

# Child Protection Evidence

## Systematic review on

# Bruising

Last updated: February 2016

The Royal College of Paediatrics and Child Health (RCPCH) is a registered charity in England and Wales (1057744) and in Scotland (SC038299)

Original reviews and content © Cardiff University, funded by NSPCC  
Updates and new material © RCPCH

**RCPCH**

Royal College of  
**Paediatrics and Child Health**

*Leading the way in Children's Health*

# Table of contents

<b>Summary</b> .....	<b>3</b>
<b>Background</b> .....	<b>4</b>
<b>Methodology</b> .....	<b>4</b>
<b>Findings for clinical question 1</b> .....	<b>5</b>
1.1 Comparative studies of non-abused and abused children .....	5
1.2 Patterns and sites – Bruising in non-abused children .....	6
1.3 Patterns and sites – Bruising in abused children .....	7
1.4 Implications for practice .....	9
1.5 Research implications .....	9
1.6 Limitations of review findings .....	9
<b>Findings for clinical question 2</b> .....	<b>10</b>
2.1 Implications for practice .....	10
2.2 Research implications .....	11
2.3 Limitations of review findings .....	11
<b>Other useful resources</b> .....	<b>11</b>
Clinical question 1 .....	11
Clinical question 2 .....	12
<b>Related publications</b> .....	<b>13</b>
<b>References</b> .....	<b>15</b>
<b>Appendix 1 - Methodology</b> .....	<b>22</b>
Inclusion criteria .....	22
Ranking of abuse .....	23
Search strategy .....	24
Pre-review screening and critical appraisal .....	26

# Summary

Bruising is the commonest injury in physical child abuse(1, 2). Diagnostic dilemmas centre around distinguishing abusive from non-abusive bruises and determining the age of the bruise.

This systematic review evaluates the scientific literature on abusive and non-abusive bruising in children published up until **February 2016** and reflects the findings of eligible studies. The review aims to answer two clinical questions:

- Which patterns are suggestive of abuse?
- Can a bruise can be accurately aged?

There are a number of possible observations to identify bruising indicative of abuse:

- Bruising in children who are not independently mobile
- Bruising in babies
- Bruises that are seen away from bony prominences
- Bruises to the face, abdomen, arms, buttocks, ears, neck, and hands
- Multiple bruises in clusters
- Multiple bruises of uniform shape
- Bruises that carry the imprint of implement used or a ligature
- Bruises that are accompanied by petechiae, in the absence of underlying bleeding disorders

Child protection agencies are required to determine the likely timing of when the injury occurred and legal agencies need to investigate potential perpetrators, to aid this clinicians may be asked to estimate the age of a bruise based on a naked eye assessment of the colour of the bruise. The challenges are:

- It is not possible to age a bruise by examining it with the naked eye
- Influence of ethnicity and socio-economic group which was not addressed by the included studies

Further challenges for clinicians are in the assessment of colour as:

- Different colours appear in the same bruise at the same time
- Not all colours appear in every bruise
- In general red / blue and purple colours were more commonly seen in bruises less than 48 hours old and yellow, brown and green bruises were most often seen in bruises over seven days old. However, the converse of this also applied: red / blue and purple were identified in up to 30% of observations in bruises older than seven days and yellow / brown or green were seen in up to 23% of bruises less than 48 hours old

- There is considerable variation in the way different observers interpret and describe colour. The accuracy with which observers estimate the age of a bruise from a photograph is little more than 50%(24/44)
- The accuracy of estimating the age of a bruise to within 24 hours in vivo was only 40%

### Key findings:

- In the most recent update, no new studies relating to the pattern or aging of bruises have been published that met the inclusion criteria. There is, however, an increasing body of literature addressing optimal imaging of bruises which is highlighted in the ‘other useful references’ section, together with a new study which explored which children with bruises should undergo skeletal survey(3)
- Bruising was the most common injury in children who have been abused and a common injury in non-abused children, the exception to this being in non-mobile infants where accidental bruising is rare. The number of bruises a child sustains increases as they get older and their level of independent mobility increases
- Further cases have been reported where bruising was a “sentinel injury”(4) in children prior to the recognition of child abuse, highlighting the importance of recognising abnormal patterns of bruising in young infants
- importance of recognising abnormal patterns of bruising in young infants

## Background

This systematic review evaluates the scientific literature on abusive and non-abusive bruising in children published up until February 2016 and reflects the findings of eligible studies. The review aims to answer two clinical questions:

- What patterns of bruising suggest physical child abuse?
- Can you age a bruise accurately?

## Methodology

A literature search was performed using all OVID Medline databases for all original articles and conference abstracts published since 1950. Supplementary search techniques were used to identify further relevant references. See [Appendix 1](#) for full methodology including search strategy and inclusion criteria.

Potentially relevant underwent full text screening and critical appraisal. To ensure consistency, ranking was used to indicate the level of confidence that abuse had taken place and also for study types.

# Findings for clinical question 1

## What patterns of bruising suggest physical child abuse?

- Of 207 studies reviewed, 42 studies were included that addressed this question(1, 2, 5-44)
- Bruising is the most common injury in children who have been physically abused
- Children sustain bruises from every day play activities and accidents
- Most studies applied to children less than ten years of age
- Two studies examined disabled children aged 2 to 20 years with accidental bruising(15, 30)
- Two comparative studies detail bruising patterns in children aged less than three years admitted to the Paediatric Intensive Care Unit (PICU) (24, 35)

### Influence of ethnicity and socio-economic group

- There was very little information about bruising in different ethnic groups for non-abused children(40, 42)
- White abused children are more likely to be bruised than black abused children(19)
- Patterns of bruising in non-abused children do not differ by socio-economic group(7, 10, 19, 22, 27, 40, 42, 43)

## 1.1 Comparative studies of non-abused and abused children

- 322 children aged 1-14 years attending out-patients were compared for bruising patterns(10):
  - A scoring system for distinguishing abusive and non-abusive cases was derived based on bruise length and location(10)
  - Bruising to the ear, face, neck, torso and buttocks was significantly more common in abused children ( $p<0.001$ )(10)
  - Abused children had significantly more bruises in all regions except the legs(10)
  - Bruises in abused children were larger than in non-abused children in all regions of the body(10)
- 105 children aged less than three years requiring intubation in PICU were examined for injuries to the ears, neck, and jaw and oral injuries(24):
  - 14 children had been abused, ten of whom had bruising(24)
  - Bruising was noted on the ears, eyelids, jaw, buttocks, abdomen and forehead(24)
  - Two of ten had petechiae in association with bruising(24)
  - Oral, jaw and neck injuries were significantly associated with abusive trauma ( $p<0.001$ )(24)
- 95 children aged 0-4 years admitted with severe head injury were compared(35):

