CATÓLICA
FACULDADE DE MEDICINA DENTÁRIA

VISEU

A REALIDADE VIRTUAL EM ODONTOPEDIATRIA, INDICAÇÕES E POTENCIAL TERAPÊUTICO - REVISÃO SISTEMÁTICA

Dissertação apresentada à Universidade Católica Portuguesa
para obtenção do grau de Mestre em Medicina Dentária

Por:
Diana Xavier de Barros Padilha

Viseu, 2023

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“Ten points to Gryffindor!"

Albus P. W. B. Dumbledor

DEDICATÓRIA

A minha família,
cujo apoio e incentivo incansáveis foram fundamentais para a concretização dos meus sonhos. Seu amor incondicional e encorajamento constante foram a força motriz que me impulsionou a superar desafios e perseverar mesmo nos momentos mais difíceis. Cada conquista que alcancei é um reflexo do amor, confiança e valores que vocês me transmitiram ao longo da minha jornada.

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RESUMO

Introdução: A realidade virtual (RV) surgiu como uma ferramenta promissora no campo da odontopediatria para aliviar a ansiedade e controlar a dor. Ao criar ambientes virtuais imersivos e interativos, a tecnologia VR pode efetivamente distrair e envolver pacientes jovens durante a consulta de medicina dentária, reduzindo assim substancialmente os seus níveis de ansiedade, tornando a consulta numa experiência positiva.

Materiais e métodos: A presente revisão sistemática seguiu as guidelines PRISMA com a seguinte questão de investigação no formato PICO: Na população pediátrica (P), a realidade virtual (I) auxilia no controlo da ansiedade e dor (O) numa consulta de medicina dentária comparando com outras técnicas de controlo comportamental (C)? Foram utilizadas as bases de dados PubMed/Medline®, SCOPUS e Web of Science.

Resultados: Da combinação dos termos de pesquisa obtiveram-se um total de 525 artigos. Após retirar os 79 artigos duplicados, obteve-se um total de 446. Após a leitura do título e resumo, 392 registos foram classificados como irrelevantes e excluídos. No final foram considerados aptos para essa revisão sistemática, 22 artigos

Conclusão: A RV é um método eficaz na redução da ansiedade e dor em crianças durante o tratamento dentário e demonstrou-se ser mais efetiva do que os métodos tradicionais. Ao proporcionar uma experiência envolvente e imersiva, a RV desvia a atenção dos pacientes do ambiente clínico, resultando numa experiência mais positiva e agradável. No entanto, é importante reconhecer as limitações dos estudos apresentados, sendo necessário investigar todo o potencial da RV em odontopediatria.

Palavras-chave: Realidade virtual, realidade aumentada, odontopediatria, distração, ansiedade dentária, controlo da dor, controlo comportamental

ABSTRACT

Background: Virtual reality (VR) has emerged as an innovative tool in the field of paediatric dentistry, improving anxiety and pain management. By leveraging immersive and interactive virtual environments, VR technology effectively distracts and engages young patients during dental procedures, leading to substantial reductions in anxiety levels and enhancing overall treatment experiences.

Methods: A systematic review was conducted according to the PRISMA guidelines with the following research question using the PICO format: Does VR (I) effectively manage anxiety and pain (O) during a paediatric dental consultation (P) compared to alternative behavioural control techniques (C)? PubMed/Medline®, SCOPUS, and Web of Science databases were meticulously searched and analysed.

Results: Search queries identified a total of 525 abstracts from three different databases. Duplicate articles were removed (n=79), leaving a total of 446 abstracts. After reading the title and abstract, 392 records were excluded. In the end, 22 articles were considered suitable for this systematic review.

Conclusion: VR is a highly effective method of behaviour management, successfully alleviating pain and anxiety in children during dental treatment, surpassing traditional tools. By offering an engaging and immersive experience, VR effectively diverts patients' attention away from the clinical environment, fostering a positive and enjoyable treatment experience. However, it is crucial to acknowledge the limitations of existing studies, highlighting the need for further research to enhance the understanding of VR's full potential in paediatric dentistry.

Keywords: Virtual reality, paediatric dentistry, dental anxiety, pain control, behaviour management

ÍNDICE

Resumo XI
Abstract XIII
1.Introdução......1
1.1 Ansiedade e percepção de dor 3
1.2 Medição da dor e ansiedade 3
1.2.1 *Frankl's behaviour rating scale* 3
1.2.2 *Facial Image Scale* (FIS) 4
1.2.3 *Modified Child Dental Anxiety Scale* (MCDAS) 4
1.2.4 *Screen for Child Anxiety Related Disorders* (SCARED) 5
1.2.5 *Wong-Baker Faces Pain Rating Scale* (WBFPS) 5
1.2.6 *Visual Analog Scale* (VAS) 5
1.2.7 *Legs, Activity, Cry, Consolability' scale* (FLACC scale) 6
1.2.8 *Venham's picture test* (VPT) 6
1.3 Ansiedade e dor na odontopediatria 7
1.4 Modulação do comportamento da criança/jovem na consulta de medicina dentária......8
1.4.1 Métodos de controlo comportamental farmacológicos 8
1.4.2 Métodos de controlo comportamental não farmacológicos......8
1.5 Realidade virtual 10
1.5.1 Como funciona 10
1.5.2 Uso geral 10
1.5.3 Uso na medicina 11
1.5.4 Uso na medicina dentária......12
1.5.5 RV e a modulação do comportamento......13
2. Materiais e métodos 15
2.1 Questão de Investigação PICO......17
2.2 Estratégia de Pesquisa......17
2.3 Filtros de pesquisa 18
2.4 Critérios de inclusão e exclusão......18

2.5 Extração de dados 19
2.6 Processo de triagem..19
3. Resultados...24
3.1 Seleção dos estudos 26
3.2 Concordância inter-examinadores...26
3.3 Características do estudo...26
4. Discussão 44
4.1 Emergência da RV na medicina dentária...46
4.2 RV e técnicas convencionais de controlo do comportamento…………….........46
4.3 RV e ecrãs digitais...47
4.4 RV e áudio...48
4.5 RV e jogos para smartphones...49
4.6 RV imersivo e não imersivo..49
4.7 Outras observações 50
4.7.1 RV e a experiência do médico-dentista 50
4.7.2 RV e os riscos à saúde 51
4.7.3 RV e a idade...52
4.7.4 Prevenção de efeitos adversos 53
4.7.5 Cybersickness……………..………………………………………………….54
4.7.6 Investimento..55
4.8 Avaliação da qualidade de risco de viés 56
4.9 Reflexão crítica 56
5. Conclusão 60
6. Bibliografia 63
7. Anexos 77
7.1 Submissão Prospero 79
7.2 Escalas newcastle ottawa 93
7.3 Artigo preparado para submissão no BMC Oral Health...................................94

ÍNDICE DE TABELAS

Table 1: Research methodology in databases 20
Table 2: Search filters 22
Table 3: Identification of selected articles ………..29
Table 4: General information of the included studies 32
Table 5: Results and conclusions ………………...35
Table 6: Dental procedures performed 39
Table 7: Measurement scales and protocols...40
Table 9: Brand and model of VR glasses………........…………………………...........42
Table 10: Paradigm of oculomotor exercises…........…………………..……...…...…54
Table 11: Modified Newcastle - Ottawa (NOS) ……..........……………..………...…58

ÍNDICE DE FIGURAS

Figure 1: PRISMA search strategy 28

LISTA DE ABREVIATURAS

AAOP: Academia Americana de Odontopediatria

AM: Anna Moura

DC: Diana Padilha

Mesh: *Medical subject headings*

NOS: *Newcastle Ottawa scale*

PRISMA: *Preferred Reporting Items for Systematic Reviews and Meta-Analysis*

PC: Patrícia Correia

RV: Realidade Virtual

HMD: *Head Mounted Devices*

FBRS: *Frankl's behaviour rating scale*

FIS: *Facial Image Scale*

MCDAS: *Modified Child Dental Anxiety Scale*

SCARED: *Screen for Child Anxiety Related Disorders*

WBFPS: *Wong-Baker Faces Pain Rating Scale*

VAS: *Visual Analog Scale*

FLACC scale: *Face, Legs, Activity, Cry, Consolability' scale*

VPT: *Venham's picture test*

MBPS: *Modified Behavioural Pain Scale*

INTRODUÇÃO

1. Introdução

1.1 Ansiedade e percepção dor

Conforme Castillo *et al*. (2000), a ansiedade é um sentimento de medo, de incerteza, de insegurança, que surge quando as pessoas percebem que estão diante de uma situação de futura ameaça, geralmente de algo desconhecido ou estranho.1

A ansiedade desempenha um papel significativo na percepção e na experiência da dor.[2] O estado elevado de ansiedade amplifica a sensibilidade à dor, levando ao aumento da percepção da dor e à redução da tolerância à dor.[3] Além disso, a ansiedade pode contribuir para a dor antecipatória, em que os indivíduos antecipam a dor antes mesmo de ocorrer o estímulo doloroso real.[4,5]

1.2 Medição da dor e ansiedade

A medição precisa dos níveis de dor e ansiedade é crucial na pesquisa envolvendo pacientes, pois fornece informações valiosas sobre as experiências subjetivas dos indivíduos e permite uma compreensão abrangente do seu bem-estar psicológico e fisiológico.[6,7] Para isso, medidas formais de avaliação são essenciais.[8,9]

1.2.1 *Frankl's behavior rating scale*

A avaliação da atitude e cooperação da criança durante as consultas é um aspecto essencial da odontopediatria. Para avaliar esses aspectos comportamentais, a *Frankl Rating Scale* foi desenvolvida por Frankl *et al*. (1962) e desde então tornou-se amplamente utilizada no campo.

Esta escala categoriza o comportamento de uma criança na clínica de medicina dentária em quatro categorias distintas, variando de uma classificação de 1 (definitivamente negativa) a uma classificação de 4 (definitivamente positiva). A primeira categoria, classificada como 1, representa um comportamento negativo definido, como recusa de tratamento, choro forte ou medo evidente. A segunda categoria, classificada como 2, indica um comportamento negativo caracterizado por relutância em aceitar o tratamento, falta de cooperação ou atitude negativa leve, que

pode se refletir em comportamento taciturno ou retraído. Movendo-se para uma perspectiva mais positiva, a terceira categoria, classificada como 3, significa um comportamento positivo em que a criança aceita o tratamento, pode ser cautelosa às vezes, mas geralmente segue as instruções do dentista cooperativamente. Por fim, a quarta categoria, avaliada como 4, demonstra um comportamento definitivamente positivo, com a criança estabelecendo um bom relacionamento com o dentista, demonstrando interesse pelo procedimento dentário, e até experimentando alegria e riso durante a visita.[10,11]

1.2.2 *Facial image scale* (FIS)

A FIS oferece um método simples e eficaz para avaliar os níveis de ansiedade dentária de crianças, em tempo real. Ao utilizar uma representação visual das emoções, esta escala permite que as crianças expressem os seus sentimentos e fornece informações valiosas sobre seus níveis atuais de ansiedade.[12]

A aplicação da escala envolve apresentar a fileira de faces para a criança e solicitar que ela indique qual face melhor representa seu estado emocional atual. A escala é então pontuada, atribuindo-se o valor um à face associada ao afeto mais positivo e um valor cinco à face associada ao afeto mais negativo.[13]

1.2.3 *Modified child dental anxiety scale* (MCDAS)

Uma versão modificada da Escala de Imagem Facial foi introduzida e denominada MCDAS.[14] O MCDAS incorpora uma escala de classificação de rostos, além do formato numérico original. Esta escala modificada foi reconhecida como uma ferramenta de medição confiável e válida para avaliar a ansiedade dentária em crianças com idades entre 8 e 12 anos.[15] A inclusão da escala de avaliação de faces no MCDAS oferece uma abordagem mais abrangente para capturar o aspecto emocional da ansiedade dentária, nessa faixa etária específica.[16] Ao combinar representações numéricas e visuais, o MCDAS aumenta a precisão e a sensibilidade da medição da ansiedade dentária em crianças dentro da faixa etária especificada.[14,15]

1.2.4 *Screen for child anxiety related disorders questionnaire* (SCARED)

O SCARED é um questionário amplamente utilizado e bem estabelecido, desenvolvido para avaliar sintomas e perturbações de ansiedade em crianças e adolescentes.[17] Consiste em versões para pais e filhos, permitindo uma avaliação abrangente das dificuldades relacionadas à ansiedade. O questionário SCARED cobre uma variedade de domínios de ansiedade, incluindo ansiedade de separação, fobia social, ansiedade generalizada, perturbação do pânico e fobia escolar.[18] Os participantes classificam a frequência e a intensidade de vários sintomas relacionados com a ansiedade numa escala Likert, fornecendo informações valiosas para fins de triagem e diagnóstico.[19,20]

1.2.5 *Wong Baker faces pain rating scale* (WBFPS)

A WBFPS é uma ferramenta amplamente utilizada para avaliar os níveis de dor em crianças de 3 anos ou mais.[21] Esta escala consiste em seis rostos de desenhos animados dispostos em graus crescentes de intensidade de dor da esquerda para a direita. Cada face recebe um valor numérico numa escala que varia de 0 a 10, permitindo que as crianças selecionem a face que melhor representa o seu nível de dor atual. Os valores numéricos atribuídos são usados para determinar a pontuação da dor, com pontuações mais altas indicando menor tolerância à dor e pontuações mais baixas indicando dor mais tolerável.[8,22]

1.2.6 *Visual analog scale* (VAS)

A VAS é uma ferramenta comumente utilizada para avaliar a intensidade de certas sensações e sentimentos, como a dor. Consiste em uma linha horizontal de 10 cm com duas extremidades que representam os extremos do comportamento ou situação a avaliar, pelo próprio ou pelo clínico/investigador. No contexto da odontopediatria, o dentista marca o comportamento da criança, colocando uma linha vertical que cruza a linha horizontal, em qualquer direção próxima ao ponto final representativo (satisfatório e insatisfatório). Isso permite uma avaliação subjetiva do

comportamento da criança com base nas ações observadas durante a consulta de medicina dentária.[23]

No entanto, existem algumas limitações para o seu uso, como dificuldades na aplicação da escala em pacientes com problemas perceptivo-motores. Certas populações, como indivíduos com limitações cognitivas ou idosos, podem ter taxas mais altas de não preenchimento ao usar a VAS.[23,24] Além disso, pontuar o VAS usando uma régua pode ser demorado e potencialmente introduzir viés ou erro.

1.2.7 *Legs, activity, cry, consolability' scale* (FLACC *scale*)

A escala FLACC é uma ferramenta observacional de avaliação comportamental da dor projetada para fornecer aos médicos um método padronizado de avaliação da dor, em pacientes incapazes de a autorrelatar.[25] Ao pontuar a expressão facial do paciente, movimentos das pernas, nível de atividade, choro e capacidade de ser consolado, numa escala de 0 a 10. Uma pontuação total variando de 0 (indicando nenhuma dor ou angústia) a 10 (indicando dor ou angústia máxima) pode ser gerado.[26] A escala FLACC é comumente recomendada para avaliar a dor de procedimentos em crianças pequenas, pois oferece uma abordagem simples e consistente para a avaliação da dor.[27,28]

1.2.8 *Venham's picture test* (VPT)

O VPT fornece um meio de avaliar a identificação das crianças com personagens ansiosos, produzindo informações valiosas sobre o seu estado emocional. É uma ferramenta de medição com oito cartões, cada um com duas figuras - uma figura ansiosa e uma figura não ansiosa.[29,30] As crianças que participam do teste são solicitadas a indicar que figura gostam mais naquele momento específico. Os cartões são apresentados em ordem sequencial e, para cada seleção da figura ansiosa, é anotada a pontuação um ou zero, para a seleção da figura não ansiosa. O número total de vezes que a figura ansiosa é escolhida é computado para obter uma pontuação final, que pode variar de zero (indicando a pontuação mínima) a oito (representando a pontuação máxima).[31,32]

1.3 Ansiedade e dor na odontopediatria

A visita ao médico dentista desencadeia frequentemente quadros de ansiedade, embora a maioria dos procedimentos não cause dor.[33] A ansiedade dentária é o medo excessivo que os pacientes apresentam antes, durante ou depois de qualquer tipo de tratamento dentário. Quando intensa, pode levar ao desenvolvimento de fobias. Podendo apresentar sintomas excessivos de ansiedade dentária, como sudorese, tremor, batimentos cardíacos acelerados, náuseas, vómitos ou até mesmo desmaios.[34,35]

Segundo Dahlander *et al*. 2019, o medo e a ansiedade frente ao tratamento dentário podem ser causados por diversos fatores, dentre os quais, a má experiência de alguém próximo, a falta de informações sobre o tratamento, a forma como o tratamento é realizado ou até mesmo os objetos do ambiente. A agulha da anestesia, o barulho dos instrumentos motorizados, a bata branca utilizado pelo dentista, o uso de materiais pontiagudos ou alicates, pode desencadear uma crise de ansiedade.[37]

A associação entre estímulos dolorosos, como a picada de agulha durante as injeções, o ambiente do consultório dentário em que foi realizado o procedimento e a vestimenta do médico dentista, levarão a criança a associar diretamente o médico com emoções negativas e sensações dolorosas.[38]

A falta de controlo da ansiedade durante o tratamento pode desencadear um desequilíbrio no sistema nervoso através de um aumentado o tónus simpático, resultando numa maior sensação de dor, aumento da pressão arterial, frequência respiratória e pulsação.[38,39]

Além disso, a dor e a ansiedade podem levar à evitação ou recusa nos cuidados de saúde, agravando o quadro de saúde geral do doente.[35] Heyman *et al*. 2013, reportou no seu estudo que a gravidade da fobia/ansiedade dentária foi fortemente associada à probabilidade de evitar serviços dentários no passado e a uma série de problemas atuais.

No trabalho clínico diário de um odontopediatra, o fator mais importante que afeta negativamente o tratamento dentário é o medo e a apreensão frente ao tratamento.[41,42]

1.4 Modulação do comportamento da criança/jovem na consulta dentária

A Academia Americana de Odontopediatria (2015) delineou várias técnicas de controlo comportamental para lidar com a ansiedade e o medo no dentista, em crianças. Elas são farmacológicas e não farmacológicas. Ambas as técnicas devem ser usadas para nutrir uma atitude positiva em relação à medicina dentária, aliviar a ansiedade e realizar cuidados de saúde oral de qualidade com segurança e eficiência para bebés, crianças, adolescentes e pessoas com necessidades especiais de saúde.

1.4.1 Métodos farmacológicos

Em odontopediatria, o controlo do medo e da ansiedade pode ser realizado com técnicas farmacológicas, como o uso de anti-histamínicos, benzodiazepínicos e a sedação por inalação com protóxido de azoto (N_2O/O_2).[44,45]

Os benzodiazepínicos apresentam efeitos sedativos, ansiolíticos e hipnóticos. São os fármacos de primeira escolha para o controlo da ansiedade no consultório odontológico por apresentarem boa eficácia e segurança, além de baixa incidência de reações adversas, fácil administração e baixo custo. Os benzodiazepínicos mais comumente empregados na clínica de medicina dentária são: diazepam, lorazepam, alprazolam, triazolam e midazolam.[46,47]

O protoxido de azoto (N_2O) não tem efeito analgésico, entretanto mantém as crianças sedadas, mas conscientes durante o tratamento e retorna à atividade normal após a interrupção do medicamento. A técnica consiste em inalar protóxido de azoto (N_2O) misturado continuamente com oxigénio com controlo do fluxo e através de uma máscara nasal.[48,49]

1.4.2 Métodos não farmacológicos

As técnicas de controlo de comportamento não farmacológico comumente usadas são a comunicação verbal, “dizer-mostrar-fazer”, controlo de voz, comunicação não verbal, reforço positivo, distração e presença ou ausência dos pais.[50,51]

A comunicação desempenha um papel fundamental como método de controle de comportamento em odontopediatria. Ao estabelecer uma comunicação efetiva, empática com as crianças e adaptada a faixa etária, os profissionais podem criar um ambiente acolhedor e seguro, promovendo confiança e reduzindo a ansiedade.[52,53]

Esta comunicação pode ser verbal, tornando a escolha de palavras extremamente importante na criação do ambiente. Também pode ser não-verbal, com alterações posturais, expressões faciais, gestos com as mãos, contato visual e toque em todas as informações de transmissão para a criança e o pai.[54,55](54,55) Comunicação adequada com a criança, integrada com técnicas comportamentais, visam estimular a criança a perceber a medicina dentária como não ameaçadora, para justificar comportamentos favoráveis que permitam a execução de tratamentos de alta qualidade.[52]

A abordagem clássica "dizer-mostrar-fazer", o método mais utilizado, é o somatório da explicação do procedimento, demonstração através dos sentidos (audição, olfato e tato) e por fim a sua execução.[56] Esta estratégia pode ser usada em antecipação ao comportamento negativo. Possui o objetivo de familiarizar o paciente pediátrico aos procedimentos dentários.[57,58]

O controlo da voz também é eficiente, quando usado para os casos adequados. A alteração controlada do volume, tom e velocidade da voz para obtenção de atenção e cooperação da criança mostra-se eficaz para crianças desatentas, mas comunicativas. Com exceção daquelas muito novas para compreender ou com perturbações de desenvolvimento intelectual ou emocional.[54,59]

Outra técnica utilizada para orientar o padrão de comportamento de uma criança no consultório é o reforço positivo.[60] A recompensa dos comportamentos que permitem o tratamento é feita através de elogios e demonstrações de validação. Este procedimento também inclui modulação de voz, expressão facial, e demonstrações físicas como certificados de comportamento ou medalhas.[52,61]

Para crianças ansiosas e com fobia a tratamentos médicos ou dentários, a distração pode ser um método eficaz de desviar a atenção do paciente da percepção de procedimentos considerados desagradáveis.[62] Para além da melhoria do comportamento durante a consulta, esta técnica também é usada por profissionais de saúde para atenuar a dor e o sofrimento do procedimento.[60,63]

A redução da experiência subjetiva de dor acontece devido à redução da quantidade de recursos de atenção, que o cérebro do paciente tem disponível, para

processar os sinais neurais recebidos dos sensores de dor.[38] Sendo assim crucial para uma orientação comportamental bem-sucedida.[17,64] Dentre estas técnicas destacam-se as que utilizam dispositivos elétricos: óculos de realidade virtual, música, vídeos, aplicações e jogos usados durante as consultas.[65-68]

1.5 Realidade virtual

A realidade virtual é uma tecnologia de simulação tridimensional que pode ser usada interativamente por meio de um computador. A realidade virtual cria um ambiente artificial que imita o mundo real, permitindo que os utilizadores experimentem um mundo alternativo.[69]

1.5.1 Como funciona

Existem vários tipos de equipamentos de realidade virtual, desde óculos de realidade virtual até sistemas de imersão total. Os óculos de realidade virtual são os mais simples e mais acessíveis, e permitem que os usuários vejam um mundo virtual tridimensional ao seu redor.[69] Os sistemas de imersão total são mais caros e complexos, e permitem que os utilizadores se movimentem livremente num mundo virtual.[70]

A experiência virtual fornece informações multissensoriais, através da sincronia entre o capacete de exibição montado na cabeça (fornece uma imagem com uma sensação de espaço e profundidade), sensores de movimentos, fones de ouvido, e *joysticks*.[71,72] Dessa forma é possível ficar totalmente imerso na simulação criada.[73]

1.5.2 Uso geral

Durante as últimas duas décadas, a realidade virtual pode ser usada para fins de entretenimento, educação, treino, pesquisa e muito mais.[74-76] A tecnologia da realidade virtual está-se a tornar cada vez mais acessível e poderosa, e os usos potenciais são praticamente ilimitados.[77,78]

Pode ser usada para criar experiências muito reais e envolventes.[70] Por exemplo, os jogos de realidade virtual permitem que os jogadores sejam imersos num

mundo virtual, onde eles podem interagir com os objetos e outros jogadores.[79] Os jogos de realidade virtual têm-se tornado cada vez mais populares, esta tecnologia está-se a tornar cada vez mais acessível.[80]

1.5.3 Uso na medicina

No campo médico, como uma ferramenta eficaz e eficiente para prevenir perturbações emocionais como a ansiedade[81-83] e lesões físicas em processos de reabilitação.[84,85] Ultimamente, tem havido um interesse crescente no uso da tecnologia de realidade virtual como método de redução da dor.[86,87]

Também está sendo usada para fins educacionais ou de investigação.[88,89] A exemplo do treino de médicos, enfermeiros e médicos dentistas, permitindo que eles experimentem situações médicas reais antes de tratarem pacientes reais.[90-92]

A realidade virtual é utilizada como medida de distração durante procedimentos clínicos dolorosos associados ao uso de agulhas.[93] Esses procedimentos incluem vacinações, recolha de sangue ou administração de medicamentos, que podem fazer com que as crianças sintam níveis aumentados de dor e medo.[94] Devido às suas propriedades imersivas, interativas e multissensoriais, a RV torna mais fácil desviar a atenção desses procedimentos dolorosos, para que as crianças tenham uma percepção reduzida aos sinais de dor, neutralizando-os com uma experiência de estímulos agradáveis.[94,95]

A exemplo do estudo de Althumairi *et al*. 2021, que através de questionários e observações durante as vacinações, eles coletaram dados e ofereceram RV como uma intervenção para reduzir o desconforto e a ansiedade relacionados à vacinação. Os resultados indicaram benefícios significativos, proporcionando uma experiência mais positiva para as crianças durante o procedimento. No entanto, é importante ressaltar que este foi um estudo observacional, limitando a capacidade de estabelecer uma relação causal entre o uso da RV e os resultados observados.

