



A systematic review and meta-analysis of medical and psychosocial care procedures for children and adolescents after (online) sexual abuse

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ABSTRACT

Background and objective: Child sexual abuse (CSA) and online child sexual abuse (OCSA) continue to pose an increasing challenge. Although structured interventions exist for CSA, no established framework currently addresses OCSA, and research on effective care procedures is scarce. Initially focused on OCSA, this review expanded to include CSA due to the absence of OCSA-specific studies, enabling a more comprehensive synthesis. The review outlines medical and psychosocial care procedures after CSA and provides recommendations for OCSA.

Methods and results: 53 studies published between 1995 and 2022 identified medical and psychosocial interventions for children and adolescents up to 17.11 years old who have experienced CSA. 17 studies with a medical focus tend to follow a common thread after CSA, although some focus on different procedural steps. Psychosocial interventions (36 articles) showed a high degree of diversity, with trauma-focused cognitive behavioral therapy (TF-CBT), adapted forms of cognitive behavioral therapy (CBT), group therapy and individual settings proving particularly effective. A subgroup meta-analysis of 31 psychosocial studies yielded a weighted mean effect size of 1.14 [0.98; 1.29], indicating the effectiveness of all psychotherapeutic interventions, with a high heterogeneity of $I^2 = 82\%$.

Conclusions: The review reveals a research gap, the lack of studies on interventions and their effectiveness in OCSA, which urgently needs to be addressed. It highlights the need for comprehensive, interdisciplinary medical and psychosocial interventions after CSA, whereby adapted interventions for OCSA are needed. This study is limited by the absence of OCSA-specific interventions, constraints on subgroup analyses due to limited data, and the high heterogeneity of included psychosocial studies. Further research on procedures specific to OCSA and training for professionals dealing with it are strongly indicated.

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1. Introduction

1.1. Background and rationale

Child sexual abuse (CSA) remains a persistent global phenomenon, with recent worldwide estimates indicating that 8.7 % children and adolescents experience some form of sexual abuse, 11.4 % are affected by sexual harassment, and 6.1 % by forced intercourse (Piolanti et al., 2025). The COVID-19 pandemic has also been linked to a rise in CSA cases, as global reports highlight an increase in child sexual exploitation during lockdown periods (INTERPOL, 2020).

German law enforcement authorities registered 16,375 cases of CSA under the age of 14 in the year 2023, which is 5.5 % more than in 2022. Sexual abuse of adolescents up to the age of 17 also exceeded the previous year by 5.7 % (Federal Criminal Police Office, 2024). According to the World Health Organization (2004), CSA is defined by the involvement of a child in sexual activity that the child does not fully understand and cannot give informed consent. Sexual activity covers a range of acts towards minors which includes fondling and asking a child to touch or be touched sexually. The ubiquitous use of mobile internet technologies, online gaming and social media by children and young people has fundamentally changed the spectrum of risks to which they are exposed (Livingstone et al., 2017). The digital native generation is increasingly merging real and virtual life, whereby their age range is decreasing significantly. The ease with which individuals seek to contact, interact with and exploit young people online has led to more cases of cyber grooming and online child sexual abuse (OCSA) (Bond & Dogaru, 2019). According to the annual report of the British Internet Watch Foundation (IWF), 23 % of the websites reported in 2023 depicting abuse showed rape or sexual torture of children. 41 % of the children depicted were between the ages of 7 and 10 years, which represents an increase of 25 % compared to 2022 in this age group (Commissioner for Child Sexual Abuse Issues, 2024). In addition, the Federal Criminal Police Office (2024) shows a drastic increase in OCSA, with 45,191 cases recorded in Germany in 2023.

1.2. The need for addressing OCSA

OCSA is defined by the use of information and communication technology as a means of sexual abuse (Interagency Working Group, 2016), whereby sexual abuse can take place online in order to facilitate sexual abuse in real life (Interagency Working Group on Sexual Exploitation of Children, 2016). It includes any child sexual abuse material, livestreaming of child sexual abuse, non-consensual sexting (the exchange of sexually explicit messages or images without the consent of one party) and sextortion (the coercion of individuals into providing sexual content through threats or blackmail) (World Health Organization, 2022b). However, determining the prevalence of OCSA heavily depends on a child's ability to recognize and admit the abuse (Kloess et al., 2014).

The increasing prevalence of OCSA presents unique challenges for both intervention and recovery. While CSA has been widely studied, research on medical and psychosocial care for OCSA victims remains scarce, leaving professionals without clear guidelines. Unlike CSA, OCSA survivors may face ongoing digital retraumatization due to the persistent circulation of abusive material online (Martin, 2015).

1.3. Purpose and scope

Given these gaps, this review was originally designed to examine interventions specifically addressing OCSA. However, due to the lack of empirical studies solely addressing OCSA, the scope was expanded to include CSA, allowing for a broader synthesis of available medical and psychosocial care procedures.

CSA has wide-ranging effects, including short-term impacts such as isolation, anxiety, and post-traumatic stress disorder, as well as long-term consequences on relationships, emotional well-being, and revictimization (Ali et al., 2024). This raises the question of which medical and psychosocial interventions exist after the occurrence of this form of abuse in order to address possible consequences for children and adolescents following (online) sexual abuse.

Several systematic reviews have previously examined psychosocial interventions for child sexual abuse survivors. Sánchez-Meca et al. (2011) conducted a meta-analysis demonstrating the efficacy of psychological treatments in reducing PTSD symptoms in affected children and adolescents. More recently, McTavish et al. (2021) reviewed various psychosocial interventions and highlighted trauma-focused cognitive behavioral therapy (TF-CBT) as the most effective approach. While these reviews provide valuable insights into existing interventions for CSA, none have specifically examined both medical and psychosocial care procedures in a combined framework or considered their applicability to OCSA. Given this gap, our review was initially designed to investigate care procedures following both CSA and OCSA.

1.4. Research questions

Given these considerations and the evolving challenges in this field, this article aims to address the following research question: What procedures are used in the medical and psychosocial care of children and adolescents who have experienced (online) sexual abuse? Based on this, the key outcome of this systematic review is the synthesis of medical and psychosocial interventions for children and adolescents following (online) sexual abuse. Additionally, the second research question is: "What patterns of psychosocial care procedures were identified through an exploratory meta-analysis including 31 studies?"

2. Method

2.1. Protocol and registration

This systematic review was registered on PROSPERO (ID: CRD42024476750) on December 22, 2023. This methodologically

