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Outcome measures for children with speech sound disorder: an umbrella review

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ABSTRACT

Objective Speech sound disorder (SSD) describes a 'persistent difficulty with speech sound production that interferes with speech intelligibility or prevents verbal communication'. There is a need to establish which care pathways are most effective and efficient for children with SSD. Comparison of care pathways requires clearly defined, evidence-based, interventions and agreement on how to measure the outcomes. At present, no definitive list of assessments, interventions or outcomes exists. The objective of this umbrella review paper is to provide a rigorous and detailed list of assessments, interventions and outcomes which target SSD in children.

Design In December 2022, a systematic search of Ovid Medline, OVID Embase, CINAHL, PsycInfo and Cochrane and a number of grey literature platforms were undertaken. 18 reviews were included, and subsequently 415 primary research articles were assessed for data related to assessments, interventions or outcomes. The AMSTAR (Assessing the Methodological Quality of Systematic Reviews) framework was used to assess the quality of the retained reviews.

Setting Reviews were retained which took place in any setting.

Participants The population is children of any age with a diagnosis of SSD of unknown origin.

Primary and secondary outcome measures Reviews reporting outcomes, assessment and interventions for children with SSD.

Results Extraction and analysis identified 37 assessments, 46 interventions and 30 outcome measures used in research reporting of SSD. Not all of the listed outcomes were linked to specific outcome measurement tools, but these were measurable through the use of one or more of the assessments extracted from the retained reviews.

Conclusions The findings of this review will be used to develop a Core Outcome Set for children with SSD. The findings are part of a rigorous process essential for advancing healthcare research and practice in the specific area of speech and language therapy for children with SSD.

PROSPERO registration number CRD42022316284.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The umbrella review is designed to collate existing systematic reviews.
⇒ This umbrella review follows the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols guidelines.
⇒ Critical appraisal of included reviews was undertaken using the AMSTAR.
⇒ Appraisal of the 415 individual primary research papers was not undertaken.

INTRODUCTION

Speech sound disorder (SSD) is a broad category of speech disorders that involve difficulties in producing and/or using speech sounds correctly.[1] SSD can be broadly categorised into two main types: articulation/motor speech disorders and phonological disorders. Articulation/motor speech disorders refer to difficulties in the movements required for producing speech sounds. Phonological disorders, on the other hand, involve difficulties with the rules that govern the use of speech sounds in a particular language.

The reported prevalence of SSD varies depending on the population studied and the definition of SSD used. However, there is agreement that SSD is a common communication disorder in children, affecting approximately 8%–9% of preschool-aged children and 2%–3% of school-aged children.[2–5] SSD is more common in boys than girls and may be more prevalent in certain populations, such as children with a history of ear infections or language delays.

The underlying causes of SSD are complex and multifactorial. Several factors have been identified as contributing to the development of SSD, including genetic, neurological, environmental and psychosocial factors. However, it is a minority of children with SSD that has a clear aetiology (eg, cerebral palsy, cleft palate +/− cleft lip and hearing impairment, genetic causes, childhood apraxia of speech). In most cases, SSD has no identifiable cause, and the evidence for intervention in this particularly heterogeneous group is limited.

SSD can have significant negative consequences for a child's communication and academic development. If left untreated, SSD can lead to a range of negative sequelae, including social and emotional problems, reduced quality of life and academic difficulties.[6–12] The latter are a common consequence of SSD, as affected children may struggle to acquire reading and writing skills, leading to poor academic performance and reduced educational attainment.[13] This may be exacerbated for those children with co-occurring developmental language disorder,[14] which can affect a child's ability to understand and follow instructions in the classroom, further impacting their academic performance.

In the UK, publicly funded, free at the point of access National Health Service (NHS) speech and language therapy is provided to children with SSD via a range of care pathways, typically defined by resource constraints, rather than robust evidence.[15] Vanhaecht *et al* defined a care pathway as "a complex intervention for the mutual decision-making and organisation of care processes for a well-defined group of patients during a well-defined period".[16] Care pathways aim to improve care, outcomes and patient satisfaction while also optimising the use of resources.

There is a need to establish which care pathways are most effective and efficient for children with SSD. Comparison of care pathways requires both clearly defined, evidence-based interventions and agreement on how best to measure the outcomes of these interventions for children with SSD. However, a review of existing NHS case notes of children treated for SSD was found to be too incomplete to compare pathways.[17] Morgan *et al* suggest that there is a need for agreement on a national UK-wide core outcome set for SSD.[17] A national consultation in 2018 identified the need to collect consistent data and recommended that NHS England support providers to collect data on the quality and outcomes of interventions (recommendation 4.5, p29).[18]

Evidence from systematic reviews and trials has shown that intervention is effective for the majority of children with SSD and that these children do not make progress without intervention.[19 20] However, a challenge with studies that have investigated the impact of interventions is that they have typically employed intervention protocols which are intense and difficult to replicate in NHS speech and language therapy services because of resource constraints and service variations.[15 21 22] Importantly, unlike research studies, clinical intervention takes place within care pathways which vary in terms of timing of intervention (eg, preschool, school age), agent of intervention (eg, speech and language therapists (SLTs), speech and language therapy assistants, teaching assistants, parents), dosage (number, frequency and duration of sessions) and involvement of parents or education staff, as well as the assessments and outcome measures used.

To determine which care pathways are most effective for children with SSD, there is a need to compare outcomes across NHS speech and language therapy services. Given the variation observed in how outcomes are measured in routine clinical care,[17] the first step is to determine what outcomes are important for service users and clinicians. Functional goals such as independence and improved social interaction have been identified as of greatest importance to parents,[15] while children have indicated that improved speech, schoolwork and skill at sports as well as making friends are their most important goals.[23 24] Preferred outcomes for preschool children with SSD among SLTs have been identified as intelligibility, social interaction and participation.[25]

It is important to understand how these outcomes can relate to systems of classification, which might be used by healthcare professionals. The International Classification of Functioning, Disability and Health (ICF) is a framework developed by the WHO to provide a comprehensive understanding of health and health-related issues, which can reflect some of the preferred outcomes outlined above. The principles and structure of the ICF were used in the development of the Speech Outcome Reporting Taxonomy (SORT).[26] SORT is a tool used to document and standardise the assessment of speech outcomes in clinical and research settings. It provides a way to link clinical assessment and intervention with the ICF, making it easier to track, compare and report changes in speech and communication abilities over time. However, even with development of this type of system, clinicians and researchers still do not have a defined and agreed set of measures mapped to the facets of the framework.

However, frameworks can help establish what outcomes are important, and the next step is then to determine how these should be measured. Systematic reviews are a useful source of evidence for interventions for SSD and are increasing in frequency in published literature. They provide a rigorous and transparent knowledge base for translating clinical research into decisions and as such are 'go to' documents to advise healthcare service construction and evaluation. These are also a useful potential source for considering the range of assessments which are available and could be used to measure outcomes in any investigation comparing effectiveness of different care pathways. Given the number of existing systematic reviews in this field, an overarching review which captures the relevant information across multiple reviews is needed. An umbrella review is a type of systematic review that synthesises and evaluates the findings of multiple scoping reviews, systematic reviews and meta-analyses on a specific topic.[27 28] Unlike traditional systematic reviews that focus on a single research question, umbrella reviews aim to provide a comprehensive overview of the existing evidence on a particular topic, including the quality and consistency of the evidence, gaps in the literature and areas that require further investigation.

The objective of this umbrella review was to collate the tools used for assessment and outcome measurement with children with SSD in speech and language therapy. To consider the range of possible interventions which might be used in care pathways, a secondary objective was

to determine what interventions for SSD are described and defined in the reviews.

METHODS AND ANALYSIS

The review was conducted in accordance with the Joanna Briggs Institute (JBI) methodology for umbrella reviews,[29] with the addition of undertaking quality appraisal using the AMSTAR tool.[30] It was registered with PROSPERO (CRD42022316284). The full protocol was published in 2023 in *BMJ Open*,[31] including the OVID Medline search strategy as an example.

Eligibility criteria

In line with the JBI guidance, the eligibility for inclusion in the review was undertaken using the concepts of population, phenomena of interest and context of data.[29] As this is an umbrella review, the only papers retained for inclusion were peer-reviewed published reviews. This included any type of review, for example, systematic reviews of effectiveness, mixed methods, qualitative and scoping reviews.[28]

Population

The population is children of any age with a diagnosis of SSD of unknown origin. Studies were not excluded if the interventions included additional therapy targets (eg, for receptive language). Children whose speech sound needs were associated with a biomedical condition with a known association with communication, such as sensorineural deafness, autistic spectrum condition or cleft palate and neurological conditions (eg, cerebral palsy) affecting speech output, were excluded.

