

## ORIGINAL RESEARCH

## Impact of Clinical History on Chest Radiograph Interpretation

Matthew Test, BS<sup>1\*</sup>, Samir S. Shah, MD, MSCE<sup>1,2,3</sup>, Michael Monuteaux, ScD<sup>4,6</sup>, Lilliam Ambroggio, PhD<sup>1</sup>,  
Edward Y. Lee, MD, MPH<sup>5</sup>, Richard I. Markowitz, MD<sup>7</sup>, Sarah Bixby, MD<sup>5</sup>, Stephanie Diperna, MD<sup>5</sup>,  
Sabah Servaes, MD<sup>7</sup>, Jeffrey C. Hellinger, MD<sup>8</sup>, Mark I. Neuman, MD, MPH<sup>4</sup>

<sup>1</sup>Division of Hospital Medicine; <sup>2</sup>Division of Infectious Diseases, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio; <sup>3</sup>Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio; <sup>4</sup>Division of Emergency Medicine, <sup>5</sup>Department of Radiology, and <sup>6</sup>Clinical Research Program, Boston Children's Hospital, Boston, Massachusetts; <sup>7</sup>Department of Radiology, Perlman School of Medicine at the University of Pennsylvania, Philadelphia, Pennsylvania; <sup>8</sup>Advanced Imaging and Informatics Laboratory, Stony Brook University Medical Center, Stony Brook, New York.

**BACKGROUND:** The inclusion of clinical information may have unrecognized influence in the interpretation of diagnostic testing.

**OBJECTIVE:** The objective of the study was to determine the impact of clinical history on chest radiograph interpretation in the diagnosis of pneumonia.

**DESIGN:** Prospective case-based study.

**METHODS:** Radiologists interpreted 110 radiographs of children evaluated for suspicion of pneumonia. Clinical information was withheld during the first interpretation. After 6 months the radiographs were reviewed with clinical information. Radiologists reported on pneumonia indicators described by the World Health Organization (ie, any infiltrate, alveolar infiltrate, interstitial infiltrate, air bronchograms, hilar adenopathy, pleural effusion).

**SETTING:** Children's Hospital of Philadelphia and Boston Children's Hospital.

**PARTICIPANTS:** Six board-certified radiologists.

**OUTCOME MEASURES:** Inter- and inter-rater reliability were assessed using the kappa statistic.

**RESULTS:** The addition of clinical history did not have a substantial impact on the inter-rater reliability in the identification of any infiltrate, alveolar infiltrate, interstitial infiltrate, pleural effusion, or hilar adenopathy. Inter-rater reliability in the identification of air bronchograms improved from fair ( $k = 0.32$ ) to moderate ( $k = 0.53$ ). Intra-rater reliability for the identification of alveolar infiltrate remained substantial to almost perfect for all 6 raters with and without clinical information. One rater had a decrease in inter-rater reliability from almost perfect ( $k = 1.0$ ) to fair ( $k = 0.21$ ) in the identification of interstitial infiltrate with the addition of clinical history.

**CONCLUSIONS:** Alveolar infiltrate and pleural effusion are findings with high intra- and inter-rater reliability in the diagnosis of bacterial pneumonia. The addition of clinical information did not have a substantial impact on the reliability of these findings. *Journal of Hospital Medicine* 2013;8:359–364. © 2012 Society of Hospital Medicine

The inclusion of clinical information in diagnostic testing may influence the interpretation of the clinical findings. Historical and clinical findings may focus the reader's attention to the relevant details, thereby improving the accuracy of the interpretation. However, such information may cause the reader to have preconceived notions about the results, biasing the overall interpretation.

