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are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms. Preoperative anxiety management in pediatric patients: a systemic review and meta-analysis of randomized controlled trials on the efficacy of distraction techniques

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**Background:** This study addresses the pervasive issue of heightened preoperative anxiety in healthcare, particularly among pediatric patients. Recognizing the various sources of anxiety, we explored both pharmacological and nonpharmacological interventions. Focusing on distraction techniques, including active and passive forms, our meta-analysis aimed to provide comprehensive insights into their impact on preoperative anxiety in pediatric patients.

**Methods:** Following the PRISMA and Cochrane guidelines, this meta-analysis and systematic review assessed the efficacy of pharmaceutical and distraction interventions in reducing pain and anxiety in pediatric surgery. This study was registered on PROSPERO (CRD42023449979).

**Results:** This meta-analysis, comprising 45 studies, investigated pharmaceutical interventions and distraction tactics in pediatric surgery. Risk of bias assessment revealed undisclosed risks in performance and detection bias. Distraction interventions significantly reduced preoperative anxiety compared to control groups, with notable heterogeneity. Comparison with Midazolam favored distraction techniques. Subgroup analysis highlighted varied efficacies among distraction methods, with a notable reduction in anxiety levels. Sensitivity analysis indicated stable results. However, publication bias was observed, suggesting a potential reporting bias.

**Conclusion:** Our study confirms distraction techniques as safe and effective for reducing pediatric preoperative anxiety, offering a valuable alternative to pharmacological interventions.

**Systematic Review Registration:** https://www.crd.york.ac.uk/prospero/display\_record.php?RecordID=449979, PROSPERO [CRD42023449979].

#### KEYWORDS

pediatric preoperative anxiety, distraction techniques, nonpharmacological interventions, pediatric surgery, systemic review and meta-analysis

# Background

Numerous healthcare professionals and patients share concerns regarding the heightened anxiety that individuals often endure while gearing up for various medical procedures. This pervasive issue not only poses a threat to patients' mental and physical well-being, but also correlates with undesirable outcomes, such as an increased requirement for anesthesia, elevated risks of surgical complications, and suboptimal rehabilitation (1).

Individuals undergoing surgical procedures often experience heightened anxiety stemming from myriad factors. This emotional distress may arise from fear of mortality, apprehensions about regaining consciousness after anesthesia, uncertainty surrounding the procedure, concerns about potential pain, loss of control over the situation, feelings of isolation, and the emotional strain of being separated from loved ones. Notably, statistics indicate that 65%–80% of pediatric patients experience preoperative anxiety, underscoring the prevalence and significance of this issue in the healthcare landscape (2).

The manifestation of anxiety in pediatric patients undergoing medical procedures is diverse and can be observed through various behavioral and physiological indicators. In more severe cases, young children might unexpectedly urinate, display hypertonic behavior, or attempt to escape from medical staff (3).

Among the various stages in the preoperative period, the induction of anesthesia is notably distressing for pediatric patients, evident in both their behavioral and physiological responses. This pivotal moment introduces distinct challenges for anesthesiologists and surgeons, as the stress experienced by both patients and parents becomes palpable. Compounded by heightened anxiety, there is a noteworthy occurrence of lastminute refusals from pediatric patients, a manifestation of preoperative fear that adds a layer of complexity to the anesthesia and surgical processes (4). Therefore, acknowledging and effectively addressing preoperative anxiety in pediatric patients is important. The use of sedative drugs has emerged as a valuable strategy to mitigate anxiety before surgery, aiding in smoother separation from friends and family and reducing discomfort during the induction process (5). However, it is essential to recognize that some young patients may resist taking medications, and the efficacy of drugs is not guaranteed. In some cases, medications may not produce the intended calming effects, leading to unforeseen side effects, such as irritability and disinhibition (6).

Furthermore, additional drawbacks associated with the use of sedative drugs in pediatric patients include prescription costs, safety concerns (including the risk of airway blockage or respiratory depression in the absence of vigilant monitoring), increased demands on nursing personnel and additional supplies, and potential for delayed hospital discharge (7). Consequently, there is growing interest in the use of nonpharmacological treatments. Medical practitioners and parents often turn to distraction as a non-pharmacological technique to alleviate the pain and anxiety associated with medical procedures in pediatric patients (8). The reduction of pain, anguish, and anxiety is attributed to diverting the attention of juvenile patients towards pleasant stimuli, thereby impeding the processing of painful sensations. Distraction treatments come in various forms and are broadly categorized as active or passive. Passive forms involve activities such as watching a film or listening to music where the patient receives external stimuli. On the other hand, active distraction entails direct engagement, with young patients participating actively, often under the guidance of an adult. Activities such as painting, playing with toys, and using virtual reality fall into the realm of active distraction, providing diverse and interactive avenues for alleviating distress during medical procedures (6).

To comprehensively evaluate the impact of distraction on preoperative anxiety, specifically in pediatric patients, we conducted a meta-analysis incorporating studies with a larger sample size. Our objective was to provide a robust foundation for therapeutic practices by scrutinizing the effects of both active and passive modes of distraction on preoperative anxiety in this demographic. This nuanced analysis aims to provide valuable insights for tailoring interventions that address the unique needs of pediatric patients undergoing medical procedures.

# Method

### Protocol

Using data from a prior registration on PROSPERO (CRD42023449979), we performed a thorough meta-analysis and systematic review to evaluate the efficacy of pharmaceutical interventions and distraction tactics in lowering pain and anxiety in children undergoing surgery. The PRISMA and Cochrane Handbook of Systematic Review and Intervention guidelines were followed in our investigation.

## Search strategy

We searched electronic databases such as PubMed, MEDLINE, Embase, and Scopus for relevant literature. Using pertinent keywords like "Child," "Pediatric," "preschool," "preoperative management," "anxiety," and "anxiety management," our search returned publications up until June 2023. Supplementary File 1 contains a separate version of the full-mesh phrase. The language used for the data search was only English.

## Eligibility criteria

We included research that satisfied certain requirements: individuals under the age of 18 who had any kind of surgery, whether minor or major, any method of distraction utilized during a minor or large medical treatment, such as virtual reality, video games, psychological preparation, entertainment videos, books, music, clown intervention, guided tour, and smartphone and tablet, and a control group receiving any pharmacological anxiolytic medication during the surgical procedure. Preoperative anxiety and anxiety levels across various distraction tactics and a pharmacological control group were assessed as primary and secondary outcomes. Cohort studies and randomized controlled trials (RCTs) were the only types considered. Studies in non-English languages, those involving non-human subjects, those involving adults older than 18, studies without the desired results, and study types other than randomized controlled trials (RCTs) or cohorts (e.g., casecontrol, case series, editorials, single-arm studies) were among the studies that we excluded.

### Study screening and data extraction

Two reviewers independently reviewed the articles. After articles that met the inclusion criteria were first included, they were later excluded based on the full-text review, title, and abstract. A third reviewer arbitrated any disputes or disagreements by reaching consensus. Details about the authors, year of publication, baseline characteristics (population age, follow-up, sample size), type of distraction technique used in the intervention, duration, type of pharmacological anxiolytics used in the control group, and outcome data (preoperative anxiety and anxiety level) were all taken from pertinent studies.

#### Data analysis and risk of bias

We used the Cochrane Collaboration's RevMan version 5.4 and Comprehensive Meta-Analysis version 3.3 to analyze the data. Risk ratios (RR) with a 95% confidence interval were utilized, along with random effect model. This model for preoperative anxiety and anxiety level was used to construct funnel plots for the primary and secondary outcomes. The heterogeneity between the included studies was evaluated using the I<sub>2</sub> statistic.  $I_2$  over 50% was considered significant heterogeneity, and the sensitivity analysis was interpreted considering the study's characteristics. Using the Cochrane methodology for the risk of bias, the risk of bias in the included RCTs was evaluated. Studies pertaining to selection, reporting, other, and performance biases were categorized as low, high, or unknown risk. Preoperative anxiety and anxiety level outcomes of eligible studies were analyzed using a funnel plot for publication bias.