- Abused children had significantly more bruising ( $p < 0.0005$ )(35)
- Bruising to the ear, neck, hand, right arm, chest and buttocks were predictive of abuse (35)
- Bruises found on the face, cheek, scalp, head and legs were non-discriminatory(35)
- Bruising on the torso, ear, or neck for a child  $\leq 4$  years of age and any bruising in any region for an infant  $< 4$  months of age were predictive of abuse(35)
- A bruising clinical decision rule was derived, (TEN-4 BCDR) with a sensitivity of 97% and a specificity of 84% for predicting abuse(35)

## 1.2 Patterns and sites – Bruising in non-abused children

### Gender

- There is no difference in bruising patterns between boys and girls(7, 20, 29, 35, 40, 42)

### Trends in accidental bruising

- Increased accidental bruising was noted in the summer months in one study(22) while this was not found in a recent study(20)
- Increased accidental bruising was noted with increased family size(7, 20)
- Children sustain more bruises as they become older(7, 20, 35, 40, 43)
- Bruising is strongly related to mobility(7, 20, 35, 40, 43)
- Bruising in a baby who is not yet crawling and therefore has no independent mobility is very uncommon(7, 20, 35, 40, 43)
- 52%-87% of children who are walking have bruises (range 1-27 bruises)(7, 20, 35, 40, 43)

### The sites and characteristics of bruising in non-abused children

- In mobile children the commonest sites of bruising are the shins and the knees(20, 40, 42-44)
- In slips, trips and falls the commonest sites of bruising are the back of the head and the front of the face, including the T of the forehead, nose, upper lip and chin(8, 20)
- Less than 5% of accidental bruising was on the cheeks and less than 6% around the eyes(8, 20)
- Most accidental bruises occur over bony prominences and are commonly seen on the front of the body. These correspond to the sites that are bumped in falls(7, 8, 20, 40)
- Children who are pulling to stand may bump their head and sustain bruising to the head, usually occurring on the forehead(7, 8, 40)
- There were areas of the body where bruising was uncommon. These sites include the buttocks, face, neck, ears, abdomen or upper arm, posterior leg, foot or hands(7, 8, 10, 20, 35, 40, 42, 43)

- Up to 10% of children who are walking may have bruising to the forearm(7, 8, 10, 20, 35, 40, 42, 43)
- Children who sustain fractures rarely have a bruise overlying the fracture when they present to hospital(44)

### **Bruising in disabled children**

- Bruising patterns in disabled children showed the feet, knees and thighs as a frequent site of accidental bruising(15, 30)
- Lower legs, ears, neck, chin, anterior chest and genitalia were rarely bruised accidentally(15, 30)
- Bruising to the hands, arms and abdomen were significantly more common in disabled than able bodied children(15, 30)
- With data stratified into categories of unrestricted walker, restricted walker and wheelchair dependent, bruising increased with increasing independent mobility ( $p=0.001$ )(30)
- Causes of injury varied by mobility with falls predominating in the walkers in comparison to equipment usage and self-infliction for wheelchair users ( $p<0.001$ )(30)

## **1.3 Patterns and sites – Bruising in abused children**

### **Gender**

- There is no difference in bruising patterns between boys and girls(19, 20, 29)

### **The sites and characteristics of bruising in abused children**

- Any part of the body is vulnerable to bruising from abuse(6, 31, 41)
- The head is by far the commonest site of bruising in child abuse(2, 5, 9, 10, 16, 17, 20, 31, 44)
- Three infants aged less than five months each presented with bruising to the face which was not investigated further. All three re-presented with abusive head trauma, reiterating that bruising to the face in a non-mobile infant may be a sentinel injury(34)
- Other commonly bruised sites in abuse include the ear, neck, trunk, buttocks, thighs, and arms(2, 5, 9, 10, 17, 20, 31, 44)
- Among a study of 519 children referred under child protection procedures, the 350 with abuse substantiated showed significantly more bruising than those with abuse excluded. The abused children had significant numbers of bruises on the cheeks, neck, head, trunk, front of thighs, upper arms, buttocks or genitalia(21)

### **Characteristics**

- Although bruising is the commonest injury in physical abuse, fatal non-accidental head injury and non-accidental fractures can occur without bruising(2, 5, 9, 10, 17, 31, 44)

- Abusive bruises can occur amongst other types of soft tissue injuries. These may be recent and older injuries e.g. scars and healed abrasions(6, 31, 41)
- The presence of areas of bruising interspersed with small abrasions is consistent with being hit with a rope(6, 31, 41)
- In contrast to non-abused children, bruises in child abuse are commonly seen on soft parts of the body(13, 20, 28, 35)
- Clusters of bruises are a common feature in abused children. These are often defensive injuries as the child tries to protect their head: on the upper arm, side of chest, outside of the thigh, or bruises on the trunk and adjacent limbs(6, 20, 21, 31, 37, 41)
- Abusive bruises can carry the imprint of the implement used. These include single or multiple linear bruising due to being struck with a rod-like instrument, banding where the hand has been tied and an imprint of the implement such as an electrical cord, studded belt or dog collar(6, 11, 12, 16-19, 21, 29, 31, 32, 37, 41)
- A combination of digital photography and a plastic overlay outlining alleged perpetrator's handprints may help to identify who caused the injury(32)
- Specific patterns of abusive bruising are described and include; vertical gluteal cleft bruising and bruising to the pinna of the ear where the shape of the bruise assumes the line of anatomical stress rather than the shape of the injuring object(12, 16, 23, 31). Patterned bruising may be accompanied by petechiae in abused children(6, 17, 21, 29). The presence of petechiae with bruising occurs more commonly in abuse than accidental injuries, positive predictive value of 80.0 (95% CI 64.1, 90.0). The absence of petechiae is not helpful in excluding abuse(29). 54/350 (15.4%) of the abused children in one study had petechiae(21)

### **Bruising associated with fractures**

- Abusive fractures were rarely accompanied by overlying bruises (58% of fractures had no bruises near the fracture site, 21% had bruising near the site of at least 1 fracture, of these bruising or subgaleal hematoma near the site of a skull fracture was seen most often(57)
- Bruising in association with long bone and rib fractures was uncommon(57)
- 23.3% of 137 infants aged less than 6 months investigated for an isolated bruise had occult fractures identified(16)
- One study of children with abusive fractures found 5% of children had subgaleal haematomas(9 / 10 with associated skull fracture)(33)

### **Scalping**

- A boggy swelling to the forehead and periorbital oedema with no skull fracture, due to 'scalping' violently pulling the child's hair leading to subgaleal haematoma(38, 39)

### **Bruising in pre-mobile children**

- One study emphasised the need to investigate all pre-mobile children with unexplained bruising (one haemophilic and two abused infants)(13)

- Three infants noted to have bruising were not investigated for child protection concerns. All three re-presented with severe abuse (rank 1 – see [ranking of abuse](#)), two fatally(36)

## 1.4 Implications for practice

A bruise must never be interpreted in isolation and must always be assessed in the context of medical and social history, developmental stage, explanation given, full clinical examination and relevant investigations.

