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Strategy nursing in children with compromised ventilation: Umbrella review

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ABSTRACT

Problem: Changes in the ventilation demand nursing interventions duly adapted to the management of said impairment and to the adaptability of the child/parents. This revision aimed to investigate the evidence behind the interventions performed on children with impaired ventilation.'

Eligibility criteria: Systematic reviews of literature in English, Spanish, French, and Portuguese from studies on nursing interventions related to children with impaired ventilation in all contexts of the clinical practice. The Joanna Briggs Institute recommendations were followed. Sample: We conducted a comprehensive search as of January 2022 and updated as of June 2023. The following electronic databases were searched: SCOPUS, Web of Science, Joanna Briggs Institute Database of Systematic Reviews and Implementation Reports, MEDLINE (via PubMed), CINAHL (via EBSCO), MedicLatina (via EBSCO), The Cochrane Database of Systematic Reviews (via EBSCO), and Database of Abstracts of Reviews of Effects (DARE). Nineteen articles published between 2012 and 2022 were included in this review.

Results: Nineteen studies investigated the efficacy of respiratory exercises (Breathing Control - relaxed breathing, pursed lip breathing, Diaphragmatic breathing exercises, respiratory expansion exercise - deep breathing exercise, thoracic expansion exercises (with device), exercises for respiratory muscle strengthening and position to optimize ventilation. In the majority of the studies, it was not possible to evaluate the interventions separately. Thirteen studies evidenced the efficacy of respiratory exercises, BIPAP, and oxygen therapy. Seven articles demonstrated the effectiveness of respiratory muscle-strengthening exercises, and only three mentioned the efficacy of positioning regarding impaired ventilation. Interventions based on respiratory exercises and respiratory muscle training were the most common ones.

Conclusions: The results suggest that nursing interventions to optimize ventilation are efficient. Nevertheless, the same present a low to moderate evidence degree, justified by the population characteristics (small and heterogeneous).

Implications: There is proof of evidence for the studied interventions. However, the lack of methodological robustness points to future research to duly describe interventions, data, and comparable results, using reliable samples in which the focus of the study is clear.

Introduction

Respiratory diseases were among the three central death and incapacitation causes for decades, responsible for approximately 4 million deaths per year in children below five. Among respiratory diseases, pneumonia is the leading cause of death worldwide (Foro de las Sociedades Respiratorias Internacionales, 2017). As an historically major cause of hospitalization among children in countries worldwide (GBD, 2020; Jain et al., 2015; Rha et al., 2020), in Portugal (2019–2010), respiratory diseases were the leading cause of hospitalization among the

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pediatric population (Sociedade de Infecciologia Pediàtrica, 2020). These diseases significantly impact children's daily routines due to common changes in ventilation patterns, regardless of the diseases' pathophysiology and clinical presentation (Postiaux et al., 2011).

Ventilation is defined by the International Council of Nurses (ICN, 2019) as a "respiratory system process characterized by the movement of air inside and out the lungs, with a determined frequency and rhythm, inspiratory depth and expiratory strength". This way, regardless of the clinical diagnosis and symptoms indicating impaired ventilation, it is crucial to implement programs that reduce symptoms, optimize functional status, and increase social participation, focused on quality-of-life improvements. (Dyer et al., 2011; Faverio et al., 2018)

Impaired ventilation in pediatric patients can be managed with various interventions, such as respiratory control, thoracic expansion, positioning techniques to optimize ventilation, and movement techniques to improve gas exchanges (Williams et al., 2022). Thus improving symptoms and the ventilation/perfusion imbalance caused by respiratory diseases. Several strategies, such as respiratory control, thoracic expansion, the use of positioning techniques to enhance ventilation, and movement techniques to bolster gas exchanges, can effectively assist patients with compromised ventilation. These methods contribute to symptom relief and rectify the imbalances in ventilation/perfusion resulting from various diseases. Consequently, these techniques specifically address the ventilation process, as the efficiency of external ventilation directly influences alveolar ventilation (Williams et al., 2022).

The applicability of an intervention for impaired ventilation depends on the assessment of the child and the analysis of all the data, which allows for the correct decision-making regarding the intervention to adopt. Therefore, the know-how of the pediatric patient, alongside the anatomy and physiology principles, is crucial for the prescription of an adequate therapeutical intervention at every age.

Several systematic reviews have already examined the efficacy of these interventions. According to the Aromataris et al. (2020), corresponding to the expansive growth observed across the scientific literature landscape, there has been a remarkable escalation in the production of systematic reviews, which is also the case of respiratory interventions. However, their rapid proliferation presents an augmented challenge to healthcare decision-makers, as it potentially intensifies the existing difficulty in discerning and integrating multitudes of evidentiary data for effective decision-making processes. The readily available systematic reviews do not simplify the decision-making process, which remains a complex task for healthcare practitioners and policy formulators, with the multiple sources and findings being dispersed across different sources, making it challenging for healthcare decision-makers to discern and integrate the wealth of evidence. As the development of the field has seen an increase in various nursing interventions for managing impaired ventilation, the efficacy and application of these interventions vary, leading to a need for comprehensive evaluation and synthesis.

Given the growing volume of systematic reviews and the absence of an Umbrella Review synthesizing the data about interventions for impaired ventilation in pediatric patients, this review will fill a significant gap. Also, given the plethora of systematic reviews that examine the efficacy of these interventions, these often present divergent outcomes and conclusions, adding another layer of complexity for healthcare decision-makers. The synthesis of these varied findings into an organized, accessible format is necessary for more effective decision-making processes, leading us to undertake this Umbrella Review. Thus, this review aims to cater to a target audience that includes clinicians, healthcare policymakers, and researchers. Its purpose is to provide a synthesized overview of the available evidence on various nursing interventions, ultimately aiding decision-making processes in clinical practice and policy formulation.

A preliminary search for existing Umbrella Reviews on the topic was conducted in the JBI Library, Cochrane Library, CINAHL (EBSCO), MEDLINE (PubMed), Epistemonikos, and PROSPERO databases, but no similar reviews were found. The unique value of this review lies in its comprehensive overview of the existing systematic reviews, which are currently dispersed across multiple sources.

The objective of this Umbrella Review is to analyze existing systematic reviews on interventions for pediatric patients with impaired ventilation using the PICO (Population, Intervention, Comparison, Outcome) framework. Specifically, it focuses on "the efficacy of implementation of respiratory control techniques", "application of positioning techniques", and "execution of thoracic expansion techniques", among other nursing interventions related to impaired ventilation in pediatric patients. The ultimate goal is to promote critical thinking in nursing, bolster evidence-based practice, and enhance the overall quality of care.

Methods

An umbrella review was carried out to identify the results of systematic reviews (with or without meta-analysis) of studies concerning the efficacy of interventions performed on children with impaired ventilation. This review was conducted according to the JBI's approach (2020). considering the following guidelines, Preferred Reporting Items for Systematic reviews, and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist (Page et al., 2021; Tricco et al., 2018a, 2018b).

Protocol

According to the recommendations of good practices to increase transparency and decrease bias, the protocol referent to the umbrella review was crafted (Hunt, 2018).

This protocol was registered in the OSF Registration Forms on the 23rd of January 2022 (DOI10.17605/OSF.IO/R3UCF). Using the same selection criteria of studies of the protocol, one intervention was added to the analysis, making the study wider.

Search strategy

With no time limit, a broad search was made to identify all relevant research summaries (Aromataris et al., 2020).

We conducted a comprehensive search as of January 2022 and updated as of June 2023.

The following electronic databases were searched: SCOPUS, Web of Science, Joanna Briggs Institute Database of Systematic Reviews and Implementation Reports, MEDLINE (via PubMed), CINAHL (via EBSCO), MedicLatina (via EBSCO), The Cochrane Database of Systematic Reviews (via EBSCO), and Database of Abstracts of Reviews of Effects (DARE).

The search strategy was developed using the SNOMED_CT terminology (SNOMED, 2022) to define the interventions under study. This approach allowed us to use standardized language in our search terms, enabling a more precise and targeted search across multiple databases.

The used search terms are described in Table 1 (Platform search terms).

Additional research on the PEDro database – 13 results – was made with the following search terms: "respiratory therapy" and "impaired ventilation" and "paediatrics" and "systematic review".

For article management, the software application Endnote was employed, and Nvivo was used for data analysis.

Study selection

To fulfill the review's objectives, the study selection considered the PICO mnemonic.

Participants

Studies that included pediatric patients under 18 years old (Ordem dos Enfermeiros, 2017) with impaired ventilation. No exclusion criteria

Table 1
Database search terms.

