# Effects of noise and a speaker's impaired voice quality on spoken language processing in school-aged children: a systematic review and meta-analysis*

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## Introduction

- Classroom noise levels ~70 dB(A) (recommended: ≤55 dB(A)) [1]
- Intensive voice use among teachers to increase intelligibility [2]
- ~50% of teachers develop voice disorders [3]
- Poor listening conditions affect children's processing of spoken language [4]

## Objective

To review and quantify the effects of noise and impaired voice on spoken language processing in school-aged children

## Methods

- Systematic review and meta-analysis reported using PRISMA [5]
- Eligibility: Studies examining 6-18-year-old children's accuracy and response times (RT) in listening tasks presented in noise and/or impaired voice
- Study search: PsycINFO/Ovid, Medline/Ovid, Eric/Ovid, and Scopus (up to 11/2019)
- Systematic review: Classification and synthesis of noise and impaired-voice effects regarding speech perception, listening comprehension, and auditory working memory
- Meta-analysis: Quantification of noise and impaired-voice effects
- Quality assessment: Tool for Observational Cohort and Cross-Sectional Studies of the National Heart, Lung, and Blood Institute [6]
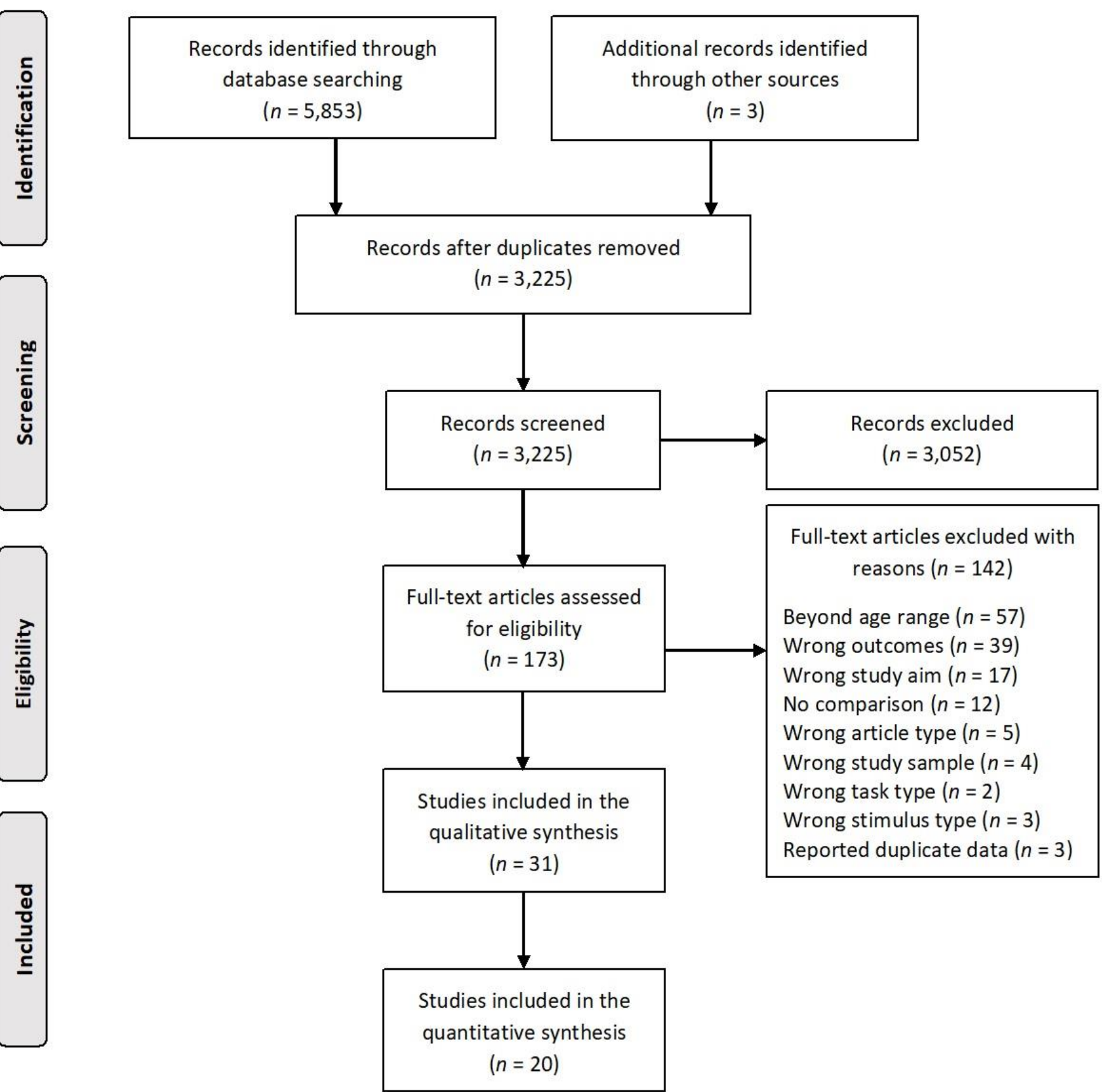