Patterns of bruising that are suggestive of physical child abuse:

- Bruising in children who are not independently mobile
- Bruising in babies
- Bruises that are seen away from bony prominences
- Bruises to the face, abdomen, arms, buttocks, ears, neck, and hands
- Multiple bruises in clusters
- Multiple bruises of uniform shape
- Bruises that carry the imprint of implement used or a ligature
- Bruises that are accompanied by petechiae, in the absence of underlying bleeding disorders
- Importance of recognising abnormal patterns of bruising in young infants

## 1.5 Research implications

Further research is needed in the following areas:

- Large comparative studies encompassing developmental stage in populations representative of ethnic and cultural diversity
- Large comparative studies of children with disabilities
- Studies exploring the relationship of explanations of injury to the pattern of bruising sustained
- Bleeding disorders

## 1.6 Limitations of review findings

- There is a lack of comparative studies between abusive and non-abusive bruising
- We have found no data on the patterns of bruising in children with bleeding disorders
- There is a lack of data on bruising patterns in children with disability

## Findings for clinical question 2

### Can you age a bruise accurately?

- In this update of the review the full texts of six studies from the international literature were screened, giving a total over the lifetime of this review of 207 studies, and three of those addressed this issue(13, 64, 65)
- It is not possible to age a bruise by examining it with the naked eye

#### **Influence of ethnicity and socio-economic group**

- Not addressed by the included studies

#### **Assessment of colour**

- Clinicians may be asked to estimate the age of a bruise based on a naked eye assessment of the colour of the bruise
- These estimates of timescale are requested by: Child protection agencies to determine the likely timing of when the injury occurred and legal agencies to investigate potential perpetrators
- The three included studies detail small numbers of bruises and show that:
  - Different colours appear in the same bruise at the same time(45, 46). One child had a blue bruise on the arm and a green / yellow bruise on the leg that were sustained at the same time(46)
  - Not all colours appear in every bruise(45, 46)
  - In general red / blue and purple colours were more commonly seen in bruises less than 48 hours old and yellow, brown and green bruises were most often seen in bruises over seven days old. However, the converse of this also applied: red / blue and purple were identified in up to 30% of observations in bruises older than seven days and yellow/brown or green were seen in up to 23% of bruises less than 48 hours old(7)
  - There is considerable variation in the way different observers interpret and describe colour(45)
  - Different estimates for when yellow is seen in a bruise are given. One study stated that yellow bruising was not seen before 24 hours(45) and a second study stated that yellow only appeared in bruises over 48 hours old(7)

## 2.1 Implications for practice

- The scientific evidence concludes that we cannot accurately age a bruise from clinical assessment or from a photograph
- Any clinician who offers a definitive estimate of the age of a bruise in a child by assessment with the naked eye is doing so without adequate published evidence

## 2.2 Research implications

Further research is needed in the following areas:

- Evaluation of novel imaging techniques in children with bruises of known age
- Is it possible to develop an accurate calibration of the colour of a bruise and overcome the huge variation in human colour discrimination
- Assessment of bruises in children of different skin colour, across all age ranges

## 2.3 Limitations of review findings

- There is a lack of data relating specifically to the use of new techniques in children
- No large-scale studies of ageing of bruises in our population of interest have been conducted

## Other useful resources

The review identified a number of interesting findings that were outside of the inclusion criteria. These are as follows:

### Clinical question 1

- Tourniquet syndrome has been described in infants as both an abusive and non-abusive injury(47-50)
- One comparative study(57 children) noted 67% were experiencing extreme poverty or neglect(48)
- Surgeons and paediatricians both need to be aware of a possible abusive aetiology(47, 49)
- Petechiae in the absence of bruising may occur as a consequence of suffocation(51)
- Mongolian blue spots are recorded on feet, scalp, knee and back as well as lumbosacral and gluteal area(52)
- Acute haemorrhagic oedema of infancy may present with multiple purpuric lesions which may mimic bruising(53)
- Subgaleal haematoma has been described in a toddler following hair braiding(54)
- Soft tissue injury, evidenced by elevated CPK(55) or renal failure as a consequence of haemoglobinuria has been sustained when children were severely beaten(56)
- Absence of abdominal bruising does not preclude a significant abdominal injury(57) just as the absence of bruising does not preclude AHT(58)
- Amongst a group of infants aged less than one year with confirmed abuse, the most frequent “sentinel injury” identified prior to this was a bruise(4)

- A study of 77 infants with abusive fractures of whom 32% had missed opportunities for the diagnosis of child abuse and the most common sign on examination at previous medical visits prior to the diagnosis of abuse was bruising or swelling(59)
- An analysis of 146 infants < 6 months with suspected abuse and an apparently isolated bruise underwent investigation. 23.3% of whom had positive skeletal survey, and 27.4% positive neuroimaging(16)
- An American study suggests an algorithm to identify the necessity to undertake skeletal survey after applying the Rand/UCLA appropriateness method. This study identified four combinations of bruises in children younger than 2 years of age where skeletal survey (SS) is necessary to undertake (please see figure 2 in original article)(3)

## Clinical question 2

### Perception of colour

- There is considerable variation in the way the same observer describes colour in a bruise and then in a photograph of the same bruise(60)
- Individual perception of the colour yellow varies and our ability to perceive it declines with age(61-63)
- A non-invasive method, reflectance spectrophotometry, of measuring haemoglobin and its degradation products may prove a useful tool in the estimation of the age of bruises(61-63)

### Histological dating

- Histological dating of bruises relies on a predictable pattern of cellular responses; however data in bruises from three children did not confirm these classical findings(64)

### Accuracy of age estimation

- Standardised bruises generated in adults had age estimation performed on clinical photographs by forensic examiners(65)
- Only 48% of bruises were estimated accurately to within 24 hours of the true age, thus age estimation from photographs is unreliable(65)

## Imaging techniques

### Ultraviolet photography

- Ultraviolet photography may reveal bruises that are no longer visible to the naked eye, i.e. two to ten month old injuries. This photography has been used in fatal and non-fatal cases, but longitudinal studies are lacking in a paediatric context(66)

### **Infra-red photography**

- Infra-red imaging was assessed to determine if it could detect bruises no longer visible with the naked eye or on conventional imaging. It did not reveal any significant evidence of bruising that was not otherwise visible(67)
- A study of post-mortem cases noted that IR identified contusions that were not visible clinically although one false negative also occurred. The precise pattern was not evident by IR(68)

### **Reflection spectra**

- Reflectance spectroscopy may assist in ageing bruises but, to date, there is only experimental data available(69, 70)
- Use of reflection spectra to determine age of bruising explored in adults and children – not yet used in clinical practice(71)
- A stochastic photon transport model in multilayer skin tissue combined with reflectance spectroscopy measurements is used to study normal and bruised skins; this is proposed as a potential model for ageing bruises(72)

