Concordance of Respiratory Care Plans Generated by Protocols From Different Hospitals: A Comparative Study

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OBJECTIVE: To assess whether respiratory care protocols from different hospitals result in similar care plans for identical patients, we asked: 1. Does applying respiratory care protocols from different hospitals to standardized patient vignettes produce identical care plans? 2. If there are differences in the care plans produced, what is the extent of the difference, and for which modalities are the differences greatest? 3. Does installing the protocol in a computerized information management system to generate the respiratory care plan improve the level of agreement? 4. Do protocols from different hospitals agree with regard to indications for respiratory care treatments and use of the Clinical Practice Guidelines from the American Association for Respiratory Care? METHODS: Protocols were compared by applying each of 4 hospitals' protocols to 15 patient vignettes that we developed, with various respiratory problems. With each vignette, 3 experienced respiratory therapist evaluators developed respiratory care plans, using both a manual (paper-based) and a computer-aided approach. RESULTS: The overall degree of agreement among the 4 protocols was moderate (kappa 0.60, 95% confidence interval 0.46–0.71). The degree of concordance differed for the individual respiratory care modalities; concordance was generally highest for oxygen, aerosol delivery, and pulse oximetry, and was lower for bronchopulmonary hygiene and hyperinflation. Concordance regarding indications for therapy also differed among the modalities; concordance was greatest for the indications for incentive spirometry, bronchodilator use, and pulse oximetry. The concordance of care plans developed with the computer-aided approach resembled that of the manual approach (kappa 0.62, 95% confidence interval 0.45–0.77). CONCLUSIONS: Our results suggest moderate agreement between care plans generated with respiratory care protocols from different hospitals. The sources of differences included differences in the indications for therapy, different degrees of protocol compliance with the American Association for Respiratory Care Clinical Practice Guidelines, and subjectivity in the indications for therapy. This study identifies opportunities to lessen regional variation in respiratory care, by encouraging uniform application of protocols and evidence-based guidelines. *Key words: protocols, respiratory care, clinical practice guidelines.* [Respir Care 2007;52(8):1006–1012. © 2007 Daedalus Enterprises]

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Introduction

Respiratory care protocols have gained widespread acceptance, based on evidence that their use can enhance the allocation of respiratory care services, by providing the right treatments to patients likely to benefit and not providing treatments to those unlikely to benefit.[1–4] With the goal to provide appropriate, effective care, many respiratory care protocols are based on evidence-based guidelines from various professional societies (eg, the American College of Chest Physicians, the American Thoracic Society, and the American College of Physicians[5–7]), and frequently on the Clinical Practice Guidelines (CPGs) developed by the American Association for Respiratory Care (AARC).[8] These CPGs were developed in the hope of "establishing appropriate practice, a desired result being reduced practice variability, in addition to appropriate practice."[8]

To the extent that respiratory care protocols aim to provide appropriate care and, in so doing, reduce unwarranted practice variation, it is reasonable to expect that protocols, even those from different institutions, would produce very similar or even identical respiratory care plans when applied to identical patients. To assess the degree of concordance among respiratory care protocols from different hospitals, we wrote 15 patient vignettes and applied them to respiratory care protocols from 4 different hospitals, then evaluated the degree to which the different protocols generated concordant respiratory care plans. In this study, the first of its kind to our knowledge, we addressed the following questions.

1. Does applying respiratory care protocols from 4 different hospitals to standardized patient vignettes produce identical care plans?
2. If there are differences in the care plans produced, what is the extent of the difference, and for which specific respiratory care modalities are the differences greatest?
3. Does using a computerized information management system to generate the respiratory care plans improve the agreement between the plans?
4. Do the 4 protocols agree with regard to indications for respiratory care treatments and their use of the AARC CPGs?