Phenomena of interest (concept)

To be included, reviews must have assessed children with SSD or the outcomes of intervention for children with SSD. This included articulation disorders, childhood apraxia of speech (formerly known as developmental verbal dyspraxia in the UK) or phonological disorders/delay. It excludes children with a known cause for their SSD, such as those with identified genetic or chromosomal anomalies, and congenital or acquired neurological conditions, often associated with childhood dysarthria.

Context

The context for included reviews was left open in that we considered reviews that retained studies which took place in any setting (eg, home, clinic, school) and geographical location (including outside of the UK).

Information sources

As the aim of this umbrella review was to provide a long list of assessments, outcomes and outcome tools (measures) used in the evaluation of SSD in children, it did not exclude relevant studies on account of their review methodology. The complete search was undertaken in December 2022 using Ovid Medline, OVID Embase, CINAHL, PsycInfo and Cochrane. These databases were selected to cover a broad range of journals pertaining to medicine, psychology (including child development) and the allied health professions.

In addition to these standard journal databases, other platforms were interrogated including Campbell Collaboration, COSMIN, Figshare, JBI, OSF, PROSPERO and Speechbite. Due to a limitation in resources, included studies were those published in English. To include literature relevant to current speech and language therapy practice, the search had a minimum publication year of 2010 (1 January 2010).

Search strategy

Following JBI protocol development guidance, an initial limited search of two databases was conducted prior to the full search being carried out.[29] A set of key terms was developed by the first author (SH), in consultation with coauthors who are subject experts with significant post-doctoral research experience in the area (JC, HS and YW). These terms were used for the initial limited search of Ovid Medline and Ovid Embase to identify articles on the topic. With the support of a clinical librarian, the text words contained in the articles and abstracts of relevant articles and the index terms used to describe the articles were used to develop a full-search strategy for Medline. Box 1 presents the full-search strategy for Medline, and online supplemental material 1 contains all search strings for the other databases. This search strategy was adapted for each selected database as appropriate. The reference list of each of the included sources of evidence was screened for additional studies.

Study/source of evidence selection

All identified citations were collated and uploaded into EndNote and duplicates removed. Inclusion and exclusion criteria are presented in table 1. The remaining citations were then downloaded and entered into the online review management software, Rayyan.ai.[32] Two reviewers (SH and SB) independently excluded studies which were clearly unrelated to the population and concept of the umbrella review from their title. The reviewers achieved 100% agreement in this process and then independently reviewed all the remaining abstracts against the stated inclusion criteria. Again, 100% consensus was achieved. Once all abstracts had been reviewed, potentially relevant sources for full-text review were retrieved. The same reviewers examined all remaining papers independently at full-text level with regular consensus meetings. Reasons for the exclusion of sources at full text were recorded and are reported in table 1. This included three articles whose content was included in a larger report, which had already been retained in the umbrella review.

Figure 1 shows other databases searched by SH using keywords (speech sound disorder AND review) including the National Grey Literature Collection (https://allcatsrgrey.org.uk), EThOS (https://ethos.bl.uk) and preprinted servers MedRxiv (www.medrxiv.org) and PsyArXiv (https://psyarxiv.com).

Box 1 Full search strategy for Medline

1. (child* or youth* or boy* or girl* or juvenil* or teenage* or adolescen* or "young person*" or "young people*" or toddler* or infan* or baby or babies).mp.
2. Child/ or Adolescent/ or Infant/ or Infant, Newborn/
3. 1 or 2
4. (phon* or speech or speech disorder* or speech impairment* or speech sound disorder* or speech sound difficult* or speech-sound* or speech retard* or speech delay* or speech disabilit* or speech handicap* or speech problem* or childhood apraxia of speech or apraxia of speech or developmental verbal dyspraxia or verbal dyspraxia or dyspraxia or articulat*).ti,ab.
5. exp Speech Sound Disorder/
6. 4 or 5
7. ("clinical service*" or "therap* service*" or NHS or "social care" or "social service*" or school* or education* or nurser* or "early year*" or preschool* or pre-school* or college* or universit*).mp.
8. Schools/ or Universities/ or Nurseries, Infant/ or Child, Preschool/ or Social Support/
9. 7 or 8
10. (exp META-ANALYSIS AS TOPIC/ or ("meta analy*" or "metaanaly*").ti,ab. or META-ANALYSIS/ or (systematic adj1 (review*1one or overview*1)).ti,ab. or exp REVIEW LITERATURE AS TOPIC/ or (cochrane or embase or psychlit or psyclit or psychinfo or psycinfo or cinahl or cinhal or "science citation index" or bids or cancerlit).ab. or ("reference list*" or bibliograph* or hand-search* or "relevant journals" or "manual search*").ab. or (("selection criter*" or "data extraction").ab. and exp REVIEW/)) not ((ANIMALS/ not (ANIMALS/ and exp HUMANS/)) and (COMMENT/ or LETTER/ or EDITORIAL/ or (letter* or comment*1one or editorial*1).ti,ab.))
11. 3 and 6 and 9 and 10
12. limit 11 to (english language and yr="2010 -Current")

The reasons that studies were excluded at full text are given in online supplemental material 2. Following the final selection and retention of review articles, critical appraisal was undertaken using the AMSTAR tool.[30] This tool was selected as it is designed to critically appraise systematic reviews that include randomised or non-randomised studies of healthcare interventions or both. Two reviewers (SH and SB) individually appraised each study, with consensus meetings to confirm ratings. Shea *et al* strongly recommend that individual item ratings from the critical appraisal are not combined to create an overall score.[30] They propose a 'confidence in the results' rating. When this confidence rating was applied, one study was rated 'moderate',[33] five were rated 'low',[15 34–37] and the remaining studies were rated 'critically low', even when excluding questions specifically related to meta-analysis.[26 38–48]

Data extraction

Data from the retained reviews were identified using a researcher-developed extraction form. This form was adapted from guidance provided by the JBI Reviewer's Manual to meet the specific requirements of the proposed review.[28]

Three of the authors (JC, HS and SB) discussed the long list of outcomes and determined which were outcomes and which were outcome measurement tools. In cases where general terms were used, more specific wording was agreed. The same authors then used the ICF and specific areas of speech development to assign outcome domains to each of the reported outcomes and outcome measures. An outcome was defined as the ultimate or long-term goal of one or more episodes of intervention for a child with SSD. An outcome measure was defined as a tool for measuring a specific outcome (ie, from baseline assessment or an intervention outcome).

RESULTS

Characteristics of retained review studies

16 reviews and two reports were retained for inclusion in this umbrella review (figure 1). Of these, one was a narrative review,[38] two were scoping reviews,[36 40] and the rest were systematic reviews. Ratings on individual AMSTAR items are provided in online supplemental material 3.

During data extraction, it became clear that insufficient detail was reported within the retained reviews. In particular, limited data regarding assessments, interventions and outcome tools (measures) were provided within the retained review manuscripts. Therefore, all papers retained within the reviews were identified and collated. Duplicates were then identified and removed. Papers published prior to 2000 were then removed, and those remaining were checked against the inclusion criteria outlined for retention in this umbrella review. This process is shown in figure 2. Figure 2 shows the number

Table 1 Inclusion and exclusion criteria of reviews and reports

Inclusion criteria	Exclusion criteria
► Children of any age ► Children with SSD of unknown origin including: – Childhood apraxia of speech/ developmental verbal dyspraxia ► Articulation disorders ► Phonological disorders of all types	► Children with SSDs associated with a biomedical condition, for example: – SSD associated with cleft palate +/– lip – Cerebral palsy – Traumatic brain injury ► Reviews not written in English ► Reviews that report outcomes for adults ► Reviews of studies with no reported assessments or outcomes from interventions for SSD

SSD, speech sound disorder.