Durante o procedimento de aspiração de medula óssea e biópsia, a RV também tem mostrado bons resultados na redução da ansiedade e da percepção da dor. Como pode ser observado no estudo de Korkmaz *et al*. 2023, que forneceu RV para o grupo teste. No entanto é preciso levar em consideração a existência de outros

fatores que podem influenciar a experiência do paciente durante o procedimento. A exemplo de pacientes que passaram anteriormente por procedimentos invasivos.[98,99]

Resultados positivos também são encontrados em protocolos para redução da ansiedade nos exames imaginológicos. Antes dos exames, a exemplo do estudo Yang *et al*. 2019, que usou o VR para realizar simulações com os pacientes. Ou durante, como pode ser observado em Garcia-Palacios *et al*. 2007, que utilizou um dispositivo de RV durante do exame de ressonância magnética e mostrou-se mais eficaz na redução temporária dos sintomas de claustrofobia comparado ao seu grupo teste (música).

1.5.4 Uso na medicina dentária

Na medicina dentária, apesar de ainda não propriamente difundida, RV tem-se mostrado uma ferramenta benéfica para a prática clínica em diversas especialidades.[76,102]

No campo da cirurgia oro-maxilo-facial, os sistemas de RV podem incluir e emular uma variedade de funções, como serrar ossos, perfurar orifícios e fixar a localização com feedback de força háptica para simular melhor os procedimentos cirúrgicos. Além disso, outra plataforma de simulação baseada em VR permite que os cirurgiões interajam com o mundo virtual, naturalmente com as mãos, por meio de controladores de rastreamento vestíveis.[103,104]

Na prótese dentária, o uso do articulador virtual combinando a realidade virtual, minimiza as limitações dos articuladores mecânicos e simula dados reais do paciente para permitir a análise da oclusão estática e dinâmica e das relações mandibulares com próteses.[105,106]

Para a educação em saúde oral de pacientes idosos e jovens, a realidade virtual pode ser considerada uma ferramenta importante. Ainda não há muitos estudos sobre o uso da realidade virtual para a educação em saúde oral, mas os poucos que existem mostram que ela pode ser uma ferramenta eficaz. Um estudo de Genaro *et al*. 2022 descobriu que a realidade virtual foi eficaz para ajudar os alunos a aprenderem como escovar os dentes.

Na pediatria, podem ser implementados na educação e manutenção da higiene oral.[107] Em adição, a diminuição da ansiedade e dor também podem ser experienciadas com o uso desta tecnologia.[108]

A odontopediatria é uma das especialidades mais desafiadoras da medicina dentária, pois o fator mais comum que determina os resultados do tratamento em tais pacientes é sua adesão e cooperação.[60,109] Os pacientes pediátricos geralmente apresentam grande ansiedade no consultório dentário.[42]

Para diminuir os níveis de ansiedade e stress desses pacientes, a realidade virtual é uma das ferramentas inovadoras que tem sido discutidas na literatura, embora de forma limitada.[96,102]

A terapia de exposição à realidade virtual é um tipo de tratamento que usa a tecnologia de realidade virtual para ajudar os pacientes a superar o medo de procedimentos dentários.[108] A terapia pode ser usada para ajudar pacientes pediátricos que têm medo de ir ao dentista ou dos procedimentos dentários. Como exemplo da primeira situação. Os pacientes experimentam todo o cenário virtualmente, antes do início do procedimento real. Assim, são ajudados a entender o tratamento e enfrentar os seus medos num ambiente seguro e controlado.[110,111]

1.5.5 RV e a modulação do comportamento

Nos últimos anos, a realidade virtual tornou-se popular em estudos de pesquisa clínica como uma técnica inovadora de modulação do comportamento pediátrico.[108] Segundo McCaul *et al*. 1992, um indivíduo deve se concentrar nos estímulos dolorosos para perceber a dor. Logo, a RV não atua nos mecanismos fisiopatológicos da dor, mas sim na percepção e atenção do paciente à dor.

O ensaio clínico randomizado conduzido por Xiang *et al*. 2021 comparou a eficácia da distração de RV ativa e passiva baseada em smartphone com o tratamento padrão no tratamento da dor de queimadura em pacientes pediátricos. O estudo envolveu uma amostra de pacientes pediátricos em tratamento para queimaduras, que foram aleatoriamente designados para receber distração de RV baseada em smartphone ou atendimento padrão. Os pesquisadores mediram os níveis de dor usando ferramentas validadas de avaliação da dor e avaliaram a satisfação e a experiência do paciente com as intervenções.

Os resultados mostraram que as técnicas de distração de RV ativas e passivas foram eficazes na redução da dor relacionada à queimadura e na melhoria da experiência geral de pacientes pediátricos em comparação com o tratamento padrão. Os resultados sugerem que a distração de RV baseada em smartphone pode ser uma intervenção não farmacológica valiosa para o controle da dor em pacientes pediátricos queimados.

MATERIAIS E MÉTODOS

2. Materiais e métodos

A revisão sistemática é um tipo de estudo que tem como objetivo avaliar e sintetizar a evidência disponível numa determinada área de pesquisa. Ela é realizada por meio de uma pesquisa rigorosa e sistemática da literatura científica, incluindo artigos publicados em revistas científicas e outros tipos de documentos relevantes. A revisão sistemática permite identificar as lacunas no conhecimento existente, avaliar a qualidade dos estudos incluídos e fornecer uma síntese dos resultados encontrados. Essa síntese pode ser usada para informar a tomada de decisões clínicas ou políticas, bem como para orientar futuras pesquisas na área.

A presente revisão sistemática fundamentou-se nas guidelines PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*), e foi definida a questão de investigação através do formato PICO (*Population, Intervention, Comparison, Outcome*).

2.1 Questão de investigação PICO

Segundo Donato *et al*. 2019, “Antes de efectuar a pesquisa, é crucial definir explicitamente a questão de investigação”. Deste modo, a presente revisão objetiva estudar a seguinte questão: Na população pediátrica (P), a realidade virtual (I) auxilia no controlo da ansiedade e dor (O) numa consulta de medicina dentária comparando com outras técnicas de controlo comportamental (C)?

2.2 Estratégia de pesquisa

A pesquisa bibliográfica foi realizada em janeiro de 2023, nas bases de dados PubMed/Medline®, SCOPUS e Web of Science, tendo como objetivo a resposta à pergunta de investigação, considerando o objetivo e os critérios previamente definidos.

Na PubMed/Medline® serão combinados diferentes termos Mesh (*medical subject headings*) e *keywords*, com os operadores booleanos, “AND” e “OR” na Scopus e Web of Science foi usada a mesma estratégia de pesquisa, com termos de

texto livre. As frases de pesquisa utilizadas nas diferentes bases de dados encontram-se na tabela 1.

A presente revisão sistemática foi registado no "*International Prospective Register of Systematic Reviews*" (PROSPERO) com o número de registo CRD42023409674 (Anexo 1).

2.3 Filtros de pesquisa

Para limitar a pesquisa, foram aplicados alguns filtros na pesquisa, quanto ao tipo de estudo, população-alvo, data de publicação e idioma. Estes foram adequados a cada base de dados (Tabela 2).

2.4 Critérios de inclusão e exclusão

Critérios de inclusão e exclusão foram estabelecidos para delinear a pesquisa desta revisão sistemática de acordo com sua temática.

Os critérios de inclusão dos estudos foram os seguintes:

(1) Estudos concebidos como ensaios clínicos randomizados (RCTs) e não randomizados, desenhos de estudos experimentais e de caso-controlo com um relatório de texto completo

(2) Artigos de Janeiro de 2003 a janeiro de 2023

(3) Crianças menores de 18 anos

(4) Intervenções de realidade virtual para controlo da ansiedade e dor durante procedimentos dentários

Critério de exclusão:

(1) Revisões sistemáticas/narrativas, metanálises e relatos de caso

(2) Estudos sem um relatório de texto completo

(4) Pacientes Invisuais e/ou surdos.

(5) Uso de dispositivos 2D

2.5 Extração de dados

As publicações obtidas das três bases de dados (PubMed/Medline®, Scopus e Web of science) foram exportadas para o software gerenciador de bibliografias *Parsifal* onde foram excluídas as réplicas. Em seguida, os dados dos artigos/estudos selecionados foram registrados num formulário padronizado num ficheiro do Microsoft Excel®, com os seguintes itens: nome do autor, data de publicação, tipo de investigação, objetivos, amostra, grupo controlo, resultados e conclusões.

2.6 Processo de triagem

Duas pesquisadoras (DP e PC) conduziram de maneira autónoma o procedimento de pesquisa e triagem da revisão sistemática de acordo com os critérios de inclusão e exclusão pré-estabelecidos. Em caso de discordância entre os pesquisadores, um terceiro pesquisador (AM) faria o desempate.

O primeiro passo consistiu na análise dos títulos e resumos. Aqueles que indicaram estar de acordo com os critérios da pesquisa seguiram para o segundo passo, a leitura minuciosa dos artigos completos. Depois da avaliação de todo o conteúdo dos estudos possivelmente pertinentes, os estudos escolhidos foram incorporados nesta revisão sistemática.

Os documentos que foram encontrados em múltiplas bases de dados foram contabilizados apenas uma vez.

Table 1: Research methodology in databases

	PUBMED
#1	“VR"[All Fields] OR "virtual reality"[All Fields] OR "augmented reality"[All Fields] OR "AR"[All Fields] OR "mixed reality"[All Fields] OR "Audiovisual distraction"[All Fields] OR "audiovisual"[All Fields] OR "Audiovisual Aids"[All Fields] OR "headset*"[All Fields] OR "vr headset*"[All Fields] OR "virtual reality headset"[All Fields] OR "AR headset"[All Fields] OR "augmented reality headset"[All Fields] OR "Artificial intelligence"[All Fields] OR "VR goggles"[All Fields] OR "virtual reality goggles"[All Fields] OR "AR goggles"[All Fields] OR "augmented reality goggles"[All Fields] OR "Virtual Reality Exposure Therapy"[All Fields] OR "VR Exposure Therapy"[All Fields] OR "Augmented Reality Exposure Therapy"[All Fields] OR "Virtual Reality Exposure Therapy"[MeSH Terms] OR "Audiovisual Aids"[MeSH Terms] OR "augmented reality"[MeSH Terms]
#2	"child, preschool"[MeSH Terms] OR "preschool child"[All Fields] OR "paediatric population"[All Fields] OR "paediatric patient*"[All Fields] OR "child"[MeSH Terms] OR "child*"[All Fields] OR "adolescent"[MeSH Terms] OR "adolescen*"[All Fields] OR "pre schooler*"[All Fields] OR "youth"[All Fields] OR "teenager*"[All Fields] OR "teen*"[All Fields] OR "preteen*"[All Fields] OR "pre teen*"[All Fields] OR "pediatrics"[MeSH Terms] OR "paediatric*"[All Fields] OR “Autistic Disorder”[MeSH Terms] OR “Autism”[All Fields] OR “Down Syndrome”[MeSH Terms] OR “Down Syndrome”[All Fields]
#3	"Pain"[All Fields] OR "Pain Management"[All Fields] OR "dental pain"[All Fields] OR "Pain Perception"[All Fields] OR "Anxiety"[All Fields] OR "Dental anxiety"[All Fields] OR "anticipatory anxiety"[All Fields] OR "fear"[All Fields] OR "stress"[All Fields] OR "Dental anxiety"[MeSH Terms] OR "Pain Management"[MeSH Terms] OR "Pain"[MeSH Terms] OR "Pain Perception"[MeSH Terms]
#4	"dental care"[All Fields] OR "dental procedure*"[All Fields] OR "dental operation*"[All Fields] OR "dental appointment*"[All Fields] OR "dental treatment*"[All Fields] OR “dent*”[All Fields] OR “dental hospital*”[All Fields] OR “dentistry”[MeSH Terms] OR "dental care"[MeSH Terms]
#5	#1 AND #2 AND #3 AND #4

Table 1: Research methodology in databases cont.

	SCOPUS
#1	“VR" OR "virtual reality" OR "augmented reality" OR "AR" OR "mixed reality" OR "Audiovisual distraction" OR "audiovisual" OR "Audiovisual Aids" OR "headset*" OR "vr headset*" OR "virtual reality headset" OR "AR headset" OR "augmented reality headset" OR "Artificial intelligence" OR "VR goggles" OR "virtual reality goggles" OR "AR goggles" OR "augmented reality goggles" OR "Virtual Reality Exposure Therapy" OR "VR Exposure Therapy" OR "Augmented Reality Exposure Therapy"
#2	"preschool child" OR "paediatric population" OR "paediatric patient*" OR "child*" OR "adolescen*" OR "pre schooler*" OR "youth" OR "teenager*" OR "teen*" OR "preteen*" OR "pre teen*" OR "paediatric*" OR "Autistic Disorder" OR "Autism" OR "Down Syndrome"
#3	"Pain" OR "Pain Management" OR "dental pain" OR "Pain Perception" OR "Anxiety" OR "Dental anxiety" OR "anticipatory anxiety" OR "fear" OR "stress"
#4	"dental care" OR "dental procedure*" OR "dental operation*" OR "dental appointment*" OR "dental treatment*" OR “dent*” OR “dental hospital*”
#5	#1 AND #2 AND #3 AND #4
	WEB OF SCIENCE
#1	(VR) OR (virtual reality) OR (augmented reality) OR (AR) OR (mixed reality) OR (Audiovisual distraction) OR (audiovisual) OR (Audiovisual Aids) OR (headset*) OR (vr headset*) OR (virtual reality headset) OR (AR headset) OR (augmented reality headset) OR (Artificial intelligence) OR (VR goggles) OR (virtual reality goggles) OR (AR goggles) OR (augmented reality goggles) OR (Virtual Reality Exposure Therapy) OR (VR Exposure Therapy) OR (Augmented Reality Exposure Therapy)
#2	(preschool child) OR (paediatric population) OR (paediatric patient*) OR (child*) OR (adolescen*) OR (pre schooler*) OR (youth) OR (teenager*) OR (teen*) OR (preteen*) OR (pre teen*) OR (paediatric*) OR (Autistic Disorder) OR (Autism) OR (Down Syndrome)
#3	(Pain) OR (Pain Management) OR (dental pain) OR (Pain Perception) OR (Anxiety) OR (Dental anxiety) OR (anticipatory anxiety) OR (fear) OR (stress)
#4	(dental care) OR (dental procedure*) OR (dental operation*) OR (dental appointment*) OR (dental treatment*) OR (dent*) OR (dental hospital*)
#5	#1 AND #2 AND #3 AND #4

Table 2: Search filters

PUBMED
2003 – 2023, Humans, English, full text, Clinical study, Clinical trial, Controlled clinical trial, Evaluation study, Multicenter study, Observational study, Pragmatic clinical trial, Randomized controlled trial, Twin study, Validation and Comparative studies
SCOPUS
English; 2003-2023; Articles
WEB OF SCIENCE
English; 2003-2023; Articles

.

RESULTADOS

3. Resultados

3.1 Seleção dos estudos

As consultas de pesquisa identificaram um total de 525 resumos de três bases de dados diferentes (Fig. 1). Os 79 artigos duplicados foram retirados, deixando um total de 446 resumos únicos. Após a leitura do título e resumo, 392 registos foram classificados como irrelevantes para a questão PICO da revisão e excluídos. Um total de 54 artigos foram selecionados para análise de texto completo. Destes, 5 era revisões sistemáticas, 24 artigos foram excluídos por usarem óculos audiovisuais sem imersão 3D e 3 tinham como amostra indivíduos maiores de 18 anos. No final foram considerados aptos para presente revisão sistemática, 22 artigos.

3.2 Concordância inter-examinadores

O método escolhido para realizar a avaliação da concordância e confiabilidade entre pesquisadores foi o coeficiente Kappa de Cohen. O coeficiente varia de -1 a 1, onde valores mais próximos de 1 indicam uma concordância maior entre os revisores, enquanto valores mais próximos de -1 indicam uma discordância maior.[115]

O valor de kappa obtido de 1, nas várias fases de seleção. Estes valores são considerados uma excelente concordância.

3.3 Características do estudo

Os estudos incluídos nesta revisão sistemática geraram resultados que foram organizados em cinco tabelas. Todas as tabelas possuem uma coluna que lista o número de cada artigo, para facilitar a leitura e a correlação entre os estudos e os parâmetros avaliados.

Foram incluídos nesta análise 22 estudos, conduzidos em vários países, incluindo Turquia, Irão, Índia, China, Jordânia, Espanha, Síria, Itália e Indonésia. Numa tabela (Tabela 3), é possível identificar os artigos por meio de informações como os autores, o título, o ano, o país e o tipo de estudo.

Os estudos investigaram a eficácia de várias técnicas de RV, como RV imersiva e não imersiva, e compararam-nas com diferentes técnicas de controlo do comportamento em odontopediatria, como distração audiovisual, distração passiva e técnica de "dizer-mostrar-fazer". Envolveram um total de 2.558 participantes. A maioria dos estudos incluiu crianças com idades entre 5 e 12 anos. Alguns estudos incluíram crianças com idades mais específicas, como 7-9 anos ou 5-8 anos. (Tabela 4).

Os procedimentos dentários avaliados variaram entre os estudos. Procedimentos com e sem injeções anestésicas, profilaxias, tratamentos endodônticos, compósitos e extrações dentárias. Em dentição temporária ou permanente (Tabela 5). Entretanto, nem todos os estudos serem específicos quanto aos procedimentos dentários realizados.

Como avaliação da ansiedade e percepção da dor, os estudos selecionados na presente pesquisa tiveram, como critérios de análise, aferições relacionadas à dor, ansiedade, batimentos cardíacos, cortisol salivar, comportamento e medo. As metodologias empregues para a mensuração desses fatores estão registradas numa tabela (Tabela 8). Os parâmetros avaliados foram a ansiedade, percepção da dor, comportamento, medo e cybersickness. Observou-se que a ansiedade foi o aspecto mais investigado, 16 artigos, enquanto a percepção de dor foi abordada em 13 artigos.

Nesta revisão sistemática, também foram observados os diferentes modelos e marca comercial dos óculos de RV. Apenas 5 dos 22 artigos incluídos não apresentaram qualquer especificação do dispositivo de RV utilizado (Tabela 9).

Os resultados foram separados primeiramente em tabela (Tabela 6) pelo objetivo de avaliação de cada estudo individualmente. Dor, ansiedade, comportamento e *cybersickness*, por exemplo. Nem todos os estudos abordaram as mesmas questões. Em seguida, os resultados foram discutidos e organizados de acordo com a técnica utilizada como grupo teste.

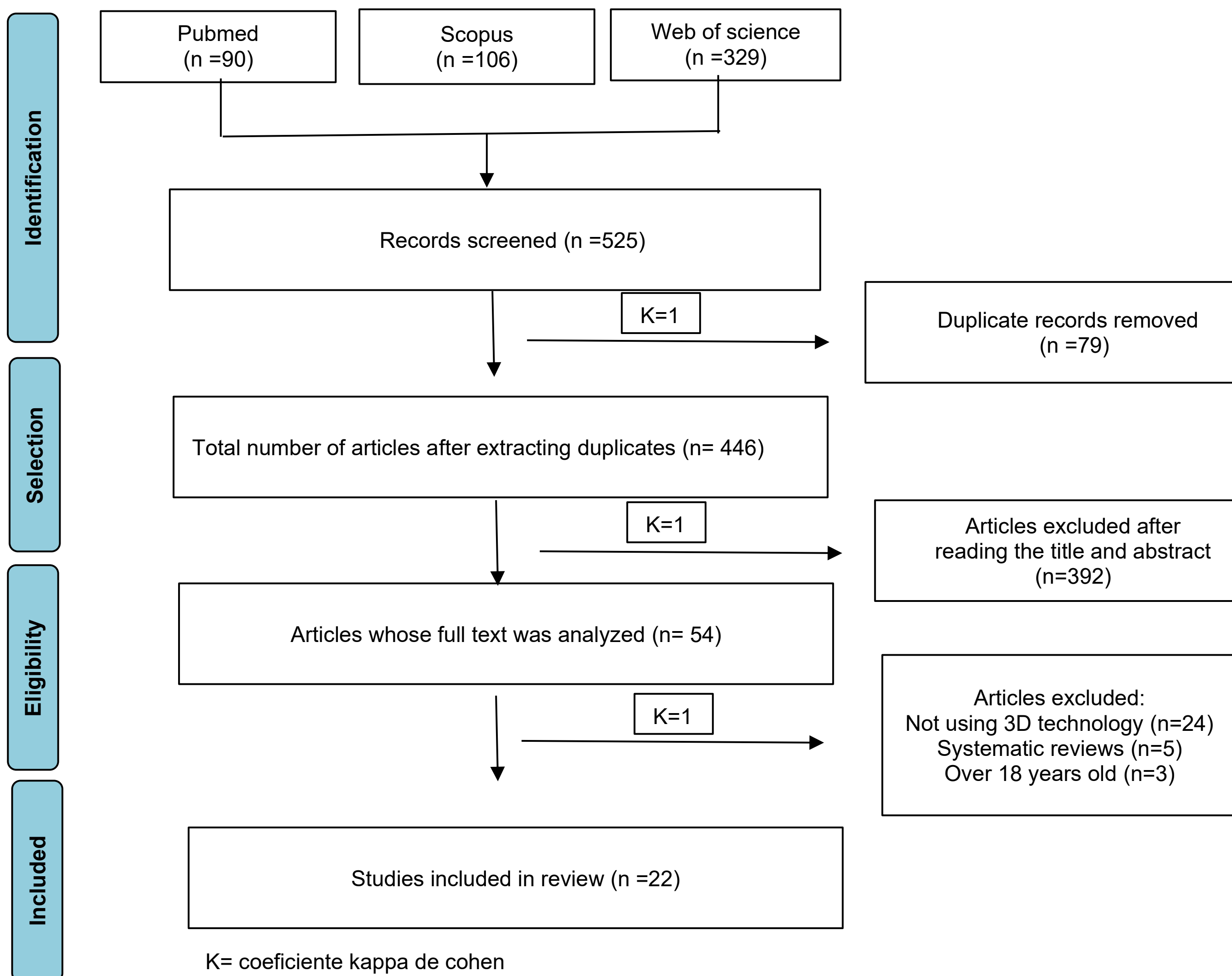

Figure 1- PRISMA search strategy

Table 3: Identification of selected articles

Article	Authors Year Country	Title	Study design
A1[116]	Ozukoc *et al.* 2020 Turkey	Reducing anxiety in children with molar hypomineralization using virtual reality - A randomized crossover study	Randomized crossover study
A2[117]	Baniebrahimi *et al.* 2022 Iran	Effects of Virtual Reality Versus Game Applications on Children's Dental Fear: A Randomized Clinical Trial	Randomized clinical trial
A3[118]	Shetty *et al.* 2019 India	Effect of Virtual Reality Distraction on Pain and Anxiety During Dental Treatment in 5 to 8 Year Old Children	Randomized controlled clinical trial
A4[119]	Kumari *et al.* 2021 India	Immersive and Non-Immersive Virtual Reality Distraction on Pain Perception to Intraoral Injections	Randomized clinical trial
A5[120]	Ran *et al.* 2021 China	Application of virtual reality on non-drug behavioral management of short-term dental procedure in children	Randomized clinical trial
A6[121]	Alshatrat *et al.* 2022 Jordan	Effect of immersive virtual reality on pain in different dental procedures in children: A pilot study	Randomized clinical trial
A7[122]	Gomez-Polo *et al.* 2021 Spain	Behaviour and Anxiety Management of Paediatric Dental Patients throughVirtual Reality: A Randomised Clinical Trial	Randomized Clinical Trial

Table 3: Identification of selected articles cont.