### **Chromophore concentrations**

- Adult studies evaluating chromophore concentrations as an aid to ageing bruises show a high amount of variance to date. Not yet suitable for clinical use(73)

### **Ultrasound of bruising**

- Ultrasound was used to determine the depth and extent of a bruise(74)

### **Colorimetric scale**

- Single case study proposing a colorimetric scale for the evaluation of bruises / bites(75)
- The accuracy with which observers estimate the age of a bruise from a photograph is little more than 50%(24/44)(45, 46)
- The accuracy of estimating the age of a bruise to within 24 hours in vivo was only 40%(45)
- Neither colour, tenderness, nor swelling was significantly correlated with accuracy of the age of a bruise(45)

## **Related publications**

### **Publications arising from this review**

Maguire S, Mann MK, Sibert J, Kemp A. Can you age bruises accurately in children? Archives of Disease in Childhood. 2005;90(2):187-189

- Added to DARE Database: The Database of Abstracts of Reviews of Effects (DARE) is a collection of quality assessed systematic reviews of health care research identified in the biomedical literature from 1994 onwards. For those reviews which meet the Centre for Reviews and Dissemination (CRD) quality criteria, structured abstracts are written summarising the content and methods used to conduct the review and offering a commentary on the rigour with which the review was conducted.

Maguire S, Mann MK, Sibert J, Kemp A. Are there patterns of bruising in childhood which are diagnostic or suggestive of abuse? *Archives of Disease in Childhood*. 2005;90(2):182-186

Maguire S. Bruising as an indicator of child abuse: when should I be concerned? *Paediatrics and Child Health*. 2008;18(12):545-549

Maguire S, Mann M. Systematic reviews of bruising in relation to child abuse—what have we learnt: an overview of review updates. *Evidence Based Child Health: A Cochrane Review Journal*. 2013;8:255-263.

## **Primary studies arising from this review**

Maguire S, Ellaway B, Bowyer VL, Graham EAM, Ruddy GN. Retrieval of DNA from the faces of children aged 0-5 years: a technical note. *Journal of Forensic Nursing*. 2008;4(1):40-44.

Lawson Z, Nuttall D, Young S, Evans S, Maguire S, Dunstan F, Kemp AM. Which is the preferred image modality for paediatricians when assessing photographs of bruises in children? *International Journal of Legal Medicine*. 2011;125(6):825-830.

Lawson Z, Dunstan F, Nuttall D, Maguire S, Kemp A, Young S, Barker M, David L. How consistently do we measure bruises? A comparison of manual and electronic methods. *Child Abuse Review*. 2013.

Graham EAM, Watkins WJ, Dunstan F, Maguire S, Nuttall D, Swinfield CE, Ruddy GN, Kemp AM. Defining background DNA levels found on the skin of children aged 0-5 years. *International Journal of Legal Medicine*. 2014;128(2):251-258.

Kemp AM, Maguire SA, Nuttall D, Collins P, Dunstan F. Bruising in children who are assessed for suspected physical abuse. *Archives of Disease in Childhood*. 2014;99(2):108-113.

# References

1. Lynch A. Child abuse in the school-age population. *The Journal of school health*. 1975;45(3):141-8. Available from: <http://onlinelibrary.wiley.com/doi/10.1111/j.1746-1561.1975.tb04481.x/abstract>.
2. Smith SM, Hanson R. 134 battered children: a medical and psychological study. *British medical journal*. 1974;3(5932):666-70. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1611652/pdf/brmedj01996-0040.pdf>.
3. Wood JN, Fakeye O, Mondestin V, Rubin DM, Localio R, Feudtner C. Development of Hospital-Based Guidelines for Skeletal Survey in Young Children With Bruises. *Pediatrics*. 2015;135(2):e312-20. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/25601982>.
4. Sheets LK, Leach ME, Koszewski IJ, Lessmeier AM, Nugent M, Simpson P. Sentinel injuries in infants evaluated for child physical abuse. *Pediatrics*. 2013;131(4):701-7. Available from: <http://pediatrics.aappublications.org/content/pediatrics/131/4/701.full.pdf>.
5. Atwal GS, Ruddy GN, Carter N, Green MA. Bruising in non-accidental head injured children; a retrospective study of the prevalence, distribution and pathological associations in 24 cases. *Forensic science international*. 1998;96(2-3):215-30. Available from: <http://www.sciencedirect.com/science/article/pii/S0379073898001261>.
6. Brinkmann B, Püschel K, Mätzsch T. Forensic dermatological aspects of the battered child syndrome. *Aktuelle Dermatologie*. 1979;5(6):217-32.
7. Carpenter RF. The prevalence and distribution of bruising in babies. *Arch Dis Child*. 1999;80(4):363-6. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1717898/pdf/v080p00363.pdf>.
8. Chang LT, Tsai MC. Craniofacial injuries from slip, trip, and fall accidents of children. *The Journal of trauma*. 2007;63(1):70-4. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/17622871>.
9. de Silva S, Oates RK. Child homicide--the extreme of child abuse. *The Medical journal of Australia*. 1993;158(5):300-1. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/8474367>.
10. Dunstan FD, Guildea ZE, Kontos K, Kemp AM, Sibert JR. A scoring system for bruise patterns: a tool for identifying abuse. *Archives of Disease in Childhood*. 2002;86(5):330-3. Available from: <http://adc.bmj.com/content/86/5/330.abstract>.
11. Ellerstein NS. The cutaneous manifestations of child abuse and neglect. *American journal of diseases of children (1960)*. 1979;133(9):906-9. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/474541>.
12. Feldman KW. Patterned abusive bruises of the buttocks and the pinnae. *Pediatrics*. 1992;90(4):633-6. Available from: <http://pediatrics.aappublications.org/content/90/4/633.long>.
13. Feldman KW. The bruised premobile infant: should you evaluate further? *Pediatric emergency care*. 2009;25(1):37-9. Available from: <http://ssr-eus-go>

[csi.cloudapp.net/v1/assets?wkmrid=JOURNAL%2Fpemca%2Fbeta%2F00006565-200901000-00010%2Froot%2Fv%2F2017-05-30T205514Z%2Fr%2Fapplication-pdf](http://csi.cloudapp.net/v1/assets?wkmrid=JOURNAL%2Fpemca%2Fbeta%2F00006565-200901000-00010%2Froot%2Fv%2F2017-05-30T205514Z%2Fr%2Fapplication-pdf).