Methods

Protocols were compared by applying each of 4 hospitals' protocols to our 15 standardized patient vignettes, with the assumption that concordant protocols would prescribe identical respiratory care treatments to the patients described in the vignettes. The vignettes (Table 1) were developed for 15 separate patients with a variety of respiratory problems (eg, pneumonia, asthma, chronic obstructive pulmonary disease, neuromuscular disease, and ab-

Table 1. The 15 Clinical Vignettes Used in the Present Study

Patient 1. Pneumonia #1
Patient 2. Asthma
Patient 3. Chronic obstructive pulmonary disease*
Patient 4. Neuromuscular disease #1
Patient 5. Abdominal surgery
Patient 6. Upper abdominal bariatric surgery
Patient 7. Severe asthma
Patient 8. Neuromuscular disease #2
Patient 9. Pneumonia #2
Patient 10. Cancer - tracheostomy
Patient 11. Severe hypoxemia
Patient 12. Diabetic ketoacidosis and asthma
Patient 13. Aortic abdominal aneurysm repair
Patient 14. Rule out subacute bacterial endocarditis with chronic obstructive pulmonary disease
Patient 15. Acute gastrointestinal bleed

Example of a Clinical Vignette
Patient 3: Exacerbation of chronic obstructive pulmonary disease
History:
   This 5-foot 7-inch female is 51 years old, weighs 240 pounds, and has a history of chronic obstructive pulmonary disease, congestive heart failure, hypertension, asthma, obesity, and sleep apnea. She does not have a smoking history. She uses supplemental oxygen at home (2 L/min via nasal cannula), and albuterol, ipratropium, and fluticasone via metered-dose inhalers. She is experiencing increased shortness of breath and daytime sleepiness.
Assessment:
   Vital signs: heart rate 104 beats/min, blood pressure 183/75 mm Hg, respiratory rate 26 breaths/min, temperature (24-h maximum) 37.6°, measured orally
   Laboratory values: white blood cells 15,000 cells/μL, hemoglobin 9.3 g/L, platelets 359,000/μL
   Arterial blood gas values: pH 7.29, P_{aCO_2} 69 mm Hg, P_{aO_2} 67 mm Hg, HCO_3^- 33 mEq/L, oxygen saturation 90% while breathing 40% oxygen
   Chest radiograph: Bilateral opacities consistent with pulmonary edema or pneumonia
   Oxygen saturation measured via pulse oximetry (S_{pO_2}) 90% while breathing 50% oxygen via mask
   The patient is alert and oriented. Her breath sounds are decreased bilaterally with wheezing throughout. She has a strong cough that produces white frothy secretions. She is nonambulatory at this time.

dominal surgery). Each vignette contained all the clinical information needed to establish indications for commonly used respiratory care treatments (oxygen, aerosol, bronchopulmonary hygiene, hyperinflation, and pulse oximetry).

The protocols were provided to us from 4 United States hospitals that have extensive experience with a comprehensive evaluate-and-treat respiratory care protocol program: the University of California San Diego Medical Center, San Diego, California; Sioux Valley Hospital, Sioux Valley, South Dakota; the Cleveland Clinic, Cleveland, Ohio; and Kettering Medical Center, Dayton, Ohio. Permission to use the protocols was granted by the directors of the respective respiratory care departments. The study was approved by the Cleveland Clinic institutional review board.

For each of the 15 clinical vignettes, and with each of the 4 protocols, respiratory care plans were developed in 2 ways: a manual method and a computer-aided method. In the manual method, printed copies of the protocols were

first reviewed by each of 3 respiratory therapist evaluators (JK, EH, ML), each of whom had at least 5 years of experience using respiratory care protocols at the Cleveland Clinic. The printed protocols were then used independently by each reviewer (and with blinding to the other reviewers' care plans) to generate a respiratory care plan for each clinical vignette. The resulting care plans (15 vignettes × 4 protocols = 60 care plans from each evaluator) were compared for agreement.

To create the computer-aided method, each of the 4 branched logic protocols were programmed into the information management system (MediServe Information Systems, Tempe, Arizona) that we use at the Cleveland Clinic. The programming of the 4 protocols into the MediServe system was performed by Michael Robinson of MediServe Information Systems. As in our routine clinical practice, the MediServe platform was used to develop a respiratory care plan for each vignette (60 plans from each of the same 3 evaluators).

To achieve respiratory care plans on which all 3 evaluators agreed (ie, consensus care plans) with the manual approach, all 3 evaluators met after each had independently developed the 60 care plans. Using a Delphi approach,[9] consensus was reached on all the manually developed care plans (ie, the 180 care plans independently created by the 3 evaluators were reduced to 60 consensus care plans).

To develop consensus on the computer-aided respiratory care plans, the 3 evaluators again met after each had independently developed the 60 computer-aided plans, compared printed versions of their computer-aided care plans, and jointly resolved any disagreements. The 60 resultant respiratory care plans were the consensus computer-aided respiratory care plans.

We also assessed whether the indications for respiratory care treatments agreed among the 4 protocols, and whether the indications agreed with the AARC CPGs. This analysis was conducted by LK, who reviewed and compared all the protocols with one another and with the AARC CPGs.

The primary study outcome measure was the degree of concordance of the consensus respiratory care plans (both manual and computer-aided) among the 4 protocols. Secondary outcome measures included the degree of concordance between the manual and computer-aided respiratory care plans for each specific vignette, and the degree to which the indications for therapy in the 4 protocols invoked and agreed with the AARC CPGs. It was not the goal of this study to assess intra-rater or inter-rater agreement; all measures of concordance were based on consensus ratings among the 3 reviewers.

Concordance among the 4 protocols on the consensus care plans for the 15 vignettes was measured with the kappa statistic for > 2 raters[10] and 95% confidence intervals (CIs). Kappa measures the agreement beyond that expected by chance alone, and is a direct function of the observed agreement (the proportion who agree) and the expected agreement (proportion of agreement expected by chance). Kappa values range from −1 to 1. The interpretation guidelines are that kappa values less than 0.4 indicate poor agreement, values of 0.4–0.75 indicate moderate agreement, and kappa values greater than 0.75 indicate excellent agreement beyond chance alone.[11,12] Kappa was calculated for each respiratory care modality within method, and for the aggregate across modalities within method. The aggregate was calculated with the formula of Fleiss[13] for combining independent estimates of kappa into an overall estimate.

In our calculation of the standard error for overall kappa values, we took into account the fact that the modalities are not likely to be independent. Kappa values for the 5 respiratory care modalities within method, or for any single modality across methods, are not independent, but, rather, correlated, because they involved the same vignettes and raters. Traditional kappa standard errors and CIs were therefore not appropriate. Instead, bootstrap resampling[14] was used in order to calculate an accurate CI for the overall kappa within each method, and to statistically compare kappa values across modalities and methods. Specifically, we resampled the data 1,000 times with replacement, and the unit of observation was all the data for a particular vignette (each with 4 observations, one for each protocol). Thus, each bootstrap sample had 15 scenarios, but some were represented more than once, because of the sampling with replacement. This method maintains the correlation among ratings within scenario across the 4 protocols, and is a commonly used bootstrapping technique, sometimes called the block bootstrap.[15–17] Individual and overall kappa values and the kappa differences of interest were then calculated within each bootstrap sample. Percentiles (2.5th and 97.5th) from the distribution of each estimator across the resampling runs were used to form CIs, and the standard errors used in tests of the null hypotheses of no difference were derived from the standard deviation across resamples.

The significance level for each hypothesis was 0.05. We made Bonferroni correction to the significance criterion for individual tests, to account for multiple comparisons within method. For example, the significance criterion when comparing modalities within method was 0.05/10 or 0.005 (ie, 10 pairwise comparisons among 5 modalities). The analyses were performed with statistics software (SAS, SAS Institute, Cary, North Carolina).