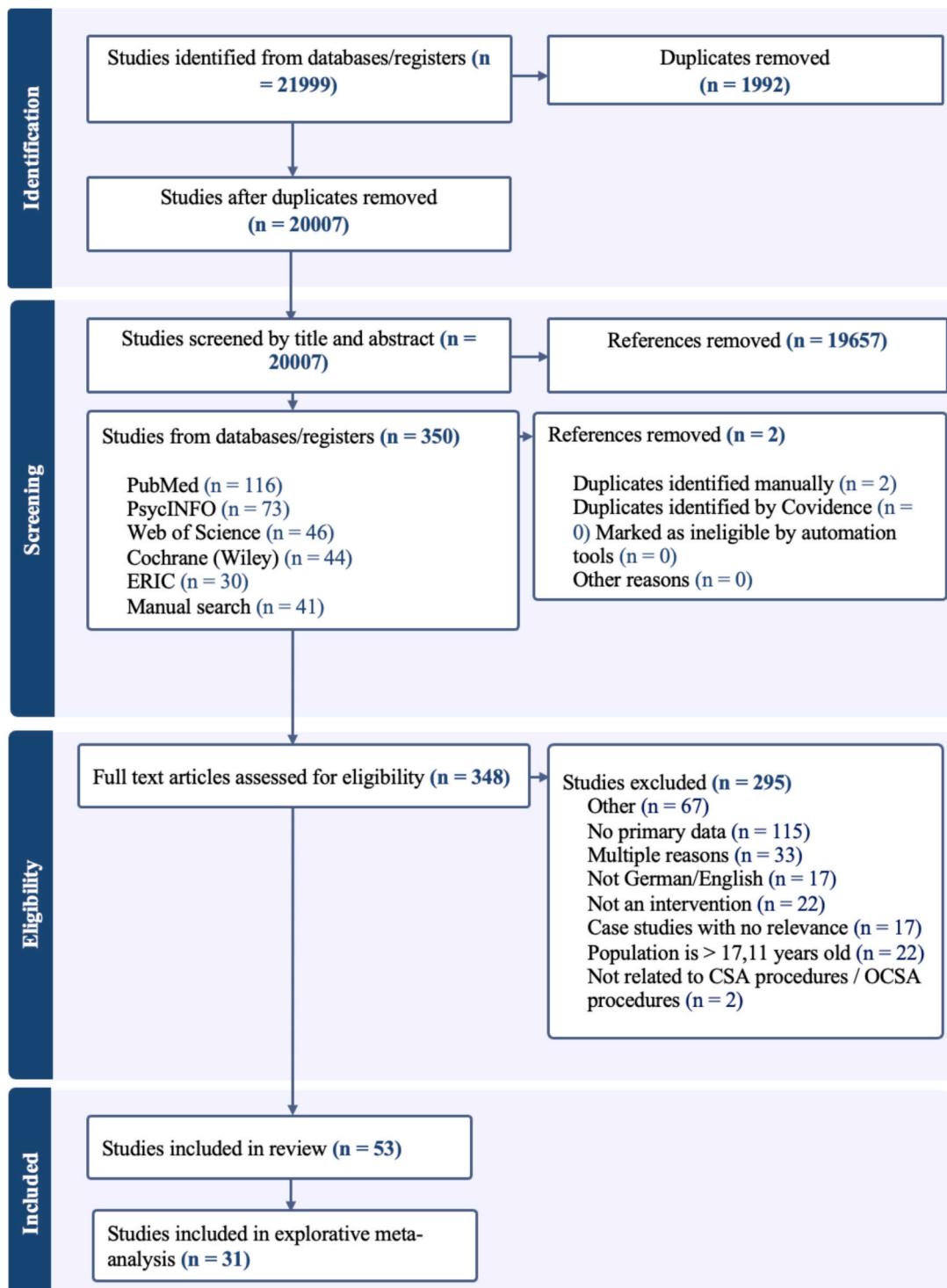


Fig. 1. PRISMA Flowchart of Study Selection.

proactive step serves to ensure transparency during the research process and the (retrospective) review of the initial research proposal. The scope and methodology of the systematic review are defined in advance and made publicly available. To ensure the review's systematic structure, the assessment tool AMSTAR-2 was used as a guideline (see Appendix 2). Although a meta-analysis was initially not planned due to assumed data limitations, the systematic review identified 53 studies of which 31 psychosocial quantitative studies allowed an exploratory meta-analysis. The remaining studies, including all medical ones, were excluded for the meta-analysis due to the absence of pre-post measurements.

2.2. Eligibility criteria

2.2.1. Inclusion criteria

The inclusion criteria were structured using the PICOS framework, where P (Population) refers to children and adolescents affected by (online) sexual abuse, I (Intervention) covers medical and psychosocial care procedures, C (Comparison) was not required, O (Outcome) focuses on the assessment of intervention effectiveness, and S (Study Design) includes RCTs, cohort studies, case-control studies, and qualitative research.

English and German-language studies containing primary data (quantitative and qualitative, as well as mixed method) on medical and psychosocial care of children and adolescents after (online) sexual abuse were included. (P, I).

2.2.2. Exclusion criteria

In accordance with the previously defined exclusion criteria, the following studies could not be included: gray literature without peer review, expert opinions, letters, notes, essays, editorial publications, e-books, books, chapters, meta-analyses, umbrella reviews, scoping reviews and other systematic reviews.

Studies on medical and psychosocial procedures following (online) sexual abuse whose populations consisted of young adults >17.11 years old were excluded, as this marks the upper age limit in German child and adolescent psychiatry, where individuals aged 18 and older are classified as adults and are usually treated within general psychiatry. (P).

Studies on prevalence and prevention were also excluded due to the focus on interventions. (O).

2.3. Search strategy

The active identification of studies concluded on February 4, 2024, using the following databases: PubMed, Web of Science, PsycINFO (Ebsco), Cochrane (Wiley) and ERIC (Ebsco). These databases were chosen for their extensive and comprehensive coverage of medical, psychological, and educational literature, which are crucial for addressing the specific focus of this review. Each database was searched using the following terms in the titles in the abstracts and in the keyword lists: (child OR children OR adolescent OR childhood OR juvenile OR minor OR victim OR teen OR youngster OR young adult OR youth AND child sexual abuse OR online child sexual abuse OR sexual OR sexual assault OR sexual maltreatment OR rape OR sexual incest OR sexual abuse AND psychosocial interventions OR forensic medical examination OR early interventions after child rape OR rape intervention OR rape crisis center OR sexual assault center NOT adult NOT adulthood NOT prevention NOT women). The search strategy was individually adapted to the different databases. In addition, a manual search was conducted by screening the reference lists of included studies (snowballing) to identify additional relevant literature.

2.4. Study selection

The systematic literature search is presented in the PRISMA flowchart in Fig. 1. 20,007 studies were screened by title and abstract by two researchers blinded to each other (KSS, RM). 350 studies were identified for full-text screening. The full-text screening was carried out using the "Covidence" tool. Two researchers blinded to each other (AHB, RM) screened the 348 full-text articles. To assess inter-rater reliability during the full-text screening stage, Cohen's Kappa was calculated, yielding a very high agreement ($\kappa = 0.92$), indicating substantial consistency between the reviewers. In addition, a third, independent researcher (ND) was identified in advance for potential conflicts, following standard systematic review methodology (Higgins et al., 2024). 53 studies were ultimately included in the analysis.

Data extraction was conducted by a single researcher (RM) using a standardized extraction form to ensure consistency. Study characteristics such as study design, sample size and intervention were extracted and coded into predefined categories for systematic synthesis. In case of uncertainties a second researcher (ND) was consulted to resolve discrepancies.

2.5. Planned analysis

As the study portfolio was very heterogeneous, various assessment tools were used to evaluate the quality of the individual studies. For randomized control trials (RCTs), the RoB-2 tool established and recommended by Cochrane was used (Higgins et al., 2024). Other qualitative studies, which did not include statistical analyses, were assessed using the JBI Critical Appraisal Checklist for Qualitative Research, an established framework for evaluating methodological quality in qualitative research. A detailed overview of the assessment according to the color-coded scheme is attached in Appendices 1a and 1b.

The meta-analysis was performed using R, and heterogeneity was assessed using the I^2 statistic, which quantifies the proportion of variability due to differences between studies. To assess publication bias, the Trim-and-Fill method was applied, addressing

potential missing studies. In addition, Egger's test was performed to examine funnel plot asymmetry. The pre- and post-Trim-and-Fill funnel plots (see Appendix 3 and 4) revealed potential asymmetry in the initial funnel plot, whereas the adjusted funnel plot showed a more symmetrical distribution of studies, suggesting that publication bias was effectively addressed. Results from Egger's test (p -value = 0.223, Egger's coefficient = 1.246) further supported the absence of significant publication bias.

3. Results

Based on the research question of medical and psychosocial procedures carried out after (online) sexual abuse in children and adolescents, the results of the respective treatments are presented separately. The 53 studies include 17 medically related and 36 psychosocial related articles.

3.1. Characteristics of the studies

Most of the studies listed in Table 1 ($n = 37$) consisted of a sample from the United States. A total of three studies were from Australia, two from Brazil, two from Canada and another two from the Netherlands. One sample each originated from South Africa, the Democratic Republic of Congo, Iran, Turkey, Spain, Germany and the United Kingdom. Included studies ranged in sample size from $N = 11$ to $N = 2348$ and had an age range of 0 to 17.11 years. Publication dates ranged from 1995 to 2022.

