Non-accidental injury for medical students – is case-based e-learning effective?

Niamh Ryan[1], David Sadler[1]

Corresponding author: Miss Niamh Ryan niamh.ryan34@gmail.com
Institution: 1. University of Dundee
Categories: Students/Trainees, Teaching and Learning, Technology, Undergraduate/Graduate

Received: 08/04/2020
Published: 14/07/2020

Abstract

Background:
Non-accidental injury (NAI) is a significant paediatric issue that can have many damaging physical and psychological consequences. Early identification has proven to be key in preventing these, however cases continue to be missed regularly. This is often due to inadequate training and therefore improving undergraduate NAI teaching is essential to tackling this. E-learning is a well-established educational method effective in many areas but there has been little investigation of this in the field of NAI.

Methodology:
An interactive, case-based e-learning module was designed for medical students, focusing on recognition and management of NAI in different clinical scenarios. It includes case-based scenarios, formative assessment and images of various injuries. In order to measure its efficacy, students were required to complete the module as well as pre- and post-module tests with questions incorporating injury knowledge and recognition and management of NAI. Scores were analysed using t-testing and multivariate analyses.

Results:
There was a significant increase in mean score between the pre- (23.37/32) and post-module (25.55/32) tests. Mean recognition (77.63% to 85.84%) and management scores (54.07% to 92.83%) also improved. Interestingly, injury knowledge score decreased (79.91% to 60.37%). Previous child protection training and year of study were found to be predictive of both pre-module score and change in score after module completion.

Discussion:
Interactive, case-based e-learning improves medical students' ability to recognise and manage NAI. It appears to be more useful in areas of clinical decision-making than theoretical knowledge. It is particularly beneficial for students in their initial years of study, who are likely to have less prior knowledge than in later years. Surprisingly, the module benefits students with previous child protection training more than others. Further research is needed to examine how e-learning in this area can be adjusted to suit students with different requirements and better teach
knowledge of injuries.

Keywords: e-learning; non-accidental injury; child abuse; technology; student; medical student; undergraduate; online learning; paediatrics

Introduction

Non-accidental injury (NAI), also known as physical abuse, is a common and important paediatric issue in the UK, affecting 3.8% of 16 to 24 year olds in England & Wales (Bentley et al., 2017). It may lead to multiple short- and long-term consequences for the child, including both physical and emotional problems. Physical problems may be immediate, such as pain or fractures, or more long-term, such as physical disability, brain damage and increased risk of multiple medical conditions in adulthood (NSPCC; Norman et al., 2012; Springer et al., 2007). The long-term emotional impact of NAI can lead to mental illness, offending behaviour, alcohol abuse and decreased educational performance (Norman et al., 2012; MacMillan et al., 2001). Physical abuse also has wider economic consequences for society, with an average cost of £89,390 per child due to a combination of lost productivity and the costs of healthcare, social care, criminal justice and education (Conti, 2017).

There have also been several cases of fatal or severe child abuse in recent years in which signs were not identified despite the child having recent contact with a healthcare professional (King, Kiesel and Simon, 2006; Griffiths and Hunter, 2014; Hall, 2003). Previous signs of abuse had been missed by clinicians in as many as 20.9% of children presenting with non-accidental fractures, as well as in 25% of children with abusive head trauma (Nisanthini et al., 2010; Letson et al., 2016). Early identification and intervention has the potential to prevent these consequences in up to 61% of cases (Jenny et al., 1999; Ellaway et al., 2004; Skellern et al., 2000; Rimsza et al., 2002).

Child protection training is mandatory for all doctors in the UK, structured around well-established national frameworks (NHS Education for Scotland, 2011; RCPCH, March 2014). Despite this, many doctors do not feel confident in recognising and reporting suspected NAI, with inadequate training a common barrier (Lazenbatt and Freeman, 2006; Anderst and Dowd, 2010). Various studies have found deficits in clinicians’ knowledge of and confidence in managing NAI, with 81% of junior doctors and 76% of general practitioners lacking confidence in this area (Menoch et al., 2011; Heisler et al., 2006; Starling et al., 2009; Flaherty et al., 2006; Macleod et al., 2003; Bannon et al., 2001).

Poor knowledge and a lack of training also appears to be the case for medical students, although the current literature on this is sparse. The ability to identify and report signs of NAI is a core requirement of Tomorrow’s Doctors (General Medical Council, 2009). However, child protection training at medical schools is variable and the limited literature available suggests that students’ knowledge of and ability to report child abuse is poor. Cullinane et al. (Cullinane, Alpert and Freund, 1997) found that medical students lack knowledge of family violence and Warner-Rogers et al. (Warner-Rogers, Hansen and Spieth, 1996) showed similar findings, with only 39% of students understanding the reporting process and its effects. In order to improve this, child protection training for medical students must improve, to ensure that every graduating doctor has a solid grounding in NAI.

There are various factors identified in the literature that potentially affect knowledge and ability to recognise and report NAI amongst clinicians, including gender, years of experience, experience managing abuse and child protection training (Starling et al., 2009; Fraser et al., 2010; Flaherty et al., 2000; Flaherty et al., 2008; Warner-Rogers, Hansen and Spieth, 1996; Alnasser et al., 2017; Grant, Al Nasir and Ashoor, 2012; Heisler et al., 2006; Bressem et al., 2016; Habib, 2012). However, no literature was found on factors affecting students.

