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Official publication of the American College of Chest Physicians



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*Chest* 2007;132:1162-1168; Prepublished online June 5, 2007;  
DOI 10.1378/chest.06-2722

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A M E R I C A N C O L L E G E O F  
 **C H E S T**  
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## Spirometry Can Be Done in Family Physicians' Offices and Alters Clinical Decisions in Management of Asthma and COPD\*

Barbara P. Yawn, MD, MSc; Paul L. Enright, MD; Robert F. Lemanske Jr, MD; Elliot Israel, MD, FCCP; Wilson Pace, MD; Peter Wollan, PhD; and Homer Boushey, MD

**Background:** Spirometry is recommended for diagnosis and management of obstructive lung disease. While many patients with asthma and COPD are cared for by primary care practices, limited data are available on the use and results associated with spirometry in primary care.

**Object:** To assess the technical adequacy, accuracy of interpretation, and impact of office spirometry.

**Design:** A before-and-after quasiexperimental design.

**Setting:** Three hundred eighty-two patients from 12 family medicine practices across the United States.

**Participants:** Patients with asthma and COPD, and staff from the 12 practices.

**Measurements:** Technical adequacy of spirometry results, concordance between family physician and pulmonary expert interpretations of spirometry test results, and changes in asthma and COPD management following spirometry testing.

**Results:** Of the 368 tests completed over the 6 months, 71% were technically adequate for interpretation. Family physician and pulmonary expert interpretations were concordant in 76% of completed tests. Spirometry was followed by changes in management in 48% of subjects with completed tests, including 107 medication changes (>85% concordant with guideline recommendations) and 102 nonpharmacologic changes. Concordance between family physician and expert interpretations of spirometry results was higher in those patients with asthma compared to those with COPD.

**Discussion and conclusions:** US family physicians can perform and interpret spirometry for asthma and COPD patients at rates comparable to those published in the literature for international primary care studies, and the spirometry results modify care. (CHEST 2007; 132:1162-1168)

**Key words:** asthma; COPD; disease management; practice-based research; primary care; spirometry; translational research

Primary care physicians diagnose and care for a significant portion of the millions of Americans with asthma and COPD.<sup>1</sup> Yet, debate continues regarding the appropriateness, value, and barriers related to in-office spirometry in primary care practices for management of obstructive lung diseases.<sup>2-14</sup> Studies show that technically adequate spirometry is possible,<sup>6</sup> that screening spirometry of all primary care patients who smoke can identify COPD and modify some COPD treatment,<sup>15,16</sup> and that spirometry in children can be interpreted in primary

care practices.<sup>17</sup> A vignette study<sup>18</sup> suggests that family physicians would use spirometry results to modify management of COPD, but no study has

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assessed the impact of incorporating spirometry into the everyday management of family medicine patients with existing diagnoses of asthma or COPD.

We introduced office spirometry into 12 community-based family medicine practices scattered through-

out the United States to assess the impact of onsite spirometry in the management of previously diagnosed COPD or asthma. We also assessed the technical adequacy and accuracy of interpretation of the tests performed. This real-world study adds another dimension to published data<sup>6,11,15-17,19,20</sup> from other countries.

## MATERIALS AND METHODS

Using a before-and-after quasiexperimental design, spirometers (Easy One; ndd Medizintechnik AG; Zurich, Switzerland) were introduced into 12 nonacademic family medicine practices without prior use of in-office spirometry. The practices were randomly selected from 35 of the 112 practices of the American Academy of Family Physicians National Research Network that volunteered for this study.<sup>21,22</sup> From each practice, a physician and the person who would administer spirometry participated in an intensive 2-day training session on performance and interpretation of spirometry led by authors E.I., R.L., P.E., B.Y., and S.S.