Article	Authors Year Country	Title	Study design
A8[123]	Du *et al*. 2022 China	A digital intervention using virtual reality helmets to reduce dental anxiety of children under local anaesthesia and primary teeth extraction: A randomized clinical trial	Randomized controlled clinical trial
A9[124]	Aditya *et al*. 2021 India	Comparison of effectiveness of three distraction techniques to allay dental anxiety during inferior alveolar nerve block in children: A randomised controlled clinical trial	Randomized controlled clinical trial
A10[125]	Nuvvula *et al*. 2015 India	Effect of audiovisual distraction with 3D video glasses on dental anxiety of children experiencing administration of local analgesia: A randomised clinical trial	Randomized Clinical Trial
A11[126]	Murali *et al*. 2021 India	Impact of Virtual Reality Distraction Technique on Dental Anxiety during short Dental Procedure among 5-8 Years Children: A Non-Randomised Clinical Trial	Non-Randomised Clinical Trial
A12[127]	Felemban *et al*. 2021 Saudi Arabia	Effect of virtual reality distraction on pain and anxiety during infiltration anaesthesia in paediatric patients: a randomized clinical trial	Randomized clinical trial
A13[128]	Al-Halabi *et al* 2018 Syria	Effectiveness of audio visual distraction using virtual reality glasses versus tablet device in child behavioural management during inferior alveolar nerve block	Randomized clinical trial
A14[129]	Buldur *et al*. 2021 Turkey	Does Virtual Reality Affect Children's Dental Anxiety, Pain, And Behaviour? A Randomised, Placebo-Controlled, Cross-Over Trial	Randomized two-armed, within-subject cross-over placebo-controlled trial

Table 3: Identification of selected articles cont.

Article	Authors Year Country	Title	Study design
A15[130]	Sharma *et al*. 2021 India	Effectiveness of Virtual Reality Glasses Digital Screens and Verbal Command as a Method to Distract Young Patients during Administration of Local Anesthesia	Randomized controlled clinical trial
A16[131]	Khan *et al*. 2019 India	Passive distraction: A technique to maintain children's behavior undergoing dental treatment	Prospective observational study
A17[132]	Atzori *et al*. 2018 Italy	Virtual Reality Analgesia for Pediatric Dental Patients	Randomized crossover study
A18[133]	Niharika *et al*. 2018 India	Effects of distraction using virtual reality technology on pain perception and anxiety levels in children during pulp therapy of primary molars	Randomized single-blind-controlled crossover
A19[134]	Pande 2020 India	Effectiveness of different behavior guidance techniques in managing children with negative behavior in a dental setting: A randomized control study	Randomized control study
A20[135]	Greeshma *et al*. 2021 India	Comparative Evaluation of the Efficacy of Virtual Reality Distraction, Audio Distraction and Tell-show-do Techniques in Reducing the Anxiety Level of Pediatric Dental Patients: An In Vivo Study	Randomized controlled clinical trial
A21[136]	Zaidman *et al*. 2022 Israel	Distraction With Virtual Reality Goggles in Paediatric Dental Treatment: A Randomised Controlled Trial	Randomized crossover Controlled Trial
A22[137]	Kaswindiarti *et al*. 2022 Indonésia	The effect of virtual reality distraction on pain perception of children aged 7-9 years during anesthesia procedure with the jet injector in dental treatment	Randomized controlled clinical trial

Table 4: General information of the included studies

Article	Sample	Groups	Aims
A1[116]	23 10-12 years	**Group 1:** VR game. **Group 2:** Conventional behaviour management techniques	To evaluate anxiety levels during dental treatments in children with molar incisor hypomineralisation (MIH)-affected teeth.
A2[117]	42 5-8 years	**Group 1:** Virtual reality glasses **Group 2:** Dental simulation game apps prior to treatment.	To evaluate dental anxiety and fear.
A3[118]	120 5 – 8 years	**Group 1:** Conventional behaviour management techniques **Group 2:** Virtual reality glasses	To evaluate pain and anxiety during short invasive dental procedures.
A4[119]	200 6–12-years	**Group 1:** Immersive VR **Group 2:** Non-immersive VR (cartoon movies)	To evaluate perceived pain during intraoral injections in children undergoing dental procedures.
A5[120]	120 4-8 years	**Group 1:** Virtual reality glasses during the procedure **Group 2:** Tell-show-do (TSD)	To evaluate anxiety, pain, and compliance scores in perioperative children.
A6[121]	54 5-12 years	**Group 1:** Dental procedures not requiring local anaesthesia **Sub group A1:** VR **Sub group A2:** conventional **Group 2:** Painful dental procedures requiring local anaesthesia **Sub group B1:** VR **Sub group B2:** Conventional	To evaluate the effectiveness of virtual reality on pain perception in dental procedures in children.
A7[122]	80 5-10 years	**Group 1:** Conventional behaviour management techniques **Group 2:** Virtual reality glasses	To evaluate anxiety and behaviour of paediatric patients during their dental treatment.
A8[123]	128 4–9 years	**Group 1:** Conventional behaviour management techniques **Group 2:** Virtual reality glasses	To evaluate dental anxiety, pain perception, behaviour triggered and occurrence of simulator sickness in local anaesthesia and primary teeth extraction.

Table 4: General information of the included studies cont.

Article	Sample	Groups	Aims
A9[124]	60 6–9 years	**Group 1**: Fidget spinner **Group 2:** Kaleidoscope **Group 3:** Virtual reality **Group 4:** No distraction	To evaluate the anxiety levels of children subjected to inferior alveolar nerve block.
A10[125]	90 7 - 10 years 49 M and 41 F	**Group 1:** Basic behavior guidance techniques **Group 2:** Music **Group 3**: Virtual reality	To evaluate dental anxiety of children
A11[126]	75 5-8 year	Pre and post intervention	To evaluate pain and anxiety during short invasive dental procedures.
A12[127]	50 6- 12 years	**Group 1:** VR goggles **Group 2:** Regular screen	To evaluate anxiety and pain during buccal infiltration anaesthesia
A13[128]	102 6 -10 years 60 M and 42 F	**Group 1:** Basic behaviour guidance techniques. **Group 2:** Virtual reality **Group 3:** Tablet device and wireless headphones	To evaluate anxiety levels of anxious paediatric patients during inferior alveolar nerve block (IAN) block
A14[129]	78 7 -11 years	**Group 1:** Attention placebo-controlled **Group 2:** Virtual Reality	To evaluate dental anxiety, pain, and behaviour at different time points among children undergoing dental treatment under local anaesthesia
A15[130]	97 4-8 years	**Group 1:** Verbal method **Group 2:** Virtual Reality **Group 3:** Digital screens	To evaluate dental pain reaction in children during administration of local anaesthesia.

Table 4: General information of the included studies cont.

Article	Sample	Groups	Aims
A16[131]	100 4-10 year	**Group 1:** Normal dental setup **Group 2:** Visual Reality Glasses 3D Box	To evaluate children's behaviour during dental treatment.
A17[132]	5 7–17 years	**1st visit:** Visual Reality Glasses 3D Box **2nd visit:** Basic behaviour guidance techniques.	To evaluate the feasibility and pain management in children and adolescents undergoing painful dental procedures.
A18[133]	40 4 - 8 years	**Group 1:** Visual Reality Glasses 3D Box **Group 2:** Basic behaviour guidance techniques.	To evaluate pain and anxiety during pulp therapy in paediatric patients considering childhood anxiety-related disorders during dental treatment.
A19[134]	60 5–8 years	**Group 1:** Tell-Show-Do (TSD) **Group 2:** Audio **Group 3:** Virtual reality **Group 4:** Mobile Phone Game	To evaluate pre and post-operative dental fear/anxiety levels using physiological and non-physiological parameters of uncooperative paediatric patients
A20[135]	90 6 to 8 years	**Group 1:** Virtual reality **Group 2**: Audio **Group 3:** TSD	To compare the efficacy of virtual reality distraction, audio distraction, and tell-show-do techniques in reducing the anxiety level of paediatric dental patients.
A21[136]	4-12 years	**Group 1:** VR device **Group 2:** Without VR device	To evaluate pain perception during local anaesthesia administered using the inferior alveolar nerve block technique and rubber dam placement during paediatric dental treatment.
A22[137]	120 5–8 years	**Group 1:** Conventional behaviour management techniques **Group 2:** Received the VR device	To evaluate pain and anxiety during short invasive dental procedures.

Table 5: Results and conclusions

Article	Results	Conclusion
A1[116]	**CPMAS:** playing VR games compared to no VR revealed a statistically significant difference ($p<0.05$). Scores were lower when VR was used across all MIH severity levels.	Children with MIH-affected teeth who are distracted from dental procedures using 3D VR games experienced less dental anxiety.
A2[117]	**FIS**: not significantly different between the groups ($P=0.068$). **MCDAS:** significantly lower in the VR group compared with the app group ($P=0.002$).	VR during dental procedures was more effective than preoperative use of dental simulation game apps for reduction of dental anxiety and fear.
A3[118]	**Pain and anxiety:** Significant reduction using VR distraction ($p<0.001$, $p=0.002$). **Salivary cortisol levels:** decrease significantly greater using VR distraction ($p<0.001$).	VR distraction can be used as a successful behaviour modification method in children undergoing short invasive dental treatments.
A4[119]	**MCDAS:** higher in non-immersive group (20.72 ± 2.822) as compared to immersive group (10.99 ± 2.227). **VAS:** higher in non-immersive group (2.72 ± 0.99) as compared to immersive group (0.75 ± 0.88). **WBFRS:** higher in non-immersive group (2.78 ± 1.097) as compared to immersive group (0.82 ± 1.104).	3D VR is an effective way to distract children during dental procedures. The immersive nature of VR was found to decrease anxiety and pain perception compared to intraoral injection in a non-immersive reality environment.
A5[120]	A**nxiety:** The decrease for the VR group and control group were 8 (7, 11) and 5 (5, 7), $p < 0.05$. **Compliance**: Same, control group 3 (2, 3), and VR intervention were 3 (3, 4), $p = 0.02$. **Pain:** Significant reduction when using VR distraction ($p < 0.05$). **Treatment time:** VR group (19.0 2 ± 5.32 min) was shorter than the control group (27.80 ± 10.40 min).	The use of VR significantly reduced the anxiety and pain of children and the length of the dental procedure and improved the compliance of children that underwent short-term dental procedures without an adverse reaction.
A6[121]	**Pain:** using VR, Group 2 had reductions in pain intensity/worst pain ($p<0.05$). Group 1 showed the predicted pattern but no significant reduction in worst pain during VR.	VR was found to be an effective distraction tool to ease pain and anxiety for children receiving painful dental procedures.

Table 5: Results and conclusions cont.

Article	Results	Conclusion
A7[122]	**Anxiety:** Significantly reduced by VR (95% of the children were happy) **Behaviour:** Improved by VR. 100% positive behaviour as compared to the control group (40% and 57.5%, respectively).	VR can effectively distract a paediatric patient, helping to reduce anxiety and manage behaviour during dental treatment
A8[123]	**Fear:** VR group was significantly decreased after dental treatment (*p* = .02). **Pain:** VR group was significantly lower than that in the control group (*p* = .015) **Behaviour:** No significant difference between VR and control group (*p* = .35) **SSQ:** No significant difference between VR and control group (*p* = .305).	The use of VR in primary teeth extraction can significantly reduce dental anxiety and pain perception in children without occurrence of simulator sickness.
A9[124]	**Anxiety:** FS, KC and VR had significantly lower scores compared to no distraction FS had the lowest score (1.1111 ± 1.2472), VR (1.8444 ± 1.7832) and KC (2.2667 ± 2.7086) **Pulse rates:** FS (97.4103 ± 16.3312) and VR (100.4103 ± 13.446) had lower mean rates. KC (107.7692 ± 18.6123) and no distraction (112.9487 ± 13.2572) had comparable high rates. **Oxygen saturation:** remained non-significant between all the Groups (p > 0.05).	Fidget spinner, kaleidoscope, and VR seem to be effective distraction methods and can be recommended as effective approaches to help alleviate children's dental anxiety during IANB procedures.
A10[125]	**Anxiety:** RV (8.3 ± 2.5) had a significant reduction compared to music (14.1 ± 4.4) and control (20.9 ± 7.2). **Pulse rate:** Music and RV groups showing less elevation in the mean pulse rate values (104.56 ± 2.9; 109.39 ± 5.0) compared to the control group (118.96 ± 13.1) **Behaviour:** highly significant reduction between control and RV (p=0.003**)	LA administration with music or 3D glasses were effective. However, high levels of satisfaction and lower level of anxiety were observed from children with 3D glasses.
A11[126]	**Anxiety:** there's a statistically significant difference (p=0.03) between the pre (3.6 ± 1.08) and post intervention (1.5 ± 0.76) when using virtual reality glasses.	VR helps the child to overcome dental anxiety during minor dental procedures.
A12[127]	**Heart rate:** significantly higher (p=0.017*) with VR (100.00 ± 15.52) compared to control group (89.44 ± 13.59). But not statistically significantly different when comparing from baseline. **Pain:** FLACC slightly higher using VR (2.58 ± 1.99) compared with the control group (2.18 ± 2.29); But not statistically significant (*P* = 0.497). WBFS lower using VR (2.40 ± 2.82) compared with the control group (2.72 ± 2.99); But not statistically significant (*P* = 0.707).	VR has a similar effect to screen distraction on heart-rate levels and pain during buccal infiltration anaesthesia among paediatric patients.

Table 5: Results and conclusions cont.

Article	Results	Conclusion
A13[128]	**Pain:** No statistically significant difference between RV and Tablet reported by WBFS (p = 0.536) and FLACC (p = 0.454). **Pulse rate:** Lower in Tablet compared to RV and control. Statistically significant difference (p = 0.043).	Tablet was the best in relieving dental anxiety and pain during IAN block. Although VR had no added advantage in a majority of children, it was more acceptable in older patients (8- 10 years).
A14[129]	**Heart rate:** Significant reduction in dental pain and anxiety was observed in the VR group. **Anxiety:** Decreased associated with the first visit sequence with VR (p=0.001). Lower during local anaesthesia in the VR group than in the APC group. **Behaviour:** No difference between the groups (p=0.978).	VR significantly reduced pain and anxiety during local anaesthesia in children undergoing dental treatment.
A15[130]	**Pain:** Less in RV (1.94±2.299) than digital screens (3.67±2.769) and highest in Verbal group (6.88±2.637). 4–6 age group (4.30±3.451) is more than in 7–8 years of age group (3.83±2.854). But no statistically significant difference (p = 0.520).	VR proved to be most effective in children and helped in reducing children's disruptive behaviour in the dental setting.
A16[131]	**Systolic blood pressure:** during the prophylaxis visit in RV (108.08) was higher as compared to the control group (106.24). During the application of local anaesthetic in RV was significantly higher than the control group children (p<0.05).	VR films made children not only less anxious and more cooperative during the invasive dental procedures.
A17[132]	**Pain:** No VR was 2.40 (SE = 1.52), and dropped to 0.60 (SD = 0.55) during virtual reality (p<0.05) “worst pain” was 3.80 (SD = 2.59) during No VR and dropped to 2.20 (SD = 1.79) during VR (p<0.05) **VR Experience, Fun and Nausea:** 7.40 (SD = 2.70) corresponding to “a strong sense of going inside the computer-generated world,” Fun during No VR (mean = 3.20, SD = 4.32) was “mildly fun” vs. “pretty fun” during Yes VR (mean = 8.20, SD = 2.49) (p<0.05).	The feasibility of using immersive, interactive VR to distract paediatric dental patients and increase fun of children during dental procedures.

Table 5: Results and conclusions cont.

Article	Results	Conclusion
A18[133]	**Pain:** Group 1, significant decrease (P < 0.001) with the use of VR (2.56 ± 0.390) during dental treatment vs. no VR (5.22 ± 0.515). Group 2, no VR (5.44 ± 0.682) and decreased (2.33 ± 0.370) with VR. **Anxiety**: significant increase (P < 0.001) with the use of VR (14.72 ± 0.843) during dental treatment vs. no VR (19.38 ± 0.897). Group 2, no VR (14.44 ± 0.805) and decreased (19.56 ± 0.883) with VR. **Pulse rate:** In treatment group 1, there was a statistically significant difference (P < 0.05) observed in pulse rate between the treatment session **I** and **II**. Group 2, no statistically significant difference	The results of this study provide an initial encouraging for the use of VR device during dental treatment by paediatric dentists, but additional empirical research is required.
A19[134]	**Blood pressure:** statistically significant difference among all the groups (*P* = 0.000), a maximum decrease in RV from 112.27 ±1.870 to 74.47 ± 2.722. **Anxiety:** RV showed the maximum decrease among all the groups from 4.73 ± 0.458 to 1.21 ± 0.426	VR was most effective and TSD alone was the least effective behaviour guidance technique in reducing dental fear/anxiety in uncooperative paediatric dental patients.
A20[135]	**Pulse rate:** Statistically significant decrease after distraction (with a p < 0.01) in all three groups. The VR distraction group was the lowest in pulse rate. **Oxygen saturation** increased in all three groups, which was statistically significant (p < 0.01). But while comparing VR to the other groups the difference was not significant (*p* = 0.270).	Children were most relaxed in VR group, followed by audio group and were least relaxed in TSD group. Hence VR distraction can be a useful technique for behaviour management of paediatric patients.
A21[136]	**Pain:** Local anaesthesia: WBFS no significant difference with and without the VR. MBPS: significantly lower in the parameters Face (*P* = .007) and Cry (*P* = .046) with VR Placement of a rubber dam: significantly less for WBFS (*P* = .005) and MBPS Face (*P* = .005), Cry (*P* = .029), and Movement (*P* = .028) when using VR.	VR can decrease pain perception during rubber dam placement in children, but it has limited benefit during administration of local anaesthesia.
A22[137]	**Pain:** Significant reduction (p<0.001) using VR. **Anxiety:** Significant reduction (p=0.002) using VR. **Salivary cortisol:** Decrease significantly greater using VR (p<0.001).	VR can be used as a successful behaviour modification method in children undergoing short invasive dental treatments

Table 6: Dental procedures performed

Article	Dental procedures
A1[116]	Composite resin
A2[117]	Infiltration of anaesthetic solution and pulpotomy and/or restoration of primary first molar
A3[118]	Formocresol pulpotomy
A4[119]	Inferior alveolar nerve block for various dental procedures
A5[120]	Short-term dental procedure (< 30 min).
A6[121]	Dental procedures not requiring local anaesthesia. Painful dental procedures requiring local anaesthesia
A7[122]	Topical anaesthesia and subsequently under intravenous anaesthesia.
A8[123]	Primary teeth extraction under local anaesthesia
A9[124]	Inferior alveolar nerve block
A10[125]	Inferior alveolar nerve block for pulp therapies in primary first and second molars.
A11[126]	Class I restoration in mandibular primary molars
A12[127]	Buccal infiltration local anaesthesia
A13[128]	Inferior alveolar nerve block
A14[129]	Class I composite resin restoration the mandibular first permanent molar tooth under local anaesthesia
A15[130]	Extraction or pulpal therapy necessitating a nerve block.
A16[131]	Dental examination, acclimatization, oral hygiene information, prophylaxis and composite filling
A17[132]	Tooth extraction or dental fillings
A18[133]	Pulp therapy treatment.
A19[134]	Composite restoration
A20[135]	Inferior alveolar nerve block for mandibular tooth extraction
A21[136]	Inferior alveolar nerve block technique and rubber dam placement
A22[137]	Short invasive dental treatment (vital pulp therapy)

Table 7: Measurement scales and protocols

Article	Measurement scales and protocols
A1[116]	**Anxiety:** The Children's Perioperative Multidimensional Anxiety Scale questionnaire (CPMAS)
A2[117]	**Behaviour:** Frankl's behaviour rating scale (Patient selection) **Anxiety:** Modified Child Dental Anxiety Scale (MCDAS) Facial Image Scale (FIS)
A3[118]	**Behaviour:** Screen for Child Anxiety Related Emotional Disorders **(**SCARED) **Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Salivary cortisol levels **Pain:** Wong Baker faces pain rating scale (WBFS)
A4[119]	**Behaviour:** Frankl's behaviour rating scale (Patient selection) **Anxiety:** Modified Child Dental Anxiety Scale (MCDAS) **Pain:** Wong Baker faces pain rating scale (WBFS) Visual Analog Scale (VAS)
A5[120]	**Behaviour:** Frankl's behaviour rating scale (Patient selection) **Pain:** Wong Baker faces pain rating scale (WBFS) **Fear:** Children's Fear Survey Schedule-Dental Subscale (CFSS-DS)
A6[121]	**Pain:** Wong Baker faces pain rating scale (WBFS) Legs, Activity, Cry, Consolability' scale (FLACC scale) Visual Analog Scale (VAS)
A7[122]	**Behaviour:** Frankl's behaviour rating scale (Patient selection) **Anxiety:** Facial Image Scale (FIS)
A8[123]	**Behavior:** Houpt Scale **Pain:** Wong Baker faces pain rating scale (WBFS) **Fear:** Children's Fear Survey Schedule-Dental Subscale (CFSS-DS) **Cybersickness:** Simulator sickness questionnaire (SSQ)
A9[124]	**Anxiety:** Venham's picture test (VPT) Pulse oximeter
A10[125]	**Behaviour:** Frankl's behaviour rating scale (Patient selection) Houpt Scale **Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Pulse rate
A11[126]	**Anxiety:** Facial Image Scale (FIS)

Table 7: Measurement scales and protocols cont

Article	Measurement scales and protocols
A12[127]	**Behaviour:** Behaviour assessment scale **Anxiety:** Pulse oximeter **Pain:** Wong Baker faces pain rating scale (WBFS) Legs, Activity, Cry, Consolability' scale (FLACC scale)
A13[128]	**Behaviour:** Behaviour assessment scale **Anxiety:** Pulse rate **Pain:** Wong Baker faces pain rating scale (WBFS)
A14[129]	**Behaviour:** Frankl's behaviour rating scale **Anxiety:** Pulse rate **Pain:** Wong Baker faces pain rating scale (WBFS)
A15[130]	**Behaviour:** Frankl's behaviour rating scale (Patient selection) **Pain:** Legs, Activity, Cry, Consolability' scale (FLACC scale)
A16[131]	**Anxiety:** Pulse rate
A17[132]	**Pain, quality of the VR experience, nausea and fun:** 0–10 graphic rating scale (Italian scale)
A18[133]	**Pain:** Wong Baker faces pain rating scale (WBFS) **Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Pulse oximeter and heart rate
A19[134]	**Anxiety:** Pulse rate Facial Image Scale (FIS)
A20[135]	**Anxiety:** Facial Image Scale (FIS) Pulse rate and oxygen saturation
A21[136]	**Pain:** Wong Baker faces pain rating scale (WBFS) Modified Behavioural Pain Scale (MBPS)
A22[137]	**Pain:** Wong Baker faces pain rating scale (WBFS) **Anxiety:** Salivary cortisol levels

Table 8: Brand and model of VR glasses

Article	Brand and model
A1[116]	VR glasses Preo VR Box (Preo, Beijing, China) and the VR game InCell VR Cardboard Android 1.4.3 (Nival Network, Moscow, Russia)
A2[117]	Not specified
A3[118]	VR device (i-glasses 920HR, Ilixco Inc., Menlo Park, CA, USA).
A4[119]	Oculus Go Standalone device (Head mounted virtual reality device with hand controller)
A5[120]	HTC's VIVE VR helmet
A6[121]	iWear Video Headphones (Vuzix®, Rochester, New York, USA
A7[122]	Zeiss Cinemizer (Carl Zeiss AG, Oberkochen, Germany) VR headset
A8[123]	VR system from HTC, wireless head-mounted helmet with noise-reducing headphones and a controller
A9[124]	VR headset (MI VR Headset, India)
A10[125]	Vuzix Eyewear Wrap 920, Rochester, NY, USA)
A11[126]	VR glasses with in-built earphones (virtual private theater system).
A12[127]	VR goggles (LG 360 virtual reality [VR] headset, LG Electronics)
A13[128]	The AV eyeglasses (BlackBug™ Virtual Reality Glasses 3D VR Box Headsets, China)
A14[129]	The VR system (PlayStation 4 VR, Sony Inc., Minato, Tokyo, Japan)
A15[130]	Not specified
A16[131]	Not specified
A17[132]	Oculus Rift DK2 and CV1 virtual reality goggles (Meta Quest, Facebook Technologies, LLC)
A18[133]	Google VR Box and Anti Tank Virtual Reality 3D Glasses
A19[134]	Not specified
A20[135]	Not specified
A21[136]	Oculus Go VR goggles from Facebook Technologies (Oculus Go virtual reality goggles, Meta Quest, Facebook Technologies, LLC)
A22[137]	VR device (i-glasses 920HR, Ilixco Inc., Menlo Park, CA, USA)

DISCUSSÃO

4. Discussão

4.1 Emergência da RV na medicina dentária

Há um número extenso de técnicas de controlo comportamental, cuja aplicação depende de aspetos específicos do paciente, dos seus pais/cuidadores, procedimento clínico e preferência do médico dentista.[60] Não obstante, há pacientes cujo comportamento se mantém desafiante, apesar do recurso a estes métodos.[137] Compreensivelmente, na medicina dentária há tratamentos considerados geradores de ansiedade ou dor, apesar do progresso na técnica e formação do profissional de saúde, como a administração da anestesia local.[36] Assim, é justificável a procura por técnicas de modulação comportamental mais eficazes, de fácil aplicação e transversais às várias faixas etárias.