The impact of clinical information on the interpretation of radiographic studies remains an issue of debate. Previous studies have found that clinical information improves the accuracy of radiographic interpretation for a broad range of diagnoses,<sup>1–4</sup> whereas others do not show improvement.<sup>5–7</sup> Additionally, clinical infor-

mation may serve as a distraction that leads to more false-positive interpretations.<sup>8</sup> For this reason, many radiologists prefer to review radiographs without knowledge of the clinical scenario prompting the study to avoid focusing on the expected findings and potentially missing other important abnormalities.<sup>9</sup>

The chest radiograph (CXR) is the most commonly used diagnostic imaging modality. Nevertheless, poor agreement exists among radiologists in the interpretation of chest radiographs for the diagnosis of pneumonia in both adults and children.<sup>10–15</sup> Recent studies have found a high degree of agreement among pediatric radiologists with implementation of the World Health Organization (WHO) criteria for standardized CXR interpretation for diagnosis of bacterial pneumonia in children.<sup>16–18</sup> In these studies, participants were blinded to the clinical presentation. Data investigating the impact of clinical history on CXR interpretation in the pediatric population are limited.<sup>19</sup>

We conducted this prospective case-based study to evaluate the impact of clinical information on the reliability of radiographic diagnosis of pneumonia among children presenting to a pediatric emergency department (ED) with clinical suspicion of pneumonia.

\*Address for correspondence and reprint requests: Samir S. Shah, MD, 3333 Burnet Avenue, ML 9016, Cincinnati Children's Hospital Medical Center, Cincinnati, OH 45229; Telephone: 513-636-6222; Fax: 513-636-4402; E-mail: samir.shah@cchmc.org

Additional Supporting Information may be found in the online version of this article.

Received: August 24, 2012; Revised: September 27, 2012; Accepted: October 5, 2012

2012 Society of Hospital Medicine DOI 10.1002/jhm.1991

Published online in Wiley Online Library (Wileyonlinelibrary.com).

## METHODS

### Study Subjects

Six board-certified radiologists at 2 academic children's hospitals (Children's Hospital of Philadelphia [n = 3] and Boston Children's Hospital [n = 3]) interpreted the same 110 chest radiographs (100 original and 10 duplicates) on 2 separate occasions. Clinical information was withheld during the first interpretation. The inter- and inter-rater reliability for the interpretation of these 110 radiographs without clinical information have been previously reported.<sup>18</sup> After a period of 6 months, the radiologists reviewed the radiographs with access to clinical information provided by the physician ordering the CXR. This clinical information included age, sex, clinical indication for obtaining the radiograph, relevant history, and physical examination findings. The radiologists did not have access to the patients' medical records. The radiologists varied with respect to the number of years practicing pediatric radiology (median, 8 years; range, 3–36 years).

Radiographs were selected from children who presented to the ED at Boston Children's Hospital with concern of pneumonia. We selected radiographs with a spectrum of respiratory disease processes encountered in a pediatric population. The final radiographs included 50 radiographs with a final reading in the medical record without suspicion for pneumonia and 50 radiographs with suspicion of pneumonia. In the latter group, 25 radiographs had a final reading suggestive of an alveolar infiltrate, and 25 radiographs had a final reading suggestive of an interstitial infiltrate. Ten duplicate radiographs were included.

### Radiograph Interpretation

The radiologists interpreted both anterior-posterior and lateral views for each subject. Digital Imaging and Communications in Medicine images were downloaded from a registry at Boston Children's Hospital, and were copied to DVDs that were provided to each radiologist. Standardized radiographic imaging software (eFilm Lite; Merge Healthcare, Chicago, Illinois) was used by each radiologist.

Each radiologist completed a study questionnaire for each radiograph (see Supporting Information, Appendix 1, in the online version of this article). The questionnaire utilized radiographic descriptors of primary endpoint pneumonia described by the WHO to standardize the radiographic diagnosis of pneumonia.<sup>20,21</sup> No additional training was provided to the radiologists. The main outcome of interest was the presence or absence of an infiltrate. Among radiographs in which an infiltrate was identified, radiologists selected whether there was an alveolar infiltrate, interstitial infiltrate, or both. Alveolar infiltrate and interstitial infiltrate are defined on the study questionnaire (Appendix 1). A radiograph classified as having either an alveolar infiltrate or interstitial infiltrate (not

atelectasis) was considered to have "any infiltrate." Additional findings including air bronchograms, hilar adenopathy, pleural effusion, and location of abnormalities were also recorded.

