies is given in our published protocol.[12]

Outcomes

The outcome of interest was medically attended poisoning or suspected poisoning from medicines, cleaning agents, garden chemicals and other household products, occurring at the child's home resulting in hospital admission, ED or MIU attendance. Poisonings from garden plants were excluded.

Exposures

Exposures of interest are shown in box 1.

Box 1. Measurements of exposure

- A. Safety equipment use
1. Safety gates across kitchen doorway*
 2. Child resistant closures (CRCs) or blister packs on all medicines*
 3. CRCs on all household products*
 4. All medicines stored in locked cupboard, medicine cabinet, drawer or fridge*
 5. All medicines stored in locked box*
 6. All household products stored in locked cupboard or drawer*
- B. Hazards
1. Use of baby walkers (ages 0-36 months only)*
 2. Presence of things child could climb on to reach high surfaces*
 3. Any medicines transferred to different container*
 4. Any household products transferred to different container*
- C. Safety behaviours
1. All medicines stored out of reach (at adult eye level or above)*
 2. All household products stored out of reach (at adult eye level or above)*
 3. All medicines stored safely (out of reach or locked or none in house)* †
 4. All household products stored safely (out of reach or locked or none in house)* †
 5. Returning medicines to usual storage place immediately after use**
 6. Returning household products to usual storage place immediately after use**
 7. Teaching rules about not what to do/not do when child sees cleaning products***
 8. Teaching rules about what to do/not do when medicines are on worktop***

*Exposures measured over the 24 hours prior to case poisoning or 24 hours prior to questionnaire completion for controls with yes/no response options.

**Exposures measured over the 7 days prior to case poisoning or 7 days prior to questionnaire completion for controls with every time/most times/sometimes/never/not applicable response options. Responses were grouped into 'at least some not put away every time' vs. 'all put away every time'. 'Not applicable' responses were excluded from the analysis.

***Exposures had yes/no response options and no time period was specified.

†Composite exposure variables for all medicines or all household products stored safely combined responses for storage out of reach, locked and having none in house. Storage was defined as safe if all medicines (or household products) were either locked away or stored out of reach or there were none in the house, and all other combinations were considered unsafe.

Confounders

As some controls were not recruited from their matched case family practice, all analyses were adjusted for the Index of Multiple Deprivation (IMD)[16] (linear term) and distance between postcodes of home and hospital[17] (quintiles of km: ≤ 2.1 , 2.2-3.3, 3.4-4.7, 4.8-8.8, >8.8). The IMD

is a small (400-1200 households) area-based measure of deprivation comprising seven domains (income, employment, health and disability, education skills and training, barriers to housing and services, living environment and crime).

We used directed acyclic graphs (DAGs) to identify the minimal set of confounders for adjusting multivariable models.[18-20] DAGs included age, sex, IMD and distance from hospital as adjusted variables and potential confounding variables which included number of children in family, ethnic group (white/other) single adult household (yes/no), first child (yes/no), infant and early child behaviour questionnaire (CBQ) score (activity and high intensity pleasure sub-scales)[21-23] (linear term), hospital anxiety and depression scale (HADS)[24] (linear term), parenting daily hassles (PDH) scale (parenting tasks subscale)[25 ,26] (linear term), hours of out of home child care per week (linear term) and ability to access poisons measured using nine questions, with 3-point Likert scale responses from “not likely” to “very likely” (grouped as “all responses not likely”, “at least one quite likely but none very likely”, “at least one very likely”). Exposures were also included in DAGs as confounders for other exposures.

Measurement of exposures and confounders

Data on exposures, potential confounding variables, socio-demographic, child health and quality of life (PedsQLTM)[27] (listed in table 2), injuries and treatment received was ascertained from age-specific parent completed questionnaires (0-12 months, 13-36 months, ≥ 37 months). Questionnaires measured all exposures across the five ongoing case-control studies.

Home visits by researchers compared observations with self-reports for all exposures across the five studies which could be ascertained by observation in a sample of 81 cases (including 26 with poisonings) and 81 controls.[28]

Study size

To detect an odds ratio of 1.59, with 80% power, $\alpha=0.05$, a correlation between exposures in cases and controls of 0.1 and an average of 4 controls per case, 266 cases and 1064 controls were required, based on exposure prevalence ranging from 21% (not putting cleaning products away immediately after use) to 65% (not storing all products safely). The odds ratio of 1.59 was chosen because we considered it the smallest clinically important difference it was feasible to detect within study resources.