14. Galleno H, Oppenheim WL. The battered child syndrome revisited. *Clinical orthopaedics and related research*. 1982;162:11-9. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/7067204>.
15. Goldberg AP, Tobin J, Daigneau J, Griffith RT, Reinert SE, Jenny C. Bruising Frequency and Patterns in Children With Physical Disabilities. *Pediatrics*. 2009;124(2):604-9. Available from: <http://pediatrics.aappublications.org/content/124/2/604.long>.
16. Harper NS, Feldman KW, Sugar NF, Anderst JD, Lindberg DM. Additional injuries in young infants with concern for abuse and apparently isolated bruises. *The Journal of pediatrics*. 2014;165(2):383-8.e1. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/24840754>.
17. Jappie F. Non accidental injuries in children. *Australian family physician*. 1994;23(6):1144-50. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/8053849>.
18. Johnson CF, Kaufman KL, Callendar C. The hand as a target organ in child abuse. *Clinical pediatrics*. 1990;29(2):66-72. Available from: [http://journals.sagepub.com/doi/abs/10.1177/000992289002900201?url\\_ver=Z39.88-2003&rfr\\_id=ori:rid:crossref.org&rfr\\_dat=cr\\_pub%3dpubmed](http://journals.sagepub.com/doi/abs/10.1177/000992289002900201?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%3dpubmed).
19. Johnson CF, Showers J. Injury variables in child abuse. *Child abuse & neglect*. 1985;9(2):207-15. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/4005661>.
20. Kemp AM, Dunstan F, Nuttall D, Hamilton M, Collins P, Maguire S. Patterns of bruising in preschool children—a longitudinal study. *Archives of Disease in Childhood*. 2015;100(5):426-31. Available from: <http://adc.bmj.com/content/early/2015/01/14/archdischild-2014-307120.abstract>.
21. Kemp AM, Maguire SA, Nuttall D, Collins P, Dunstan F. Bruising in children who are assessed for suspected physical abuse. *Arch Dis Child*. 2014;99(2):108-13. Available from: <http://adc.bmj.com/content/archdischild/99/2/108.full.pdf>.
22. Labbe J, Caouette G. Recent skin injuries in normal children. *Pediatrics*. 2001;108(2):271-6. Available from: <http://pediatrics.aappublications.org/content/108/2/271.long>.
23. Leavitt EB, Pincus RL, Bukachevsky R. Otolaryngologic manifestations of child abuse. *Archives of otolaryngology--head & neck surgery*. 1992;118(6):629-31. Available from: <http://jamanetwork.com/journals/jamaotolaryngology/article-abstract/620741>.
24. Lopez MR, Abd-Allah S, Deming DD, Piantini R, Young-Snodgrass A, Perkin R, et al. Oral, jaw, and neck injury in infants and children: from abusive trauma or intubation? *Pediatric emergency care*. 2014;30(5):305-10. Available from: <http://ssr-eus-go-csi.cloudapp.net/v1/assets?wkmrid=JOURNAL%2Fpemca%2Fbeta%2F00006565-201405000-00002%2Froot%2Fv%2F2017-05-30T205643Z%2Fr%2Fapplication-pdf>.
25. Lyons TJ, Oates RK. Falling out of bed: a relatively benign occurrence. *Pediatrics*. 1993;92(1):125-7. Available from: <http://pediatrics.aappublications.org/content/92/1/125.long>.
26. McMahon P, Grossman W, Gaffney M, Stanitski C. Soft-tissue injury as an indication of child abuse. *The Journal of bone and joint surgery American volume*. 1995;77(8):1179-83. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/7642662>.

27. Mortimer PE, Freeman M. Are facial bruises in babies ever accidental? *Arch Dis Child*. 1983;58(1):75-6. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1628150/pdf/archdisch00750-0083c.pdf>.
28. Naidoo S. A profile of the oro-facial injuries in child physical abuse at a children's hospital. *Child abuse & neglect*. 2000;24(4):521-34. Available from: <http://www.sciencedirect.com/science/article/pii/S0145213400001149>.
29. Nayak K, Spencer N, Shenoy M, Rubithon J, Coad N, Logan S. How useful is the presence of petechiae in distinguishing non-accidental from accidental injury? *Child abuse & neglect*. 2006;30(5):549-55. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/16698081>.
30. Newman CJ, Holenweg-Gross C, Vuillerot C, Jeannet PY, Roulet-Perez E. Recent skin injuries in children with motor disabilities. *Arch Dis Child*. 2010;95(5):387-90. Available from: <http://adc.bmj.com/content/archdischild/95/5/387.full.pdf>.
31. Murty OP, Ming CJ, Ezani MA, Yan PK, Yong TC. Physical injuries in fatal and non-fatal child abuse cases: A review of 16 years with hands on experience of 2 years in Malaysia. *International Journal of Medical Toxicology and Legal Medicine*. 2006;9(1):33-43.
32. Patno K, Jenny C. Who slapped that child? *Child maltreatment*. 2008;13(3):298-300. Available from: [http://journals.sagepub.com/doi/abs/10.1177/1077559507312961?url\\_ver=Z39.88-2003&rfr\\_id=ori:rid:crossref.org&rfr\\_dat=cr\\_pub%3dpubmed](http://journals.sagepub.com/doi/abs/10.1177/1077559507312961?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%3dpubmed).
33. Peters ML, Starling SP, Barnes-Eley ML, Heisler KW. The presence of bruising associated with fractures. *Archives of pediatrics & adolescent medicine*. 2008;162(9):877-81. Available from: [http://archpedi.jamanetwork.com/data/journals/peds/9220/poa80022\\_877\\_881.pdf](http://archpedi.jamanetwork.com/data/journals/peds/9220/poa80022_877_881.pdf).
34. Petska HW, Sheets LK, Knox BL. Facial bruising as a precursor to abusive head trauma. *Clinical pediatrics*. 2013;52(1):86-8. Available from: [http://journals.sagepub.com/doi/abs/10.1177/0009922812441675?url\\_ver=Z39.88-2003&rfr\\_id=ori:rid:crossref.org&rfr\\_dat=cr\\_pub%3dpubmed&](http://journals.sagepub.com/doi/abs/10.1177/0009922812441675?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%3dpubmed&).
35. Pierce MC, Kaczor K, Aldridge S, O'Flynn J, Lorenz DJ. Bruising Characteristics Discriminating Physical Child Abuse From Accidental Trauma [published erratum appears in *Pediatrics* 2010;125(4):861]. *Pediatrics*. 2010;125(1):67-74. Available from: <http://pediatrics.aappublications.org/content/125/1/67.long>.
36. Pierce MC, Smith S, Kaczor K. Bruising in infants: those with a bruise may be abused. *Pediatric emergency care*. 2009;25(12):845-7. Available from: <http://ssr-eus-go-csi.cloudapp.net/v1/assets?wkmrid=JOURNAL%2Fpemca%2Fbeta%2F00006565-200912000-00009%2Froot%2Fv%2F2017-05-30T205529Z%2Fr%2Fapplication-pdf>.
37. Mosqueda Peña R, Ardura García C, Barrios López M, Casado Picón R, Palacios Cuesta A. Lesiones equimóticas en miembro superior [Spanish]. *Ecchymotic injuries in upper extremity*. *Acta Pediátrica Española*. 2008;66(4):198-200.
38. Schultes A, Lackner K, Rothschild MA. "Scalping": A possible indicator for child abuse [German]. *Rechtsmedizin*. 2007;17(5):318-20. Available from: <http://dx.doi.org/10.1007/s00194-007-0462-y>.