The Easy One device was chosen for its modest capacity and stability precluding the requirement of daily calibration.<sup>23</sup> The output was standardized: single "best flow volume loop", FEV<sub>1</sub> and FVC in milliliters and percentage of predicted, the FEV<sub>1</sub>/FVC ratio,<sup>24-27</sup> a grade of the technical adequacy (A through F), and a suggested interpretation of the results. FVC was used in preference to forced expiratory volume in 6 s due to the inclusion of children in the study who frequently reach a plateau prior to 6 s of expiration.<sup>28</sup>

After receiving institutional review board approval, each site spent the next 6 months enrolling patients >7 years old with a previously documented diagnosis of asthma or COPD and were attending the office for an asthma- or COPD-related visit. Thus, spirometry was incorporated into everyday practice rather than being used only as a research tool or screening add-on or a test requiring referral.<sup>15,16,19</sup> Prior lung function testing was not required to confirm the diagnosis of asthma or COPD. Only two patients refused to participate.

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Funding was provided by grants from the National Heart, Lung, and Blood Institute, National Institutes of Health: University of Wisconsin at Madison #HL074212-03; Harvard Medical School #HL074227; and University of California at San Francisco #HL074204.

Dr. Enright is a paid consultant to ndd Medizintechnik AG. The other authors have no conflicts of interest to disclose. Manuscript received February 1, 2007; revision accepted April 26, 2007.

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DOI: 10.1378/chest.06-2722

Enrolled patients provided demographic and disease-related information including current symptoms, perceived severity, and level of disease control. Nursing staff documented current medications on the study forms. Physician visits proceeded as usual without the use of spirometry, and at the end of the visit the physician documented the therapy recommended that day using a list of the common asthma and COPD medications with ranges of dosages. This was the "before" data.

The patient then underwent spirometry, and a copy of the results was reviewed by the family physician who recorded his/her interpretation of the results on the study forms. The physician again saw the patient (during the same visit) for a quick follow-up to discuss test results and make any desired changes to the management plan, which were recorded on the "after" section of the study forms using a medication checklist and for nonmedication changes answering the question: "Would you make any nonmedication changes after seeing the spirometry results? If yes, please describe." Responses included "more frequent follow-up," "referral to evaluate a non-COPD diagnosis," or "repeat spirometry testing in 3 months." A combination of patient-provided symptom information, spirometry results, and before-and-after medications allowed us to judge whether the medications appeared to be consistent or inconsistent with National Asthma Education and Prevention Program<sup>24</sup> or Global Initiative for Chronic Obstructive Lung Disease<sup>25</sup> guidelines.

Copies of the spirometry results and the family physician's interpretation were sent to one of the experts for their review and scoring. Technical adequacy of all tracings was scored by P.E. based on published American Thoracic Society and European Respiratory Society criteria as adequate or inadequate.<sup>23,26,27</sup> The family physician's interpretation was assessed as concordant or nonconcordant with the expert's review (R.L., E.I. or H.B.) based on standard criteria for obstruction, restriction, and asthma.<sup>24,29</sup> "Nonconcordant" results were further subclassified into "obstruction reported but not present," "obstruction present but not reported," "obstruction less severe than reported," or "other abnormality present but not reported." The concordance between the Easy One reading and the expert review was also assessed.

### Statistical Analysis

Simple descriptive statistics were used to assess rates of management change by comparing before-and-after data for medications and nonmedication management, rates of technical adequacy, and rates of agreement. Rates of nonconcordance were compared using  $\chi^2$  and Mantel Haenzel tests.

## RESULTS

The 12 practice investigators were all family physicians working in communities with populations  $\leq 100,000$ . The 382 patients were mainly women (63%) and adults (76%) with a mean age of 46.1 years (SD, 19.9 years; range, 7 to 89 years). Overall, 248 patients (65%) had a previous diagnosis of asthma only, 100 patients (26%) had COPD only, and 32 patients (8%) had both asthma and COPD.

