Analysis of the Predictive Potential of Pulse Oximeter Data for Admission

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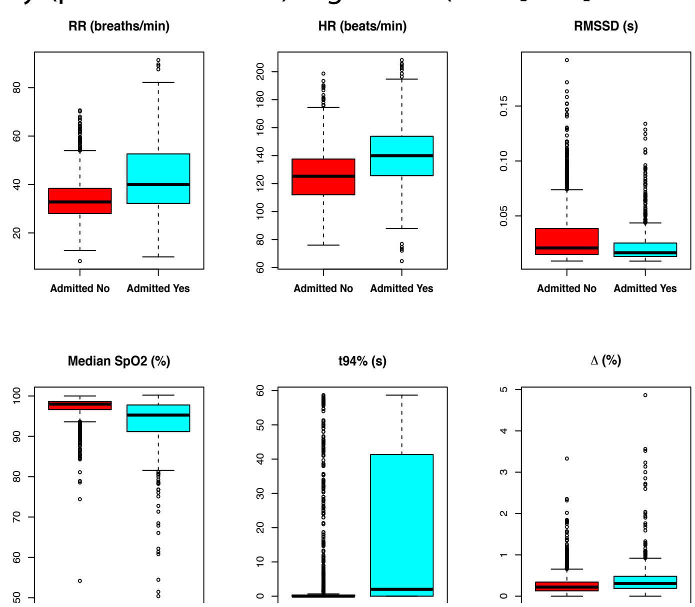
Introduction: Annually, more than 13 million children die from sepsis caused by conditions such as pneumonia and diarrhea due to a lack of resources and clinical expertise [1]. An objective test for which children should be referred to a facility would help community healthcare workers to best utilize resources. Mobile phones are now widely used even in low resource settings and provide an ideal platform for both vital signs assessment and automatic diagnosis. The first step is to identify differences in objective measures between children who need to be admitted and those who can return home.

Methods: Using the Phone Oximeter, a mobile device integrating a pulse oximeter with a phone, we have designed a mobile data collection application, called PhoneOxR2, that includes measurement of oxygen saturation (SpO_2), heart rate (HR) [2] and a respiratory rate (RR) count by tapping the screen [3]. PhoneOxR2 also provides a waveform that reflects blood volume changes, the photoplethysmogram (PPG), which permits the estimation of HR variability (HRV) [4]. Using PhoneOxR2 on iPod touch devices (Apple Inc, Cuppertino, USA), 1-min PPG, SpO_2 and HR were collected along with RR from a total of 3374 children presenting at a not for profit private tertiary level hospital in Bangladesh from October 2012 to April 2013. Children were excluded if they had a known chronic disease, previously documented low SpO_2, or other conditions such as cardiac disease. Additionally, the analysis was limited to children who presented at least 30 seconds of good quality pulse oximetry, which excluded 1323 children from the analysis. Therefore, the SpO_2, HRV, RR and HR were studied for 2051 children. The SpO_2 was characterized through its median, cumulative time spent below 94% (t94%) and variability measure computed in 12-s intervals (Δ index). HRV was estimated through the standard deviation of pulse peak (PP) intervals of the PPG (SDNN) and the root mean square of the successive differences between adjacent PP intervals (RMSSD). Median and interquartile ranges were used (median [IQR]) to summarize data and the Mann–Whitney U test was used to derive confidence intervals for median differences (CI) and associated p-values. Bonferroni correction was used to adjust for multiple (n=7) comparisons.

Results: Children admitted to the facility had significantly (p-value < 0.05/n) higher RR (40.0 [20.4] versus 32.8 [10.4], CI 5.9 to 9.1 breaths/min), higher HR (140.0 [28.1] versus 125.2 [25.5], CI 11.4 to 17.6 beats/min) and lower SDNN (0.016 [0.014] versus 0.022 [0.023], CI -0.006 to -0.003 s) and RMSSD (0.016 [0.012] versus 0.021 [0.024], CI -0.004 to -0.002 s), compared to children not admitted to the facility. Admitted children also showed lower SpO_2 (95.3 [6.6] versus 98.0 [2.0], CI -2.8 to -1.7 %), and higher SpO_2 variability t94% (2.0



[41.3] versus 0.0 [0.3], CI 0.33 to 2.33 s) and Δ (0.308 [0.291] versus 0.220 [0.210], CI 0.061 to 0.115 %).

Conclusion: The difference in these objective measures between children admitted and those not admitted indicates that an objective, automated stay-or-go test is feasible. Further analysis is being done to create a predictive model combining these objective measures. This predictive model will generate a risk score for the probability of the need for the child to be admitted to a facility. If this score is above a specific threshold, it will be recommended that the child be referred for admission. We will provide community healthcare workers with real-time tools for making objective measurements to provide a rapid prediction that a child would require admission to a facility. These tools will provide the smart application greatly needed in low resource settings where expertise is lacking to manage life-threatening infections.

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[3] Karlen, W., Gan, H., et al., "Improving the Accuracy and Efficiency of Respiratory Rate Measurements in Children using Mobile Devices", *PLOS ONE*, 9(6): e99266.

[4] Dehkordi, P., et al., "Pulse Rate Variability Compared with Heart Rate Variability in Children with and without Sleep Disordered Breathing", *35th Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBS)*, Jul 3-7, 2013, p. 6563-6566.