Search (Platforms)	Query	Records retrieved
SCOPUS	(TITLE-ABS ("Pulmonary rehabilitation" OR "Oscillating positive expiratory pressure physiotherapy" OR "Respiratory therapy" OR "Physiotherapeutic breathing exercise" OR "Diaphragmatic breathing exercises" OR "Relaxed breathing" OR "Breathing exercise, blow bottle" OR "Respiratory expansion exercises" OR "Apical expansion exercises" OR "Basal expansion exercises" OR "Lower lateral costal expansion exercises" OR "Thoracic expansion exercises" OR "Lower thoracic expansion exercises" OR "Upper thoracic expansion exercises" OR "Breathing control" OR "Inspiratory muscle training" OR "Incentive spirometry")) AND (TITLE-ABS ("Thorax expansion" OR "Continuous positive airway pressure titration" OR "Eucapnic voluntary hyperventilation challenge" OR "Physiotherapy of chest" OR "Active cycle of breathing technique")) AND (TITLE-ABS (review OR meta-analysis OR metareview OR "meta-review"))	481
Web of Science	(TS = ("Pulmonary rehabilitation" OR "Oscillating positive expiratory pressure physiotherapy" OR "Respiratory therapy" OR "Physiotherapeutic breathing exercise" OR "Diaphragmatic breathing exercises" OR "Relaxed breathing" OR "Breathing exercise, blow bottle" OR "Respiratory expansion exercises" OR "Apical expansion exercises" OR "Basal expansion exercises" OR "Lower lateral costal expansion exercises" OR "Thoracic expansion exercises" OR "Lower thoracic expansion exercises" OR "Upper thoracic expansion exercises" OR "Breathing control" OR "Inspiratory muscle training" OR "Incentive spirometry")) AND (TS = ("Thorax expansion" OR "Continuous positive airway pressure titration" OR "Eucapnic voluntary hyperventilation challenge" OR "Physiotherapy of chest" OR "Active cycle of breathing technique")) AND (TS = (review OR meta-analysis OR metareview OR "meta-review"))	406
Ebsco	(TI ("Pulmonary rehabilitation" OR "Oscillating positive expiratory pressure physiotherapy" OR "Respiratory therapy" OR "Physiotherapeutic breathing exercise" OR "Diaphragmatic breathing exercises" OR "Relaxed breathing" OR "Breathing exercise, blow bottle" OR "Respiratory expansion exercises" OR "Apical expansion exercises" OR "Basal expansion exercises" OR "Lower lateral costal expansion exercises" OR "Thoracic expansion exercises" OR "Lower thoracic expansion exercises" OR "Upper thoracic expansion exercises" OR "Breathing control" OR "Inspiratory muscle training" OR "Incentive spirometry") OR AB ("Pulmonary rehabilitation" OR "Oscillating positive expiratory pressure physiotherapy" OR "Respiratory therapy" OR "Physiotherapeutic breathing exercise" OR "Diaphragmatic breathing exercises" OR "Relaxed breathing" OR "Breathing exercise, blow bottle" OR "Respiratory expansion exercises" OR "Apical expansion exercises" OR "Basal expansion exercises" OR "Lower lateral costal expansion exercises" OR "Thoracic expansion exercises" OR "Lower thoracic expansion exercises" OR "Upper thoracic expansion exercises" OR "Breathing control" OR "Inspiratory muscle training" OR "Incentive spirometry")) AND (TI ("Thorax expansion" OR "Continuous positive airway pressure titration" OR "Eucapnic voluntary hyperventilation challenge" OR "Physiotherapy of chest" OR "Active cycle of breathing technique") OR AB ("Thorax expansion" OR "Continuous positive airway pressure titration" OR "Eucapnic voluntary hyperventilation challenge" OR "Physiotherapy of chest" OR "Active cycle of breathing technique")) AND (TI (review OR meta-analysis OR metareview OR "meta-review") OR AB (review OR meta-analysis OR metareview OR "meta-review")	202
PubMed	("Pulmonary rehabilitation"[tiab] OR "Oscillating positive expiratory pressure physiotherapy"[tiab] OR "Respiratory therapy"[tiab] OR "Physiotherapeutic breathing exercise"[tiab] OR "Diaphragmatic breathing exercises"[tiab] OR "Relaxed breathing"[tiab] OR "Breathing exercise, blow bottle"[tiab] OR "Respiratory expansion exercises"[tiab] OR "Apical expansion exercises"[tiab] OR "Basal expansion exercises"[tiab] OR "Lower lateral costal expansion exercises"[tiab] OR "Thoracic expansion exercises"[tiab] OR "Lower thoracic expansion exercises"[tiab] OR "Upper thoracic expansion exercises"[tiab] OR "Breathing control"[tiab] OR "Inspiratory muscle training"[tiab] OR "Incentive spirometry"[tiab]) AND ("Thorax expansion"[tiab] OR "Continuous positive airway pressure titration"[tiab] OR "Eucapnic voluntary hyperventilation challenge"[tiab] OR "Physiotherapy of chest"[tiab] OR "Active cycle of breathing technique"[tiab]) AND (review[tiab] OR meta-analysis[tiab] OR metareview[tiab] OR "meta-review"[tiab])	5

children aged <18 years, language limits: articles published in English, French, Spanish and Portuguese, no Limited to date.

based on gender, illness, duration of illness, disease subtype, or functional capacity were considered.

Intervention

Studies that evaluated the effectiveness of nonpharmacological interventions on pediatric patients included nonpharmacological interventions on the ventilatory domain, namely, "training of the respiratory muscle", "execution of techniques of breathing control", "execution of positioning techniques", and "execution of thoracic expansion techniques"—without limitations on frequency/intensity, the intervention prescriber, or the intervention executioner, and they were isolated or combined. We included studies in which nonpharmacological interventions were used to respond to impaired ventilation in children in any given context of the clinical practice. Due to the multifactorial nature of ventilation changes, no exclusions were made regarding the interventions' content, duration, or local. Nonpharmacological and non-surgical interventions to optimize ventilation in children were included in the study.

Comparator

Studies that compared an intervention with a placebo or other nonpharmacological interventions were included.

Outcomes

Studies that included the following outcomes: vital signs, Oxygen saturation (spO2), Heart rate, Respiratory rate, Symmetry of respiratory movement, Inspection (signs of respiratory distress), Presence of comfort or agitation, Chest palpation, Assessment of thoracic mobility, Assessment of diaphragmatic mobility, Depth of ventilation, Dyspnea, Auscultation, Imaging semiology, Functional semiology (Respiratory function tests, Spirometry, Maximum spontaneous expiratory output, Maximum respiratory pressures, oxygenation monitoring (pO2, SaO2), pulmonary ventilation (pCO2) and acid-base balance, synchronization with ventilator cycles, mechanical ventilation monitoring data -

volumes and pressures, pulmonary compliance. In addition, the decrease in acute events post-intervention, symptomatic control, and impact on the quality of life were also considered.

Context

There were no limitations of context in this umbrella review.

Types of studies

Quantitative systematic reviews (with or without meta-analyses), systematic reviews of mixed methods were included. Reviews that incorporate theoretical studies or text and opinion as their primary source of evidence were excluded.

All the studies focused on the evaluation of the efficacy of interventions in children with impaired ventilation, regardless of diagnosis, and including acute or chronic events were the focus of the study (Diário da República, 2.ª série — N.° 85, 2019).

Articles in English, French, Spanish, and Portuguese, with no temporal limit, were considered.

Articles concerning interventions not directed to impaired ventilation were excluded, alongside studies with a different population, studies about interventions exclusive to other professional groups, pharmacological or surgical interventions, and economic analysis articles.

Quality assessment and data extraction

After research in all databases, duplicates were excluded. Two revisors examined, independently, the titles and summaries of the articles. Upon divergency, the convergent points were considered. Divergent points were discussed until a consensus was reached.

According to the inclusion criteria, studies eligible for integral reading were evaluated in detail.

After a descriptive evaluation of each study, data were extracted to a data extraction sheet, developed according to the goals and investigation questions, following the methodology of the Joanna Briggs Institute to umbrella reviews (JBI, 2020). Finally, the extracted data were summarized in Table 2, allowing for better analysis and conclusions.

For data extraction, the categorization of interventions was guided by the SNOMED_CT taxonomy (SNOMED, 2022). This international healthcare terminology is designed to capture clinical information across multiple specialties, providing a standardized language that enables consistent description, recording, and sharing of healthcare data. As such, it offers a comprehensive framework that is globally recognized, and therefore ideal for this review, as it can include a wide range of nonpharmacological interventions.

For data summary, the Principles from Grading of Recommendations Assessment, Development, and Evaluation (GRADE) were used for an overall assessment of the quality of evidence for each intervention or phenomena of interest.

Results

Literature search and study selection

After sorting 1108 articles, 29 were fully included, and 19 were included according to the criteria. Fig. 1 shows the study selection process.

Study characteristics

Table 2 summarizes the characteristics of the nineteen studies, classified according to study design, population, location and year of publishing, interventions, data and results of the interventions, and general classification of the studies' quality and relevance.

Regarding location, six studies (31,5%) were done in Australia, three (15%) in the United Kingdom, two (10,5%) in Denmark, two (10.5%) in Brazil and China, as well as Philadelphia (USA), India, Cairo and Costa Rica with one study.

The nineteen systematic reviews included were published between 2012 and 2022. Of the nineteen, five included meta-analysis. Nevertheless, none conducted meta-analysis on the results of each mentioned intervention. The remaining studies presented the results via narrative synthesis (Bredemeyer & Foster, 2012; Ferguson, 2017; Beningfield & Jones, 2018; Kneale et al., 2019; Zhang et al., 2021).

