Title
Roadmap for improving the accuracy of respiratory rate measurements

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We thank Dr Wong for his detailed description of the importance of respiratory rate (RR) and his astute reflections on the interactions between predictable human errors and the systems in which humans work. We agree that RR is prone to error because of the human element. However, what is unique to healthcare compared with aviation is not that human error exists, but that tolerance for these errors has become an accepted part of everyday practice.[1] We hypothesise that RRs can be measured both accurately and efficiently, but this requires institutional culture change starting with improvements in staff education, expectations and accountability, which can be accomplished through a quality improvement (QI) initiative. We have initiated this process at our own institution.

To guide our local ongoing QI initiative, we mapped the workflows for routine RR measurements by patient care assistants (PCA) through direct observation in a single inpatient unit of our large, urban safety-net hospital. Our prospective observations reaffirmed our previous study findings: RR measurements were frequently recorded inaccurately.[2] We also compared PCA-measured RR with a 'gold-standard' RR as measured by trained study team members (NK, KB). The median gold-standard RR was 16 (IQR 12–18) vs 18 (IQR 18–20) for PCAs, with a mean difference of 4.4 breaths per minute ($P<0.01$). Only 36% of PCA-measured RRs were 'accurate', defined as being ±2 breaths per minute of the gold-standard RR.

From direct observation and interviews with PCAs, we identified two key logistical barriers to accurate RR measurement: lack of a time-keeping device and a perceived lack of time to measure RR, consistent with findings from prior studies.[3] To address these barriers, our intervention (1) adds a time-keeping device to automated sphygmomanometer carts; and (2) modifies the existing PCA vital signs measurement workflow to call for assessment of the RR (30 s) during time previously spent waiting for the automated blood pressure measurement (approximately 45 s), a time-neutral workflow modification (figure 1). In a feasibility trial, two PCAs tested the revised workflow and noted that the new workflow was 'practical' and 'time-effective'. We plan to conduct further evaluation to assess whether the revised vital sign process is truly time-neutral.

In addition to workflow modification, instilling institutional culture change and accountability for accurate RR measurement will be paramount for enduring success of our intervention. To this end, we engaged key stakeholders including nursing operations management, nursing education leadership and hospital administration to lead ongoing development of several additional concurrent intervention components, including (1) implementing new vital skills labs during new PCA orientation training, emphasising the importance of accuracy in all measurements; (2) retraining existing PCAs on RR measurement during monthly unit staff meetings and daily PCA huddles; (3) implementing regular vital sign measurement audits; and (4) designating PCA 'Vital Sign Champions' to be local unit champions for cooperation, accomplishment and excellence in vital sign measurement.[4] Through continuous QI and ongoing collaboration, we hope to create a lasting culture change to overcome our collective long-standing complacency for human error in RR measurement, to ultimately improve patient outcomes.

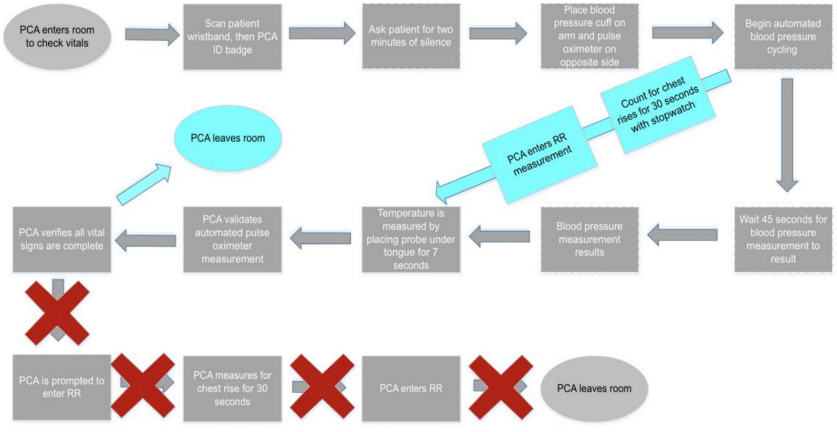

Figure 1 Patient care assistant (PCA) vital signs measurement workflow map. Light grey illustrates the existing workflow for measuring patient vital signs. Our proposed modifications call for PCAs to measure and record the respiratory rate (RR) while the automated sphygmomanometer is cycling (light blue) instead of waiting to measure RR after all other vital signs are completed (red X marks), resulting in a time-neutral modification.

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