### Statistical Analysis

Inter-rater reliability was assessed using the kappa statistic to determine the overall agreement among the 6 radiologists for each outcome (eg, presence or absence of alveolar infiltrate). The kappa statistic for more than 2 raters utilizes an analysis of variance approach.<sup>22</sup> To calculate 95% confidence intervals (CI) for kappa statistics with more than 2 raters, we employed a bootstrapping method with 1000 replications of samples equal in size to the study sample. Intra-rater reliability was evaluated by examining the agreement within each radiologist upon review of 10 duplicate radiographs. We used the following benchmarks to classify the strength of agreement: poor (<0.0), slight (0–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), almost perfect (0.81–1.0).<sup>23</sup> Negative kappa values represent agreement less than would be predicted by chance alone.<sup>24,25</sup> To calculate the kappa, a value must be recorded in 3 of 4 of the following categories: negative to positive, positive to negative, concordant negative, and concordant positive reporting of pneumonia. If raters did not fulfill 3 categories, the kappa could not be calculated.

The inter-rater concordance for identification of an alveolar infiltrate was calculated for each radiologist by comparing their reporting of alveolar infiltrate with and without clinical history for each of the 100 radiographs. Radiographs that were identified by an individual rater as "no alveolar infiltrate" when read without clinical history, but those subsequently identified as "alveolar infiltrate" with clinical history were categorized as "negative to positive reporting of pneumonia with clinical history." Those that were identified as "alveolar infiltrate" but subsequently identified as "no alveolar infiltrate" were categorized as "positive to negative reporting of pneumonia with clinical history." Those radiographs in which there was no change in identification of alveolar infiltrate with clinical information were categorized as "concordant reporting of pneumonia."

The study was approved by the institutional review boards at both children's hospitals.

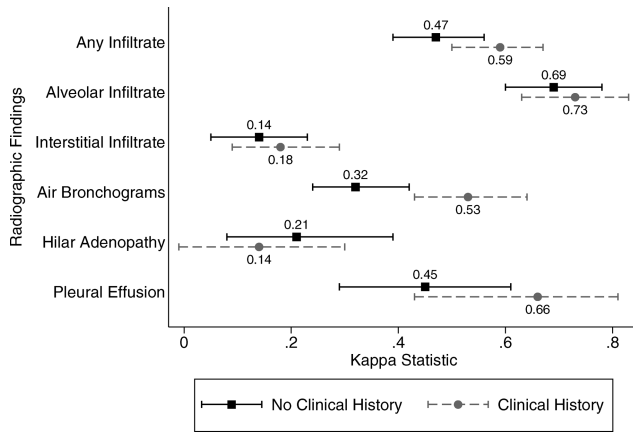
## RESULTS

### Patient Sample

The radiographs were from patients ranging in age from 1 week to 19 years (median, 3.5 years; interquartile range, 1.6–6.0 years). Fifty (50%) patients were male.

### Inter-rater Reliability

The kappa coefficients of inter-rater reliability between the radiologists across the 6 clinical measures



**FIG. 1.** Inter-rater reliability of radiologists ( $n = 6$ ) evaluating chest radiographs with and without access to clinical history data in children presenting to the emergency department with suspected pneumonia ( $n = 100$ ).

of interest with and without access to clinical history are plotted in Figure 1. Reliability improved from fair ( $k = 0.32$ , 95% CI: 0.24 to 0.42) to moderate ( $k = 0.53$ , 95% CI: 0.43 to 0.64) for identification of “air bronchograms” with the addition of clinical history. Although there was an increase in kappa values for identification of “any infiltrate,” “alveolar infiltrate,” “interstitial infiltrate,” and “pleural effusion,” and a decrease in the kappa value for identification of “hilar adenopathy” with the addition of clinical information, there was substantial overlap of the 95% CIs, suggesting that inclusion of clinical history did not result in a statistically significant change in the reliability of these findings.