A variety of educational methods and tools have been studied in the field of NAI. Case-based learning, which involves applying knowledge and skills to clinical scenarios, has found to be effective in improving recognition and
management in clinicians and dental students (Shapiro, Anderson and Lal, 2014; Anderst and Dowd, 2010; Tiyyagura et al., 2015). Possible reasons for this are that it creates context behind injuries and helps users look at preconceived ideas (Anderst and Dowd, 2010). Another educational tool that has proved effective in the literature is the use of clinical photographs in NAI teaching in order to increase learners’ recognition of injuries (Menick and Ngoh, 2005; Tiyyagura et al., 2015; Leung et al., 2009).

E-learning is another method widely used in NAI education programmes. This is the use of online technology in learning and is often composed of teaching material organised into modules. It is widely used by the NHS (Childs et al., 2005) and in medical education in general (Ruiz, Mintzer and Leipzig, 2006). Reasons for its success include accessibility, interactivity, self-directed nature, opportunity for formative assessment and cost-effectiveness (Bates, 2005; Ruiz, Mintzer and Leipzig, 2006). However, e-learning also has some disadvantages. It is highly reliant on self-motivation (Mobbs, 2003; Docherty and Sandhu, 2006) and dependent on working IT systems (Fernández Alemán, Carrillo de Gea and Rodríguez Mondéjar, 2011; Lu and Li, 2009). It may be unsuitable for some learners, for example those with visual impairments (although inclusion is improving) and those with poor computer literacy or without access to IT facilities (Mobbs, 2003).

E-learning has been shown to be an effective tool in NAI teaching amongst clinicians, improving both confidence and ability (Welbury et al., 2001; Smeekens et al., 2011; McEvoy et al., 2011). Learners found it to be accessible, time-efficient and satisfying to use and was preferred to alternative teaching methods (McEvoy et al., 2011; Welbury et al., 2001; Anderst and Dowd, 2010).

However, there is no similar literature available on medical students. E-learning was shown in one study to be effective in improving medical students’ knowledge of child sexual abuse (Dorsey et al., 1996) and another in teaching dental students about NAI (Shapiro, Anderson and Lal, 2014).

In light of the need to improve undergraduate teaching around NAI and a gap in the literature around the role of e-learning in this, this study aims to determine whether e-learning improves medical students’ knowledge and ability to recognise and report NAI. It also investigates any relationship between participant characteristics and both prior knowledge and learning from the module.

**Methods**

**Study design**

The study followed a pre- and post-intervention methodology, with participants completing a pre-module test, an e-learning module and a post-module test. The first measured outcome was score in the pre-module test, which acted as an indicator of ‘baseline’ knowledge. The second measured outcome was the difference between pre- and post-module scores, which was used to indicate the change in students’ knowledge after completing the module.

**The tests**

The pre-module test was divided into two parts, a survey and a knowledge test, whilst the post-module test had a knowledge test only. The survey was used to determine the participant characteristics listed in Table 1. The knowledge test was designed around a series of anonymous photographs depicting various injuries sustained in children alongside fictional vignettes, with case-based questions attached. A list of topics (Table 2) deemed important for students to have knowledge of was compiled by reviewing the literature. Questions were arranged to cover most of these areas, using multiple choice and multiple response formats, as they are fairly straightforward to score.
Table 1: Participant characteristics surveyed in the pre-module test

|                           |                  |
|---------------------------|------------------|
| **Age**                   |                  |
| **Gender**                |                  |
| **Year of study**         |                  |
| **Graduate-entry status** |                  |
| **Previous child protection training** | |
| **Previous identification of NAI** | |
| **Previous reporting of NAI** | |
| **Self-assessed confidence in identifying NAI** | |
| **Self-assessed confidence in reporting NAI** | |

Table 2: Topics included within the module and tests

|                                             |                  |
|---------------------------------------------|------------------|
| **Definitions of the main types of abuse and neglect** | |
| **Epidemiology of NAI**                      |                  |
| **Aetiology of and risk factors for NAI**    |                  |
| **Differentiating between physical abuse and other types of abuse and neglect** | |
| **How NAI can be recognised in different areas of healthcare** | |
| **Who can refer to child protection, when this is appropriate and the referral process** | |
| **Differentiating between different types of injury and their causation, including bruises, abrasions, burns, scalds and fractures** | |
| **Features of injuries that are concerning** |                  |
| **Management of possible cases of NAI, including examination, consent, information sharing and investigation** | |
| **Recognising patterned injuries and their causation, including tramline bruising** | |
| **The role of the medical student**          |                  |
| **Recognising signs on xray that may suggest NAI** | |
| **Conditions that may mimic NAI**            |                  |
| **Signs of shaken baby syndrome**            |                  |

Both tests were scored out of 32 and questions categorised into 3 domains: injury knowledge, recognition of NAI and management of NAI. The tests were designed at the same time with the aim of ensuring they covered topics in similar proportions. However, due to the photographs available, there was a slightly different proportion of questions from each domain in each test. In the pre-module test, there were 8 points for knowledge, 17 for recognition and 7 for management. In the post-module test, there were 10 points for knowledge, 13 for recognition and 9 for management.