Statistical methods

Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated using logistic regression (conditional for matched analyses), adjusted as described above. Linearity of relationships between continuous confounders and case/control status was ascertained by adding higher order terms to models. We examined if associations varied by child age, gender, ethnicity, housing tenure, unemployment and single parenthood by adding interaction terms to models and assessing significance with likelihood ratio tests ($p < 0.01$). The population attributable fraction (PAF) percent was calculated for exposures with statistically significantly raised adjusted odds ratios using a published formula.[29] As storing medicines safely included storage at adult eye level or above, PAFs for safe storage and storage out of reach are not independent of each other.

For the PedsQLTM, mean scale scores were computed by summing items and dividing by number of items answered. Means were not computed where $\geq 50\%$ of items were missing.[30] We imputed single missing item values for subscales of the HADS using the mean of the remaining 6 items. Where more than one item was missing, subscale scores were not computed.[31] We were unable to find missing data guidance for the PDH so we used the approach used for the HADS. The CBQ allowed missing values and was scored as the total score divided by the number of questions

answered.[32] The main analyses are complete case analyses, including the single imputed values for the PedsQL™, HADS and PDH. We imputed missing data based on all exposure and potential confounding variables (including single imputed values for scales described above) and case/control status, to create 20 imputed datasets. These were combined using Rubin's rules.[33]

Results

567 cases, 2320 community and 2253 hospital controls participated in the study. The process of recruitment to the study is shown in figure 1. Response rates were similar for cases (28.4%) and community controls (28.3%). Participants and non-participants were similar by age group and sex (0-12 months: 11% vs. 10%; 13-36 months: 67% vs. 69%; ≥37 months 21% vs. 22% respectively; 54% and 53% male respectively).

[insert figure 1 here]

The mean number of community controls per case was 4.09. The median time from date of poisoning to date of questionnaire completion was 12 days (IQR 6, 22). Just over half the cases (57%, n=325) were medicinal poisonings and 43% (n=242) were non-medicinal poisonings. Thirty nine cases (6.9%) were suspected poisonings. Table 1 shows poisoning agent by age and sex.

Table 1. Age and sex distribution by poisoning agent.

	Medicinal poisoning (%)	Non-medicinal poisoning (%)
Age in months ¹		
0-2	0 (0)	3 (1.2)
3-5	2 (0.6)	2 (0.8)
6-8	4 (1.3)	7 (2.9)
9-11	5 (1.5)	26 (10.7)
12-23	82 (25.2)	110 (45.5)
24-35	129 (39.7)	67 (27.7)
36-47	75 (23.1)	20 (8.3)
48-60	28 (8.6)	7 (2.9)
Sex		

Male	154 (47.4)	126 (52.1)
Female	171 (52.6)	116 (47.9)

¹One case was aged 60 months. The poisoning occurred prior to the child's 5th birthday but study questionnaire was completed after 5th birthday

Most cases (84%, n=473) were seen and examined but did not require treatment, 6% (n=33) were treated in ED, 8% (n=45) were admitted to hospital and 2% (n=10) were discharged from ED and followed up in outpatient clinics or family practices. Cases and community controls were of similar age (2.20 vs 2.24 years). More case than community control families were single adult households (17% vs. 12%), with at least one unemployed parent (53% vs. 44%), receiving state benefits (42% vs. 35%), living in rented housing (44% vs. 34%) and in neighbourhoods with higher deprivation scores (17.7 vs 15.1). More mothers of cases than community controls were under the age of 20 when their first child was born (17% vs. 10%). More parents of cases than community controls thought their children were very likely to access poisons in at least one of nine scenarios (78% vs 72%). Hospital controls were younger than community controls, had younger mothers, a range of measures indicating greater deprivation, lived closer to hospital and fewer thought their children were very likely to access poisons (table 1 online).

Table 2. Characteristics of cases and community controls (percentage, unless stated otherwise)

Characteristics	Cases n=567	Community controls n=2320
Study centre		
Nottingham	193 (34.0)	738 (31.8)
Bristol	179 (31.6)	794 (34.2)
Norwich	106 (18.7)	467 (20.1)
Newcastle	89 (15.7)	321 (13.8)
Median age in years (IQR) ¹	2.18 (1.49, 2.92)	2.24 (1.54, 3.02)
Age group:		
0-12 months	65 (11.5)	204 (8.8)
13-36 months	378 (66.7)	1575 (67.9)
37-62 months	124 (21.9)	541 (23.3)
Male	280 (49.4)	1210 (52.2)
Ethnic group: white	514 (92.1) [9]	2115 (92.6) [36]
Children aged 0-4 years in family	[11]	[29]
0	6 (1.1)	16 (0.7)
1	299 (53.7)	1379 (60.2)
2	229 (41.2)	810 (35.4)
≥3	22 (4.0)	86 (3.8)