3.2. Medical key findings

As the first medical step after CSA, * Argent et al. (1995) and * Bakal et al. (2016) describe a physical examination of the child. This is followed by a particularly genital and anogenital examination for signs of sexual abuse (* Argent et al., 1995; * Bechtel et al., 2008). The time frame for the medical examinations should be adapted according to the urgency of the situation, whereby acute referrals (within 72 h) should receive an examination as soon as possible (* Palusci et al., 2006). During the forensic examination * Heger et al. (2002) and * Walsh et al. (2007) state the preference for use of a colposcope. To document the findings of the examination in a standardized form, * Bravo-Queipo-de-Llano et al. (2022) refers to the use of renewed, specific protocols. Part of the documentation includes the application of a rape kit to preserve evidence (* Christian et al., 2000). Evidence collection includes vaginal, anal (* Argent et al., 1995) and oral swabs (* Christian et al., 2000). Stained skin should be tested for blood, sperm, and evidence of semen. Hair samples should be taken (* Christian et al., 2000). * Girardet et al. (2011) state that it is highly relevant to gather evidence, also from linen and clothing, within the first 24 h after the alleged assault. If physical contact has been reported, the next step is screening for sexually transmitted diseases and infections (* Argent et al., 1995; * Bechtel et al., 2008; * Bravo-Queipo-de-Llano et al., 2022; * Heger et al., 2002, * Majeed-Ariss et al., 2021). Collection of blood samples for syphilis serology should be taken (* Argent et al., 1995; * Bechtel et al., 2008) as well as tests for hepatitis B and C and HIV (* Bechtel et al., 2008). In addition, a prophylaxis for STIs, HIV (* Bechtel et al., 2008) and pregnancy (* Bravo-Queipo-de-Llano et al., 2022; * Edinburgh et al., 2008) is prescribed. * Goodman and Goodpasture (2020) also suggest implementation of an HPV vaccination in the medical care after CSA.

Follow-up care should be performed in the period from two days to 16 weeks (* Argent et al., 1995; * Makoroff et al., 2002). * Campbell et al. (2010) emphasize that time is of the essence in the provision of medical care following CSA so child protection professionals should ensure 24/7 access to forensic examinations to stem the further cycle of abuse. Results also showed that different health care is provided in a hospital-based children advocacy center (CAC) than in regular emergency departments or hospitals, whereby more children had a physical and genital examination as well as referral for counseling in CAC's (* Edinburgh et al., 2008). Additionally, the training of the practitioners plays a decisive role. * Makoroff et al. (2002) found that physicians with child abuse training assessed abnormal findings during genital examinations in a fundamentally different way to pediatric emergency physicians. Further training is needed for professionals in this field (* Makoroff et al., 2002; * Campbell et al., 2010). * Bechtel et al. (2008) show that the assignment of specially trained nurses dramatically increases the quality of medical care after CSA, with more affected children receiving STI screenings and prophylactic measures. In addition, referrals to Rape Crisis Centers were more frequent. Thus, a multidisciplinary approach and a child-centered setting should always be maintained throughout the medical procedure (* Raman & Hotton, 2017). Fig. 2 summarizes the described medical practice for children and adolescents after experiencing sexual abuse from 17 studies.

3.3. Psychosocial key findings

For a more detailed structure and a comprehensive overview of this data set, the psychosocial studies on procedures following child sexual abuse are shown in Fig. 3 as a frequency diagram.

Fig. 3 shows the absolute and relative frequencies of the various interventions implemented across the 36 psychosocial studies. In a comparative analysis of psychotherapeutic treatment forms in some RCT studies, it was found that TF-CBT always showed higher efficacy and more significant results than the comparison group which focused on treatments such as CCT and NST (* Cohen & Mannarino, 1996a, 1996b; * Cohen et al., 2004; * Cohen et al., 2005). The proportion of mentions of NST illustrated in Fig. 3, is related to the RCT study design, whereby this treatment form consistently showed smaller improvements than the therapeutic comparator form (* Cohen & Mannarino, 1996a, 1996b; * Cohen & Mannarino, 1996a, 1996b, * Cohen & Mannarino, 1997; * Cohen & Mannarino, 1998a; * Cohen & Mannarino, 1998b; * Cohen & Mannarino, 2000; * Cohen et al., 2005). * Cohen et al. (2004) revealed that TF-CBT reduced behavioral problems and depressive symptoms in children after CSA. Similarly, parents assigned to TF-CBT reported greater

Table 1.

List of included studies and characteristics.

Study	Description	Procedures after (online) sexual abuse	Study design	Sample characteristics	Summary of findings
Argent et al. (1995) South Africa	Investigation of child sexual abuse (CSA) by a multidisciplinary team, treatment of medical problems, and urgent social and psychological interventions	Medical and genital examination, STD, Swabs from the vaginal introitus and rectum, blood collection and follow-up after 6 weeks	Retrospective Study	N = 96 Laboratory evidence of sexually transmitted diseases of children (1.11 to 14) after CSA	N = 96 Laboratory evidence of sexually transmitted diseases of children (1.11 to 14) after CSA
Arnold et al. (2003) United States	Treatment of Incarcerated, Sexually-Abused Adolescent Females	Gender-specific, cognitive-behavioral therapy (CBT) intervention	Outcome Study	N = 100 Incarcerated, Sexually-Abused Adolescent Females (12 to 17)	Improvements in their psychosocial functioning after receiving gender-specific CBT
Bakal et al. (2016) Turkey	Children with perineal injuries were reviewed retrospectively	Physical examination, use of genital injury score (GIS)	Retrospective Study	N = 75 Children (1 to 14), only 4 patients experienced CSA	The genital injury score is a useful genital trauma scale for predicting anogenital injury severity
Bechtel et al. (2008) United States	Evaluation of the impact of SANEs in a PED in terms of improvement of the medical care of pediatric and adolescent sexual assault victims	Genitourinary (GU) examination, Evaluation for sexually transmitted infections (STIs) and serologies for hepatitis B and C, HIV, prescription of prophylaxis for STIs, HIV, and pregnancy	Retrospective Study	N = 114 Children with a history of CSA	Many more patients who had been sexually assaulted received STI testing, pregnancy prophylaxis, and referrals to the Rape Crisis Center when a SANE was present for the evaluation in the PED
Bravo-Queipo-de-Llano et al. (2022) Spain	Detection and management CSA in the Pediatric Emergency Room (ER)	STIs screening when physical contact is reported, STI and HIV prophylaxis, use of renewed specific protocols	Retrospective Study	N = 213 Sexually abused children (up to 16) who were seen in the ER	CSA recognition in the ER is highly relevant, as many patients there seek help for the first time
Campbell et al. (2010) United States	Examination of CSA cases with a focus on anogenital injuries treated in a pediatric Forensic Nurse Examiner (FNE) program	Forensic medical exam (FME) to address patient's medical, psychological and legal needs performed by physicians or forensic nurses to identify and treat injuries, evaluate the risk for STI and pregnancy and collect evidence	Observational Study	N = 203 Children after CSA (4 months to 13 years)	Clinical pediatric practice would benefit from additional practitioner training in injury detection. Providing 24/7 medical examinations could help to interrupt the cycle of abuse
Carnes et al. (2001) United States	CAC's forensic evaluation and the length of it for children referred due to suspected sexual abuse	Forensic evaluation: 4 sessions or 8 sessions (incl. One session with a NOC), 50 min each session	Multisite Field Study	N = 147 Children (2 to 17) with suspicion of CSA who did not make a clear disclosure	4 to 8 session extended evaluations do not differ in success vs. nonsuccess
Christian et al. (2000) United States	Forensic evidence findings in prepubertal children after CSA in three different emergency departments in Philadelphia	Medical examination, Standardized documentation, Rape kits, Swabs were taken from genital, anal, and oral areas and stained skin were tested for blood, sperm, and evidence of semen. Collection of hair samples and clothing	Retrospective Study	N = 273 Medical records of children (up to 10) who were evaluated in hospital emergency departments (in Philadelphia) and had forensic evidence processed by the Philadelphia Police Criminalistics Laboratory	Evidence collection depends on the timing of the medical examination. 90 % of children with positive forensic evidence findings were seen within 24 h of their assault. Most of the forensic evidence (64 %) was found on clothing and linens
Cohen and Mannarino (1996a, 1996b) United States	Efficacy of TF-CBT vs. NST vs. CBT-SAP	12 individual sessions of one treatment for both child and NOP	Randomized Control Trial (RCT)	N = 67 Preschool children (2.11 to 7.1)	CBT-SAP was most efficient for children and their NOP in reducing symptoms
Cohen and Mannarino (1996a, 1996b) United States	CBT-SAP vs. NST, mediating factors on treatment outcome were evaluated	Sexually abused preschool children and their NOP received CBT-SAP or NST	RCT	N = 67 Preschool children (2.11 to 7.1)	Parental distress strongly effects the outcome, SAS-CBT was superior to the NST