Data were extracted from ten systematic reviews of Randomized Controlled Trials) (RCTs), (Korang et al., 2016; Macêdo et al., 2016; Human et al., 2017; Moran et al., 2017; Eman et al., 2019; Irons et al., 2019; Stanford et al., 2020; Bamat et al., 2021;Jat et al., 2022; Bhandari et al., 2022); One observational systematic review RCTS (Castilho et al., 2020); Two systematic reviews (Hawkins & Jones, 2015; Nørgaard, 2020) and one mixed methods systematic review (Harris, 2019).

Regarding the methodological evaluation of the systematic reviews by levels of effectiveness JBI, all studies were classified as level 1 of evidence (Aromataris & Munn, 2020) (Table 1), with seventeen reviews being 1A (systematic reviews of Randomized Controlled Trials) and two being 1B (systematic review of RCTs and other study designs).

Concerning population, the number of participants varied between $n = 40$ and $n = 14{,}174$. The age corresponds to the studied population, children under 18 years old. One systematic review presented a very heterogeneous population, involving eighteen studies with neonatal population, three with a population aged between 1 month and five years, and three with a population aged between 1 week and 14 years. (Nørgaard, 2020).

Another systematic review with five studies, all focused on the neonatal population ($n = 114$), evaluates the efficacy of positioning in apnea's decrease (Bredemeyer & Foster, 2012). One reviews focused the positioning four acute respiratory distress in hospitalized infant and children (Bhandari et al., 2022).

One reviews focused on acute bronchiolitis in children, six systematic reviews focused on the population with asthma, four focused on children with cystic fibrosis, six reviews on respiratory rehabilitation interventions in children exposed to a mechanic and non-mechanic ventilation, one study pointed to the efficacy of interventions in the post-operatory stage of cardiac surgeries, and one study focused on the positioning decreasing apnea in the neonatal population. Nineteen reviews were included in the final synthesis.

All reviews mentioned the interventions that were in the scope of the study, with the majority included in combined intervention programs. It is emphasized that three reviews included breathing control techniques (relaxed an pursed lip breathing exercises) (Castilho et al., 2020; Macêdo et al., 2016; Zhang et al., 2021), four systematic reviews included diaphragmatic breathing exercises (Macêdo et al., 2016; Irons et al., 2019;Castilho et al., 2020; Stanford et al., 2020). Two reviews included respiratory expansion exercise (deep breathing exercises) (Castilho et al., 2020; Macêdo et al., 2016), and five reviews focused thoracic expansion exercise whith device (Bamat et al., 2021; Castilho et al., 2020; Hawkins & Jones, 2015; Jat et al., 2022; Korang et al., 2016), one review included a hyperinflation device as a thoracic expansion technique (Hawkins & Jones, 2015). Regarding thoracic expansion techniques, four reviews included CPAP in the intervention (Bamat et al., 2021; Hawkins & Jones, 2015; Korang et al., 2016); Jat et al., 2022). Seven reviews shown the importance of respiratory muscle-strengthening exercises (Macêdo et al., 2016; Beningfield & Jones, 2018; Human et al., 2017; Irons et al., 2019; Zhang et al., 2021; Castilho et al., 2020; Stanford et al., 2020); Lastly, three reviews included positioning techniques to optimize ventilation (Bhandari et al., 2022; Bredemeyer & Foster, 2012; Castilho et al., 2020).

Quality assessment of articles

The evaluation of the methodological quality followed the JBI criteria (JBI, 2020). The cut-off/treshold for critical appraisal was based

Table 2
Characteristics of included studies.

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
1.A.	Body positioning for spontaneously breathing preterm infants with apnoea	Bredemeyer & Foster, 2012	Australia	Systematic Review and Meta - analysis	To determine the effect of body positioning on cardiorespiratory functioning in spontaneously breathing preterm infants with clinically significant apnoea.	Five studies (N = 114)	Episodes of apnoea, bradycardia and oxygen desaturation	The following positions will be compared: • supine versus prone (lying on back versus lying on front); • supine versus right lateral (lying on back versus lying on right side); • supine versus left lateral (lying on back versus lying on left side); • prone versus right lateral (lying on front versus lying on right side); • prone versus left lateral (lying on front versus lying on left side); • right versus with left lateral (lying on right side versus lying on left side). Horizontal (flat) versus head elevated positions will be analyzed separately for all body positions: • prone horizontal versus prone head elevated; • supine horizontal versus supine head elevated; • right lateral horizontal versus right lateral head elevated; • left lateral horizontal versus left lateral head elevated.	None of the individual studies or the meta-analyses showed a reduction in apnoea, bradycardia, oxygen desaturation or oxygen saturation with body positioning (supine versus prone; prone versus right lateral; prone versus left lateral; right lateral versus left lateral; prone horizontal versus prone head elevated; right lateral horizontal versus right lateral head elevated and left lateral horizontal versus left lateral head elevated). Overall, there was insufficient evidence to determine the role of body position on apnoea, bradycardia, oxygen desaturation and oxygen saturation in preterm infants."
1 B.	What is the role of the physiotherapist in pediatric intensive care units? A systematic review of the evidence for respiratory and rehabilitation interventions for mechanically ventilated patients	Hawkins & Jones, 2015	Australia	Systematic review	To determine the role of physiotherapists in the management of mechanically ventilated patients in PICU.	Six studies on (CPT) in pediatric (n = 418) < 18	oxygenation, dead space, tidal volumes, peak expiratory flows/ peak expiratory flow ratios, airway compliance, airway resistance, forces applied during manual techniques e.g. suction produced significant reductions in airway compliance. Haemodynamic stability	CPT" (MHI "suction", vibrations, percussions, compressions, or postural drainage	Evidence supports the use of CPT as a safe and effective treatment for secretion clearance, and usually involves MHI, vibrations, and suction. Improves volumes reduces dead space and improves oxygenation

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Table 2 (*continued*)

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
1. A.	Breathing exercises for children with asthma (Review)	Macêdo et al., 2016	Brazil	Systematic Review of Randomized Controlled Trials	To assess the effects of breathing exercises in children with asthma.	three studies (n = 112 children younger than 18 years) with mild to severe asthma,	(heart rate, blood pressure), oxygenation (SpO2) Quality of live Asthma symptoms, reduction in medication usage, number of acute exacerbations Physiological measures, such as lung function (especially low flow rates) and functional capacity.	the breathing exercises: lateral costal breathing and diaphragmatic breathing, children performed diaphragmatic breathing and inspiratory patterns with pursed lips. inspiratory muscle training, relaxation exercises, endurance exercises, rhythmic mobilization exercises, vibrations, percussion, forced expiration technique). educational programme	We found no primary outcomes (measures of quality of life, asthma symptoms and side eLects of treatment) that were reported as comparisons between the treatment and control groups. The outhers outcoms is not clear
1. A.	Non-invasive positive pressure ventilation for acute asthma in children (Review)	Korang et al. (2016)	Denmark	Systematic Review of Randomized Controlled Trials	To assess the benefits and harms ofNPPV as an add-on therapy to usual care (e.g. bronchodilators and corticosteroids) in children with acute asthma.	The two studies included a total of n = 40 participants.	quality of life, arterial blood gases/pH, Pediatric Asthma Severity Score, heart rate, respiratory rate, transcutaneous oxygen saturation, need for supplemental oxygen set by the respiratory therapist to keep oxygen saturation at >92% Side effects: (minor) nasal bridge pain and skin irritation, gastric insufflations, sinus and ear pain, dry eyes	Both included trials used BiPAP. interventions with BIPAP, with gradual increase in expiratory positive pressure	Both trials showed a statistically significant reduction in symptom scores.
1A	Non-invasive ventilation for cystic fibrosis (Review)	Moran et al. (2017)	Australia	Systematic review of randomized Controlled trials	To compare the effect of non-invasive ventilation versus no non-invasive ventilation in people with cystic fibrosis for airway clearance, during sleep and during exercise.	Ten trials met the inclusion criteria with a total of n = 191 participants (any age)	Lung function, Gas exchange, Respiratory symptom scores and sputum production, Exercise tolerance, Impact on health resources, Nocturnal polysomnography, Nutrition and weight, Right-sided cardiac function. Cost, Adherence to treatment	non-invasive mask ventilation,	There is some evidence that the introduction of NIV to airway clearance preserved muscle strength and improved expiratory muscle strength. No deleterious effects on small airway function were observed. In terms of overnight ventilatory support in a single nocturnal treatment session, NIV offers benefits over oxygen or room air. By attenuating the decrease in ventricular tachycardia and improving ventilation during

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Table 2 (*continued*)