Of the 382 patients, 2 patients withdrew before testing and 12 others never completed a test maneuver. Ten of these 12 patients were <9 years old ( $n = 4$ ) or >70 years old ( $n = 6$ ). Of the 368 completed tests, 261 tests (71%) were considered to be technically "good" (Fig 1, 2). For 66 tests (18%), the

## Spirometry Outcomes

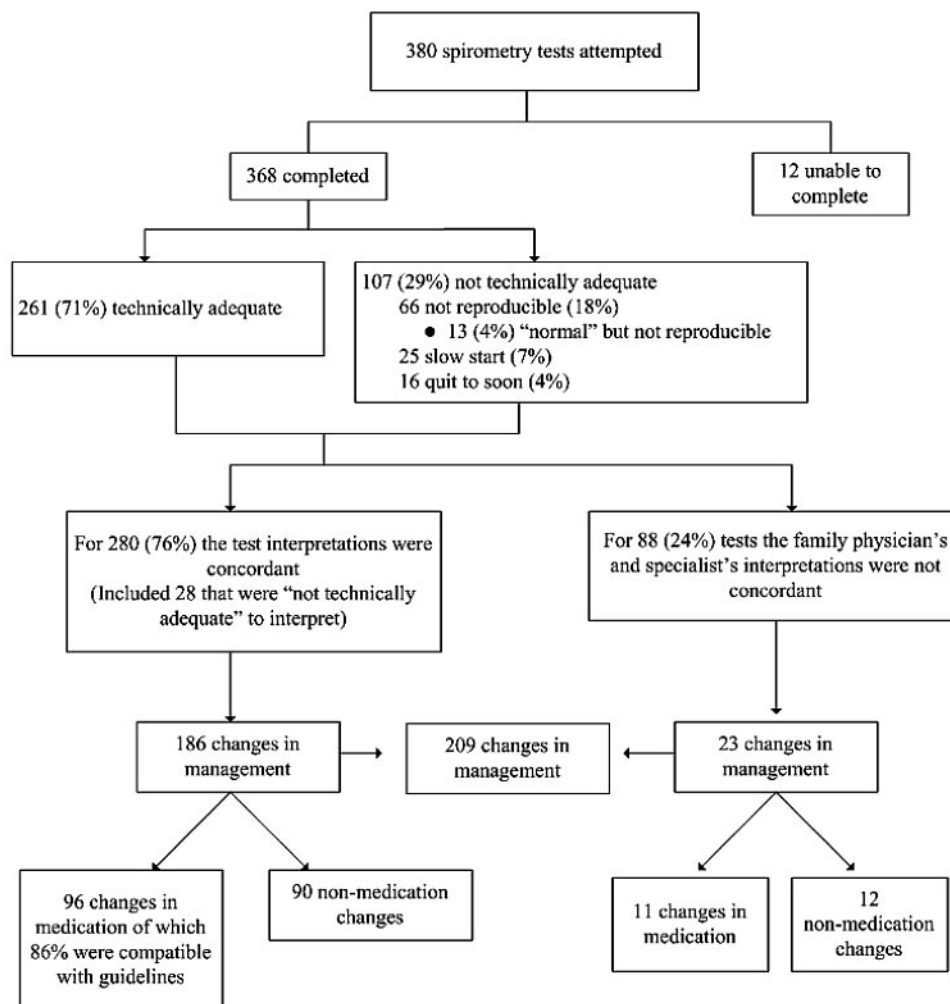


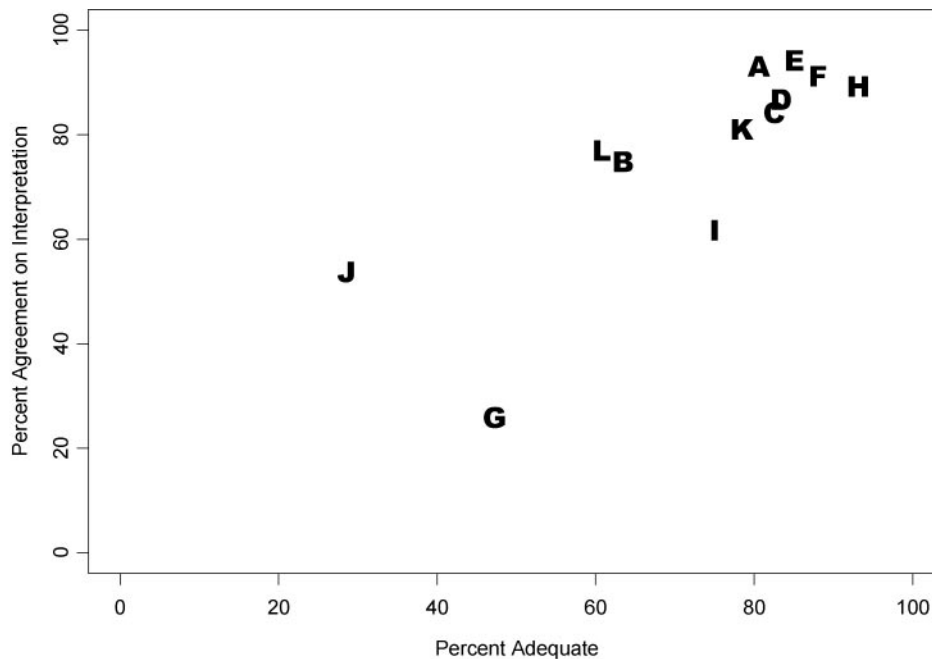
FIGURE 1. Spirometry outcomes.

results were not reproducible; in 16 tests (4%), the best maneuver was <4 s in duration and did not reach a plateau; and in 25 tests (7%), the best maneuver showed a slow start. Among the group of subjects with nonreproducible maneuvers, 13 tests had one result that was technically good and interpreted as normal. The percentage of tests that were reproducible and technically adequate varied by practice site ( $p = 0.045$  for a difference in rates of technical adequacy among practices) [Fig 2], with 7 of the 12 sites having technical adequacy rates >80%.

Interpretations of the spirometry results were concordant in 280 patients (76% of all completed tests) [Table 1; Fig 2], including 28 tests rated as “not interpretable” by both the family physician and the lung specialist. The percentage of nonconcordance was higher in people with prior COPD diagnoses

compared to those with prior asthma diagnoses (30.0% vs 19.8%, respectively;  $p < 0.05$ ; Table 1). Common types of nonconcordance included overreporting of airflow obstruction in those with normal spirometry results, interpreting restrictive patterns in people with poor effort, and an affirmation of COPD in the absence of an FEV<sub>1</sub>/FVC ratio <70% (Table 1). Approximately 3% of the spirometry tracings had complex or combination abnormalities (such as restriction combined with obstruction) that the family physician often did not even attempt to interpret except as “unknown” or “abnormal.”

ndd Medizintechnik AG and the expert review were concordant in 93.7% of tests. All but one of the nonconcordant interpretations were read as “restrictive pattern” by ndd Medizintechnik AG, but the experts determined the tests to be inadequate due to poor effort.



\* N = number of spirometries

Number of spirometries completed by site:

A	B	C	D	E	F	G	H	I	J	K	L
33	41	40	24	20	25	30	30	32	33	33	27

FIGURE 2. Spirometry by site.

Comparing before-and-after data demonstrated 207 reported changes in management in 182 of the 382 patients tested (48%), with decisions in 186 of 207 patients based on technically accurate and correctly interpreted tests (Fig 2). Over half (n = 107, 51.6%) were changes in medications that are described in Table 2. Most medication increases were for “mild” disease reclassified as moderate or severe asthma or COPD after spirometry assessment. Nor-

mal spirometry results were associated with six medication decreases or discontinuations.