Both tests were constructed directly on DELTA, the University of Dundee medical school's e-learning platform. This is a secure platform accessible to students using individual login details, allowing the researcher to view whether students have completed the module and their answers to the tests.

The module

The e-learning module was designed using Articulate 360 and then uploaded to DELTA. It included some information slides and activities followed by 6 interactive fictional cases including photographs of injuries, formative assessment and feedback slides. The module was designed to take approximately 30 minutes to complete and covered the topics listed in Table 2. A variety of question types were used within the module, including multiple choice, multiple response and short answer questions.
All photographs of injuries in both the module and the tests were sourced from the clinical record held by the Centre for Forensic & Legal Medicine, University of Dundee for paediatric examinations between 2011 and 2016. All photographs were taken with consent of the parent/guardian for documentation, peer review and teaching/research.

Participants

All year 2, 4 and BMSc medical students at the University of Dundee were invited to participate in the study using a link via email, which brought students to the study page and participant information sheet on DELTA. Participation was voluntary and students were free to undertake the module and pre- and post-module tests in their own time. For the purposes of the study, year 4 and BMSc students were categorised as one, as they had completed the same number of years of university.

Data collection & analysis

Collection and analysis of data was performed using SPSS Statistics v22. Total pre- and post-module scores were inputted using raw score, as this provides optimum statistical analyses. However, scores within each domain were entered using the percentage score, due to difference between the available marks in domains within the pre- and post-module tests.

Various statistical analyses were undertaken. Descriptive statistics was used to present the demographic characteristics of participants and t-testing was performed to analyse the change in score between pre- and post-module tests. Finally, multivariate regression analysis was undertaken to identify whether any of the participant characteristics were predictive of pre-module score or change in score, adjusting for other variables.

Results/Analysis

124 students entered the study although 17 are not included as they did not complete all three components. Table 3 illustrates the participant characteristics. Analysis of the associations between previous identification and reporting of NAI was not done due to the small sample sizes. Table 4 illustrates mean self-reported confidence scores.

Table 3: Participant characteristics

| Variable                          | Number of participants n=118 (%) |
|-----------------------------------|----------------------------------|
| Age                               |                                  |
| 18-20                             | 71 (60.2)                        |
| 21-24                             | 38 (32.2)                        |
| 25-29                             | 8 (6.8)                          |
| >30                               | 1 (0.8)                          |
| Gender                            |                                  |
| Male                              | 41 (34.7)                        |
| Female                            | 77 (65.3)                        |
| Year of study                     |                                  |
| Year 2                            | 97 (82.2)                        |
| BMSc                              | 10 (8.5)                         |
| Year 4                            | 11 (9.3)                         |
| Graduate-entry student            | 19 (16.2)                        |
| Previous child protection training| 39 (33.3)                        |
| Previously identified NAI         |                                  |
| Within medical course             | 3 (2.6)                          |
| Out-with medical course           | 3 (2.6)                          |
| Previously reported NAI           |                                  |
| Within medical course             | 0 (0)                            |
| Out-with medical course           | 3 (2.6)                          |
On t-testing, there was a significant increase in participants’ mean score after completion of the e-learning module, both overall and in the domains of recognition and management of NAI.

In the pre-module test, students scored highest in injury knowledge and lowest in management. Mean recognition, management and total scores significantly increased after module completion, with management score showing the largest increase. Unexpectedly however, injury knowledge score significantly decreased after completing the module. This is summarised in Table 5 and the mean change in scores is depicted in Table 6.

### Table 5: Summary of pre- and post-module score within each domain and overall

| Domain                | Pre-module Mean | SD  | Post-module Mean | SD  |
|-----------------------|-----------------|-----|------------------|-----|
| Injury knowledge %    | 79.91           | 11.49| 60.37            | 12.81|
| Recognition of NAI %  | 77.63           | 10.14| 85.84            | 11.09|
| Management of NAI %   | 54.07           | 17.44| 92.83            | 11.14|
| Total raw score /32 (%)| **23.37 (73.03)** | 2.42| **25.55 (79.84)** | 2.52|

### Table 6: Difference between pre- and post-module scores within each domain and overall

| Domain                | Mean difference | SD  | SE  | Confidence intervals (95%) | t   | df  | p     |
|-----------------------|-----------------|-----|-----|----------------------------|-----|-----|-------|
| Injury knowledge %    | -19.54          | 16.9| 1.63| -22.77 to -16.29           | -11.96 | 106 | <0.001|
| Recognition of NAI %  | 8.21            | 14.19| 1.37| 5.49 to 10.93              | 5.99 | 106 | <0.001|
| Management of NAI %   | 38.76           | 20.1| 1.94| 34.91 to 42.61             | 19.95 | 106 | <0.001|
| Change in total raw score | 2.18           | 3.21| .31 | 1.56 to 2.79               | 7.03 | 106 | <0.001|

On multivariate regression analysis of pre-module scores, higher year of study (year 4/BMSc vs year 2) was found to be significantly positively predictive of total (Beta=0.34, p=0.001) and management (Beta=0.29, p=0.004) scores. Previous child protection training (Beta=-0.36, p=0.001) and confidence in identifying NAI (Beta=-0.20, p=0.035) were both found to be negatively predictive of management score.