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
							and preference Adverse events		sleepNIVdecreases hypoventilation in people with moderate to severe lung disease.Overall, the results from included studies demonstrate that NIV improves the physiological markers ofearly respiratory failure following a single nocturnal treatment session, with improvements in exercise tolerance, selected aspects ofquality of life and nocturnal carbon dioxide levels when used over a longer period.
1. A.	Peri-operative chest physiotherapy for pediatric cardiac patients: a systematic review and meta-analysis	Beningfield & Jones, 2018	Australia	a systematic review and meta-analysis	To determine whether peri-operative CPT is both safe and effective in the immediate and long term for pediatric cardiac patients with CHD	11 studies as inclusion in total $n = 424$. Age < 18 years.	peripheral oxygen saturation, heart rate and the perception of pain.were vital signs, post-operative complications, adverse reactions, length of stay in ICU and hospital, chest x-rays and compliance with physiotherapeutic treatment	education, ambulation, upper extremity exercises, deep breathing.	The meta-analysis results indicated that physiotherapy was not statistically effective in preventing and treating atelectasis. The intervention group in the study by Carmini et al. [received pre-operative breathing exercises, coughing techniques and ambulation. The intervention group achieved adequate arterial oxygen saturation on room air (mean 2.52 days; $P = 0.026$), had normal breath sounds on auscultation (mean 3.37 days; $P = 0.026$), had an effective cough (mean 1.41 days; $P = 0.034$), and were sitting (mean 2.04 days; $P < 0.001$) and walking (mean 3.0 days; $P < 0.001$) sooner compared with the control group who received no pre-operative treatment. Therefore, there is some evidence to suggest that active pre-operative treatment may enhance recovery in this population; however, generalisability is limited by the low-quality study design (level III—2) in conjunction with the small sample size and narrow age range.
1.A.	Interventions to Improve Rates of Successful Extubation in Preterm Infants	Ferguson, Roberts, Manley, & Davis (2017)	Austrália	Systematic Review and Meta - analysis	to improve rates of successful extubation in preterm infants.	enrolled intubedated preterm infants (born <37 weeks gesation) Fifty studies were eligible for inclusion	oxygen saturation, reintubation	CPAP, higher pressures (7–9 cm H2O), NIPPV, BIPAP, Chest physioterapi	CPAP deliveredby nasal mask was associatedwith fewer intubations in the first 72 h post-extubation in comparisonwith binasal prongs, this effect was not sustained. No particular method ofgenerating CPAP was found to be superior. Nasal intermittent positive pressure ventilation was more effective than CPAP to prevent extubation failure, regardless of whether synchronization was used. S-NIPPV seemed to have a greater benefit than NS-NIPPV. Mechanical ventilation

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Table 2 (*continued*)

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
									increases lung secretions and can result in lung atelectasis. Preterm infants should be extubated to noninvasive respiratory support. Chest physiotherapy significantly improved extubation success; however, thismustbeinterpretedcautiously.
1. A.	Inspiratory muscle training for children and adolescents with neuromuscular diseases: A systematic review	Human et al., 2017)	South Africa	Systematic review of randomized Controlled trials	to determine the safety of IMT and its efficacy with regard to improving inspiratory muscle strength and endurance, exercise capacity, pulmonary function, dyspnoea and HRQoL in pediatric and adolescent patients (5–18 years) living with NMDs.	From a total of 7 studies ($n = 168$) participants, children and adolescent (5–18 anos)	"desaturation, cardiac failure, muscle fatigue and muscle fibre damage, hyperinflation, and barotrauma such as a pneumothorax. Pulmonary function tests (e.g. VC, Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), Total Lung Capacity (TLC); cough efficacy (measured by Peak Expiratory Cough Flow (PECF)); vital signs (including heart rate (HR), respiratory rate (RR), arterial blood gases (ABG)); diaphragmatic changes (measured with ultrasound); measures of inspiratory muscle strength (maximal inspiratory pressure (MIP), maximal inspiratory capacity (MIC), sniff nasal inspiratory pressure (SNIP), transdiaphragmatic pressure (Pdi)); and endurance (maximal voluntary ventilation (MVV)) as well as HRQoL measured	inspiratory muscle trainer, PEP, Breathing exercises (diaphragmatic and segmenta,	Most of the included studies reported that there were no statistically significant changes in pulmonary function tests such as VC, FEV1, FVC, FRC and TLC between patients in the experimental (respiratory muscle training) compared to those in the control groups. It is possible that the effect of respiratory muscle training is not sufficient to counterbalance the natural decline of pulmonary function in these patients.improved respiratory muscle strength and endurance of these patients can assist with maintaining adequate lung inflation, expansion, ventilation and gas exchange which will prevent atelectasis and respiratory complications Respiratory muscle training is widely incorporated into physiotherapy management of NMD patients and aims to enhance respiratory function by improving respiratory muscle strength and endurance, in an effort to reduce morbidity and mortality.
1 A.	Effectiveness of school-based self-management interventions for asthma among children and adolescents: findings from a	Kneale et al., 2019	London, UK	systematic review and meta-analysis	Identify the key design features and processes associated with successful implementation of school-based asthma self-management interventions and	32 studies ($n = 12,217$) Participants included children with asthma aged 5–18 years who participated within	exacerbations or asthma attacks leading to admission to hospital (hospitalization); asthma symptoms leading to emergency hospital visits; absence	self-management of asthma among children through at least one of the following components: (1) increasing knowledge of asthma and its	Self-management interventions for children with asthma delivered in schools reduce the number of acute episodes of healthcare usage. We conclude that the school environment is an important space for delivering interventions to improve children's health. Since self-management

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Table 2 (*continued*)

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
	Cochrane systematic review and meta-analysis				understand whether school-based interventions can effectively change asthma self-management behaviour.	their own school environment	from school; and days of restricted activity.	management; (2) enhancing self-management skills; and (3) improving self-management behaviours and practice	interventions delivered in schools reduce the number of acute episodes of healthcare usage
1. A.	Chest Physiotherapy on Pulmonary Functions 4 Children with Cystic Fibrosis: Systematic Review of Randomized Controlled Trials	Eman et al., 2019	Cairo	Systematic Review of Randomized Controlled Trials	To investigate the effect of chest physiotherapy on pulmonary functions in children with CF.	7 Studies ($N = 152$). Children with CF aged From 1 month To 18 years.	Pulmonary functions as forced vital capacity (FVC) and forced expiratory volume in one second (FEV1).	postural drainage (PD), autogenic drainage(AD), non-invasive ventilation and independent active cycle of breathing technique (ACBT)Noninvasive ventilation, Positive expiratory pressure	The present evidence supports the use of different CPT interventions for improving pulmonary functions in children with CF. Although findings of this review support the effectiveness of using CPT interventions for children with CF; additional RCTs with larger sample sizes are still needed to confirm the present evidence. The limited evidence about the effectiveness of modified PD, PEP and therapist-assisted ACBT also needs further well-designed researches.
1. B.	School-based self management interventions for asthma in children and adolescents: a mixed methods systematic review	Harris et al. (2019)	UK, London	a mixed methods systematic review	To assess the effects of school-based interventions for improvement ofasthma selfmanagement on children's outcomes. • To identify the processes and methods that are aligned with effective and non-effective interventions.	55 studies in the review. Thirty-three studies in 14,174 children provided information for the QCA, and 33 RCTs in 12,623 children measured the effects of interventions. Eleven studies contributed to both the QCA and the analysis of effectiveness.	Asthma symptoms leading to emergency hospital visits. • Parent-reported absence from school. • Days of restricted activity. • daytime and night-time symptoms. • Lung function (e.g. forced expiratory volume in one second (FEV1) in clinic, peak flow at home). • Use of reliever therapies such as beta2-agonists. • Health-related quality of life (HRQoL)	interventions that aim to develop and enhance self management ofasthma among children through at least one or all of the following components. • Reinforcement of regular monitoring of lung function. • Emphasis on the importance of self management practice and behaviour. • Instruction on inhaler techniques. • Non-pharmacological self management strategies focused on avoiding or reducing the risk of experiencing asthma or asthma attacks, including lifestyle and behavioural modifications prescribed on the	The interventions all attempted to improve knowledge of asthma. School-based self-management interventions probably reduce mean hospitalisations by an average of about 0.16 admissions per child over 12 months (moderate certainty evidence). Self-management interventions probably reduce the number of days of restricted activity by just under half a day over a two-week period (moderate certainty evidence). Self-management interventions probably improve children's asthma-related quality of life by a small amount (moderate certainty evidence)School-based asthma self-management interventions probably reduce hospital admission and may slightly reduce ED attendance, although their impact on school attendance could not be measured reliably. They may also reduce the number of days where children experience asthma symptoms, and probably lead to small improvements in asthma-related quality of life.

