Variability and day-to-night differences in continuously measured vital signs in hospital at home, and their implication for alarm settings.

Authors.

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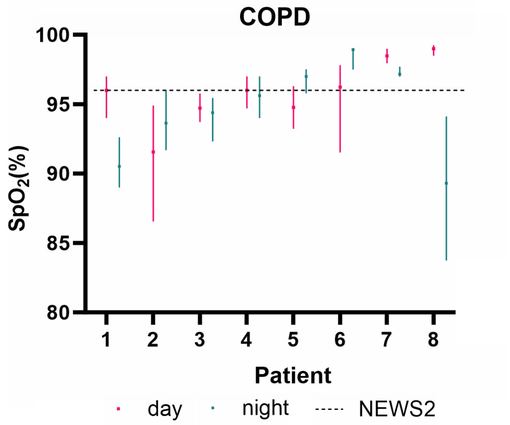
Background.

Remote patient monitoring must account for physiological variability, both within and between patients, resulting from activities of daily living, primarily movement (daytime) and postural change (overnight). Hospital alarm thresholds (e.g., NEWS2) may not be appropriate for hospital at home (HAH). We investigated variability in continuous vital signs in HAH and the merits of different alarm thresholds for day and night.

Method.

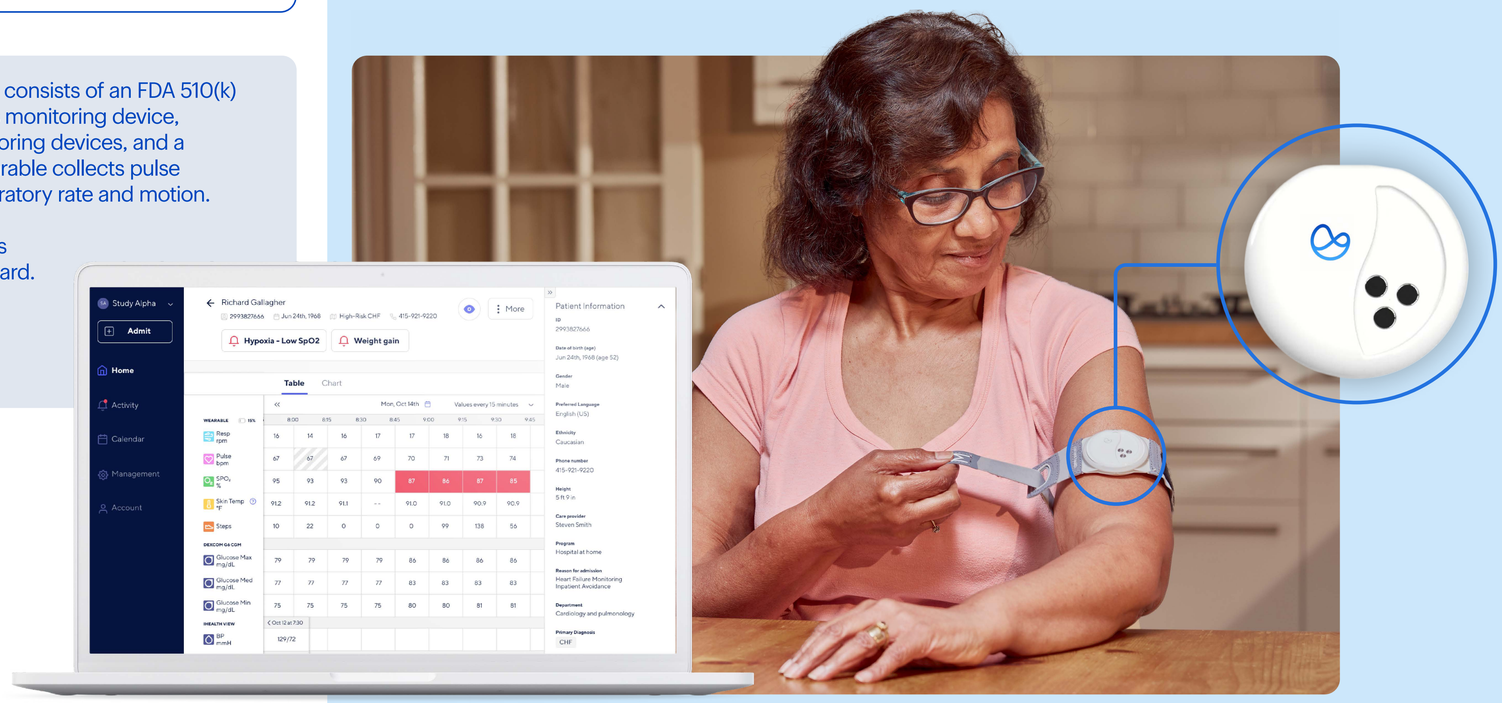
We continuously recorded vital signs in US HAH patients with acute/post-acute COPD and CHF. Pulse rate (PR) and oxygen saturation (SpO_2) of 150 COPD and 145 CHF patients (monitored for > 1 day with wearable adherence ≥ 60%) were summarized by day (1000-2000) and night (0000-0600). We calculated statistical significance (Wilcoxon Signed Rank, $p < 0.05$ post-Bonferroni) and those for whom the NEWS2 alarm threshold (SpO_2 < 96% or PR >90 bpm) was within their vital signs' interquartile ranges (Figure 1).

Figure 1. (See right)
Example SpO_2 interquartile ranges for 8 patients and the NEWS2 alarm threshold (96%). When the NEWS2 alarm threshold intersects a patient's SpO_2 interquartile range, that patient is counted in the 'alarm trigger' group.



The **Current Health** platform consists of an FDA 510(k) cleared wearable continuous monitoring device, peripheral intermittent monitoring devices, and a clinician dashboard. The wearable collects pulse rate, oxygen saturation, respiratory rate and motion.

Deviation in these parameters trigger alarms on the dashboard.



Results.

Table 1: Median (IQR) vital signs during the day and night in COPD and CHF.

	COPD		CHF	
Median (IQR)	**Day**	**Night**	**Day**	**Night**
Pulse Rate (bpm)	77.2 (69.1 - 86.0)*	70.1 (63.8 - 77.3)*	71.1 (65.6 - 79.7)**	70 (64.1 - 77.6)**
SpO_2 (%)	94.8 (93.2 - 96.2)	95 (93.4 - 96.6)	95 (92.7 - 96.1)***	94.3 (92 - 96)***

Statistically significant difference between day vs. night for:
* PR in COPD, ** PR in CHF, *** SpO_2 in COPD.

There were significant differences between day and night PR in COPD (-6.2 (-10.9 to -1.6) bpm, $p < 0.001$) and CHF (-1.5 (-4.4 to 0.5) bpm, $p < 0.001$). SpO_2 values were significantly different in CHF (-0.4 (-1.9 to 1)%, $p = 0.004$) but not in COPD (0.2 (-0.8 to 1.3)%, $p = 0.61$).

Applying NEWS2 escalation criteria would trigger SpO_2 alarms in 90% (COPD) and 92% (CHF) patients in daytime and 84% (COPD) and 90% (CHF) overnight.

It would lead to PR alarms in 16% (CHF) and 29% (COPD) patients in daytime and 9% (CHF) and 12% (COPD) of patients overnight.

Conclusion.

Though statistically significant, differences between day/night values were not clinically significant. The added complexity of day/night alarms outweighed potential benefits. However, "normal" hospital thresholds for SpO_2 should be lower in HAH (e.g., 90%) to balance sensitivity and specificity, optimising clinical risk.

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