### Intra-rater Reliability

The estimates of inter-rater reliability for the interpretation of the 10 duplicate images with and without clinical history are shown in Table 1. The inter-rater reliability in the identification of “alveolar infiltrate” remained substantial to almost perfect for each rater with and without access to clinical history. Rater 1 had a decrease in inter-rater reliability from almost perfect ( $k = 1.0$ , 95% CI: 1.0 to 1.0) to fair ( $k = 0.21$ , 95% CI:  $-0.43$  to 0.85) in the identification of “interstitial infiltrate” with the addition of clinical history. This rater also had a decrease in agreement from almost perfect ( $k = 1.0$ , 95% CI: 1.0 to 1.0) to fair ( $k = 0.4$ , 95% CI:  $-0.16$  to 0.96) in the identification of “any infiltrate.”

### Intra-rater Concordance

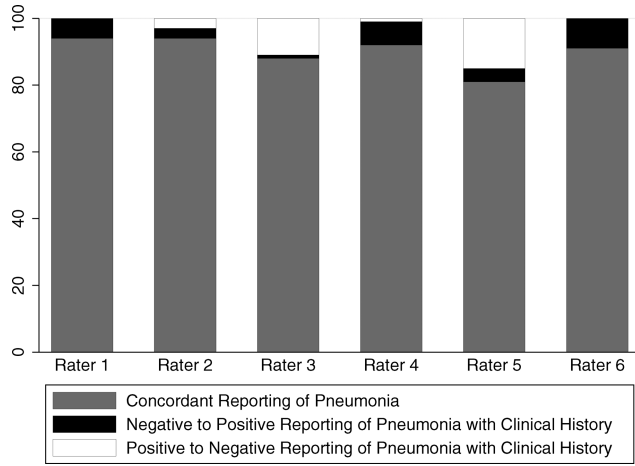
The inter-rater concordance of the radiologists for the identification of alveolar infiltrate during the interpretation of the 100 chest radiographs with and without access to clinical history is shown in Figure 2. The availability of clinical information impacted physicians differently in the evaluation of alveolar infiltrates. Raters 1, 4, and 6 appeared more likely to identify an alveolar infiltrate with access to the clinical information, whereas raters 3 and 5 appeared less likely to identify an alveolar infiltrate. Of the 100 films that were interpreted with and without clinical information, the mean number of discordant interpretations per rater was 10, with values ranging from 6 to 19 for the individual raters. Radiographs in which more than 3 raters changed their interpretation

**TABLE 1.** Intra-rater Reliability of Radiologists With and Without Access to Clinical History While Evaluating Chest Radiographs ( $n = 10$ ) for Pneumonia in Children

	Phase 1—No Clinical History		Phase 2—Access to Clinical History	
	Kappa	95% Confidence Interval	Kappa	95% Confidence Interval
<b>Any infiltrate</b>				
Rater 1	1.00	1.00 to 1.00	0.40	$-0.16$ to 0.96
Rater 2	0.60	0.10 to 1.00	0.58	0.07 to 1.00
Rater 3	0.80	0.44 to 1.00	0.80	0.44 to 1.00
Rater 4	1.00	1.00 to 1.00	0.78	0.39 to 1.00
Rater 5	N/A*	—	$-0.11$	$-0.36$ to 0.14
Rater 6	1.00	1.00 to 1.00	1.00	1.00 to 1.00
<b>Alveolar infiltrate</b>				
Rater 1	1.00	1.00 to 1.00	1.00	1.00 to 1.00
Rater 2	1.00	1.00 to 1.00	1.00	1.00 to 1.00
Rater 3	1.00	1.00 to 1.00	1.00	1.00 to 1.00
Rater 4	1.00	1.00 to 1.00	0.78	0.39 to 1.00
Rater 5	0.78	0.39 to 1.00	1.00	1.00 to 1.00
Rater 6	0.74	0.27 to 1.00	0.78	0.39 to 1.00
<b>Interstitial infiltrate</b>				
Rater 1	1.00	1.00 to 1.00	0.21	$-0.43$ to 0.85
Rater 2	0.21	$-0.43$ to 0.85	$-0.11$	$-0.36$ to 0.14
Rater 3	0.74	0.27 to 1.00	0.78	0.39 to 1.00
Rater 4	N/A†	—	N/A†	—
Rater 5	0.58	0.07 to 1.00	0.52	$-0.05$ to 1.00
Rater 6	0.62	$-0.5$ to 1.00	N/A*	—