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Table 2 (*continued*)

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
								basis of asthma severity.	
1.A.	Singing as an adjunct therapy for children and adults with cystic fibrosis (Review)	Irons et al., 2019	Derby, UK	Systematic review of randomized Controlled trials	To evaluate the effects of singing as an adjunct therapy to standard treatment on the quality of life, morbidity, respiratory muscle strength and pulmonary function of children and adults with cystic fibrosis.	The review includes one study with 40 children with cystic fibrosis aged between seven and 17 years of age.	Respiratory muscle function, MIP, MEP, Spirometry	exercises to develop the desired posture for singing; diaphragmatic breathing exercises; vocal warm-ups; and singing using the diaphragmatic technique.	Participants from both the singing and recreation groups reported some improvement in quality of life measurements. Participants in the singing group showed a greater increase in maximal expiratory pressure (a substitute measure of respiratory muscle strength test), while there was no improvement in this outcome for those in the recreation group. No adverse events were reported.
1 A.	Effects of physical therapy on lung function in children with asthma: a systematic review and meta-analysis	Zhang et al., 2021	China	a systematic review and meta-analysis	To Investigate the effects of physical therapy on lung function in children with asthma	18 studies ($\acute{n} = 711$) population included had to meet the age < 18 years and the diagnosis as asthma by clearly defined or internationally recognized criteria.	peak expiratory flow (PEF), forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), FEV1/FVC, and forced expiratory flow (FEF) in percent predicted values or absolute values.	breathing exercise, and inspiratory muscle training (IMT), Physical training	This meta-analysis demonstrates that physical training significantly improved FVC(%pred) in children with asthma. This finding may support the therapy of physical training in asthmatic children. But further research involving the physical training mode, the duration, and the frequency is needed. Besides, more trials on the effects of breathing exercise and IMT in children with asthma should be conducted in the future.
1. A.	Respiratory muscle training for cystic fibrosis	Stanford et al., 2020	Cost Rca	review of randomized Controlled trials	To determine the effectiveness of respiratory muscle training on clinical outcomes in people with cystic fibrosis.	10 studies with 238 participants met the review's inclusion criteria.	FEv1 predicted, FVC predicted	Respiratory muscle training (RMT)	There was a greater improvement in the respiratory muscle training groups muscle respiratory. Descriptive analysis of considered studies suggests that PImax and RME time are the measures that can best detect the eAects of a RMT intervention. Although it is acknowledged that this is not supported by a meta-analysis of studies, they are the measures the included studies report as showing significant improvement within the RMT groups.
1 A.	To Bubble or Not? A Systematic Review of Bubble Continuous Positive Airway Pressure in Children in Low- and Middle-Income Countries	Norgaard, M.;Stagstrup, C.;Lund, S.; Poulsen, A. (2020)	Denmark	Systematic review	To examine, whether bCPAP is a safe and effective treatment for children in all age-groups presenting with respiratory distress from any cause, LMIC-implemented bCPAP devices including their technical specifications	A total of 18 studies included only neonates, 3 studies included children aged 1 month to 5 years, and the remaining 3 studies included children aged 1 week to 14 years	Respiratory rate, Saturation, oxigenoterapi	BCPAP	For neonates bCPAP was superior in improving survival and clinical progression compared with oxygen therapy and mechanical ventilation (MV). In two studies bCPAP was superior to low flow oxygen in reducing mortality in children 29 days to 13 months. Respiratory rate reductions were significant across all ages. Only three of six studies in children of all ages evaluated serious adverse events. In neonates and

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Table 2 (*continued*)

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
									children below 13 months bCPAP is a safe treatment improving clinical outcomes and reducing the need for MV, without an increase in mortality.
1. B.	Effects of inspiratory muscle training and breathing exercises in children with asthma: systematic review	Castilho et al., 2020	Santa Catarina. Brasil	Systematic Review RCT and Observations	To describe the effects of inspiratory muscle training (IMT) and breathing exercises in children with asthma	8 studies with 288 participants met the review's inclusion criteria.	CPulmonary function tests (e.g. VC, Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), Total Lung Capacity (TLC), peak expiratory flows/peak expiratory flow ratios, exacerbations or asthma	Respiratory muscle training (RMT), the breathing exercises: lateral costal breathing and diaphragmatic breathing, children performed diaphragmatic breathing and inspiratory patterns with pursed lips. inspiratory muscle training, relaxation exercises, endurance exercises, rhythmic mobilization exercises, vibrations, percussion, forced expiration technique). educational programme	It was evidenced that the IMT in children with Asthma can improve the strength of inspiratory and expiratory muscles, but there is still uncertainty about the clinical improvement that this treatment can provide, and the scientific literature is scarce about this intervention in the pediatric population. Regarding breathing exercises, these are widely used, both in clinical practice and in the scientific environment, since they are well established in the management of asthma. However, as no study included in this review applied the exercises in isolation and there is no standardization regarding their performance, it is still not possible to measure their effects in children with asthma.
1.A	Nasal continuous positive airway pressure levels for the prevention of morbidity and mortality in preterm infants	Bamat et al., 2021	Philadelphia, USA	Systematic review of randomized Controlled trials	To assess the efects of 'low' (K 5 cm H2O) versus 'moderate-high' (> 5 cm H2O) initial nasal CPAP pressure levels in preterm_infants receiving CPAP either	316 infants of gestational age < 37 weeks or birth weight < 2500 g within the first 28 days of life to diFerent nasal CPAP levels	Treatment failure as indicated by study author prespecified values of recurrent apnea, hypoxia, hypercarbia, increasing oxygen requirement; or the need for mechanical ventilation. If this outcome was reported for more than one time point (e.g. failure by three days, failure by five days, etc.), we used the latest time point up to seven days from randomization	CPAP, Toracic expension exercises with a device	There are insuFicient data from randomized trials to guide nasal CPAP level selection in preterm infants, whether provided as initial respiratory support or following extubation from invasive mechanical ventilation. We are uncertain as to whether low or moderate-high nasal CPAP levels improve morbidity and mortality in preterm infants. Well-designed trials evaluating this important aspect of a commonly used neonatal therapy are needed.
1.A	Positioning for acute respiratory distress in hospitalized infants and children.	Bhandari et al., 2022	Austrália	Systematic review of randomized Controlled trials	To compare the eIects of diIerent body positions in hospitalized infants and children with acute respiratory distress_syndrome aged	198 participants aged between 4 weeks and 16 years	Oxygenation arterial oxygen saturation, partial pressure of oxygen and carbon dioxide in arterial blood, lung function, and oxygenation index.	Body positions used for the management of infants and children with acute respiratory distress included the following. 1. Sitting – erect	Although included studies suggest that prone positioning may oIer some advantage, there was little evidence to make definitive recommendations. There appears to be low certainty evidence that positioning improves oxygenation in mechanically ventilated children

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Table 2 (*continued*)

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
					between four weeks and 16 years		Ventilatory outcomes included: tidal volume, minute volume, dynamic lung compliance, inspiratory resistance, expiratory resistance, total pulmonary resistance, respiratory rate, work of breathing, and laboured breathing index. Other outcomes were heart rate, oesophageal pressure, and adverse events. These are listed below, with their definition and significance.	sitting, forward-leaning sitting, and non-erect sitting 2. Prone – prone abdomen free, prone abdomen restricted, semiprone, quarter-prone, horizontal (flat), and head elevated 3. Lateral recumbent or side-lying position – horizontal (flat) and head elevated (this position can be good-lung dependent, where the person lies on the side of the healthy lung; or good-lung independent, where the person lies on the side opposite to the healthy lung). 4. Supine – horizontal (flat) and head elevated 5. Kinetic positioning – continuous postural therapy (usually with an automated bed) 6. Body tilting	with ARDS. Due to the increased risk of SIDS with prone positioning and lung injury with artificial ventilation, it is recommended that hospitalized infants and children should only be placed in this position while under continuous cardiorespiratory monitoring
1.A	Continuous positive airway pressure (CPAP) for acute bronchiolitis in children	Jat et al., 2022	India	Systematic review of randomized Controlled trials	To assess the eficacy and safety of CPAP compared to no CPAP or sham CPAP in infants and children up to three years of age with acute bronchiolitis	122 children (62/60 in intervention/ control arms) aged up to 12 months investigating nasal CPAP compared with supportive (or 'standard') therapy	Proportion of children requiring mechanical ventilation. Respiratory rate. arterial oxygen saturation. arterial partial pressure of carbon dioxide (pCOE) and partial pressure of oxygen (pOE). Hospital admission rate (from emergency department to hospital). Duration of hospital stay. Need for intensive care unit admission.	CPAP, Toracic expension exercises with a device	The use of CPAP did not reduce the need for mechanical ventilation in children with bronchiolitis, although the evidence was of low certainty. Limited, low certainty evidence suggests that breathing improved (a decreased respiratory rate) in children with bronchiolitis who received CPAP; this finding is unchanged from the 2015 review and 2019 update. Due to the limited available evidence, the eJect of CPAP in children with acute bronchiolitis is uncertain for our other outcomes. Larger, adequately powered trials are needed to evaluate the eJect of CPAP for children with acute bronchiolitis.

Table 2 (*continued*)

Quality of the evidence (JBI Effectiveness)	Studies	Author/Year	Location	Study design	Aim	Study Population	Outcome measures	Types of interventions	Results
							Adverse events, e.g. local nasal effects, pneumothorax, and shock.		

on the following decision rules:

1. If a study receives a low quality score or very low quality score according to JBI's appraisal checklist.
2. If a study does not provide sufficient detail on the research design, participant selection, data collection, or data analysis to allow for an accurate assessment of its methodological quality.

According to Table 3, most studies presented all the criteria determining the quality and validity of the systematic review. However, three articles did not present the biased probability (Castilho et al., 2020; Hawkins & Jones, 2015; Nørgaard, 2020).