### Results

#### Study selection and characteristics

Depicted is the schematic representation of our search and selection process, encompassing data until July 2023. The initial pool of 850 studies underwent rigorous curation, resulting in 504 unique records after duplicates were removed. Subsequent scrutiny of titles and abstracts led to the exclusion of 372 irrelevant studies, followed by a thorough assessment of the full text of 132 articles. Of these, 87 were excluded for specific reasons. This meticulous process culminated in the final selection of 45 studies that met the eligibility criteria. The PRISMA Flowchart presented in Figure 1 lists the studies that met our inclusion requirements. The baseline characteristics of the patients are shown in Table 1.

### Risk of bias

While conducting a comprehensive review, it was noted that a significant proportion of the studies included in our analysis had undisclosed risks of performance and detection bias as these critical factors were not explicitly addressed in the text. However, the level of selection bias was generally low to moderate in these studies. Notably, randomized trials displayed variability in reporting randomization procedures, with the majority lacking participant masking to the interventions, as anticipated in the experimental design.

Despite these observations, overall management of other potential latent biases was effective, leading to a relatively consistent risk of bias across trials. Supplementary Figure S1 offers a detailed overview of each trial's potential biases, providing valuable insights into the study landscape.

### The outcomes between the distraction intervention group and the control group at the entrance of the operation room

The combined results from the studies suggest a noteworthy reduction in anxiety levels by 10.93 in the distraction group compared to the control group (with a mean difference of -10.93 and a 95% confidence interval of -13.37 to -8.50), as shown in Figure 2. However, the *Q*-test and *I*<sub>2</sub> statistics revealed substantial heterogeneity among the included studies (*P* < 0.00001, *I*<sub>2</sub> = 95%).

#### Comparison with midazolam

In the context of preoperative anxiety control, Figure 3 highlights a limited number of studies that have compared the utilization of midazolam and distraction techniques. The collective analysis of these studies demonstrated that distraction techniques offer greater efficacy in managing pre-operative anxiety, as indicated by a risk ratio (RR) of -6.03 within a 95% confidence interval (CI) ranging from -9.93 to -2.14 (*P*-value <0.002). Notably, a substantial degree of heterogeneity was observed with an I2 value of 83%.

#### Subgroup analyses

Analysis of the data presented in the table, which examines the effectiveness of both active and passive distraction methods, reveals



significant differences in anxiety reduction between the distraction and control groups. These results underscore the superior efficacy of distraction interventions in lowering anxiety levels compared to the control group. Notably, the most substantial anxiety reduction was observed in the "Entertainment Videos" subgroup (MD = -23.66, 95% CI: -40.72 to -6.59) (P < 0.007), demonstrating a statistically significant difference. Similarly, the "Virtual Reality" (MD = -12.79, 95% CI: -17.60 to -7.99) (P < 0.0001) and "Psychological Preparation" (MD = -11.36, 95% CI: -16.33 to -6.39) (P < 0.0001) subgroups exhibited significant reductions. On the other hand, the "Videogames" subgroup (MD = -7.80, 95% CI: -20.77 to 5.16) (P = 0.24) did not show a statistically significant difference in anxiety reduction. Similarly, the "Books" (MD = -1.74, 95% CI: -3.91 to 0.43) (P = 0.12) and "Clown Intervention" (MD = -13.04, 95% CI: -27.85 to 1.76) (P = 0.08) subgroups were also non-significant. In contrast, the "Music" subgroup (MD = -6.52, 95% CI: -10.19 to -2.85) (P = 0.0005), "Guided Tour" (MD = -19.67, 95% CI: -35.53 to -3.81) (P = 0.02), and "Smartphone and Tablet" (MD = -9.23, 95% CI: -14.33 to -4.14) (P = 0.0004) exhibited statistically significant anxiety reduction. The overall effect size across all subgroups was also noteworthy (MD = -11.89, 95% CI: -14.81 to -8.98) (P < 0.0001). However, itItit is important to note that even within these subgroups, substantial heterogeneity persisted. Figure 4.

### Sensitivity analysis

To assess the robustness of the results obtained in this metaanalysis, a sensitivity analysis was conducted using leave-one-out

study	במו				ווורבו אבו		Control group	Mean age 1/C	sex male/	
			setting		Holding area	Induction room			temale	
William Li et al. (9)	2007	Honkong	Outpatient	Therapeutic play	NA	NA	Routine care	7-12	0/63	C-SAS
Yu et al. (10)	2009	China	inpatient	Music	NA	NA	Routine care	8.26 ± 2.83/7.87 ± 3.35	36	m-YPAS score
Golan et al. (11)	2009	Occupied	Inpatient	Clown Intervention	YES	YES	Routine care	4.5	NA	m-YPAS
Kim et al. (12)	2010	Korea	inpatient	Maternal recorded voice	YES	NA	Routine care	8 ± 42/82 ± 42	1510/13	m-YPAS
Vangoli et al. (13)	2010	Italy	Inpatient	Clown	YES	YES	Routine care	6.85/7.3	T70/30 C75/ 25	m-YPAS
Huet et al. (14)	2011	France	Outpatient	Hypnosis	NA	NA	Routine care	8 (5-12)/9 (5-12)	15/15	m-YPAS
Cuzzocoria et al. (15)	2013	Italy	Inpatient	Psychological preparation activities	YES	YES	Routine care	NA	42/8	m-YPAS
Tunney et al. (16)	2013	Northern Ireland	Outpatient	Story book	NA	NA	Routine care	7.7	0/44 (55%F)	HFRS
Lim et al. ( <b>17</b> )	2013	Singapore	NA	Head Play	YES	YES	Routine care	9.4/8.77	T27/3 C24/6	m-YPAS
Karimi et al. (18)	2014	Iran	Inpatient	Orientated tour of Operation Room	NA	YES	Routine care	NA	25/45	m-YPAS
Heilbrunn et al. (19)	2014	USA	Inpatient	Hospital Clown	YES	YES	Routine care	7.70/7.48	36/36	m-YPAS
Gao et al. ( <mark>20</mark> )	2014	China	Inpatient	Game	YES	YES	Routine care	4.52/4.37	T20/9 C23/7	m-YPAS
He et al. (21)	2015	China	NA	Therapeutic play	NA	NA	Routine care	16/15.66	61/34	SAS-C scores
Batuman et al. (22)	2016	Turkey	Outpatient	Preoperative information video	NA	YES	Routine care	NA	NA	m-YPAS
Bumin Aydin et al. (23)	2016	Turkey	Inpatient	Play Dough	YES	NA	Routine care	5 (3-7)	51/53	m-YPAS
Fortier et al. (24)	2016	USA	Outpatient	Web-Based Tailored Intervention	YES	YES	Routine care	$4.3 \pm 1.8/c4.4 \pm 1.7$	46	m-YPAS score
Cumino et al. (25)	2017	Brazil	Inpatient	Smartphone and information leaflet	YES	YES	Routine care	5.29/5.65	59/25	m-YPAS
Hatipoglu et al. ( <b>2</b> 6)	2018	Turkey	Outpatient	Video	NA	YES	Routine care	7.6/7.6	33/33	m-YPAS
Ryu et al. (27)	2018	Korea	Outpatient	Virtual reality tour of the operating theatre	YES	YES	Routine care	6 (5–8)	50/30	m-YPAS
Wantanakorn et al. (28)	2018	Thailand	Outpatient	Mobile Application	NA	NA	Routine care	9.22 6 3.43/9.57 6 3.06	35/25	m-YPAS
Liu et al. (29)	2018	China	Inpatient	Children's ride-on car	YES	YES	Midazolam/Routine care	3.6/3.4	T19/15 C17/ 17	m-YPAS
Meletti et al. (30)	2019	Ireland	Outpatient	Psychological preparation	NA	YES	Basic preparation, 33% O2 and 66% N2O	NA	87/13	modified Yale Preoperative Anxiety Scale (m-YPAS)
Vangoli et al. (31)	2019	Italy	Inpatient	Relaxation-guided imagery	NA	YES	Basic prep	8.3+-1.4	32/28	m-YPAS, FLACC
Churasia et al. (32)	2019	India	NA		NA	YES	Routine care	5.3/5.2	T34/6 C31/9	m-YPAS
Park et al. (33)	2019	Korea	Inpatient	Virtual reality tour of the operating theatre	YES	YES	Routine care	85 (69-101),81 (64- 105)	47/33	m-YPAS
Stewart et al. (8)	2019	USA	Inpatient	Tablet-based interactive distraction	YES	YES	Midazolam	6.8 (2.4) y (4–12 y);6.9 (2.5) y (4–12 y)	59/43	m-YPAS