39. Seifert D, Puschel K. Subgaleal hematoma in child abuse. *Forensic science international*. 2006;157(2-3):131-3. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/16191474>.
40. Sugar NF, Taylor JA, Feldman KW. Bruises in infants and toddlers: those who don't bruise rarely bruise. Puget Sound Pediatric Research Network. *Archives of pediatrics & adolescent medicine*. 1999;153(4):399-403. Available from: <http://archpedi.jamanetwork.com/data/journals/peds/8446/poa8307.pdf>.
41. Sussman SJ. Skin manifestations of the battered-child syndrome. *The Journal of pediatrics*. 1968;72(1):99. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/5634943>.
42. Tush BA. Bruising in healthy 3-year-old children. *Maternal-child nursing journal*. 1982;11(3):165-79. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/6923981>.
43. Wedgwood J. Childhood bruising. *The Practitioner*. 1990;234(1490):598-601. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/2392410>.
44. Worlock P, Stower M, Barbor P. Patterns of fractures in accidental and non-accidental injury in children: a comparative study. *British Medical Journal (Clinical research ed)*. 1986;293(6539):100-2. Available from: <http://www.bmj.com/content/bmj/293/6539/100.full.pdf>.
45. Bariciak ED, Plint AC, Gaboury I, Bennett S. Dating of bruises in children: an assessment of physician accuracy. *Pediatrics*. 2003;112(4):804-7. Available from: <http://pediatrics.aappublications.org/content/112/4/804.long>.
46. Stephenson T, Bialas Y. Estimation of the age of bruising. *Archives of Disease in Childhood*. 1996;74(1):53-5. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1511603/>.
47. Biehler JL, Sieck C, Bonner B, Steumky JH. A survey of health care and child protective services provider knowledge regarding the toe tourniquet syndrome. *Child abuse & neglect*. 1994;18(11):987-93. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/7850607>.
48. Claudet I, Pasian N, Marechal C, Salanne S, Debuissson C, Grouteau E. [Hair-thread tourniquet syndrome]. *Archives de pediatrie : organe officiel de la Societe francaise de pediatrie*. 2010;17(5):474-9. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/20338735>.
49. Klusmann A, Lenard HG. Tourniquet syndrome--accident or abuse? *European journal of pediatrics*. 2004;163(8):495-8; discussion 9. Available from: <https://link.springer.com/article/10.1007%2Fs00431-004-1466-1>.
50. Cutrone M, Magagnato L. Hair thread tourniquet syndrome. Three cases in ten years. *European Journal of Pediatric Dermatology*. 2009;19(1):23-6.
51. Oehmichen M, Gerling I, Meissner C. Petechiae of the baby's skin as differentiation symptom of infanticide versus SIDS. *Journal of forensic sciences*. 2000;45(3):602-7. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/10855965>.
52. Egemen A, Ikizoglu T, Ergor S, Mete Asar G, Yilmaz O. Frequency and characteristics of mongolian spots among Turkish children in Aegean region. *The Turkish journal of pediatrics*. 2006;48(3):232-6. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/17172067>.

53. Robl R, Robl M, Marinoni LP, Abagge KT, Carvalho VO. Target-shaped edematous purple lesions: is it child abuse? *Archives of Disease in Childhood*. 2014;99(1):44-5. Available from: <http://adc.bmj.com/content/99/1/44.short>.
54. Onyeama CO, Lotke M, Edelstein B. Subgaleal hematoma secondary to hair braiding in a 31-month-old child. *Pediatric emergency care*. 2009;25(1):40-1. Available from: <http://ssr-eus-go-csi.cloudapp.net/v1/assets?wkmrid=JOURNAL%2Fpemca%2Fbeta%2F00006565-200901000-00011%2Froot%2Fv%2F2017-05-30T205514Z%2Fr%2Fapplication-pdf>.
55. Sussman S, Squires J, Stitt R, Zuckerbraun N, Berger RP. Increased serum creatine phosphokinase in a child with bruising due to physical abuse. *Pediatric emergency care*. 2012;28(12):1366-8. Available from: <http://ssr-eus-go-csi.cloudapp.net/v1/assets?wkmrid=JOURNAL%2Fpemca%2Fbeta%2F00006565-201212000-00021%2Froot%2Fv%2F2017-05-30T205620Z%2Fr%2Fapplication-pdf>.
56. Rimer RL, Roy S, 3rd. Child abuse and hemoglobinuria. *Jama*. 1977;238(19):2034-5. Available from: <http://jamanetwork.com/journals/jama/article-abstract/356475>.
57. Barnes PM, Norton CM, Dunstan FD, Kemp AM, Yates DW, Sibert JR. Abdominal injury due to child abuse. *Lancet (London, England)*. 2005;366(9481):234-5. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/16023514>.
58. Maguire SA, Kemp AM, Lumb RC, Farewell DM. Estimating the probability of abusive head trauma: a pooled analysis. *Pediatrics*. 2011;128(3):e550-64. Available from: [http://pediatrics.aappublications.org/content/128/3/e550.long?sso=1&sso\\_redirect\\_count=1&nftstatus=401&nftoken=00000000-0000-0000-0000-000000000000&nftstatusdescription=ERROR%3a+No+local+token](http://pediatrics.aappublications.org/content/128/3/e550.long?sso=1&sso_redirect_count=1&nftstatus=401&nftoken=00000000-0000-0000-0000-000000000000&nftstatusdescription=ERROR%3a+No+local+token).
59. Thorpe EL, Zuckerbraun NS, Wolford JE, Berger RP. Missed opportunities to diagnose child physical abuse. *Pediatric emergency care*. 2014;30(11):771-6. Available from: <http://ssr-eus-go-csi.cloudapp.net/v1/assets?wkmrid=JOURNAL%2Fpemca%2Fbeta%2F00006565-201411000-00001%2Froot%2Fv%2F2017-05-30T205651Z%2Fr%2Fapplication-pdf>.
60. Munang LA, Leonard PA, Mok JY. Lack of agreement on colour description between clinicians examining childhood bruising. *Journal of clinical forensic medicine*. 2002;9(4):171-4. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/15274931>.
61. Hughes VK, Ellis PS, Burt T, Langlois NE. The practical application of reflectance spectrophotometry for the demonstration of haemoglobin and its degradation in bruises. *Journal of clinical pathology*. 2004;57(4):355-9. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1770270/pdf/jcp05700355.pdf>.
62. Hughes VK, Ellis PS, Langlois NE. The perception of yellow in bruises. *Journal of clinical forensic medicine*. 2004;11(5):257-9. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/15489178>.
63. Mimasaka S, Ohtani M, Kuroda N, Tsunenari S. Spectrophotometric evaluation of the age of bruises in children: measuring changes in bruise color as an indicator of child physical abuse. *The Tohoku journal of experimental medicine*. 2010;220(2):171-5. Available from: [https://www.jstage.jst.go.jp/article/tjem/220/2/220\\_2\\_171/\\_pdf](https://www.jstage.jst.go.jp/article/tjem/220/2/220_2_171/_pdf).