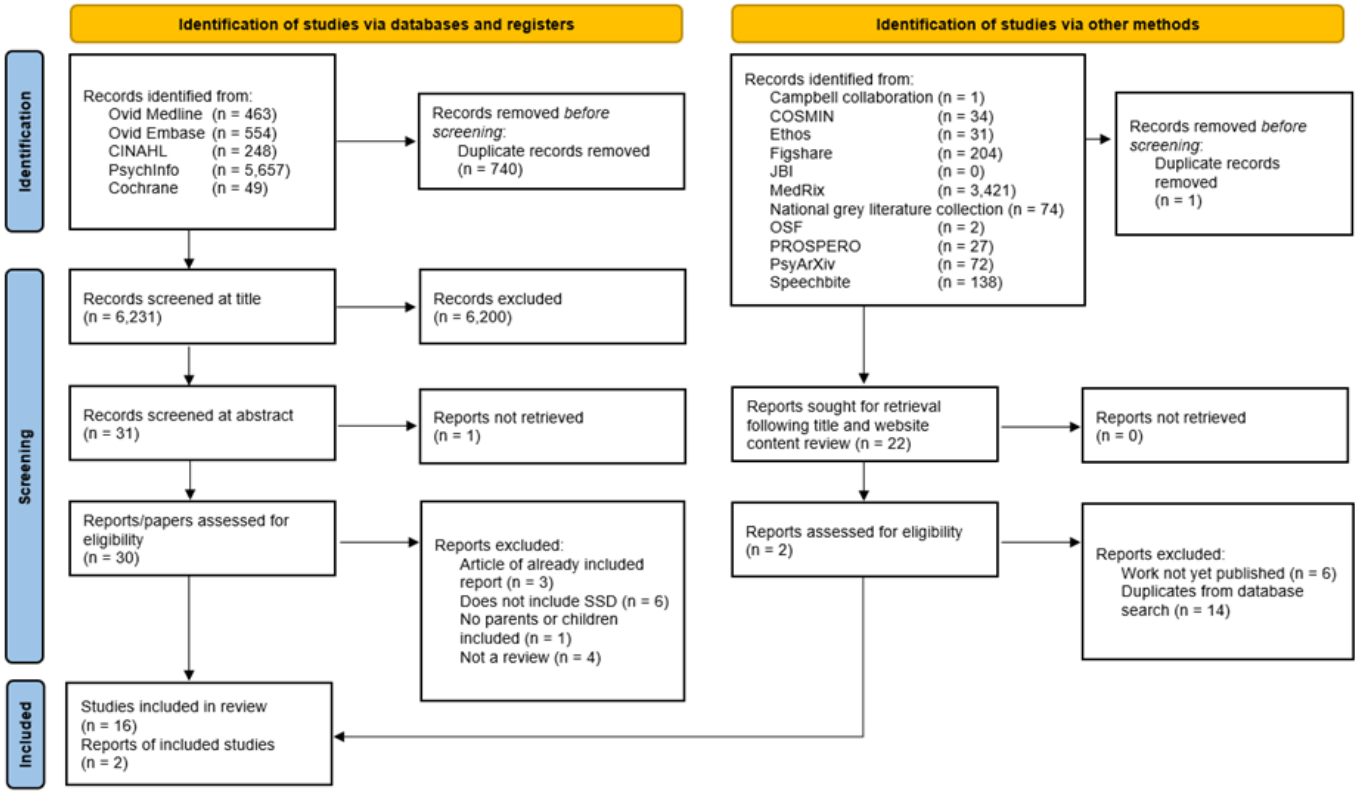

Figure 1 Preferred Reporting Items for Systematic Review and Meta-Analyses flow chart. JBI, Joanna Briggs Institute.

of papers retained from within the reviews published between 2000 and 2022. The articles are spread by date, with the majority of papers published between 2008 and 2015.

The 415 articles were sourced and basic data regarding assessments, interventions, outcomes and outcome tools used were extracted and compiled. Figure 3 shows the number of articles by year of publication of 415 relevant papers retained within the reviews published between 2000 and 2022 and the year of publication of the retained reviews.

Following the raw extraction, SH and SB screened for duplicates and checked eligibility of data where they were not familiar with it. Another member of the team (JC) resolved any disagreements through discussion. Consensus agreement for assessments and interventions was achieved through discussion between SB, HS and JC and by application of inclusion and exclusion criteria (table 2) developed through agreement between SB, HS and JC.

Domains of SSD assessed by outcome measures

Table 3 presents the outcomes and outcome measurement tools that were retained in this review. The outcome measures are mapped, but not all measures extracted were linked to specific measurement tools in the retained reviews. Where this is the case, the cell is left blank. Broad outcome domains relating to the ICF and speech development are indicated in each case to highlight the spread of reported outcomes and outcome measurement tools across these domains.

Areas assessed by identified assessment tools

A total of 37 published assessments were identified which could be used to provide speech data for outcome measurement. Many focus on measurement of specific skills required for speech development while others were comprehensive test batteries (table 4).

Interventions for SSD

A total of 46 interventions were retained in the review (box 2). These included national and international published clinical interventions spanning all domains of speech sound development.

DISCUSSION

The current study sought to summarise previous reviews of outcome measures, assessments and interventions for SSD of unknown origin using an umbrella review methodology. Using a previously published umbrella review protocol,[31] we identified 18 reviews. The critical appraisal undertaken on the reviews found that the majority (12) of the studies were rated as 'critically low'. The aim of the umbrella review was to provide a rigorous and detailed list of assessments, interventions or outcomes, as such the quality of review did not impact this collation, so weighting has not been assigned to any of the 18 retained reviews. In order to identify specific assessments, interventions and outcomes, we needed to take the additional step of retrieving the primary sources within the review papers. From these individual studies, we identified 37 assessments, 46 interventions and 30 outcome measures.

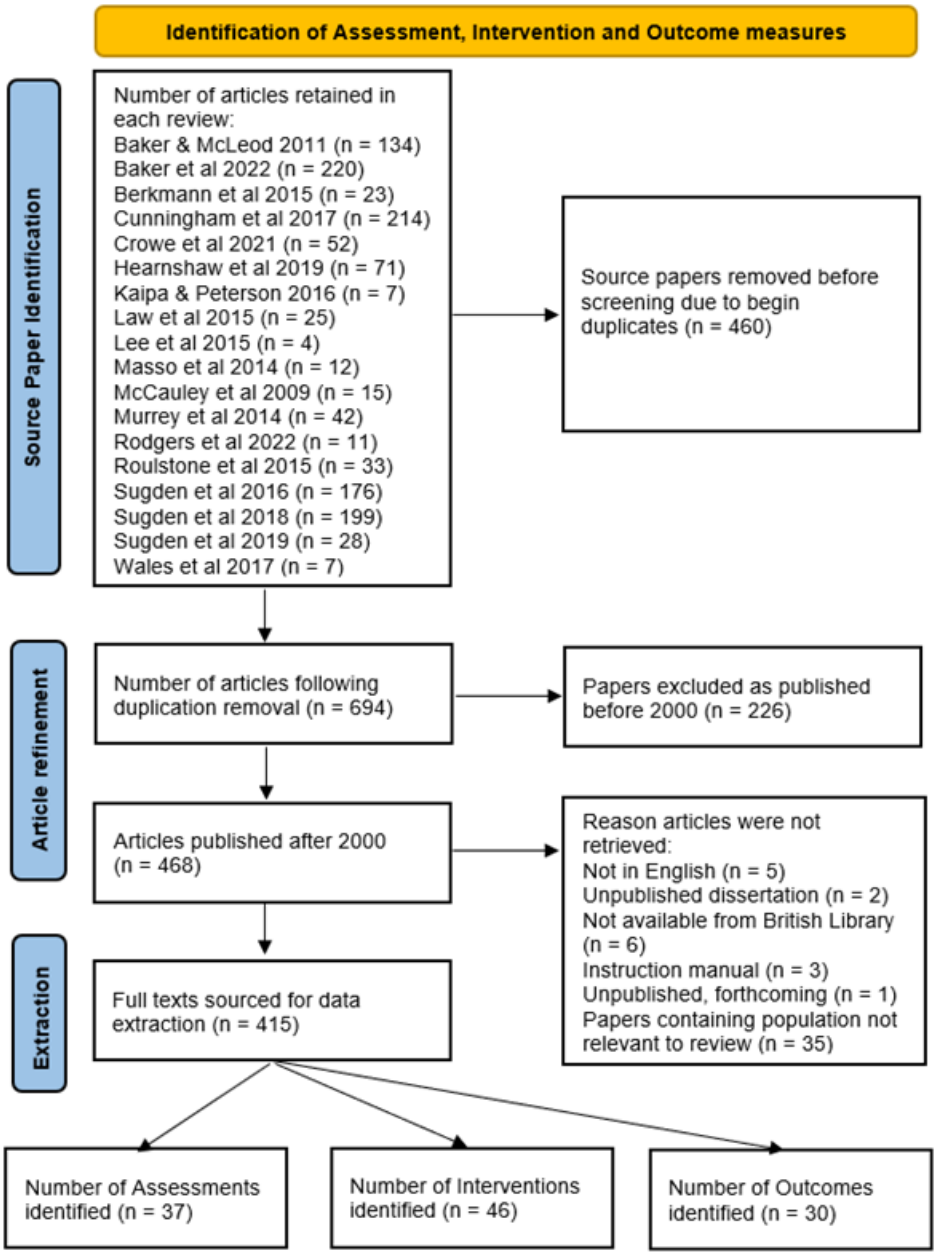

Figure 2 Follow-on Preferred Reporting Items for Systematic Review and Meta-Analyses flow chart.