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Table 1. (continued)

Study	Description	Procedures after (online) sexual abuse	Study design	Sample characteristics	Summary of findings
Cohen and Mannarino (1997) United States	Efficacy of TF-CBT vs. NST, outcome during a one year follow-up (6 and 12 months)	CBT-SAP vs. NST	RCT	<i>N</i> = 43 Children (4.2 to 7.11) <i>N</i> = 28 CBT-SAP, <i>N</i> = 15 NST	CBT-SAP is more effective in maintaining lower symptoms after one year
Cohen and Mannarino (1998a) United States	Treatment interventions after CSA. Children were randomly assigned to receive either sexual abuse-specific CBT (SAS-CBT) or nondirective supportive therapy (NST)	12 treatment sessions sexual abuse-specific CBT (SAS-CBT) or nondirective supportive therapy (NST) over a 12-week period. Each session included 45 min with the child and 45 min with the nonoffending parent (NOP)	Initial Treatment Outcome Study	<i>N</i> = 49 Recently sexually abused children (7 to 14) and their NOP	SAS-CBT is effective especially for reducing depressive symptoms and inappropriate sexual behavior in children
Cohen and Mannarino (1998b) United States	Children and their NOP who received either CBT-SAP or NST. Reevaluation at the completion of treatment and 6 and 12 months after treatment	Cognitive-behavioral therapy for sexually abused preschoolers (CBT-SAP) vs. nondirective supportive therapy (NST)	RCT	<i>N</i> = 43 Preschool children (4.2 to 7.11) and their NOP	Parental support has an impact on treatment outcome of a 12-month follow-up. Findings support the superiority of CBT-SAP over NST in long-term outcome for this population
Cohen and Mannarino (2000) United States	Interventions to predict treatment outcome after CSA	12-week sexual-abuse specific CBT (SAS-CBT) vs. 12-week NST both 45 min including NOP	RCT	<i>N</i> = 49 Recently sexually abused children (7 to 14) and their NOP	Parental support is important for recovery, SAS-CBT was superior to the NST intervention in decreasing depressive symptoms
Cohen et al. (2004) United States	Efficacy of TF-CBT vs. child-centered therapy for treating PTSD after CSA	12-week TF-CBT for children and their NOP vs. 12-week child-centered therapy for children and their NOP	RCT	<i>N</i> = 229 Sexually abused children (8 to 14)	TF-CBT showed greater improvement for children and their NOP than child-centered therapy
Cohen et al. (2005) United States	Measuring the durability of improvement of TF-CBT vs. NST after one year	12 sessions of one treatment for both child and NOP	1 Year Follow-Up of RCT	<i>N</i> = 82 Children (8 to 15) and their NOP	TF-CBT showed greater effectiveness
Cohen et al. (2007) United States	Combined TF-CBT and sertraline after CSA	12 weeks of TF-CBT + sertraline or TF-CBT + placebo	RCT	<i>N</i> = 24 Female children (10 to 17) and their NOP	Both groups improved without a significant difference
Deblinger et al. (1996) United States	Comparison of the impact of treatment interventions	Group 1: community control condition Group 2: child intervention, Group 3: NOP intervention, Group 4: CBT for both, all interventions had a duration of 12 weeks	Initial Treatment Outcome Study	<i>N</i> = 100 Children (7 to 13) and their nonoffending mothers (NOM)	CBT intervention is effective for children after CSA, parental involvement is crucial for reducing PTSD symptoms
Deblinger et al. (2001) United States	Efficacy of CBT vs. supportive group therapy for children and their NOM	Either CBT (11 sessions) for children and NOM or supportive group therapy (11 sessions) for both	Comparative Efficacy Study	<i>N</i> = 44 Sexually abused children (2 to 8) and their NOM who were referred to the Regional CSA Diagnostic Center	Findings support the superiority of CBT over supportive group therapy for children and NOM. Nevertheless, supportive group therapy is effective
Deblinger et al. (1999) United States	CBT after CSA: 2-year follow-up (after 3, 6, 12 and 24 months)	Group 1: community control condition Group 2: child intervention, Group 3: NOP intervention, Group 4: CBT for both, all interventions had a duration of 12 weeks	Two-Year Follow-Up Study	<i>N</i> = 100 Male and females (7 to 13) and their nonoffending mothers (NOM)	Post-treatment improvements in externalizing behavior, depression and PTSD were maintained over the 2-year-period
Deblinger et al. (2006) United States	TF-CBT vs. child-centered therapy, follow-up after 6 and 12 months	TF-CBT or child-centered therapy, both with their NOP	Follow-Up Study of a Multisite RCT	<i>N</i> = 183 Children (8 to 14) and their primary caregivers	Children and their NOP continued to have fewer PTSD symptoms after TF-CBT
Dietz et al. (2012) United States	Evaluation and comparison of the effectiveness of three types of group therapies after CSA	Treatment interventions consisted of 12 sessions of group therapy. Group 1: no dogs,	Outcome Study	<i>N</i> = 153 Children (7 to 17) and their NOP at a Child Advocacy Center (CAC)	Groups that included therapy dogs showed significant decreases in trauma symptoms, group

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Table 1. (continued)