One study did not present practical recommendations for the results and specific guidelines for future investigations (Castilho et al., 2020).

All articles were classified as level 1 of evidence (Aromataris & Munn, 2020) (Table 3). Eleven articles were systematic reviews of randomized controlled trials, five were systematic reviews with meta-analysis, two were systematic reviews, and one was a mixed methods systematic review.

Outcomes

This study was crucial to map the interventions that have an impact on pediatric patients with impaired ventilation, being, respiratory exercises, respiratory control (relaxation techniques, abdominal diaphragmatic techniques), thoracic expansion, thoracic expansion with a medical device, respiratory muscles strengthening exercises and positioning techniques to optimize ventilation.

In addition, the study was central to mapping the data that points out the need for interventions and to evaluate the efficacy of the intervention (Fig. 2).

All studies included in this review show positive results of interventions in impaired ventilation. Table three presents the interventions and outcomes. All studies present the results of interventions, although not separately.

Two studies considered in the umbrella review presented a rehabilitation program, not specifying the studied interventions. These studies aimed at teaching and capacitating children during their disease, with gains in ventilation, disease stabilization, and quality of life (Harris, 2019; Kneale et al., 2019).

Five articles specify the benefits of "breathing control" (regime/therapy), including relaxed breathing and diaphragmatic breathing exercises (Castilho et al., 2020; Irons et al., 2019; Macêdo et al., 2016; Stanford et al., 2020; Zhang et al., 2021).

Two articles give particular emphasis to "respiratory expansion exercises" (Macêdo et al., 2016), with low evidence and (Castilho et al., 2020), with moderate evidence in the population in analysis (children aged <18 years old).

Four studies present low evidence of inspiratory muscle training (Macêdo et al., 2016; Human et al., 2017; Irons et al., 2019; Stanford et al., 2020), and three studies present moderate evidence of the same intervention (Beningfield & Jones, 2018; Zhang et al., 2021; Castilho et al., 2020).

Thoracic expansion techniques with a device–manual hyperinflation techniques (procedure) were also considered. When performed is an intervention with high evidence of applicability to patients with impaired ventilation (Hawkins & Jones, 2015). Equally, Continuous positive airway pressure (CPAP) (procedure), used as a thoracic expansion technique, presents a huge benefit when used as an adjuvant towards impaired ventilation (Korang et al., 2016).

Concerning the intervention "position to optimize ventilation", only three studies were found, being focused on a distinct population. One study performed on premature neonates presented low evidence Bredemeyer & Foster, 2012). The second focused on children under 18 and presented moderate evidence (Castilho et al., 2020) and the las one focused the positioning for acute respiratory distress in hospitalized on

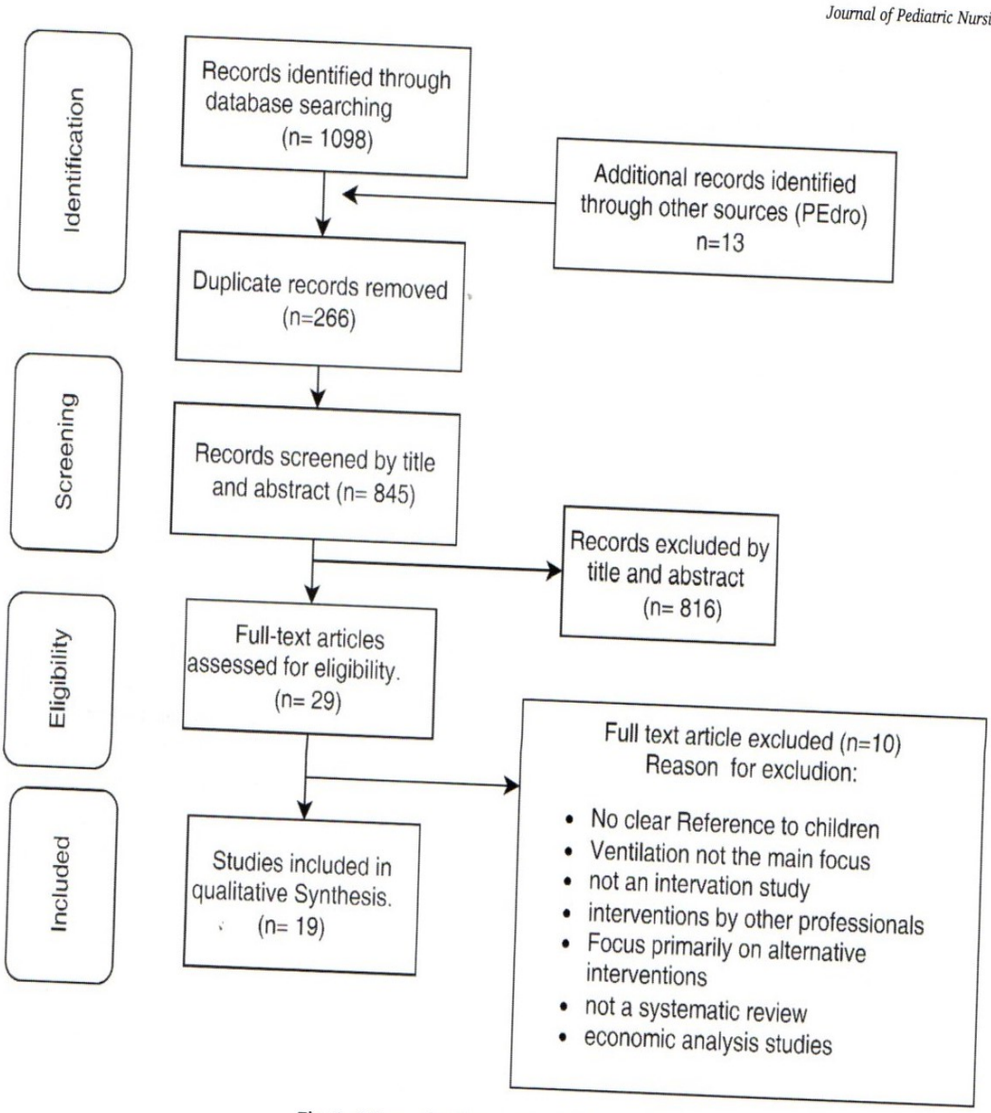

Fig. 1. Prisma of evidence search and selection.

Table 3
Critical appraisal results of eligible systematic reviews.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Quality
Bhandari et al. (2022)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Jat et al., 2022	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Bamat et al. (2021)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Hight
Zhang et al. (2021)	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Y	Hight
Stanford et al. (2020)	Y	Y	Y	Y	Y	Y	Y	N/A	N	N	N	Moderate
Castilho et al. (2020)	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Y	High
Irons et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	High
Nørgaard, (2020)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Kneale et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Eman et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Moran et al. (2017)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Beningfield and Jones (2018)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Ferguson et al. (2017)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Human et al., 2017	N	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Y	Moderate
Korang et al. (2016)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Macêdo et al. (2016)	Y	Y	Y	Y	Y	Y	Y	N/A	Y	Y	Y	High
Harris, (2019)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Hawkins and Jones (2015)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	High
Bredemeyer and Foster (2012)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
%	100	100	100	100	100	100	100	73	84	95	95	

Y – Yes; N – No; U – Unclear.

JBI critical appraisal checklist for systematic reviews and research syntheses: Q1: review question clearly and explicitly stated; Q2: inclusion criteria appropriate for the review question; strategy appropriate; Q4: sources and resources used to search for studies adequate; Q5: criteria for appraising studies appropriate; Q6 was critical appraisal conducted by two or more reviewers independently; Q7: were there methods to minimize errors in data extraction; Q8: Were the methods used to combine studies appropriate; Q9: Was the likelihood of publication bias assessed; Q10: Were recommendations policy and/or practice upported by the reported data; Q11 Were the specific directives for new research appropriate.

0–3 very low quality score. 4–6 low quality score; 7–9 – moderate quality score M 10–11 high quality score.