Although not all of the listed outcomes were linked to specific outcome measurement tools in the retained studies, for the most part these are measurable by one or more of the assessments listed in this review. For example, increase in percentage of phonemes correct could be derived from any of the tools which assess spoken output, such as single-word naming tests like the Diagnostic Evaluation of Articulation and Phonology and Goldman-Fristoe test of articulation.[49 50]

It is interesting to note that there are more assessments than outcome measures identified in this umbrella review. In intervention research, it is common that assessments are used as diagnostic or screening tools to check suitability for the therapy being investigated. These measures may therefore only be completed at baseline and not at the end of any intervention and as such do not serve as outcome tools. The outcome measures are typically used to assess the impact or broader outcomes of the interventions. These measures may include standardised test scores or other indicators of change. The choice of outcome measures also frequently depends on the research goals, the scope of the intervention and the timeframe for assessing its impact.

Classifying SSD outcomes

The identified assessments include diagnostic and outcome measurement tools which as well as measures of communicative participation[51] cover a full range of measurement tools that look at treatment needs or outcomes. The SORT[26] is a tool designed to support the

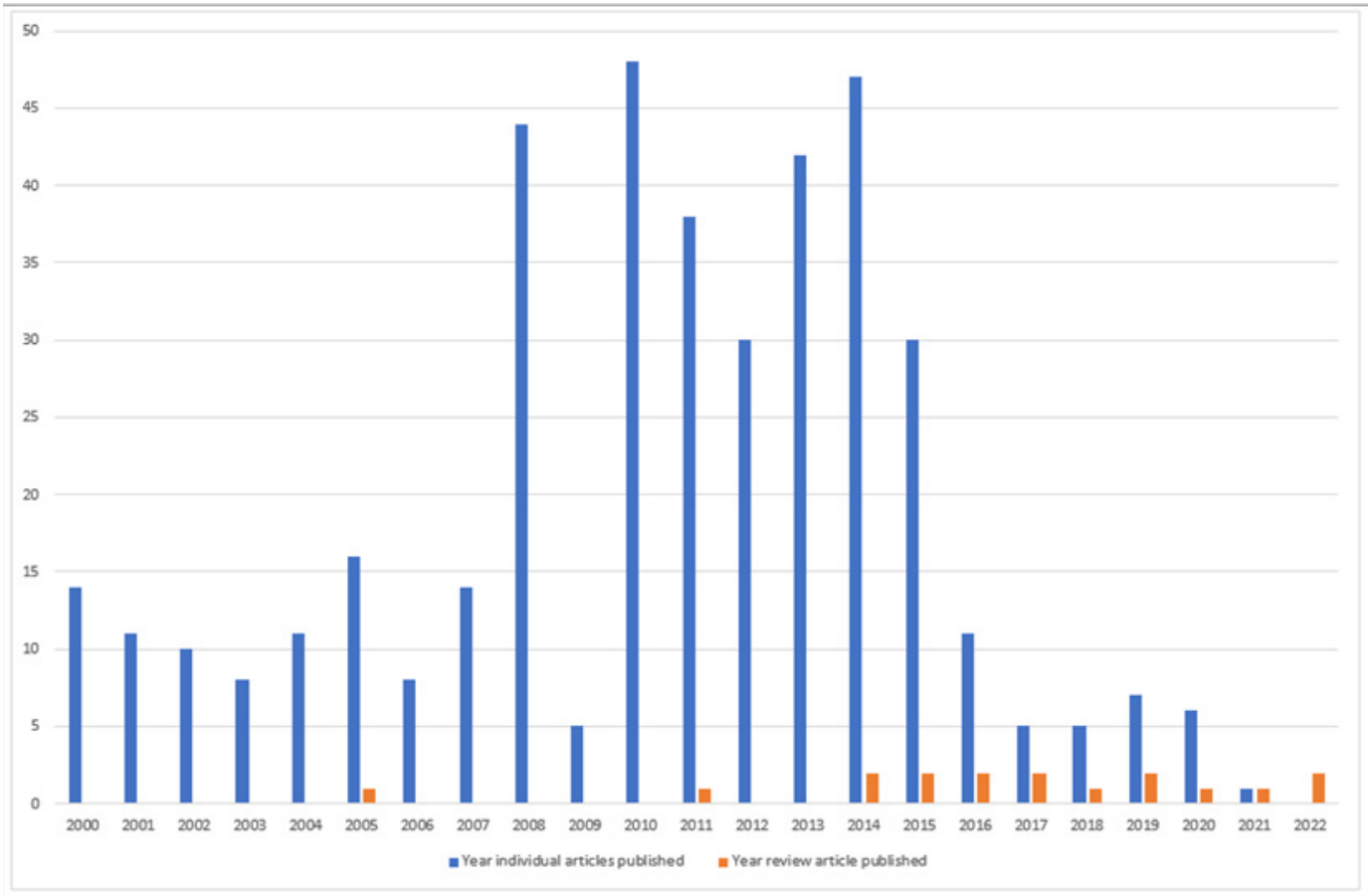

Figure 3 Number of articles by year of publication of 415 relevant papers retained within the reviews published between 2000 and 2022 and the year of publication of the retained reviews.

classification of outcome and experiences for children with SSD. The SORT consists of eight domains ranging from clinical treatment data (Domain 1) through to levels of generalisation (Domains 2–4), intelligibility (Domain 5), activity and participation (Domain 6), quality of life and well-being (Domain 7) and the impact of SSD on other people in the child's life (Domain 8). The outcomes identified in this current umbrella review map across all eight of the SORT domains, with the 25 of the 30 identified outcomes assigned to Domains 1, 2, 3, 5 and 6. The outcome '*generalisation to a new context*' (table 3) does not map to the SORT because of the broad reference of this outcome and the availability of more specific generalisation outcomes within the retained data. Outcomes for quality of life, and the impact of SSD on other people in the child's life, were also not measured in the retained papers.

The differing outcome tools and outcomes listed here may in part reflect differences in the way SSD is classified. There are several systems for the classification of SSD. Three clinically commonly used paediatric-specific SSD classification systems were reviewed and critically

Table 2 Inclusion and exclusion criteria for screening of assessments and interventions

	Inclusion criteria	Exclusion criteria
Assessment	► Named, published assessment ► Available in English language ► SSD-specific assessment (including phonological awareness) ► Standardised assessments	► Unpublished assessment (ie, due to unavailability and unreliability) ► Data analysis tools for analysing primary assessment results ► Unavailable in English language ► Assessments of language, syntax or morphology ► General development assessments ► Cognitive assessments ► Assessments for populations other than SSD of unknown origin (eg, children with hearing impairment or autism)
Intervention	► Published evidence available for the intervention or approach	► Lack of published evidence for the intervention approach

SSD, speech sound disorder.

Table 3 Outcomes and outcome measurement tools

Outcome	Outcome measurement tool	Outcome domain
Improved language	Bristol Language Development Scale (BLADES)*[56]	Language
Improved vocabulary	British Picture Vocabulary Scales 2 (BPVS)*[57]	Language
Improved quality of life	Family Adaptability and Cohesion Evaluation Scales (FACES III)*[58]	Quality of Life
Improved communicative activity and participation	Focus on the Outcomes of Communication Under Six (FOCUS)*[59]	Communicative activity and participation
Increased speech intelligibility	Functional Communication Measure (FCM) for speech intelligibility*[60]	Speech
Increased speech intelligibility	intelligibility outcomes by peer group listeners[61]	Speech
Generalisation to a new context	–	Speech
Generalisation across linguistic units	–	Speech
Generalisation across word positions	–	Speech
Generalisation of known sounds	–	Speech
Generalisation of the intervention target to other response contexts (eg, non-treatment words, other word positions, conversational speech)	–	Speech
Generalisation related to the target (eg, generalisation to other phonemes within and across sound classes)	–	Speech
Increased accuracy of target	–	Speech
Increased confidence when talking	Kiddy-Communication and Attitude Test (KiddyCAT)*[62]	Communicative activity and participation
Increased mean length of utterance (MLU)	–	Language
Improved oromotor skills	Movements in Context and Sequenced Oral Movements tasks**[63]	Oromotor
Improved oromotor skills	Peabody Developmental Motor Scales 2 (PDMS-2)**[64]	Oromotor
Increase in number of phonemes	–	Speech
Parent report on increased structural complexity	–	Speech complexity
Parent report on increased phrase complexity	–	Language
Increase in percentage of child utterance attempts that are fully intelligible from language sample	–	Speech
Increased accuracy measured by Percentage Consonants Correct	–	Speech
Increase in egressive output	–	Speech
Increase in phonological awareness	–	Phonological awareness
Decrease in phonological variability	Phonological Variability Test	Speech
Increase in percentage of intelligible utterances	–	Speech
Decrease in proportion of errors	–	Speech
Increase in percentage of phonemes correct	–	Speech
Increase in production of target sounds	–	Speech
Increase in percentage vowels correct	–	Speech
Increase in percentage of words correct	–	Speech
Increased stimulability	Scaffolding Scale of Stimulability (SSS)*[65]	Speech

Measures supported by normative data are indicated by*. Those that have been validated are indicated by**.