A tecnologia dos meios audiovisuais tem avançado a larga escala, possibilitando ao utilizador uma experiência imersiva e bastante realista.[68,138,139] Um exemplo notável dessa evolução é o uso de ecrâs de entretenimento, como os *smartphones*, *tablets e dispositivos de RV.*[68,140] A RV surge como uma técnica apelativa, facilmente adequável aos interesses da criança ou jovem, bem aceite pelos pais e praticamente sem complicações pela sua utilização.[141]

Nesta revisão sistemática pretende-se analisar a literatura acerca do uso da RV, em pacientes pediátricos, comparando-o com outras técnicas tradicionais de modulação do comportamento, numa consulta de medicina dentária. Os estudos incluíam diversos procedimentos clínicos, desde a consulta inicial, à profilaxia dentária, a extração dentária, a anestesia infiltrativa ou por bloqueio do nervo alveolar inferior.

4.2 RV e técnicas convencionais de controlo do comportamento

Com exceção dos artigos A4[119] e A11[126].Todos os estudos incluídos nesta revisão sistemática utilizaram, como grupo de controlo, as técnicas convencionais de controlo do comportamento. Sejam elas especificadas, como nos estudos A5[120] e A19[134], que utilizaram a técnica "dizer-mostrar-fazer" ou abordadas como um conjunto, englobando técnicas verbais mais conhecidas em odontopediatria, nos restantes estudos.

Nos estudos A1[116], A2[117], A3[118], A5[120], A6[121], A7[122], A8[123], A12[127], A14[129], A16[131], A17[132], A18[133], A21[136], A22[137], apenas havia um grupo teste em que se usou a RV, No A9[124] havia outros grupos testes incluindo o uso do *Fidget spinner* e do caleidoscópio. Nos estudos A10[125] e A20[135] utilizou-se também o áudio. Nos A13[128] e A15[130] utilizou-se ecrãs digitais. No A19[134] usou-se áudio e jogos de *smartphones.*

Nesta revisão sistemática, verificou-se que, as técnicas convencionais de controle do comportamento são eficazes quando avaliadas isoladamente. Entretanto, nenhum dos estudos demonstrou que essas técnicas tradicionais foram mais eficazes na redução da ansiedade e da percepção da dor do que as demais técnicas testadas.

Este resultado pode ser justificado pela grande capacidade da RV de desviar a atenção de um ambiente desagradável, para um mundo virtual agradável e envolvente. Consequentemente, reduzindo a experiência de dor física do paciente.

Nesses casos, usar uma combinação de técnicas, como "dizer-mostrar-fazer" e RV, poderia ser mais eficaz, dado que individualiza a atenção à criança, como foi realizado em A9[124], A16[131], A18[133] e A22[137]. Em que antes da utilização dos óculos de RV foi feita uma explicação dos procedimentos, adaptada ao nível de compreensão de cada idade. Nenhum dos estudos incluídos fizeram uma comparação do uso do RV com e sem a técnica "dizer-mostrar-fazer".

4.3 RV e ecrãs digitais

Três estudos distintos investigaram a eficácia do uso de ecrãs planos digitais, em comparação com dispositivos RV, como método de distração para crianças durante consultas de medicina dentárias, com a administração de anestesia local. Os dispositivos utilizados foram um *tablet* (A13[128] e A15[130]) e um ecrã conectado a um computador acoplado à cadeira dentária (A12[127]).

Apenas o artigo A15[130] apresentou resultados favoráveis ao uso de dispositivos RV, onde a percepção de dor foi menor em comparação com os outros grupos avaliados (digital e verbal).

Por outro lado, os artigos A12[127] e A13[128] concluíram que o uso de vídeo reproduzido em dispositivos de tablet resultou no melhor alívio da ansiedade e dor dentária durante a anestesia por infiltração. Ambos utilizaram métodos de medição semelhantes, como oxímetro de pulso, escala de avaliação da dor de Wong-Baker e a escala *"Legs, Activity, Cry, Consolability"*. Ambos os estudos indicaram uma

frequência cardíaca mais elevada nos grupos que usaram dispositivos RV, além de resultados que não foram estatisticamente significativos na escala FLACC e WBFS em todos os grupos.

É importante ressaltar que a interpretação dos resultados do estudo deve ser feita com cautela, pois existem inúmeras variáveis que podem influenciar a experiência da criança durante os procedimentos dentários. O aumento observado na frequência cardíaca (FC) entre o grupo de teste, nesse estudo pode ser atribuído a vários fatores. Em primeiro lugar, o estudo concentrou-se na avaliação da dor durante a administração da anestesia, que é considerada um dos procedimentos que mais provocam medo em crianças.[142] Além disso, a maioria dos participantes do estudo não teve exposição anterior a óculos de realidade virtual, resultando numa experiência nova e potencialmente emocionante.

Em segundo lugar, muitos dos indivíduos tinham experiências dentárias anteriores e estavam cientes de que provavelmente receberiam anestesia. E, finalmente, o facto dos óculos de RV bloquearem a visão do mundo real e a falta de visualização dos seus cuidadores no campo visual, podem ter causado uma sensação de isolamento e maior antecipação de um estímulo desagradável, levando ao aumento da ansiedade e da frequência cardíaca. Por outro lado, a tecnologia dos tablets ou smartphones que reproduzem vídeos é mais acessível no quotidiano das crianças. Estando mais familiarizadas com o seu funcionamento.

4.4 RV e áudio

Três estudos (A10[125], A19[134] e A20[135]) conduzidos na Índia exploram a eficácia de diferentes técnicas na redução do nível de ansiedade de pacientes pediátricos durante procedimentos dentários. Dentre elas a RV e o áudio.

Estes estudos sugerem que as técnicas de distração de áudio e RV podem ser eficazes na redução da ansiedade dentária em pacientes pediátricos quando comparada com os seus grupos controlo, que usaram a técnica “Dizer-Mostrar-Fazer”. Entretanto, a distração realizada com a RV pode ser uma técnica ainda mais eficaz na redução do nível de ansiedade e percepção da dor.

A utilização de música no ambiente dentário, como método de distração, é largamente utilizada e a sua eficácia é comprovada por diversos estudos. Por vezes é relatado que as crianças pedem para que repitam as mesmas músicas nas

consultas seguintes.[63,67] Apesar disso, a geração de crianças que são atendidas atualmente nos consultórios dentários são cada vez mais experientes em tecnologia, assim manter a sua atenção, torna-se mais difícil com métodos não eletrónicos.[143,144] Logo, RV demonstrou ser, nessa categoria, uma alternativa viável para o controlo do comportamento.

4.5 RV e jogos para *smartphones*

Apenas o estudo A19[134] inclui jogos para *smartphones*. Eles utilizaram um design controlado randomizado e incluíram 120 crianças de 4 a 8 anos aleatoriamente distribuídas por quatro grupos: técnica “Dizer-Mostrar-Fazer”, técnica de reforço positivo, técnica de RV e jogo para *smartphones*.

O estudo sugere que as técnicas de distração de RV e de jogos para *smartphones* foram as mais eficazes no controlo do comportamento negativo, em pacientes odontopediátricos, entre os quatro grupos. No entanto, ao comparar a eficácia dessas técnicas de distração entre elas. A técnica de distração VR foi considerada mais eficaz do que a técnica de distração do jogo para *smartphones*. É importante considerar que a técnica de distração com RV proporcionou uma experiência mais imersiva e interativa, o que pode ter contribuído para sua maior eficácia.

4.6 RV imersivo e não imersivo

Apenas um estudo (A4[119]) avaliou a relação do tipo de imersão da RV na percepção de dor, durante as injeções intraorais. Nele foi definido como RV imersiva, quando o equipamento envolvia o uso de um fone de ouvido com áudio binaural e um ambiente virtual interativo em 3D, enquanto o RV não imersivo envolvia apenas assistir a um vídeo em 2D sem fones de ouvido. O RV imersivo foi projetado para proporcionar uma experiência mais envolvente e imersiva do que o RV não imersivo.

Os resultados mostraram que ambos os métodos de distração foram eficazes em reduzir a percepção de dor, sendo a realidade virtual imersiva ligeiramente mais eficaz do que a não imersiva.

Uma possível explicação para a diferença reduzida entre os dois grupos, pode ser o facto de que ambos os tipos de RV foram igualmente eficazes em desviar a

atenção do paciente da dor. Por ambos isolarem o campo visual, impedem o contacto com objetos que podem servir de gatilho para ansiedade e medo.

A razão para esta diferença, apesar de pequena, na eficácia pode dever-se ao facto de a distração imersiva da RV criar uma experiência sensorial mais completa e envolvente que capta totalmente a atenção do utilizador e proporciona uma maior sensação de imersão e presença no ambiente virtual.[72] A utilização de imagens em 3 dimensões e auricular binaural, pode levar a um maior grau de distração do estímulo doloroso, resultando numa maior redução na percepção da dor.[86]

É importante notar, no entanto, que o estudo tem várias limitações que podem afetar a generalização dos resultados. Por exemplo, o tamanho da amostra foi relativamente pequeno e não representativo da população geral. Além disso, o estudo mediu apenas a percepção da dor imediatamente após a injeção, e não avaliou o efeito da distração por RV noutros aspectos do tratamento, como a ansiedade do paciente ou a satisfação geral do paciente com o tratamento.

4.7 Outras observações

Além das comparações entre RV e as demais técnicas de modulação do comportamento, é importante entender as outras variantes que um tratamento com imersão tridimensional pode ter. Eles são: a experiência do médico-dentista, a idade do paciente, o risco à saúde dos pacientes, a prevenção a esses riscos e o valor do investimento.

4.7.1 RV e a experiência do médico - dentista

Embora os óculos de RV possam parecer uma opção interessante para tornar os tratamentos dentários mais confortáveis e agradáveis para os pacientes, é importante considerar a experiência proporcionada ao profissional e considerar suas vantagens e desvantagens.

A primeira delas é o custo da tecnologia. Que a depender do modelo e marca, pode ter um custo é relativamente alto e não ser acessível para todos os profissionais.[69,145]

Além disso, a RV, pode ser considerada uma forma de distanciamento do paciente.[70,86] O uso de óculos de RV pode criar barreiras de comunicação entre pacientes e profissionais de saúde, uma vez que o paciente pode estar imerso em um

ambiente virtual e com visão limitada do mundo real ao seu redor.[119,146] Isso pode dificultar a comunicação verbal e não verbal, pois o profissional de saúde pode não ter uma visão clara das expressões faciais, gestos e outras pistas de comunicação do paciente.

Os óculos de RV, dependendo do formato e tamanho, podem dificultar o acesso à cavidade oral do paciente. Em especial, no bloqueio do nervo alveolar inferior.[147]

Em algumas crianças, especialmente aquelas em idade escolar, a ausência dos cuidadores no campo visual pode levar a um aumento da ansiedade, e consequentemente, baixa cooperação.[148]

Por fim, com a utilização da VR, é possível que o profissional economize tempo e aumente a sua eficiência no diagnóstico e no tratamento. No entanto, é necessário que o dentista tenha conhecimento e habilidade no uso da tecnologia, o que pode exigir um período de adaptação e treino.

Apenas um estudo (A17[132]) reportou a experiência do médico-dentista ao utilizar a RV, a qual foi positiva. Os profissionais sentiram-se mais relaxados, o que possibilitou ter mais concentração em seu trabalho. Neste caso, o tamanho dos óculos de RV não impediu a realização dos procedimentos dentários. Não houve também dificuldade de comunicação com o paciente, apesar de existirem auriculares no modelo de RV utilizado.

4.7.2 RV e os riscos à saúde

O uso de óculos de RV tem aumentado em popularidade nos últimos anos, especialmente com a crescente disponibilidade de dispositivos acessíveis e a melhoria da tecnologia.[149] Embora os óculos de RV possam proporcionar uma experiência imersiva e divertida, o uso desses dispositivos pode levar a problemas de saúde.[150]

Uma das principais preocupações em relação ao uso da realidade virtual é o efeito que ela pode ter sobre os olhos.[151] O uso prolongado do equipamento pode causar fadiga ocular, desidratação dos olhos e até mesmo problemas de visão a longo prazo, como miopia. Além disso, a realidade virtual pode gerar enxaquecas e tonturas em algumas pessoas, especialmente quando utilizada por períodos prolongados ou em jogos com muitos movimentos bruscos.[111,151]

Um dos problemas de saúde mais comuns associados ao uso de óculos de VR é o "enjoo de movimento" ou *cybersickness*.[152] Isto ocorre quando a informação visual que o utilizador recebe através dos óculos de RV não corresponde ao seu movimento físico real, levando a uma sensação de tontura, náusea e desorientação.[153] Pela mesma razão, a imersão pode gerar reflexo com movimentos de cabeça, braços ou até mesmo tronco, podendo haver um aumento do risco de quedas ou lesões durante o tratamento a depender do estágio de atendimento.

Outro problema de saúde potencialmente grave associado ao uso de óculos de RV é a epilepsia fotossensível.[154] Alguns estudos mostraram que a exposição a certos padrões de luz e cor em ambientes de RV pode desencadear convulsões em pessoas com predisposição à epilepsia.[155] Portanto, é importante que os desenvolvedores de aplicativos de VR tomem medidas para evitar o risco de convulsões.

Além disso, o uso prolongado de óculos de VR pode levar a problemas de saúde mental, como ansiedade e depressão.[156] Embora a pesquisa ainda seja limitada nessa área, alguns estudos mostraram que a imersão em ambientes virtuais pode levar à dissociação da realidade e ao isolamento social.[111]

Embora os óculos de RV ofereçam uma experiência de entretenimento única e emocionante, é importante usá-los com moderação e estar ciente dos riscos de saúde associados.[150] O diagnóstico preciso do profissional para selecionar os casos em que a tecnologia será usada e o treino correto para minimizar os efeitos adversos da tecnologia será a chave para o sucesso do tratamento.

4.7.3 RV e a idade

Muito se debate quanto à idade apropriada para a utilização de equipamento digitais, tais como smartphones e tablets.[124] A realidade virtual, por ser uma tecnologia mais recente, necessita de mais estudos. Atualmente, temos apenas estudos de curta duração sem avaliação a longo prazo dos efeitos dessa tecnologia nas diferentes faixas etárias.

Crianças menores de 6 anos estão em uma fase de desenvolvimento em que estão adquirindo e melhorando suas habilidades motoras finas e habilidades de linguagem. Nessa idade, eles podem ter dificuldade em articular seus sentimentos e sensações de forma precisa e verbalizada, especialmente quando se trata de desconforto físico ou sintomas específicos.[157]

Dessa forma, podem não possuir o conhecimento e as habilidades necessárias para articular o desconforto ocular e remover os visores montados na cabeça ou *Head Mounted Devices* (HMD) se os acharem desconfortáveis. Consequentemente, há uma necessidade de educadores e pais estarem atentos à saúde ocular das crianças ao usar HMDs e encorajar pausas frequentes para aliviar a tensão e o potencial desconforto ocular. Além disso, de acordo com o estudo[158], verificou-se que a adoção de um design ergonômico e o uso de conteúdo apropriado para a idade são aspectos essenciais na redução do risco de problemas oculares associados ao uso prolongado de headset de realidade virtual em crianças jovens.

Muitas empresas de hardware de mídia imersiva estabeleceram recomendações de segurança para a utilização dos seus produtos. Dentre elas, indicam uma faixa etária em que a consideram segura. Empresas como Sony Interactive Entertainment[159], Oculus[160], Playstation[161] e Samsung[162], declararam explicitamente que os seus produtos não são recomendados para crianças menores de 12 ou 13 anos. A LG[163] é a que apresenta o limite mais alto para o utilizador, 15 anos. A HTC[164], inserida no estudo A5[120], possui o limite mais baixo de todos, 4 anos. Além de não possuir "modo de segurança" nos seus aparelhos.

Alguns estudos não especificaram a marca do equipamento utilizada na pesquisa (Tabela 9), a maioria dos artigos desta revisão sistemática fez uso de óculos de RV em crianças abaixo da recomendação de faixa etária dos respectivos fabricantes.

No estudo A13[128], foi relatado que em algumas crianças o dispositivo não ficou devidamente ajustado a cabeça. Essa situação pode surgir devido ao fato de que os óculos de realidade virtual (assim como os fones de ouvido) são inicialmente projetados para atender às necessidades dos adultos, o que implica em dificuldades de adaptação às dimensões das crianças.

4.7.4 Prevenção de efeitos adversos

Para mitigar os efeitos negativos da RV, têm-se investigado o uso de exercícios oculomotores e pausas durante o consumo de conteúdo de RV. Park *et al*. 2017 realizou um estudo na redução da *cybersickness* por exercício oculomotor. Esse consiste em quatro etapas: exercícios óculo-motores de alcance, sacádicos, de busca e de vergência. (Tabela 10) Sendo realizados imediatamente antes da utilização de

óculos de realidade virtual. De acordo com os achados, os exercícios oculomotores sugeridos demonstram um método eficiente para aliviar o *cybersickness*.

Pausas durante a utilização dos óculos pode ser mais uma estratégia para prevenir e aliviar a fadiga ocular digital. Para a Academia Americana de Oftalmologia, em 2020, sugeriu uma pausa de 20 segundos a cada 20 minutos imerso na realidade virtual.[166] Essa pausa deverá ser feita a olhar em frente, ou pausas de 15 em 15 minutos de acordo com a sugestão de 2020 do Departamento do Reino Unido para Energia Empresarial e Estratégia Industrial.[167]

Nenhum dos estudos incluídos reportou um protocolo de prevenção das lesões oculares.

Tabela 10: Paradigm of oculomotor exercise

Exercise order	Procedure	Exercise duration	Ordem de exercício
1. Range oculo-motor exercise	1) Close your eyes. 2) Slowly left-right, up-down, diagonal, and rotate your eyes.	75 seconds	
2. Saccadic oculo-motor exercise	The eyes are fixated on newly appearing objects.	75 seconds	
3. Pursuit oculo-motor exercise	Keep your eyes fixated on slowly moving objects.	75 seconds	5 times
4. Vergence oculo-motor exercises	1) Move your eyes slowly from the nearest point to a point far away (about 5 cm → about 50 cm). 2) Move your eyes slowly from a point far away to a point nearby (about 50 cm → about 5 cm).	75 seconds	

4.7.5 *Cybersickness*

A avaliação do *cybersickness* é de extrema importância no campo da VR e simuladores.[168] A *cybersickness* refere-se ao desconforto e sintomas experimentados por indivíduos quando expostos a ambientes virtuais, como *headsets* VR ou simuladores. Pode se manifestar como náusea, tontura, dor de cabeça, fadiga ocular

e desconforto geral, impactando significativamente a experiência do utilizador e potencialmente limitando a eficácia dos aplicativos de RV.[153,169]

A avaliação do *cybersickness* permite que pesquisadores e desenvolvedores entendam sua prevalência, gravidade e possíveis fatores contribuintes, permitindo a implementação de estratégias de mitigação e melhorias no design de RV.[170] Além disso, a avaliação do *cybersickness* fornece informações valiosas sobre as diferenças individuais de suscetibilidade, auxiliando no desenvolvimento de experiências de RV personalizadas e aumentando a satisfação do usuário.[152]

A avaliação do c*ybersickness* normalmente envolve medidas subjetivas de autorrelato, medições fisiológicas objetivas e observações comportamentais.[171]

Além disso, observações comportamentais, incluindo mudanças na postura, marcha e coordenação motora geral, podem ser usadas para avaliar o impacto do cybersickness. A combinação dessas abordagens de avaliação permite uma avaliação abrangente do *cybersickness*, fornecendo dados valiosos para a melhoria das tecnologias de RV e das experiências do usuário.[170]

4.7.6 Investimento

O valor investido num aparelho de imersão 3D vai depender do tipo de óculos escolhido. No mercado, atualmente, existem os *cardboard*, *high experience* e *gamer*.[69]

O modelo *cardboard* pertence à categoria mais económica do mercado devido à sua construção em papelão e por não possuir um ecrã próprio, mas utilizar a do telemóvel.[172,173] É possível encontrar equipamentos dessa categoria entre 6 e 20 euros no mercado português.[174,175]

Na *high experience* apesar de usar o *smartphone* como ecrã, conta com software e hardware próprios, dessa maneira, podem oferecer uma melhor qualidade de imersão.[69] Os óculos mais acessíveis dessa categoria custam 300 euros.[176]

Os equipamentos de RV mais caros são os óculos *gamers*, o seu preço pode começar em 1500 euros, sem o computador compatível para fazer a conexão. São os mais procurados por jogadores profissionais, por oferecerem um desempenho superior em comparação aos demais.[145] Devido à melhor resolução, necessitam de um computador de alta performance para transmitir os jogos. Para uma consulta dentária, esse equipamento não parece justificar a aquisição.[177]

4.8 Avaliação da qualidade de risco de viés

A avaliação da qualidade dos estudos foi realizada por meio do preenchimento da Escala de Newcastle Ottawa (NOS) (Anexo 2). A pontuação total de cada estudo determinou sua classificação. Para cada tipo de estudo, há um conjunto específico de questões que se aplicam. Cada resposta às perguntas recebe um valor em asterisco (*).[178]

O valor total é apresentado numericamente, sendo que cada asterisco corresponde a um ponto, totalizando de zero a nove pontos. Com base na pontuação total da escala Newcastle-Ottawa, é possível determinar o grau de viés: se for menor ou igual a seis, o estudo apresenta alto risco de viés; se for entre sete e oito, o estudo apresenta risco moderado de viés; e se for maior ou igual a nove, o estudo apresenta baixo risco de viés.[179]

A tabela 11 apresenta a Escala de Newcastle Ottawa para os estudos incluídos nesta revisão. A análise da tabela revela que 2 artigos obtiveram um valor $\geq$ 9, indicando um risco baixo de viés e 13 artigos com valor entre 7 e 8, classificados como risco moderado. Já nos outros 7 artigos, o valor $\leq$ 6 representa um risco elevado de viés.

4.9 Reflexão crítica

Tendo em conta os artigos selecionados nesta revisão sistemática e o que foi referido anteriormente, alguns estudos apresentavam limitações devido ao tamanho reduzido da amostra, fatores associados com o desenho do estudo e pelo facto da exposição à tecnologia RV ser ocasional, não aferindo o seu efeito a médio prazo.

Na população pediátrica há também que considerar aspetos socio-culturais, os quais poderão ter afetado a resposta à intervenção. Por outro lado, a diversidade dos tratamentos dentários considerados e as escalas de ansiedade e dor dificultam a comparação entre os estudos.

Nesta revisão sistemática utilizaram-se 3 bases de dados e a metodologia PRISMA. Não obstante, não está destituída de limitações como, por exemplo, pelo viés na seleção dos artigos, de acordo com os critérios de inclusão e exclusão. De

facto, apesar da metodologia rigorosa, existe a possibilidade da eliminação de artigos importantes, devido à utilização de filtros de linguagem, limitação temporal e tipo de estudo.