Study	Description	Procedures after (online) sexual abuse	Study design	Sample characteristics	Summary of findings
		Group 2: dogs, no story, Group 3: dogs with stories			with therapeutic stories showed more change than the other groups
Edinburgh et al. (2008) United States	Comparison of treatment of sexually abused adolescents seen at a hospital-based CAC vs. community providers	CAC cases: physical/genital exam, STI testing, screening for pregnancy and prophylactic treatment	Retrospective Matched Case-Comparison Study	N = 128 Sexually abused children (10 to 15) diagnosed with extra-familial sexual abuse at a CAC	Different health care is provided in a hospital-based CAC compared to elsewhere
Faller and Nelson-Gardell (2010) United States	Evaluation of how many sessions are sufficient after CSA, randomized comparison: 4 or 8 sessions	8 sessions of extended evaluations are most effective	Multisite Extended Evaluation Study	N = 138 Children after CSA (2 to 17)	Cases assigned to 8 sessions were more likely to be classified as a credible disclosure
Girardet et al. (2011) United States	Collection of forensic evidence after CSA	Medical examination within 24 h of sexual assault. Evidence collection from linens and clothing	Retrospective Study	N = 277 Evidence-collection kits of children (up to 13) after CSA, N = 151 children <10	Most children with DNA-confirmed biological evidence present to a medical facility within 24 h of assault
Goodman and Goodpasture (2020) United States	The impact of providing HPV vaccination after CSA in a child protection team (CPT) clinic	HPV vaccination after CSA	Quality Improvement Project	N = 111 (9 to 17) Sexually abused children	Implementing HPV vaccinations after CSA in medical care is crucial
Grosz et al. (2000) United States	Treatment after extrafamilial CSA for children and their families	Group therapy for children and parent support group (both 1.5 h sessions for 6 to 9 months)	Pilot Study	N = 246 children (2 to 14, N = 117: 3 to 5) and their NOP N = 323	Children's Treatment groups, and Parent Support Groups led to a positive outcome
Habigzang et al. (2009) Brazil	Effects of a CBT group therapy after CSA	CBT group therapy, 16 weekly sessions (1.5 h)	Non-randomized Clinical Trial	N = 40 Female CSA survivors (9 to 16)	CBT group therapy reduced symptoms of depression, anxiety, child stress and post-traumatic stress disorder
Habigzang et al. (2013) Brazil	Evaluation of a CBT group therapy after CSA	CBT group therapy, 16 weekly sessions (1.5 h)	Non-randomized Clinical Trial	N = 49 Female CSA survivors (9 to 16)	Therapeutic effects lasted 6 to 12 months after the treatment ended
Hahn et al. (2016) United States	Early intervention after CSA in CACs	Child and Family Traumatic Stress Intervention (CFTSI) after acute CSA	Chart Review Study	N = 114 Caregiver-child dyads (7 to 16, male and female) in a CAC setting	CFTSI has demonstrated effectiveness in reducing symptoms
Hébert and Amedée (2020) Canada	Complex PTSD after CSA and the response to TF-CBT	Trauma-focused Cognitive behavioral therapy (TF-CBT)	Latent Class Analysis with Treatment Outcome Measurement	N = 384 Males and females (6 to 14) recruited in a CAC	TF-CBT is effective to address the negative outcomes associated with CSA
Heger et al. (2002) United States	Referral of children after possible CSA; medical findings	Medical examination: use of a colposcope, collection of forensic evidence and STD screening	Prospective Study	N = 2348 Males and females (up to 17.11)	Other professions have relied too much on the medical examination in diagnosing CSA
Hubel et al. (2014) United States	CAC based group treatment after CSA	12-week cognitive-behavioral group treatment for families	Outcome Study	N = 97 Children and their nonoffending caregiver (NOC) who were referred to Project SAFE (sexual abuse family education)	CBT group therapy reduced symptoms of children after CSA
Jaberghaderi et al. (2004) Iran	Comparison of two treatments for sexually-abused Iranian girls	12 sessions of CBT or EMDR	RCT	N = 14 Iranian girls (12 to 13)	EMDR showed more significant effects than CBT
King et al. (2000) Australia	Evaluation of the efficacy of child and caregiver participation in CBT after CSA	Group 1: children received individual CBT (20 sessions, 50 min), Group 2: child and NOP	RCT	N = 36 Sexually abused children (5 to 17)	Parental involvement did not improve the efficacy of CBT after CSA
Kirsch et al. (2011) Germany	Efficacy of trauma-focused behavioral (TF-CBT) therapy for children and adolescents after abuse/maltreatment	12 to 31 sessions of TF-CBT	Pilot Study	N = 15 Children with PTSD (4.6 to 16.6) N = 4 Sexual abuse	TF-CBT therapy led to a significant reduction in symptoms
Liotta et al. (2015) United States	Efficacy of group therapy (game-based CBT) vs.	Group therapy in form of GB-CBT-GM: 12 sessions	Quasi-Experimental Study	N = 153 Children (5 to 13) who disclosed CSA	Individual therapy addresses sexual concerns

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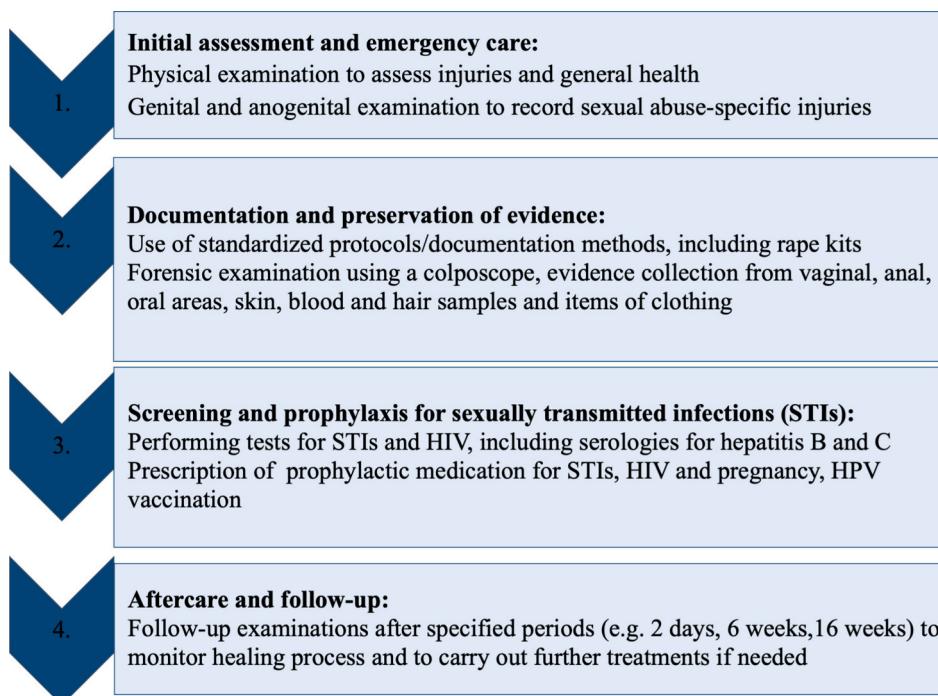
Table 1. (continued)

Study	Description	Procedures after (online) sexual abuse	Study design	Sample characteristics	Summary of findings
Majeed-Ariss et al. (2021) United Kingdom	group-plus-individual therapy after CSA STI services after CSA at Saint Mary's Sexual Assault Referral Center	STI at FME, older adolescents: Genitourinary Medicine (GUM)	Retrospective Chart Review	N = 843 Children (0 to 17) who attended Saint Mary's SARC	but does not augment the effect of group therapy 65 % of participants had an STI during FME, 35 % were advised to a local GUM
Makoroff et al. (2002) United States	Comparison of abnormal genital examination findings by pediatric emergency medicine (PEM) physicians vs. examinations by physicians trained in CSA	Medical examination by a CSA specialist, follow-up examinations after 2 days –16 weeks	Prospective Study	N = 46 Prepubertal girls (2 to 12)	PEM should receive additional training in CSA
Misurell et al. (2011) United States	Efficacy of a GB-CBT group program	GB-CBT group therapy, 12 sessions, 1.5 h per session	Outcome Study	N = 48 Children (5 to 10) after CSA	GB-CBT is an effective approach after experiencing CSA
O'Callaghan et al. (2013) Democratic Republic of Congo	Efficacy of a group-based TF-CBT program for Congolese girls	15 session, group-based, culturally modified TF-CBT group or a wait-list control group	RCT	N = 52 (12 to 17) Sexually exploited, war-affected girls	Modified TF-CBT is effective for a population that culturally differs from its original target population
Palusci et al. (2006) United States	Acute medical assessment after CSA at a CAC	Group 1: urgent referrals (< 72 h), Group 2: non-urgent referrals (> 72 h), Early medical examination	Retrospective Cohort Study	N = 190 Sexually abused children under 13	It is more likely to find forensic evidence in females (> 10) who reported ejaculation/genital contact without bathing
Raman and Hotton (2017) Australia	Quality of local clinical assessments after CSA	Clinical assessments based on a clinical protocol, pediatric and psychosocial follow-up	Descriptive Study	N = 304 N = 297 Children (< 16) after CSA	Locally relevant standards are feasible in the acute sector. Ensuring proper medical and psychosocial follow-up is more difficult
Reeker and Ensing (1998) United States	Evaluation of a group therapy for young children after CSA	12-week group therapy (psycho-educational), 1.5 h per session, one group consisted of 4 to 8 children	Outcome Study	N = 19 Sexually abused children (5 to 8)	Group therapy shows significant effectiveness. 12 to 24 sessions are sufficient
Reeson et al. (2020) United States	Intensive and novel multimodal treatment program designed for young females after CSA	2-week program includes TF-CBT, group, individual, art, music, recreational and meditative therapy, EMDR, AAT and cultural activities	Preliminary Study / Pilot Study	N = 27 Sexually abused females (13 to 16)	Positive short-term findings that suggest great effectiveness. Long-term follow-up in larger groups is appropriate
Rheingold et al. (2013) United States	Video intervention for children and caregivers prior to medical examination in cases of CSA	Psycho-educational video to instruct children and caregivers about the medical exam procedures	Randomized Controlled Pilot Study	N = 69 Children (4 to 15) N = 35 (video) N = 34 (no video)	Caregiver and child distress decreased but there were no significant differences in decreases between groups
Salvagni and Wagner (2006) United States	Development of a questionnaire for the assessment of sexual abuse in children	Reported or suspected CSA control group: no CSA suspicion. Questionnaire was handed out to a parent/ guardian of each child	Case-Control Study	N = 192 Children (2 to 12) N = 97 (case group) N = 95 (control group)	The questionnaire is easy to apply and helps in the identification of CSA
Smith and Kelly (2008) Australia	Evaluation of group therapy after CSA including NOP/NOC	12-week sexual abuse-specific CBT (SAS-CBT) intervention with NOP/NOC, 1.5 h per session	Exploratory Study	N = 11 Children experienced CSA (11 to 16)	Group therapy positively affects psychological outcomes after CSA
Springer et al. (2012) United States	Three month follow-up investigation: GB-CBT group therapy for sexually abused children	12-week GB-CBT group therapy, 1.5 h per session which included TF-CBT and psychoeducation	Follow-Up Study	N = 123 Sexually abused children and their NOC (5 to 10)	GB-CBT improved symptoms immediately after treatment and at three month follow-up
Tourigny et al. (2005) Canada	Efficacy of group therapy for adolescent girls after sexual abuse	20-week group therapy, 2 h per session	Pre-test/Post-test Control Group	N = 42 Females (13 to 17) Case group: therapy (N = 27) Control group: no therapy (N = 17)	Significant improvement in case group compared with the control group