First child	210 (41.7) [64]	895 (42.7) [222]
Maternal age \leq 19 at birth of first child ²	84 (16.5) [8]	208 (9.7) [14]
Single adult household	92 (16.6) [13]	262 (11.5) [43]
Median weekly hours out-of-home child care (IQR)	12 (0.5, 22.0) [31]	15 (2.5, 24.0) [112]
Adults in paid work	[11]	[35]
\geq 2	263 (47.3)	1281 (56.1)
1	184 (33.1)	742 (32.5)
0	109 (19.6)	262 (11.5)
Receives state benefits	228 (41.7) [20]	795 (35.1) [54]
Overcrowding (>1 person per room)	46 (8.8) [42]	163 (7.4) [128]
Non-owner occupier	241 (43.5) [13]	771 (33.8) [41]
Household has no car	81 (14.6) [11]	219 (9.6) [28]
Median IMD score (IQR)	17.5 (10.3, 31.7)	15.1 (9.3,26.5) [24]
Median distance (km) from hospital (IQR)	3.5 (2.2, 5.9)	4.0 (2.4, 7.6) [24]
Mean child behaviour questionnaire (CBQ) score (SD)	4.75 (0.91) [24]	4.61 (0.86) [186]
Long term health condition	53 (9.4) [5]	187 (8.1) [21]
Median child health visual analogue scale (IQR)	9.8 (8.8, 10) [2]	9.6 (8.4, 10) [14]
Median health related quality of life (PedsQL TM) (IQR) ³	n=326 [3] 91.7 (85.7, 97.2)	n=1354 [24] 89.3 (82.1, 95.2)
Parental assessment of child's ability to access poisons ⁴	[21]	[96]
All scenarios 'not likely'	22 (4.0)	112 (5.0)
\geq 1 scenario 'quite likely' and none 'very likely'	100 (18.3)	513 (23.1)
\geq 1 scenario 'very likely'	424 (77.7)	1599 (71.9)
Median parenting daily hassles (PDH) scale(IQR) ⁵	14.0 (10.3,18.0) [50]	14.0 (11.0,18.0) [113]
Mean hospital anxiety and depression scale (HADS)(SD) ⁵	10.9 (6.1) [15]	10.8 (6.2) [25]

[] missing values. ¹ For cases and community controls aged over five years, the case poisoning occurred prior to 5th birthday but study questionnaire was completed after 5th birthday. ² Asked only when mothers completed questionnaire. IMD: higher score reflects greater deprivation. CBQ: higher score reflects more active and intense behaviour. PDH: higher score reflects more hassle. HADS: higher score reflects greater symptoms of anxiety/depression. Child health visual analogue scale: range 0-10, higher score reflects better health. PedsQLTM: measured only in those aged \geq 2 years, higher score reflects better quality of life. ³ Missing values are those with \geq 50% items on any scale missing. Ability to access poisons measured by responses to the following questions. How likely do you think it is that your child could: (a) reach or climb onto a worktop; (b) reach or climb onto something to reach a cupboard at adult eye level; (c) open cupboards, drawers or medicine cabinets with locks or safety catches on them; (d) open a fridge with a lock or safety catch on it; (e) open a container with a child resistant cap; (f) open a lockable medicine box; (g) get medicines out of blister packs; (h) touch things that you have told him/her not to; (i) open a safety gate. Response options were very likely, quite likely, not likely, don't know. Responses were categorised as shown in the table ⁵ Missing values are those with >1 item missing

Table 3 shows that compared with community controls, parents of poisoned children were significantly more likely not to store medicines out of reach (PAF 15%) were significantly more likely not to store medicines safely (locked or out of reach; PAF 16%) and were significantly more likely not to have put all medicines (PAF 20%) and household products (PAF 11%) away immediately after use. Compared with community controls, parents of poisoned children were significantly less likely not to have taught their children what to do or not do if medicines were left

on the worktop and were significantly less likely not to store all household products safely (locked or out of reach). There were a greater number of significant findings in the analysis using hospital than community controls (table 3 online). These included significantly raised odds ratios for not having CRCs or blister packs on all medicines, not locking all medicines away, not having CRCs on all household products, having things children could climb on to reach high surfaces and not teaching children rules about household products. In addition, odds ratios for 12 out of 18 exposures for community controls were closer to unity than those for hospital controls.

