DIGITALLY RECORDED LUNG SOUNDS IN CASES AND CONTROLS COMPARED TO STANDARD LUNG AUSCULTATION IN THE PNEUMONIA ETIOLOGY RESEARCH FOR CHILD HEALTH (PERCH) STUDY

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INTRODUCTION

Digitally recorded lung sounds may be useful for research and clinical care, but there is limited information on comparability to standard stethoscope auscultation in children. We compared digital and standard auscultation among children who were expected to have varying auscultatory findings, including pneumococcal-infected cases, respiratory syncytial virus (RSV) infected pneumonia cases, cases without abnormal radiographic findings, and controls. Describing similarities or differences informs the use and interpretation of digital auscultation findings (compared to standard auscultation) in research and clinical settings.

METHODS

In six African and Asian countries, clinicians documented standard auscultation findings using traditional stethoscopes in cases <5years hospitalized with WHO-defined severe or very severe pneumonia, and recorded sounds from pre-specified chest locations using commercial digital stethoscopes in a convenience subset of cases and age-matched community controls. Eight physicians blinded to case-control status classified filtered recordings using standardized criteria.

Comparisons between standard and digital auscultation were done among cases where standard and digital auscultations were performed within two hours of each other. Radiographic pneumonia cases (CXR+) were cases with consolidation and/or other infiltrate identified on chest x-ray.
- Pneumococcal cases were culture-positive in blood or lung specimens, lung PCR-positive, or C-reactive protein>=40mg/L and high pneumococcal DNA load in whole blood or nasopharyngeal/ oropharyngeal swab samples (NP/OP).
- RSV cases were PCR-positive for RSV A/B NP/OP swab.

Dichotomous classification agreement was measured between and within primary listeners using Cohen's kappa statistic.

RESULTS

Compared to eligible digital auscultation non-participants, participants were older, more likely to be from Asian sites and have malaria parasitemia, less likely to have >2 PCV doses, and less likely to be hypoxemic (table1).

Of 384 cases with recordings taken within two hours of standard auscultation, 261 (68%) had crackles, wheeze, or both compared to 43/284 (15.1%) controls (p<0.001); 90/136 (66%) CXR+ cases had abnormal lung sounds.

Kappa agreement between standard and digital auscultation findings taken within two hours of each other were moderate for normal auscultation findings, and fair for specific categories of abnormal lung sounds (table 2).

Crackles were identified more frequently in standard vs. digital auscultation, and was the most common finding in all case stratifications, ranging from 90% in pneumococcal pneumonia cases to 69% in cases with normal CXRs (figure 1).

Wheeze was common in both standard and digital auscultation among RSV-infected cases, and tended to be lower in pneumococcal pneumonia cases (among whom 75% also had a virus detected by NP/OP PCR).

CONCLUSIONS

The digital auscultation process produced similar trends compared to standard auscultation conclusions, but tended to have a higher proportion of normal conclusions and a lower proportion of crackles.

The digital auscultation process differentiated between cases and controls, suggesting that false abnormal findings are unlikely.

Within case groups, wheeze was detected in a similar proportion of standard and digital auscultation findings.

The high frequency of crackles detected by standard auscultation may suggest higher sensitivity for detection of crackles compared to digital auscultation; however, the high frequency in both RSV-infected cases and normal CXR cases may also indicate bias towards crackles in unblinded standard auscultation.