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Table 1. (continued)

Study	Description	Procedures after (online) sexual abuse	Study design	Sample characteristics	Summary of findings
van Duin et al. (2018) Netherlands	Psychological treatment of young children who were involved in the Amsterdam Sexual Abuse Case (ASAC) and the impact on their NOPs 3 years after disclosure	Children: trauma therapy, parent child therapy Parents: trauma therapy, parent child therapy, relationship therapy, hypnotherapy, group therapy	Longitudinal Study	N = 44 Children (3 to 11) N = 41 NOP of children involved in the ASAC	Interventions should focus the wide spectrum of problems that follow CSA and parents psychopathology as well as parent-child relationship
Vrolijk-Bosschaart et al. (2017) Netherlands	Early recognition of CSA: Physical symptoms after CSA in very young children (ASAC study)	Medical examination, including anogenital examination, STI testing	Mixed-Method Study	N = 54 Confirmed cases of sexual abuse (0 to 6), predominantly boys	Deviant behavioral reaction during the anogenital examinations was prominent, physical complaints were non-specific
Walsh et al. (2007) United States	Impact of CACs and factors that mediate which child receives a FME after CSA	Medical examination, using a colposcope, timing of the medical examination: 72 h after the assault	Quasi-Experimental Study	N = 1220 FME records of children after CSA N = 143 NOC	CACs are an effective tool for furthering access to FMEs after CSA. 48 % of children at the CACs had a FME compared to 21 % of children at comparison communities

**Fig. 2.** Overall described medical procedure after CSA. Findings of 17 studies.

improvement in abuse-specific distress and child support. * [Cohen et al. \(2007\)](#) was the only study to examine the effect of TF-CBT in combination with sertraline. Little evidence was found to indicate that sertraline provides a benefit in combination with TF-CBT. In their RCT study, * [Jaberghaderi et al. \(2004\)](#) compared the effectiveness of TF-CBT and EMDR after CSA for Iranian girls, with EMDR achieving more significant results. The average duration of therapy for TF-CBT was 12 weeks or 12 sessions, with non-abusive parents/caregivers also receiving therapy (* [Cohen et al., 2004](#); *[Cohen & Mannarino, 1996a, 1996b](#); * [Cohen et al., 2005](#)). * [O'Callaghan et al. \(2013\)](#) conducted 15 sessions of group-based and cultural-modified TF-CBT for Congolese girls, which showed great improvement in depression and anxiety. The second most common treatment, CBT, also presents a high level of effectiveness (* [Deblinger et al., 1996](#)). CBT performs particularly well in comparison with Supportive Group Therapy (* [Deblinger et al., 2001](#)) and NST (* [Cohen & Mannarino, 1997](#)). This also applies to specific forms of CBT for certain age groups, such as pre-school children (* [Cohen & Mannarino, 1998b](#)) and CBT-SAP (* [Cohen & Mannarino, 1998a](#)).

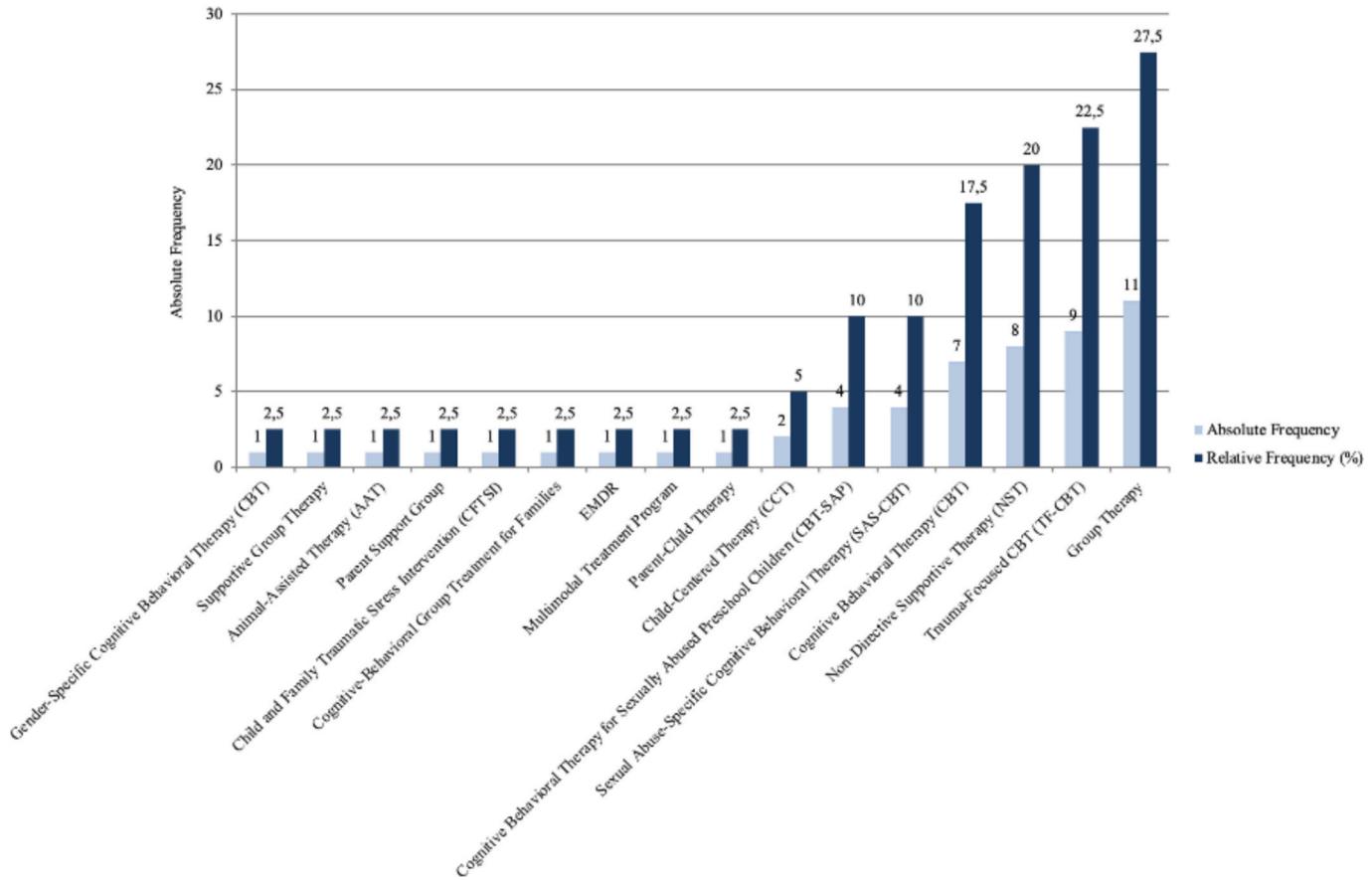


Fig. 3. Psychosocial treatment forms after CSA. Findings of 36 studies.