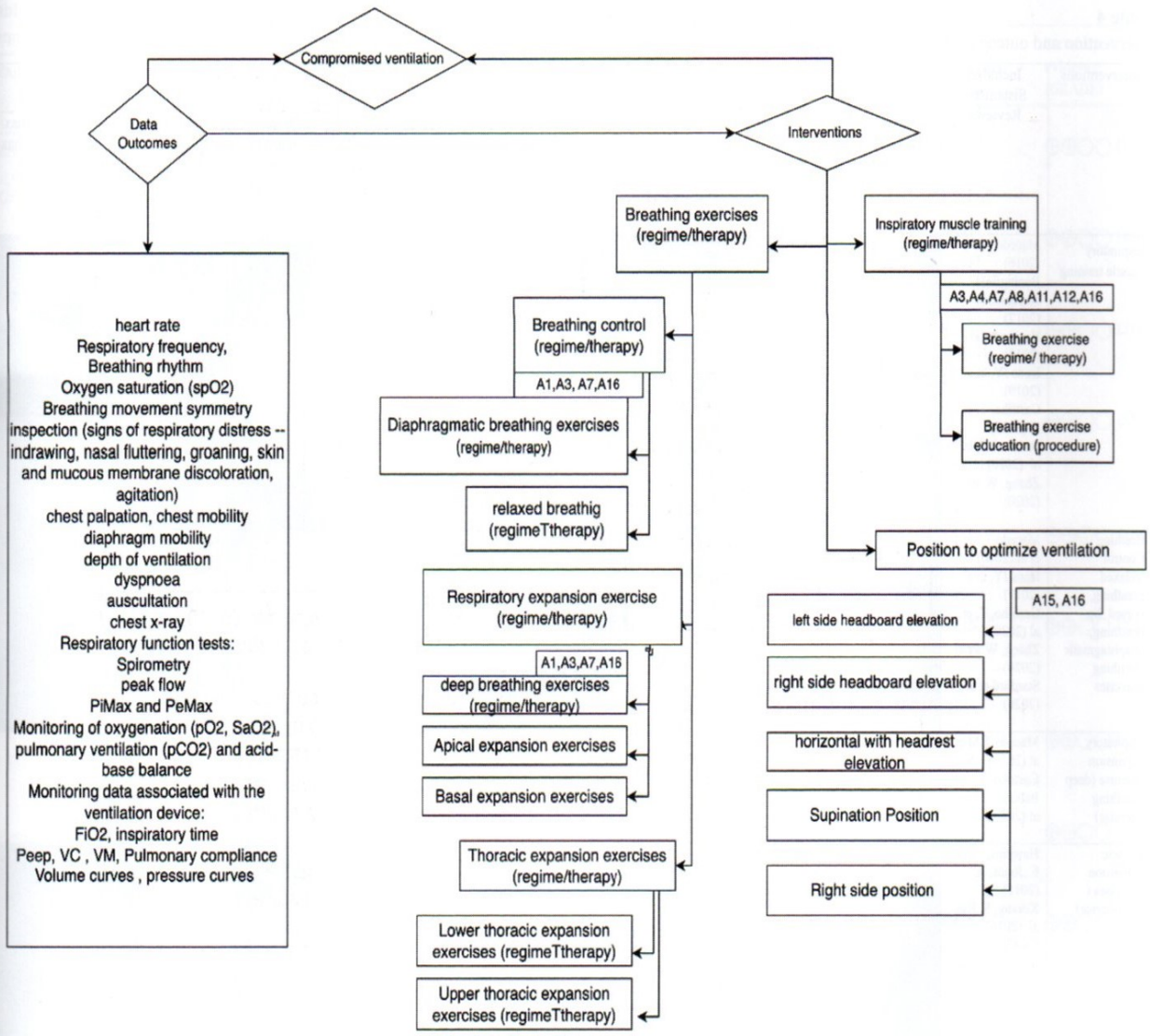

Fig. 2. Intervention and data mapping.

children under 16 and presented low evidence that positioning improves oxygenation in mechanically ventilated children with ARDS (Bhandari et al., 2022).

All the studies included planning and evaluation of the studied interventions.

Only one study considered the division of the population by different age classes as a relevant metric, even though it has not presented different results in the analysis of the interventions' efficacy. (Nørgaard, 2020).

All the studies included in this revision show the interventions' benefits towards impaired ventilation. Table 4 presents the level of evidence for each intervention. (See Table 5.)

All the studies present the interventions' results, although not separately. All interventions present a low to moderate level of evidence.

Discussion

Nineteen systematic reviews were included, representing 219 primary studies on the efficacy of interventions for impaired ventilation patients.

Several structural changes occur in the respiratory system during childhood (Harless et al., 2014). Therefore, the stage should be considered when prescribing and executing interventions towards impaired ventilation. Only one systematic review grouped the population by classes, although the efficacy of the intervention was identical in each group (Nørgaard, 2020).

This review identified low to moderate evidence in the majority of interventions. Respiratory exercises (teachings of respiratory techniques, relaxation exercises, and abdominal diaphragmatic techniques) and "thoracic expansion techniques" present low evidence due to the low number of participants, methodological differences, and heterogeneity of the primary studies, not being conclusive regarding their benefits or risks in population with asthma (Macêdo et al., 2016).

The goal of the respiratory exercises (relaxation exercises, abdominal diaphragmatic techniques, and "thoracic expansion techniques") is to decrease the respiratory work, improve alveolar ventilation and improve coordination and efficiency of the respiratory muscles. As a result, they allow for better ventilation distribution, a decrease in energy consumption, and a decrease in the usage of accessory muscles (Donner et al., 2020).

The respiratory exercises are widely used in patients with impaired ventilation but since they are not applied separately in any study, effectiveness cannot be measured. Therefore, the evaluation regarding efficacy is assumed by the author (Castilho et al., 2020).

There is some evidence that respiratory exercises performed in children post-surgery, in a structured way, in pre and post-operative stages, can improve their post-operative recovery. Nevertheless, due to the small sample size and heterogeneity of primary studies, the authors do not recommend the intensity and frequency of the intervention's applicability (Beningfield & Jones, 2018).

The thoracic expansion technique (with device) and non-invasive ventilation present moderate evidence of their applicability.

Table 4
Intervention and outcomes (Summary of evidence).

Interventions	Included Sistematic Reviews	Outcomes											
		Oxigen Saturation (spO2)	Monitoring of oxygenation, pulmonar ventilation and ph	adventitious sounds	RX	dyspnea	Respiratory rate. And heart rate	Breathing rhythm and breathing pattern	Inspection, signs Mucous staining	Thoracic mobility and diaphragm mobility	Minute ventilation , lung complisnce, dead space and peep	Spirometry pulmonary function measure	Pimax/ Pemax
Inspiratory muscle training	Macêdo et al., (2016) Beningfield, A.;Jones, A. (2017) Human, et al (2017) Irons JY, et al (2019) Castilho, T, et al (2020) Stanford G, et al (2020) Zhang, W.;et al (2020)												
Brething Control (relaxed breathing, pursed lip breathing, Diaphragmatic breathing exercises	Macedo T.M.; et al (2016) Irons JY, et al., (2019) Castilho, T, et al (2020) Zhang, W.;et al (2020) Stanford et al., (2020)												
respiratory expansion exercise (deep breathing exercise)	Macedo T.M et al (2016) Castilho, T, Itaborahy, B et al (2020)												
Toracic expansion exercises (with device)	Hawkins, E.;Jones, A. (2015) Korang, S. Ket al (2016) Castilho, T, Itaborahy, B et al (2020) Bamat, N., et al., (2021) Jat, et al., (2022)												
Position to optimize ventilation	Bredemeyer SL,Foster JP (2012) Castilho, T, Itaborahy, B et al (2020) Bhandari AP, et al,.(2022)												

Overall effective;
Overall no effect or difference compared to a control treatment;
No data reported.
All significant effects identified by systematic reviews had a small magnitude. The variability among the included studies precludes a detailed evaluation of effect sizes as well as separate comparisons against the individual interventions. The transposition of this evidence into practice should be based on the assumption that each of these interventions was effective against placebo or some other form of clinical acceptable intervention.

Introducing non-invasive ventilation preserved muscular strength and increased expiratory muscle strength in children with cystic fibrosis. Regarding ventilatory support, non-invasive ventilation offers benefits related to the stabilization of oxygenation. By mitigating the decrease of ventricular tachycardia and increased ventilation during sleep, non-invasive ventilation reduces hypoventilation in children with moderate to severe pulmonary disease. In general, the results of the studies show that non-invasive ventilation improved the pattern of respiratory failure (Moran et al., 2017).

In the same way, regarding the manual hyperinflation technique (procedure), the evidence points out its use associated with airway cleaning interventions as a safe and effective treatment that improves pulmonary volumes, decreases dead space, and improves oxygenation (Hawkins & Jones, 2015).

Inspiratory muscle training (IMT) can improve the strength of inspiratory and expiratory muscles, but even though its benefits are proven, there is no sufficient evidence to suggest its implementation.

A descriptive analysis of the studies suggests that maximum inspiratory pressure (PImax), evaluation of the airway's resistance, maximum expiratory flow, and diffusion, evaluated in respiratory function tests are the measures that better detect the effects of any given intervention.

Although it is recognized that this is not supported by meta-analysis,

Table 5
Summary of finding.