Table 4 Assessments identified

Assessment	Aspect of speech assessed
Individual Growth Development Indicator: Rhyming**[66]	Phonology
Arizona Articulation Proficiency Scale** (AAPS)[67]	Articulation, motor
Arizona Articulation Proficiency Scale**—Revised (AAPS-R)[68]	Articulation, motor
Hodson Assessment of Phonological Patterns—third edition** (HAPP-3)[69]	Phonology
Bankson-Bernthal Test of Phonology** (BBTOP)[70]	Phonology
Children's Test of Nonword Repetition**[71]	Articulation, motor
Comprehensive Test of Phonological Processing – second edition (CTOPP-2)**[72]	Phonology
Computer-Based Phonological Awareness Assessment*[73]	Phonology
Computerized Articulation and Phonology Evaluation System (CAPES)**[74]	Articulation, motor
Denver Articulation Screening Exam**[75]	Articulation, motor
Diagnostic Evaluation of Articulation and Phonology (DEAP)**[49]	Articulation, motor, phonology
Edinburgh Articulation Test (EAT)**[76]	Articulation, motor
School Speech Questionnaire[77]	Communicative participation
Goldman-Fristoe Test of Articulation** (GFTA)[50]	Articulation, motor
Glaspey Dynamic Assessment of Phonology** (GDAP)[78]	Phonology
Grammar and Phonology Screening (GAPS)**[79]	Phonology
Preschool and Primary Inventory of Phonological Awareness (PIPA)**[80]	Phonology
McDonald Screening Deep Test of Articulation**[81]	Articulation, motor
Oral Speech Mechanism Screen Examination (OSMSE)**[82]	Articulation, motor
Phonological Abilities Test (PAT)*[83]	Phonology
Phonological Assessment Battery (PhAB)**[84]	Phonology
Phonological Assessment of Child Speech (PACS)**[85]	Phonology
Phonological Awareness Literacy Screening—PreK (PALS-PreK)**[86]	Phonology
Phonological Awareness Literacy Screening—PreK Pre-Reading**[86]	Phonology
Phonological Awareness Test**[87]	Phonology
Phonological Knowledge Protocol (PKP)*[88]	Phonology
Phonological Variability Test[89]	Phonology
Scaffolding Scale of Stimulability (SSS)*[90]	Articulation, motor
Sutherland Phonological Awareness Test—Revised (SPAT-R)**[91]	Phonology
Test of Phonological Awareness–Second Edition: Plus Test of Preschool Early Literacy (TOPA)**[92]	Phonology
Syllable Repetition Task (SRT)*[93]	Articulatory, phonetic and motor based assessments
Templin-Darley Articulation Screening Test**[94]	Articulatory, phonetic and motor based assessments
Test of Polysyllables[95]	Articulatory, phonetic and motor based assessments
Verbal Motor Production Assessment for Children**[96]	Articulatory, phonetic and motor based assessments
Word Complexity Measure[97]	Phonological interventions: complexity approaches

Assessments supported by normative data are indicated by *. Those that have been validated are indicated by **.

evaluated by Waring and Knight.[52] These systems are the Speech Disorder Classification System (SDCS)[3]; the Differential Diagnosis System (DDS)[53] and the Psycholinguistic Framework.[54] The DDS and the SDCS are the two that are most commonly utilised globally.[55] The DDS incorporates the subtype labels of phonological delay; consistent atypical phonological disorder; inconsistent phonological disorder; articulation disorder and childhood apraxia of speech (also known as developmental verbal dyspraxia), based on the features of children's surface-level speech presentation. The SDCS on the other hand is an aetiology-based system that includes the terms:

Box 2 Interventions identified

Intervention

- ⇒ Articulation with facilitative vowel contexts[98]
- ⇒ Auditory bombardment/stimulation[99]
- ⇒ Broad target recasts[100]
- ⇒ Complexity approach[101]
- ⇒ Contrast word procedures (min or max pairs)[102 103]
- ⇒ Core vocabulary[104]
- ⇒ Cycles therapy[105]
- ⇒ Drill play[106]
- ⇒ Electropalatography[107]
- ⇒ Focused stimulation[108]
- ⇒ FONEMZ: a multimodal approach[109]
- ⇒ Integral Stimulation/Dynamic Temporal and Tactile Cueing[110]
- ⇒ Integrated Phonological Awareness Intervention[111]
- ⇒ Intraoral stimulation[112]
- ⇒ Maximal oppositions contrast (maximal pairs)[102]
- ⇒ Maximal/empty sets[102]
- ⇒ Melodic intonation therapy[113]
- ⇒ Metaphon programme[114]
- ⇒ Minimal oppositions contrast (minimal pairs)[115]
- ⇒ Minimal or near-minimal contrasts[115]
- ⇒ Modified core vocabulary treatment[116]
- ⇒ Modified cycles approach[117]
- ⇒ Morphosyntax intervention[118]
- ⇒ Motor speech treatment protocol[119]
- ⇒ Multiple oppositions approach[120]
- ⇒ Multiple oppositions approach[120]
- ⇒ Naturalistic intervention for speech intelligibility[121]
- ⇒ Nonlinear phonological intervention[122]
- ⇒ Non-speech oromotor intervention[33]
- ⇒ Nuffield Centre Dyspraxia Programme[123]
- ⇒ Parents and Children Together therapy[124]
- ⇒ Phonological Stimulation Program[125]
- ⇒ PROMPT (Prompts for Restructuring Oral Muscular Phonetic Targets) system therapy (targeting articulation)[126]
- ⇒ Rapid Syllable Transition Treatment[127]
- ⇒ Rate control therapy[128]
- ⇒ Sound Contrasts in Phonology software program[129]
- ⇒ Speech perception (SAILS - Speech Assessment and Interactive Learning System)[130]
- ⇒ Speech perception training[131]
- ⇒ Stimulability (STP - Stimulability Training Protocol)[132]
- ⇒ Teaching prosodic patterns[133]
- ⇒ Touch cue method[134]
- ⇒ Traditional articulation therapy[135]
- ⇒ Traditional multiple phonemic approach[136]
- ⇒ Ultrasound visual biofeedback[137]
- ⇒ Vocal imitation training[138]
- ⇒ Vowel-targeted intervention[139]
- ⇒ Whole language therapy[140]

speech delay-genetic; speech delay-otitis media with effusion; speech delay-developmental psychosocial involvement. The motor speech disorder 'dysarthria' is absent from the DDS. This is because the DDS is specific to SSD of unknown origin.

An example of how the differences in classification of SSD lead to differences in outcome tools and outcomes is provided by the DDS. A child with inconsistent phonological disorder may receive interventions to improve consistency, rather than correctness of phonemes. In this case, the outcome and outcome tool used will differ from children where the focus is on improving the production of specific consonants.

The mapping of the findings of this umbrella review to one or more of these classification systems for SSD will enable SLTs to select appropriate tools for their practice context.

Towards a core outcome set for SSD

With the potential to map the assessments and outcomes to a framework or system of classification, the speech and language therapy profession can start the conversation around what outcomes are needed to cover all elements/aspects of the framework. Although the measures identified in this umbrella review are the first step in drawing together a list of outcomes which could be used in a core outcome set, it is a crucial starting point and provides the data that are needed to drive follow-up work.

Developing a core outcome set for SSD can help standardise the reporting of outcomes in research studies, making it easier to synthesise findings and assess the overall effectiveness of interventions for this condition. It can also ensure that the outcomes considered most important by patients and healthcare providers are consistently measured and reported.

Strengths and limitations of this review

Umbrella reviews offer several strengths, such as efficiency, comprehensive synthesis, statistical rigour, identification of discrepancies and identification of research gaps. However, they also face challenges, including heterogeneity of studies, quality assessment complexities, publication bias, potential duplications and limited control over methodological choices. In the current review, we have mitigated some of these limitations by extracting retained articles from the individual reviews and deduplicating their representation. We have also critically appraised the reviews using the AMSTAR, although it must be acknowledged that we have also not undertaken an appraisal of all the 415 papers from which we extracted data. Understanding these strengths and weaknesses is crucial for researchers, policymakers and practitioners to interpret and apply the findings of umbrella reviews effectively in evidence-based decision-making processes. Future research should focus on addressing these limitations to further enhance the utility of umbrella reviews as a valuable tool for evidence synthesis.