On examination of the mean increase in score after module completion, higher year of study was found to be
negatively predictive of change in total (Beta=-0.23, p=0.028) and management score (Beta=-0.29, p=0.003) whilst previous child protection training was positively predictive of change in total (Beta=0.29, p=0.01) and management score. (Beta=0.35, p=0.001)

The above data is summarised in Table 7. Age, gender, graduate-entry status and confidence in reporting NAI were not found to be significant predictors of pre-module score or change in score between pre- and post-module tests.

### Table 7: Significant predictors of dependent variables and their regression models

| Dependent variable                  | Factor                        | Multiple linear regression |
|-------------------------------------|-------------------------------|----------------------------|
|                                     |                               | Beta | se   | t     | p     |
| Pre-module management score         | Year of study                 | 0.29 | 4.35 | 2.99  | 0.004 |
|                                     | Previous CP training          | -0.36| 3.70 | -3.58 | 0.001 |
|                                     | Confidence in identifying NAI | -0.20| 2.14 | -2.13 | 0.035 |
| Pre-module total score              | Year of study                 | 0.34 | 0.58 | 3.44  | 0.001 |
| Increase in management score        | Year of study                 | -0.29| 8.73 | -3.00 | 0.003 |
|                                     | Previous CP training          | 0.35 | 7.40 | 3.41  | 0.001 |
| Increase in raw total score         | Year of study                 | -0.23| 0.80 | -2.24 | 0.028 |
|                                     | Previous CP training          | 0.29 | 0.68 | 2.64  | 0.010 |

### Discussion

#### Pre-module scores

In this study, pre-module score represents students’ ‘baseline’ knowledge; in other words, what students know already. Due to the lack of literature on this topic and the fact that the module and tests were specifically designed for this research, it is difficult to compare these scores with any other study. However, the questions were based around knowledge that medical students would be expected to have by the end of the degree, so considering the mean score was above 70% and that the questions ranged from mild to severe difficulty, it could be said that students generally had good understanding of the topics.

The highest mean score was in the area of injury knowledge. This could be because it is a topic common to multiple specialties that students are likely to have come across before. On the other hand, the specific recognition and management of NAI in relation to child protection are generally covered less in the general medical curriculum.

#### Change in score between pre- and post-module tests

It was found that students’ scores improved, both overall and in the areas of recognition and management of NAI, after the use of the e-learning module. Although no literature could be found on e-learning in this field specific to students, the results of this study are consistent with others based on clinicians and dental students, that showed e-learning to be effective in improving management, detection and general knowledge of NAI (Smeekens et al., 2011; McEvoy et al., 2011; Shapiro, Anderson and Lal, 2014; Al-Dabaan, Asimakopoulou and Newton, 2015). They are also consistent with Dorsey et al.’s study (although based on child sexual abuse) showing that an e-learning package was effective in teaching medical students (Dorsey et al., 1996).

This improvement could be due to multiple factors in the e-learning module that have been shown in previous studies to enhance learning. The module’s interactive nature allowed students to take a more active approach, which has been shown to enhance learning (Cook, Levinson and Garside, 2010). The frequent use of photographs throughout is likely to have been partly responsible for improving students’ ability to recognise NAI, as it allowed them to easily visualise and remember what concerning patterns of injury may look like and has previously been
shown to be an effective aid in improving the recognition of NAI (Menick and Ngoh, 2005). The case-based approach of the module may also have contributed to this increase in score, as it provides context to injuries, focusing learning on recognition and management (Anderst and Dowd, 2010). In addition, the module’s use of formative assessment may have helped reinforce information by encouraging students to actively apply their learning and allowing the opportunity for feedback, allowing them to identify and fill gaps in their knowledge (Cook, Levinson and Garside, 2010; Welbury et al., 2001; Harden, 2012).

A surprising finding from the study was that students’ injury knowledge scores decreased after the use of the module. This could be due to its case-based nature of the module and its use of photographs and scenarios, therefore emphasising recognition and management of NAI more than injury knowledge. This focus may have distracted students from or made them second-guess their previously gained injury knowledge when completing the post-module test.

Another possible explanation is that the pre-module injury knowledge questions assessed topics that students had previously learned about more than the post-module questions, causing this difference in score.

In future studies a control group should be used to investigate whether this decrease in injury knowledge score was due to the module or another factor.

**Characteristics predictive of pre-module score**

Higher year of study was found to be predictive of both higher management and total pre-module scores. This could be due to students in higher years having undergone more teaching on this subject than students in lower years, which both will have increased their overall knowledge of NAI but also their ability to manage it, an area specific to child protection.

This contradicts Warner-Rogers et al., who found year of study to have no effect on knowledge of NAI (Warner-Rogers, Hansen and Spieth, 1996). However, this was published in 1996, and child protection teaching in medical school has become a lot more widespread since, so we can now expect students in higher years of study to have undergone some kind of child protection teaching.

Another possible explanation is that most students in higher years will have had more experience of medical exams and tests than in lower years, so will be more familiar with the question format, potentially increasing their scores.