Results

In considering the primary outcome of agreement of the 4 protocols, Tables 2 and 3 present the observed and expected proportion of agreement and the kappa values (which

Table 2. Agreement Among Respiratory Care Plans Created With the Manual Technique*

Respiratory Care Modality	Expected Agreement (%)	Observed Agreement (%)	Kappa Value and (95% CI)†
Aerosol	50	87	0.73 (0.52–0.94)
Bronchopulmonary hygiene	51	68	0.35 (0.14–0.56)
Hyperinflation	52	78	0.54 (0.31–0.77)
Oxygen	66	97	0.90 (0.50–1.0)
Pulse oximetry	66	97	0.90 (0.50–1.0)
Overall (95% CI)	59 (52–70)	85 (80–89)	0.60 (0.46–0.71)

*The data in Table 2 represent the consensus of the 3 raters for each modality and technique within the hospital.
†Kappa statistic guidelines: < 0.40 = poor, 0.40–0.75 = moderate, > 0.75 = excellent. Kappa value differences were considered significantly different if p < 0.005 (adjusting for 10 comparisons within each method). Manual versus computer-aided: no differences, either within modality or comparing on overall kappa. Comparing modalities: Manual: no significant differences (p = 0.032) for bronchopulmonary hygiene versus oxygen and pulse oximetry. Computer-aided: Concordance for bronchopulmonary hygiene was lower than for aerosol (p = 0.001), oxygen (p < 0.001), or pulse oximetry (p = 0.003).
CI = confidence interval

Table 3. Agreement Among Respiratory Care Plans Created With the Computer-Aided Technique*

Respiratory Care Modality	Expected Agreement (%)	Observed Agreement (%)	Kappa Value and (95% CI)†
Aerosol	50	92	0.84 (0.64–1.0)
Bronchopulmonary hygiene	50	62	0.24 (0.04–0.45)
Hyperinflation	52	82	0.63 (0.40–0.86)
Oxygen	68	1.0	1.0 (0.57–1.0)
Pulse oximetry	66	97	0.90 (0.50–1.0)
Overall (95% CI)	59 (52–70)	87 (82–91)	0.62 (0.45–0.77)

*The data in Table 3 represent the consensus of the 3 raters for each modality and technique within the hospital.
†Kappa statistic guidelines: See footnote Table 2.
CI = confidence interval

represent the degree of agreement beyond chance alone) and 95% CIs. The analysis was conducted with the consensus ratings for both the manual method (see Table 2) and the computer-aided method (see Table 3). For each method, agreement results for the protocols are presented for each of the 5 respiratory therapy modalities, as well as for the aggregate across modalities.

With the manual approach (see Table 2), the overall observed agreement among the protocols was 85% (95% CI 80–89%), ranging from 0.68 for bronchopulmonary hygiene, to 0.97 for oxygen and pulse oximetry. Agreement beyond chance, as reflected by the overall kappa among the 4 protocols was moderate, at 0.60 (95% CI 0.46–0.71). The kappa estimates for individual modalities ranged from as low as 0.35 for bronchopulmonary hygiene to 0.90 for oxygen and pulse oximetry. Notably, the 95% CI for

the kappa value for bronchopulmonary hygiene showed that the true value could be as low as 0.14, which indicates a potentially poor agreement beyond chance between the 4 protocols regarding bronchopulmonary hygiene therapy. Similarly, for hyperinflation (which was the next least concordant modality across the 4 protocols), the lower value of the 95% CI for that kappa value was 0.31, which again indicates potentially poor agreement beyond chance. No significant differences in kappa were found among modalities with the manual method, after applying a Bonferroni correction to the significance criterion for multiple comparisons (ie, significant if p < 0.005), although kappa was lower at the p < 0.05 level (p = 0.032) when comparing bronchopulmonary hygiene to each of oxygen and pulse oximetry.

The overall results were similar with the computer-aided consensus plans (see Table 3). Specifically, the overall observed agreement among the protocols was 87% (95% CI 82–90%), ranging from 62% for bronchopulmonary hygiene, to 100% for oxygen. As with the manual approach, the agreement was lowest for bronchopulmonary hygiene and hyperinflation. The overall kappa value was similar to that for the manual method, at 0.62 (95% CI 0.45–0.77), which indicates moderate agreement beyond chance.