Further research

The umbrella review reported herein will be used to develop a speech and language therapy core outcome set for children with SSD. However, this requires a rigorous and collaborative process aimed to provide consistent and quality outcomes data, enhance patient-centred care and facilitate evidence-based decision-making. The findings are part of the process essential for advancing healthcare

research and practice in the specific area of speech and language therapy for children with SSD.

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REFERENCES

1 American Psychiatric Association. *DSM-5 Task Force. Diagnostic and Statistical Manual of Mental Disorders*. 5th edn. American Psychiatric Publishing, Available: https://psychiatryonline.org/doi/book/10.1176/appi.books.9780890425596
2 Eadie P, Morgan A, Ukoumunne OC, *et al*. Speech sound disorder at 4 years: prevalence, Comorbidities, and predictors in a community cohort of children. *Develop Med Child Neuro* 2015;57:578–84.
3 Shriberg LD, Fourakis M, Hall SD, *et al*. Extensions to the speech disorders classification system (SDCS). *Clin Linguist Phon* 2010;24:795–824.
4 Shriberg LD, Tomblin JB, McSweeny JL. Prevalence of speech delay in 6-year-old children and Comorbidity with language impairment. *J Speech Lang Hear Res* 1999;42:1461–81.
5 Wren Y, Miller LL, Peters TJ, *et al*. Prevalence and predictors of persistent speech sound disorder at eight years old: findings from a population cohort study. *J Speech Lang Hear Res* 2016;59:647–73.
6 Anthony JL, Aghara RG, Dunkelberger MJ, *et al*. What factors place children with speech sound disorders at risk for reading problems? *Am J Speech Lang Pathol* 2011;20:146–60.
7 Beitchman JH, Wilson B, Johnson CJ, *et al*. Fourteen-year follow-up of speech/language-impaired and control children: psychiatric outcome. *J Am Acad Child Adolesc Psychiatry* 2001;40:75–82.
8 Felsenfeld S, Broen PA, McGue M. A 28-year follow-up of adults with a history of moderate phonological disorder: educational and occupational results. *J Speech Hear Res* 1994;37:1341–53.
9 McCormack J, McLeod S, McAllister L, *et al*. A systematic review of the association between childhood speech impairment and participation across the LifeSpan. *Int J Speech-Language Pathol* 2009;11:155–70.
10 McAllister J, Skinner J, Hayhow R, *et al*. The association between atypical speech development and adolescent self-harm. *J Speech Lang Hear Res* 2023;66:1600–17.
11 Wren Y, Pagnamenta E, Orchard F, *et al*. Social, emotional and behavioural difficulties associated with persistent speech disorder in children: A prospective population study. *JCPP Adv* 2023;3:e12126.
12 Wren Y, Pagnamenta E, Peters TJ, *et al*. Educational outcomes associated with persistent speech disorder. *Intl J Lang & Comm Disor* 2021;56:299–312.
13 Gillon GT. Phonological Awareness: From Research to Practice. New York: Guildford Press, 2004.
14 Broomfield J, Dodd B. Children with speech and language disability: caseload characteristics. *Intl J Lang & Comm Disor* 2004;39:303–24.
15 Roulstone SE, Marshall JE, Powell GG, *et al*. Evidence-based intervention for preschool children with primary speech and language impairments: child talk – an exploratory mixed-methods study. *Programme Grants Appl Res* 2015;3:1–408.
16 Vanhaecht K, De Witte K, Sermeus W. The impact of clinical pathways on the Organisation of care processes [PhD dissertation]. Belgium, KU Leuven, 2007
17 Morgan L, Overton S, Bates S, *et al*. Making the case for the collection of a minimal Dataset for children with speech sound disorder. *Int J Lang Commun Disord* 2021;56:1097–107.
18 RCSLT & ICAN. Bercow: Ten Years On: An independent review of provision for children and young people with speech, language and communication needs in England, 2018. Available: https://www.bercow10yearson.com/wpcontent/uploads/2018/03/337644-ICAN-Bercow-Report-WEB.pdf
19 Roulstone S, Coad J, Ayre A, *et al*. The preferred outcomes of children with speech. language and communication needs and their parents. 2012. Available: http://dera.ioe.ac.uk/16329/7/DFE-RR247-BCRP12_Redacted.pdf
20 Wren Y, Harding S, Goldbart J, *et al*. A systematic review and classification of interventions for speech sound disorder in preschool children. *Intl J Lang Comm Disor* 2018;53:446–67.
21 Horwitz RI, Hayes-Conroy A, Caricchio R, *et al*. From evidence based medicine to medicine based evidence. *Am J Med* 2017;130:1246–50.
22 McFaul H, Mulgrew L, Smyth J, *et al*. Applying evidence to practice by increasing intensity of intervention for children with severe speech sound disorder: a quality improvement project. *BMJ Open Qual* 2022;11:e001761.
23 Lyons R, Roulstone S. Labels, identity and narratives in children with primary speech and language impairments. *Int J Speech Lang Pathol* 2017;19:503–18.
24 McLeod S, Bleile K. The ICF: a framework for setting goals for children with speech impairment. *Child Lang Teach Ther* 2004;20:199–219.
25 Williams C, Harding S, Wren Y. An exploratory study of speech and language therapy intervention for children born with cleft Palate±Lip. *Cleft Palate Craniofac J* 2021;58:455–69.
26 Baker E, Masso S, Huynh K, *et al*. Optimizing outcomes for children with phonological impairment: A systematic search and review of outcome and experience measures reported in intervention research. *Lang Speech Hear Serv Sch* 2022;53:732–48.
27 Choi GJ, Kang H. The umbrella review: a useful strategy in the rain of evidence. *Korean J Pain* 2022;35:127–8.
28 Fusar-Poli P, Radua J. Ten simple rules for conducting umbrella reviews. *Evid Based Ment Health* 2018;21:95–100.
29 Aromataris E, Fernandez R, Godfrey C, *et al*. Chapter 10: umbrella reviews. In: Aromataris E, Munn Z, eds. *JBI Manual for Evidence Synthesis, JBI*. 2020. Available: https://synthesismanual.jbi.global. https://doi.org/10.46658/JBIMES-20-11
30 Shea BJ, Reeves BC, Wells G, *et al*. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of Healthcare interventions, or both. *BMJ* 2017;358:j4008.
31 Harding S, Burr S, Cleland J, *et al*. Outcome measures for children with speech sound disorder: an umbrella review protocol BMJ open 2023;13:E068945. *BMJ Open* 2023;13:e068945.
32 Ouzzani M, Hammady H, Fedorowicz Z, *et al*. Rayyan-a web and mobile App for systematic reviews. *Syst Rev* 2016;5:210.
33 Lee AS-Y, Gibbon FE. Non-speech oral motor treatment for children with developmental speech sound disorders. *Cochrane Database Syst Rev* 2015;2015:CD009383.

34 Crowe K, Cuervo S, Guiberson M, *et al*. A systematic review of interventions for Multilingual Preschoolers with speech and language difficulties. *J Speech Lang Hear Res* 2021;64:4413–38.
35 McCauley RJ, Strand E, Lof GL, *et al*. Evidence-based systematic review: effects of Nonspeech oral motor exercises on speech. *Am J Speech Lang Pathol* 2009;18:343–60.
36 Rodgers L, Harding S, Rees R, *et al*. Interventions for Pre-School children with Co-Occurring phonological speech sound disorder and expressive language difficulties: A Scoping review. *Intl J Lang & Comm Disor* 2022;57:700–16.
37 Sugden E, Lloyd S, Lam J, *et al*. Systematic review of ultrasound visual Biofeedback in intervention for speech sound disorders. *Int J Lang Commun Disord* 2019;54:705–28.
38 Baker E, McLeod S. Evidence-based practice for children with speech sound disorders: part 1 narrative review. *LSHSS* 2011;42:102–39.
39 Berkman ND, Wallace I, Watson L, *et al*. Screening for Speech and Language Delays and Disorders in Children Age 5 Years or Younger: A Systematic Review for the U.S. Preventive Services Task Force. Rockville (MD): Agency for Healthcare Research and Quality (US), 2015.
40 Cunningham BJ, Washington KN, Binns A, *et al*. Current methods of evaluating speech-language outcomes for Preschoolers with communication disorders: A Scoping review using the ICF-CY. *J Speech Lang Hear Res* 2017;60:447–64.
41 Hearnshaw S, Baker E, Munro N. Speech perception skills of children with speech sound disorders: A systematic review and meta-analysis. *J Speech Lang Hear Res* 2019;62:3771–89.
42 Kaipa R, Peterson AM. A systematic review of treatment intensity in speech disorders. *Int J Speech Lang Pathol* 2016;18:507–20.
43 Law J, Garrett Z, Nye C. Speech and language therapy interventions for children with primary speech and language delay or disorder. *Cochrane Database Syst Rev* 2003;2003:CD004110.
44 Masso S, Baker E, McLeod S, *et al*. Identifying phonological awareness difficulties in preschool children with speech sound disorders, speech. *Speech Lang Hear* 2014;17:58–68.
45 Murray E, McCabe P, Ballard KJ. A systematic review of treatment outcomes for children with childhood Apraxia of speech. *Am J Speech Lang Pathol* 2014;23:486–504.
46 Sugden E, Baker E, Munro N, *et al*. Involvement of parents in intervention for childhood speech sound disorders: a review of the evidence. *Int J Lang Commun Disord* 2016;51:597–625.
47 Sugden E, Baker E, Munro N, *et al*. Service delivery and intervention intensity for phonology-based speech sound disorders. *Int J Lang Commun Disord* 2018;53:718–34.
48 Wales D, Skinner L, Hayman M. The efficacy of Telehealth-delivered speech and language intervention for primary school-age children: A systematic review. *Int J Telerehabil* 2017;9:55–70.
49 Dodd B, Hua Z, Crosbie S, *et al*. Diagnostic Evaluation of Articulation and Phonology (DEAP). Harcourt, 2005.
50 Goldman R, Fristoe M. Goldman-Fristoe Test of Articulation-3 (GFTA-3). Pearson Clinical, 2015. Available: https://www.pearsonclinical.co.uk/store/ukassessments/en/goldman-gristle/Goldman-Fristoe-Test-of-Articulation-3/p/P100009111.html
51 Eadie TL, Yorkston KM, Klasner ER, *et al*. Measuring communicative participation: a review of self-report instruments in speech-language pathology. *Am J Speech Lang Pathol* 2006;15:307–20.
52 Waring R, Knight R. How should children with speech sound disorders be classified? A review and critical evaluation of current classification systems. *Intl J Lang &Amp; Comm Disor* 2013;48:25–40.
53 Dodd B. Differential diagnosis of pediatric speech sound disorder. *Curr Dev Disord Rep* 2014;1:189–96.
54 Stackhouse J, Wells B. Psycholinguistic assessment of developmental speech disorders. *Intl J Lang & Comm Disor* 1993;28:331–48.
55 Terband H, Maassen B, Maas E. A Psycholinguistic framework for diagnosis and treatment planning of developmental speech disorders. *Folia Phoniatr Logop* 2019;71:216–27.
56 Gutfreund M, Harrision C, Wells G. Bristol Language Development Scales. Windsor, Berks: NFER-Nelson, 1989.
57 Dunn L, Dunn L, Whetton C, *et al*. *British Picture Vocabulary Scales*. 2nd edn. Windsor, Berks: NFER-Nelson Publishing Company Ltd, 1997.
58 Olson DH, Portner J, Lavee Y. Family Adaptability and Cohesion Evaluation Scales III. Paul, MN: Routledge, 1987.
59 Thomas-Stonell NL, Oddson B, Robertson B, *et al*. Development of the FOCUS (focus on the outcomes of communication under six), a communication outcome measure for preschool children. *Dev Med Child Neurol* 2010;52:47–53.
60 American Speech Hearing Association. National outcome measurement system (NOMS) functional communication measures (Fcms). *SLP Healthcare Registry* 2022;13. Available: https://www.asha.org/siteassets/uploadedfiles/ASHA/NOMS/SLP-NOMS-Functional-Communication-Measures.pdf
61 Speake J, Stackhouse J, Pascoe M. Vowel targeted intervention for children with persisting speech difficulties: impact on Intelligibility. *Child Lang Teach Therapy* 2012;28:277–95.
62 Vanryckeghem M, Brutten GJ, Langevin M, *et al*. Kiddycat communication attitude test for preschool and kindergarten children who stutter. *Psychology* 2006.
63 Ozanne AE. Normative data for sequenced oral movements and movements in context for children aged three to five years. *Aust J Human Commun Dis* 1992;20:47–63.
64 Folio RR, Fewell MRF. The Peabody Developmental Motor Scales (PDMS). Pearson Publishing, 2000.
65 Glaspey A, Stoel-Gammon C. A dynamic approach to phonological assessment. *Advances in Speech Language Pathology* 2007;9:286–96.
66 Early Childhood Research Institute on measuring Growth and Development. Individual Growth and Development Indicators for Preschool Children: Rhyming/Early Literacy and Alliteration/Early Literacy. Minneapolis, MN: Center for Early Education and Development, University of Minnesota, 2000.
67 Fudala JB. Arizona Articulation Proficiency Scale (Revised): Manual. Los Angeles: Western Psychological Services, 1970.
68 Fudula JB, Stegall S. Arizona-4) Arizona Articulation and Phonology Scale, Fourth Revision. Los Angeles: Western Psychological Services, 2017.
69 Hodson BW. Hodson Assessment of Phonological Patterns-3 (HAPP-3). ProEd Publishing, 2004.
70 Bankson NW, Bernthal JE. BBTOP-2 Bankson-Bernthal test of phonology. *Applied Symbolix* 1990.
71 Gathercole SE, Willis CS, Baddeley AD, *et al*. The children's test of Nonword repetition: a test of phonological working memory. *Memory* 1994;2:103–27.
72 Wagner RK, Torgesen JK, Rashotte CA, *et al*. Comprehensive test of phonological processing - second edition (CTOPP 2) Pearson assessment. 2013.
73 Wise BW, Olson RK. Computer-based phonological awareness and reading instruction. *Ann Dyslexia* 1995;45:97–122.
74 Masterson J, Bernhardt BH. Capes: Computerized Articulation & Phonology Evaluation System (Windows Version 1.0). Psychological Corp, 2001.
75 Drumwright A, Van Natta P, Camp B, *et al*. The Denver articulation screening exam. *J Speech Hear Disord* 1973;38:3–14.
76 Anthony A, Bogle D, Ingram TTS. Edinburgh articulation test. *Archives of Disease in Childhood* 1972;47:843.
77 Bergman L. School Speech Questionnaire. UCLA Semel Institute for Neuroscience and Human Behavior 2008, Available: https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/pdf/treatments/forms_and_worksheets.pdf
78 Glaspey A. Glaspey Dynamic Assessment of Phonology (GDAP), 2019. Available: https://assessments.academictherapy.com/i/glaspey-dynamic-assessment-of-phonology-gdap
79 Gardner H, Froud K, McClelland A, *et al*. Development of the grammar and phonology screening (GAPS) test to assess key markers of specific language and literacy difficulties in young children. *Int J Lang Commun Disord* 2006;41:513–40.
80 Dodd B, Crosbie S, McIntosh B, *et al*. Preschool and Primary Inventory of Phonological Awareness (PIPA). Pearson Publishing, 2000.
81 McDonald ET. A Screening Deep Test of Articulation. Stanwix House, 1968.
82 St.KO, Ruscello DM. Oral Speech Mechanism Screen Examination (OSMSE). Baltimore: University Park Press, 1981.
83 Muter V, Hulme C, Snowling M, *et al*. Segmentation, not rhyming, predicts early progress in learning to read. *J Exp Child Psychol* 1997;65:370–96.
84 Gallagher A, Frederickson N. The phonological assessment battery (PHAB): an initial assessment of its theoretical and practical utility. *Bpsecp* 1995;12:53–67.
85 Grunwell P. Phonological assessment, evaluation and explanation of speech disorders in children. *Clin Ling Phonet* 1988;2:221–52.
86 Invernizzi M, Meier J, Swank L. Phonological awareness literacy screening for Preschoolers (PALS-Prek) [database record]. APA Psyctests. 2004.
87 Robertson C, Salter W. Phonological Awareness Test-2: Normative Update (PAT-2:NU), 2018. Available: https://assessments.academictherapy.com/i/phonological-awareness-test-2-normative-update-pat-2-nu

88 Gierut JA, Elbert M, Dinnsen DA. A functional analysis of phonological knowledge and generalization learning in Misarticulating children. *J Speech Hear Res* 1987;30:462–79.
89 Dodd B, Gillon G, Oerlemans M, *et al*. Phonological disorder and the acquisition of literacy. In: Dodd B, ed. *Differential diagnosis and treatment of children with speech disorder*. London: Whurr, 1995: 125–46.
90 Glaspey AM. Dynamic assessment in phonological disorders: the scaffolding scale of Stimulability [Unpublished doctoral dissertation]. Seattle, Washington, University of Washington, 2006
91 Neilson R. The Sutherland phonological awareness test. Australian Speech and Hearing Association National Conference; 1995
92 Torgeson JK, Bryant BR. Test of Phonological Awareness–Second Edition: Plus Test of Preschool Early Literacy (TOPA-2+). WPS Publishing, 2004.
93 Shriberg LD, Lohmeier HL, Campbell TF, *et al*. A Nonword repetition task for speakers with Misarticulations: the syllable repetition task (SRT). *J Speech Lang Hear Res* 2009;52:1189–212.
94 Templin MC, Darley FL. The Templin-Darley Tests of Articulation, Manual. Iowa: The University of Iowa, 1969.
95 Gozzard H, Baker E, McCabe P. Children's productions of Polysyllabic words. *ACQuiring Knowledge in Speech, Language and Hearing* 2006;8:113–6.
96 Hayden D, Square P. n.d. Verbal motor production assessment for children (VMPAC) [database record]. APA Psyctests 1999.
97 Stoel-Gammon C. The word complexity measure: description and application to developmental phonology and disorders. *Clin Linguist Phonet* 2010;24:271–82.
98 Stokes SF, Griffiths R. The use of Facilitative vowel contexts in the treatment of Postalveolar fronting: a case study. *Intl J Lang Comm Disor* 2010;45:368–80.
99 Hodson B, Paden E. Targeting Intelligible Speech. San Diego: College-Hill Press, 1983.
100 Yoder PJ, Molfese D, Gardner E. Initial mean length utterance predicts the relative efficacy of two grammatical treatments in Preschoolers with specific language impairment. *J Speech Lang Hear Res* 2011;54:1170–81.
101 Storkel HL. The complexity approach to phonological treatment: how to select treatment targets. *Lang Speech Hear Serv Sch* 2018;49:463–81.
102 Gierut JA. Maximal opposition approach to phonological treatment. *J Speech Hear Disord* 1989;54:9–19.
103 Weiner F. Treatment of phonological disability using the method of meaningful minimal contrast: two case studies. *J Speech Hear Disord* 1981;46:97–103.
104 Crosbie S, Holm A, Dodd B. Intervention for children with severe speech disorder: A comparison of two approaches. *Int J Lang Commun Disord* 2005;40:467–91.
105 Hodson BW, Paden EP. Phonological processes which characterize unintelligible and intelligible speech in early childhood. *J Speech Hear Disord* 1981;46:369–73.
106 Shriberg LD, Kwiatkowski J. Phonological disorders II: a conceptual framework for management. *J Speech Hear Disord* 1982;47:242–56.
107 Wood S, Wishart J, Hardcastle W, *et al*. The use of Electropalatography (EPG) in the assessment and treatment of motor speech disorders in children with down's syndrome: evidence from two case studies. *Dev Neurorehabil* 2009;12:66–75.
108 Girolametto L, Pearce PS, Weitzman E. Interactive focused stimulation for toddlers with expressive language delays. *J Speech Lang Hear Res* 1996;39:1274–83.
109 Pieretti RA, Kaul SD, Zarchy RM, *et al*. Using a Multimodal approach to facilitate articulation, phonemic awareness and literacy in young children. *Communication Disorders Quarterly* 2015;36:131–41.
110 Strand EA, Skinder A. Treatment of developmental Apraxia of speech: integral stimulation methods. In: Caruso A, Strand E, eds. *Clinical management of motor speech disorders in children*. New York, NY: Thieme, 1999: 109–48.
111 Gillon GT, MacNeill BC. Integrated Phonological Awareness An intervention program for preschool children with Speech-language impairment, 2007. Available: https://www.canterbury.ac.nz/media/documents/education-and-health/gail-gillon---phonological-awareness-resources/programmes/preschool/01-Integrated-Phonological-Awareness-Manual-Sept-07.pdf
112 Vaughn GR, Clark RM. Speech Facilitation: Extraoral and Intraoral Stimulation Technique for Improvement of Articulation Skills. Springfield, Illinois: Thomas, 1979.
113 Norton A, Zipse L, Marchina S, *et al*. Melodic intonation therapy: shared insights on how it is done and why it might help. *Ann N Y Acad Sci* 2009;1169:431–6.
114 Dean EC, Howell J, Waters D, *et al*. Metaphon: A Metalinguistic approach to the treatment of phonological disorder in children. *Clinical Linguistics & Phonetics* 1995;9:1–19.
115 Weiner FF. Treatment of phonological disability using the method of meaningful minimal contrast: two case studies. *J Speech Hear Disord* 1981;46:97–103.
116 Iuzzini J, Forrest K. Evaluation of a combined treatment approach for childhood Apraxia of speech. *Clinical Linguistics & Phonetics* 2010;24:335–45.
117 Almost D, Rosenbaum P. Effectiveness of speech intervention for phonological disorders: a randomized controlled trial. *Dev Med Child Neurol* 1998;40:319–25.
118 Tyler AA, Lewis KE, Haskill A, *et al*. Efficacy and cross-domain effects of a Morphosyntax and a phonology intervention. *Lang Speech Hear Serv Sch* 2002;33:52–66.
119 Namasivayam A, Pukonen M, Hard J, *et al*. Motor speech treatment protocol for developmental motor speech disorders. *Dev Neurorehabil* 2015;18:296–303.
120 Williams L. Multiple oppositions: theoretical foundations for an alternative Contrastive intervention approach. *Am J Speech Lang Pathol* 2000;9:282–8.
121 Camarata S. Naturalistic intervention for speech Intelligibility and speech accuracy. In: Williams L, McLeod S, McCauley R, eds. *Interventions for speech sound disorders in children*. Baltimore, MD: Brookes Publishing, 2010.
122 Bernhardt B. The application of Nonlinear phonological theory to intervention with one Phonologically disordered child. *Clinical Linguistics & Phonetics* 1992;6:283–316.
123 Williams P, Stephens H. *The Therapy Manual of The Nuffield Centre Dyspraxia Programme*. 3rd edn. London: The Nuffield Centre Dyspraxia Programme Ltd, 2004.
124 Bowen C, Cupples L. Parents and children together (PACT): a collaborative approach to phonological therapy. *Intl J Lang Comm Disor* 1999;34:35–55.
125 Sá M, Miranda J, Capelas S, *et al*. Development of the phonological awareness stimulation programme (PECF) - Digital version. 2019 14th Iberian Conference on Information Systems and Technologies (CISTI); 1–6. Coimbra, Portugal.
126 Chumpelik HD, Sherman J. n.d. Treatment comparisons for developmental Apraxia of speech. unpublished research, Thistletown Regional Centre, Toronto 1983.
127 Thomas DC, McCabe P, Ballard KJ. Rapid syllable transitions (rest) treatment for childhood Apraxia of speech: the effect of lower dose-frequency. *J Commun Disord* 2014;51:29–42.
128 Rosenthal JB. Rate control therapy for developmental Apraxia of speech. *Clin Commun Disord* 1994;4:190–200.
129 Williams AL. SCIP: Sound Contrasts in Phonology, 2016. Available: https://www.scipapp.com/
130 Rvachew S. Speech assessment and interactive learning system (version 2) [computer software]. DIALSpeech. 2009.
131 Rvachew S. Speech perception training can facilitate sound production learning. *J Speech Lang Hear Res* 1994;37:347–57.
132 Powell TW, Miccio AW. Stimulability: a useful clinical tool. *Journal of Communication Disorders* 1996;29:237–53.
133 Diehl JJ, Paul R. The assessment and treatment of prosodic disorders and neurological theories of Prosody. *Int J Speech Lang Pathol* 2009;11:287–92.
134 Bashir AS, Grahamjones F, Bostwick RY. A touch-cue method of therapy for developmental verbal Dyspraxia. *Semin Speech Lang* 1984;5:127–37.
135 Van C. *Speech Correction: Principles and Methods*. 5th edn. Englewood Cliffs, NJ: Prentice-Hall, 1972.
136 McCabe R, Bradley D. Systematic multiple Phoneme approach to articulation therapy. *Acta Symbolica* 1975;6:1–18.
137 Queen Margaret University. Evaluating Ultrasound Visual Biofeedback Therapy in Treating Residual Speech Sound Disorder, no.112, Available: https://eresearch.qmu.ac.uk/handle/20.500.12289/7684
138 Eikeseth S, Nesset R. Behavioral treatment of children with phonological disorder: the efficacy of vocal imitation and sufficient-response-exemplar training. *J Appl Behav Anal* 2003;36:325–37.
139 Speake J, Stackhouse J, Pascoe M. Vowel targeted intervention for children with persisting speech difficulties: impact on Intelligibility. *Child Language Teaching and Therapy* 2012;28:277–95.
140 Hoffman PR. A whole-language treatment perspective for phonological disorder. *Semin Speech Lang* 1993;14:142–52.