64. Byard RW, Wick R, Gilbert JD, Donald T. Histologic dating of bruises in moribund infants and young children. *Forensic Science, Medicine, and Pathology*. 2008;4(3):187-92. Available from: <http://dx.doi.org/10.1007/s12024-008-9030-3>.
65. Pilling ML, Vanezis P, Perrett D, Johnston A. Visual assessment of the timing of bruising by forensic experts. *Journal of forensic and legal medicine*. 2010;17(3):143-9. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/20211455>.
66. Barsley RE, West MH, Fair JA. Forensic photography. Ultraviolet imaging of wounds on skin. *The American journal of forensic medicine and pathology*. 1990;11(4):300-8. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/2275466>.
67. Rowan P, Hill M, Gresham GA, Goodall E, Moore T. The use of infrared aided photography in identification of sites of bruises after evidence of the bruise is absent to the naked eye. *Journal of forensic and legal medicine*. 2010;17(6):293-7. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/20650415>.
68. Bernstein M, Nichols G, Blair J. The use of black and white infrared photography for recording blunt force injury. *Clinical anatomy (New York, NY)*. 2013;26(3):339-46. Available from: <http://onlinelibrary.wiley.com/doi/10.1002/ca.22078/abstract>.
69. Randeberg LL, Haugen OA, Haaverstad R, Svaasand LO. A novel approach to age determination of traumatic injuries by reflectance spectroscopy. *Lasers in surgery and medicine*. 2006;38(4):277-89. Available from: <http://onlinelibrary.wiley.com/doi/10.1002/lsm.20301/abstract>.
70. Stam B, van Gemert MJC, van Leeuwen TG, Aalders MCG. 3D finite compartment modeling of formation and healing of bruises may identify methods for age determination of bruises. *Medical & Biological Engineering & Computing*. 2010;48(9):911-21. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2926474/>  
<https://link.springer.com/content/pdf/10.1007%2Fs11517-010-0647-5.pdf>.
71. McMurdy JW, Duffy S, Crawford GP, editors. *Monitoring bruise age using visible diffuse reflectance spectroscopy* 2007.
72. Kim O, McMurdy J, Lines C, Duffy S, Crawford G, Alber M. Reflectance spectrometry of normal and bruised human skins: experiments and modeling. *Physiological measurement*. 2012;33(2):159-75. Available from: <http://iopscience.iop.org/article/10.1088/0967-3334/33/2/159/meta;jsessionid=B82F6B7D097C53F0CDDD4C2F9D2A74C2.c2.iopscience.cld.iop.org>.
73. Duckworth MG, Caspall JJ, Mappus Iv RL, Kong L, Yi D, Sprigle SH, editors. *Bruise chromophore concentrations over time* 2008.
74. Mimasaka S, Oshima T, Ohtani M. Characterization of bruises using ultrasonography for potential application in diagnosis of child abuse. *Legal Medicine*. 2012;14(1):6-10. Available from: <http://www.sciencedirect.com/science/article/pii/S1344622311001155>.
75. Nuzzolese E, Di Vella G. The development of a colorimetric scale as a visual aid for the bruise age determination of bite marks and blunt trauma. *The Journal of forensic odontology*. 2012;30(2):1-6. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/23474503>.

76. Centre for Reviews and Dissemination. Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care. University of York, 2009.
77. Critical Appraisal Skills Programme (CASP). Available from: <http://www.casp-uk.net/>.
78. Polgar A, Thomas SA. Chapter 22. Critical evaluation of published research in Introduction to research in the health sciences. 3rd ed. Melbourne: Churchill Livingstone; 1995.
79. Weightman AL, Mann MK, Sander L, Turley RL. Health Evidence Bulletins Wales: A systematic approach to identifying the evidence. Cardiff: January 2004.
80. Rychetnik L, Frommer M. A schema for evaluating evidence on public health interventions. Melbourne: University of Sydney, 2002.
81. Weaver N, Williams JL, Weightman AL, Kitcher HN, Temple JMF, Jones P, et al. Taking STOX: developing a cross disciplinary methodology for systematic reviews of research on the built environment and the health of the public. Journal of Epidemiology and Community Health. 2002;56(1):48-55. Available from: <http://jech.bmj.com/content/56/1/48.abstract>.

## Appendix 1 - Methodology

We performed an all-language literature search of original articles, their references and conference abstracts published since 1950. The initial search strategy was developed across OVID Medline databases using keywords and Medical Subject Headings (MeSH headings) and was modified appropriately to search the remaining bibliographic databases. The search sensitivity was augmented by the use of a range of supplementary ‘snowballing’ techniques including consultation with subject experts and relevant organisations, and hand searching selected websites, non-indexed journals and the references of all full-text articles.

Standardised data extraction and critical appraisal forms were based on criteria defined by the National Health Service’s Centre for Reviews and Dissemination(76). In addition we used a selection of systematic review advisory articles to develop our critical appraisal forms(77-81). Articles were independently reviewed by two reviewers. A third review was undertaken to resolve disagreement between the initial reviewers when determining either the evidence type of the article or whether the study met the inclusion criteria. Decisions related to inclusion and exclusion criteria were guided by Cardiff Child Protection Systematic Reviews, who laid out the basic parameters for selecting the studies.

Our panel of reviewers included paediatricians, designated and named doctors and specialist nurses in child protection. All reviewers underwent standardised critical appraisal training, based on the CRD critical appraisal standards(77), and this was supported by a dedicated electronic critical appraisal module.

This methodology has been applied since the systematic review programme began in 2002. We aim to update each review bi-annually. Prior to each review the key questions, inclusion criteria, search strategy, critical appraisal materials and quality standards are reviewed and updated as deemed necessary according to clinical requirements and the body of literature within the reviews.

### Inclusion criteria

The inclusion criteria used in this update of the review are listed in the table below.

#### General criteria

Inclusion	Exclusion
Studies which defined patterns of bruising in non-abused or abused children	Personal practice
Studies assessing age of bruises	Review papers

Patients between 0-17 years of age	Post-mortem studies
English and non-English articles	Studies where the population included adults and children but where we could not extract data that applied solely to children
Conference abstracts	Single case reports
	Methodologically flawed papers

## Ranking of abuse

Distinguishing abuse from non-abuse is central to our review questions. The systematic reviews span more than 40 years and include international publications. Standards for defining abuse have changed markedly over time and across continents. To optimise the ability to apply a consistent quality standard across all publications, we have devised the following ranking score based upon legal and social care child protection decision processes where “1” indicates the highest level of confidence that abuse has taken place. These rankings are used throughout our systematic reviews (where appropriate).