Unexpectedly, previous child protection training was predictive of lower pre-module management score. This was surprising, as previous training would be expected to result in greater ability to manage NAI. It contradicts previous studies, which argue that training increases knowledge, although these are both based on clinicians, whose training would be expected to be far more comprehensive (Starling et al., 2009; Flaherty et al., 2006).

However, this was a self-reported survey question, with no clear definition of what ‘child protection training’ is, so students may have reported having previous training which did not cover any of the material tested. It may also have worked the other way around, with students that had had previous relevant training not declaring this. This may explain why those who reported previous training didn’t do better, but it doesn’t explain why they scored significantly worse than those who did not.

One possible explanation is that basic child protection training, particularly within the voluntary sector, often emphasises caution and the reporting of concerns without any assessment or discussion with the family, leaving it to professionals to investigate further. However, medical students should be aware that, as a doctor, there are other actions that can be taken alongside this to assist with diagnosis. This caution may have led to students with previous child protection training to score poorly in the management domain.

It was surprising to find that students who reported lower confidence scores in identifying NAI did better in the pre-
module management domain compared to those with more confidence. This may be because those with poor confidence often deliberate longer and question themselves more than students who have more confidence. Due to the nature of this topic, it is important to think carefully about answers, so students who do this may score higher.

**Characteristics predictive of improvement in score between pre- and post-module tests**

Year of study was found to be negatively predictive of improvement in both overall and management score after completion of the module. This suggests that year 2 students learned more from the module than year 4/BMSc students. This is likely because year 2 students have had less previous teaching on this topic and have lower baseline knowledge (as highlighted above). Again, this association with management score is likely particularly strong because of the specificity of this area to child protection teaching, which year 2 students have had less of.

Previous child protection training was also predictive of increased rise in total and management scores. This is surprising, as it was expected that this group would learn less from the module due to previous knowledge gained from this training. However, there are some possible reasons.

As discussed above, the self-reported nature of the questionnaire and the poor clarity is defining what ‘child protection training’ is are likely to have contributed to students answering the question inaccurately. However, another possible explanation is that many students with child protection training had undertaken this voluntarily so may be more interested in the topic. Therefore, they may have learned more from the module than students who had not undertaken previous training and were perhaps not so interested in the material.

**Limitations**

This study has some limitations. There was no control group used so it cannot be proven that the improvement in scores was due to the e-learning module – other factors such as repeating testing increasing familiarity with question format and the time between tests could also be contributory. Sample sizes were relatively small, so some of the findings may be unreliable, although this was difficult to avoid in a study within a single medical school. Due to the voluntary nature of the study, there could be some self-selection bias, so results may be skewed towards students with an interest in this area. As discussed previously, there was no clear definition for previous child protection training, so students’ interpretation of this may have influenced results. To clarify these results in future studies, the questionnaire should outline clear criteria for what ‘child protection training’ means.

**Conclusion**

This study has demonstrated that an interactive, case-based e-learning module improves students’ recognition and management of NAI. However, it was not helpful in improving knowledge of injuries. This suggests e-learning is more helpful in teaching areas of clinical reasoning, such as recognition and management of NAI, than knowledge of injuries.

Students in higher years of study had higher pre-module scores and smaller improvements in score after module than those in lower years, suggesting that the module is most beneficial for those in earlier years of medical school. Unexpectedly, students with previous child protection training had lower scores and larger improvements in score after the module, although this was likely due to study design. Further research, including a revised questionnaire, is required to clarify this and establish how it can be adapted to suit different students and to better teach knowledge of injuries. Gender, age and graduate-entry status were not predictive of baseline knowledge or learning from the module.
Take Home Messages

- An interactive, case-based e-learning module improves students' ability to recognise and manage NAI
- It is most effective in areas of NAI focusing on clinical reasoning
- It is most useful for students in lower years of study
- Medical students generally have a better knowledge of injuries in general than in recognising and managing NAI
- E-learning on NAI is a useful tool that should be considered for inclusion into medical school curricula

Notes On Contributors

Niamh Ryan is a final year medical student at the University of Dundee.

Dr David Sadler is a consultant forensic pathologist at the University of Dundee.

Acknowledgements

The authors wish to acknowledge the students who took part in this study. They would also like to thank Alison Gray from the University of Dundee School of Medicine's Technology in Learning & Teaching Team for her guidance in developing the e-learning module and tests used in this study.

The authors would also like to thank AMEE for the opportunity to present this study as an ePoster at the AMEE annual conference (Tuesday 27th August 2019) as 'An evaluation of a case-based e-learning module on non-accidental injury for medical students'. This was presented by Niamh Ryan and the programme for this can be found at https://amee.org/getattachment/Conferences/AMEE-2019/Programme/AMEE-2019-Conference-Programme-v3.pdf.