Frontiers in Pediatrics

HuldHoldingInductionMusic TherapyEdeaVeloNaMusic TherapyYESYESNaMagon transportationYESNomal stretcherMagon transportationYESNaReading booket prepared byNANomal stretcherVirtual RealityYESYESNAVirtual RealityNANAVirtual RealityNANAVirtual RealityNANAVirtual RealityNANAVirtual RealityNANAVirtual RealityNANASelf-produced audio-visualYESRoutine careIntoVideo GameYESNASelf-produced audio-visualYESRoutine careMusicNANARoutine careMusicNANASelf-produced audio-visualYESSelf-produced audio-visualNAMusicNASelf-produced audio-visualNASelf-produced audio-visualNAMusicNASelf-produced audio-visualNASelf-produced audio-visualNASelf-produced audio-visualNAMusicYESSelf-produced audio-visualNASelf-produced audio-visualNAMusicNASelf-produced audio-visualNASelf-produced audio-visualNASelf-produced audio-visualNASelf-produced audio-visualNASelf-produced audio-visualNA <th>Study</th> <th>Year</th> <th>Year Country</th> <th>Intervention</th> <th>Method of intervention</th> <th>Interven</th> <th>Intervention period</th> <th>Control group</th> <th>Mean age T/C</th> <th>Sex male/</th> <th>Outcome measures</th>	Study	Year	Year Country	Intervention	Method of intervention	Interven	Intervention period	Control group	Mean age T/C	Sex male/	Outcome measures
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102021MABooksMAEASBasic Frep2021ChinaInpatientSelf-produced audio-visualYESRoutine care2021ChinaInpatientMusicYESYESRoutine care2021ChinaInpatientMusicYESRoutine care2021ChinaInpatientSituational adaptation trainingNANARoutine care2021ChinaInpatientSituational adaptation trainingNANARoutine care2021TukeyInpatientSituational adaptation trainingNANARoutine care2022TukeyInpatientVirtual RealityYESYESRoutine care2022ChinaOupatientTable/ComputerYESYESRoutine care2023ChinaOupatientVirtual RealityYESYESRoutine care2023ChinaOupatientVirtual RealityYESYESRoutine care2023ChinaOupatientVirtual RealityYESYESRoutine care2023ChinaOupatientVirtual RealityYESRoutine care2023FanceInpatientVirtual RealityYESRoutine care2023ChinaOupatientVITUALYESRoutine care2023FanceInpatientVirtual RealityYESRoutine care2023ChinaOupatientVirtual RealityYESRoutine care2023China				Outpatient	Video Game			Midazolam			m-YPAS
2021ChinaInpatientSelf-produced audio-visualYESYESRoutine care2021ChinaInpatientMusicYESYESRoutine care2021ChinaInpatientStruational adaptation trainingNANARoutine care2021ChinaInpatientStruational adaptation trainingNANARoutine care2021ChinaInpatientStruational adaptation trainingNANARoutine care2021TurkeyInpatientVirtual RealityYESYESBasic prep2022ChinaInpatientVirtual RealityYESYESRoutine care2022ChinaOupatientVirtual RealityYESNABasic prep2023ChinaOupatientVirtual RealityYESNABasic prep2023ChinaOutpatientVirtual RealityNANASoutine care2023FranceInpatientVirtual RealityNANASoutine care2023FranceOutpatientVirtual RealityNANASoutine care2023FranceInpatientVirtual RealityNANASoutine care2023FranceOutpatientVirtual RealityNANASoutine care2023FranceInpatientVirtual RealityNANASoutine care2023FranceInpatientVirtual RealityNANASoutine care2023FranceInp	Cordray et al. (40)	2021		NA	Books	NA	YES	Basic Prep	7.64 + -2.2	82/62	m-YPAS
2021ChinaInpatientMusicYESYESRoutine care2021ChinaInpatientSituational adaptation trainingNANARoutine care2021UnkeyInpatientStory bookYESRoutine care2022TurkeyInpatientVirtual RealityYESRoutine care2022UnkeyInpatientVirtual RealityYESRoutine care2022UnkeyInpatientTablet/ComputerYESRoutine care2023UsiaOutpatientAnimated picture bookYESRoutine care2023ChinaOutpatientVirtual RealityYESRoutine care2023ChinaOutpatientVirtual RealityNARasic prep2023USAOutpatientVirtual RealityNARoutine care2023USAOutpatientVirtual RealityNARoutine care2023USAOutpatientVirtual RealityNARoutine care2023USAOutpatientVirtual RealityNARoutine care2023USAOutpatientVirtual RealityNARoutine care2023USAOutpatientMANARoutine care2023USAOutpatientNANARoutine care2023USAOutpatientNANANAMidazolan2023USAOutpatientMaNANANANA2023USAInpatientHinter car	Jin et al. (41)	2021	China	Inpatient	Self-produced audio-visual animation	YES	YES	Routine care		53/47	m-YPAS
2021ChinaInpatientSituational adaptation training combined with childlike nursingNANARoutine careal.2021TurkeyInpatientStory bookYESRoutine care2022TurkeyInpatientVirtual RealityYESYESBasic prep2022TurkeyInpatientTablet/ComputerYESYESBasic prep2022TurkeyInpatientTablet/ComputerYESYESMidazolam2023ChinaOutpatientNitual RealityYESNABasic prep2023ChinaOutpatientVirtual RealityYESNABasic prep2023ChinaOutpatientVirtual RealityNABasic prep2023ChinaOutpatientNANABasic prep2023ChinaOutpatientNANANANA2023USAOutpatientNANANANA2023USAOutpatientNaNANANa2023USAOutpatientNANANANA2023USAOutpatientNANANANA2023USAOutpatientNANANANA2023USAOutpatientNANANANA2023USAOutpatientNANANANA2023USAInpatientNANANANA2023USAInpatientNA <td< td=""><td>Huang et al. (42)</td><td>2021</td><td>China</td><td>Inpatient</td><td>Music</td><td>YES</td><td>YES</td><td>Routine care</td><td>7.53/6.3</td><td>50/38</td><td>m-YPAS</td></td<>	Huang et al. (42)	2021	China	Inpatient	Music	YES	YES	Routine care	7.53/6.3	50/38	m-YPAS