**Figure 1.** Flow diagram illustrating study selection process



**Figure 2.** Quality assessment of included studies using shortened NIH tool [5]
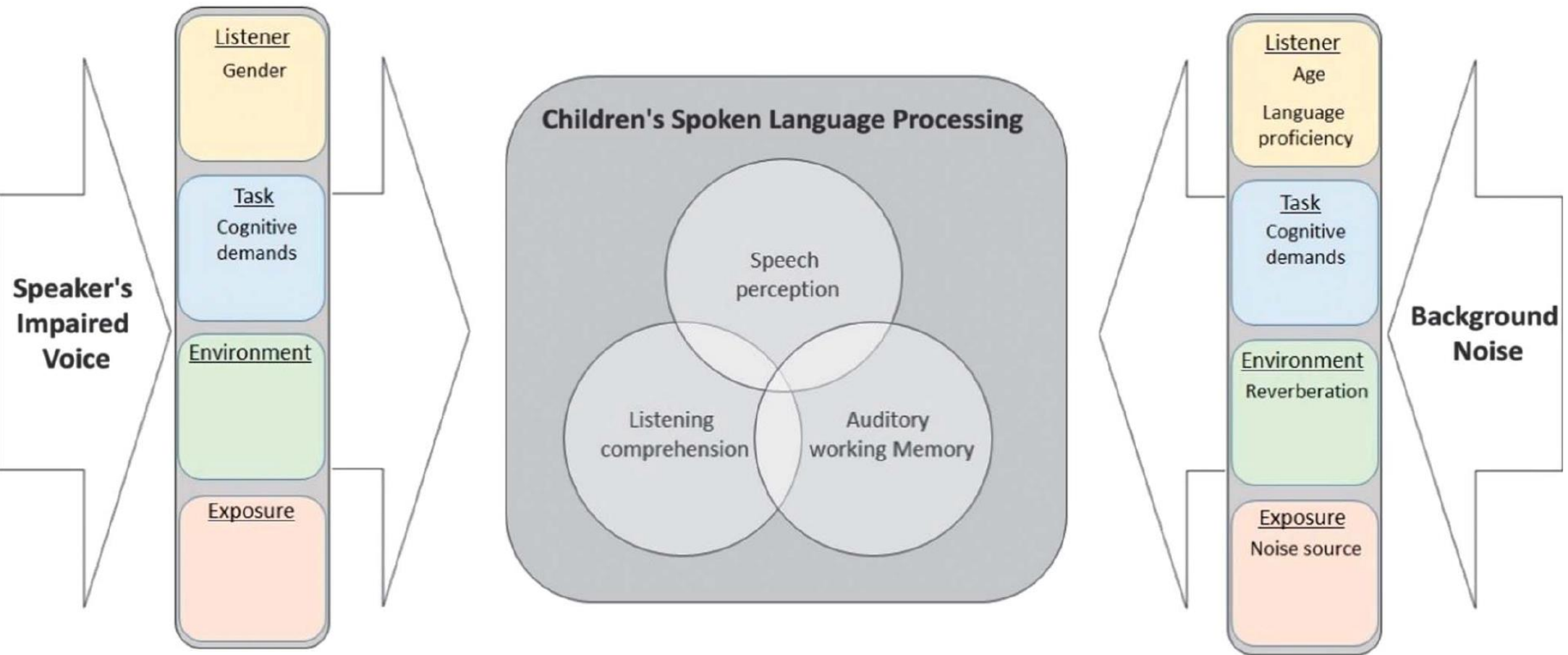NR = not reported; NA = not applicable; CD = cannot determine



