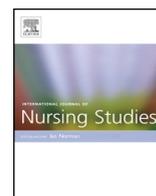




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## Letters

## Efficiency of respiratory rate measurements: Comment on Black et al., 2015: “Can simple mobile phone applications provide reliable counts of respiratory rates in sick infants and children? An initial evaluation of three new applications”

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The article by Black et al. (2015) discusses the accuracy of three new methods to estimate respiratory rate that are based on the registration of a fixed number of breaths with a mobile phone. The technology was designed to replace the WHO/UNICEF recommended approach of counting breaths over a full minute (World Health Organisation (WHO), 2008). Black et al. have shown that the 95% limits of agreement are relatively poor across all methods, including the WHO/UNICEF one minute count. This is in agreement with other research and illustrates the fact that an objective observation of respiratory rate is difficult and observer agreement is poor (Bianchi et al., 2013; Lovett et al., 2005).

It is our contention that the duration of a measurement (efficiency) is as important as accuracy when assessing the usefulness of a respiratory rate estimation method. As observed in Black et al. (2015), a longer observation period will result in improved accuracy. This is mainly due to increased dilution of error, but it comes at the cost of reduced usability. In practice, manual breath counting is frequently shortened to a subset of 60 s and then multiplied to obtain an estimate over a full minute. This practice increases the risk that the error is amplified, especially when a mistake occurs at the start of the

counting interval. The calculation of the median instead of the mean eliminates these outliers. We have previously described a respiratory rate measurement approach that calculates the median breath interval from a fixed number of breaths ( $N$ ) and analyzes this set of breath intervals for consistency (maximal deviation of each breath from the median breath interval) (Karlen et al., 2014). When the consistency is exceeding a fixed threshold ( $Th_c$ ), further breath intervals are collected to remove the inconsistent breaths from the calculation.

To complement the accuracy analysis presented in Black et al. (2015) with a description of the effects on efficiency, we compared the proposed algorithms OPB10-Count (fixed recording of 10 breath intervals), OPB20Count (fixed recording of 20 breath intervals) and OPB60Count (recording of breaths intervals for 60 s) to the efficiency of the approach presented in Karlen et al. (2014) with the settings  $Th_c = 13\%$  and  $N = 4$  breaths using our previously published and publicly available data set (<http://www.phoneoximeter.org/projects/rtrate/>). The data contains recordings of breath intervals obtained from 22 observers of 10 standardized, 60 s duration videos with children breathing at 17 to 59 breaths/min. The analyzed data set contains 218 observations (2 cases where the 60 s observation time was not completed have been excluded).

As expected, limiting the number of breaths in the calculation improved efficiency of the respiratory rate

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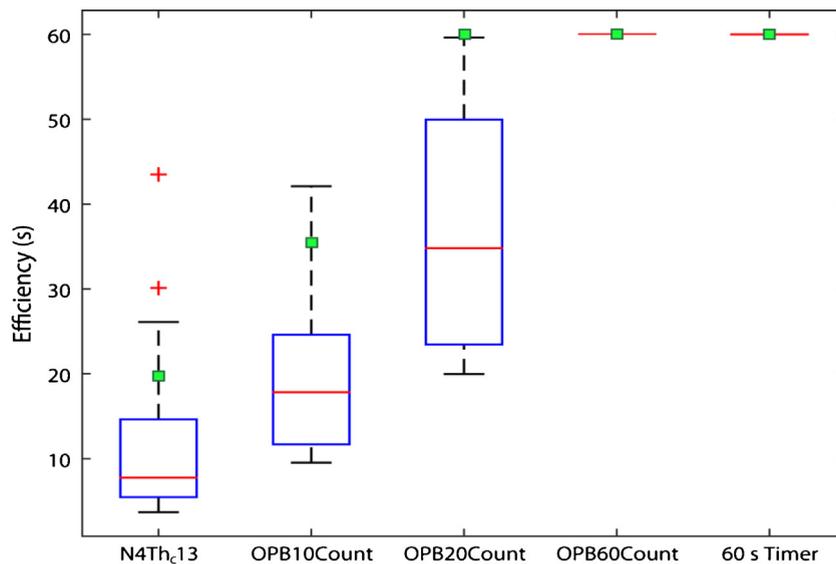


Fig. 1. Distribution of efficiency for various respiratory rate measurement methods developed in Black et al. (2015) and Karlen et al. (2014). The red horizontal lines of the boxplots depict the median and the blue boxes are the lower and upper quartile range. The whiskers represent the most extreme values within 1.5 times of the interquartile range from the quartile. The outliers (crosses) are values beyond this interquartile range. The green squares depict the 95% percentile. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

measurement (Fig. 1). Using 10 breaths resulted in 95% of recordings having a duration below 35.5 s. Using the first consecutive 4 consistent breaths reduced this duration to 19.6 s. The reduction in duration can typically be achieved without a significant reduction in accuracy. This is compared to the OPB20Count, OPB60Count and the 60 s timer that had a 95% percentile efficiency of 60 s.

As saving time is essential in a busy clinical setting, the measurement of efficiency should be an integral part in the evaluation of respiratory rate assessment techniques.

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