Since its introduction, rank 1 in this classification has been expanded to include ‘independently witnessed, and reported by the child’.

Ranking	Criteria used to define abuse
1	Abuse confirmed at case conference or civil or criminal court proceedings or admitted by perpetrator
2	Abuse confirmed by stated criteria including multidisciplinary assessment
3	Abuse defined by stated criteria
4	Abuse stated but no supporting detail given
5	Suspected abuse

Studies are also ranked according to their study type. The published literature in this field is based primarily upon observational studies. The higher ranking of comparative studies, providing the highest quality evidence.

## Ranking of evidence by study type

Ranking of evidence by study type	
T <sub>1</sub>	Randomised controlled trial (RCT)
T <sub>2</sub>	Controlled trial (CT)

T <sub>3</sub>	Controlled before-and-after intervention study (CBA)
O <sub>1</sub>	Cohort study/longitudinal study
O <sub>2</sub>	Case-control study
O <sub>3</sub>	Cross-sectional
O <sub>4</sub>	Study using qualitative methods only
O <sub>5</sub>	Case series
O <sub>6</sub>	Case study
X	Formal consensus or other professional (expert) opinion (automatic exclusion)

## Search strategy

Seventeen databases were searched. In previous iterations of this review four journals which were hand searched and two websites as well. For this update and going forward hand searching will no longer be carried out. A complete list of the resources searched can be found below.

Databases	Time period searched
ASSIA (Applied Social Sciences Index and Abstracts)	1987 – 2016
Child Data	1996 – 2009 <sup>†</sup>
CINAHL ( <i>Cumulative Index to Nursing and Allied Health Literature</i> )	1982 – 2016
Cochrane Central Register of Controlled Trials (CENTRAL)	1960 – 2016
EMBASE	1980 – 2016
HMIC (Health Management Information Consortium)	1979 – 2016
MEDLINE	1951 – 2016
MEDLINE In-Process and Other Non-Indexed Citations	1951 – 2016
Open SIGLE (System for Information on Grey Literature in Europe)	1980 – 2005 <sup>*</sup>
PsycINFO	1987 – 2004 <sup>†</sup>
Pubmed E publications (Epub ahead of print)	2016
Scopus	2009 – 2016
Social Care online (previously Caredata)	1970 – 2016

Trip Plus	1997 – 2012 <sup>†</sup>
Web of Knowledge – ISI Proceedings	1990 – 2016
Web of Knowledge – ISI Science Citation Index	1981 – 2016
Web of Knowledge – ISI Social Science Citation Index	1981 – 2016
* ceased indexing † institutional access terminated ‡ no yield so ceased searching	
<b>Journals ‘hand searched’</b>	<b>Time period searched</b>
Child Abuse and Neglect	1977 – 2016
Child Abuse Review	1992 – 2016
<b>Websites searched</b>	<b>Date accessed</b>
Child Welfare Information Gateway (formerly National Clearinghouse on Child Abuse and Neglect)	April 2016
National Center on Shaken Baby Syndrome (NCSBS)	April 2016

The search terms used in Medline database search are presented below, truncation and wildcard characters were adapted to the different databases where necessary. Changes to the search strategy were adopted only after consultation with the clinical expert sub-committee.

1. child*.mp.	41. (bruise: adj3 child:).mp.
2. baby.mp.	42. (petechiae adj3 child abuse).mp.
3. (infant\$ or baby or babies or toddler\$).mp.	43. (ecchymoses adj3 child abuse:).mp.
4. exp child/	44. ((petechiae or ecchymoses) and child abuse:).mp.
5. 1 or 3 or 4	45. ((petechiae or ecchymoses) and child maltreatment).mp.
6. child abuse.mp.	46. ((petechiae or ecchymoses) and child protection).mp.
7. child protection.mp.	47. ((petechiae or ecchymoses) and injur\$).mp.
8. child maltreatment.mp.	48. ((petechiae or ecchymoses) adj3 injur\$).mp.
9. (battered child or shaken baby or battered baby).mp.	49. (hemosid: adj3 bruise:).mp.
10. or/6-9	50. or/41-47
11. Soft Tissue Injuries/	51. 40 or 50
12. physical abuse.mp.	52. (dat: adj3 bruise:).mp.
13. physical punishment.mp.	

14. serial abuse.mp.	53. (pattern: adj3 bruise:).mp.
15. non-accidental injur\$.mp.	54. (age: adj3 bruise:).mp.
16. nonaccidental injur\$.mp.	55. or/52-54
17. non-accidental trauma.mp.	56. (imaging or images or photograph*).tw.
18. nonaccidental trauma.mp.	57. cross polarized imag*.tw.
19. (nonaccidental: and injur:).mp.	58. ((Infrared or ultraviolet) adj2 (imag* or photograph*)).mp.
20. wound:.mp.	59. Infra-red imag*.tw.
21. "Wounds and Injuries"/	60. exp Time Factors/
22. *Skin/in [Injuries]	61. exp Color/
23. "Soft Tissue Injuries"/di [Diagnosis]	62. exp Spectrophotometry/
24. (or/11-23) and 5	63. Image Processing, Computer-Assisted/
25. 10 or 24	64. Photography/
26. exp Contusions/	65. Imaging, Three-Dimensional/
27. exp Purpura/	66. or/56-65
28. Bruis*.mp.	67. 25 and 55
29. (hematoma or haematoma).mp.	68. 25 and 51 and 66
30. Hematoma/	69. 67 or 68
31. exp Scalp/	70. limit 69 to yr="2016 - Current"
32. (contusion or scalping).mp.	
33. H?emophilia.mp.	
34. platelet disorder*.mp.	
35. blood disorder*.mp.	
36. von Willebrand Factor/	
37. Blood Coagulation Disorders/	
38. von Willebrand Diseases/	
39. Hemophilia A/	
40. or/26-39	

## Pre-review screening and critical appraisal

Papers found in the database and hand searches underwent three rounds of screening before they were included in this update. The first round was a title screen where papers that obviously did not meet the inclusion criteria were excluded. The second was an abstract screen

where papers that did not meet the inclusion criteria based on the information provided in the abstract were excluded. In this round the pre-review screening form was completed for each paper. These first two stages were carried out by a systematic reviewer at the RCPCH and a clinical expert. Finally a full text screen with a critical appraisal was carried out by members of the clinical expert sub-committee. Critical appraisal forms were completed for each of the papers reviewed at this stage. Examples of the pre-review screening and critical appraisal forms used in previous reviews are available on request ([clinical.standards@rcpch.ac.uk](mailto:clinical.standards@rcpch.ac.uk)).