Outcomes	Impact	N° of participants (studies)	certainty of the evidence (GRADE)
Brething Control (relaxed breathing, pursed -lip breating, Diaphragmatic breathing exercises			
Oxigen Saturation (spO2)	Effective improvement with moderate positive effects**	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Monitoring oxygenation, pulmonary ventilation and acid base balance	Effective improvement with moderate positive effects**	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Adventtitious souds	Effective improvement with moderate positive effects**	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
dispnea	Effective improvement with moderate positive effects**	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Respiratory rate / heart rate	Effective improvement with moderate positive effects**	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Breathing rhythm and brathing pattern	Effective improvement with moderate positive effects**	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Thoracic mobility and diaphragm mobility	Effective improvement with moderate positive effects**	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Minute ventilation, lung compliance, peep, dead space	Effective improvement with small positive effects*	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Respiratory function tests: spirometry or peak flow	Effective improvement with small positive effects*	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
PiMAX and Pemax	Effective improvement with small positive effects*	1941 (5 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
respiratory expansion exercise (deep breathingexercise)			
Adventtitious souds	Effective improvement with moderate positive effects**	400 (2 reviews)	⊕⊕◯◯ LOW
Chest X-Ray	Effective improvement with moderate positive effects**	400 (2 reviews)	⊕⊕◯◯ LOW
Thoracic mobility and diaphragm mobility	Effective improvement with moderate positive effects**	400 (2 reviews)	⊕⊕◯◯ LOW
Respiratory function tests: spirometry or peak flow	Effective improvement with moderate positive effects**	400 (2 reviews)	⊕⊕◯◯ LOW
Toracic expansion exercise (with device)			
Oxigen Saturation (spO2)	Effective improvement with small positive effects*	1184 (5 reviews)	⊕⊕◯◯ LOW
Monitoring oxygenation, pulmonary ventilation and acid base balance	Effective improvement with small positive effects*	1184 (5 reviews)	⊕⊕◯◯ LOW
Adventtitious souds	Effective improvement with small positive effects*	1184 (5 reviews)	⊕⊕◯◯ LOW
Chest X-Ray	Effective improvement with small positive effects*	1184 (5 reviews)	⊕⊕◯◯ LOW
dispnea	Effective improvement with small positive effects*	1184 (5 reviews)	⊕⊕◯◯ LOW
Respiratory rate / heart rate	Effective improvement with small positive effects*	1184 (5 reviews)	⊕⊕◯◯ LOW
Thoracic mobility and diaphragm mobility	Effective improvement with small positive effects*	1184 (5 reviews)	⊕⊕◯◯ LOW
Respiratory function tests: spirometry or peak flow	Effective improvement with small positive effects*	1184 (5 reviews reviews)	⊕⊕◯◯ LOW
PiMAX and Pemax	Effective improvement with small positive effects*	1184 (5 reviews reviews)	⊕⊕◯◯ LOW
Position to optimize ventilation			
Oxigen Saturation (spO2)	Effective improvement with small positive effects*	600 (3 reviews)	⊕⊕◯◯ LOW
Monitoring oxygenation, pulmonary ventilation and acid base balance	Effective improvement with moderate positive effects**	198 (1 reviews)	⊕⊕◯◯ LOW
Respiratory rate / heart rate	Effective improvement with small positive effects*	600 (3 reviews)	⊕⊕◯◯ LOW
Breathing rhythm and brathing pattern	Effective improvement with moderate positive effects**	198 (1 reviews)	⊕⊕◯◯ LOW

(continued on next page)

Table 5 (*continued*)

Outcomes	Impact	N° of participants (studies)	certainty of the evidence (GRADE)
Inspection, signs Mucous staining	Effective improvement with small positive effects*	600 (3 reviews)	⊕⊕◯◯ LOW
Inspiratory muscle training			
Oxigen Saturation (spO2)	Effective improvement with small positive effects*	2247 (7 reviews)	⊕⊕◯◯ LOW
Monitoring oxygenation, pulmonary ventilation and acid base balance	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Adventtitious souds	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Chest X-Ray	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
dispnea	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Respiratory rate / heart rate	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Breathing rhythm and breathing pattern	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Thoracic mobility and diaphragm mobility	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Minute ventilation, lung compliance, peep, dead space	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
Respiratory function tests: spirometry or peak flow	Effective improvement with moderate positive effects**	2247 (7 reviews))	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)
PiMAX and Pemax	Effective improvement with moderate positive effects**	2247 (7 reviews)	⊕⊕⊕◯ MODERATE due to inconsistency (due to significant heterogeneity)

there are measures that studies include in their evaluation and recommendation. There is no evidence to suggest that this intervention is beneficial, with the scarce literature regarding this intervention in children. Healthcare workers should then consider IMT in a case-by-case scenario. Nevertheless, its evidence level is low (Beningfield & Jones, 2018; Castilho et al., 2020; Human et al., 2017; Irons et al., 2019; Macêdo et al., 2016; Stanford et al., 2020). IMT is used in rehabilitation programs for children with neuromuscular diseases, aiming to improve respiratory function, strength, and respiratory muscle resistance, contributing to the morbidity and mortality decrease in this population (Human et al., 2017).

Regarding the intervention "positioning to improve ventilation", there is evidence of its influence on improving the ratio of ventilation/perfusion (Postiaux et al., 2011). However, only three articles referred to this intervention. One article mentioned positioning as an integral technique in therapeutical plans, with moderate evidence (Castilho et al., 2020). In the systematic review targeting the neonatal population, no individual study nor meta-analysis showed a decrease in apnea, bradycardia, oxygen desaturation, or oxygen saturation with body positioning (supine versus prone; prone versus right side; prone versus left side; right side versus left side, horizontal prone head in high pronation)(Bredemeyer & Foster, 2012). No sufficient evidence was found to determine the role of body positioning in decreasing apnea, bradycardia, oxygen desaturation, or oxygen saturation in premature babies. In one review, although it suggests that the prone position may have some efficacy, the limited evidence is not sufficient for a strong recommendation. There seems to be low-quality evidence that positioning improves oxygenation in mechanically ventilated children with ARDS. Due to the increased risk associated with prone positioning and the potential for lung injury with artificial ventilation, the authors recommend that hospitalized infants and children should only be placed in this position under continuous cardiorespiratory monitoring (Bhandari et al., 2022).

Strengths and limitations

This umbrella review investigated the efficacy of the interventions directed to impaired ventilation. The included systematic reviews present outstanding methodological robustness, as intended in any umbrella review (Aromataris & Munn, 2020).

The use of SNOMED_CT is a clear strength of this review as it, not only allows for precise coding of the diverse interventions under study but also facilitates comparison of findings across different studies, and even countries, as it transcends language and cultural barriers. However, it's important to note that while coding interventions using SNOMED_CT is valuable, it may also present challenges. Given the breadth and depth of SNOMED_CT, identifying the most appropriate code for an intervention may be complex. It requires an understanding of the underlying structure of SNOMED_CT and the specific terminology used. Therefore, this step of data extraction should be carried out by reviewers with sufficient training and expertise in using SNOMED_CT.

The quality of a systematic review depends on the number of the population and methodological quality of the primary studies and this fact was not considered in this review.

The evaluation cleared the evidence of interventions of the results of each primary study used in the included systematic reviews. A

significant limitation of this study is the heterogeneity and methodological quality of the primary studies used in the included systematic reviews that prevent a firm conclusion on the effectiveness of the studied interventions. The fact that the interventions are not analyzed separately in each review also harms our analysis.

Implications for practice

Assessing the applicability of interventions in impaired ventilation allows for building critical thinking, improving evidence-based practice, and improving the quality of care for children with impaired ventilation.

Importantly, by using this standardized coding system, the interventions identified in this review can be readily integrated into a nursing information system or electronic health record. This has direct implications for practice, as it eases the transferability of evidence-based interventions into clinical practice, promoting efficiency, and improving patient care. Furthermore, in a broader context, using SNOMED_CT in systematic reviews contributes to the ongoing development and refinement of the taxonomy. By highlighting how SNOMED_CT is used in research, and by identifying any potential gaps or issues in its application, researchers can contribute to its ongoing evolution and improvement.

Interventions involving abdominal diaphragmatic exercises, chest expansion exercises, and IMT are effective in children with impaired ventilation. The early use of positioning techniques to optimize ventilation should be present. The best available evidence in this comprehensive review identifies its effectiveness. Although it is considered low or moderate, its use is recommended.

Uncertainty about the effectiveness of interventions is linked to the lack of high-quality primary studies and the fact that interventions are not analyzed separately. However, high theoretical foundations point to the implementation of these interventions. (Postiaux et al., 2011).

The authors of the systematic reviews included in this umbrella review recommended more primary studies on the studied interventions. In addition, these studies must have a high methodological quality that allows the analysis of the efficacy of each intervention.

Conclusions

The most compelling evidence at our disposal indicates that these interventions are indeed effective for children dealing with impaired ventilation. However, the strength of this evidence can be considered only low to moderate, largely owing to the specific features of the population under study - its size being relatively small and its composition quite diverse. Therefore, it becomes evident that the development of primary studies targeting this area is of paramount importance.

In an era of evidence-based practice, our findings underscore the necessity for more comprehensive and well-designed primary studies that can conclusively illuminate the impact and value of these interventions. Such studies would provide a more robust evidence base and facilitate more confident and informed decision-making in the care of children with impaired ventilation.

In conclusion, while existing interventions show promise, their potential can only be fully realized through the conduct of more rigorous, focused, and large-scale studies. The efforts towards generating high-quality evidence will be instrumental in improving healthcare strategies, policies, and ultimately the quality of life of children suffering from impaired ventilation.

CRediT authorship contribution statement

Neuza Reis: Conceptualization, Writing – original draft. **Luís Jorge Gaspar:** Validation. **Abel Paiva:** Methodology, Validation, Resources. **Paula Sousa:** Methodology, Supervision, Resources, Writing – review & editing. **Natália Machado:** Methodology, Supervision, Writing – review & editing.

Declaration of Competing Interest

None.

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