Table 3. Frequency of exposures in cases and community controls and adjusted odds ratios

Exposures	Cases n=567	Community controls n=2320	Adjusted OR (95% CI)†	Confounders adjusted for ¹
<i>Medicines</i>				
All in CRCs/blister packs ¹ Yes No	459 (81.8) 102 (18.2) [6]	1991 (86.1) 321 (13.9) [8]	1.00 1.25 (0.95,1.65)	First child, ability to access poisons ⁵
All in locked box ¹ Yes No	115 (20.5) 447 (79.5) [5]	397 (17.2) 1914 (82.8) [9]	1.00 0.82 (0.47,1.43)	CRCs, HADS, PDH, ability to access poisons, hours out-of-home care, first child, medicines locked, medicines put away immediately after use, kitchen safety gate, medicines stored out of reach, things child could climb on to reach high surfaces
All locked away ¹ Yes No	89 (16.4) 454 (83.6) [24] ((0))	325 (14.6) 1897 (85.4) [92] ((6))	1.00 0.91 (0.64,1.31)	CRCs, HADS, PDH, kitchen safety gate, medicines stored out of reach, things child could climb on to reach high surfaces, hours out-of-home care
All stored out of reach ^{1,2} Yes No	275 (59.3) 189 (40.7) [101] ((2))	1374 (69.2) 612 (30.8) [324] ((10))	1.00 1.59 (1.21, 2.09)	CRCs, HADS, PDH, ability to access poisons, first child, kitchen safety gate, things child could climb on to reach high surfaces, hours out-of-home care
All stored safely ^{1,3} Yes No	315 (65.6) 165 (34.4) [87]	1527 (75.1) 506 (24.9) [287]	1.00 1.83 (1.38, 2.42)	CRCs, HADS, PDH, ability to access poisons, first child, kitchen safety gate, things child could climb on to reach high surfaces, hours out-of-home care
Transferred into different container ¹ No Yes	533 (95) 28 (5.0) [6]	2206 (95.5) 104 (4.5) [10]	1.00 0.96 (0.52,1.76)	CRCs, HADS, PDH, locked medicines box, medicines locked, medicines stored out of reach
All put away immediately after use ⁴ Yes No	298 (61.3) 213 (38.7) [16] ((40))	1467 (76.9) 522 (23.1) [57] ((274))	1.00 2.11 (1.54, 2.90)	HADS, PDH, ability to access poisons, first child, medicines locked, medicines stored out of reach, things child could climb on to reach high surfaces
Taught child rules about medicines Yes No	304 (56.0) 239 (44.0) [24]	1108 (49.3) 1138 (50.7) [74]	1.00 0.66 (0.45, 0.96)	CRCs, HADS, PDH, ability to access poisons, first child, locked medicines box, medicines locked, medicines put away immediately after use, kitchen safety gate, medicines stored out of reach, medicines transferred to different container
<i>Household products</i>				

All in CRCs ¹ Yes No	405 (72.5) 154 (27.6) [8]	1620 (70.3) 686 (29.8) [14]	1.00 0.87 (0.69,1.10)	First child, ability to access poisons
All locked away ¹ Yes No	156 (30.6) 353 (69.4) [54] ((4))	614 (27.9) 1590 (72.1) [106] ((10))	1.00 0.90 (0.69,1.17)	CRCs, HADS, PDH, kitchen safety gate, products stored out of reach, things child could climb on to reach high surfaces, hours out-of-home care
All stored out of reach ^{1,2} Yes No	81 (16.5) 409 (83.5) [73] ((4))	296 (14) 1823 (86.0) [191] ((10))	1.00 0.95 (0.67,1.35)	CRCs, HADS, PDH, ability to access poisons, kitchen safety gate, things child could climb on to reach high surfaces, hours out-of-home care
All stored safely ^{1,3} Yes No	240 (50.1) 239 (49.9) [88]	948 (45.4) 1138 (54.6) [234]	1.00 0.77 (0.59,0.99)	CRCs, HADS, PDH, ability to access poisons, first child, kitchen safety gate, things child could climb on to reach high surfaces, hours out-of-home care
Transferred into different container ¹ No Yes	545 (97.0) 17 (3.0) [5]	2272 (98.4) 38 (1.7) [10]	1.00 1.20 (0.54,2.65)	CRCs, HADS, PDH, products locked, products stored out of reach
All put away immediately after use ⁴ Yes No	392 (74.6) 131 (24.4) [30] ((14))	1834(83.2) 378 (16.8) [74] ((34))	1.00 1.79 (1.29,2.48)	HADS, PDH, ability to access poisons, first child, products locked, products stored out of reach, things child could climb on to reach high surfaces
Taught child rules about household products Yes No	343(63.9) 194 (36.1) [30]	1349(60.0) 899 (40.0) [72]	1.00 0.81 (0.59,1.12)	CRCs, HADS, PDH, ability to access poisons, first child, products locked, products stored out of reach, products put away immediately after use, kitchen safety gate, products transferred to different container
<i>Other exposures</i>				
Safety gate to stop child accessing kitchen ¹ Yes No	150 (26.7) 411 (73.3) [6]	575 (24.9) 1735 (75.1) [10]	1.00 1.05 (0.80,1.37)	HADS, PDH, first child, hours out-of-home care
Things child could climb on to reach high surfaces ¹ No Yes	281 (50.0) 281 (50.0) [5]	1256 (54.3) 1056 (45.7) [8]	1.00 1.20 (0.93,1.54)	CRCs, HADS, PDH, ability to access poisons, first child
Safety practices measured only in children aged 0-36	Cases n=443	Controls n=1779	Adjusted OR (95% CI)†	Confounders adjusted for ^l