Nesta revisão sistemática, também foram analisados os diversos modelos e marcas comerciais de óculos de RV. Dos 22 artigos incluídos, apenas 5 não forneceram informações sobre o dispositivo de RV utilizado, o que impossibilitou a análise da correlação dos resultados com o tamanho, peso ou indicações de segurança do dispositivo.

Tabela 11: Modified Newcastle - Ottawa (NOS)

Article	Selection	Comparability	Exposure	Total score Risk: $\leq$ 6 = high 7 to 8 = moderate $\geq$ 9 = low
A1[116]	***	*	***	7
A2[117]	***	*	***	7
A3[118]	****	*	***	8
A4[119]	****	*	**	7
A5[120]	****	*	**	7
A6[121]	**	*	**	5
A7[122]	***	*	**	6
A8[123]	**	*	***	6
A9[124]	***	*	**	6
A10[125]	****	*	***	8
A11[126]	***	*	**	6
A12[127]	***	*	***	7
A13[128]	****	*	****	9
A14[129]	****	*	***	8
A15[130]	****	*	**	7
A16[131]	***	*	***	6
A17[132]	***	*	**	6
A18[133]	****	*	****	9
A19[134]	****	*	***	8
A20[135]	****	*	***	8
A21[136]	****	*	**	7
A22[137]	****	*	***	8

CONCLUSÃO

5. Conclusão

Esta revisão sistemática teve como objetivo responder à pergunta: "Na população pediátrica, a realidade virtual auxilia no controlo da ansiedade e dor durante as consultas de medicina dentária, em comparação com outras técnicas de controle comportamental?" Por meio de uma análise abrangente dos artigos selecionados, foram investigados os efeitos da RV na ansiedade e na percepção da dor durante diferentes procedimentos dentários em odontopediatria.

Os resultados demonstram consistentemente que a RV pode efetivamente reduzir os níveis de ansiedade e dor em crianças submetidas a tratamento dentário. Ao fornecer uma experiência imersiva e envolvente, a RV ajuda a desviar a atenção dos pacientes do ambiente médico, levando a uma experiência mais positiva e agradável. Essa técnica de distração tem-se mostrado mais eficaz do que os métodos tradicionais, como distrações audiovisuais, distrações passivas e comandos verbais. No entanto, apesar dos achados promissores, é importante reconhecer as limitações das evidências atuais.

A maioria dos estudos tinha amostras pequenas e a sua metodologia e intervenções de RV eram variáveis. No futuro, espera-se que os estudos incluam tamanhos de amostra maiores e protocolos padronizados para obter resultados mais robustos e generalizáveis. Além disso, examinar a faixa etária ideal para implementação da RV, o custo-benefício e identificar os procedimentos dentários que mais beneficiam da intervenção de RV garantirá a integração segura e apropriada da tecnologia VR na prática odontopediátrica de rotina.

Para aproveitar plenamente os seus benefícios e minimizar os riscos potenciais, há uma necessidade crítica de estabelecer diretrizes claras e protocolos padronizados para a sua implementação segura e eficaz no atendimento odontopediátrico. Ao atingir esse delicado equilíbrio, a RV tem o poder de transformar a experiência médico-dentária das crianças, melhorando os resultados do tratamento e, por fim, promovendo o seu bem-estar geral, abrindo caminho para um futuro em que as tecnologias inovadoras moldarão o cenário da odontopediatria.

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ANEXOS

1 # 7. Anexos

2

3 ## 7.1 Submissão PROSPERO

PROSPERO
International prospective register of systematic reviews

UNIVERSITY *of York*
Centre for Reviews and Dissemination

Systematic review

A list of fields that can be edited in an update can be found here

1. * Review title.

Give the title of the review in English

Virtual reality in Pediatric Dentistry, indications and therapeutic potential – a systematic review

2. Original language title.

For reviews in languages other than English, give the title in the original language. This will be displayed with the English language title.

Realidade virtual em Odontopediatria, indicações e potencial terapêutico – uma revisão sistemática

3. * Anticipated or actual start date.

Give the date the systematic review started or is expected to start.

03/04/2023

4. * Anticipated completion date.

Give the date by which the review is expected to be completed.

31/07/2023

5. * Stage of review at time of this submission.

This field uses answers to initial screening questions. It cannot be edited until after registration.

Tick the boxes to show which review tasks have been started and which have been completed.

Update this field each time any amendments are made to a published record.

The review has not yet started: Yes

4

5

Review stage	Started	Completed
Preliminary searches	No	No
Piloting of the study selection process	No	No
Formal screening of search results against eligibility criteria	No	No
Data extraction	No	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

Provide any other relevant information about the stage of the review here.

6. * Named contact.

The named contact is the guarantor for the accuracy of the information in the register record. This may be any member of the review team.

Diana Padilha

Email salutation (e.g. "Dr Smith" or "Joanne") for correspondence:

Miss Padilha

7. * Named contact email.

Give the electronic email address of the named contact.

dra.dianapadilha@gmail.com

8. Named contact address

Give the full institutional/organisational postal address for the named contact.

Universidade Católica Portuguesa

Estrada da Circunvalação 3504-505 Viseu

6
7
8

9. Named contact phone number.

Give the telephone number for the named contact, including international dialling code.

00351232419500

10. * Organisational affiliation of the review.

Full title of the organisational affiliations for this review and website address if available. This field may be completed as 'None' if the review is not affiliated to any organisation.

Universidade Católica Portuguesa, Faculty of Dental Medicine, Viseu, Portugal

Organisation web address:

https://fmd.viseu.ucp.pt/pt-pt

11. * Review team members and their organisational affiliations.

Give the personal details and the organisational affiliations of each member of the review team. Affiliation refers to groups or organisations to which review team members belong. **NOTE: email and country now MUST be entered for each person, unless you are amending a published record.**

Miss Diana Padilha. Universidade Católica Portuguesa
Dr Patrícia Correia. Universidade Católica Portuguesa
Dr Ana Moura. Universidade Católica Portuguesa

12. * Funding sources/sponsors.

Details of the individuals, organizations, groups, companies or other legal entities who have funded or sponsored the review.

Not applicable

Grant number(s)

State the funder, grant or award number and the date of award

Not applicable

13. * Conflicts of interest.

List actual or perceived conflicts of interest (financial or academic).

None

14. Collaborators.

Give the name and affiliation of any individuals or organisations who are working on the review but who are

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10
11

not listed as review team members. **NOTE: email and country must be completed for each person, unless you are amending a published record.**

15. * Review question.

State the review question(s) clearly and precisely. It may be appropriate to break very broad questions down into a series of related more specific questions. Questions may be framed or refined using PI(E)COS or similar where relevant.

This review aims to study the following question: In the pediatric population (P), virtual reality (I) helps to control anxiety and pain (O) in a dental medicine consultation compared to other behavioral control techniques (C)?

16. * Searches.

State the sources that will be searched (e.g. Medline). Give the search dates, and any restrictions (e.g. language or publication date). Do NOT enter the full search strategy (it may be provided as a link or attachment below.)

The bibliographical research will be carried out in the PubMed/MEDLINE® databases, Scopus and Web of Science, aiming to answer the research question, considering the previously defined objective and criteria. Using PubMed, different MeSH terms (medical subject headings) and keywords will be combined, with Boolean operators, AND and OR. Using Scopus and Web of Science will apply the same search strategy, with free text terms

Searches will be restricted to English. Articles from 2003 to 2023

17. URL to search strategy.

Upload a file with your search strategy, or an example of a search strategy for a specific database, (including the keywords) in pdf or word format. In doing so you are consenting to the file being made publicly accessible. Or provide a URL or link to the strategy. Do NOT provide links to your search **results**.

Not applicable

Alternatively, upload your search strategy to CRD in pdf format. Please note that by doing so you are consenting to the file being made publicly accessible.

Do not make this file publicly available until the review is complete

18. * Condition or domain being studied.

Give a short description of the disease, condition or healthcare domain being studied in your systematic review.

In the daily clinical work of a pediatric dentist, the most important factor that negatively affects dental treatment is fear and apprehension regarding dental treatment. Although most procedures do not cause pain, often triggers anxiety. It can lead to excessive symptoms, such as sweating, tremor, rapid heartbeat, nausea, vomiting or even fainting.

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The lack of anxiety control during the visit to the dentist can make treatment difficult and even lead to avoidance/refusal of health care, worsening the patient's general health condition.

In pediatric dentistry, the control of fear and anxiety by Non-pharmacological behavior control techniques are based on distraction/motivation. In this context, Virtual Reality can be used as a distraction measure during painful clinical procedures.

Virtual reality is a three-dimensional simulation technology that can be used interactively through a computer. Virtual reality creates an artificial environment that mimics the real world, allowing users to experience an alternate world. The virtual experience provides multi-sensory information through synchronization between 3D audiovisual goggles , motion sensors and joysticks.

The use of these 3D Audiovisual goggles comprise one of the most advanced Audiovisual resources available for the public and therefore it is relevant to study them for their use in Dentists appointment.

19. * Participants/population.

Specify the participants or populations being studied in the review. The preferred format includes details of both inclusion and exclusion criteria.

Patients under 18 years old, any gender, without visual and/or hearing impairment

20. * Intervention(s), exposure(s).

Give full and clear descriptions or definitions of the interventions or the exposures to be reviewed. The preferred format includes details of both inclusion and exclusion criteria.

Use of virtual reality interventions to help relieve anxiety and pain during dental procedures.

21. * Comparator(s)/control.

Where relevant, give details of the alternatives against which the intervention/exposure will be compared (e.g. another intervention or a non-exposed control group). The preferred format includes details of both inclusion and exclusion criteria.

Use of traditional child behavior management to help relieve anxiety and pain during dental procedures

22. * Types of study to be included.

Give details of the study designs (e.g. RCT) that are eligible for inclusion in the review. The preferred format includes both inclusion and exclusion criteria. If there are no restrictions on the types of study, this should be stated.

Inclusion criteria: (1) studies designed as randomized controlled trials (RCTs), experimental and case-control study designs

with a full-text report

(2)Articles from 2003-2023?

(3) children under 18, female or male

(4) Used virtual reality interventions to help relieve anxiety and pain during dental procedures

Exclusion criteria:

(1) Systematic/narrative reviews and meta-analyses, case reports, or duplicated publications

(2) Studies without a full text report

(4) Patients with any visual and/or hearing impairment.

(5) Use of 2D devices

23. Context.

Give summary details of the setting or other relevant characteristics, which help define the inclusion or exclusion criteria.

Not applicable

24. * Main outcome(s).

Give the pre-specified main (most important) outcomes of the review, including details of how the outcome is defined and measured and when these measurement are made, if these are part of the review inclusion criteria.

The main outcomes is to identify changes in fear, anxiety or pain during dental treatments using Virtual

Reality compared to traditional child behavior management techniques

Measures of effect

Please specify the effect measure(s) for you main outcome(s) e.g. relative risks, odds ratios, risk difference, and/or 'number needed to treat.

Not applicable

25. * Additional outcome(s).

List the pre-specified additional outcomes of the review, with a similar level of detail to that required for main outcomes. Where there are no additional outcomes please state ‘None’ or ‘Not applicable’ as appropriate to the review

Not applicable

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Measures of effect

Please specify the effect measure(s) for you additional outcome(s) e.g. relative risks, odds ratios, risk difference, and/or 'number needed to treat.

Not applicable

26. * Data extraction (selection and coding).

Describe how studies will be selected for inclusion. State what data will be extracted or obtained. State how this will be done and recorded.

-Defined the research question through PICO format (Population, Intervention, Comparison, Outcome)

-PRISMA guidelines will be used through the search strategy.

-Papers/ studies selection will be screened by two investigators independently and by a third reviewer, in case of discrepancies.

-Data extractions of selected papers/ studies will be recorded in a standardized form.

-The following items will be extracted: year, authors, country, study type, participants (gender, age), control/study group, aims, main findings.

27. * Risk of bias (quality) assessment.

State which characteristics of the studies will be assessed and/or any formal risk of bias/quality assessment tools that will be used.

-State which characteristics of the studies will be assessed and/or any formal risk of bias/quality assessment tools that will be used.

-Risk bias will be addressed utilizing the the Newcastle- Ottawa Scale

The results of the risk of bias assessment will be presented in the review and will

provide an overall risk of bias assessment of all included studies.

-Studies will be considered:

Good quality: 3 or 4 stars in selection domain AND 1 or 2 stars in comparability domain AND 2.

Fair quality: 2 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3.

Poor quality: 0 or 1 star in selection domain OR 0 stars in comparability domain OR 0 or 1 stars.

28. * Strategy for data synthesis.

Describe the methods you plan to use to synthesise data. This **must not be generic text** but should be **specific to your review** and describe how the proposed approach will be applied to your data. If meta-analysis is planned, describe the models to be used, methods to explore statistical heterogeneity, and software package to be used.

We will present data according to the papers/study design, in a table format and narrative summary.
The following items will be included: the year, authors, country, study type, participants (gender, age),

control/study group, aims, main findings.

29. * Analysis of subgroups or subsets.

State any planned investigation of 'subgroups'. Be clear and specific about which type of study or participant will be included in each group or covariate investigated. State the planned analytic approach.

If possible, all data will be analyzed according to the following subgroups:
1)What kind of dental appointment/dental procedure

2)Type of child behavior management used as control group

3)Main findings

30. * Type and method of review.

Select the type of review, review method and health area from the lists below.

Type of review

Cost effectiveness

No

Diagnostic

No

Epidemiologic

No

Individual patient data (IPD) meta-analysis

No

24

25

26

Intervention
No

Living systematic review
No

Meta-analysis
No

Methodology
No

Narrative synthesis
No

Network meta-analysis
No

Pre-clinical
No

Prevention
No

Prognostic
No

Prospective meta-analysis (PMA)
No

Review of reviews
No

Service delivery
No

Synthesis of qualitative studies
No

Systematic review
Yes

Other
No

Health area of the review

Alcohol/substance misuse/abuse
No

Blood and immune system
No

Cancer
No

Cardiovascular
No

Care of the elderly
No

Child health
Yes

Complementary therapies
No

COVID-19
No

Crime and justice
No

Dental
Yes

Digestive system
No

Ear, nose and throat
No

Education
No

Endocrine and metabolic disorders
No

Eye disorders
No

General interest
No

Genetics
No

Health inequalities/health equity
No

Infections and infestations
No

International development
No

Mental health and behavioural conditions

No

Musculoskeletal
No

Neurological
No

Nursing
No

Obstetrics and gynaecology
No

Oral health
Yes

Palliative care
No

Perioperative care
No

Physiotherapy
No

Pregnancy and childbirth
No

Public health (including social determinants of health)
No

Rehabilitation
No

Respiratory disorders
No

Service delivery
No

Skin disorders
No

Social care
No

Surgery
No

Tropical Medicine
No

Urological

No

Wounds, injuries and accidents

No

Violence and abuse

No

31. Language.

Select each language individually to add it to the list below, use the bin icon to remove any added in error.

English

Portuguese-Brazil

There is not an English language summary

32. * Country.

Select the country in which the review is being carried out. For multi-national collaborations select all the countries involved.

Portugal

33. Other registration details.

Name any other organisation where the systematic review title or protocol is registered (e.g. Campbell, or The Joanna Briggs Institute) together with any unique identification number assigned by them. If extracted data will be stored and made available through a repository such as the Systematic Review Data Repository (SRDR), details and a link should be included here. If none, leave blank.

Not applicable

34. Reference and/or URL for published protocol.

If the protocol for this review is published provide details (authors, title and journal details, preferably in Vancouver format)

Not applicable

Add web link to the published protocol.

This file will be publicly available when the review is complete

Or, upload your published protocol here in pdf format. Note that the upload will be publicly accessible.

No I do not make this file publicly available until the review is complete

Please note that the information required in the PROSPERO registration form must be completed in full even if access to a protocol is given.

35. Dissemination plans.

Do you intend to publish the review on completion?

Yes

Give brief details of plans for communicating review findings.?

After completion of the systematic review a scientific paper will be written. We intend well to present the results of this research in national or international scientific congresses

36. Keywords.

Give words or phrases that best describe the review. Separate keywords with a semicolon or new line. Keywords help PROSPERO users find your review (keywords do not appear in the public record but are included in searches). Be as specific and precise as possible. Avoid acronyms and abbreviations unless these are in wide use.

Virtual Reality, Virtual Reality Exposure Therapy, Paediatric dentistry, Distraction, dental anxiety, Pain Management

37. Details of any existing review of the same topic by the same authors.

If you are registering an update of an existing review give details of the earlier versions and include a full bibliographic reference, if available.

Not applicable

38. * Current review status.

Update review status when the review is completed and when it is published.New registrations must be ongoing so this field is not editable for initial submission.

Please provide anticipated publication date

Review_Ongoing

39. Any additional information.

Provide any other information relevant to the registration of this review.

Not applicable

40. Details of final report/publication(s) or preprints if available.

Leave empty until publication details are available OR you have a link to a preprint (NOTE: this field is not editable for initial submission). List authors, title and journal details preferably in Vancouver format.

Give the link to the published review or preprint.

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45 **7.2 Escala Newcastle Ottawa**

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE: RANDOMIZED CONTROLLED TRIAL

Note: A study can be awarded a maximum of one star (*) for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

1) Is the case definition adequate?
    a) yes, with independent validation *
    b) yes, e.g., record linkage or based on self reports
    c) no description
2) Representativeness of the cases
    a) consecutive or obviously representative series of cases *
    b) potential for selection biases or not stated
3) Selection of Controls
    a) community controls *
    b) hospital controls
    c) no description
4) Definition of Controls
    a) no history of disease (endpoint) *
    b) no description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis
    a) study controls for _______________ (Select the most important factor.) *
    b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

1) Ascertainment of exposure
    a) secure record (eg surgical records) *
    b) structured interview where blind to case/control status *
    c) interview not blinded to case/control status
    d) written self report or medical record only
    e) no description
2) Same method of ascertainment for cases and controls
    a) yes *
    b) no
3) Non-Response rate
    a) same rate for both groups *
    b) non respondents described
    c) rate different and no designation

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7.3 Artigo preparado para submissão no BMC Oral Health

Virtual Reality and Behaviour Management in Paediatric Dentistry: A Systematic Review

ABSTRACT

Background: Virtual reality (VR) has emerged as an innovative tool in medicine and dentistry, improving anxiety and pain management in children. The immersive and interactive environments of VR technology helps distract and engage young patients during dental procedures, potentially reducing anxiety levels and improving treatment experience. The aim of this review was to provide current evidence-based guidance on the usage of VR in the clinical practice of paediatric dentistry.

Methods: A systematic review was conducted according to the PRISMA guidelines with the following research question using the PICO format: Does VR (I) effectively manage anxiety and pain (O) during a paediatric dental consultation (P) compared to alternative behavioural control techniques (C)? PubMed/Medline®, SCOPUS, and Web of Science databases were searched and analysed.

Results: Search queries identified a total of 525 abstracts from three different databases. Duplicate articles were removed (n=79), leaving a total of 446 abstracts. After reading the title and abstract, 392 records were excluded. In the end, 22 articles were considered suitable for this systematic review.

Conclusions: VR is a highly effective method of behaviour management, successfully alleviating pain and anxiety in children during dental treatment, surpassing traditional tools. By

75 offering an engaging and immersive experience, VR effectively diverts patients' attention away
76 from the clinical environment, fostering a positive and enjoyable treatment experience.
77 However, it is crucial to acknowledge the limitations of existing studies and the need for further
78 research to enhance the understanding of VR's full potential in paediatric dentistry.
79
80 **Keywords:** Virtual reality, paediatric dentistry, distraction, dental anxiety, pain control,
81 behaviour management
82
83
84 **BACKGROUND**
85
86 Fear and apprehension regarding dental treatment are the most significant factors
87 negatively impacting the daily clinical work of paediatric dentists [1] Dental appointments can
88 trigger anxiety and pain, leading to treatment avoidance or refusal, which can worsen the
89 patient's overall health condition. Factors contributing to dental fear and anxiety, as noted by
90 Dahlander *et al.* 2019, include previous negative experiences of close acquaintances, lack of
91 information about the treatment, the way the treatment is performed, and the dental
92 environment itself [1]
93 For anxious children with a phobia of medical/dental treatments, distraction can be an
94 effective method of diverting the patient's attention away from their perception of procedures
95 that are considered unpleasant [3] A variety of distraction techniques are employed to mitigate
96 anxiety and enhance the dental experience for young patients [4] Audiovisual distractions,
97 such as tablet devices and smartphones, play a crucial role in engaging children and amusing
98 attention in their daily lives [5,6] And are widely accepted by children and parents during
99 medical procedures [7]
100 With the rapid advancement of technology, audiovisual glasses emerged as a significant
101 development in distraction techniques. These glasses allowed videos to be displayed in a two-
102 dimensional format [2D], providing an enhanced visual experience for paediatric patients.

103 However, a notable progression in this field came with the introduction of virtual reality glasses
104 [8] Unlike their 2D counterparts, virtual reality glasses enable the display of interactive content
105 in a three-dimensional format [3D]. This advancement immerses patients in a more realistic
106 and engaging virtual environment, offering a heightened sense of presence and interactivity
107 during dental procedures [9] The transition from 2D to 3D glasses represents a substantial
108 leap in distraction techniques, demonstrating the continuous efforts to improve the dental
109 experience for paediatric patients [10]

110

111 Virtual reality is a three-dimensional simulation technology that can be used interactively
112 through a computer. Virtual reality creates an artificial environment that mimics the real world,
113 allowing users to experience an alternate world [11,12] The virtual experience provides multi-
114 sensory information through synchronization between the head-mounted display helmet
115 (provides an image with a sense of space and depth), motion sensors, headphones, and
116 joysticks. In this way, it is possible to be fully immersed in the simulation created [13]

117 During the past two decades, virtual reality can be used for entertainment[14],
118 education[15], training[16], research[17] and much more. Virtual reality technology is
119 becoming increasingly accessible and powerful, and the potential uses are virtually limitless
120 [18,19]

121 In the medical field, as an effective and efficient tool to prevent emotional disorders such
122 as anxiety [20] and physical impairments in rehabilitation processes [21] Lately, there has
123 been a growing interest in the use of virtual reality technology as a method of pain reduction
124 [22,23] It is also being used for educational or research purposes [24] Like training doctors,
125 nurses and dentists, allowing them to experience real medical situations before treating real
126 patients [25,26]

127 In dentistry, although not yet widespread, VR has proven to be a beneficial tool for
128 clinical practice in several specialties [27] From student training [26,28] to predicting surgical
129 complications[29], physicians can use virtual reality technology to show their patients the
130 expected results even before undergoing any procedure [30]

131 In paediatrics, they can be implemented in the education and maintenance of oral
132 hygiene [31] In addition, the reduction of anxiety and pain can also be experienced with the
133 use of this technology [32]
134 One specific application of VR is virtual reality exposure therapy, which employs VR
135 technology to assist patients in overcoming their fear of dental procedures [33] By allowing
136 patients to virtually experience the entire scenario before the actual procedure begins, they
137 can gain a better understanding of the treatment and confront their fears in a safe and
138 controlled environment[34]
139
140 In recent years, virtual reality has gained popularity in clinical research studies as an
141 innovative technique for modulating paediatric behaviour [19,24,28] According to Mccaul *et al*.
142 1992, the perception and attention to pain play crucial roles in pain experience. VR does not
143 directly impact the pathophysiological mechanisms of pain but rather focuses on modifying
144 patients' perception and attention to pain [35].
145 While VR in dentistry is not yet widely adopted, it has demonstrated considerable
146 benefits across various specialties [27] In paediatrics, sees its VR can be effectively utilized
147 for oral hygiene education and maintenance [31] However, this technology has been showing
148 promising results in reducing anxiety and pain levels in paediatric patients [33,36]
149 This research aims to provide a systematic review assessing VR in controlling pain and
150 anxiety in children during dental consultations.
151
152

153 **METHODOLOGY**

154
155 This systematic review adhered to the PRISMA (Preferred Reporting Items for
156 Systematic Reviews and Meta-Analyses) guidelines, and the research question was
157 formulated using the PICO (Population, Intervention, Comparison, Outcome) format. The
158 objective of this review was to investigate the effectiveness of virtual reality (VR) in controlling

159 anxiety and pain during dental appointments in the paediatric population (P), in comparison to
160 other behavioural control techniques (C).