NOTE: Abbreviations: N/A, not applicable.

\* Too few categories of agreement to calculate kappa. † Both responses are negative for all 10 paired radiographs; kappa cannot be calculated.



**FIG. 2.** Intra-rater concordance of radiologists before and after access to clinical history while evaluating chest radiographs (n = 100) for alveolar infiltrate in children.

regarding the presence of an alveolar infiltrate are shown in Figure 3. For Figure 3D, 4 radiologists changed their interpretation from “no alveolar infiltrate” to “alveolar infiltrate,” and 1 radiologist changed from “alveolar infiltrate” to “no alveolar infiltrate” with the addition of clinical history.

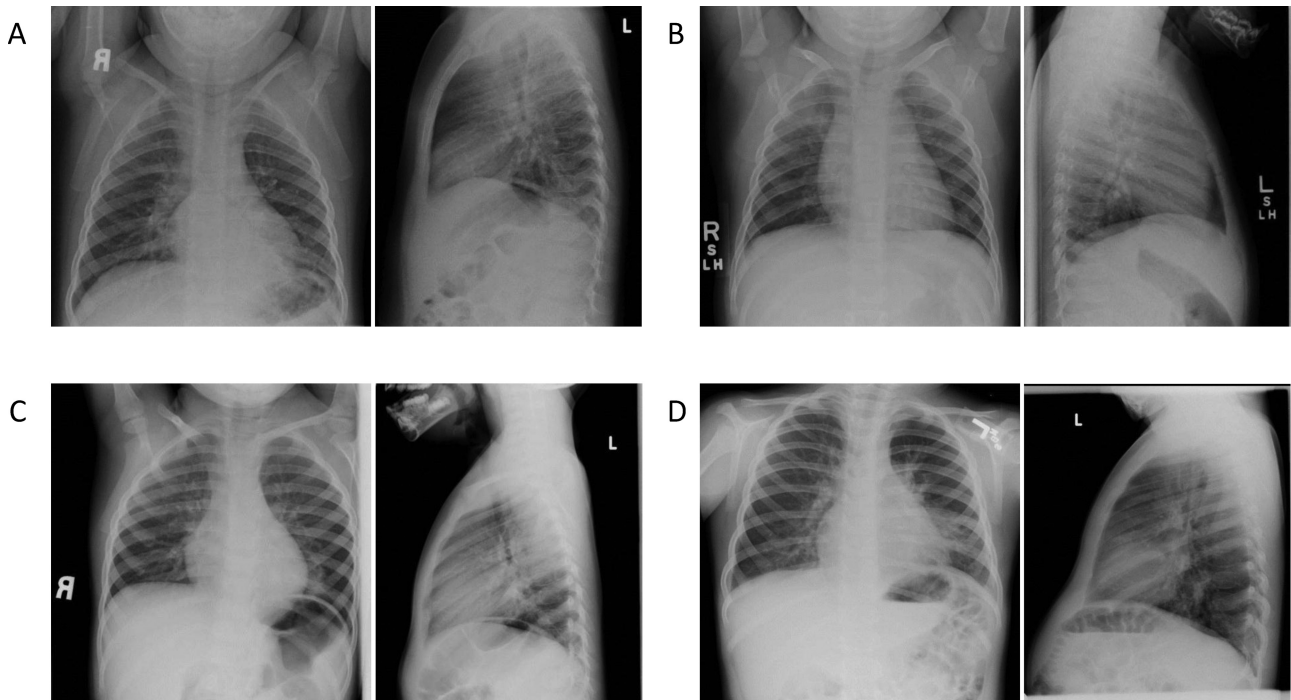
**Comment**

We investigated the impact of the availability of clinical information on the reliability of chest radiographic interpretation in the diagnosis of pneumonia. There was improved inter-rater reliability in the identification of air bronchograms with the addition of clinical