Bibliography/References

Alnasser, Y., Albijadi, A., Abdullah, W., Aldabeeb, D., et al. (2017) ‘Child maltreatment between knowledge, attitude and beliefs among Saudi pediatricians, pediatric residency trainees and medical students’, Annals of Medicine and Surgery, 16(Supplement C), pp. 7-13. https://doi.org/10.1016/j.amsu.2017.02.008

Al-Dabaan, R., Asimakopoulou, K. and Newton, J. T. (2015) 'Effectiveness of a web-based child protection training programme designed for dental practitioners in Saudi Arabia: a pre- and post-test study', European Journal of Dental Education, 20(1), pp. 45-54. https://doi.org/10.1111/eje.12141

Anderst, J. and Dowd, M. (2010) 'Comparative needs in child abuse education and resources: perceptions from three medical specialties', Medical Education Online, 15(1). https://doi.org/10.3402/meo.v15i0.5193

Bannon, M. J., Carter, Y. H., Jackson, N. R., Pace, M., et al. (2001) 'Meeting the training needs of GP registrars in child abuse and neglect', Child Abuse Review, 10(4), pp. 254-261. https://doi.org/10.1002/car.695
Bates, A. (2005) *Technology, e-learning and distance education*. 2nd edn. Abingdon, UK: Routledge.

Bentley, H., O'Hagan, O., Brown, A., Vasco, N., *et al.* (2017) *How safe are our children? The most comprehensive overview of child protection in the UK 2017*, London.

Bressem, K., Ziegenhain, U., Doelitzsch, C., Hofer, A., *et al.* (2016) ‘A German e-learning-training in the context of early preventive intervention and child protection: preliminary findings of a pre-post evaluation’, *Child and Adolescent Psychiatry and Mental Health*, 10(1), pp. 25. https://doi.org/10.1186/s13034-016-0113-8

Childs, S., Blenkinsopp, E., Hall, A. and Walton, G. (2005) ‘Effective e-learning for health professionals and students--barriers and their solutions. A systematic review of the literature--findings from the HeXL project’, *Health Information and Libraries Journal*, 22 Suppl 2, pp. 20-32. https://doi.org/10.1111/j.1470-3327.2005.00614.x

Conti, G. e. a. (2017) *The economic cost of child maltreatment in the UK: a preliminary study*, London.

Cook, D. A., Levinson, A. J. and Garside, S. (2010) ‘Time and learning efficiency in Internet-based learning: a systematic review and meta-analysis’, *Advances In Health Sciences Education: Theory And Practice*, 15(5), pp. 755-770. https://doi.org/10.1007/s10459-010-9231-x

Cullinane, P. M., Alpert, E. J. and Freund, K. M. (1997) ‘First-year medical students’ knowledge of, attitudes toward, and personal histories of family violence’, *Academic Medicine*, 72(1).

Docherty, A. and Sandhu, H. (2006) ‘Student-perceived barriers and facilitators to e-learning in continuing professional development in primary care’, *Education for Primary Care*, 17(4), pp. 343-353. https://doi.org/10.1080/14739879.2006.11864084

Dorsey, J. K., Gocey, J., Murrell, K., Rinderer-Rand, H., *et al.* (1996) ‘Medical student response to an interactive patient simulation program used to supplement child abuse education’, *Child Abuse & Neglect*, 20(10), pp. 973-977. https://doi.org/10.1016/0145-2134(96)00086-5

Ellaway, B. A., Payne, E. H., Rolfe, K., Dunstan, F. D., *et al.* (2004) ‘Are abused babies protected from further abuse?’, *Arch Dis Child*, 89(9), pp. 845-6. https://doi.org/10.1136/adc.2003.035493

Fernández Alemán, J. L., Carrillo de Gea, J. M. and Rodríguez Mondéjar, J. J. (2011) ‘Effects of competitive computer-assisted learning versus conventional teaching methods on the acquisition and retention of knowledge in medical surgical nursing students’, *Nurse Education Today*, 31(8), pp. 866-871. https://doi.org/10.1016/j.nedt.2010.12.026

Flaherty, E., Sege, R., Binns, H. J., Mattson, C. L., *et al.* and for the Pediatric Practice Research, G. (2000) ‘Health care providers' experience reporting child abuse in the primary care setting’, *Archives of Pediatrics & Adolescent Medicine*, 154(5), pp. 489-493. https://doi.org/10.1001/archpedi.154.5.489

Flaherty, E. G., Sege, R., Price, L. L., Christoffel, K. K., *et al.* (2006) ‘Pediatrician Characteristics Associated With Child Abuse Identification and Reporting: Results From a National Survey of Pediatricians’, *Child Maltreatment*, 11(4), pp. 361-369. https://doi.org/10.1177/1077559506292287

Flaherty, E. G., Sege, R. D., Griffith, J., Price, L. L., *et al.* (2008) ‘From Suspicion of Physical Child Abuse to Reporting: Primary Care Clinician Decision-Making’, *Pediatrics*, 122(3), pp. 611. https://doi.org/10.1542/peds.2007-2311

Fraser, J. A., Mathews, B., Walsh, K., Chen, L., *et al.* (2010) ‘Factors influencing child abuse and neglect recognition and reporting by nurses: a multivariate analysis’, *Int J Nurs Stud*, 47(2), pp. 146-53. https://doi.org/10.1016/j.ijnurstu.2009.05.015
General Medical Council (2009) *Tomorrow's doctors*, Manchester.

Grant, N., Al Nasir, F. and Ashoor, L. (2012) 'Children abuse: factors affecting case reporting by physicians', *Bahrain Medical Bulletin*, 34(3), pp. 133.

Griffiths, S. and Hunter, D. (2014) *Child C1: serious case review [overview]*, Manchester.