161 The review protocol was registered in the International Prospective Register of
162 Systematic Reviews (PROSPERO) with the registration number CRD4202340967. A
163 comprehensive literature search was conducted in January 2023, using the
164 PubMed/Medline®, SCOPUS, and Web of Science databases. The search results were
165 exported to the Parsifal bibliography manager software, where duplicates were removed, and
166 articles were selected based on the defined objective and criteria (Table 1).

167

168 **Table 1:** Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Studies designed as randomized clinical trials (RCTs), experimental and case-control study designs with a full-text report	Systematic/narrative reviews and meta-analyses, case reports, case series.
Full text papers from 2003-2023	Studies without a full-text report
Children under 18, female or male	Patients with any visual and/or hearing impairment.
Used virtual reality interventions to help ease anxiety and pain during dental procedures	Use of 2D devices

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170

171 The search strategy employed a combination of subject heading terms, keywords and
172 text words, utilizing Boolean operators such as 'OR' and 'AND' (Table 2).

173 Two independent researchers (DP and PC) performed the search and screening
174 procedure for this systematic review, following the predetermined inclusion and exclusion
175 criteria. In the event of any disagreement between the researchers, a third researcher (AM)
176 was consulted to resolve it.

177 To assess agreement and reliability between researchers, Cohen's Kappa coefficient
178 was employed. The coefficient ranges from -1 to 1, with values closer to 1 indicating higher
179 agreement between reviewers and values closer to -1 indicating greater disagreement.

180 Data extracted included author, year, study design, sample size, age, dental procedure,
181 intervention used, timing of intervention, control/comparison groups, outcomes, and outcome
182 measures.

183 The quality assessment of the included studies was conducted using the Newcastle
184 Ottawa Scale (NOS) [36].

185

186 **Table 2:** Research methodology

PUBMED	
#1	"VR"[All Fields] OR "virtual reality"[All Fields] OR "augmented reality"[All Fields] OR "AR"[All Fields] OR "mixed reality"[All Fields] OR "Audiovisual distraction"[All Fields] OR "audiovisual"[All Fields] OR "Audiovisual Aids"[All Fields] OR "headset*"[All Fields] OR "vr headset*"[All Fields] OR "virtual reality headset"[All Fields] OR "AR headset"[All Fields] OR "augmented reality headset"[All Fields] OR "Artificial intelligence"[All Fields] OR "VR goggles"[All Fields] OR "virtual reality goggles"[All Fields] OR "AR goggles"[All Fields] OR "augmented reality goggles"[All Fields] OR "Virtual Reality Exposure Therapy"[All Fields] OR "VR Exposure Therapy"[All Fields] OR "Augmented Reality Exposure Therapy"[All Fields] OR "Virtual Reality Exposure Therapy"[MeSH Terms] OR "Audiovisual Aids"[MeSH Terms] OR "augmented reality"[MeSH Terms]
#2	"child, preschool"[MeSH Terms] OR "preschool child"[All Fields] OR "paediatric population"[All Fields] OR "paediatric patient*"[All Fields] OR "child"[MeSH Terms] OR "child*"[All Fields] OR "adolescent"[MeSH Terms] OR "adolescen*"[All Fields] OR "pre schooler*"[All Fields] OR "youth"[All Fields] OR "teenager*"[All Fields] OR "teen*"[All Fields] OR "preteen*"[All Fields] OR "pre teen*"[All Fields] OR "pediatrics"[MeSH Terms] OR "paediatric*"[All Fields] OR "Autistic Disorder"[MeSH Terms] OR "Autism"[All Fields] OR "Down Syndrome"[MeSH Terms] OR "Down Syndrome"[All Fields]
#3	"Pain"[All Fields] OR "Pain Management"[All Fields] OR "dental pain"[All Fields] OR "Pain Perception"[All Fields] OR "Anxiety"[All Fields] OR "Dental anxiety"[All Fields] OR "anticipatory anxiety"[All Fields] OR "fear"[All Fields] OR "stress"[All Fields] OR "Dental anxiety"[MeSH Terms] OR "Pain Management"[MeSH Terms] OR "Pain"[MeSH Terms] OR "Pain Perception"[MeSH Terms]
#4	"dental care"[All Fields] OR "dental procedure*"[All Fields] OR "dental operation*"[All Fields] OR "dental appointment*"[All Fields] OR "dental treatment*"[All Fields] OR "dent*"[All Fields] OR "dental hospital*"[All Fields] OR "dentistry"[MeSH Terms] OR "dental care"[MeSH Terms]
#5	#1 AND #2 AND #3 AND #4

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188 **Table 2:** Research methodology (cont.)

SCOPUS	
#1	"VR" OR "virtual reality" OR "augmented reality" OR "AR" OR "mixed reality" OR "Audiovisual distraction" OR "audiovisual" OR "Audiovisual Aids" OR "headset*" OR "vr headset*" OR "virtual reality headset" OR "AR headset" OR "augmented reality headset" OR "Artificial intelligence" OR "VR goggles" OR "virtual reality goggles" OR "AR goggles" OR "augmented reality goggles" OR "Virtual Reality Exposure Therapy" OR "VR Exposure Therapy" OR "Augmented Reality Exposure Therapy"
#2	"preschool child" OR "paediatric population" OR "paediatric patient*" OR "child*" OR "adolescen*" OR "pre schooler*" OR "youth" OR "teenager*" OR "teen*" OR "preteen*" OR "pre teen*" OR "paediatric*" OR "Autistic Disorder" OR "Autism" OR "Down Syndrome"
#3	"Pain" OR "Pain Management" OR "dental pain" OR "Pain Perception" OR "Anxiety" OR "Dental anxiety" OR "anticipatory anxiety" OR "fear" OR "stress"
#4	"dental care" OR "dental procedure*" OR "dental operation*" OR "dental appointment*" OR "dental treatment*" OR "dent*" OR "dental hospital*"
#5	#1 AND #2 AND #3 AND #4
WEB OF SCIENCE	
#1	(VR) OR (virtual reality) OR (augmented reality) OR (AR) OR (mixed reality) OR (Audiovisual distraction) OR (audiovisual) OR (Audiovisual Aids) OR (headset*) OR (vr headset*) OR (virtual reality headset) OR (AR headset) OR (augmented reality headset) OR (Artificial intelligence) OR (VR goggles) OR (virtual reality goggles) OR (AR goggles) OR (augmented reality goggles) OR (Virtual Reality Exposure Therapy) OR (VR Exposure Therapy) OR (Augmented Reality Exposure Therapy)
#2	(preschool child) OR (paediatric population) OR (paediatric patient*) OR (child*) OR (adolescen*) OR (pre schooler*) OR (youth) OR (teenager*) OR (teen*) OR (preteen*) OR (pre teen*) OR (paediatric*) OR (Autistic Disorder) OR (Autism) OR (Down Syndrome)
#3	(Pain) OR (Pain Management) OR (dental pain) OR (Pain Perception) OR (Anxiety) OR (Dental anxiety) OR (anticipatory anxiety) OR (fear) OR (stress)
#4	(dental care) OR (dental procedure*) OR (dental operation*) OR (dental appointment*) OR (dental treatment*) OR (dent*) OR (dental hospital*)
#5	#1 AND #2 AND #3 AND #4

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190 **RESULTS**

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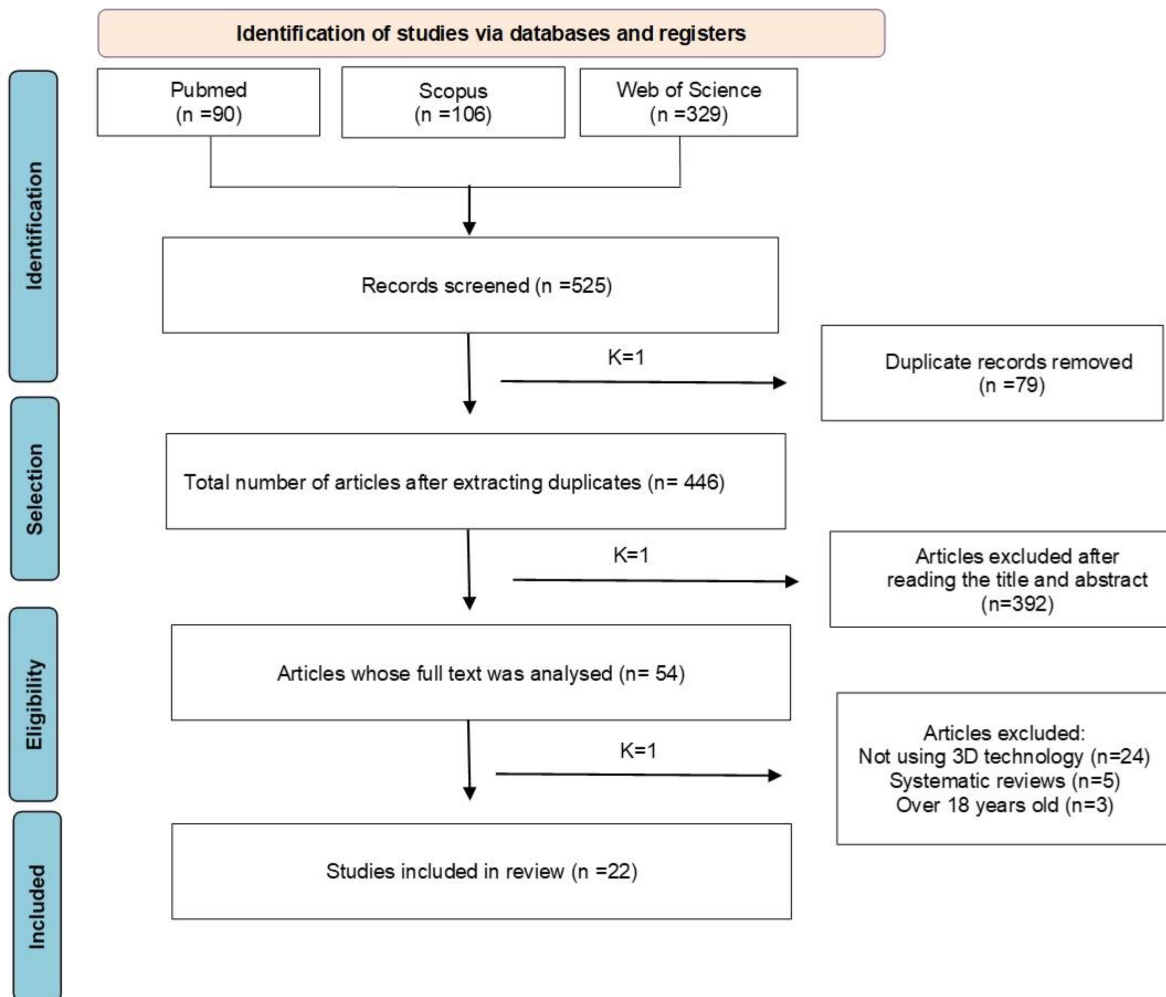
192 **Study selection**

193 The search queries yielded a total of 525 abstracts from three different databases. After
194 removing 79 duplicate articles, 446 unique abstracts remained. Upon reviewing the titles and
195 abstracts, 392 records were deemed irrelevant and excluded. Subsequently, 54 articles were
196 selected for full-text analysis. Among these, 32 articles were excluded as they utilized
197 audiovisual glasses without 3D immersion. Ultimately, 22 articles were considered suitable for
198 inclusion in this systematic review (Fig 1).



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200 **Figure 1-** PRISMA search strategy.

201 (K= Cohen's kappa coefficient)

202 As stated in Fig 1, inter-rater agreement, was determined and a kappa value of 1 was
203 obtained during the selection process, indicating an excellent agreement.
204

205 **Study Characteristics**

206 This analysis included 22 studies conducted in various countries, including Turkey, Iran,
207 India, China, Jordan, Spain, Syria, Italy, and Indonesia. All of these studies were randomised
208 control trials [37-58]. Table 3 offers a comprehensive overview of the studies characteristics:
209 authors, publication date, country, study type, participants number and ages and study
210 outcomes. The VR equipment utilized in the studies is also included.
211

212 **Table 3:** Summary of results (A1-A6)

Study ID	Authors Year Country	Study design	Participants Number Age	Results	Dependent variables	Control groups	VR Equipment
A1 [37]	Özükoç et al [37] 2020 Turkey	RCT	23 10-12 years	VR had best result across all MIH severity levels	CPMAS	Vs control	Preo VR Box
A2 [38]	Baniebrahimi et al [38] 2022 Iran	RCT	42 5-8 years	Anxiety significantly lower in the VR	FBRS, MCDAS, FIS	Vs Dental simulation game	Not specified
A3 [39]	Shetty et al [39] 2019 India	RCT	120 5 – 8 years	Pain and anxiety significant reduction in VR group	SCARED, MCDAS, Salivary cortisol levels, WBFS	Vs control	i-glasses 920HR, Ilixco Inc.
A4 [40]	Kumari et al [40] 2021 India	RCT	200 6–12-years	Immersive group had best results	FBRS, MCDAS, WBFS, VAS	Vs Non-immersive VR	Oculus Go
A5 [41]	Ran et al [41] 2021 China	RCT	120 4-8 years	VR significantly reduced the anxiety and pain	FBRS, WBFS, CFSS-DS	Vs control	HTC's VIVE
A6 [42]	Alshatrat et al [42] 2022 Jordan	RCT	54 5-12 years	VR was found to be an effective distraction	WBFS, FLACC, VAS	Vs control	iWear Vuzix®

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216 **Table 3:** Summary of results (A13-A17)

Study ID	Authors Year Country	Study design	Participants Number Age	Results	Dependent variables	Control groups	VR Equipment
A7 [43]	Gomez-Polo et al [43] 2021 Spain	RCT	80 5-10 years	VR effectively managed anxiety and behavior	FBRS, FIS	Vs control	Zeiss Cinemizer (Carl Zeiss AG)
A8 [44]	Du et al [44] 2022 China	RCT	128 4–9 years	VR significantly reduced anxiety/pain perception	Houpt Scale, WBFS, CFSS-DS, SSQ	Vs control	HTC
A9 [45]	Aditya et al [45] 2021 India	RCT	60 6–9 years	VR significantly reduced the anxiety and pain	VPT, Pulse oximeter	vs control vs Fidget spinner vs Kaleidoscope	MI VR Headset
A10 [46]	Nuvvula et al [46] 2015 India	RCT	90 7 - 10 years	3D group had higher levels of satisfaction.	FBRS, Houpt Scale, MCDAS, Pulse rate	vs control vs Music	Vuzix Eyewear Wrap 920
A11 [47]	Murali et al [47] 2021 India	RCT	75 5-8 year	VR had best results	FIS	vs control	Virtual private theater system
A12 [48]	Felemban et al [48] 2021 Saudi Arabia	RCT	50 6- 12 years	VR helped to overcome dental anxiety	BAS, Pulse oximeter, WBFS, FLACC	vs regular screen	LG 360, LG Electronics

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229 **Table 3:** Summary of results (A13-A17)

Study ID	Authors Year Country	Study design	Participants Number Age	Results	Dependent variables	Control groups	VR Equipment
A13 [49]	Al-Halabi et al [49] 2018 Syria	RCT	102 6 -10 years	Tablet had the bests results for anxiety and pain	BAS, Pulse rate, WBFS	vs control vs tablet	BlackBug™
A14 [50]	Buldur et al [50] 2021 Turkey	RCT	78 7 -11 years	VR significantly reduced pain and anxiety	FBRS, Pulse rate, WBFS	vs control	PlayStation 4 VR, Sony Inc.
A15 [51]	Sharma et al [51] 2021 India	RCT	97 4-8 years	VR effectively managed anxiety and behaviour	FBRS, FLACC	vs control	Not specified
A16 [52]	Daa Khan et al [52] 2019 India	RCT	100 4-10 year	VR made children less anxious and more cooperative	Pulse rate	vs control	Not specified
A17 [53]	Atzori et al [53] 2018 Italy	RCT	5 7–17 years	VR increased fun during dental procedures	0–10 graphic rating scale	vs control	Oculus Rift DK2 and CV1

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231 **Table 3:** Summary of results (A18-A22)

Study ID	Authors Year Country	Study design	Participants Number Age	Results	Dependent variables	Control groups	VR Equipment
A18 [54]	Niharika et al [54] 2018 India	RCT	40 4 - 8 years	VR significantly reduced the anxiety and pain	WBFS, MCDAS, oximeter, heart rate	vs control	Anti Tank VR
A19 [55]	Pande et al [55] 2020 India	RCT	60 5–8 years	VR was most effective in reducing dental fear/anxiety	Pulse rate, FIS	vs control vs audio vs smartphone app	Not specified
A20 [56]	Greeshma et al [56] 2021 India	RCT	90 6 to 8 years	Children were most relaxed in VR group,	FIS, Pulse rate, oximeter	vs control vs audio	Not specified
A21 [57]	Zaidman et al [57] 2022 Israel	RCT	29 4-12 years	VR decreased pain during rubber dam placement	WBFS, MBPS	vs control	Oculus Go
A22 [58]	Kaswindiarti et al [58] 2022 Indonésia	RCT	120 5–8 years	Pain/anxiety decreased significantly using VR	WBFS, Salivary cortisol levels	vs control	i-glasses 920HR, Ilixco Inc

232

233 The studies investigated the effectiveness of different immersive VR techniques,
234 compared to various behavioural control techniques in paediatric dentistry: passive distraction,
235 the tell-show-do technique [37, 39, 41-47, 50, 52-58], including digital screen and audio-visual
236 distraction [38, 40, 48, 49, 51, 55]. The total number of participants involved in the studies was
237 2,558, with most studies focusing on children aged between 5 and 12 years. However, some
238 studies included children within narrower age ranges, such as 7-9 years or 5-8 years.

239 The evaluated dental procedures varied across the studies, ranging from the delivery of
240 local anaesthesia, to pulp therapy, tooth extractions and dental restorations. Some studies
241 focused on specific procedures, such as inferior alveolar nerve blocks, while others assessed
242 intervention effectiveness in a variety of dental procedures, or cooperation at the first dental
243 appointment (Table 4).

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261 **Table 4:** Summary of dental procedures

Article	Dental procedures
A1 [37]	Composite restorations
A2 [38]	Infiltration of anaesthesia, pulpotomy and/or restoration of primary first molar
A3 [39]	Pulpotomy
A4 [40]	Inferior alveolar nerve block for various dental procedures
A5 [41]	Short-term dental procedure (< 30 min)
A6 [42]	Dental procedures, not requiring local anaesthesia Painful dental procedures, requiring local anaesthesia
A7 [43]	Topical and infiltrative anaesthesia
A8 [44]	Primary teeth extraction under local anaesthesia
A9 [45]	Inferior alveolar nerve block
A10 [46]	Inferior alveolar nerve block for pulp therapies in primary molars
A11 [47]	Class I restorations in mandibular primary molars
A12 [48]	Buccal infiltration local anaesthesia
A13 [49]	Inferior alveolar nerve block
A14 [50]	Class I composite resin restorations in mandibular first permanent molars under local anaesthesia
A15 [51]	Nerve block, extraction or pulpal therapy
A16 [52]	Dental examination, acclimatization, oral hygiene information, prophylaxis and composite restoration
A17 [53]	Tooth extraction or dental restoration
A18 [54]	Pulp therapy treatment.
A19 [55]	Composite restorations
A20 [56]	Inferior alveolar nerve block, mandibular tooth extraction
A21 [57]	Inferior alveolar nerve block, rubber dam placement
A22 [58]	Short invasive dental treatment (vital pulp therapy)

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263
264 In this systematic review, different models and brands of VR glasses were observed.
265 Only 5 of the 22 articles included did not present any specifications on the VR device used
266 [38, 51, 52, 55, 56], which prevents data comparisons, based on the devices´ specifications,
267 based on size, weight, comfort or safety indications.
268
269 **Results Summary**

270 The majority of studies compared the usage of VR, with an alternative technique,
271 during a dental procedure or initial consultation, peri-operatively, except one [38] where the
272 control group included pre-operative exposure to a dental simulation game.
273 In this systematic review, the primary outcomes were anxiety and pain management in
274 a paediatric dental consultation. In the selected studies, several scales were used for
275 preliminary behaviour assessment and anxiety and pain evaluation, during the appointment.
276 It was observed that anxiety was the most investigated aspect, 16 papers [37-40, 43, 45-50,
277 52, 54-56, 58], while the perception of pain was addressed in 12 papers [39-42, 44, 48-51,
278 53, 54, 57, 58]. Scales for anxiety and pain measurement depend on the child´s age and
279 development, hence the variety encountered in the reported studies, as there was a wide
280 age range of participants, from pre-schoolers to pre-teenagers. The referred anxiety scales
281 were CPMAS, MCDAS, MCDAS(f)-r, FIS, VPT and the described pain scales were WBFS,
282 VAS, FLACC, MBPS (Table 5). Some studies also included objective physiological
283 parameters, such as salivary cortisol [39, 58], pulse oximeter [45, 48, 54] and pulse rate [46,
284 49, 50, 52, 54-56]. In a small number of studies, there were also evaluated other
285 parameters, such as fear [41, 44] and cybersickness, nausea and fun [53].
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287
288 **Table 5:** Measurement scales and protocols
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Study ID	Measurement Scales and Potocols
A1 [37]	**Anxiety:** The Children's Perioperative Multidimensional Anxiety Scale (CPMAS)
A2 [38]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Anxiety:** Modified Child Dental Anxiety Scale (MCDAS) Facial Image Scale (FIS)
A3 [39]	**Behaviour:** Screen for Child Anxiety Related Emotional Disorders **(**SCARED) **Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Salivary cortisol levels **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)
A4 [40]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Anxiety:** Modified Child Dental Anxiety Scale (MCDAS) **Pain:** Wong Baker Faces Pain Rating Scale (WBFS) Visual Analogue Scale (VAS)
A5 [41]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Pain:** Wong Baker Faces Pain Rating Scale (WBFS) **Fear:** Children's Fear Survey Schedule-Dental Subscale (CFSS-DS)
A6 [42]	**Pain:** Wong Baker Faces Pain Rating Scale (WBFS) Face, Legs, Activity, Cry, Consolability (FLACC) scale Visual Analogue Scale (VAS)
A7 [43]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Anxiety:** Facial Image Scale (FIS)
A8 [44]	**Behaviour:** Houpt Scale **Pain:** Wong Baker Faces Pain Rating Scale (WBFS) **Fear:** Children's Fear Survey Schedule-Dental Subscale (CFSS-DS) **Cybersickness:** Simulator sickness questionnaire (SSQ)
A9 [45]	**Anxiety:** Venham picture test (VPT) Pulse oximeter
A10 [46]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) Houpt Scale **Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Pulse rate
A11 [47]	**Anxiety:** Facial Image Scale (FIS)
A12 [48]	**Behaviour:** Behaviour assessment scale **Anxiety:** Pulse oximeter **Pain:** Wong Baker Faces Pain Rating Scale (WBFS) Face, Legs, Activity, Cry, Consolability (FLACC) scale
A13 [49]	**Behaviour:** Behaviour assessment scale **Anxiety:** Pulse rate **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)
A14 [50]	**Behaviour:** Frankl's behaviour rating scale **Anxiety:** Pulse rate **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)
A15 [51]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Pain:** Face, Legs, Activity, Cry, Consolability (FLACC) scale
A16 [52]	**Anxiety:** Pulse rate
A17 [53]	**Pain, quality of the VR experience, nausea and fun:** 0–10 graphic rating scale (Italian scale)
A18 [54]	**Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Pulse oximeter and heart rate **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)
A19 [55]	**Anxiety:** Pulse rate Facial Image Scale (FIS)
A20 [56]	**Anxiety:** Facial Image Scale (FIS) Pulse rate and oxygen saturation
A21 [57]	**Pain:** Wong Baker Faces Pain Rating Scale (WBFS) Modified Behavioural Pain Scale (MBPS)
A22 [58]	**Anxiety:** Salivary cortisol levels **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)

290

291 Overall, the benefit of VR in controlling anxiety and pain was significantly consistent in
292 the included studies, comparing to the corresponding control group, with the exception of the
293 studies by Alshatrat *et al* [42], Aditya *et al* [45], Felenbam *et al* [48], Al-Halabi [49] and
294 Zaidman *et al* [57]. In study, VR had a similar effect to screen distraction on heart-rate levels
295 and pain during buccal infiltration anaesthesia.