information; however, clinical history did not have a substantial impact on the inter-rater reliability of other findings. The addition of clinical information did not alter the inter-rater reliability in the identification of alveolar infiltrate. Clinical history affected individual raters differently in their interpretation of alveolar infiltrate, with 3 raters more likely to identify an alveolar infiltrate and 2 raters less likely to identify an alveolar infiltrate.

Most studies addressing the impact of clinical history on radiographic interpretation evaluated accuracy. In many of these studies, accuracy was defined as the raters’ agreement with the final interpretation of each film as documented in the medical record or their agreement with the interpretation of the radiologists selecting the cases.<sup>1-3,5-7</sup> Given the known inter-rater variability in radiographic interpretation,<sup>10-15</sup> accuracy of a radiologist’s interpretation cannot be appropriately assessed through agreement with their peers. Because a true measure of accuracy in the radiographic diagnosis of pneumonia can only be determined through invasive testing, such as lung biopsy, reliability serves as a more appropriate measure of performance. Inclusion of clinical information in chest radiograph interpretation has been shown to improve reliability in the radiographic diagnosis of a broad range of conditions.<sup>15</sup>

The primary outcome in this study was the identification of an infiltrate. Previous studies have noted consistent identification of the radiographic features that are most suggestive of bacterial pneumonia, such



**FIG. 3.** Chest radiographs of children in which 3 or more radiologists changed their interpretation in regard to the presence or absence of an alveolar infiltrate with the addition of clinical information. (A, B, and C) Three of 6 radiologists changed their interpretation. (D) Five of 6 radiologists changed their interpretation. (A) Female, 2 years old. (B) Male, 9 months old. (C) Male, 3 years old. (D) Male, 3 years old. The clinical history provided for (D) read as follows: “3-year-old male with cough and difficulty breathing. Rales at left base.”

as alveolar infiltrate, and less consistent identification of other radiographic findings, including interstitial infiltrate.<sup>18,26,27</sup> Among the radiologists in this study, the addition of clinical information did not have a meaningful impact on the reliability of either of these findings, as there was substantial inter-rater agreement for the identification of alveolar infiltrate and only slight agreement for the identification of interstitial infiltrate, both with and without clinical history. Additionally, inter-rater reliability for the identification of alveolar infiltrate remained substantial to almost perfect for all 6 raters with the addition of clinical information.

Clinical information impacted the raters differently in their pattern of alveolar infiltrate identification, suggesting that radiologists may differ in their approach to incorporating clinical history in the interpretation of chest radiographs. The inclusion of clinical information may impact a radiologist's perception, leading to improved identification of abnormalities; however, it may also guide their decision making about the relevance of previously identified abnormalities.<sup>28</sup> Some radiologists may use clinical information to support or suggest possible radiographic findings, whereas others may use the information to challenge potential findings. This study did not address the manner in which the individual raters utilized the clinical history. There were also several radiographs in which the clinical information resulted in a change in the identification of an alveolar infiltrate by 3 or more raters, with as many as 5 of 6 raters changing their interpretation for 1 particular radiograph. These changes in identification of an infiltrate suggest that unidentified aspects of a history may be likely to influence a rater's interpretation of a radiograph. Nevertheless, these changes did not result in improved reliability and it is not possible to determine if these changes resulted in improved accuracy in interpretation.