Habib, H. (2012) 'Pediatrician knowledge, perception, and experience on child abuse and neglect in Saudi Arabia', *Ann Saudi Med* 32(3), pp. 236-242. [https://doi.org/10.5144/0256-4947.2012.236](https://doi.org/10.5144/0256-4947.2012.236)

Hall, D. (2003) 'Child protection—lessons from Victoria Climbié : Recommendations will work only with professional and managerial commitment', *BMJ : British Medical Journal*, 326(7384), pp. 293-294. [https://doi.org/10.1136/bmj.326.7384.293](https://doi.org/10.1136/bmj.326.7384.293)

Harden, R. M. (2012) *Essential skills for a medical teacher : an introduction to teaching and learning in medicine*. Edinburgh: Churchill Livingstone.

Heisler, K. W., Starling, S. P., Edwards, H. and Paulson, J. F. (2006) 'Child Abuse Training, Comfort, and Knowledge Among Emergency Medicine, Family Medicine, and Pediatric Residents', *Medical Education Online*, 11(1), pp. 4600. [https://doi.org/10.3402/meo.v11i1.4600](https://doi.org/10.3402/meo.v11i1.4600)

Jenny, C., Hymel, K. P., Ritzen, A., Reinert, S. E., *et al*. (1999) 'Analysis of missed cases of abusive head trauma', *JAMA*, 281(7), pp. 621-626. [https://doi.org/10.1001/jama.281.7.621](https://doi.org/10.1001/jama.281.7.621)

King, W. K., Kiesel, E. L. and Simon, H. K. (2006) 'Child abuse fatalities: are we missing opportunities for intervention?', *Pediatr Emerg Care*, 22(4), pp. 211-4. [https://doi.org/10.1097/01.pec.0000208180.94166.dd](https://doi.org/10.1097/01.pec.0000208180.94166.dd)

Lazenbatt, A. and Freeman, R. (2006) 'Recognizing and reporting child physical abuse: a survey of primary healthcare professionals', *Journal of Advanced Nursing*, 56(3), pp. 227-236. [https://doi.org/10.1111/j.1365-2648.2006.04030.x](https://doi.org/10.1111/j.1365-2648.2006.04030.x)

Letson, M. M., Cooper, J. N., Deans, K. J., Scribano, P. V., *et al*. (2016) 'Prior opportunities to identify abuse in children with abusive head trauma', *Child Abuse & Neglect*, 60, pp. 36-45. [https://doi.org/10.1016/j.chiabu.2016.09.001](https://doi.org/10.1016/j.chiabu.2016.09.001)

Leung, R. S., Nwachuckwu, C., Pervaiz, A., Wallace, C., *et al*. (2009) 'Are UK radiologists satisfied with the training and support received in suspected child abuse?', *Clinical Radiology*, 64(7), pp. 690-698. [https://doi.org/10.1016/j.jicrad.2009.02.012](https://doi.org/10.1016/j.jicrad.2009.02.012)

Lu, D. F. and Li, Y. J. (2009) 'Effects of a web-based course on nursing skills and knowledge learning', *Journal of Nursing Education*, 48(2), pp. 70-77. [https://doi.org/10.3928/01484834-20090201-10](https://doi.org/10.3928/01484834-20090201-10)

Macleod, C., Dornan, O., Livingstone, A., McCormack, L., *et al*. (2003) 'Teaching junior doctors to recognise child abuse and neglect', *Medical Education*, 37(11), pp. 1046. [https://doi.org/10.1046/j.1365-2923.2003.01662.x](https://doi.org/10.1046/j.1365-2923.2003.01662.x)

MacMillan, H. L., Fleming, J. E., Streiner, D. L., Lin, E., Boyle, M. H., *et al*. (2001) 'Childhood Abuse and Lifetime Psychopathology in a Community Sample', *American Journal of Psychiatry*, 158(11), pp. 1878-1883. [https://doi.org/10.1176/appi.ajp.158.11.1878](https://doi.org/10.1176/appi.ajp.158.11.1878)

McEvoy, M. M., Butler, B., MacCarrick, G. and Nicholson, A. J. (2011) 'Virtual patients: an effective educational intervention to improve paediatric basic specialist trainee education in the management of suspected child abuse?', *Irish Medical Journal*, 104(8), pp. 250-252.

Menick, D. M. and Ngoh, F. (2005) 'Child abuse in Cameroon: Evaluation of a training course on awareness,
detection, and reporting of child abuse', *Medicine tropicale: revue du corps de sante colonial*, 65(1), pp. 33-38.

Menoch, M., Zimmerman, S., Garcia-Filion, P. and Bulloch, B. (2011) 'Child Abuse Education: An Objective Evaluation of Resident and Attending Physician Knowledge', *Pediatric Emergency Care*, 27(10), pp. 937-940. [https://doi.org/10.1097/PEC.0b013e3182307ae5](https://doi.org/10.1097/PEC.0b013e3182307ae5)

Mobbs, R. (2003) *Disadvantages of eLearning*. Available at: [https://www.le.ac.uk/users/rjm1/etutor/elearning/disadvofelearning.html](https://www.le.ac.uk/users/rjm1/etutor/elearning/disadvofelearning.html) (Accessed: 5th April 2020).

NHS Education for Scotland (2011) *Core Competency Framework for the Protection of Children*, Edinburgh.