296 Özükoç *et al* found that children with MIH-affected teeth who are distracted from dental
297 procedures using 3D VR games experienced less dental anxiety ($p<0.05$) [37]. Concerning
298 short time appointments, Shetty *et al*, Ran *et al* and Kaswindiarti *et al*., showed a significant
299 reduction in pain, anxiety [39, 41, 58], salivary cortisol ($p<0.001$) [39, 58] and a shorter
300 treatment time [41]. Regarding delivery of intraoral anaesthesia, MCDAS, VAS and WBFRS
301 improved in the immersive VR group [40]. Others presented similar results [38, 44, 46, 49-
302 51, 53, 56].

303 High levels of satisfaction from children who experienced treatment with 3D video
304 glasses were observed in the study by Nuvvula *et al* [46] and increased fun during dental
305 procedures was reported by the participant children in the study of Atzori *et al* [53].

306

307

308 **DISCUSSION**

309

310 This systematic review focus on comparing the use of VR with conventional non-
311 pharmacological behavioural management techniques in paediatric dental consultations. The
312 selected articles cover various dental procedures such as dental examination, restorations,
313 pulp treatment and anaesthesia. VR was used perioperatively, behaviour, anxiety and pain
314 scales were used to determine efficacy and patient satisfaction. There is strong evidence of
315 the success of VR as a behaviour management tool, in the paediatric dental setting, which is
316 some instances rates superior to conventional behaviour management techniques.

317 The studies included in this review examined different behavioural control techniques in
318 paediatric dentistry. Conventional techniques were used as a control group in all studies.

319 Some studies used only VR as a test group, while others using a combination of VR with
320 additional techniques like audio, digital screens, and smartphone games. Interestingly, none
321 of the studies demonstrated that traditional techniques were more effective than the tested
322 techniques in reducing anxiety and pain perception. This can be attributed to VR's ability to
323 divert patients' attention to a pleasant virtual environment, thereby reducing physical pain.

324 Three studies A12[48], A13[49] and A15[51] compared the use of digital flat panel
325 devices with VR devices as methods of distraction during local anaesthesia administration.
326 One study A15[51] found VR devices to be more effective in reducing pain perception
327 compared to other groups. However, two other studies A12[48] and A13[49] concluded that
328 tablets provided greater relief from anxiety and pain during anaesthesia. It's important to
329 consider variables that influence children's experiences during dental procedures, such as the
330 type of anaesthesia and the technology (tablet or smartphone) they are familiar with.

331 Three studies conducted in India A10[46], A19[55] and A20[56] compared the use of VR
332 and audio. Results showed that both audio and VR distraction were effective in reducing
333 anxiety, compared to the conventional "Tell-Show-Do" technique. However, VR proved to be
334 more effective in reducing anxiety and pain perception. While music distraction in the dental
335 environment is widely adopted, VR presents itself as a viable alternative. Only one study
336 A19[55] included smartphone games alongside VR. It suggested that VR and smartphone
337 gaming were the most effective distraction techniques for managing negative behaviour in
338 paediatric dental patients. When comparing the effectiveness of these techniques, VR
339 distraction was found to be more effective than smartphone game distraction. The VR provided
340 simultaneously an immersive and interactive experience, which is likely to have contributed to
341 its greater effectiveness.

342 One study A4[40] compared the effect of immersive and non-immersive VR on pain
343 perception during intraoral injections. Both distraction methods were effective in reducing pain
344 perception, with immersive VR slightly more effective. However, the study had limitations such
345 as a small sample size and limited assessment of pain immediately after the injection. Further

346 research is needed to assess the impact of VR distraction in different time points and in a
347 larger sample.
348 While VR glasses can improve patient cooperation, other factors need to be addressed,
349 such as costs, communication issues, dentists' perceptions. Some top range VR appliances
350 are expensive; however, prices have become more accessible. VR can also interfere with
351 communication between the dentist and patient during complex procedures, potentially
352 impairing diagnosis and treatment. Vision blockage and absence of caregivers in the visual
353 field can increase children's anxiety.[58] However, one study A17[53] reported a positive
354 experience of dentists who used VR, feeling more relaxed and focused on their work.
355 Communication with patients was not affected, despite the use of headsets. These issues
356 need to be considered when evaluating the use of VR in dentistry.
357 The increasing use of VR headsets raises health concerns. Prolonged use can lead to
358 eyestrain, dry eyes, vision problems, migraines, dizziness, and motion sickness and risk of
359 photosensitive epilepsy. Responsible use of VR headsets is critical to ensure patients' well-
360 being.[59,60]
361 The appropriate age for using digital equipment, including smartphones and tablets, is
362 debated, and virtual reality (VR) requires further studies, particularly evaluating its long-term
363 effects and across different age groups.[5,61] Immersive media hardware companies have
364 established safety recommendations, with Sony Interactive Entertainment[62], Oculus[63],
365 PlayStation[64], and Samsung[65] stating that their products are not recommended for
366 children under 12 or 13 years old. LG[66] sets the highest age limit at 15, while HTC[67],
367 examined in study A5[41], has the lowest limit of 4 years without a "safe mode." All articles in
368 this systematic review used VR glasses in children below the manufacturers'
369 recommendations, except for studies without specified equipment brands.
370 To mitigate adverse effects, researchers have explored strategies such as oculomotor
371 exercises before using VR glasses, which have shown effectiveness in reducing
372 cybersickness and associated symptoms.[68] Taking breaks during VR use is also
373 recommended to prevent digital eye strain, with suggestions including a 20-second break

374 every 20 minutes or breaks every 15 minutes as recommended by the UK Department for
375 Business Energy and Industrial Strategy in 2020.[69] However, reviewed studies did not
376 include a specific protocol for preventing eye injuries related to VR glasses.
377 Assessing cybersickness is crucial as it can cause discomfort and symptoms like
378 nausea, dizziness, headache, eyestrain, and general discomfort. It significantly impacts the
379 user experience and may limit the effectiveness of VR applications.[59] However, among the
380 selected articles, only one A8[44] evaluated cybersickness.
381 The cost of 3D immersion devices varies based on the type of glasses chosen.
382 Cardboard glasses, the most economical option, use the smartphone screen for
383 display.[70,71] High-end glasses offer better immersion quality, have their own software and
384 hardware, but still utilize the smartphone as a screen.[9] Gaming glasses are the most
385 expensive, and required a computer connection. They are primarily sought after by
386 professional players for superior performance but acquiring them for a dental appointment
387 may not be justified.[72,73] Overall, VR appears to be a viable alternative to pharmacological
388 behaviour methods, such as conscious sedation or general anaesthesia, which carry
389 associated costs and health risks. By utilizing VR, the need for these pharmacological
390 interventions can potentially be reduced and in certain circumstances eliminated.[22,33]
391
392 Finally, in this systematic review, the quality of the evidence is good. However, the
393 review is limited by the diverse range of pain and anxiety scales used in the included studies,
394 making direct comparisons challenging. Future research should consider conducting
395 qualitative studies to explore patient-reported outcomes and investigate the long-term effects
396 of VR on anxiety and pain.
397
398
399 **CONCLUSION**
400 This systematic review has showed that virtual reality technology during dental treatment
401 is an effective tool for reducing anxiety and pain in children, when compared to conventional

behavioural management techniques. By creating an engaging and immersive experience, VR successfully shifts the patients' focus away from the clinical environment, resulting in a more positive and enjoyable treatment experience. Therefore, it is crucial that dental professionals become familiar with VR as a valuable tool in the management of paediatric patients. Further research is required to determine the sustained benefits of VR and its integration into routine clinical practice.

Abbreviations

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PICO: Population, Intervention, Comparison, Outcome
Mesh: Medical subject headings
NOS: Newcastle Ottawa scale;
HMD: Head Mounted Devices
FBRS: Frankl's behaviour rating scale;
FIS: Facial Image Scale:
MCDAS: Modified Child Dental Anxiety Scale:
SCARED: Screen for Child Anxiety Related Disorders;
WBFPS: Wong-Baker Faces Pain Rating Scale;
VAS: Visual Analog Scale;
FLACC scale: Face, Legs, Activity, Cry, Consolability' scale;
VPT: Venham's picture test;
MBPS: Modified Behavioural Pain Scale
SSQ: Simulator sickness questionnaire

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652 **Annex 1:** Modified Newcastle-Ottawa scale (NOS): Randomised Control Trial

653

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE: RANDOMIZED CONTROLLED TRIAL

Note: A study can be awarded a maximum of one star (*) for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

1) Is the case definition adequate?
   a) yes, with independent validation *
   b) yes, e.g., record linkage or based on self reports
   c) no description
2) Representativeness of the cases
   a) consecutive or obviously representative series of cases *
   b) potential for selection biases or not stated
3) Selection of Controls
   a) community controls *
   b) hospital controls
   c) no description
4) Definition of Controls
   a) no history of disease (endpoint) *
   b) no description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis
   a) study controls for _______________ (Select the most important factor.) *
   b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

1) Ascertainment of exposure
   a) secure record (eg surgical records) *
   b) structured interview where blind to case/control status *
   c) interview not blinded to case/control status
   d) written self report or medical record only
   e) no description
2) Same method of ascertainment for cases and controls
   a) yes *
   b) no
3) Non-Response rate
   a) same rate for both groups *
   b) non respondents described
   c) rate different and no designation

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658 **Virtual Reality and Behaviour Management in Paediatric Dentistry:**

659 **A Systematic Review**

660

661 **ABSTRACT**

662

663 **Background:** Virtual reality (VR) has emerged as an innovative tool in medicine and dentistry,
664 improving anxiety and pain management in children. The immersive and interactive
665 environments of VR technology helps distract and engage young patients during dental
666 procedures, potentially reducing anxiety levels and improving treatment experience. The aim
667 of this review was to provide current evidence-based guidance on the usage of VR in the
668 clinical practice of paediatric dentistry.

669

670 **Methods:** A systematic review was conducted according to the PRISMA guidelines with the
671 following research question using the PICO format: Does VR (I) effectively manage anxiety
672 and pain (O) during a paediatric dental consultation (P) compared to alternative behavioural
673 control techniques (C)? PubMed/Medline®, SCOPUS, and Web of Science databases were
674 searched and analysed.

675

676 **Results:** Search queries identified a total of 525 abstracts from three different databases.
677 Duplicate articles were removed (n=79), leaving a total of 446 abstracts. After reading the title
678 and abstract, 392 records were excluded. In the end, 22 articles were considered suitable for
679 this systematic review.

680

681 **Conclusions:** VR is a highly effective method of behaviour management, successfully
682 alleviating pain and anxiety in children during dental treatment, surpassing traditional tools. By
683 offering an engaging and immersive experience, VR effectively diverts patients' attention away

from the clinical environment, fostering a positive and enjoyable treatment experience. However, it is crucial to acknowledge the limitations of existing studies and the need for further research to enhance the understanding of VR's full potential in paediatric dentistry.

Keywords: Virtual reality, paediatric dentistry, distraction, dental anxiety, pain control, behaviour management

BACKGROUND

Fear and apprehension regarding dental treatment are the most significant factors negatively impacting the daily clinical work of paediatric dentists [1] Dental appointments can trigger anxiety and pain, leading to treatment avoidance or refusal, which can worsen the patient's overall health condition. Factors contributing to dental fear and anxiety, as noted by Dahlander *et al.* 2019, include previous negative experiences of close acquaintances, lack of information about the treatment, the way the treatment is performed, and the dental environment itself [1]

For anxious children with a phobia of medical/dental treatments, distraction can be an effective method of diverting the patient's attention away from their perception of procedures that are considered unpleasant [3] A variety of distraction techniques are employed to mitigate anxiety and enhance the dental experience for young patients [4] Audiovisual distractions, such as tablet devices and smartphones, play a crucial role in engaging children and amusing attention in their daily lives [5,6] And are widely accepted by children and parents during medical procedures [7]

With the rapid advancement of technology, audiovisual glasses emerged as a significant development in distraction techniques. These glasses allowed videos to be displayed in a two-dimensional format [2D], providing an enhanced visual experience for paediatric patients. However, a notable progression in this field came with the introduction of virtual reality glasses

712 [8] Unlike their 2D counterparts, virtual reality glasses enable the display of interactive content
713 in a three-dimensional format [3D]. This advancement immerses patients in a more realistic
714 and engaging virtual environment, offering a heightened sense of presence and interactivity
715 during dental procedures [9] The transition from 2D to 3D glasses represents a substantial
716 leap in distraction techniques, demonstrating the continuous efforts to improve the dental
717 experience for paediatric patients [10]
718
719 Virtual reality is a three-dimensional simulation technology that can be used interactively
720 through a computer. Virtual reality creates an artificial environment that mimics the real world,
721 allowing users to experience an alternate world [11,12] The virtual experience provides multi-
722 sensory information through synchronization between the head-mounted display helmet
723 (provides an image with a sense of space and depth), motion sensors, headphones, and
724 joysticks. In this way, it is possible to be fully immersed in the simulation created [13]
725 During the past two decades, virtual reality can be used for entertainment[14],
726 education[15], training[16], research[17] and much more. Virtual reality technology is
727 becoming increasingly accessible and powerful, and the potential uses are virtually limitless
728 [18,19]
729 In the medical field, as an effective and efficient tool to prevent emotional disorders such
730 as anxiety [20] and physical impairments in rehabilitation processes [21] Lately, there has
731 been a growing interest in the use of virtual reality technology as a method of pain reduction
732 [22,23] It is also being used for educational or research purposes [24] Like training doctors,
733 nurses and dentists, allowing them to experience real medical situations before treating real
734 patients [25,26]
735 In dentistry, although not yet widespread, VR has proven to be a beneficial tool for
736 clinical practice in several specialties [27] From student training [26,28] to predicting surgical
737 complications[29], physicians can use virtual reality technology to show their patients the
738 expected results even before undergoing any procedure [30]

739 In paediatrics, they can be implemented in the education and maintenance of oral
740 hygiene [31] In addition, the reduction of anxiety and pain can also be experienced with the
741 use of this technology [32]
742 One specific application of VR is virtual reality exposure therapy, which employs VR
743 technology to assist patients in overcoming their fear of dental procedures [33] By allowing
744 patients to virtually experience the entire scenario before the actual procedure begins, they
745 can gain a better understanding of the treatment and confront their fears in a safe and
746 controlled environment[34]
747
748 In recent years, virtual reality has gained popularity in clinical research studies as an
749 innovative technique for modulating paediatric behaviour [19,24,28] According to Mccaul *et al*.
750 1992, the perception and attention to pain play crucial roles in pain experience. VR does not
751 directly impact the pathophysiological mechanisms of pain but rather focuses on modifying
752 patients' perception and attention to pain [35].
753 While VR in dentistry is not yet widely adopted, it has demonstrated considerable
754 benefits across various specialties [27] In paediatrics, sees its VR can be effectively utilized
755 for oral hygiene education and maintenance [31] However, this technology has been showing
756 promising results in reducing anxiety and pain levels in paediatric patients [33,36]
757 This research aims to provide a systematic review assessing VR in controlling pain and
758 anxiety in children during dental consultations.
759
760
761 **METHODOLOGY**
762
763 This systematic review adhered to the PRISMA (Preferred Reporting Items for
764 Systematic Reviews and Meta-Analyses) guidelines, and the research question was
765 formulated using the PICO (Population, Intervention, Comparison, Outcome) format. The
766 objective of this review was to investigate the effectiveness of virtual reality (VR) in controlling

767 anxiety and pain during dental appointments in the paediatric population (P), in comparison to
768 other behavioural control techniques (C).

769 The review protocol was registered in the International Prospective Register of
770 Systematic Reviews (PROSPERO) with the registration number CRD4202340967. A
771 comprehensive literature search was conducted in January 2023, using the
772 PubMed/Medline®, SCOPUS, and Web of Science databases. The search results were
773 exported to the Parsifal bibliography manager software, where duplicates were removed, and
774 articles were selected based on the defined objective and criteria (Table 1).

775

776 **Table 1:** Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Studies designed as randomized clinical trials (RCTs), experimental and case-control study designs with a full-text report	Systematic/narrative reviews and meta-analyses, case reports, case series.
Full text papers from 2003-2023	Studies without a full-text report
Children under 18, female or male	Patients with any visual and/or hearing impairment.
Used virtual reality interventions to help ease anxiety and pain during dental procedures	Use of 2D devices

777

778

779 The search strategy employed a combination of subject heading terms, keywords and
780 text words, utilizing Boolean operators such as 'OR' and 'AND' (Table 2).

781 Two independent researchers (DP and PC) performed the search and screening
782 procedure for this systematic review, following the predetermined inclusion and exclusion
783 criteria. In the event of any disagreement between the researchers, a third researcher (AM)
784 was consulted to resolve it.

785 To assess agreement and reliability between researchers, Cohen's Kappa coefficient
786 was employed. The coefficient ranges from -1 to 1, with values closer to 1 indicating higher
787 agreement between reviewers and values closer to -1 indicating greater disagreement.

788 Data extracted included author, year, study design, sample size, age, dental procedure,
789 intervention used, timing of intervention, control/comparison groups, outcomes, and outcome
790 measures.
791 The quality assessment of the included studies was conducted using the Newcastle
792 Ottawa Scale (NOS) [36].
793

794

Table 2: Research methodology

PUBMED	
#1	"VR"[All Fields] OR "virtual reality"[All Fields] OR "augmented reality"[All Fields] OR "AR"[All Fields] OR "mixed reality"[All Fields] OR "Audiovisual distraction"[All Fields] OR "audiovisual"[All Fields] OR "Audiovisual Aids"[All Fields] OR "headset*"[All Fields] OR "vr headset*"[All Fields] OR "virtual reality headset"[All Fields] OR "AR headset"[All Fields] OR "augmented reality headset"[All Fields] OR "Artificial intelligence"[All Fields] OR "VR goggles"[All Fields] OR "virtual reality goggles"[All Fields] OR "AR goggles"[All Fields] OR "augmented reality goggles"[All Fields] OR "Virtual Reality Exposure Therapy"[All Fields] OR "VR Exposure Therapy"[All Fields] OR "Augmented Reality Exposure Therapy"[All Fields] OR "Virtual Reality Exposure Therapy"[MeSH Terms] OR "Audiovisual Aids"[MeSH Terms] OR "augmented reality"[MeSH Terms]
#2	"child, preschool"[MeSH Terms] OR "preschool child"[All Fields] OR "paediatric population"[All Fields] OR "paediatric patient*"[All Fields] OR "child"[MeSH Terms] OR "child*"[All Fields] OR "adolescent"[MeSH Terms] OR "adolescen*"[All Fields] OR "pre schooler*"[All Fields] OR "youth"[All Fields] OR "teenager*"[All Fields] OR "teen*"[All Fields] OR "preteen*"[All Fields] OR "pre teen*"[All Fields] OR "pediatrics"[MeSH Terms] OR "paediatric*"[All Fields] OR "Autistic Disorder"[MeSH Terms] OR "Autism"[All Fields] OR "Down Syndrome"[MeSH Terms] OR "Down Syndrome"[All Fields]
#3	"Pain"[All Fields] OR "Pain Management"[All Fields] OR "dental pain"[All Fields] OR "Pain Perception"[All Fields] OR "Anxiety"[All Fields] OR "Dental anxiety"[All Fields] OR "anticipatory anxiety"[All Fields] OR "fear"[All Fields] OR "stress"[All Fields] OR "Dental anxiety"[MeSH Terms] OR "Pain Management"[MeSH Terms] OR "Pain"[MeSH Terms] OR "Pain Perception"[MeSH Terms]
#4	"dental care"[All Fields] OR "dental procedure*"[All Fields] OR "dental operation*"[All Fields] OR "dental appointment*"[All Fields] OR "dental treatment*"[All Fields] OR "dent*"[All Fields] OR "dental hospital*"[All Fields] OR "dentistry"[MeSH Terms] OR "dental care"[MeSH Terms]
#5	#1 AND #2 AND #3 AND #4

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Table 2: Research methodology (cont.)

SCOPUS	
#1	"VR" OR "virtual reality" OR "augmented reality" OR "AR" OR "mixed reality" OR "Audiovisual distraction" OR "audiovisual" OR "Audiovisual Aids" OR "headset*" OR "vr headset*" OR "virtual reality headset" OR "AR headset" OR "augmented reality headset" OR "Artificial intelligence" OR "VR goggles" OR "virtual reality goggles" OR "AR goggles" OR "augmented reality goggles" OR "Virtual Reality Exposure Therapy" OR "VR Exposure Therapy" OR "Augmented Reality Exposure Therapy"
#2	"preschool child" OR "paediatric population" OR "paediatric patient*" OR "child*" OR "adolescen*" OR "pre schooler*" OR "youth" OR "teenager*" OR "teen*" OR "preteen*" OR "pre teen*" OR "paediatric*" OR "Autistic Disorder" OR "Autism" OR "Down Syndrome"
#3	"Pain" OR "Pain Management" OR "dental pain" OR "Pain Perception" OR "Anxiety" OR "Dental anxiety" OR "anticipatory anxiety" OR "fear" OR "stress"
#4	"dental care" OR "dental procedure*" OR "dental operation*" OR "dental appointment*" OR "dental treatment*" OR "dent*" OR "dental hospital*"
#5	#1 AND #2 AND #3 AND #4
WEB OF SCIENCE	
#1	(VR) OR (virtual reality) OR (augmented reality) OR (AR) OR (mixed reality) OR (Audiovisual distraction) OR (audiovisual) OR (Audiovisual Aids) OR (headset*) OR (vr headset*) OR (virtual reality headset) OR (AR headset) OR (augmented reality headset) OR (Artificial intelligence) OR (VR goggles) OR (virtual reality goggles) OR (AR goggles) OR (augmented reality goggles) OR (Virtual Reality Exposure Therapy) OR (VR Exposure Therapy) OR (Augmented Reality Exposure Therapy)
#2	(preschool child) OR (paediatric population) OR (paediatric patient*) OR (child*) OR (adolescen*) OR (pre schooler*) OR (youth) OR (teenager*) OR (teen*) OR (preteen*) OR (pre teen*) OR (paediatric*) OR (Autistic Disorder) OR (Autism) OR (Down Syndrome)
#3	(Pain) OR (Pain Management) OR (dental pain) OR (Pain Perception) OR (Anxiety) OR (Dental anxiety) OR (anticipatory anxiety) OR (fear) OR (stress)
#4	(dental care) OR (dental procedure*) OR (dental operation*) OR (dental appointment*) OR (dental treatment*) OR (dent*) OR (dental hospital*)
#5	#1 AND #2 AND #3 AND #4

802

RESULTS

Study selection

The search queries yielded a total of 525 abstracts from three different databases. After removing 79 duplicate articles, 446 unique abstracts remained. Upon reviewing the titles and abstracts, 392 records were deemed irrelevant and excluded. Subsequently, 54 articles were selected for full-text analysis. Among these, 32 articles were excluded as they utilized audiovisual glasses without 3D immersion. Ultimately, 22 articles were considered suitable for inclusion in this systematic review (Fig 1).