This study had several limitations. First, radiographs were purposefully selected to encompass a broad spectrum of radiographic findings. Thus, the prevalence of pneumonia and other abnormal findings was artificially higher than typically observed among a cohort of children for whom pneumonia is considered. Second, the radiologists recruited for this study all practice in an academic children's hospital setting. These factors may limit the generalizability of our findings. However, we would expect these results to be generalizable to pediatric radiologists from other academic institutions. Third, this study does not meet the criteria of a balanced study design as defined by Loy and Irwig.<sup>19</sup> A study was characterized as balanced if half of the radiographs were read with and half without clinical information in each of the 2 reading sessions. The proposed benefit of such a design is to control for possible changes in ability or reporting practices of the raters that may have occurred between study periods. The use of a standard-

dized reporting tool likely minimized changes in reporting practices. Also, it is unlikely that the ability or reporting practices of an experienced radiologist would change over the study period. Fourth, the radiologists interpreted the films outside of their standard workflow and utilized a standardized reporting tool that focused on the presence or absence of pneumonia indicators. These factors may have increased the radiologists' suspicion for pneumonia even in the absence of clinical information. This may have biased the results toward finding no difference in the identification of pneumonia with the addition of detailed clinical history. Thus, the inclusion of clinical information in radiograph interpretation in clinical practice may have greater impact on the identification of these pneumonia indicators than was found in this study.<sup>29</sup> Finally, reliability does not imply accuracy, and it is unknown if changes in the identification of pneumonia indicators led to more accurate interpretation with respect to the clinical or pathologic diagnosis of pneumonia.

In conclusion, we observed high intra- and inter-rater reliability among radiologists in the identification of an alveolar infiltrate, the radiographic finding most suggestive of bacterial pneumonia.<sup>16-18,30</sup> The addition of clinical information did not have a substantial impact on the reliability of its identification.

Disclosures: Samir S. Shah MD, and Michael Monuteaux, ScD, had full access to the data. Related publication: Neuman MI, Lee EY, Bixby S, et al. Variability in the interpretation of chest radiographs for the diagnosis of pneumonia in children. *J Hosp Med.* 2012;7:294-298. The authors have no funding, financial relationships, or conflicts of interest to disclose.

## References

- Berbaum KS, Franken EA Jr, Dorfman DD, et al. Tentative diagnoses facilitate the detection of diverse lesions in chest radiographs. *Invest Radiol.* 1986;21(7):532-539.
- Berbaum KS, Franken EA Jr, Dorfman DD, Barloon TJ. Influence of clinical history upon detection of nodules and other lesions. *Invest Radiol.* 1988;23(1):48-55.
- Berbaum KS, Franken EA Jr, Dorfman DD, Lueben KR. Influence of clinical history on perception of abnormalities in pediatric radiographs. *Acad Radiol.* 1994;1(3):217-223.
- Song KS, Song HH, Park SH, et al. Impact of clinical history on film interpretation. *Yonsei Med J.* 1992;33(2):168-172.
- Cooperstein LA, Good BC, Eelkema EA, et al. The effect of clinical history on chest radiograph interpretations in a PACS environment. *Invest Radiol.* 1990;25(6):670-674.
- Good BC, Cooperstein LA, DeMarino GB, et al. Does knowledge of the clinical history affect the accuracy of chest radiograph interpretation? *AJR Am J Roentgenol.* 1990;154(4):709-712.
- Quekel LG, Goei R, Kessels AG, van Engelsehoven JM. Detection of lung cancer on the chest radiograph: impact of previous films, clinical information, double reading, and dual reading. *J Clin Epidemiol.* 2001;54(11):1146-1150.
- Eldevik OP, Dugstad G, Orrison WW, Haughton VM. The effect of clinical bias on the interpretation of myelography and spinal computed tomography. *Radiology.* 1982;145(1):85-89.
- Griscom NT. A suggestion: look at the images first, before you read the history. *Radiology.* 2002;223(1):9-10.
- Albaum MN, Hill LC, Murphy M, et al. Interobserver reliability of the chest radiograph in community-acquired pneumonia. PORT Investigators. *Chest.* 1996;110(2):343-350.
- Bloomfield FH, Teele RL, Voss M, Knight DB, Harding JE. Inter- and intra-observer variability in the assessment of atelectasis and consolidation in neonatal chest radiographs. *Pediatr Radiol.* 1999;29(6):459-462.
- Gatt ME, Spectre G, Paltiel O, Hiller N, Stalnikowicz R. Chest radiographs in the emergency department: is the radiologist really necessary? *Postgrad Med J.* 2003;79(930):214-217.
- Hopstaken RM, Witbraad T, van Engelsehoven JM, Dinant GJ. Inter-observer variation in the interpretation of chest radiographs for

