

## LETTERS

**Is it feasible to use indicators to collect data on asthma care performance in the primary care setting? A feasibility study****\*Teresa To<sup>a</sup>, Susan McLimont<sup>a</sup>, Corinne Daly<sup>a</sup>, Ginette Moores<sup>a</sup>, Andrea Gershon<sup>b</sup>, Diane Loughheed<sup>c</sup>**<sup>a</sup> Child Health Evaluative Sciences, The Hospital for Sick Children, Toronto, Ontario, Canada<sup>b</sup> The Institute for Clinical Evaluative Sciences, Toronto, Ontario, Canada<sup>c</sup> Department of Medicine, Queen's University, Kingston, Ontario, Canada

\*Correspondence: Dr Teresa To, Senior Scientist, Child Health Evaluative Sciences, The Hospital for Sick Children, 555 University Avenue, Toronto, ON M5G 1X8 Canada. Tel: +1 (416) 813-8498 Fax: +1 (416) 813-5979 E-mail: teresa.to@sickkids.ca

Received 26th May 2011; revised 15th June 2011;  
accepted 19th June 2011

© 2011 Primary Care Respiratory Society UK. All rights reserved

<http://dx.doi.org/10.4104/pcrj.2011.00081>

**Dear Sirs,**

Despite well-established management guidelines, variations in quality of asthma care exist and are common in primary care settings.<sup>1</sup> Community-based quality of care (or performance) indicators can help identify barriers to, and enablers of, the development, dissemination and uptake of clinical guidelines for disease management. Despite the development and application of evidence-based performance indicators in diseases such as diabetes and stroke,<sup>2,3</sup> the parallel in asthma is not well established. Klomp *et al.*<sup>4</sup> developed indicators to measure asthma control, but fell short in providing a dynamic measure of asthma quality of care. There still remains a lack of standard asthma-specific quality of care indicators that measure process and health outcomes as part of a broader, comprehensive asthma surveillance system. Previously, using a modified Delphi approach, we developed a set of 15 evidence-based asthma performance indicators (APIs).<sup>5</sup> The objective of this study was to test the feasibility of collecting patient data for these APIs as a means of measuring the quality of asthma care in primary care practice.

Five primary care sites across Ontario, Canada participated in the feasibility study. These sites were volunteers from an ongoing provincial Primary Care Asthma Program. To assess the utility of the APIs, we developed a data collection tool to aid primary health care (PHC) practitioners capture patient information. The tool, copyrighted as the Primary Care Asthma Performance Indicators Form "PC-API" (see Appendix, available online at [www.thepcrj.org](http://www.thepcrj.org)) detailed the 15 APIs into nine categories: pulmonary function tests (PFTs) – including spirometry, peak flow or methacholine challenge; medication use; asthma control; exacerbations; health care use; action plan; asthma education;

smoking cessation; and quality of life (QoL).

Participating sites were responsible for applying the PC-API Form to 10 randomly selected prospective patient visits and 10 randomly selected retrospective patients via chart abstraction. Patients with physician-diagnosed asthma were included. Those with co-morbidities (diabetes, cancer, COPD, arthritis, cardiovascular conditions) were excluded. Sites were provided with three options for submitting the PC-API Form: 1) hard copy paper; 2) electronically by email; or 3) web-based. The hard-copy paper form was completed manually by a PHC practitioner and submitted via postal service mail or fax. The electronic Adobe® PDF form was completed electronically and submitted as an encrypted attachment to an email or printed and then submitted via postal service mail or fax. The third option, used by most sites, was an electronic web-based form to be completed and submitted on-line to a secure web server housed at The Hospital for Sick Children in Toronto, Ontario, Canada. The pilot study spanned from June 1 until August 31, 2010 and collected API information for a total of 100 patients. Analyses were descriptive in nature, presented with overall means and proportions, and stratified by site, prospective and retrospective patient visits.

Overall, PHC practitioners reviewed the various versions of the PC-API Form as "feasible" and "practical to use". Our results (see Table) showed that the majority of patients' asthma diagnoses were confirmed by PFTs (76% and 74% in the prospective and retrospective study, respectively). However, use of PFTs for ongoing asthma monitoring in the previous 12 months was lower (66% in the prospective and 61% in the retrospective study). While significant variations across the sites were observed, ranging from 10% to 100%, the combined results can potentially be used as a "benchmark" for the respective indicator. Practices "performing" below the combined average may use it as a benchmark to improve delivery of care.

In general, patients in the prospective study showed a higher average number of inhaled corticosteroid prescriptions, lower average short-acting  $\beta_2$ -agonist (SABA) use, larger number of SABA-free days, and also a higher percentage of these patients had demonstrated their inhaler technique regularly compared to patients in the retrospective chart review. Forty-one percent of the prospective patients and 31% of the retrospective patients reported more than one asthma exacerbation in the previous 12

**Table 1. Means and variations of asthma performance indicators in prospective patients and retrospective chart abstraction patients**

| API category                  | Definition of Asthma Performance Indicator                                                                    | Patient visit n=50* | Range     | Chart Abstraction n=50* | Range     |
|-------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------|-----------|-------------------------|-----------|
| Pulmonary Function Test (PFT) | % patient's asthma <i>diagnosis</i> confirmed by PFTs (spirometry, peak flow or methacholine challenge)       | 76%                 | 40-100%   | 74%                     | 0-100%    |
|                               | % patients <i>monitored</i> with spirometry in last 12 months                                                 | 66%                 | 10-100%   | 61%                     | 50-90%    |
| Medication use                | % patients using <i>inhaled corticosteroids</i> (ICS)                                                         | 90%                 | 80-100%   | 82%                     | 40-100%   |
|                               | In last 12 months, average number of patient's self-reported ICS prescription filled                          | 4.4                 | 3.3-6.2   | 3.8                     | 1.3-5.1   |
|                               | In last 4 weeks, average number of patient's self-reported short-acting $\beta_2$ -agonist (2 puffs) per week | 3.6                 | 1.7-5.6   | 4.9                     | 2.5-7.0   |
|                               | In last 4 weeks, average number of patient's self-reported $\beta_2$ -agonist-free days                       | 21.9                | 19.1-25.6 | 18.7                    | 18.4-18.9 |
|                               | % patients have demonstrated their inhaler technique regularly                                                | 84%                 | 60-100%   | 68%                     | 10-100%   |
| Asthma control                | In last 6 months, % patient's asthma symptoms control were assessed                                           | 75%                 | 33-100%   | 56%                     | 0-90%     |
|                               | In last 4 weeks, % patient's asthma is well-controlled                                                        | 68%                 | 60-80%    | 61%                     | 40-83%    |
|                               | In last 4 weeks, average number of patient's self-reported days symptom-free                                  | 19.7                | 15.4-23.1 | 18.5                    | 18.3-18.6 |
|                               | In last 12 months, average patient's self-reported days missed from school or work due to asthma              | 1.1                 | 0-12      | 0.8                     | 0-10      |
| Exacerbations                 | In last 12 months, % patients with more than 1 asthma exacerbation                                            | 41%                 | 0-70%     | 31%                     | 0-70%     |
| Health care use               | In last 12 months, average number of <i>ED visits</i> for asthma                                              | 0.4                 | 0-12      | 0.1                     | 0.3       |
|                               | In last 12 months, average number of <i>urgent care visits</i> for asthma                                     | 0.1                 | 0-2       | 0.1                     | 0-5       |
|                               | In last 12 months, average number of <i>primary care visits</i> for asthma                                    | 2.5                 | 0-12      | 1.5                     | 0-4       |
|                               | % patients with a routine healthcare provider                                                                 | 100%                | 100%      | 100%                    | 100%      |
| Action plan                   | % patients received a written asthma action plan                                                              | 54%                 | 20-90%    | 54%                     | 10-70%    |
| Asthma education              | % patients referred to see a certified asthma educator                                                        | 98%                 | 90-100%   | 94%                     | 70-100%   |
| Smoking cessation             | % patients who smoke                                                                                          | 12%                 | 0-20%     | 17%                     | 0-30%     |
|                               | % smokers who have received advice to stop smoking                                                            | 50%                 | 0-100%    | 100%                    | 100%      |
| Quality of life               | Average patient's assessment of quality of life 1=excellent, 2=very good, 3=good, 4=fair, 5=poor              | 1.8                 | 1.6-2.1   | 2.4                     | 2.4       |

months. A total of 19 emergency department, 3 urgent care and 124 primary care visits for asthma were reported among the prospective patients. Slightly higher numbers were reported from the retrospective review. About 12% of the prospective patients and 10% of the retrospective patients were smokers, and the majority (75%) received advice to stop smoking. A 5-point scale was used to measure QoL in the prospective patients, indicating an average score of 1.8 across sites (suggesting very good to excellent QoL).

We have demonstrated that implementation of the 15 evidence-based APIs in community-based primary care practices is feasible. The collected data can help establish benchmarks for optimal health service delivery and identify areas for improvement in asthma care. Future direction includes the validation of the PC-API Form across various populations, which will collect both provider- and population-level data to establish benchmarks for optimal asthma care in primary healthcare settings.

### Conflicts of interest

The authors declare that they have no conflicts of interest in relation to this article.

### Contributorship

Teresa To was responsible for the concept and design, interpretation of data, drafting and revising the manuscript. Teresa To and Corinne Daly participated in the interpretation of data, analysis and drafting the manuscript; Ginette Moores participated in the interpretation of data; and Susan McLimont, Andrea Gershon

and Diane Loughheed assisted with revising the manuscript. All authors have approved the manuscript as submitted and take full responsibility for the manuscript.

### Funding

This study was funded by the Canadian Institutes of Health Research [PHE – 85212]; the Government of Ontario; and the Public Health Agency of Canada. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by the Canadian Institutes of Health Research and Government of Ontario is intended or should be inferred. The views expressed herein do not necessarily represent the official policy of the Public Health Agency of Canada.

### References

- Katz A, Soodeen R, Bogdanovic B, De Coster C, Chateau D. Can the quality of care in family practice be measured using administrative data? *Health Serv Res* 2006;**41**(6):2238-54. <http://dx.doi.org/10.1111/j.1475-6773.2006.00589.x>
- Ontario Health Quality Council. 2008 Report on Ontario's Health System. Toronto (ON); 2008 Contract No.: Document Number].
- Lewis M, Trypuc J, Lindsay P, O'Callaghan C, A. D. Has Ontario's Stroke System really made a difference? *Healthc Q* 2006;**9**(4):50-9.
- Klomp H, Lawson JA, Cockcroft DW, et al. Examining asthma quality of care using a population-based approach. *CMAJ* 2008;**178**(8):1013-21. <http://dx.doi.org/10.1503/cmaj.070426>
- To T, Guttman A, Loughheed MD, et al. Evidence-based performance indicators of primary care for asthma: a modified RAND Appropriateness Method. *Int J Qual Health Care* 2010;**22**(6):476-85. <http://dx.doi.org/10.1093/intqhc/mzq061>

See online Appendix 1 at [www.thepcrj.org](http://www.thepcrj.org) for online-only supplement

## Lung function changes in non-asthmatic allergic rhinitis patients: a case series

\*Yousser Mohammad<sup>a,b</sup>, Rafea Shaaban<sup>c</sup>, Moustafa Ibrahim<sup>d</sup>, Moussa Ismail<sup>e</sup>

<sup>a</sup> Department of Internal Medicine, Tishreen University, Lattakia, Syrian Arab Republic

<sup>b</sup> Department of Internal Medicine, Al-Assad Hospital, Lattakia, Syrian Arab Republic

<sup>c</sup> Department of Public Health, Tishreen University, Lattakia, Syrian Arab Republic

<sup>d</sup> Department of ENT, Tishreen University, Lattakia, Syrian Arab Republic

<sup>e</sup> Department of General Medicine, Tishreen University, Lattakia, Syrian Arab Republic

\*Correspondence: Professor Yousser Mohammad, Department of Internal Medicine, Tishreen University, Faculty of Medicine POB 1479, Lattakia 052, Syrian Arab Republic

Tel: +963933755240 E-mail: yousser.mohammad@yahoo.com

Received 16th May 2011; revised 9th August 2011;

accepted 16th August 2011

© 2011 Primary Care Respiratory Society UK. All rights reserved

<http://dx.doi.org/10.4104/pcrj.2011.00089>

### Dear Sirs,

Is allergic rhinitis (AR) a marker for subclinical asthma or a predictor for the future development of asthma? Firstly, there is evidence that the lower airways of patients with AR show evidence of inflammation.<sup>1</sup> Secondly, pulmonary function tests in AR patients with no symptoms suggestive of asthma have shown alterations in forced expiratory volume in one second (FEV<sub>1</sub>), forced vital capacity (FVC), FEV<sub>1</sub>/FVC ratio, and forced expiratory flow between 25-75% of forced vital capacity (FEF<sub>25-75</sub>).<sup>1,2</sup> Both FEV<sub>1</sub> and FVC are normally associated with overt airway obstruction, whereas FEF<sub>25-75</sub> is reduced in patients with small airways inflammation, may be altered before FEV<sub>1</sub>, and is considered a predictor of airway obstruction.<sup>3,4</sup> We wanted to track the profile of airway obstruction in a case series of non-asthmatic AR patients presenting to a general medicine practice in a developing country, aiming to investigate the role and limits of spirometry at the primary care level.

We therefore conducted a prospective cross sectional observational study and investigated the lung function of all AR patients who presented consecutively to the General Medicine outpatient clinic of the University Hospital in Lattakia, Syria, between October 1st 2008 and August 1st 2009. The main inclusion criterion was a clinical diagnosis of AR as noted in the patient's medical record. Exclusion criteria included a past history of asthma and bronchitis, a history of current or previous smoking, immunotherapy, anatomic nasal abnormalities, and AR treatment in the last four weeks. We obtained ethics approval from the hospital Ethics Board and obtained signed informed consent from every participant.

The diagnosis of AR was confirmed by clinical history and positive skin prick tests. Patients were classified into intermittent or persistent rhinitis, and stratified into mild, moderate or severe categories. Treatment was administered according to the ARIA-WHO report of 2008.<sup>1</sup> The treatment protocol included two nasal inhalations of 50 µg beclometasone twice-daily.<sup>1</sup>

Patients had pulmonary function tests conducted upon

enrolment and after two weeks of therapy. Pulmonary function tests were interpreted using European Respiratory Society guidelines.<sup>3,4</sup> Specifically, a flow volume loop was performed at baseline for all included patients using Vmax Sensor Medics Body Box. FEV<sub>1</sub> and FVC were expressed as % predicted and were considered abnormal if < 80% predicted using ECSC reference equations.<sup>3</sup> FEF<sub>25-75</sub> was considered abnormal if less than 65% predicted,<sup>4,6</sup> especially if the shape of the expiratory curve was concave.<sup>3</sup> In patients showing a reduction in FEV<sub>1</sub>, FVC or FEF<sub>25-75</sub>, reversibility test (after inhalation of 200 µg of salbutamol via Aerochamber) was performed and was considered positive if FEV<sub>1</sub> improved by 12% and 200 ml or FEF<sub>25-75</sub> improved by > 30% of baseline values.<sup>3,4</sup> Flow volume loop was repeated after two weeks of treatment for patients who showed alteration of any spirometric value at baseline. Statistical analysis was carried out with Stata version 6. We considered p values <0.05 to be significant.

Sixty patients were enrolled, 34 women and 26 men; mean age was 28 ± 9 years. AR was intermittent in (23%), persistent in (77%), mild in (73%) and moderate/severe in (27%). Pulmonary function tests revealed that the mean FEV<sub>1</sub>% was 105 ± 17% of predicted, FVC was 114 ± 17% of predicted, and FEF<sub>25-75</sub> was 92 ± 25% of predicted. Four patients had FEV<sub>1</sub>% < 80% predicted, two patients had FVC < 80%, while 21 patients had FEF<sub>25-75</sub> below 65% predicted. FEV<sub>1</sub>% predicted was the highest in mild intermittent AR patients and the least in moderate to severe AR patients (120 ± 11% versus 89 ± 14%, p < 0.001). Similar findings were observed for FEF<sub>25-75</sub> (see Table 1). We did not find any functional abnormalities in intermittent AR.

FEV<sub>1</sub>% predicted and FEF<sub>25-75</sub>% predicted were inversely correlated with the degree of severity of AR. These associations were independent of potential confounding factors (age, gender, allergic rhinitis duration) as shown by multiple linear regressions (see Table 2). For the 21 patients who showed alteration of any spirometric value at baseline, reversibility testing was positive in all cases for both FEV<sub>1</sub> and FEF<sub>25-75</sub>. FEV<sub>1</sub> improved by 22 ± 11% (p < 0.001), FVC by 5 ± 9% (p = 0.03) and FEF<sub>25-75</sub> improved by 30 ± 11% (p < 0.001) after treatment.

In this study, we provide evidence that the presence of a reduced FEF<sub>25-75</sub> in patients with AR, even in the absence of a reduction in FEV<sub>1</sub> or FVC, may signify airway obstruction in these patients. Alteration in FEF<sub>25-75</sub> reflects inflammation of small airways less than 2mm diameter,<sup>3,4</sup> so FEF<sub>25-75</sub> may well be an early predictor of airway obstruction.<sup>2-7</sup> Using a definition of reduced FEF<sub>25-75</sub> as < 80% of predicted, Ciprandi found that 87% of patients with persistent moderate/severe AR had a reduction in

**Table 1. Characteristics of patients included in the analysis, according to the category of allergic rhinitis**

| Allergic Rhinitis             |                   |                                 |                 |                               |        |
|-------------------------------|-------------------|---------------------------------|-----------------|-------------------------------|--------|
|                               | Mild intermittent | Moderate to severe intermittent | Mild persistent | Moderate to severe persistent |        |
|                               | 11                | 3                               | 33              | 13                            | p      |
| Women, n (%)                  | 4 (36.4)          | 1 (33.3)                        | 19 (57.6)       | 10 (76.9)                     | 0.20   |
| Age, year, mean±SD            | 26.7±4.3          | 23.3±8                          | 28.7±9.9        | 26.5±7.7                      | 0.68   |
| AR duration, mean±SD          | 5.5±4.0           | 9±5.6                           | 4.7±4.1         | 3.7±2.6                       | 0.18   |
| FEV <sub>1</sub> % predicted, |                   |                                 |                 |                               |        |
| • mean±SD                     | 120±11            | 111±21                          | 105±15          | 89±14                         | <0.001 |
| • <80%, n (%)                 | 0                 | 0                               | 2(6.1)          | 2(15.6%)                      | 0.46   |
| FVC % predicted,              |                   |                                 |                 |                               |        |
| • mean±SD                     | 119±11            | 124±17                          | 110±16          | 116±23                        | 0.30   |
| • <80%, n (%)                 | 0                 | 0                               | 1(3)            | 1(7.7)                        | 0.74   |
| FEF 25-75%,                   |                   |                                 |                 |                               |        |
| • mean±SD                     | 114±17            | 102±21                          | 94±23           | 66±15                         | <0.001 |
| • < 65%, n (%)                | 0                 | 0                               | 9(27.3)         | 12(92.3)                      | <0.001 |

**Table 2. Relationship between allergic rhinitis respiratory function by multivariate<sup>†</sup> linear regression**

|                                    | Regression coefficient | 95% Confidence Interval | p value <sup>‡</sup> |
|------------------------------------|------------------------|-------------------------|----------------------|
| <b>FEV<sub>1</sub> % predicted</b> |                        |                         |                      |
| Allergic rhinitis, %               |                        |                         |                      |
| • Mild Intermittent                | 0                      | reference               |                      |
| • Moderate to severe intermittent  | -0.11                  | (-0.30, 0.08)           | 0.24                 |
| • Mild persistent                  | -0.12                  | (-0.23, -0.02)          | 0.02                 |
| • Moderate to severe persistent    | -0.28                  | (-0.40, -0.15)          | <0.001               |
| <b>FVC % predicted</b>             |                        |                         |                      |
| Allergic rhinitis, %               |                        |                         |                      |
| • Mild Intermittent                | 0                      | reference               |                      |
| • Moderate to severe intermittent  | 0                      | (-0.22, 0.22)           | 0.99                 |
| • Mild persistent                  | -0.08                  | (-0.20, 0.04)           | 0.20                 |
| • Moderate to severe persistent    | -0.03                  | (-0.17, 0.12)           | 0.70                 |
| <b>FEF (25-75%)</b>                |                        |                         |                      |
| Allergic rhinitis, %               |                        |                         |                      |
| • Mild Intermittent                | 0                      | reference               |                      |
| • Moderate to severe intermittent  | -0.14                  | (-0.40, 0.11)           | 0.24                 |
| • Mild persistent                  | -0.16                  | (-0.30, -0.02)          | 0.02                 |
| • Moderate to severe persistent    | -0.42                  | (-0.59, -0.25)          | <0.001               |

<sup>†</sup>Adjustment for sex, age and allergic rhinitis duration. <sup>‡</sup> for regression coefficient

FEF<sub>25-75</sub>.<sup>7</sup> We believe that using a definition of reduced FEF<sub>25-75</sub> as <65% is more clinically relevant and would result in better identification of the concomitant presence of airway obstruction in AR. The rationale for our cut-off value is that FEF<sub>25-75</sub> is a highly variable spirometric test and needs a very good technique and normal FVC.<sup>3-5</sup> McFadden comments on technical problems and the non-standardisation of normal value of FEF<sub>25-75</sub>,<sup>5</sup> referring to the NHLBI cut-off of 65%.<sup>6</sup>

Our data are consistent with published reports advocating the use of FEF<sub>25-75</sub> as a predictor of airway obstruction in selected patients.<sup>2-7</sup> In the medical literature, “positive reversibility test” refers to reversibility in FEV<sub>1</sub>. The reversibility of FEF<sub>25-75</sub> is difficult to interpret, but a cut-off of more than 30% improvement from baseline covers the normal over-time changes.<sup>4</sup> For example, air trapping in asthma patients in the presence of normal FEV<sub>1</sub> has been documented;<sup>6</sup> in these

patients, FEF<sub>25-75</sub> has been shown to be better correlated with air trapping than FEV<sub>1</sub>%, which explains the ability of FEF<sub>25-75</sub> to predict response to bronchodilator administration.<sup>6</sup>

Our results support the one airway/one disease hypothesis,<sup>1,2,8</sup> linking AR and asthma. This is plausible for several reasons. First, genetically, there are common atopic predispositions for AR and asthma. Second, AR and asthma share common pathological aspects; in biopsy studies, there was a high eosinophil count in AR even without asthma, with thickness of the bronchial reticular basement membrane in isolated AR. Third, from the pathogenesis point of view, the systemic release of IL-5 and the stimulation of bone marrow eosinopoiesis after allergen inhalation (challenge test) are important factors involved in the process of global airway allergy.<sup>8</sup>

One limitation of our study is the small numbers. We do not recommend spirometry testing for patients classified as intermittent allergic rhinitis. This could save time and money in primary care, but we do need a larger sample to confirm this finding.

Data from our study raise some additional questions that require further research. First, what is the appropriate cut-off for a clinically relevant reduction in FEF<sub>25-75</sub>? There is a need to reach consensus on interpretation of FEF<sub>25-75</sub>,<sup>3</sup> including technical recommendations, the normal cut-off normal values, the methods and reference for a positive reversibility test using FEF<sub>25-75</sub>, and consensus regarding its utility in practice and its significance as a risk factor for asthma in AR patients. Secondly, can early treatment of AR prevent the onset of asthma? Several pharmacological trials have shown that intranasal inhaled steroids improve asthma control. However, the role in preventing the allergic march from rhinitis to asthma has not been investigated.<sup>8</sup>

#### Acknowledgments

We are grateful to Prof. Mounir Osman, the director of the Lattakia hospital, and to Prof. Bassim Dubaybo from Wayne State University for his help in reviewing the manuscript before submission.

#### Conflicts of interest

The authors declare that they have no conflicts of interest in relation to this article.

#### Contributorship

Dr Yousser Mohammad participated in the study design, writing the manuscript and supervising. Dr Rafea Shaaban participated for the statistical analysis, and the writing of the manuscript. Dr Mustafa Ibrahim participated in the study design and nose examination. Moussa Ismail is a post graduate medical student, he did the data collection and performed plethysmography, and also participated in the drafting of the manuscript.

#### Funding

None.

#### References

1. Bousquet J, Khaltaev N, Cruz AA, et al. Allergic Rhinitis and its Impact on Asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA(2)LEN and AllerGen). *Allergy* 2008;**63**:Suppl86:8-160. <http://dx.doi.org/10.1111/j.1398-9995.2007.01620.x>
2. Cruz AA, Popov T, Pawankar R, et al. Common characteristics of upper and lower airways in rhinitis and asthma: ARIA update, in collaboration with GA (2)LEN. *Allergy* 2007;**62**:Suppl84:1-41. <http://dx.doi.org/10.1111/j.1398-9995.2007.01551.x>
3. Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung function tests. *Eur Respir J* 2005;**26**:948-68. <http://dx.doi.org/10.1183/09031936.05.00035205>
4. French Language Society of Pneumology. Recommendations pour le suivi médical des patients asthmatiques adultes et adolescents. *Rev Mal Respir* 2005;**22**:3587-3590
5. McFadden ER, Jr. Resurrection men and the FEF(25-75). *J Allergy Clin Immunology* 2010;**126**:535-6. <http://dx.doi.org/10.1016/j.jaci.2010.06.035>
6. Simon MR, Chinchilli VM, Phillips BR, et al. Forced expiratory flow between 25% and 75% of vital capacity and FEV(1)/forced vital capacity ratio in relation to clinical and physiological parameters in asthmatic children with normal FEV(1) values. *J Allergy Clin Immunology* 2010;**126**:527. <http://dx.doi.org/10.1016/j.jaci.2010.05.016>
7. Ciprandi G, Cirillo I, Pistorio A. Impact of allergic rhinitis on asthma: effects on spirometric parameters. *Allergy* 2008;**63**:255-60. <http://dx.doi.org/10.1111/j.1398-9995.2007.01544.x>
8. Braunstahl GJ. United Airways Concept. What Does it Teach Us about Systemic Inflammation in Airways Disease? *Proc Am Thorac Soc* 2009;**6**:652-4. <http://dx.doi.org/10.1513/pats.200906-052DP>

## Knowledge of pulse oximetry among general practitioners in South Australia

\*Quirine CA Huijgen<sup>a,b</sup>, Tanja W Effing<sup>a</sup>, Kerry L Hancock<sup>c</sup>, Tjard R Schermer<sup>d</sup>, Alan J Crockett<sup>e</sup>

<sup>a</sup> Respiratory Department, Repatriation General Hospital, Adelaide, South Australia

<sup>b</sup> Department of Surgery, Gelre ziekenhuizen, Apeldoorn, The Netherlands

<sup>c</sup> Chandlers Hill Surgery, Adelaide, South Australia

<sup>d</sup> Radboud University Nijmegen Medical Centre - Primary and Community Care, Nijmegen, The Netherlands

<sup>e</sup> Primary Care Respiratory Research Unit, The University of Adelaide, School of Population Health & Clinical Practice, Adelaide, South Australia

\*Correspondence: Miss Quirine Huijgen, Department of Surgery, Gelre Ziekenhuizen, Albert Schweitzerlaan 31, Apeldoorn, the Netherlands  
Tel: 0031641166403 E-mail: quirine\_h@hotmail.com

Received 8th August 2011; accepted 14th August 2011

© 2011 Primary Care Respiratory Society UK. All rights reserved

<http://dx.doi.org/10.4104/pcrj.2011.00088>

#### Dear Sirs,

Pulse oximetry is a non-invasive, reliable technology for measuring arterial oxygen saturation (SpO<sub>2</sub>).<sup>1</sup> Pulse oximeters are part of standard care and it is hard to imagine emergency departments, intensive care units and general hospital wards without them. Recently, portable, user-friendly and relatively non-expensive pulse oximeters have become available, making them

**Table 1. Associations between knowledge score and different descriptive variables**

| Variable                                                        | N=46<br>Frequency<br>n (%) | Mean score %<br>(SD and range) | p-value            |
|-----------------------------------------------------------------|----------------------------|--------------------------------|--------------------|
| Number of years of experience as GP*                            |                            |                                |                    |
| • < 1 year                                                      | 3 (6.5)                    | 53.3 (5.9; 48.6-60.0)          | 0.03 <sup>†‡</sup> |
| • 1-5 years                                                     | 8 (17.4)                   | 45.7 (16.2; 22.9-68.6)         |                    |
| • 6-10 years                                                    | 5 (10.9)                   | 33.1 (20.2; 8.6-62.9)          |                    |
| • >10 years                                                     | 29 (63.0)                  | 30.2 (19.2; 0.0-68.6)          |                    |
| Experience with the pulse oximeter                              |                            |                                |                    |
| • Yes                                                           | 35 (76.1)                  | 39.5 (17.0; 8.6-68.6)          | 0.006 <sup>§</sup> |
| • No                                                            | 11 (23.9)                  | 20.8 (19.3; 0.0-57.1)          |                    |
| Number of years of experience with pulse oximetry <sup>†¶</sup> |                            |                                |                    |
| • < 1 year                                                      | 2 (5.7)                    | 25.7 (4.0; 22.9-28.6)          | 0.9 <sup>†</sup>   |
| • 1-5 years                                                     | 16 (45.7)                  | 42.9 (15.9; 17.1-68.6)         |                    |
| • 6-10 years                                                    | 4 (11.4)                   | 35.0 (2.9; 31.4-40.0)          |                    |
| • >10 years                                                     | 11 (31.4)                  | 42.1 (21.4; 8.6-68.6)          |                    |
| In possession of pulse oximeter*                                |                            |                                |                    |
| • Yes                                                           | 28 (60.9)                  | 38.5 (17.7; 8.6-68.6)          | 0.17 <sup>§</sup>  |
| • No                                                            | 17 (37.0)                  | 29.7 (21.2; 0.0-68.6)          |                    |
| Use of pulse oximeter per week <sup>¶¶</sup>                    |                            |                                |                    |
| • I don't use it                                                | 10 (28.6)                  | 39.7 (15.6; 17.1-68.6)         | 0.97 <sup>†</sup>  |
| • 1-6 times a week                                              | 9 (25.7)                   | 38.1 (20.3; 8.6-68.6)          |                    |
| • 7-10 times a week                                             | 3 (8.6)                    | 26.7 (4.4; 22.9-31.4)          |                    |
| • >10 times a week                                              | 3 (8.6)                    | 53.3 (21.6; 28.6-68.6)         |                    |
| • Other #                                                       | 8 (22.9)                   | 42.9 (15.6; 22.9-60.0)         |                    |

SD: standard deviation. N/A not applicable.

\* 1 missing; <sup>†</sup> One-way ANOVA; <sup>‡</sup> To obtain subgroups of equal size, the categories were redefined into 0-5 years of experience (p=0.009), 6-10 years of experience (p=0.733) and more than 10 years of experience in general practice (p=0.744); <sup>§</sup> Mann Whitney U test; <sup>¶</sup> Only GPs with experience with pulse oximetry (n=35); <sup>¶¶</sup> 3 Gps used the pulse oximeter less than weekly, 5 GPs used the pulse oximetry when working in the hospital

much more accessible for general practitioners (GPs). Pulse oximetry appears to have a wide range of indications in the primary care setting.<sup>2</sup> COPD guidelines suggest that oxygen saturation measurements should be performed to aid GPs in effective patient management.

In order to interpret measurements, knowledge is required of pulse oximetry technology, respiratory anatomy and physiology, and the oxyhaemoglobin dissociation curve.<sup>3,4</sup> The latter explains the relationship between arterial oxygen saturation and partial pressure of arterial oxygen. Pulse oximetry does not provide information about the haemoglobin level, the adequacy of ventilation, nor the efficiency of oxygen delivery to the tissues.<sup>5</sup> Also, pulse oximeters can give inaccurate information when used on polished nails, with bright overhead lights and in low perfusion states.<sup>4,6</sup> It is essential to be aware of these limitations. Research in different hospital settings has shown that clinicians' understanding of pulse oximetry is rather limited.

As far as we are aware, no previous research has been conducted of GPs' knowledge of pulse oximetry. Therefore, the aim of this cross-sectional questionnaire study was to gain insight into the current knowledge, interpretative skills and attitudes of South-Australian GPs regarding pulse oximetry.

We approached all GP networks in the Adelaide area to recruit participants. An internet-based questionnaire was used to assess interpretative skills, attitudes, and knowledge regarding pulse oximetry (when and how to use the device; normal range of oxygen saturation; accuracy; oxyhaemoglobin dissociation curve; limitations of the pulse oximetry device). The questionnaire

(available online at [www.thepcrj.org](http://www.thepcrj.org)) was based on questionnaires used in previously reported surveys.<sup>7-10</sup> A maximum of 35 points could be obtained. Scores were converted to percentages (0-100%). Data were collected in November 2010. Descriptive characteristics were used to describe the different variables. Associations between total knowledge score and descriptive variables were analysed using the Mann-Whitney U test and one-way ANOVA combined with multiple regression analyses (SPSS version 17.0).

A total of 46 questionnaires were returned from 42 GPs (91.3%) and 4 GP registrars (8.7%). The majority of participants (76.1%) had experience with pulse oximetry and a pulse oximeter was owned by 60.9% of the participants. Most participants (58.7%) believed they had not received adequate training in the use of pulse oximetry. The mean test score was 35.0% (19.1% SD) and ranged from 0% to 68.6%. Half of the participants did not know that a pulse oximeter measures the percentage of oxygenated haemoglobin and only 45.7% knew that the normal oxygen saturation range for an adult is 96 to 99%. Overall, only 31.2% of the questions about the limitations were answered correctly. Only one GP answered all three questions about the oxyhaemoglobin dissociation curve correctly and 45.7% answered all three questions incorrectly.

Experience with pulse oximetry resulted in a significantly higher score (p<0.01). Years of experience in general practice was overall significantly negatively associated with the knowledge test score (Table 1).

Although the group of GP registrars was very small, a

significant difference in test scores was found between GP registrars and GPs (53.6% versus 33.3%,  $p=0.046$ ).

This study, albeit small, confirmed our hypothesis that knowledge of pulse oximetry among GPs is relatively poor across all aspects of pulse oximetry. Whereas years of experience in general practice had a negative correlation with knowledge, experience with the pulse oximeter correlated positively with knowledge. To our knowledge this is the first study about pulse oximetry knowledge performed in a primary care setting. Our questionnaire is not identical to those used in other studies, but when we compare our results to earlier studies performed in hospital settings, the overall score seems low.<sup>5</sup>

The response rate on the internet survey was very low, with only 1.6% of all invited GPs completing the internet-based questionnaire – a significant limitation of this study. However, although the study population was small, we believe it to be a representative sample of GPs in Australia.

Before pulse oximetry can be more widely implemented in primary care, knowledge about its technology, limitations and the principles behind the oxyhaemoglobin dissociation curve should be improved. Therefore, appropriate training of GPs and registrars is essential.

#### Conflicts of interest

The authors declare that they have no conflicts of interest in relation to this article.

#### Contributorship

QH: study preparation and execution, analyses, paper writing; TE: study

preparation, analyses, paper writing; KH: study preparation, study logistics, paper writing; TS: initiator of study, paper writing; AC: initiator of study, paper writing.

#### Funding

None.

#### References

1. Anzueto A, Casaburi R, Holmes S, Schermer T. Clinical use of pulse oximetry, pocket reference 2010. [http://www.theipcrj.org/resources/oximetry\\_pocket\\_guide.pdf](http://www.theipcrj.org/resources/oximetry_pocket_guide.pdf)
2. Schermer T, Leenders J, in 't Veen H, *et al.* Pulse oximetry in family practice: indications and clinical observations in patients with COPD. *Fam Pract* 2009;**26**(6):524-31. <http://dx.doi.org/10.1093/fampra/cmp063>
3. Elliott M, Tate R, Page K. Do clinicians know how to use pulse oximetry? A literature review and clinical implications. *Aust Crit Care* 2006;**19**(4):139-44. [http://dx.doi.org/10.1016/S1036-7314\(06\)80027-5](http://dx.doi.org/10.1016/S1036-7314(06)80027-5)
4. Holmes S, Peffers S, Mallet S. PCRS-UK Opinion Sheet No. 28: Pulse Oximetry in Primary Care. [www.pcrs-uk.org](http://www.pcrs-uk.org). 2009.
5. Grap MJ. Pulse oximetry. *Crit Care Nurse* 1998;**18**(1):94-9.
6. Amar D, Neidzwski J, Wald A, Finck AD. Fluorescent light interferes with pulse oximetry. *J Clin Monit* 1989;**5**(2):135-6. <http://dx.doi.org/10.1007/BF01617888>
7. Rodriguez LR, Kotin N, Lowenthal D, Kattan M. A study of pediatric house staff's knowledge of pulse oximetry. *Pediatrics* 1994;**93**(5):810-13.
8. Attin M, Cardin S, Dee V, *et al.* An educational project to improve knowledge related to pulse oximetry. *Am J Crit Care* 2002;**11**(6):529-34.
9. Stoneham MD, Saville GM, Wilson IH. Knowledge about pulse oximetry among medical and nursing staff. *Lancet* 1994;**344**(8933):1339-42. [http://dx.doi.org/10.1016/S0140-6736\(94\)90697-1](http://dx.doi.org/10.1016/S0140-6736(94)90697-1)
10. Popovich DM, Richiuso N, Danek G. Pediatric health care providers' knowledge of pulse oximetry. *Pediatr Nurs* 2004;**30**(1):14-20.