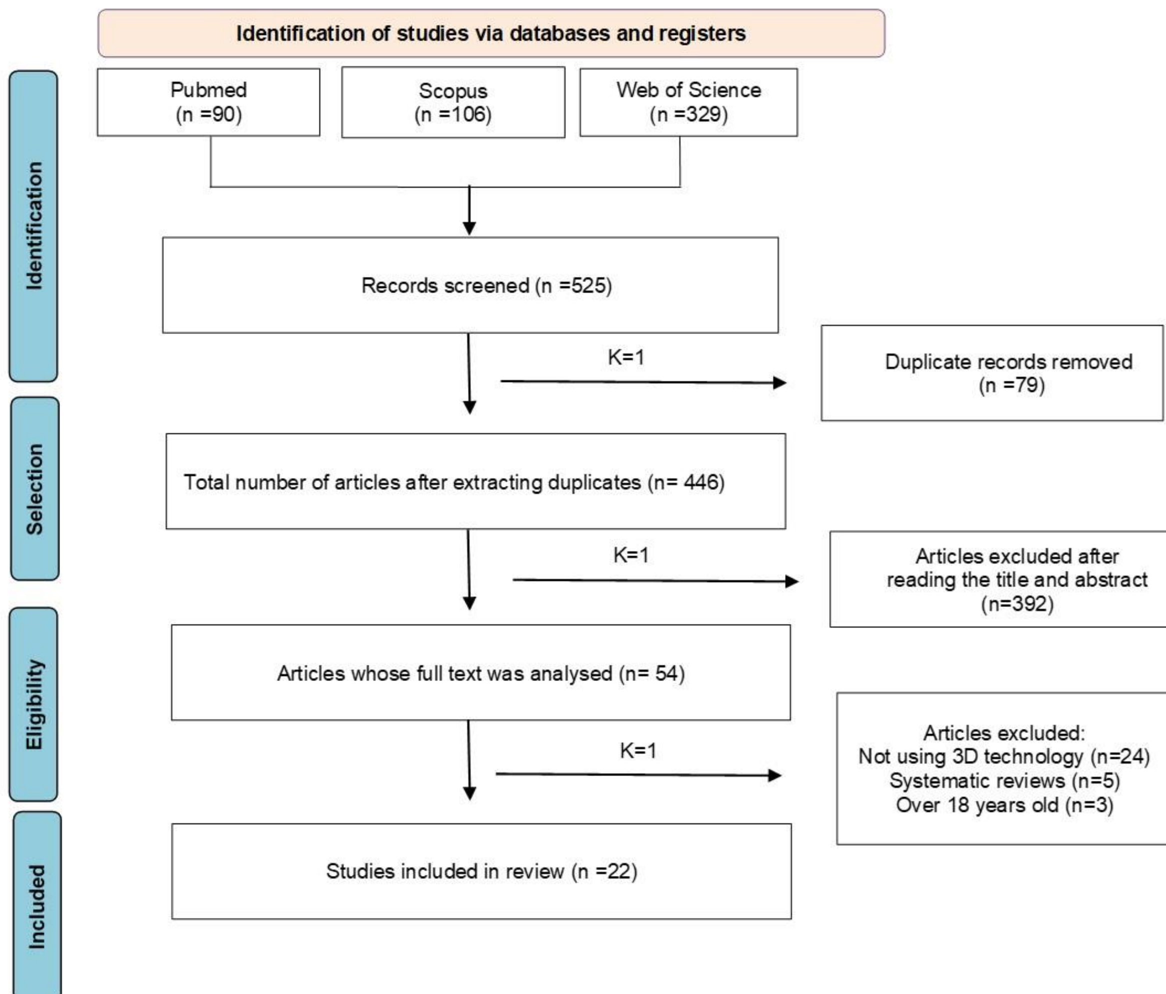

Figure 1- PRISMA search strategy.

(K= Cohen's kappa coefficient)

As stated in Fig 1, inter-rater agreement, was determined and a kappa value of 1 was obtained during the selection process, indicating an excellent agreement.

Study Characteristics

This analysis included 22 studies conducted in various countries, including Turkey, Iran, India, China, Jordan, Spain, Syria, Italy, and Indonesia. All of these studies were randomised control trials [37-58]. Table 3 offers a comprehensive overview of the studies characteristics: authors, publication date, country, study type, participants number and ages and study outcomes. The VR equipment utilized in the studies is also included.

Table 3: Summary of results (A1-A6)

Study ID	Authors Year Country	Study design	Participants Number Age	Results	Dependent variables	Control groups	VR Equipment
A1 [37]	Özükoç et al [37] 2020 Turkey	RCT	23 10-12 years	VR had best result across all MIH severity levels	CPMAS	Vs control	Preo VR Box
A2 [38]	Baniebrahimi et al [38] 2022 Iran	RCT	42 5-8 years	Anxiety significantly lower in the VR	FBRS, MCDAS, FIS	Vs Dental simulation game	Not specified
A3 [39]	Shetty et al [39] 2019 India	RCT	120 5 – 8 years	Pain and anxiety significant reduction in VR group	SCARED, MCDAS, Salivary cortisol levels, WBFS	Vs control	i-glasses 920HR, Ilixco Inc.
A4 [40]	Kumari et al [40] 2021 India	RCT	200 6–12-years	Immersive group had best results	FBRS, MCDAS, WBFS, VAS	Vs Non-immersive VR	Oculus Go
A5 [41]	Ran et al [41] 2021 China	RCT	120 4-8 years	VR significantly reduced the anxiety and pain	FBRS, WBFS, CFSS-DS	Vs control	HTC's VIVE
A6 [42]	Alshatrat et al [42] 2022 Jordan	RCT	54 5-12 years	VR was found to be an effective distraction	WBFS, FLACC, VAS	Vs control	iWear Vuzix®

Table 3: Summary of results (A13-A17)

Study ID	Authors Year Country	Study design	Participants Number Age	Results	Dependent variables	Control groups	VR Equipment
A7 [43]	Gomez-Polo et al [43] 2021 Spain	RCT	80 5-10 years	VR effectively managed anxiety and behavior	FBRS, FIS	Vs control	Zeiss Cinemizer (Carl Zeiss AG)
A8 [44]	Du et al [44] 2022 China	RCT	128 4–9 years	VR significantly reduced anxiety/pain perception	Houpt Scale, WBFS, CFSS-DS, SSQ	Vs control	HTC
A9 [45]	Aditya et al [45] 2021 India	RCT	60 6–9 years	VR significantly reduced the anxiety and pain	VPT, Pulse oximeter	vs control vs Fidget spinner vs Kaleidoscope	MI VR Headset
A10 [46]	Nuvvula et al [46] 2015 India	RCT	90 7 - 10 years	3D group had higher levels of satisfaction.	FBRS, Houpt Scale, MCDAS, Pulse rate	vs control vs Music	Vuzix Eyewear Wrap 920
A11 [47]	Murali et al [47] 2021 India	RCT	75 5-8 year	VR had best results	FIS	vs control	Virtual private theater system
A12 [48]	Felemban et al [48] 2021 Saudi Arabia	RCT	50 6- 12 years	VR helped to overcome dental anxiety	BAS, Pulse oximeter, WBFS, FLACC	vs regular screen	LG 360, LG Electronics

Table 3: Summary of results (A13-A17)

Study ID	Authors Year Country	Study design	Participants Number Age	Results	Dependent variables	Control groups	VR Equipment
A13 [49]	Al-Halabi et al [49] 2018 Syria	RCT	102 6 -10 years	Tablet had the bests results for anxiety and pain	BAS, Pulse rate, WBFS	vs control vs tablet	BlackBug™
A14 [50]	Buldur et al [50] 2021 Turkey	RCT	78 7 -11 years	VR significantly reduced pain and anxiety	FBRS, Pulse rate, WBFS	vs control	PlayStation 4 VR, Sony Inc.
A15 [51]	Sharma et al [51] 2021 India	RCT	97 4-8 years	VR effectively managed anxiety and behaviour	FBRS, FLACC	vs control	Not specified
A16 [52]	Daa Khan et al [52] 2019 India	RCT	100 4-10 year	VR made children less anxious and more cooperative	Pulse rate	vs control	Not specified
A17 [53]	Atzori et al [53] 2018 Italy	RCT	5 7–17 years	VR increased fun during dental procedures	0–10 graphic rating scale	vs control	Oculus Rift DK2 and CV1

Table 3: Summary of results (A18-A22)

Study ID	Authors Year Country	Study design	Participants Number Age	Results	Dependent variables	Control groups	VR Equipment
A18 [54]	Niharika et al [54] 2018 India	RCT	40 4 - 8 years	VR significantly reduced the anxiety and pain	WBFS, MCDAS, oximeter, heart rate	vs control	Anti Tank VR
A19 [55]	Pande et al [55] 2020 India	RCT	60 5–8 years	VR was most effective in reducing dental fear/anxiety	Pulse rate, FIS	vs control vs audio vs smartphone app	Not specified
A20 [56]	Greeshma et al [56] 2021 India	RCT	90 6 to 8 years	Children were most relaxed in VR group,	FIS, Pulse rate, oximeter	vs control vs audio	Not specified
A21 [57]	Zaidman et al [57] 2022 Israel	RCT	29 4-12 years	VR decreased pain during rubber dam placement	WBFS, MBPS	vs control	Oculus Go
A22 [58]	Kaswindiarti et al [58] 2022 Indonésia	RCT	120 5–8 years	Pain/anxiety decreased significantly using VR	WBFS, Salivary cortisol levels	vs control	i-glasses 920HR, Ilixco Inc

The studies investigated the effectiveness of different immersive VR techniques, compared to various behavioural control techniques in paediatric dentistry: passive distraction, the tell-show-do technique [37, 39, 41-47, 50, 52-58], including digital screen and audio-visual distraction [38, 40, 48, 49, 51, 55]. The total number of participants involved in the studies was 2,558, with most studies focusing on children aged between 5 and 12 years. However, some studies included children within narrower age ranges, such as 7-9 years or 5-8 years.

The evaluated dental procedures varied across the studies, ranging from the delivery of local anaesthesia, to pulp therapy, tooth extractions and dental restorations. Some studies focused on specific procedures, such as inferior alveolar nerve blocks, while others assessed intervention effectiveness in a variety of dental procedures, or cooperation at the first dental appointment (Table 4).

Table 4: Summary of dental procedures

Article	Dental procedures
A1 [37]	Composite restorations
A2 [38]	Infiltration of anaesthesia, pulpotomy and/or restoration of primary first molar
A3 [39]	Pulpotomy
A4 [40]	Inferior alveolar nerve block for various dental procedures
A5 [41]	Short-term dental procedure (< 30 min)
A6 [42]	Dental procedures, not requiring local anaesthesia Painful dental procedures, requiring local anaesthesia
A7 [43]	Topical and infiltrative anaesthesia
A8 [44]	Primary teeth extraction under local anaesthesia
A9 [45]	Inferior alveolar nerve block
A10 [46]	Inferior alveolar nerve block for pulp therapies in primary molars
A11 [47]	Class I restorations in mandibular primary molars
A12 [48]	Buccal infiltration local anaesthesia
A13 [49]	Inferior alveolar nerve block
A14 [50]	Class I composite resin restorations in mandibular first permanent molars under local anaesthesia
A15 [51]	Nerve block, extraction or pulpal therapy
A16 [52]	Dental examination, acclimatization, oral hygiene information, prophylaxis and composite restoration
A17 [53]	Tooth extraction or dental restoration
A18 [54]	Pulp therapy treatment.
A19 [55]	Composite restorations
A20 [56]	Inferior alveolar nerve block, mandibular tooth extraction
A21 [57]	Inferior alveolar nerve block, rubber dam placement
A22 [58]	Short invasive dental treatment (vital pulp therapy)

In this systematic review, different models and brands of VR glasses were observed. Only 5 of the 22 articles included did not present any specifications on the VR device used [38, 51, 52, 55, 56], which prevents data comparisons, based on the devices´ specifications, based on size, weight, comfort or safety indications.

Results Summary

The majority of studies compared the usage of VR, with an alternative technique, during a dental procedure or initial consultation, peri-operatively, except one [38] where the control group included pre-operative exposure to a dental simulation game.

In this systematic review, the primary outcomes were anxiety and pain management in a paediatric dental consultation. In the selected studies, several scales were used for preliminary behaviour assessment and anxiety and pain evaluation, during the appointment. It was observed that anxiety was the most investigated aspect, 16 papers [37-40, 43, 45-50, 52, 54-56, 58], while the perception of pain was addressed in 12 papers [39-42, 44, 48-51, 53, 54, 57, 58]. Scales for anxiety and pain measurement depend on the child´s age and development, hence the variety encountered in the reported studies, as there was a wide age range of participants, from pre-schoolers to pre-teenagers. The referred anxiety scales were CPMAS, MCDAS, MCDAS(f)-r, FIS, VPT and the described pain scales were WBFS, VAS, FLACC, MBPS (Table 5). Some studies also included objective physiological parameters, such as salivary cortisol [39, 58], pulse oximeter [45, 48, 54] and pulse rate [46, 49, 50, 52, 54-56]. In a small number of studies, there were also evaluated other parameters, such as fear [41, 44] and cybersickness, nausea and fun [53].

Table 5: Measurement scales and protocols

Study ID	Measurement Scales and Potocols
A1 [37]	**Anxiety:** The Children's Perioperative Multidimensional Anxiety Scale (CPMAS)
A2 [38]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Anxiety:** Modified Child Dental Anxiety Scale (MCDAS) Facial Image Scale (FIS)
A3 [39]	**Behaviour:** Screen for Child Anxiety Related Emotional Disorders **(**SCARED) **Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Salivary cortisol levels **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)
A4 [40]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Anxiety:** Modified Child Dental Anxiety Scale (MCDAS) **Pain:** Wong Baker Faces Pain Rating Scale (WBFS) Visual Analogue Scale (VAS)
A5 [41]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Pain:** Wong Baker Faces Pain Rating Scale (WBFS) **Fear:** Children's Fear Survey Schedule-Dental Subscale (CFSS-DS)
A6 [42]	**Pain:** Wong Baker Faces Pain Rating Scale (WBFS) Face, Legs, Activity, Cry, Consolability (FLACC) scale Visual Analogue Scale (VAS)
A7 [43]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Anxiety:** Facial Image Scale (FIS)
A8 [44]	**Behaviour:** Houpt Scale **Pain:** Wong Baker Faces Pain Rating Scale (WBFS) **Fear:** Children's Fear Survey Schedule-Dental Subscale (CFSS-DS) **Cybersickness:** Simulator sickness questionnaire (SSQ)
A9 [45]	**Anxiety:** Venham picture test (VPT) Pulse oximeter
A10 [46]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) Houpt Scale **Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Pulse rate
A11 [47]	**Anxiety:** Facial Image Scale (FIS)
A12 [48]	**Behaviour:** Behaviour assessment scale **Anxiety:** Pulse oximeter **Pain:** Wong Baker Faces Pain Rating Scale (WBFS) Face, Legs, Activity, Cry, Consolability (FLACC) scale
A13 [49]	**Behaviour:** Behaviour assessment scale **Anxiety:** Pulse rate **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)
A14 [50]	**Behaviour:** Frankl's behaviour rating scale **Anxiety:** Pulse rate **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)
A15 [51]	**Behaviour:** Frankl's behaviour rating scale (Patients' selection) **Pain:** Face, Legs, Activity, Cry, Consolability (FLACC) scale
A16 [52]	**Anxiety:** Pulse rate
A17 [53]	**Pain, quality of the VR experience, nausea and fun:** 0–10 graphic rating scale (Italian scale)
A18 [54]	**Anxiety:** Modified Child Dental Anxiety Scale [MCDAS(f)-r] Faces version Pulse oximeter and heart rate **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)
A19 [55]	**Anxiety:** Pulse rate Facial Image Scale (FIS)
A20 [56]	**Anxiety:** Facial Image Scale (FIS) Pulse rate and oxygen saturation
A21 [57]	**Pain:** Wong Baker Faces Pain Rating Scale (WBFS) Modified Behavioural Pain Scale (MBPS)
A22 [58]	**Anxiety:** Salivary cortisol levels **Pain:** Wong Baker Faces Pain Rating Scale (WBFS)

Overall, the benefit of VR in controlling anxiety and pain was significantly consistent in the included studies, comparing to the corresponding control group, with the exception of the studies by Alshatrat *et al* [42], Aditya *et al* [45], Felenbam *et al* [48], Al-Halabi [49] and Zaidman *et al* [57]. In study, VR had a similar effect to screen distraction on heart-rate levels and pain during buccal infiltration anaesthesia.

Özükoç *et al* found that children with MIH-affected teeth who are distracted from dental procedures using 3D VR games experienced less dental anxiety ($p<0.05$) [37]. Concerning short time appointments, Shetty *et al*, Ran *et al* and Kaswindiarti *et al*., showed a significant reduction in pain, anxiety [39, 41, 58], salivary cortisol ($p<0.001$) [39, 58] and a shorter treatment time [41]. Regarding delivery of intraoral anaesthesia, MCDAS, VAS and WBFRS improved in the immersive VR group [40]. Others presented similar results [38, 44, 46, 49-51, 53, 56].

High levels of satisfaction from children who experienced treatment with 3D video glasses were observed in the study by Nuvvula *et al* [46] and increased fun during dental procedures was reported by the participant children in the study of Atzori *et al* [53].

DISCUSSION

This systematic review focus on comparing the use of VR with conventional non-pharmacological behavioural management techniques in paediatric dental consultations. The selected articles cover various dental procedures such as dental examination, restorations, pulp treatment and anaesthesia. VR was used perioperatively, behaviour, anxiety and pain scales were used to determine efficacy and patient satisfaction. There is strong evidence of the success of VR as a behaviour management tool, in the paediatric dental setting, which is some instances rates superior to conventional behaviour management techniques.

The studies included in this review examined different behavioural control techniques in paediatric dentistry. Conventional techniques were used as a control group in all studies.

Some studies used only VR as a test group, while others using a combination of VR with additional techniques like audio, digital screens, and smartphone games. Interestingly, none of the studies demonstrated that traditional techniques were more effective than the tested techniques in reducing anxiety and pain perception. This can be attributed to VR's ability to divert patients' attention to a pleasant virtual environment, thereby reducing physical pain.

Three studies A12[48], A13[49] and A15[51] compared the use of digital flat panel devices with VR devices as methods of distraction during local anaesthesia administration. One study A15[51] found VR devices to be more effective in reducing pain perception compared to other groups. However, two other studies A12[48] and A13[49] concluded that tablets provided greater relief from anxiety and pain during anaesthesia. It's important to consider variables that influence children's experiences during dental procedures, such as the type of anaesthesia and the technology (tablet or smartphone) they are familiar with.

Three studies conducted in India A10[46], A19[55] and A20[56] compared the use of VR and audio. Results showed that both audio and VR distraction were effective in reducing anxiety, compared to the conventional "Tell-Show-Do" technique. However, VR proved to be more effective in reducing anxiety and pain perception. While music distraction in the dental environment is widely adopted, VR presents itself as a viable alternative. Only one study A19[55] included smartphone games alongside VR. It suggested that VR and smartphone gaming were the most effective distraction techniques for managing negative behaviour in paediatric dental patients. When comparing the effectiveness of these techniques, VR distraction was found to be more effective than smartphone game distraction. The VR provided simultaneously an immersive and interactive experience, which is likely to have contributed to its greater effectiveness.

One study A4[40] compared the effect of immersive and non-immersive VR on pain perception during intraoral injections. Both distraction methods were effective in reducing pain perception, with immersive VR slightly more effective. However, the study had limitations such as a small sample size and limited assessment of pain immediately after the injection. Further

research is needed to assess the impact of VR distraction in different time points and in a larger sample.

While VR glasses can improve patient cooperation, other factors need to be addressed, such as costs, communication issues, dentists' perceptions. Some top range VR appliances are expensive; however, prices have become more accessible. VR can also interfere with communication between the dentist and patient during complex procedures, potentially impairing diagnosis and treatment. Vision blockage and absence of caregivers in the visual field can increase children's anxiety.[58] However, one study A17[53] reported a positive experience of dentists who used VR, feeling more relaxed and focused on their work. Communication with patients was not affected, despite the use of headsets. These issues need to be considered when evaluating the use of VR in dentistry.

The increasing use of VR headsets raises health concerns. Prolonged use can lead to eyestrain, dry eyes, vision problems, migraines, dizziness, and motion sickness and risk of photosensitive epilepsy. Responsible use of VR headsets is critical to ensure patients' well-being.[59,60]

The appropriate age for using digital equipment, including smartphones and tablets, is debated, and virtual reality (VR) requires further studies, particularly evaluating its long-term effects and across different age groups.[5,61] Immersive media hardware companies have established safety recommendations, with Sony Interactive Entertainment[62], Oculus[63], PlayStation[64], and Samsung[65] stating that their products are not recommended for children under 12 or 13 years old. LG[66] sets the highest age limit at 15, while HTC[67], examined in study A5[41], has the lowest limit of 4 years without a "safe mode." All articles in this systematic review used VR glasses in children below the manufacturers' recommendations, except for studies without specified equipment brands.

To mitigate adverse effects, researchers have explored strategies such as oculomotor exercises before using VR glasses, which have shown effectiveness in reducing cybersickness and associated symptoms.[68] Taking breaks during VR use is also recommended to prevent digital eye strain, with suggestions including a 20-second break

every 20 minutes or breaks every 15 minutes as recommended by the UK Department for Business Energy and Industrial Strategy in 2020.[69] However, reviewed studies did not include a specific protocol for preventing eye injuries related to VR glasses.

Assessing cybersickness is crucial as it can cause discomfort and symptoms like nausea, dizziness, headache, eyestrain, and general discomfort. It significantly impacts the user experience and may limit the effectiveness of VR applications.[59] However, among the selected articles, only one A8[44] evaluated cybersickness.

The cost of 3D immersion devices varies based on the type of glasses chosen. Cardboard glasses, the most economical option, use the smartphone screen for display.[70,71] High-end glasses offer better immersion quality, have their own software and hardware, but still utilize the smartphone as a screen.[9] Gaming glasses are the most expensive, and required a computer connection. They are primarily sought after by professional players for superior performance but acquiring them for a dental appointment may not be justified.[72,73] Overall, VR appears to be a viable alternative to pharmacological behaviour methods, such as conscious sedation or general anaesthesia, which carry associated costs and health risks. By utilizing VR, the need for these pharmacological interventions can potentially be reduced and in certain circumstances eliminated.[22,33]

Finally, in this systematic review, the quality of the evidence is good. However, the review is limited by the diverse range of pain and anxiety scales used in the included studies, making direct comparisons challenging. Future research should consider conducting qualitative studies to explore patient-reported outcomes and investigate the long-term effects of VR on anxiety and pain.

CONCLUSION

This systematic review has showed that virtual reality technology during dental treatment is an effective tool for reducing anxiety and pain in children, when compared to conventional

behavioural management techniques. By creating an engaging and immersive experience, VR successfully shifts the patients' focus away from the clinical environment, resulting in a more positive and enjoyable treatment experience. Therefore, it is crucial that dental professionals become familiar with VR as a valuable tool in the management of paediatric patients. Further research is required to determine the sustained benefits of VR and its integration into routine clinical practice.

Abbreviations

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PICO: Population, Intervention, Comparison, Outcome

Mesh: Medical subject headings

NOS: Newcastle Ottawa scale;

HMD: Head Mounted Devices

FBRS: Frankl's behaviour rating scale;

FIS: Facial Image Scale:

MCDAS: Modified Child Dental Anxiety Scale:

SCARED: Screen for Child Anxiety Related Disorders;

WBFPS: Wong-Baker Faces Pain Rating Scale;

VAS: Visual Analog Scale;

FLACC scale: Face, Legs, Activity, Cry, Consolability' scale;

VPT: Venham's picture test;

MBPS: Modified Behavioural Pain Scale

SSQ: Simulator sickness questionnaire

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Annex 1: Modified Newcastle-Ottawa scale (NOS): Randomised Control Trial

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE: RANDOMIZED CONTROLLED TRIAL

Note: A study can be awarded a maximum of one star (*) for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

1) Is the case definition adequate?
    a) yes, with independent validation *
    b) yes, e.g., record linkage or based on self reports
    c) no description
2) Representativeness of the cases
    a) consecutive or obviously representative series of cases *
    b) potential for selection biases or not stated
3) Selection of Controls
    a) community controls *
    b) hospital controls
    c) no description
4) Definition of Controls
    a) no history of disease (endpoint) *
    b) no description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis
    a) study controls for _______________ (Select the most important factor.) *
    b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

1) Ascertainment of exposure
    a) secure record (eg surgical records) *
    b) structured interview where blind to case/control status *
    c) interview not blinded to case/control status
    d) written self report or medical record only
    e) no description
2) Same method of ascertainment for cases and controls
    a) yes *
    b) no
3) Non-Response rate
    a) same rate for both groups *
    b) non respondents described
    c) rate different and no designation

Annex 2: Risk of bias of included studies

Article	Selection	Comparability	Exposure	Total score Risk of Bias ≤ 6 = high 7- 8 = moderate ≥ 9 = low
A1	***	*	***	7
A2	***	*	***	7
A3	****	*	***	8
A4	****	*	**	7
A5	****	*	**	7
A6	**	*	**	5
A7	***	*	**	6
A8	**	*	***	6
A9	***	*	**	6
A10	****	*	***	8
A11	***	*	**	6
A12	***	*	***	7
A13	****	*	****	9
A14	****	*	***	8
A15	****	*	**	7
A16	***	*	***	6
A17	***	*	**	6
A18	****	*	****	9
A19	****	*	***	8
A20	****	*	***	8
A21	****	*	**	7
A22	****	*	***	8