The high proportion of group therapy interventions shown in Fig. 3 is primarily due to the setting in which behavioral therapy interventions were primarily used. This also includes specific forms of CBT, such as game-based CBT (* Misurell et al., 2011; * Springer et al., 2012), culturally modified TF-CBT (* O'Callaghan et al., 2013) and GB-CBT in combination with TF-CBT and psychoeducation. 12 sessions over 12 weeks are offered, with caregivers included in the intervention. Psychosocial interventions in the form of group therapy differ from the individual setting in their duration, lasting on average 1.5 h–2 h over 12–16 weeks (* Dietz et al., 2012; * Grosz et al., 2000; * Habigzang et al., 2009; * Habigzang et al., 2013; * Hubel et al., 2014; * Misurell et al., 2011; * Reeker & Ensing1998; * Springer et al., 2012; * Smith & Kelly, 2008; * Tourigny et al., 2005).

3.4. Meta analysis

In order to make an exploratory statement about the effectiveness of the various forms of psychosocial treatment and their frequency in the studies, a meta-analysis was carried out with 31 of the 53 included studies. The 22 remaining studies could not be included due to a lack of pre-post measurement. The analyzed studies provide effect sizes (Cohen's d) that measure the strength of the interventions. The weighted mean effect size was 1.14 with a variance of 0.0063 and a 95 % confidence interval ranging from [0.98; 1.29], indicating an effectiveness of the interventions. Overall, the studies show a high heterogeneity of $I^2 = 82\%$.

The results of the Forest Plot shown in Fig. 4, indicate a strong positive impact of the psychosocial interventions as the mean diamond presents an overall effect size of 1.14 [0.98; 1.29]. * Dietz et al. (2012) and * Hubel et al. (2014) demonstrate high effect sizes, while other studies show weaker or even negative effects (* Rheingold et al., 2013; * Arnold et al., 2003). The width of the confidence intervals (CI) also varies, reflecting differences in the precision of these studies. Studies with larger sample sizes (* Hébert & Amédée, 2020), have narrower confidence intervals, indicating more reliable estimates of the effect size. * Jaberghaderi et al. (2004) demonstrates a smaller effect size with a wide CI indicating considerable uncertainty. Cochrane's Q-test reveals a high heterogeneity among the studies ($Q = 159.91$; $df = 29$; $p < 0.01$; $I^2 = 82\%$).

4. Discussion

4.1. Medical interventions after CSA

The review provides the first specific overview of the current state of medical and psychosocial care after CSA. A total of 53 studies listed in Table 1 were included, which show a spectrum of different countries, with a distinct tendency towards Western cultures, in which they were conducted. The 17 studies on the medical procedure after CSA tended to have a common thread, which is why a

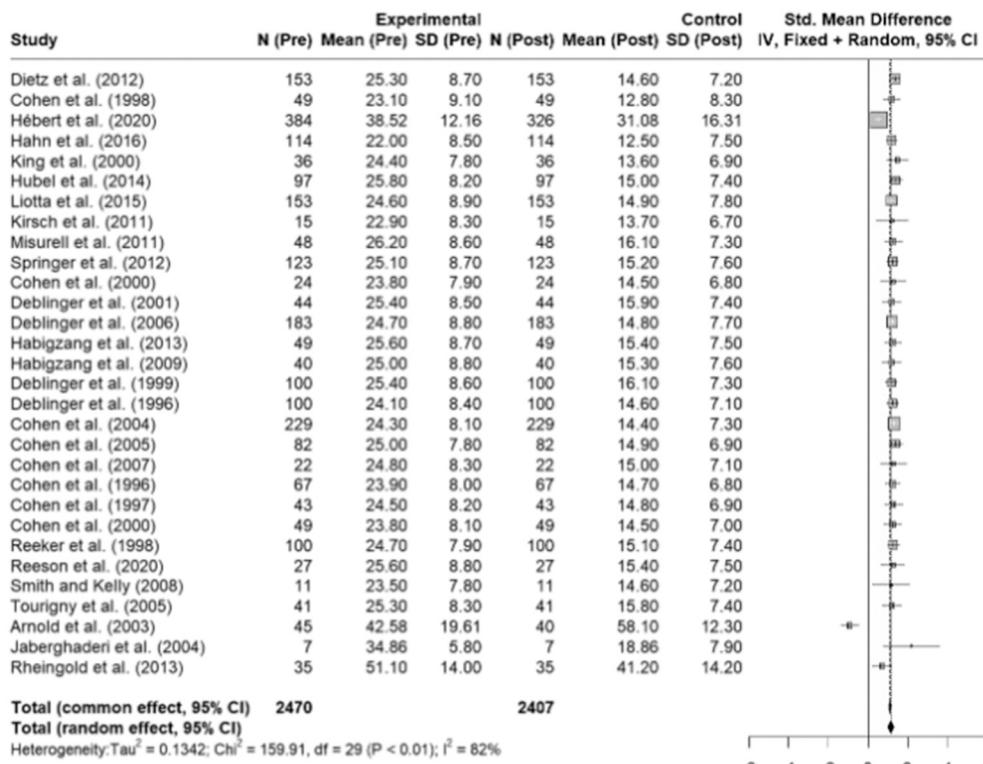


Fig. 4. Forest Plot.

concise procedure can be presented in [Fig. 2](#). Differences were found in the use of medical instruments such as the colposcope, with the use of examination instruments and positions that minimize physical discomfort strongly recommended as good practice according to the [World Health Organization \(2017\)](#). The Association of the Scientific Medical Societies (2018) in Germany even considers using a colposcope to be mandatory. It was noticeable that relatively older studies (* [Argent et al., 1995](#)) did not mention the use of such devices, which could be related to the year of publication. In addition, the 17 studies focused partly on different steps in the medical care process. For example, * [Goodman and Goodpasture \(2020\)](#) focused their study on the relevance of HPV vaccinations after CSA, which is strongly recommended by the [World Health Organization \(2017\)](#) for girls in the age group 9–14 years. * [Bechtel et al. \(2008\)](#) and * [Bravo-Queipo-de-Llano et al. \(2022\)](#) on the other hand concentrated on more holistic medical procedures after CSA such as the physical examination, STI screening and the prescription of prophylactics. The importance described by * [Girardet et al. \(2011\)](#) and * [Palusci et al. \(2006\)](#) of collecting evidence ideally within the first 24 h after CSA is consistent with the AWMF guideline, which also advises securing clothing and bedding after >7 days ([Blesken et al., 2018](#)). Overall, the procedures are in line with the recommendations of the [World Health Organization \(2017\)](#), although neither the examination of the child's psychological and mental status nor the preventive child protection medical full-body examination, which validates the physical health status, is explicitly mentioned in any of the 17 medical studies, despite being an essential component.