Other reasons for differences between standard and digital auscultation may include intrinsically different sound profiles, and the time lag between standard and digital auscultation that may have been confounded by treatments such as antibiotics, bronchodilators, or breath pattern variation between examinations including differing tidal volumes and patient state (agitated or calm).
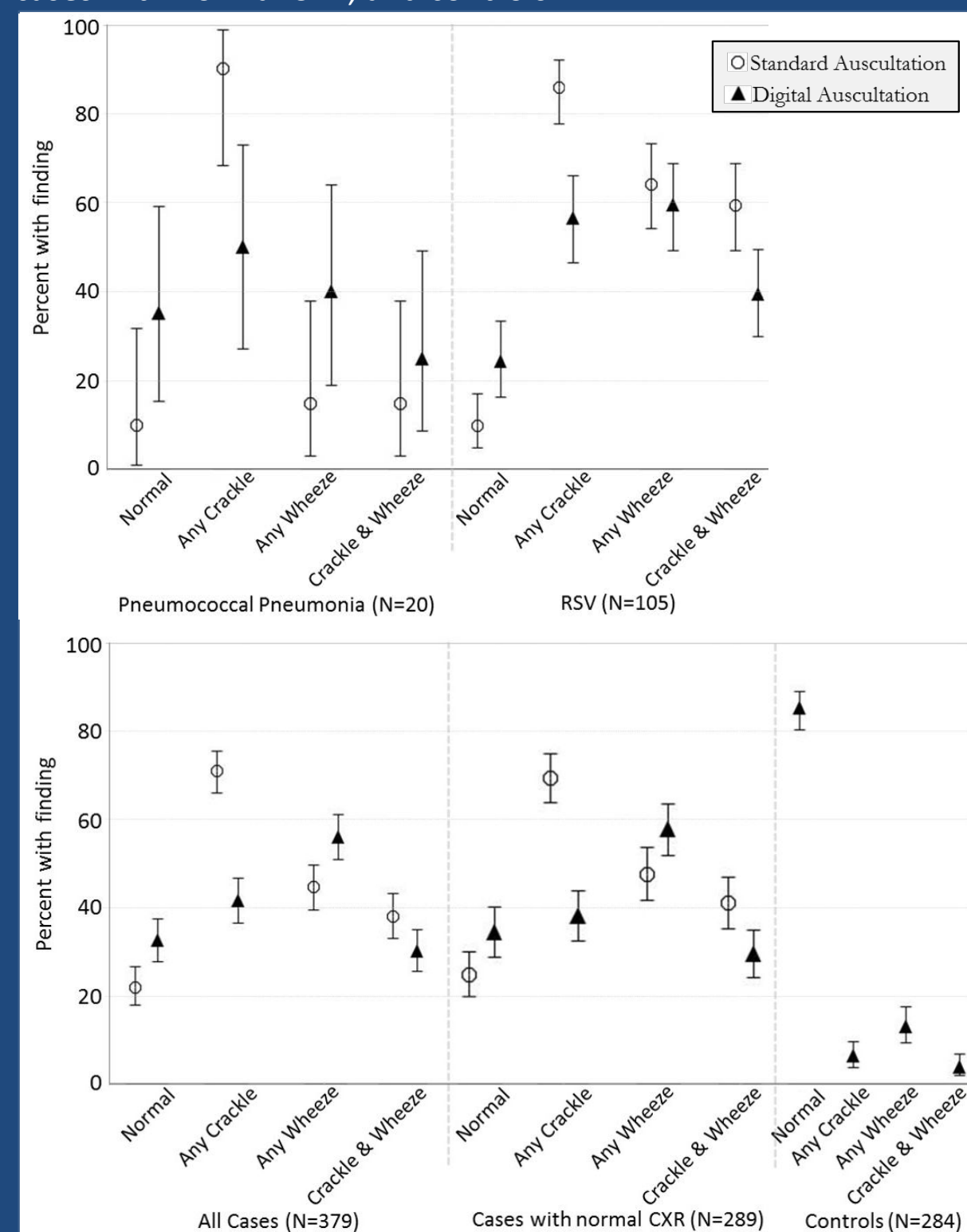
TABLE 1. Comparison of PERCH digital auscultation case eligible participants vs nonparticipants aged 2-59 months

Characteristic	Cases			Controls		
	Participants N=788 N (%)	Nonparticipants N=572 N (%)	Chi-Sq P-value	Participants N=301 N (%)	Nonparticipants N=1416 N (%)	Chi-Sq P-value
Females	341 (43.3)	233 (40.7)	0.349	140 (46.5)	684 (48.3)	0.564
Age, month (median)	7	6				
0-5m	335 (42.5)	272 (47.6)		73 (24.3)	450 (31.8)	
6-11m	185 (23.5)	151 (26.4)	0.007	70 (23.3)	350 (24.7)	0.0209
12-23m	165 (20.9)	103 (18.0)		83 (27.6)	341 (24.1)	
24-59m	103 (13.1)	46 (8.0)		75 (24.9)	275 (19.4)	
Region						
Africa	576 (73.1)	568 (99.3)	<0.001	103 (34.2)	1213 (85.7)	<0.001
Asia	212 (26.9)	4 (0.7)		198 (65.8)	203 (14.3)	
≥2 doses PCV	202 (40.8)	291 (56.8)	<0.001	47 (17.6)	729 (66.1)	<0.001
HIV-infection	59 (7.5)	36 (6.3)	0.394	2 (0.7)	74 (5.2)	0.001
Severe malnutrition	174 (23.6)	117 (22.3)	0.600	21 (7.0)	126 (9.1)	0.241
Malaria parasitemia	17 (2.2)	2 (0.4)	0.005	1 (0.3)	11 (0.8)	0.389
Very sev. pneumonia	264 (33.5)	181 (31.6)	0.471	-	-	-
Bacteremia	24 (3.2)	16 (2.8)	0.713	-	-	-
Hypoxemia	267 (34.0)	286 (50.3)	<0.001	-	-	-

TABLE 2. Comparison of acoustic and digital lung stethoscope sounds taken within two hours of each other, CXR+ cases (N=136)

Patient sound classification	Standard auscultation	Digital auscultation	Conclusion on both standard and digital, N	P-value	Kappa
Normal	34 (25.0%)	46 (33.8%)	25	0.029	0.474
Abnormal	102 (75.0%)	90 (66.2%)	81		
Crackles, any	96 (70.6%)	67 (49.3%)	59	<0.001	0.342
Wheeze, any	49 (35.8%)	69 (50.4%)	34	0.005	0.272
Crackle & Wheeze	43 (31.4%)	45 (32.9%)	21	0.768	0.230

FIGURE 1. Standard and digital auscultation findings for pneumococcal pneumonia cases, RSV pneumonia cases, all cases, cases with normal CXR, and controls