**Figure 3. Speech Processing under Acoustic DEgradations (SPADE) Framework** illustrates: impaired voice and noise can disrupt children's spoken language processing regarding speech perception, listening comprehension, and auditory working memory. Based on reviewed studies, factors concerning the listener, task, environment, and exposure can moderate these effects.

## Results

- 31 studies reviewed (Figure 1; 21 = noise; 8 = impaired voice; 2 = combined effect)
- Good study quality in 71% and fair quality in 29% of studies (Figure 2)
- Qualitatively, noise and impaired voice impede speech perception, listening comprehension, and auditory working memory (Figure 3)
- Quantitatively, moderate-severe effects of noise (Table 1) and mild-moderate effects of impaired voice on response accuracy (Table 2); effects on RT inconclusive

**Table 1.** Effects of noise on answer accuracy in listening tasks as a function of SNR

| Predictor | Studies N | Children N | Main effects Cohen's d [95% CI] | z value | p value | Heterogeneity test I² | p value |
|---|---|---|---|---|---|---|---|
| Noise (SNR bins) | | | | | | | |
| +6 to +10 dB | 5 | 130 | −0.67 [−0.92, −0.42] | −5.24 | < .01** | 0% | .93 |
| +1 to +5 dB | 5 | 156 | −1.20 [−2.00, −0.40] | −2.94 | < .01** | 90% | < .01** |
| 0 dB | 7 | 371 | −1.74 [−2.60, −0.88] | −3.96 | < .01** | 95% | < .01** |
| −1 to −5 dB | 5 | 131 | −2.24 [−3.82, −0.65] | −2.77 | < .01** | 96% | < .01** |
| −6 to −12 dB | 3 | 70 | −2.65 [−4.10, −1.21] | −3.60 | < .01** | 89% | < .01** |

*Note.* SNR = signal-to-noise ratio.
**p < .01.

**Table 2.** Effects of impaired voice on answer accuracy in listening comprehension and auditory working memory tasks

| Predictor | Studies N | Children N | Main effects Cohen's d [95% CI] | z value | p value | Heterogeneity test I² | p value |
|---|---|---|---|---|---|---|---|
| Impaired voice | | | | | | | |
| Listening comprehension | 9 | 545 | −0.35 [−0.59, −0.11] | −2.82 | < .01** | 73% | < .01** |
| Auditory working memory | 2 | 81 | −0.13 [−0.72, 0.46] | −0.42 | .67 | 67% | .08 |

*Note.* The dimension of speech perception is not featured as it was assessed in only one study (Morsomme et al.).
**p < .01.

## Conclusions

- Noise and impaired voice may disrupt children's spoken language processing from very early up to highly complex processing stages.
- Further research on combined effects of noise and impaired voice required
- Study quality generally good, but more rigorous reporting needed

## Recommendations

- Improving classroom listening conditions (e.g., classroom management techniques, noise insulation, and voice amplification for teachers)
- Investigating combined effects and potential interactions of noise and speaker's impaired voice
- Enhancing 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] Moher D, et al. (2009). *PLOS Med* 6(7). [6] NIH National Heart, Lung and Blood Institute. (retrieved 12 Jan 2022). From www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools.