Selecting a reference standard for evaluating respiratory rate devices to detect symptoms of pneumonia in children under five: Lessons from resource-poor settings in sub-Saharan Africa and Asia

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Key messages
- We recommend that video panel review remains as the best practice reference standard for evaluating respiratory rate (RR) devices.
- Further studies should aim to reduce human counting error in the video panel, for example by assisting counters with video annotation software.

Methods
- Four RR devices were tested by community health workers (CHWs) on children 0-59 months across four countries in sub-Saharan Africa and Southeast Asia.
- Three reference standards were used: 1) simultaneous video recording of child’s chest movements with independent RR assessment by a three-person expert panel; 2) contemporaneous expert clinician (EC) counting RR with a manual stopwatch; and 3) simultaneous continuous RR with a Masimo capnography CO2 module on a patient monitor.
- Agreement was calculated using the proportion of observations that were ±2 and ±5 breaths per minute (bpm). Bland-Altman plots with limits of agreement (LOA) were used for analysis of agreement between methods.

Results
- A total 120 of 146 videos (82%) were readable, of which 97 (81%) had video expert panel agreement between any two of three panel members. Of 97 video panel rates, corresponding comparator information could be analysed for 90 (93%). For the continuous monitor, 20 comparisons were excluded due to connection failures. For the EC, nine comparisons were excluded due to failure to get a reading.
- Agreement ±2 bpm between references is lowest for the continuous monitor versus EC (29%). Agreement ±2 bpm with the video panel is higher at ~40% for both comparators. Agreement ±5 bpm is similar between all references (55-59%) (Table 1).
- Agreement between reference standards tends to decrease as average RR between reference standards increases (Figures 1, 2 and 3). On average, continuous monitor RR were lower than the video panel rate and EC rate (mean difference -3.6 bpm and -3.1 bpm, respectively) (Figures 1 and 3).

Conclusion
Agreement between all reference standards was low. Continuous monitor RR readings are consistently lower in comparison to EC and video panel RR readings.

Table 1: Agreement between reference standards

<table>
<thead>
<tr>
<th>Level of agreement</th>
<th>Continuous monitor versus video panel (n=77)</th>
<th>EC versus video panel (n=88)</th>
<th>Continuous monitor versus EC (n=75)</th>
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</thead>
<tbody>
<tr>
<td>±2 bpm</td>
<td>N: 31 (40.3%)</td>
<td>N: 34 (38.6%)</td>
<td>N: 22 (29.3%)</td>
</tr>
<tr>
<td>±5 bpm</td>
<td>N: 45 (58.4%)</td>
<td>N: 48 (54.6%)</td>
<td>N: 42 (56.0%)</td>
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</table>

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