al.2021TurkeyInpatientStory bookYESRedutine care2022TurkeyInpatientVirtual RealityYESYESBasic prep2022TurkeyInpatientTablet/ComputerYESYESBasic prep2022TurkeyOutpatientTablet/ComputerYESYESMidazolam2023ChinaOutpatientNitual tour of operating tourYESNABasic prep2023ChinaOutpatientVirtual RealtyNABasic prepNABasic prep2023USAOutpatientVirtual RealtyNANANANANA2023USAOutpatientActive distraction (tablet)NANANANA2023USAOutpatientEctric Toy CarYESRoutine care2023USAOutpatientBectric Toy CarYESRoutine care2023USAOutpatientBectric Toy CarYESYESRoutine care2023ChinaInpatientMatedNANANANA2023ChinaOutpatientBectric Toy CarYESYESRoutine care2023ChinaInpatientMatedNANANANA2023ChinaOutpatientNANANANA2023FranceInpatientInpatientYESRoutine care2023ChinaInpatientMatedNANANA2023 <td< td=""><td>Li et al. (<b>43</b>)</td><td>2021</td><td>China</td><td>Inpatient</td><td>Situational adaptation training combined with childlike nursing</td><td>NA</td><td>NA</td><td>Routine care</td><td>8±6</td><td>NA</td><td>VAS score</td></td<>	Li et al. ( <b>43</b> )	2021	China	Inpatient	Situational adaptation training combined with childlike nursing	NA	NA	Routine care	8±6	NA	VAS score
2022ImpatientVirtual RealityYESBasic prepNeasic Prep2022TurkeyImpatientTablet/ComputerYESYESMidazolam2022ChinaOutpatientAnimated picture bookYESYESRoutine care2023ChinaOutpatientVirtual tour of operating tourYESNABasic prep2023ChinaOutpatientVirtual RealityNABasic prepNa2023USAOutpatientActive distraction (tablet)NANABasic prep2023USAOutpatientActive distraction (tablet)NANAMidazolam2023USAOutpatientActive distraction (tablet)NANAMidazolam2023USAInpatientElectric Toy CarYESRoutine careNa2023USAInpatientMidazolamNANANANa2023USAInpatientElectric Toy CarYESYESRoutine care2023InneInpatientMusicYESNANidazolam2023Virtual RealityNANANANANa2023USAInpatientElectric Toy CarYESNANa2023InneInpatientMusicYESNANa2023Virtual RealityNANANANa2023InneInpatientElectric Toy CarYESNa2023InneInpatientMusic </td <td>Bumin Aydin et al. (44)</td> <td>2021</td> <td>Turkey</td> <td>Inpatient</td> <td>Story book</td> <td>YES</td> <td>YES</td> <td>Routine care</td> <td>c 6.39 ± 0.6 6.53 exp ± 0.8</td> <td>53/49</td> <td>m-YPAS</td>	Bumin Aydin et al. (44)	2021	Turkey	Inpatient	Story book	YES	YES	Routine care	c 6.39 ± 0.6 6.53 exp ± 0.8	53/49	m-YPAS
2022TurkeyInpatientTablet/ComputerYESYESMidazolamIndiazolam2022ChinaOutpatientAnimated picture bookYESYESRoutine careIndiazolam2023ChinaOutpatientVirtual tour of operating tourYESNABasic prepIndiazolam2023USAOutpatientVirtual RealtyNAPSRoutine careIndiazolam2023USAOutpatientActive distraction (tablet)NANAMidazolamIndiazolam2023FranceInpatientEctric Toy CarYESRoutine careIndiazolam2023ChinaOutpatientEctric Toy CarYESRoutine careIndiazolam2023FranceInpatientElectric Toy CarYESRoutine careIndiazolam2023ChinaInpatientMusicYESYESRoutine careIndiazolam	Wu et al. (45)	2022		Inpatient	Virtual Reality	YES	YES	Basic prep	NA	86/13	m-YPAS
2022ChinaOutpatientAnimated picture bookYESRoutine careNet8)2023InpatientVirtual tour of operating tourYESNABasic prepNA2023ChinaOutpatientVirtual RealtyNAYESRoutine careNA2023USAOutpatientActive distraction (tablet)NAYESRoutine careNA2023FranceInpatientElectric Toy CarYESRoutine careNA2023FranceInpatientElectric Toy CarYESRoutine careNA2023ChinaInpatientElectric Toy CarYESRoutine careNA2023ChinaInpatientElectric Toy CarYESRoutine careNA	Sahin et al. (46)	2022	Turkey	Inpatient	Tablet/Computer	YES	YES	Midazolam	NA		m-YPAS
8)     2023     Inpatient     Virtual tour of operating tour     YES     NA     Basic prep       2023     China     Outpatient     Virtual Realty     NA     Pasic prep     Index       2023     USA     Outpatient     Virtual Realty     NA     YES     Routine care       2023     USA     Outpatient     Active distraction (tablet)     NA     NA     Midazolam       2023     France     Inpatient     Electric Toy Car     YES     Routine care       2023     France     Inpatient     Electric Toy Car     YES     Routine care       2023     China     Inpatient     Blectric Toy Car     YES     Routine care	Yang et al. (47)	2022	China	Outpatient	Animated picture book	YES	YES	Routine care	4.7/4.4	43/73	m-YPAS
2023ChinaOutpatientVirtual RealtyNAYESRoutine care2023USAOutpatientActive distraction (tablet)NANAMidazolam2023FranceInpatientElectric Toy CarYESRoutine care2023ChinaInpatientElectric Toy CarYESRoutine care2023ChinaInpatientMusicYESRoutine care	Castany et al. (48)	2023		Inpatient	Virtual tour of operating tour	YES	NA	Basic prep	NA	95/30	m-YPAS
2023USAOutpatientActive distraction (tablet)NANAMidazolam2023FranceInpatientElectric Toy CarYESRoutine care2023ChinaInpatientMusicYESRoutine care2023ChinaInpatientMusicYESRoutine care	Luo et al. (49)	2023	China	Outpatient	Virtual Realty	NA	YES	Routine care			m-YPAS
2023FranceInpatientElectric Toy CarYESRoutine care2023ChinaInpatientMusicYESRoutine care	Levay et al. (50)	2023	USA	Outpatient	Active distraction (tablet)	NA	NA	Midazolam	3–5 years	60/39	m-YPAS
2023 China Inpatient Music YES YES Routine care	Chambon et al. (51)	2023	France	Inpatient	Electric Toy Car	YES	YES	Routine care	4.7/6.3	24	mYPAS-SF
	Wang et al. (52)	2023	China	Inpatient	Music	YES	YES	Routine care	7.63/6.97	86	m-YPAS
Cartoon/Animation YES YES Routine care				Inpatient	Cartoon/Animation	YES	YES	Routine care	7.63/7.23	89	m-YPAS

06

NA, not available; T, test group; C, control group; CJ, contractue interva, interva, intervation with renal syndrome. FLACC, Face, Legs, Activity, Cry and Consolability; C-SAS, Chemotherapy Symptom Assessment Scale; HFRS, Hemorrhagic fever with renal syndrome.

Frontiers in Pediatrics

TABLE 1 Continued

		erventio			ontrol			Mean Difference		Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% Cl	Year	IV, Random, 95% Cl
/Villiam Li 2007	34.36	8.09	97	38.6	8.53	106	2.6%	-4.24 [-6.53, -1.95]	2007	-
ru 2009	28.23	3.36	30	34.24	6.96	30	2.5%	-6.01 [-8.78, -3.24]	2009	~
Golan 2009	37.3	12.3	21	50	17.4	22	1.9%	-12.70 [-21.67, -3.73]	2009	
<im 2010<="" td=""><td>28</td><td>9</td><td>23</td><td>35</td><td>12</td><td>23</td><td>2.3%</td><td>-7.00 [-13.13, -0.87]</td><td>2010</td><td></td></im>	28	9	23	35	12	23	2.3%	-7.00 [-13.13, -0.87]	2010	
/angoli 2010	37.5	21.48	20	68.25	28.42	20	1.3%	-30.75 [-46.36, -15.14]	2010	
Huet 2011	34	24.4	15	50.33	57.03	15	0.5%	-16.33 [-47.72, 15.06]	2011	
<arimi 2012<="" td=""><td>59.83</td><td>18.12</td><td>35</td><td>78.14</td><td>12.9</td><td>20</td><td>2.0%</td><td>-18.31 [-26.56, -10.06]</td><td>2012</td><td></td></arimi>	59.83	18.12	35	78.14	12.9	20	2.0%	-18.31 [-26.56, -10.06]	2012	
Nang 2012	34.41			50.64	20.96	40	2.1%	-16.23 [-23.91, -8.55]	2012	
_im 2013	37.1	14.2	30	37.2	17.7	30	2.0%	-0.10 [-8.22, 8.02]	2013	
Funney 2013	25.13			28.95		40	2.3%	-3.82 [-9.75, 2.11]	2013	
Cuzzocoria 2013	33.88	11.7		49.68		25	1.9%	-15.80 [-24.93, -6.67]	2013	
Heilbrunn 2014	25.2	3.1	43	26.1	4.9	29	2.6%	-0.90 [-2.91, 1.11]		4
Gao 2014	51.32			58.89		30	2.2%	-7.57 [-13.89, -1.25]	2014	
He 2015	17.02	3.43	48	18.6	4.52	47	2.6%	-1.58 [-3.20, 0.04]	2015	_
Batuman 2016	27.8	7.8	20	78.9	12.9	20	2.2%	-51.10 [-57.71, -44.49]	2016	
Bumin Aydin 2016	30.66	14.07		33.33		52	2.2%	-2.67 [-7.80, 2.46]	2016	_
Fortier 2016	36.4	12.7	38	40.7	16.6	44	2.4%		2016	
Cumino 2017	25.6	4.88		51.13		21		-25.53 [-37.82, -13.24]	2010	
_iu 2018			34	39.6	10.8	34	2.3%			
	30.37	13.5						-9.23 [-15.04, -3.42]	2018	
Ryu 2018	37.1	19.77	41	47.76		39	1.9%	-10.66 [-19.89, -1.43]	2018	-
Nantanakorn 2018	55.37	12.86		63.08		30	2.2%	-7.71 [-14.27, -1.15]		
Hatipoglu 2018	27.4	7.1	33	73.1	18	33	2.2%	-45.70 [-52.30, -39.10]	2018	
Meletti 2019	27.8	7.4	50	34.2	16.6	50	2.4%	-6.40 [-11.44, -1.36]	2019	
Park 2019	28.3	9.92	40		15.48	40	2.3%	-10.00 [-15.70, -4.30]		
Stewart 2019	25.7	8.7	51	29.3	12.2	51	2.5%	-3.60 [-7.71, 0.51]		
/angoli 2019	39.6	4.5	30	83.7	16.2	30		-44.10 [-50.12, -38.08]		
Churassia 2019	32.4	6.5	40	52.6	11.4	40		-20.20 [-24.27, -16.13]	2019	
<hulman 2020<="" td=""><td>14.9</td><td>3.2</td><td>61</td><td>14.4</td><td>2.9</td><td>58</td><td>2.6%</td><td>0.50 [-0.60, 1.60]</td><td>2020</td><td>f</td></hulman>	14.9	3.2	61	14.4	2.9	58	2.6%	0.50 [-0.60, 1.60]	2020	f
Park 2020	44.5	16.1	37	54.5	25	39	1.9%	-10.00 [-19.41, -0.59]	2020	
Beyedhejazi 2020	37	5.41	24	36.7	6.03	24	2.5%	0.30 [-2.94, 3.54]	2020	+
Huang 2021	34.57	9.63	44	45.32	12.37	44	2.4%	-10.75 [-15.38, -6.12]	2021	
Jin 2021	38.2	10.45	50	45.3	9.75	50	2.5%	-7.10 [-11.06, -3.14]	2021	~
Jung 2021	28.31	7.4	33	45.1	17.1	37	2.3%	-16.79 [-22.85, -10.73]	2021	
_i 2021	47.65	3.17	80	60.67	5.96	80	2.6%	-13.02 [-14.50, -11.54]	2021	-
Jyar 2021	35	3.03	43	38.6	3.74	46	2.6%	-3.60 [-5.01, -2.19]	2021	-
Bumin Aydin 2021	27.16	5.5	51	29.67	5.8	51	2.6%	-2.51 [-4.70, -0.32]	2021	-
Cordray 2021	36.8	7.3	72	36.2	7.4	72	2.6%	0.60 [-1.80, 3.00]	2021	+
Sahin 2022	30.5	11.1	93	45.9	23.7	100	2.4%	-15.40 [-20.56, -10.24]	2022	
Nu 2022	28.5	7.7	51	42.7	16.2	48	2.4%	-14.20 [-19.25, -9.15]		
rang 2022	27.8	7.6	58	33.2	13.6	58	2.5%	-5.40 [-9.41, -1.39]	2022	
_evay 2023	30.16	15		38.66	32.3	47	1.8%	-8.50 [-18.59, 1.59]		
_uo 2023	25.7	4.7	34	35	3.8	36	2.6%	-9.30 [-11.31, -7.29]		-
Nang 2023	45.6	11	61	48.9	12.4	60	2.4%	-3.30 [-7.48, 0.88]		
Castany 2023	24.27	9.22	61	32.57		64	2.5%	-8.30 [-12.07, -4.53]		-
Chambon 2023		29.26	22		24.66	22	1.2%	-18.70 [-34.69, -2.71]		
Fotal (95% CI)			1912			1807	100.0%	-10.93 [-13.37, -8.50]		•
Heterogeneity: Tau <sup>2</sup> =	- 69 61· (	ni≊– o¢		HF- AAA				- 10:00 [- 10:01, -0:00]		· · · · · · · · · · · · · · · · · · ·
	- UO.UT, U	200 E = 86	UJ.04,	ui = 44 (	ט.טנ	500 I J, I	- 90.20			-100 -50 Ó 50 100 <sup>°</sup>

#### FIGURE 2

Illustrates the influence of distraction interventions on preoperative anxiety in children undergoing surgery. The figure compares the outcomes between the Intervention group and the control group at the entrance of the Operation Room.

Churches and Church surgers		en	Tedal		CD	T-4-1	Interimeter	B/ Developer OFW CL	10	N/ Davidana OFW Cl
Study or Subgroup	Mean	SD	Total	Mean	SD	lotal	Weight	IV, Random, 95% Cl	rear	IV, Random, 95% Cl
Liu 2018	30.37	13.5	34	39.6	10.8	34	15.1%	-9.23 [-15.04, -3.42]	2018	
Stewart 2019	25.7	8.7	51	29.3	12.2	51	18.1%	-3.60 [-7.71, 0.51]	2019	-
Seyedhejazi 2020	37	5.41	24	36.7	6.03	24	19.6%	0.30 [-2.94, 3.54]	2020	+
Uyar 2021	35	3.03	43	38.6	3.74	46	22.0%	-3.60 [-5.01, -2.19]	2021	•
Sahin 2022	30.5	11.1	93	45.9	23.7	100	16.2%	-15.40 [-20.56, -10.24]	2022	+
Levay 2023	30.16	15	52	38.6	32.3	47	9.0%	-8.44 [-18.53, 1.65]	2023	
Fotal (95% CI)			297			302	100.0%	-6.03 [-9.93, -2.14]		◆
Heterogeneity: Tau <sup>2</sup> :	= 17.40; (	Chi² = 0	29.68, 1	df = 5 (P	< 0.0	001); P	= 83%			
Test for overall effect	: Z = 3.04	(P = 0	1.002)							-100 -50 0 50 100 Distraction Techniques Midazolam
URE 3										

Study or Subgroup 1.2.1 Virtual Reality	Interv Mean	/ention SD T	ſotal		ontrol SD	Total	Weight	Mean Differenc IV, Random, 95		Year	Mean Diffe IV, Random,	
Jung 2021 Wu 2022 Luo 2023 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect:				45.1 42.7 35 2 (P = 1	17.1 16.2 3.8 0.02); F	37 48 36 <b>121</b> = 74%	2.7% 2.8% 3.0% <b>8.5</b> %	-16.79 [-22.85, -1 -14.20 [-19.25, - -9.30 [-11.31, - - <b>12.79 [-17.60</b> , - <sup>2</sup>	9.15] 7.29]	2022		
<b>1.2.2 Psychological F</b> Cuzzocoria 2013 Meletti 2019 Li 2021 <b>Subtotal (95% CI)</b> Heterogeneity: Tau <sup>2</sup> = Test for overall effect:	33.8 27.8 47.65 12.76; Ch	11.7 7.4 3.17 ni² = 6.6:	50 80 155 2, df=	49.68 34.2 60.67 2 (P = 1	16.6 5.96	25 50 80 <b>155</b> = 70%	2.3% 2.8% 3.0% <b>8.2</b> %	-15.88 [-25.01, - -6.40 [-11.44, - -13.02 [-14.50, -1 - <b>11.36 [-16.33</b> , -	1.36] 1.54]	2019	 •	
1.2.3 Entertainment 1 Wang 2012 Hatipoglu 2018 Vang 2019 Jin 2021 Wang 2023 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect:	34.41 1 27.4 39.6 38.2 1 43.3 370.00; C	7.1 4.5 0.45 12 20	33 30 50 60 <b>213</b> 00.18,	50.64 73.1 83.7 45.3 48.9 df= 4 (l	18 16.2 9.75 12.4	40 33 30 50 60 <b>213</b> 0001); F	2.7% 2.9% 2.8% <b>13.6</b> %	-16.23 [-23.91, - -45.70 [-52.30, -3 -44.10 [-50.12, -3 -7.10 [-11.06, - -5.60 [-9.97, - -23.66 [-40.72, -	9.10] 8.08] 3.14] 1.23]	2018 2019		
1.2.4 Videogames Gao 2014 Wantanakom 2018 Churassia 2019 Uyar 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>®</sup> = Test for overall effect:		2.86 6.5 7.69 hi² = 10	30 40 45 144 03.65,	58.89 63.08 52.6 38.6 df = 3 (l	13.05 11.4 3.74	30 30 40 <b>46</b> <b>146</b> )001); F	3.0% <b>11.2</b> %	-7.57 [-13.89, - -7.71 [-14.27, - -20.20 [-24.27, -1 4.10 [1.61, - <b>7.80 [-20.77</b> , 5	1.15] 6.13] 6.59]	2018 2019	  •	
12.5 Books Tunney 2013 Seyedhejazi 2020 Bumin Aydin 2021 Cordray 2021 Yang 2022 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect:	27.16 36.8 27.8 3.25; Chi <sup>a</sup>	5.41 5.5 7.3 7.6 *= 9.16,	24 51 72 58 <b>245</b> , df = 4	28.95 36.7 29.67 36.2 33.2 (P = 0.	6.03 5.8 7.4 13.6	40 24 51 72 58 <b>245</b> 56%	2.7% 2.9% 3.0% 3.0% 2.9% <b>14.5</b> %	-3.82 [-9.75, 0.30 [-2.94, -2.51 [-4.70,- 0.60 [-1.80, -5.40 [-9.41,- - <b>1.74 [-3.91,</b> ]	3.54] 0.32] 3.00] 1.39]	2020 2021 2021	   •	
1.2.6 Music Yu 2009 Huang 2021 Wang 2023 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect:	28.23 34.57 45.6 6.70; Chi <sup>a</sup>	3.36 9.63 11 *= 5.57,	30 44 61 <b>135</b> , df = 2	34.24 45.32 48.9 ! (P = 0.	12.4	30 44 60 134 :64%	3.0% 2.8% 2.9% <b>8.7</b> %	-6.01 [-8.78, - -10.75 [-15.38, - -3.30 [-7.48, - <b>6.52 [-10.19,</b> -)	6.12] 0.88]			
1.2.7 Clown Intervent Golan 2009 Vangoli 2010 Heilbrunn 2014 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect:	37.3 37.5 2 25.2 146.37; C	21.48 3.1 hi² = 19	43 84 3.63, d	68.25 26.1	4.9	22 20 29 71 )1); I <sup>2</sup> =	3.0% <b>7.0</b> %	-12.70 [-21.67, - -30.75 [-46.36, -1 -0.90 [-2.91, - <b>13.04 [-27.85</b> ,	5.14] 1.11]			
1.2.8 Guided Tour Karimi 2012 Batuman 2016 Ryu 2018 Park 2019 Castany 2023 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect:	24.27 : 314.64; C	7.8 9.77 9.92 9.22 2hi <sup>2</sup> = 13	20 41 40 61 <b>197</b> 30.24,	78.14 78.9 47.76 38.3 32.57 df= 4 (l	12.9 22.2 15.48 12.14	35 20 39 40 64 <b>198</b> 0001); F	2.3% 2.7% 2.9% <b>13.0</b> %	-18.31 [-26.84, - -51.10 [-57.71, -4 -10.66 [-19.89, - -10.00 [-15.70, - -8.30 [-12.07, - - <b>19.67 [-35.53</b> , -	4.49] 1.43] 4.30] 4.53]	2016 2018 2019		
1.2.9 Smartphone an Curnino 2017 Wantanakorn 2018 Stewart 2019 Uyar 2021 Sahin 2022 Levay 2023 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect	25.6 55.37 1 25.7 35 30.5 30.16 29.34; Ch	8.7 3.03 11.1 15 ni <sup>2</sup> = 31.4	30 51 43 93 52 <b>299</b> 48, df	51.13 63.08 29.3 38.6 45.9 38.6 = 5 (P =	13.05 12.2 3.74 23.7 32.2	21 30 51 46 100 47 <b>295</b> 01); <b>I</b> <sup>2</sup> =	2.6% 2.9% 3.0% 2.8% 2.2% <b>15.5</b> %	-25.53 [-37.82, -1 -7.71 [-14.27, - -3.60 [-7.71, -3.60 [-5.01, - -15.40 [-20.56, -1 -8.44 [-18.51, - <b>9.23 [-14.33,</b> -	1.15] 0.51] 2.19] 0.24] 1.63]	2018 2019 2021 2022		
Total (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect: Test for subgroup diff	Z = 8.00 (	ni² = 842 P ≤ 0.00	0001)			)001); l		-11.89 [-14.81, -)	3.98]		-100 -50 0 Intervention C	50 101 ontrol

FIGURE 4

Subgroup analysis of different distraction techniques. The figure compares the outcomes between the Intervention group and the control group at the entrance of the Operation Room.

William Li 2007   -     Yu 2009   -     Golan 2009   -     Kim 2010   -     Vangoli 2010   -     Huet 2011   -     Wang 2012   -     Karimi 2012   -     Lim 2013   -     Tunney 2013   -     Cuzzocoria 2013   -     Heilbrunn 2014   -	Point -0.894 -0.878 -0.884 -0.888 -0.876 -0.893 -0.883 -0.883	Standard error 0.110 0.107 0.107 0.107 0.107	Variance 0.012 0.012 0.012	Lower limit -1.109 -1.089	Upper limit	Z-Value	n Value	
Yu 2009 - Golan 2009 - Kim 2010 - Vangoli 2010 - Huet 2011 - Wang 2012 - Karimi 2012 - Lim 2013 - Tunney 2013 - Cuzzocoria 2013 - Heilbrunn 2014 -	-0.878 -0.884 -0.888 -0.876 -0.893 -0.883	0.107 0.107 0.107	0.012		0.000		p-value	
Golan 2009     -       Kim 2010     -       Vangoli 2010     -       Huet 2011     -       Wang 2012     -       Karimi 2012     -       Lim 2013     -       Cunney 2013     -       Cuzzocoria 2013     -       Heilbrunn 2014     -	-0.884 -0.888 -0.876 -0.893 -0.883	0.107 0.107		1 080	-0.680	-8.163	0.000	1 42- 1 1
Kim 2010   -     Vangoli 2010   -     Huet 2011   -     Wang 2012   -     Karimi 2012   -     Lim 2013   -     Funney 2013   -     Cuzzocoria 2013   -     Heilbrunn 2014   -	-0.888 -0.876 -0.893 -0.883	0.107	0.012	-1.003	-0.668	-8.182	0.000	<del> </del>
Vangoli 2010 - Huet 2011 - Wang 2012 - Karimi 2012 - Lim 2013 - Tunney 2013 - Cuzzocoria 2013 - Heilbrunn 2014 -	-0.876 -0.893 -0.883			-1.095	-0.674	-8.235	0.000	
Huet 2011     -       Wang 2012     -       Karimi 2012     -       Lim 2013     -       Tunney 2013     -       Cuzzocoria 2013     -       Heilbrunn 2014     -	-0.893 -0.883	0 107	0.012	-1.099	-0.678	-8.265	0.000	
Wang 2012 - Karimi 2012 - Lim 2013 - Funney 2013 - Cuzzocoria 2013 - Heilbrunn 2014 -	-0.883	0.107	0.011	-1.086	-0.666	-8.189	0.000	1 42- 1 1
Karimi 2012 - Lim 2013 - Funney 2013 - Cuzzocoria 2013 - Heilbrunn 2014 -		0.107	0.011	-1.103	-0.683	-8.343	0.000	
Lim 2013 - Tunney 2013 - Cuzzocoria 2013 - Heilbrunn 2014 -		0.108	0.012	-1.094	-0.671	-8.184	0.000	
Funney 2013 Cuzzocoria 2013 - Heilbrunn 2014 -	-0.878	0.107	0.011	-1.088	-0.668	-8.189	0.000	
Cuzzocoria 2013 Heilbrunn 2014	-0.903	0.107	0.011	-1.112	-0.693	-8.453	0.000	
Heilbrunn 2014	-0.898	0.108	0.012	-1.108	-0.687	-8.341	0.000	
	-0.882	0.107	0.012	-1.092	-0.671	-8.209	0.000	
Gao 2014	-0.898	0.107	0.012	-1.109	-0.688	-8.365	0.000	
	-0.890	0.108	0.012	-1.101	-0.679	-8.262	0.000	
	-0.895	0.108	0.012	-1.107	-0.684	-8.291	0.000	
	-0.826	0.101	0.010	-1.023	-0.628	-8.196	0.000	
	-0.900	0.108	0.012	-1.111	-0.689	-8.365	0.000	
	-0.897	0.108	0.012	-1.108	-0.686	-8.338	0.000	
	-0.872	0.107	0.011	-1.082	-0.663	-8.167	0.000	12-
	-0.887	0.108	0.012	-1.098	-0.675	-8.223	0.000	
	-0.893	0.108	0.012	-1.104	-0.681	-8.268	0.000	
	-0.890	0.108	0.012	-1.101	-0.679	-8.264	0.000	
10	-0.829	0.101	0.010	-1.027	-0.632	-8.244	0.000	
	-0.893	0.108	0.012	-1.105	-0.681	-8.253	0.000	
	-0.886	0.108	0.012	-1.098	-0.675	-8.208	0.000	
	-0.897	0.108	0.012	-1.108	-0.685	-8.306	0.000	
· · · · · · · · · · · · · · · · · · ·	-0.826	0.100	0.010	-1.022	-0.629	-8.238	0.000	
	-0.851	0.104	0.011	-1.055	-0.648	-8.194	0.000	
	-0.907	0.106	0.011	-1.114	-0.700	-8.590	0.000	
	-0.893	0.108	0.012	-1.105	-0.682	-8.281	0.000	
2. Second and the second s	-0.903	0.107	0.011	-1.112	-0.694	-8.470	0.000	
	-0.882	0.108	0.012	-1.093	-0.670	-8.172	0.000	
	-0.888	0.108	0.012	-1.101	-0.676	-8.201	0.000	
•	-0.875	0.107	0.011	-1.085	-0.665	-8.163	0.000	- 1남
	-0.827	0.096	0.009	-1.015	-0.639	-8.623	0.000	
	-0.879	0.108	0.012	-1.091	-0.668	-8.163	0.000	
	-0.894	0.108	0.012	-1.106	-0.682	-8.269	0.000	
	-0.906	0.106	0.011	-1.113	-0.698	-8.549	0.000	
	-0.886	0.109	0.012	-1.101	-0.672	-8.098	0.000	
	-0.878	0.108	0.012	-1.089	-0.667	-8.152	0.000	
· · · · · · · · · · · · · · · · · · ·	-0.894	0.108	0.012	-1.106	-0.681	-8.242	0.000	
100000000	-0.897	0.108	0.012	-1.108	-0.685	-8.307	0.000	
	-0.852	0.104	0.011	-1.056	-0.648	-8.176	0.000	
	-0.898	0.108	0.012	-1.110	-0.687	-8.320	0.000	
	-0.887	0.109		-1.100	-0.674	-8.165	0.000	
	-0.887	0.107	0.012		-0.677	-8.261	0.000	
07	-0.883	0.106	0.011	-1.090	-0.676	-8.361	0.000	
								-2.00 -1.00 0.00 1.00
								Intervention Control
Leave one out An								

method (Figure 5). The purpose was to ascertain whether the pooled effect size remained consistent or underwent significant changes. The outcomes of this analysis provided insights into the stability of the meta-analysis results and the potential influence of individual studies on the overall findings. Sensitivity analysis indicated that the removal of any single

study did not lead to substantial alterations in the pooled effect size. This observation implies that the conclusions drawn from the meta-analysis are relatively stable and that the overall results demonstrating a more favorable effect of distraction on preoperative anxiety compared to the control groups remain unchanged.

### Publication bias test

The funnel chart representation revealed a notable bias, with an aggregation of studies predominantly concentrated in the upper region of the triangular space. On visual assessment, the funnel plot revealed asymmetry and the begg test was significant (z = 3.77; P = 0.00008). Sensitivity analysis using the trim-and-fill method was performed with 11 imputed studies, which produced a symmetrical funnel plot. This pattern suggests the possibility of publication bias or outcome reporting bias, wherein studies exhibiting significant or favorable outcomes are more likely to be published or included in the analysis (Supplementary File 1).

## Discussion

Young children, from preschoolers to school-age, often struggle to grasp the need for and importance of surgery. This, along with being away from family in a new place with the fear of pain, creates various levels of stress and anxiety. While we relied solely on medicine for this purpose in the past, distraction techniques are increasingly being used to alleviate feelings of intense distress and fear in children undergoing surgical procedures (53). This study is an update on a previous meta-analysis performed by Wu et al. (54). Our analysis of 45 studies showed that the use of non-pharmacological distraction techniques serves as an effective means to alleviate distress and anxiety in pediatric patients preoperatively.

A group of diverse and complex neuropathophysiological mechanisms underlies the development of anxiety and the natural response to fear (55). Studies have demonstrated that preoperative anxiety is associated with increased anesthesia and analgesic requirements, adverse postoperative outcomes, and delayed recovery (1). Distraction and nonpharmacological techniques can directly or indirectly interfere with these underlying mechanisms and provide a simple and readily available method for reducing anxiety. Furthermore, a systematic review corroborated that nonpharmacological interventions can effectively reduce stress and anxiety levels in children, which was confirmed by the measurement of salivary cortisol levels (56).

The non-pharmacological distraction techniques explored in our study was Virtual reality, Psychological Preparation, Entertainment Videos, Videogames, Books, Music, Clown Intervention, Guided Tour, and Smartphone and Tablet.

Video distraction was a prevalent distraction tool applied across numerous studies that included cartoons (52, 57), relaxation-guided imagery (13), and self-produced audiovisual presentations (41). They were found to be effective tools for diverting children's attention to painful stimuli and curbing preoperative anxiety. Studies have shown that cartoons and audiovisual presentations are superior to traditional toy play (57) and only auditory interventions (26). Virtual reality (VR) interventions have been demonstrated to be an effective distraction technique owing to a high degree of immersion due to its improved tracking, stereoscopy, and wide field of view that can make Virtual reality experiences feel realistic and effectively divert the patients' attention from adverse stimuli (58). In a related review, Tas et al. validated the effectiveness of Virtual reality techniques in reducing preoperative anxiety and pain in various medical procedures (59). Accordingly, the use of smartphones and tablet-based interactive interventions has enabled pediatric patients to be more comfortable and has alleviated feelings of distress and anxiety. Nonetheless, balancing the benefits of distraction with the potential negative effects of prolonged screen time is important. However, in our study, video games did not have a substantial effect on preoperative anxiety, which may be due to factors such as effectiveness depending on the child's age and individual preferences. Therefore, more robust ongoing research is required to provide more specific efficacy rates for these techniques, catering to narrower age groups, and modified based on specific case characteristics.

Furthermore, psychological preparation provides a potent nonpharmacological method for managing preoperative anxiety in pediatric patients. These methods improve children's emotional health, cooperation during surgery, and overall recovery experiences by providing them with knowledge, coping skills, and a sense of control. Children can be given the tools they need to manage their anxiety in a healthy way using techniques such as progressive muscle relaxation, deep breathing, and guided imagery. Coping skills such as visualization, distraction tactics, and positive self-talk can help them deal with stress better. In addition, age-appropriate explanations, tours of the operating room, and introductions to medical staff could also create a comfortable environment and occupy the preoperative time period in a more relaxed way. In an experimental study, Kain et al. used a preoperative preparatory program that included role-playing, a hospital tour, and perioperative information (60). The program was conducted over a period of one to seven days and was adjusted based on age. They discovered that patients aged 6 years and up experienced the least anxiety if the program started more than 5–7 days prior to surgery (P < 0.04), emphasizing the crucial nature of psychological preparation (61). Parental involvement in the planning process can also create a supportive atmosphere.

Among the included studies, many other distraction methods were applied, such as music, clown-based intervention, and books. Music intervention has been reported to significantly reduce preoperative anxiety, as in our study, offering a cost-effective and non-invasive approach for alleviating perioperative psychological pressure (62, 63). Listening to music decreases the sympathetic nervous activity and activates the parasympathetic nervous system. Its widespread availability makes it particularly suitable for clinical use, especially in operating rooms, effectively lowering anxiety levels in children before anesthesia induction, consistent with prior meta-analysis results (9).

According to a study, when compared to the control group, the music group's postoperative patient satisfaction increased while the postoperative State-Trait Anxiety Inventory form 1 (STAI-1) score decreased after listening to their favorite music prior to elective inguinal hernia surgery, signifying its importance in anxiety controlling (64). Furthermore, In light of the conflicting findings

in multiple studies about the impact of music therapy on blood pressure and heart rate, Agüero-Millan et al. propose that patients should select the music they listen to in order to enhance these physiological parameters, urging the need for more confounding studies to be conducted on this distraction technique (65).

Despite the statistical insignificance in our study, clown-based intervention has previously been shown to reduce preoperative anxiety in comparison to premedication (11). According to Vangoli (2010), clown interventions may create a more positive and memorable experience for children, potentially making future inductions less frightening than the amnesic effect of medication (13). However, it is important to consider the potential negative impacts that can occur in children with a fear of clowns (11). Despite statistical insignificance in our study, clown-based intervention has previously been shown to reduce preoperative anxiety in comparison to premedication (11). According to Vangoli (2010), clown interventions may create a more positive and memorable experience for children, potentially making future inductions less frightening compared to the amnesic effect of medication (13). However, it's important to consider the potential negative impact can occur in children with a fear of clowns (11). Factors that may have led to the insignificant correlation may be fear or discomfort, age appropriateness, cultural sensitivity, or a lack of understanding of such forms of entertainment.

In the context of utilizing books as a distraction technique, our meta-analysis did not reveal any statistical significance, but individual studies illuminate the promising benefits of employing diverse forms of books in pediatric preoperative settings. Notably, random factors, such as small sample sizes, methodological variances, and different individual preferences in terms of distraction, may have affected the results. This highlights the need for more in-depth trials to be conducted in the future, focusing on each non-pharmacological treatment for anxiety management in pediatric patients preoperatively and encompassing different age groups in the pediatric field.

In operative settings, midazolam is often used as an adjunct to reduce anxiety in pediatric patients, and our comparison demonstrated that distraction techniques are equally or more effective than midazolam. It is clinically significant, as midazolam is associated with prolonged onset of effects and adverse impacts such as agitation and restlessness. According to studies, the administration of midazolam is associated with an extended duration of hospitalization among patients (8, 66). Seiden et al. compared tablet-based interactive distraction to midazolam and found distraction to be superior in decreasing parental perception of anxiety (66).

#### Limitations

While our study provides valuable insights into various distraction techniques aimed at easing preoperative anxiety in pediatric settings, it is crucial to acknowledge certain limitations. The diverse range of distraction methods explored is beneficial, yet there is still room for future research to uncover additional interventions that are not covered in our analysis. Despite our efforts to provide the most up-to-date insights until July 2023, the limited availability of comprehensive studies in the existing database prevents us from drawing broad conclusions. The diverse nature of pediatric patients, including factors such as age, sex, parental anxiety, and experience with pain, could influence the effectiveness of distraction techniques. Unfortunately, due to limitations in the design of the included studies, we could not conduct detailed analyses considering these factors. Additionally, the high heterogeneity observed among the studies, despite our efforts to account for it, suggests variations in how the studies were conducted and in the characteristics of the participants. Finally, the possibility of publication bias raises some concerns. Our study, while making strides in understanding distraction interventions, may be influenced by a bias towards publishing studies with significant or favorable outcomes. Despite our attempts to address this bias, it is important to interpret the results cautiously and acknowledge the potential impact of selective reporting on our findings.

## Conclusion

In summary, our study established distraction techniques as safe, inexpensive, and efficient methods for alleviating preoperative anxiety in the pediatric population, approving it as an alternative to pharmacologic interventions. However, additional research is required to compare various active and passive techniques to enhance our understanding of the intricate mechanisms underlying these techniques and to provide insights into their potential applications in different clinical scenarios.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## Author contributions

MM: Writing – original draft, Writing – review & editing. MA: Writing – original draft, Writing – review & editing. SZ: Writing – original draft, Writing – review & editing. AQ: Writing – original draft, Writing – review & editing. BS: Writing – original draft, Writing – review & editing, Supervision. AA: Writing – original draft, Writing – review & editing. SZ: Writing – original draft, Writing – review & editing. HR: Writing – original draft, Writing – review & editing. MN: Writing – original draft, Writing – review & editing. MA: Writing – original draft, Writing – review & editing. MS: Writing – original draft, Writing – review & editing. MS: Writing – original draft, Writing – review & editing. MS: Writing – original draft, Writing – review & editing. AH: Writing – original draft, Writing – review & editing. AH: Writing – original draft, Writing – review & editing.

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# Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fped.2024. 1353508/full#supplementary-material

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