

## Introduction

- Classroom noise levels ~70 dB(A) (recommended: ≤55 dB(A)) [1]
- To be understood, teachers speaking level is ~80 dB(A) [2]
- >50% of teachers develop voice disorders [3]
- Acoustic degradations interfere with children's speech processing [4]

## Objective

To review the effects of noise and/or speaker's impaired voice quality on spoken language processing in school-aged children

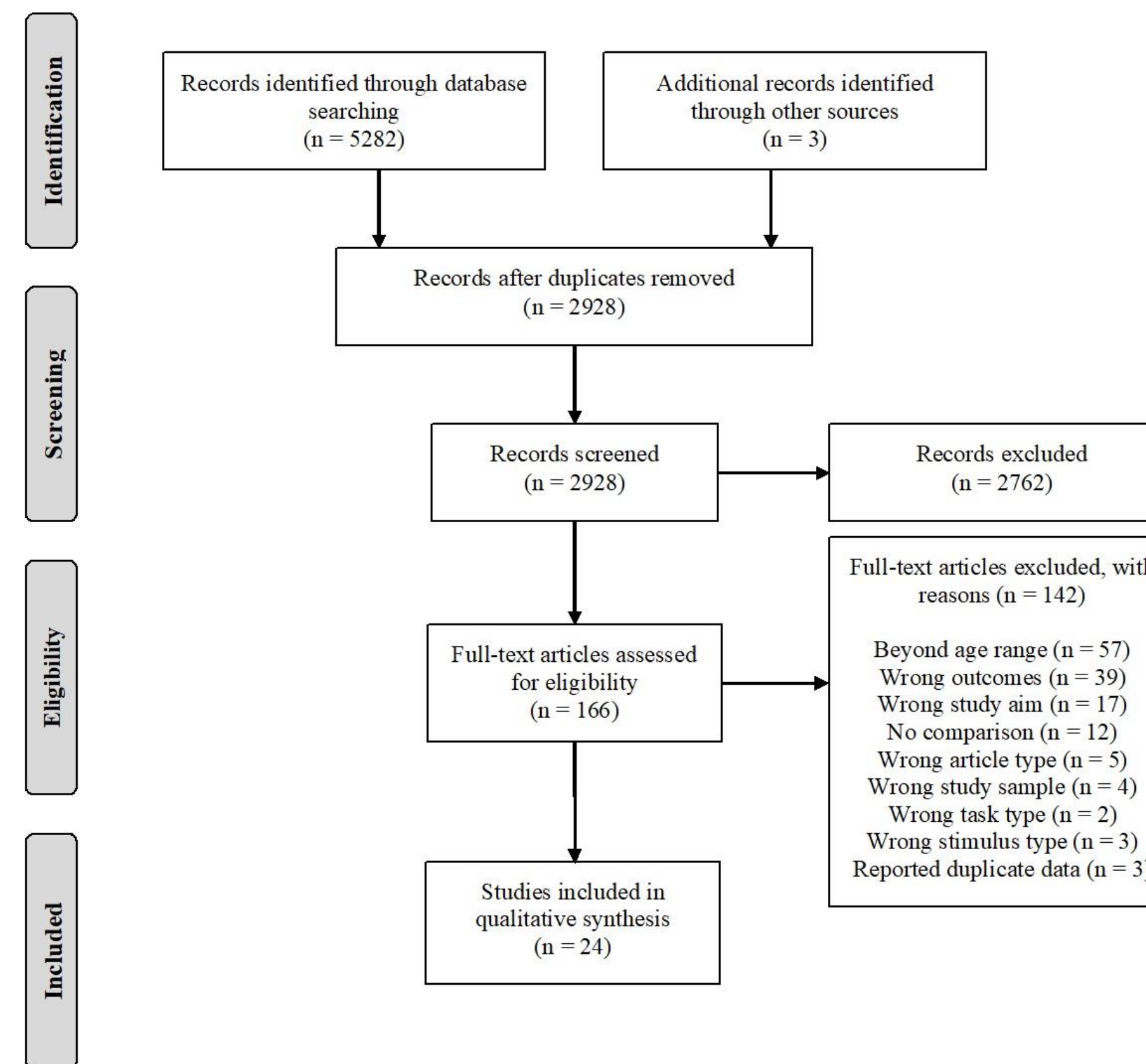
## Methods

- PRISMA-informed systematic review
- Study search: PsycINFO/Ovid, Medline/Ovid, Eric/Ovid, and Scopus searched up to August 2018 (example in Table 1)
- Eligibility: studies assessing 6-18-year-old children's performance and response times (RT) in listening tasks presented in noise and/or impaired voice (study selection process in Figure 1)
- Findings classified and synthesized regarding speech perception, listening comprehension, and auditory working memory
- Study quality assessment: shortened version of Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies of the National Heart, Lung, and Blood Institute [5] (see Figure 2)

**Table 1.** Search strategy applied in Medline/Ovid

Concepts	Subject headings	Keywords
#1 Child	Child; Adolescent	child*; teen*; youth*; adolescen*; preadolescen*
#2 Spoken language processing	Speech Perception; Speech Intelligibility; Speech Discrimination Tests; Speech Reception Threshold Test	Spoken language adj2 (perception or percei* or reception or recei* or process* or comprehen*); Speech adj2 (perception or percei* or reception or recei* or intelligib* or discriminat* or process* or comprehen* or recogni*); Listening adj2 (comprehen* or effort* or task* or test*)
#3 Noise	Noise; Signal-To-Noise Ratio; Perceptual Masking	nois*; babbl*; chatter; cocktail party effect (Perceptual or energetic or informational or speech or auditory) adj2 mask*.
#4 Impaired voice	exp Voice Disorders; Voice Quality	(Voice or vocal or phonat*) adj2 (impair* or disord* or rough* or breath* or fatigue or disturb* or quality or absen*); dysphon*; aphon*; hoarse*
Search strategy: #1 AND #2 AND (#3 OR #4)		

Note. \* for truncation; adj2 is a proximity operator; exp retrieves results on selected term and more specific terms; keyword search limited to abstracts and titles; results limited to English language.



**Figure 1.** Flow diagram illustrating study selection process

Study	Objective clearly stated? (Q1)	Population clearly specified? (Q2)	Participation rate ≥ 50%? (Q3)	Inclusion criteria clearly reported? (Q4)	Power or effect estimates reported? (Q5)	Exposure measures defined a priori? (Q6)	Outcome measures defined a priori? (Q7)	Outcome assessors blinded? (Q8)	Confounders variables considered? (Q9)	Overall Quality	
Bradley et al. (2008)	YES	CD	NR	NO	NO	YES	NO	YES	NR	YES	FAIR
Bränström, Kastberg, et al. (2018)	YES	YES	YES	YES	NA	CD	YES	NR	CD	GOOD	
Bränström, von Lochow, et al. (2018)	YES	NO	NR	NR	NO	NA	CD	YES	NR	CD	FAIR
Chui & Ma (2018)	YES	YES	NR	YES	NO	YES	CD	CD	NR	YES	GOOD
Crandell & Smaldino (1996)	YES	NO	NR	NO	NO	YES	YES	YES	NR	YES	GOOD
Howard et al. (2010)	YES	NO	NR	NR	NO	YES	NO	YES	NR	NO	GOOD
Hurtig et al. (2016)	YES	YES	YES	NO	YES	NA	YES	CD	NR	YES	GOOD
Jamieson et al. (2004)	YES	NO	NR	CD	NO	YES	CD	NO	NR	CD	FAIR
Lyberg-Åhlander, Haake, et al. (2015)	YES	YES	YES	YES	YES	NA	CD	YES	NR	YES	GOOD
Lyberg-Åhlander, Holm, et al. (2015)	YES	NO	YES	NO	YES	NA	CD	YES	NR	CD	GOOD
McGarrigle et al. (2017)	YES	NO	NR	NO	CD	NA	YES	CD	NR	NO	FAIR
Morsomme et al. (2011)	YES	NO	NR	NR	NO	NA	CD	CD	NR	YES	FAIR
Morton & Watson (2001)	YES	NO	NR	YES	NO	NA	CD	NO	NR	CD	FAIR
Nakeva von Mentzer (2017)	YES	NO	YES	NO	YES	NA	CD	YES	NR	YES	GOOD
Nelson et al. (2005)	YES	YES	YES	CD	YES	NA	NO	NO	NR	CD	GOOD
Nirme et al. (2018)	YES	YES	YES	YES	NO	NA	YES	YES	NR	CD	GOOD
Osman et al. (2014)	YES	YES	NR	CD	NO	YES	YES	YES	NR	YES	GOOD
Peng & Jiang (2016)	YES	NO	NR	NO	NO	YES	YES	YES	NR	NO	GOOD
Peng et al. (2016)	YES	NO	NR	NO	NO	NA	YES	YES	NR	NO	FAIR
Rogerson & Dodd (2005)	YES	CD	NR	NO	NO	YES	NO	CD	NR	YES	FAIR
Sahlén et al. (2017)	YES	NO	NR	NO	YES	NA	CD	YES	NR	CD	GOOD
Sullivan et al. (2015)	YES	YES	YES	CD	YES	NA	NO	YES	NR	CD	GOOD
von Lochow et al. (2018)	YES	YES	YES	NO	YES	YES	CD	CD	NR	NO	GOOD
Yacullo & Hawkins (1987)	YES	YES	NR	YES	NO	NA	YES	CD	NR	NO	GOOD

**Figure 2.** Quality assessment of included studies using shortened NIH tool [5]

## Results

- 24 studies included (14 on noise effects; 8 on impaired-voice effects; 2 on combined effects)
- Negative effects of noise and impaired voice on speech perception, listening comprehension, and auditory working memory (see Table 2)
- Study quality: good = 67%, fair = 33% (see Figure 2)

**Table 2.** Effects of noise and impaired voice on children's spoken language processing

Speech perception	Listening comprehension	Auditory working memory
<b>Noise</b> lowered performance in word-picture matching, word-word matching, word repetition, sentence repetition, and phoneme discrimination	<b>Noise</b> lowered performance in veracity judgements and passage comprehension	<b>Noise</b> lowered performance in forward digit recall, backward digit recall, and word recall
<b>Impaired voice</b> lowered performance in phoneme discrimination	<b>Impaired voice</b> lowered performance in acceptability judgements and passage comprehension, and increased girls' RTs in a sentence comprehension task	<b>Impaired voice</b> lowered word recall performance
<b>Noise x impaired voice</b> not investigated	<b>Noise x impaired voice</b> not significant	<b>Noise x impaired voice</b> not investigated

## Conclusions

- Noise and impaired voice may disrupt children's perception, comprehension, and memory of spoken language
- Research on combined effects of noise and impaired voice still scarce
- Study quality generally good, but more rigorous reporting required

## Recommendations

- Enhancing classroom listening conditions (e.g. noise insulation, voice-care programs, voice amplification)
- Investigating combined effects and potential interactions of noise and speaker's impaired voice
- Improving study quality (e.g. reporting participation rate, effect estimates, and blinding methods)

## References

- [1] Silva LT et al. (2016). *Appl Acoust* 106:2-9. [2] Remacle A et al. (2014). *JSLHR* 57(2):406-415. [3] Roy N et al. (2004). *JSLHR* 47:2-551. [4] Johnson CE. (2000). *JLSHR* 43(1):144-157. [5] NIH National Heart, Lung and Blood Institute. (retrieved 26 Oct 2019). From www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools.