

# Pulse oximetry in discharge decision-making: a survey of emergency physicians

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## ABSTRACT

**Objectives:** Our primary objective was to describe the pulse oximetry discharge thresholds used by general and pediatric emergency physicians for well-appearing children with bronchiolitis and pneumonia, and to assess the related practice variability.

**Methods:** This mail-in survey was conducted in August and September 2001 and included the 281 active members of the Pediatric Emergency Medicine Section of the American College of Emergency Physicians. The survey consisted of 2 case scenarios of previously healthy, well-appearing children: a 2-year-old with pneumonia and a 10-month-old with bronchiolitis. Respondents were asked about their years of experience, teaching load, percentage of children in their practice, whether they currently have a written departmental guideline at their institution, and the lowest pulse oximetry reading that they would accept and still discharge the patient directly home.

**Results:** One hundred and eighty-two (65%) physicians answered the survey and met the inclusion criteria. The respondents' median oximetry value and interquartile range (IQR) for the pneumonia and bronchiolitis cases were 93% (92%–94%) and 94% (92%–94%) respectively. With the exception of the 3 physicians practising >1000 metres above sea level, the responses by subgroups were similar.

**Conclusions:** There does not yet exist a safe, clinically validated pulse oximetry discharge threshold. Emergency physicians from this study sample have a modest degree of practice variability in a self-reported pulse oximetry discharge threshold. Emergency physicians may use this data to compare their own practice with that reported by this group.

**Key words:** pulse oximetry, practice guideline, pneumonia, bronchiolitis, emergency department

## RÉSUMÉ

**Objectifs :** Notre objectif principal était de décrire les seuils de décharge de l'oxymétrie de pouls utilisés par des médecins d'urgence généralistes et pédiatriques chez des enfants atteints de bronchiolite et de pneumonie dont l'apparence physique est bonne et d'évaluer la variabilité dans la pratique.

**Méthodes :** Ce sondage par la poste fut mené en août et septembre 2001 et incluait les 281 membres actifs de la section de médecine d'urgence pédiatrique du American College of Emergency Physicians. Le sondage comprenait deux scénarios présentant des enfants auparavant en bonne santé, soit un enfant de deux ans atteint de pneumonie, et un bébé de dix mois atteint de bronchiolite. On demanda aux participants de donner leurs années d'expérience, leur charge d'enseignement, le pourcentage d'enfants dans leur pratique, l'existence de lignes directrices écrites pour le département de leur établissement, et la lecture d'oxymétrie de pouls la plus basse qu'ils accepteraient pour donner le congé au patient.

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Received: June 18, 2002; final submission: Aug. 23, 2002; accepted: Sept. 2, 2002

*This article has been peer reviewed.*

**Résultats :** Cent quatre-vingt-deux médecins (65 %) répondirent au sondage et satisfaisaient aux critères d'inclusion. La valeur d'oxymétrie médiane et l'intervalle interquantile des participants pour les cas de pneumonie et de bronchiolite étaient de 93 % (92 %–94 %) et 94 % (92 %–94 %) respectivement. À l'exception de trois médecins pratiquant >1000 mètres au-dessus du niveau de la mer, les réponses par sous-groupe étaient semblables.

**Conclusions :** Il ne semble pas exister de seuil de décharge d'oxymétrie de pouls sécuritaire et validé en clinique. Selon le seuil de décharge pour l'oxymétrie de pouls rapporté dans cette étude, la pratique à cet égard varie très peu d'un médecin d'urgence à l'autre. Les médecins d'urgence peuvent utiliser ces données pour comparer leur propre pratique à celle de ce groupe.

## Introduction

Young children present to emergency departments (EDs) every day with respiratory illnesses, and emergency physicians must decide whether or not to hospitalize them. One data point used in this decision-making process is the pulse oximeter reading. The pulse oximeter is now so commonly used that the readings it provides have recently come to be called “the fifth pediatric vital sign.”<sup>1</sup> Although many factors enter into the decision to hospitalize a young child, as a general principle, hypoxic children should be hospitalized and others may be considered for discharge.

Unfortunately, the pulse oximetry level that constitutes clinically meaningful hypoxia has not been established. In reviewing major emergency medicine textbooks for information on the minimal pulse oximetry value at which young children should be discharged from the ED, we found unreferenced recommendations that included: hospitalizing children with pneumonia and oxygen saturations <90%,<sup>2</sup> hospitalizing children with bronchiolitis and oxygen saturations <93%,<sup>3</sup> hospitalizing children with bronchiolitis and oxygen saturations <95% at sea level,<sup>4</sup> and “probably” hospitalizing “most children” with bronchiolitis and oxygen saturations <91%.<sup>5</sup>

We surveyed a group of general and pediatric emergency physicians in an attempt to assess the pulse oximetry discharge thresholds used in clinical practice. We studied several factors that may impact the discharge threshold used by the respondents, including years of experience, patient volume and caseload, and involvement with physicians-in-training. In addition, because healthy children at higher elevations have lower baseline oximetry readings,<sup>6–8</sup> we attempted to assess the effect of practising at clinically important elevations above sea level. Our primary objective was to describe the pulse oximetry discharge thresholds used by general and pediatric emergency physicians, and to assess the related practice variability. The responses from this survey allow emergency physicians to compare their own clinical practice to that of our study group.

## Methods

### Subjects

The Pediatric Emergency Medicine Section of the American College of Emergency Physicians (ACEP) was surveyed based on a mailing list purchased from ACEP. The study group included practising emergency physicians who treat children in their clinical practice, and excluded medical students, resident physicians, nonpractising physicians, and those who do not use pulse oximetry for discharge decision-making. An initial email was sent to the group alerting them of an upcoming survey to arrive in the mail. A single-page survey and a cover letter were mailed to each member of the group. Four weeks later another email was sent out, and a follow-up mailing was sent to physicians who failed to respond. The surveys were numbered to track physicians who failed to respond to the second mailing, and to identify the elevation at which the respondents practise. Responders to these mailings were referred to as “early responders.” Approximately one year later a convenience sample of 60 physicians who failed to respond to the mailings and had email addresses published in the ACEP 2002 *Reference Guide and Membership Directory* was surveyed by email. Responders to this email survey were referred to as “late responders.” All others were referred to as “nonresponders.” The identity of respondents was kept confidential, and this study was approved by our Institutional Review Board.

We recorded subjects' addresses and zip codes, then used standard reference sources (e.g., *Rand McNally 2001 Commercial Atlas and Marketing Guide*, [www.topozone.com](http://www.topozone.com) [accessed 2002 Sept 16]) to determine the geographical distribution of the study group and the elevation above sea level for each respondent. The addresses used were preferred mailing addresses and may reflect the physicians' home or work address.

### Survey items

Respondents were asked to estimate the percentage of pediatric patients in their clinical practice and describe their

involvement in teaching resident physicians (i.e., generally seeing patients without residents, seeing patients and supervising residents, or supervising residents who see most of the patients). Respondents were also asked whether their department had a written protocol defining the minimum pulse oximetry reading at which children may be discharged from the ED, and to indicate their number of years in practice (0–5, 5–10, or more than 10). The two case scenarios presented in the cover letter described well-appearing children (Box 1). After each case, respondents were asked: “What is the lowest pulse oximetry reading that you would accept and still discharge this patient directly home?”

### Data analysis

The distributions of the data from the case scenarios were assessed for normality using a one-sample Kolmogorov–

Smirnov (K–S) goodness-of-fit test.<sup>9</sup> Data from both the pneumonia case scenario ( $z = 1.908$ ,  $p = 0.001$ ) and the bronchiolitis case scenario ( $z = 2.311$ ,  $p < 0.001$ ) were deemed to have non-normal distributions; therefore, results are reported as medians, ranges and interquartile ranges (IQRs) (25th to 75th percentile).<sup>10</sup> Statistical analyses were performed using SPSS 10.0 for Windows (SPSS, Inc. Chicago, Ill.).

### Results

One hundred and eighty-eight (67%) of 281 physicians responded to the survey. Six respondents were excluded: 3 who no longer practise clinical medicine, 1 who refused to participate, 1 who reported not using pulse oximetry to make discharge decisions, and 1 who does not see children. The study group ( $n = 182$ ) included 176 early respondents and 6 late respondents, representing a geographically diverse group throughout the United States. Responses were similar for early and late responders, and geographic distribution was similar for responders and nonresponders (Table 1). Median pulse oximetry discharge thresholds for both clinical cases were 94% (IQR 93%–95%) in the Northeast and 93% (IQR 92%–94%) in all other regions.

Figure 1 shows that the median pulse oximetry discharge threshold for a well-appearing 2-year-old with pneumonia was 93% (range 88%–98%; IQR 92%–94%). The most frequent response (mode) was 92%, and 86% of all responses were between 92% and 95%.

Figure 2 shows that the median pulse oximetry discharge threshold for a well-appearing 10-month-old with bronchiolitis was 94% (range 88%–98%, IQR 92%–94%). The most frequent response (mode) was 94%, and 83% of all responses were between 92% and 95%. For both case scenarios, the responses from physicians with

#### Box 1. Case scenarios

- Each of the children has a normal birth history.
  - Prior to the emergency department visit, the child has taken no medications.
  - The child is well appearing, playful and well hydrated.
  - Feeding and urination are normal.
  - Immunizations are up-to-date and complete.
  - Close follow-up is assured, and there are no suspicions of abuse or neglect.
1. You are seeing a 2-year-old who clinically and radiographically has pneumonia. The child has no past medical history and is in no respiratory distress. In considering discharging this patient home, a pulse oximetry reading is obtained.
  2. You are seeing a 10-month-old boy who clinically has bronchiolitis. The child is initially wheezing but clears completely after a single 2.5-mg albuterol nebulized treatment. In considering discharging this patient home, a pulse oximetry reading is obtained.

**Table 1. Geographic (United States) location of responders and non-responders**

	Geographic distribution, no. (and %)			
	Northeast*	Southeast†	Midwest‡	West§
Responders ( $n = 182$ )	50 (27)	38 (21)	48 (26)	46 (25)
Nonresponders ( $n = 93$ )	28 (30)	21 (23)	17 (18)	27 (29)

Note: Percentages may not add up to 100 due to rounding.

\*Northeast (zip codes 00919–26508): Massachusetts, Maine, Rhode Island, Connecticut, New Jersey, New York, Pennsylvania, Delaware, the District of Columbia, Virginia, Maryland, West Virginia, and Puerto Rico.

†Southeast (zip codes 27103–40299): North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Mississippi, and Kentucky.

‡Midwest (zip codes 43017–73126): Ohio, Indiana, Michigan, Wisconsin, Minnesota, Illinois, Missouri, Kansas, Louisiana, Arkansas, and Oklahoma.

§West (zip codes 75063–99705): Texas, Colorado, Idaho, Arizona, New Mexico, Utah, Nevada, California, Hawaii, Oregon, Washington, and Alaska.

different practice characteristics were similar, with the exception of the 3 physicians practising at >1000 m elevation (Table 2).

One hundred forty-five physicians (80%) gave the same pulse oximetry threshold for the 2 cases, but 24 (13%) gave a higher oximetry threshold for bronchiolitis, and 13 (7%) gave a higher pulse oximetry threshold for pneumonia. Seven respondents reported that they had a written department protocol for the pulse oximetry discharge threshold, and their responses ranged from 92%–95% (median =

94% for both cases). All but one of the respondents who report having written protocols used the same pulse oximetry threshold for the 2 cases.

Three physicians had mailing addresses at elevations greater than 1000 m above sea level (range, 1200 m–1650 m). Their pulse oximetry discharge thresholds ranged from 88% to 90%. Of all 182 respondents, only 3 had discharge thresholds below 90%, and 2 of these practised at greater than 1000 m above sea level.

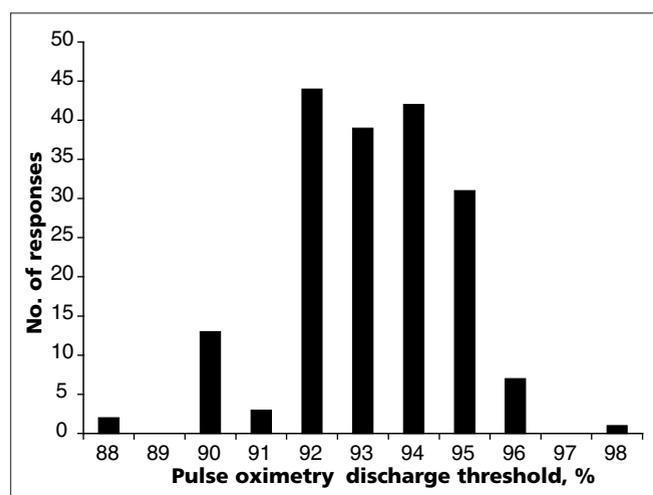


Fig. 1. Pulse oximetry discharge thresholds for a well appearing 2-year-old with clinical and radiographic pneumonia

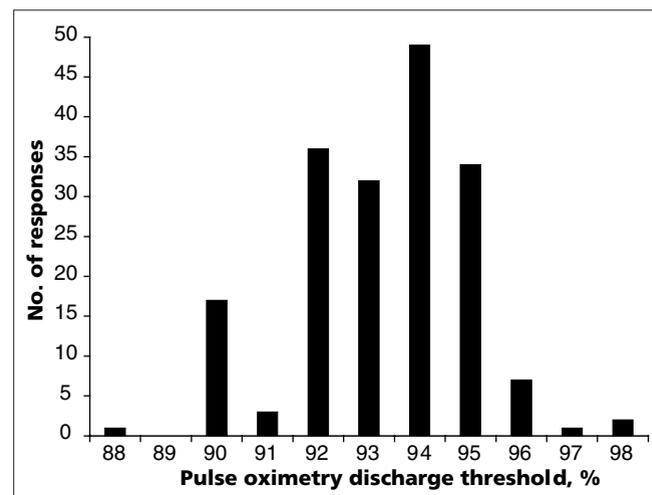


Fig. 2. Pulse oximetry discharge thresholds for a well appearing 10-month-old with bronchiolitis

Table 2. Pulse oximetry discharge thresholds for physicians with different practice characteristics

Practice characteristic	No. (and %) of physicians	Pneumonia pulse oximetry discharge threshold			Bronchiolitis oximetry discharge threshold		
		Median	Range	IQR*	Median	Range	IQR*
<b>Percentage of children in clinical practice (n = 163)*</b>							
<25	31 (19)	93	90–95	92–94	93	90–96	92–94
25–49	39 (24)	94	90–96	93–94	94	90–97	93–95
50–75	12 (7)	93	90–96	93–94	94	90–98	93–95
>75	81 (50)	93	88–98	92–94	93	88–98	92–94
<b>Years in practice (n = 181)*</b>							
<5	14 (8)	94	92–96	93–96	94	92–98	93–95
5–10	36 (20)	94	90–95	92–95	94	90–96	93–94
>10	131 (72)	93	88–98	93–94	93	88–98	92–94
<b>Elevation above sea level (n = 182)</b>							
<1000 m	179 (98)	93	88–98	92–94	94	90–98	92–94
>1000 m	3 (2)	90	88–90	89–90	90	88–90	89–90
<b>Involvement with resident physicians (n = 181)*</b>							
Primarily without residents	44 (24)	93	90–96	92–94	94	90–96	92–94
Seeing patients and teaching	97 (54)	93	88–98	92–94	94	88–98	92–94
Primarily supervising	40 (22)	93	90–96	92–95	93	90–98	92–95

IQR = interquartile range

\*Not all the physicians responded to all the queries on the survey.

## Discussion

These data suggest that most physicians report using pulse oximetry discharge thresholds of 92%–95% and that there is a modest degree of practice variability. Pulse oximetry has many characteristics that make it well suited to the care of children in the ED. Pulse oximetry is noninvasive and has been shown to correlate well with arterial blood gas measurements.<sup>11</sup> Oximetry data are reproducible and readily available in the ED.<sup>12,13</sup> Unlike other important factors in clinical decision-making (e.g., work of breathing or parental reliability), pulse oximetry yields a reliable, objective number that can be used for trending over time.

The introduction of pulse oximetry to the ED has changed physician practice over the past 15 years. A pediatric ED study from the late 1980s showed that, in a group of 1100 wheezing children, physicians blinded to oximetry values discharged 17 (57%) of 30 hypoxic patients whose oximetry readings ranged from 83% to 88%.<sup>14</sup> This study was terminated after 5 months because pulse oximetry clearly influenced physician discharge decisions. More recent studies have shown that pulse oximetry influences physician decision-making,<sup>1,15</sup> but that it does not correlate well with clinical examination findings or patient outcome.<sup>16–19</sup> In our survey of physicians practising near sea level, all but 1 (99.5%) chose values >90% as the lowest pulse oximetry reading they would accept and still discharge a young child with a respiratory illness.

The oxyhemoglobin dissociation curve describes the relationship between hemoglobin oxygen saturation ( $SaO_2$ ) and the partial pressure of arterial oxygen ( $PaO_2$ ).<sup>20</sup> This curve has a sigmoid shape, such that at  $PaO_2$  values over 60 mm Hg, there is relatively little change in  $SaO_2$  with changing  $PaO_2$ . Under normal circumstances, a  $PaO_2$  of 60 mm Hg corresponds to a  $SaO_2$  of 90%. But when  $PaO_2$  drops below 60 mm Hg, there is a steep slope to the curve and a proportionately large drop in  $SaO_2$  with falling  $PaO_2$ . This is a critical physiologic relationship for physicians to understand, and it suggests there may be value in setting a threshold value that influences physician decisions. A  $PaO_2$  of 60 mm Hg has been suggested,<sup>11</sup> and many use this level or an oxygen saturation <90% to define clinically important hypoxia in young children. While this is logical, we are unaware of any studies showing that the use of these criteria improves clinically important patient outcomes, and it is likely that many children in the “pre-oximetry” era were discharged home with saturation levels below 90%.<sup>14</sup>

### Limitations

This survey had a 65% response rate, and it is possible that

nonresponders may have been systematically different from responders. In addition, our study sample was drawn from a group who, by virtue of voluntary membership in a national subspecialty organization, have a high level of interest in pediatric emergency medicine. Their responses may differ from those of emergency physicians in general. Our survey has not been previously validated, and it did not assess the reasons that physicians select specific pulse oximetry thresholds. We assume that most physicians live and work at similar elevations, but it is possible that mailing addresses may not always accurately reflect the practice elevation. It is likely that physicians who practise at significant elevations use different oximetry discharge thresholds, but our sample included only a few physicians who practise above 1000 m sea level; therefore, we cannot make meaningful conclusions regarding this issue and it remains an area for future research.

Our study is the first to attempt to assess emergency physician practice variability in the use of pulse oximetry for discharge decisions. It suggests that most physicians use oximetry discharge thresholds of 92%–95% and that there is a modest degree of practice variability. Since no clinically validated, evidence-based oximetry discharge threshold has been identified, these data offer practising emergency physicians the opportunity to compare their own practice with that reported by this group. Further study is needed to determine whether a clinically validated, safe pulse oximetry discharge threshold can be established for children in the ED.

**Competing interests:** None declared.

**Acknowledgments:** We thank Steven M. Green and Tamara L. Thomas for their thoughtful reviews of this manuscript.

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