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Can simple mobile phone applications provide reliable counts of respiratory rates in sick infants and children? An initial evaluation of three new applications

James Black [a,*], Marie Gerdtz [b,c], Pat Nicholson [b], Dianne Crellin [b,d,e], Laura Browning [f], Julie Simpson [g], Lauren Bell [a], Nick Santamaria [b,c]

[a] Nossal Institute for Global Health, Melbourne School of Population and Global Health, The University of Melbourne, Australia
[b] Department of Nursing, The University of Melbourne, Australia
[c] Melbourne Health, Australia
[d] Royal Children's Hospital, Melbourne, Australia
[e] Murdoch Children's Research Institute, Melbourne, Australia
[f] Department of Physiotherapy, The University of Melbourne, Australia
[g] Melbourne School of Population and Global Health, The University of Melbourne, Australia

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ABSTRACT

Background: Respiratory rate is an important sign that is commonly either not recorded or recorded incorrectly. Mobile phone ownership is increasing even in resource-poor settings. Phone applications may improve the accuracy and ease of counting of respiratory rates.

Objectives: The study assessed the reliability and initial users' impressions of four mobile phone respiratory timer approaches, compared to a 60-second count by the same participants.

Methods: Three mobile applications (applying four different counting approaches plus a standard 60-second count) were created using the Java Mobile Edition and tested on Nokia C1-01 phones. Apart from the 60-second timer application, the others included a counter based on the time for ten breaths, and three based on the time interval between breaths ('Once-per-Breath', in which the user presses for each breath and the application calculates the rate after 10 or 20 breaths, or after 60 s). Nursing and physiotherapy students used the applications to count respiratory rates in a set of brief video recordings of children with different respiratory illnesses. Limits of agreement (compared to the same participant's standard 60-second count), intra-class correlation coefficients and standard errors of measurement were calculated to compare the reliability of the four approaches, and a usability questionnaire was completed by the participants.

Results: There was considerable variation in the counts, with large components of the variation related to the participants and the videos, as well as the methods. None of the methods was entirely reliable, with no limits of agreement better than −10 to +9 breaths/min. Some of the methods were superior to the others, with ICCs from 0.24 to 0.92. By ICC the Once-per-Breath 60-second count and the Once-per-Breath 20-breath count were the most consistent, better even than the 60-second count by the participants. The 10-breath approaches performed least well. Users' initial impressions were positive, with little difference between the applications found.

* Corresponding author. Tel.: +61 383442179.
E-mail address: jim.black@unimelb.edu.au (J. Black).

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Conclusions: This study provides evidence that applications running on simple phones can be used to count respiratory rates in children. The Once-per-Breath methods are the most reliable, outperforming the 60-second count. For children with raised respiratory rates the 20-breath version of the Once-per-Breath method is faster, so it is a more suitable option where health workers are under time pressure.

What is already known about the topic?

- Respiratory rate, though important, is often not counted or counted incorrectly.
- Mobile phone ownership is increasing even among health workers in developing countries, where the greatest burden of childhood pneumonia is found.

What this paper adds

- Four new approaches to counting respiratory rates, plus a 60-second timer, were developed into Java applications for mobile phones for testing: The new approaches were three 'One-press-per-Breath' approaches for 10 breaths, 20 breaths and 60 s, and a simpler 10-breath counter.
- In the hands of senior nursing and physiotherapy students all the applications scored equally well on usability measures.
- The 20-breath and 60-second Once-per-Breath approaches were the most reliable, and between them the 20-breath counter allows for faster counting in children with fast breathing.

1. Introduction

Rapid respiratory rate is a well-established marker of critical illness in infants and children. Accurate counting of respiratory rate is a clinically important measure of respiratory function in children of all ages. Paediatric pneumonia is one of the most important causes of morbidity and mortality globally in children under the age of five. In the World Health Organization (WHO)/UNICEF programmes of Integrated Management of Childhood Illness (IMCI) and integrated Community Case Management (iCCM) fast breathing is the critical sign for the diagnosis of pneumonia (World Health Organization Department of Child and Adolescent Health and Development, 2005). iCCM is now recommended at community level in more than forty countries, but community health workers (CHWs) often have no clock or wrist-watch to use as a one-minute timer.

Current international guidelines such as IMCI recommend counting breaths for a full minute. UNICEF and WHO recommend that Community Health Workers use a specific one-minute timer, but such timers have some limitations, such as having batteries that cannot be replaced by the user or a potentially distracting ticking sound.

For several reasons counting the respiratory rate is difficult for health workers to do consistently and accurately – a point which has been observed for decades (Kory, 1957). In developing countries CHWs may be semi-innumerate, having difficulty counting beyond ten. Even in industrialised countries it is the least often recorded vital sign (Bianchi et al., 2013; Cheng et al., 2008; McGain et al., 2008). In our experience experienced health workers often cut corners when counting respiratory rates, such as by counting for 15 s and multiplying by four. We have known busy clinicians in developing country settings to see up to 100 patients in a single session. Adding 60 s to each consultation could easily add more than 90 min to a clinic, with negative implications for costs and efficiency.

In addition, the actual counting process is not highly accurate. In an early study used to determine the optimum period to count breaths, the limits of agreement between the observers' counts and an electronic counter (referred to as a 'pneumogram', although little detail is given) were noted to be very broad – of the order of −11 to +16 breaths/min. (Berman et al., 1991).

In recent years mobile phones have become almost ubiquitous, even in developing countries where access to other technologies is often limited. Mobile phone coverage is increasing rapidly and many health workers have mobile phones and carry them throughout the working day. Mid-range phones ('feature phones' with cameras) can generally run Java applications, so it has become feasible to propose the use of mobile phone applications as tools for the counting of respiratory rates in the clinical setting even in resource-poor settings. Smart phones (although not yet as widespread as feature phones, especially in Africa) could run even more complex applications. Smart phone applications similar to the Once-per-Breath application tested in this study are available on the Google Play and Apple App Store, but we are not aware of other applications for feature phones.

In this project we aimed to test whether any of four alternative mobile phone respiratory timer application approaches for feature phones could potentially replace the current standard one-minute timer approach among professional health workers. In particular we assessed intra-rater (test–retest) reliability and agreement of the methods when used by senior nursing and physiotherapy students to count respiratory rates in video recordings of children with different illnesses. In addition we assessed the participants' initial impressions of the applications.

The population of interest for this study was children under five with respiratory illnesses and the assessment of respiratory rate was performed by a population of clinical health workers (student nurses and physiotherapists).

2. Methods

The Human Research Ethics Committee of Melbourne Health approved the study as a quality assurance project (HREC number QA2011066). Participants provided written consent to take part in the study.