months				
Used baby walker ¹				HADS, PDH, first child, hours out-of-home care
No	321 (75.7)	1225 (69.4)	1.00	
Yes	103 (24.3) [19]	539 (30.6) [15]	0.82 (0.61,1.10)	

[missing values] ((not applicable responses))

¹ In the last 24 hours. ² Out of reach = adult eye level or above. ³ Safely = out of reach or locked. ⁴ At least some days in the last week. ⁵ See definition in footnote to table 2. [All models adjusted for Index of Multiple Deprivation and distance from hospital in addition to listed confounders. CRC = child resistant closure, CBQ = Child behaviour questionnaire, PDH = Parenting daily hassles scale. HADS= Hospital anxiety and depression scale.

† Analysis includes single imputed values for hospital anxiety and depression scale and parenting daily hassles scale as described in methods

AORs from complete case (CC) and multiple imputation (MI) analysis differed by more than 10% for not storing medicines safely (11% lower in MI analysis), not storing all household products safely (18% higher in MI analysis) transferring cleaning products to different containers (23% higher in MI analysis) and not putting household products away immediately after use (10.1% lower in MI analysis). Statistical significance differed only for not storing all household products safely (AOR(MI) 0.91, 95%CI 0.73, 1.13; AOR(CC) 0.77, 95%CI 0.59,0.99).

There were two significant interactions. Firstly, the odds of poisoning in families not storing household products out of reach was greater in single adult (2.43, 95%CI 1.09, 5.43) than 2 adult households (AOR 0.76, 95%CI 0.52, 1.11). Secondly, the odds of poisoning in families who did not keep medicines locked away was greater in families with male (AOR 1.48, 95%CI 0.85, 2.58) than female cases (AOR 0.59, 95%CI 0.37, 0.94). These interactions remained statistically significant ($p < 0.01$) in the multiple imputation analyses.

Discussion

Main findings

We found not storing medicines out of reach, not storing medicines safely (locked away or out of reach) and not putting medicines and household products away immediately after use increased the odds of secondary care attended poisonings in 0-4 year olds. If our associations are causal, implementing these poison prevention practices could each prevent between 11% and 20% of poisonings.

Strengths and limitations

To our knowledge, this is the largest case-control study measuring associations between poison prevention practices and medically attended poisoning in young children published to date. We exceeded our sample size requirements, giving the study adequate power to detect odds ratios smaller than 1.59. The study was conducted in NHS hospitals across England, including urban and rural

areas. Analysis included adjustment for a wide range of potential confounders identified using DAGs. Odds ratios for most associations were similar in the complete case and multiple imputation analyses. Where odds ratios did differ by more than 10%, the statistical significance of findings differed for only one exposure.