- pneumonia in community-acquired lower respiratory tract infections. *Clin Radiol*. 2004;59(8):743–752.
14. Novack V, Avnon LS, Smolyakov A, Barnea R, Jotkowitz A, Schlaeffer F. Disagreement in the interpretation of chest radiographs among specialists and clinical outcomes of patients hospitalized with suspected pneumonia. *Eur J Intern Med*. 2006;17(1):43–47.
  15. Tudor GR, Finlay D, Taub N. An assessment of inter-observer agreement and accuracy when reporting plain radiographs. *Clin Radiol*. 1997;52(3):235–238.
  16. Shimol BS, Dagan R, Givon-Lavi N, et al. Evaluation of the World Health Organization criteria for chest radiographs for pneumonia diagnosis in children. *Eur J Pediatr*. 2011;171(2):369–374.
  17. Cherian T, Mulholland EK, Carlin JB, et al. Standardized interpretation of paediatric chest radiographs for the diagnosis of pneumonia in epidemiological studies. *Bull World Health Organ*. 2005;83(5):353–359.
  18. Neuman MI, Lee EY, Bixby S, et al. Variability in the interpretation of chest radiographs for the diagnosis of pneumonia in children. *J Hosp Med*. 2012;7(4):294–298.
  19. Loy CT, Irwig L. Accuracy of diagnostic tests read with and without clinical information: a systematic review. *JAMA*. 2004;292(13):1602–1609.
  20. Standardization of interpretation of chest radiographs for the diagnosis of pneumonia in children. In: World Health Organization: Pneumonia Vaccine Trial Investigators' Group. Geneva: Department of Vaccine and Biologics; 2001.
  21. Hansen J, Black S, Shinefield H, et al. Effectiveness of heptavalent pneumococcal conjugate vaccine in children younger than 5 years of age for prevention of pneumonia: updated analysis using World Health Organization standardized interpretation of chest radiographs. *Pediatr Infect Dis J*. 2006;25(9):779–781.
  22. Landis JR, Koch GG. A one-way components of variance model for categorical data. *Biometrics*. 1977;33:671–679.
  23. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159–174.
  24. Juurlink DN, Detsky AS. Kappa statistic. *CMAJ*. 2005;173(1):16.
  25. Kramer MS, Feinstein AR. Clinical biostatistics. LIV. The biostatistics of concordance. *Clin Pharmacol Ther*. 1981;29(1):111–123.
  26. Bartlett JG, Dowell SF, Mandell LA, File TM Jr, Musher DM, Fine MJ. Practice guidelines for the management of community-acquired pneumonia in adults. Infectious Diseases Society of America. *Clin Infect Dis*. 2000;31(2):347–382.
  27. Niederman MS, Mandell LA, Anzueto A, et al. Guidelines for the management of adults with community-acquired pneumonia. Diagnosis, assessment of severity, antimicrobial therapy, and prevention. *Am J Respir Crit Care Med*. 2001;163(7):1730–1754.
  28. Berbaum KS, Franken EA Jr. Commentary does clinical history affect perception? *Acad Radiol*. 2006;13(3):402–403.
  29. Berbaum KS, Franken EA Jr. The effect of clinical history on chest radiograph interpretations in a PACS environment. *Invest Radiol*. 1991;26(5):512–514.
  30. Korppi M, Kiekara O, Heiskanen-Kosma T, Soimakallio S. Comparison of radiological findings and microbial aetiology of childhood pneumonia. *Acta Paediatr*. 1993;82(4):360–363.