Overall, 86% of the medication changes were consistent with the Global Initiative for Chronic Obstructive Lung Disease guidelines<sup>25</sup> for COPD management or the 2002 National Asthma Education and Prevention Program guidelines<sup>30</sup> for asthma management. Two thirds of the medication changes that appeared to be inconsistent with guidelines

**Table 1—Categories of Agreement of Interpretation\***

Categories of Specialist Interpretation	Preexisting Diagnosis of Asthma (n = 248)	Preexisting Diagnosis of COPD (n = 100)	Preexisting Diagnosis of Asthma and COPD (n = 32)
Concordant	199 (80.2)	70 (70.0)	23 (75.0)
Nonconcordance	49 (19.8)	30 (30.0)	9 (25.0)
Expert opinion that was not reported by the family physician			
Not interpretable	17 (6.9)	4 (4.0)	2 (6.2)
No obstruction	22 (8.9)	18 (18)	5 (15.6)
Shows obstruction	9 (3.6)	3 (3)	1 (3.1)
Other†	1 (0.4)	5 (5)	1 (3.1)

\*Data are presented as No. of times that interpretation agreed or differed from the family physician’s interpretation (%).

†Of these seven patients, five had restrictive disease and two had combined restrictive and obstructive disease.

**Table 2—Management Changes Following Spirometry  
182 Patients**

Variables	Patients, No.
Medication changes (n = 107)	
Additions of new drugs (n = 47)	
Short-acting bronchodilator	2
Inhaled steroids	16
Long-acting bronchodilator	11
Second bronchodilator	6
Combination therapy	12
Increased dose of same drug (n = 42)	
Short-acting bronchodilator	5
Inhaled steroids	10
Long-acting bronchodilator	7
Combination therapy	20
Decreased or discontinued drug (n = 6)	
Short-acting bronchodilator	2
Long-acting bronchodilator	2
Combination therapy	2
Replaced drug (n = 12)	
All theophylline	12
Nonmedication changes (n = 75)	
Intense smoking cessation	16
Repeat spirometry test in 3 to 6 mo	14
Order additional diagnostic tests*	12
Plan more frequent follow-up visits	12
Reassess diagnosis*	11
Refer to pulmonologist or cardiologist*	10
Medication and nonmedication change combinations (n = 27)	
Smoking cessation and medication increase	12
Increased visit frequency and medication increase	5
Repeat spirometry and medication increase	5
Asthma education and medication increase	4
Increased visit frequency and medication decrease	1

\*The 26 people included under these groups were found to have spirometry results not consistent with the previous diagnosis of asthma or COPD, or to have more severe COPD than anticipated (n = 7), and were referred to a pulmonologist for consultation on management.

were made following technically inadequate or incorrectly interpreted spirometry results.

Nonmedication management changes were made in 102 patients, 75 not associated with medication changes and 27 with a coincident change in medications (Table 2). Of particular note are the 19 patients referred for other potential diagnoses following normal spirometry findings, and 28 patients who were referred for co-management of severe obstructive lung disease.

## DISCUSSION

Incorporation of spirometry testing into these family medicine practices led to spirometry testing with acceptable levels of technical quality and con-

cordant interpretation and was followed by management changes for almost half of the patients. Poor technical quality and low rates of concordant interpretations were limited primarily to two practices (G and J in Fig 2).

Our results support previous work<sup>6,11,17,30–32</sup> demonstrating moderate-to-high levels of technical adequacy and ability to accurately interpret spirometry in primary care. Specifically, in Dutch general practices, a rate of technical adequacy of 82% was reported.<sup>6,31</sup> In 10 general pediatrician offices in Italy, 78% of the 109 tests were of technically good quality.<sup>17</sup> These are much higher than the technical adequacy rates of 52 to 66% reported in earlier studies<sup>5,33</sup> from general practitioner offices. Part of the improvement in technical adequacy may be a result of the newer spirometry equipment that grades each spirometry effort, providing immediate feedback related to technical adequacy. No threshold of technically acceptable rates has been established for primary care practices.<sup>5,14,26,34</sup> While the standards reported from the Lung Health Study<sup>35</sup> are optimal, it appears that rates closer to 80% technical adequacy are more realistic for both primary care and pulmonary function laboratories.<sup>6,17</sup>

Reproducibility was a major barrier to technical adequacy in our study, including 13 patients who had a single normal spirometry finding but could not repeat the results. Normal but nonreproducible results can be useful in guiding therapy<sup>36</sup> and would push our rates of clinically useful and interpretable spirometry to 75%. The addition of the complex studies that the family physicians correctly decided not to attempt to interpret push accuracy rates to 78%. Another important reason for nonconcordant readings were tests that experts suggested had inadequate effort that both the family physician and nnd Medizintechnik AG interpreted as “restrictive patterns” (n = 21). In these cases, nnd Medizintechnik AG was not helpful in suggesting interpretation of results.