4.2. Psychosocial interventions and their effectiveness

The 36 psychosocial studies showed a broad spectrum of interventions whereby tendencies towards TF-CBT and (adapted) CBT in both individual and group settings were noticeable. * [Jaberghaderi et al. \(2004\)](#) was the only study that compared EMDR with TF-CBT and found a superior improvement of EMDR over TF-CBT. Since the study relates to Iranian girls between the ages of 12 and 13, the result should also be interpreted in this context. However, it is crucial to conduct further RCTs to investigate the effectiveness of EMDR, especially in comparison to TF-CBT, to draw more general conclusions. In addition, *[Cohen et al. \(2004\)](#), *[Cohen and Mannarino \(1996a, 1996b\)](#), *[Cohen et al. \(2005\)](#) indicate that the involvement of non-abusive parents or caregivers can support the success of therapy. This finding is aligned with [McTavish et al. \(2021\)](#), who highlighted that CBT with a trauma focus, when provided to children and involving their caregivers, can reduce mental health symptoms associated with sexual abuse experiences. Additionally, [Sánchez-Meca et al. \(2011\)](#) concluded that trauma-focused cognitive-behavioral treatments, combined with supportive therapy and psychodynamic elements, showed the best results, which is consistent with the findings of this review. These studies collectively highlight the importance of psychosocial interventions in general, demonstrating their effectiveness in mitigating the mental health consequences of CSA.

4.3. Results of the meta-analysis

The 31 studies in the meta-analysis showed significant effects with a high heterogeneity of $I^2 = 82\%$. Although the high diversity of treatment forms leads to different results, it can be stated that all psychosocial interventions contributed to a reduction in symptoms.

The first inference of this review is that medical care after CSA follows a certain approach and shows considerably more similar results than psychosocial care. Nevertheless, the medical studies do not show a child-centered approach that asks how the children and adolescents perceived the medical care. In addition, the studies are not based on a differentiation from CSA and OCSA, which keeps the question open as to what extent an adapted medical approach is required for OCSA. Secondly, the highly significant outcomes of the meta-analysis show a distinct effectiveness of psychosocial interventions after CSA. Despite this, there is enormous heterogeneity in the results ($I^2 = 82\%$), which points to the high degree of inconsistency in the forms of treatment. It is questionable whether the effectiveness of the interventions is merely due to a temporal effect, as the patients showed fewer symptoms after each of the different forms of treatment and there were no control groups.

4.4. Implications for clinical and research practice

Despite this evident improvement for those affected of CSA, it is not fully understood whether the forms of intervention for OCSA have the same or a deviating efficacy. Uncertainty about whether digital footage of the traumatic event exists can lead to a persistent state of trauma as those affected can feel constantly exposed to the situation. Thus, [Martin \(2015\)](#) states that TF-CBT as a treatment for OCSA could potentially have negative effects as it involves elements of exposure. Given the unique nature of OCSA, there is a need to adapt existing therapeutic approaches or even develop new ones that are specifically tailored to address the distinct psychological and emotional impacts on affected children and adolescents. The focus should be on dealing with the permanent availability of images of abuse, the associated shame, guilt and loss of control. It is equally vital that professionals receive specific training on OCSA and systematically inquire about its variations of OCSA whenever children and adolescents have experienced any form of abuse.

4.5. The need for interdisciplinary approaches

Even though cooperation between forensic nurses and doctors is described within medical care (* [Bechtel et al., 2008](#)), there is no interdisciplinary reference to psychosocial structures. [Herbert and Bromfield \(2019\)](#) point out that there is sufficient evidence to assume a significant improvement in care when multidisciplinary teams are involved in treating CSA. Similarly, [Walsh et al. \(2007\)](#) demonstrated that CACs, which are always based on an interdisciplinary approach, are an effective tool for improving care after CSA (see [Table 1](#)). [Nwogu et al. \(2016\)](#) also confirm the high effectiveness of CACs, whereby close cooperation with the police and judiciary

in particular can lead to an increased conviction rate for offenders. In future, specialized centers such as CACs, and Barnahus should therefore be used to ensure fully comprehensive, interdisciplinary care in accordance with CSA and OCSA.

4.6. Future research directions

Finally, it can be stated that OCSA has to this point been neglected in medical and psychosocial intervention research. The present review was also unable to identify any studies dealing with explicit OCSA care procedures. In contrast, the data on preventive interventions appears to be more comprehensive, as shown by [Patterson et al. \(2022\)](#). Although prevention is a crucial approach to hinder OCSA it must be remembered that OCSA cannot always be prevented, and explicit interventions should be developed for this form of abuse.

5. Limitations

The most critical limitation in this review is the lack of specific OCSA studies. As this field of research appears to have attracted far too little research to date in terms of interventions that are not concerned with prevention, it was not possible to identify enough primary studies that met our inclusion criteria. Therefore, we could only provide theoretical recommendations for care procedures after OCSA and were unable to conduct a subgroup analysis on medical and psychosocial care after OCSA. Moreover, the well-researched topic of CSA provided extensive literature, resulting in a relatively high number of studies of 53. Due to the number of studies found, an initially unforeseen meta-analysis was calculated, whereby no conclusive subgroups could be formed, and no meta-regression could be carried out due to the high heterogeneity ($I^2 = 82\%$) of the studies. Due to its exploratory design, the meta-analysis does not allow for generalizable conclusions, as the outcome measures correspond to various disorders across the included studies.

6. Conclusion

This systematic review with meta-analysis is the first to focus on both the medical and psychosocial procedures after CSA. It became clear that there is a significant gap in research and care regarding OCSA, while a relatively large number of heterogeneous procedures for CSA were identified in the 53 studies. In terms of psychosocial interventions, TF-CBT, adapted, age-appropriate forms of CBT and group therapies have proven to be particularly effective forms of treatment after CSA. However, due to a lack of studies, it is currently unclear how effective these forms of treatment are for OCSA in particular. Since OCSA can also include CSA as a hands-on act, it can be assumed that the listed psychosocial interventions would achieve an improvement in symptoms. Nevertheless, it should be borne in mind that the ongoing exposure to the circulating image material could cause long-term damage to the privacy of those affected ([Martin, 2015](#)). Further research is also needed to elaborate which aspects should be taken into account during a medical examination according to OCSA. An example of this could be the handling of photo documentation of injuries. As OCSA is a form of CSA and one can, but does not have to, merge into the other ([Kloess et al., 2019](#)), it is highly relevant to develop specific medical as well as psychosocial care procedures following OCSA and to systematically inquire about the component of digital abuse in existing CSA. In addition, the online component should be included in the current medical child protection guidelines, as no clear recommendations currently exist ([Blesken et al., 2018](#)).

The lack of interdisciplinarity across the 53 studies shows that there is still potential for improvement regarding practical cooperation between different professions after CSA and OCSA. The legal component, which is highly relevant in criminal prosecution, should be considered in the case of OCSA, to curb the spread of abusive digital images ([Barnahus Network, 2020](#)). Moreover, preventive procedures to educate children and especially preadolescents about risks and dangers appear to be helpful in curbing OCSA ([Patterson et al., 2022](#)). It may be beneficial for them to understand the manipulations that offenders engage in and to know that adults who are concerned about their well-being would not suggest sexual relationships or involve them in risky encounters and sending and receiving sexual material ([Wolak et al., 2004](#)). While some professionals also expressed concerns about having a different understanding of the wide range of technologies compared to children and adolescents, this could be a barrier in recognizing OCSA and intervening accordingly ([Quayle et al., 2023](#)). A comprehensive, multiprofessional training concept on OCSA should therefore be implemented for professionals as part of prevention ([Hamilton-Giachritsis et al., 2021](#)).

CRediT authorship contribution statement

Rebecca Menhart: Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kerstin Stellermann-Strehlow:** Writing – review & editing, Validation, Data curation. **Astrid Helling-Bakki:** Writing – review & editing, Validation, Data curation. **Rita Horvay:** Writing – review & editing, Investigation. **Nele Dippel:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Conceptualization. **Sibylle Maria Winter:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.chabu.2025.107540>.

Data availability

Data will be made available on request.

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