In the validation study[28] only three poisonings exposures had at least moderate agreement (medicines kept in fridge ($\kappa=0.54$), all household products stored at adult eye level or above ($\kappa=0.48$) and having a kitchen safety gate ($\kappa=0.57$)), and sensitivity and specificity were both $\geq 70\%$ only for three exposures (all household products stored out of reach, all medicines and household products stored out of reach, and use of kitchen safety gates). These relatively low levels of agreement may have resulted from parents reporting “socially acceptable” responses, or changing prevention practices after their child’s injury, after completing the study questionnaire or in anticipation of the home visit. It is also possible that our study questions may not have reliably measured poisoning practices, and further research could help develop better questions. The accuracy of reporting differed significantly between cases and controls for only one exposure (household products transferred to different containers) with controls under-reporting to a greater degree than cases ((sensitivity cases=14%, controls=0%; specificity cases=100%, controls=96%; test for homogeneity $p=0.03$). As non-differential misclassification can result in odds ratios tending towards unity,[34] some of our odds ratios may be under-estimated. Our study used community and hospital controls. Hospital controls had a higher prevalence of socio-demographic risk factors and exposures for poisoning than community controls. The greater number of significant findings and the greater magnitude of odds ratios amongst hospital controls may therefore reflect Berkson bias.

Participation rates for cases and community controls were low (28%). Selection bias may have occurred if reasons for non-participation were associated with exposures or with secondary care attendance for poisoning. Participation rates were similar by age and sex, but we were not able to measure exposures in non-participants. Most poisonings in our study did not require treatment in the ED, and if seeking medical attention was associated with our exposures, this may have led to odds ratios being overestimated. Our study included a small number (n=39) of suspected poisonings, which is unlikely to have a major impact on our findings. There may have been residual confounding in our analyses despite adjusting for a range of confounding factors. We did not measure previous poisonings, which could be associated with health care behaviour and safety practices, but the number of repeat poisonings is likely to be small. PAFs for storing medicines safely and storing out of reach were not independent of each other and very similar in magnitude; hence our study suggests storage out of reach may be more important for prevention than locking medicines away. .

Our significant interactions should be interpreted with caution due to multiple significance testing and small numbers in sub-groups. It is plausible that not locking medicines away increases poisoning risk more amongst boys than girls, , as boys may receive less active supervision than girls.[35-37] It is also plausible that not storing households products out of reach increases poisoning risk more amongst single adult households, where supervision may be more challenging or involve more frequent sibling supervision.[38 ,39]

Comparisons with previous literature

Three case-control studies report findings consistent with ours. An Australian study of 1-3 year olds attending an ED following a poisoning and hospital and community controls , found accessible storage of medicines in bathrooms increased the odds of poisoning (OR 1.03, 95%CI 1.002, 1.080).[7] Two studies using of 0-4 year olds treated in hospital for poisoning and hospital controls found storing toxic substances in boxes/cabinets (OR 3.80, 95%CI 1.15,12.49) or <150cm from the floor (OR 16.59, 95%CI 2.86,96.20)[8], unsafe storage of chemicals and medicines (OR 5.6 95%CI

1.9, 16.7) and storing kerosene and petrol in soft drinks bottles (OR 3.8, 95%CI 2.0, 7.3) increased the odds of poisoning.[9] In contrast, two small studies failed to find significant associations between safely packaged household products,[10] presence of toxic substances, storage practices, frequencies of use, packaging or disposal and poisonings.[11] Differences in findings between these studies and ours may relate to control groups used, confounders adjusted for, sample size, exposure measurement or types of poisoning.

We found not teaching children safety rules was associated with a lower odds of poisoning. Previous research suggests teaching safety rules can increase the risk of interactions with hazards and injuries in young children[40] unless it results in a high level of understanding about the safety issue.[41] As teaching safety rules is a strategy commonly used by parents, further work should explore relationships between teaching safety rules and poison prevention in young children.

Implications for policy and practice

If our associations are causal, improving prevention practices, particularly storing out of reach and putting poisons away immediately after use could reduce medically attended poisonings in 0-4 year olds. Poison prevention education can be provided during well-child contacts, when prescribing for families with young children and after poisoning events. Advice should cover cupboard/cabinet lock use and provision of free or low-cost locks for low income families. Commissioners should ensure child health services include these activities. Increasing effectiveness and durability of cupboard/drawer/cabinet latches and locks and changes to CRCs, their testing protocols and specifications of products required to be in such containers could also help prevent poisonings.

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Contributions

DK, CC, MH and RR designed the study and GMN, PB, CT, TG and AH contributed to study design. DK and RR supervised the study. GMN, PB, CT, TG and AH collected data. DK, GMN, PB, CC and CT analysed data and all authors interpreted data. DK, GMN, PB and CT drafted sections of the manuscript. All authors critically reviewed the manuscript and approved the final manuscript.

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