See online Appendix 2 at [www.theipcrj.org](http://www.theipcrj.org) for online-only supplement

Available online at <http://www.theipcrj.org>

Appendix 1 - To *et al.*

# Asthma Indicators Pilot Study

Primary Care Asthma  
Performance Indicators  
(PC-API)  
A Feasibility Study

Site ID:

## Patient's Demographic Data:

Person who filled out this form:

Sex: ☐ Male ☐ Female

Patient Visit Date:

Year of birth (yyyy):

Visit Type:

First 3 Digits in Postal Code(e.g. M5G \_\_\_):

## Asthma Indicators

- |                      |                                                                                                              |                                                                                                        |
|----------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| 1. PFT               | a) Patient's asthma diagnosis was confirmed by PFTs (spirometry, peak flow or methacholine challenge test)   | <input type="radio"/> Yes <input type="radio"/> No                                                     |
|                      | b) Patient was monitored with spirometry in last 12 months                                                   | <input type="radio"/> Yes <input type="radio"/> No                                                     |
| 2. Medication Use    | a) Patient is using inhaled corticosteroids (ICS)                                                            | <input type="radio"/> Yes <input type="radio"/> No                                                     |
|                      | b) In last 12 months, patient's self-reported number of ICS prescription filled                              | <input type="text"/>                                                                                   |
|                      | c) In last 4 weeks, patient's self-reported number of short-acting B2-agonist (2 puffs) per week             | <input type="text"/>                                                                                   |
|                      | d) In last 4 weeks, patient's self-reported number of B2-agonist-free days                                   | <input type="text"/>                                                                                   |
|                      | e) Patient has demonstrated their inhaler technique regularly                                                | <input type="radio"/> Yes <input type="radio"/> No                                                     |
| 3. Asthma Control    | a) In last 6 months, patient's asthma symptoms control were assessed                                         | <input type="radio"/> Yes <input type="radio"/> No                                                     |
|                      | b) In last 4 weeks, patient's asthma is well-controlled                                                      | <input type="radio"/> Yes <input type="radio"/> No                                                     |
|                      | c) In last 4 weeks, patient's self-reported symptom-free days                                                | <input type="text"/>                                                                                   |
|                      | d) In last 12 months, patient's self-reported days missed from school or work due to asthma                  | <input type="text"/>                                                                                   |
| 4. Exacerbations     | In last 12 months, patient has more than 1 asthma exacerbation                                               | <input type="radio"/> Yes <input type="radio"/> No                                                     |
| 5. Health Care Use   | a) In last 12 months, number of ED visits for asthma                                                         | <input type="text"/>                                                                                   |
|                      | b) In last 12 months, number of urgent care visits for asthma                                                | <input type="text"/>                                                                                   |
|                      | c) In last 12 months, number of primary care visits for asthma                                               | <input type="text"/>                                                                                   |
|                      | d) Patient has a routine health care provider                                                                | <input type="radio"/> Yes <input type="radio"/> No                                                     |
| 6. Action Plan       | Patient has received a written asthma action plan                                                            | <input type="radio"/> Yes <input type="radio"/> No                                                     |
| 7. Asthma Education  | Referred to see a certified asthma educator                                                                  | <input type="radio"/> Yes <input type="radio"/> No                                                     |
| 8. Smoking Cessation | Patient has received advice to stop smoking                                                                  | <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A (patient is a non-smoker) |
| 9. Quality of Life   | Patient's assessment of quality of life<br>(5 point scale: 1=excellent, 2=very good, 3=good, 4=fair, 5=poor) | <input type="text"/>                                                                                   |

**Thank you for filling out this form.**

To submit please click on the appropriate button.

Submit by Email

Print Form

Primary Care Asthma Performance Indicators (PC-API) Form, authored by Dr. Teresa To, © The Hospital for Sick Children, 2009 November

Appendix 2 - Huijgen *et al.*

## Knowledge about pulse oximetry among GPs



The new Royal Australian College of General Practitioners *Standards for general practices* highlight the pulse oximeter as 'discretionary'. While knowledge about this tool is required for correct interpretation of results, few GPs have received formal training. The aim of this study is to investigate GPs' knowledge about pulse oximetry.

Please answer the following questions as accurately as possible. All questionnaires will be processed anonymously.

## Demographic and descriptive characteristics (Please circle the answer which is applicable)

1. What is your age?.....years old
2. What is your gender? Male/Female
3. Are you a:
  - a. VR/ non-VR General Practitioner
  - b. GP registrar
  - c. Other, please specify.....
4. On average, how many sessions a week do you work?
  - a.  $\leq 2$
  - b. 2-5
  - c. 6-8
  - d. 8-10
  - e.  $\geq 11$
  - f. Other, please specify.....
5. What type of practice do you work in?
  - a. Solo GP practice (or equivalent of 1 full time GP)
  - b. Small group practice ( $\leq 4$  full time equivalent GPs)
  - c. Large group practice (5-7 full time equivalent GPs)
  - d. Very large group practice ( $\geq 8$  full time equivalent GPs)
  - e. Other, please specify.....
6. Where is your practice situated?
  - a. Inner metropolitan
  - b. Outer metropolitan
  - c. Rural
  - d. Remote
  - e. Other, please specify.....
7. Number of years of patient related experience in general practice?
  - a.  $< 6$  months
  - b. 6-12 months
  - c. 1-5 years
  - d. 6-10 years
  - e.  $> 10$  years
8. Are you specialised in respiratory diseases or are you a member of a committee for respiratory diseases?
  - a. Yes
  - b. No
  - c. Other, please specify.....
9. Have you had any clinical experience in using pulse oximetry?
  - a. No  $\rightarrow$  skip question 10, 14, 15 and 16
  - b. Yes (if yes, please indicate all that apply)
    - cc. In a hospital setting
    - dd. In a general practice setting
    - ee. Other, please specify.....

Appendix 2 - Huijgen *et al.***10. How many years of experience have you had using pulse oximeters?**

- a. < 6 months
- b. 6-12 months
- c. 1-5 years
- d. 6-10 years
- e. >10 years
- f. Other, please specify.....

**11. Does your practice have a pulse oximeter?**

- a. Yes (skip question 17)
- b. No (skip question 12 and 13)

**12. When was it purchased?**

- a. <1 year ago
- b. 1-2 years ago
- c. 2-5 years ago
- d. >5 years ago
- e. I don't know

**13. How often do you estimate it is being used across the whole practice?**

- a. Daily
- b. Weekly
- c. Monthly
- d. Rarely
- e. Other, please specify.....

**14. How often do you use the pulse oximeter in your practice?**

- a. I don't use it ( skip question 15+16)
- b. 1-3 times a week
- c. 4-6 times a week
- d. 7-10 times a week
- e. > 10 times a week
- f. I use pulse oximetry elsewhere, specify where and how often:.....

**15. In which of the situations do you use the pulse oximeter?**

|                                                                                                   |        |
|---------------------------------------------------------------------------------------------------|--------|
| To obtain an objective measurement in patients with acute or worsening dyspnoea                   | Yes/No |
| Assessing severity of COPD exacerbations                                                          | Yes/No |
| Rule out acute respiratory failure or low oxygenation                                             | Yes/No |
| Assessing severity of lower airways disease                                                       | Yes/No |
| Differentiation between hypoventilation and cardiopulmonary disorders                             | Yes/No |
| To obtain an objective measurement in patients with COPD with suspected respiratory insufficiency | Yes/No |
| Determination of a baseline/comparator value in patients with COPD or asthma                      | Yes/No |
| Monitoring the course or recovery after respiratory failure                                       | Yes/No |
| Monitoring the course or recovery of dyspnoea in patients with COPD or asthma                     | Yes/No |
| To assist in determining starting or continuing oxygen therapy in patients with terminal disease  | Yes/No |
| Other, please specify:                                                                            |        |

**16. How often do you document the reading from the pulse oximeter in the clinical record?**

- a. Every time
- b. Most of the times
- c. Sometimes
- d. Never

**17. Are you or your practice considering purchasing a pulse oximeter in the next 12 months?**

- a. No
- b. Yes, regardless of practice accreditation requirements
- c. Yes, only if it becomes a required piece of equipment for practice accreditation

**18. Do you feel you have received adequate training in the use of pulse oximeters?**

- a. Yes
- b. No

Appendix 2 - Huijgen *et al.***19. What kind of training have you had in the use of pulse oximeters? (Circle all that apply)**

- a. No training
- b. Formal lecture
- c. Self study
- d. Informal training during clinical practice
- e. In-service by equipment supplier
- f. Equipment manual
- g. Other, please specify .....

**Pulse oximetry knowledge questions (please circle the answer which is applicable)****1. What does the pulse oximeter measure?**

- a. The percentage of haemoglobin which is oxygenated (oxyhaemoglobin)
- b. The percentage of body surface area which is adequately oxygenated
- c. PaO<sub>2</sub> (partial pressure of oxygen)
- d. PtcO<sub>2</sub> (transcutaneous partial pressure of oxygen)
- e. I don't know

**2. Normal saturation for a 2-year-old is best described in which one of the following ranges:**

- a. 85-90%
- b. 90-95%
- c. 93-97%
- d. 97-99%
- e. 98-100%
- f. I don't know

**3. Normal saturation for an adult is best described in which one of the following ranges:**

- a. 85-90%
- b. 90-95%
- c. 93-97%
- d. 96-99%
- e. 97-100%
- f. I don't know

**4. Pulse oximeter readings are least accurate at which of the following saturations?**

- a. 95-100%
- b. 85-95%
- c. 70-85%
- d. <70%
- e. I don't know

**5. Patient A's oximeter reading has fallen from 95% to 90%. Patient B's oximeter reading has fallen from 80% to 75%. Assuming the clinical and laboratory parameters are the same between the two patients, which of the following is correct**

- a. Patient A had a change in partial pressure of oxygen that is fourfold greater than patient B
- b. Patient A and B had equal changes in partial pressure of oxygen
- c. Patient B had a change in partial pressure of oxygen that is fourfold greater than patient A
- d. These changes are within the error of the method
- e. I don't know

**6. An oxygen saturation of 90%, under normal metabolic conditions, will correspond to partial pressure of oxygen (PaO<sub>2</sub>) of approximately:**

- a. 90 mmHg
- b. 85 mmHg
- c. 75 mmHg
- d. 60 mmHg
- e. 50 mmHg
- f. I don't know

Appendix 2 - Huijgen *et al.*

7. A 1-month-old infant is in 30% oxygen with an O<sub>2</sub> saturation of 99%. The PaO<sub>2</sub> is:

- 99 mmHg
- 140 mmHg
- 220 mmHg
- Cannot be determined from the information given
- I don't know

8. Identify what effect, if any, the following factors have on the pulse oximetry reading?  
(please tick one box per item)

|                             | No effect | Falsely decrease | Falsely increase | May not be able to pick up signal | I don't know |
|-----------------------------|-----------|------------------|------------------|-----------------------------------|--------------|
| Nail polish                 |           |                  |                  |                                   |              |
| Carbonmonoxide poisoning    |           |                  |                  |                                   |              |
| Jaundice                    |           |                  |                  |                                   |              |
| Shivering                   |           |                  |                  |                                   |              |
| Dark skinned race           |           |                  |                  |                                   |              |
| Peripheral vasoconstriction |           |                  |                  |                                   |              |
| Hypertension                |           |                  |                  |                                   |              |
| Tremor                      |           |                  |                  |                                   |              |
| Cardiac arrhythmias         |           |                  |                  |                                   |              |
| Shock                       |           |                  |                  |                                   |              |
| Hypotension                 |           |                  |                  |                                   |              |
| Hypothermia                 |           |                  |                  |                                   |              |
| Anaemia                     |           |                  |                  |                                   |              |
| Movement                    |           |                  |                  |                                   |              |
| Bright overhead lights      |           |                  |                  |                                   |              |

- An SpO<sub>2</sub> of 92% or less (at sea level) suggests hypoxemia True/false/ I don't know
- Pulse oximetry is a method for continuous non-invasive measurement of adequacy of ventilation True/false/ I don't know
- Clinical observation alone is as effective as pulse oximetry monitoring in the rapid detection of hypoxemia True/false/ I don't know
- Pulse oximetry sensors can be placed at the same extremity as the non-invasive blood pressure monitoring device True/false/ I don't know
- Spot checks of pulse oximetry readings are as helpful in assessing a patients oxygenation status as evaluation of continuous monitoring over time True/false/ I don't know
- Oxygen saturation monitoring could replace arterial blood gases when monitoring ventilation abnormalities True/false/ I don't know
- In older children who are receiving inotropes, vasopressors, vasodilators, sedatives, or analgesics, changes in oxygenation are more accurately detected by pulse oximetry than by any other non-invasive method True/false/ I don't know
- During vasoconstriction and hypotension, the overall performance of finger sensors is generally better than performance of sensors at other sites (ie, ear, forehead, nose) True/false/ I don't know
- If a patient is breathing normal air, 100% saturation can be achieved True/false/ I don't know
- In a patient with a pulse oximeter reading of 92%, the true saturation value could be 90% True/false/ I don't know
- If an anaemic patient has a normal saturation value, he could still be hypoxic True/false/ I don't know
- Body temperature should be taken in account, when you are using the pulse oximeter True/false/ I don't know
- The pulse oximeter measures the absorption of electrical waves by haemoglobin True/false/ I don't know

Thank you for your participation!