Two sites with the poorest technical performance (G and J in Fig 2) reported that multiple nurses and medical assistants performed spirometry despite not being trained in spirometry techniques. The high rates of technical adequacy in the majority of the sites are reassuring, but problems in the sites using untrained staff highlight the need for simple, inexpensive, interactive education tools for spirometry performance.<sup>8,27,37</sup> The reasons for the low concordance of interpretation of the results in the same two sites with poor technical quality are unknown. Each site received individual feedback from specialists at the end of the study.

Few studies in the literature have assessed the

impact of incorporating spirometry into the management of previously diagnosed asthma or COPD. Buffels et al<sup>11</sup> reported that spirometry was helpful in identifying new COPD cases but did not assess the impact on management of known cases of COPD. Dales and colleagues<sup>15</sup> added screening spirometry to rural primary care practice for all smoker  $\geq 35$  years old, reporting 9% new diagnoses and 11% previous COPD diagnoses removed. For those with no change in diagnoses, 41% had reported medication changes, of which 8% were documented in medical record review. Walker and colleagues<sup>19</sup> offered "open access spirometry testing" (easy referral to a pulmonary laboratory) and reported testing was done but provided little information on the actual incorporation of spirometry into primary care practice. They did, however, report postspirometry increases in prescriptions for inhaled corticosteroids and long-acting bronchodilators, further supporting our findings of the effect of spirometry on patient management.

Chavannes et al<sup>16</sup> and Kaminsky et al<sup>18</sup> used vignette studies with spirometry data to conclude that spirometry had an impact on primary care clinical decision making. A study<sup>38</sup> of nurse-based protocol care reported that spirometry affected decision making in only 4% of 109 cases but assessed only the impact of worsening FEV<sub>1</sub>.

In our study, both normal and abnormal results appeared to be useful in determining the care for patients with asthma and COPD diagnoses. For example, 18 adults with COPD had normal spirometry results suggesting that their breathing symptoms were not due to COPD.<sup>25</sup> Three patients were referred to cardiologists for further evaluation, five patients were referred to pulmonologists for further testing, and the others were scheduled for further evaluation in the primary care office. Unlike the high rate of "overprescribing" reported by Walker et al,<sup>19</sup> most of the medication changes reported appeared to be consistent with guidelines. This may be due to greater current awareness of guidelines and concerns about over use of medications.

Generalization of our results is limited by the sample size of only 12 family physician practices. Our study should be repeated with a larger group of practices. However, similar findings in other studies<sup>5,6,17,31</sup> using different designs reinforce our practice-based data. We assessed the impact of only the first spirometry for these patients and therefore cannot assess the impact of repeated spirometry in chronic management of obstructive lung disease. Not requiring spirometry confirmation of all COPD diagnoses for patient inclusion in the study is likely to have increased the number of people found to not have COPD on spirometry.<sup>25</sup> In addition, the physicians

knew they were part of a research study and may have overreported changes in clinical practice. However, this overreporting would have had to last for 6 months, and few studies have shown the ability to modify physician behavior over such an extended period of time. In summary, our study demonstrates that spirometry can be incorporated into family medicine practice with acceptable levels of technical adequacy and accurate interpretations, and that the results influence management of patients with previously diagnosed asthma or COPD.

**ACKNOWLEDGMENT:** The authors appreciate the dedicated work of the staff of the National Research Network of the American Academy of Family Physicians, especially Jennifer Kappus, BS, Elias Brandt, and the members of the office staff and physicians of the 12 practices included in this study, as well as the help of Stuart Stoloff, MD, during the training sessions.

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