Nisanthini, R., Schuh, S., Bejuk, M., Al-Harthy, N., et al. (2010) 'Delayed identification of pediatric abuse-related fractures', *Pediatics*, 125(1), pp. 60-66. [https://doi.org/10.1542/peds.2008-3794](https://doi.org/10.1542/peds.2008-3794)

Norman, R. E., Byambaa, M., De, R., Butchart, A., et al. (2012) 'The Long-Term Health Consequences of Child Physical Abuse, Emotional Abuse, and Neglect: A Systematic Review and Meta-Analysis', *PLOS Medicine*, 9(11), pp. e1001349. [https://doi.org/10.1371/journal.pmed.1001349](https://doi.org/10.1371/journal.pmed.1001349)

NSPCC *Physical abuse - Signs, indicators and effects*. Available at: [https://www.nspcc.org.uk/preventing-abuse/child-abuse-and-neglect/physical-abuse/signs-symptoms-effects/](https://www.nspcc.org.uk/preventing-abuse/child-abuse-and-neglect/physical-abuse/signs-symptoms-effects/) (Accessed: 5th April 2020).

RCPCH (March 2014) *Safeguarding children and young people: roles and competences for health care staff: intercollegiate document*, London.

Rimsza, M. E., Schackner, R. A., Bowen, K. A. and Marshall, W. (2002) 'Can child deaths be prevented? The Arizona Child Fatality Review Program experience', *Pediatrics*, 110(1 Pt 1), pp. e11.

Ruiz, J. G., Mintzer, M. J. and Leipzig, R. M. (2006) 'The impact of E-learning in medical education', *Acad Med*, 81(3), pp. 207-12. [https://doi.org/10.1097/00001888-200603000-00002](https://doi.org/10.1097/00001888-200603000-00002)

Shapiro, M. C., Anderson, O. R. and Lal, S. (2014) 'Assessment of a novel module for training dental students in child abuse recognition and reporting', *J Dent Educ*, 78(8), pp. 1167-75.

Skellern, C. Y., Wood, D. O., Murphy, A. and Crawford, M. (2000) 'Non-accidental fractures in infants: risk of further abuse', *J Paediatr Child Health*, 36(6), pp. 590-2. [https://doi.org/10.1046/j.1440-1754.2000.00592.x](https://doi.org/10.1046/j.1440-1754.2000.00592.x)

Smeekens, A. E. F. N., Broekhuizen-van Henten, D. M., Sittig, J. S., Russel, I. M. B., et al. (2011) 'Successful e-learning programme on the detection of child abuse in Emergency Departments: a randomised controlled trial', *Archives of Disease in Childhood*, 96(4), pp. 330. [https://doi.org/10.1136/adc.2010.190801](https://doi.org/10.1136/adc.2010.190801)

Springer, K. W., Sheridan, J., Kuo, D. and Carnes, M. (2007) 'Long-term physical and mental health consequences of childhood physical abuse: Results from a large population-based sample of men and women', *Child Abuse & Neglect*, 31(5), pp. 517-530. [https://doi.org/10.1016/j.chiabu.2007.01.003](https://doi.org/10.1016/j.chiabu.2007.01.003)

Starling, S. P., Heisler, K. W., Paulson, J. F. and Youmans, E. (2009) 'Child Abuse Training and Knowledge: A National Survey of Emergency Medicine, Family Medicine, and Pediatric Residents and Program Directors', *Pediatrics*, 123(4), pp. e595-e602. [https://doi.org/10.1542/peds.2008-2938](https://doi.org/10.1542/peds.2008-2938)

Tiyyagura, G., Gawel, M., Koziel, J. R., Asnes, A., et al. (2015) 'Barriers and Facilitators to Detecting Child Abuse and Neglect in General Emergency Departments', *Annals Of Emergency Medicine*, 66(5), pp. 447-454. [https://doi.org/10.1016/j.annemergmed.2015.06.020](https://doi.org/10.1016/j.annemergmed.2015.06.020)

Warner-Rogers, J. E., Hansen, D. J. and Spieth, L. E. (1996) 'The influence of case and professional variables on
identification and reporting of physical abuse: A study with medical students’, *Child Abuse & Neglect*, 20(9), pp. 851-864. [https://doi.org/10.1016/0145-2134(96)00073-7](https://doi.org/10.1016/0145-2134(96)00073-7)

Welbury, R. R., Hobson, R. S., Stephenson, J. J. and Jepson, N. J. A. (2001) ’Evaluation of a computer-assisted learning programme on the oro-facial signs of child physical abuse (non-accidental injury) by general dental practitioner’, *British Dental Journal*, 190, pp. 668. [https://doi.org/10.1038/sj.bdj.4801070](https://doi.org/10.1038/sj.bdj.4801070)

### Appendices

None.

### Declarations

*The author has declared that there are no conflicts of interest.*

*This has been published under Creative Commons “CC BY 4.0” ([https://creativecommons.org/licenses/by-sa/4.0/](https://creativecommons.org/licenses/by-sa/4.0/))*

### Ethics Statement

Approved by the University of Dundee School of Medicine’s Research Ethics Committee - reference SMED REC 96/17.

### External Funding

This article has not had any External Funding