With the computer-aided approach the kappa values for the individual modalities again indicate that concordance beyond chance was lowest for bronchopulmonary hygiene and hyperinflation. The kappa value for bronchopulmonary hygiene was lower than aerosol therapy (p = 0.001), oxygen therapy (p < 0.001), or pulse oximetry (p = 0.003).

The similarity of the overall kappa values between the manual approach and the computer-aided approach (0.60 and 0.62, respectively) indicates that the level of concordance across protocols was similar with the manual technique and the computer-aided technique (p = 0.72).

Regarding other secondary outcomes, the degree of agreement among the 4 protocols on indications for therapy and agreement with the AARC CPGs differed among the 5 modalities. Descriptively, concordance among the 4 protocols and with the CPGs was greatest in the indications for incentive spirometry (hyperinflation), bronchodilator use, and pulse oximetry For incentive spirometry, all 4 protocols used the indications in the AARC CPGs (ie, predisposition to or presence of atelectasis and restrictive chest disease associated with quadriplegia or a dysfunctional diaphragm). For bronchodilator use, although no AARC CPG was available, all 4 protocols agreed on the indications: bronchospasm, a history of bronchospasm or bronchospastic disease, or the patient uses bronchodilators at home. For pulse oximetry, all 4 protocols used criteria based on the AARC CPG.

In contrast, agreement was poorest regarding indications for bronchopulmonary hygiene and supplemental oxygen. Specifically, 2 protocols used the indications in the

AARC CPG (difficulty clearing secretions, atelectasis due to mucus plugging, mucus-producing disease, and foreign-body aspiration). Two protocols agreed with the first three of the AARC CPG indications, but did not use a criterion regarding the volume of mucus produced. All 4 protocols used additional indications (eg, productive cough, post-lobar collapse, cystic fibrosis, and hemoptysis). Regarding supplemental oxygen, all 4 protocols used more lenient oxygenation criteria to prescribe supplemental oxygen than the criteria specified by the AARC home care CPG: 2 protocols used a $P_{aO_2} < 60$ mm Hg or an oxygen saturation (measured via pulse oximetry [S_{pO_2}]) $< 92\%$, 1 protocol used a $P_{aO_2} < 60$ mm Hg mm Hg or an $S_{pO_2} < 90\%$, and 1 protocol used a $P_{aO_2} < 65$ mm Hg mm Hg or an $S_{pO_2} < 92\%$.

Discussion

The main findings of this study of concordance of respiratory care plans based on protocols from 4 different hospitals are:

1. With both the manual and computer-aided approaches, the consensus respiratory care plans agreed moderately but incompletely.
2. Concordance was lower for some modalities (particularly bronchopulmonary hygiene under the computer-aided approach) than for others (aerosol, oxygen, and pulse oximetry).
3. The method by which the protocol was implemented (manual vs computer-aided) did not affect the level of concordance between the care plans generated.
4. Comparison of the protocols to the AARC CPGs regarding the indications for therapy showed a large overall degree of variation. There was greater agreement regarding the indications for hyperinflation, aerosolized bronchodilator, and pulse oximetry, and poorer agreement regarding the indications for bronchopulmonary hygiene and oxygen.

To our knowledge, this is the first study of concordance between respiratory care plans based on protocols from different hospitals or to assess the sources of differences between care plans. In the context of interpreting concordance, it is important to point out that the purpose of protocols is to eliminate geographic variation in practice when available evidence supports a specified approach. At the same time, a care plan may appropriately diverge from a protocol when specific patient conditions preclude applying the protocol (eg, the patient's condition is not addressed by the protocol, or clinical data needed to apply the protocol are not available). Furthermore, protocols must be tailored to local practice factors, including availability of personnel and equipment, and, even local practitioners'

preferences, when available evidence does not dictate a clear course of action. Because the vignettes were written to include all the information needed in all four of the protocols to generate care plans, we eliminated care plan variations related to patient conditions that fall outside the protocol. Thus, the observed differences between the care plans reflects the aggregate effect of other factors, including lack of protocol clarity (and possible misapplication), divergence of protocols from evidence-based recommendations (as assessed here by variation in the indications for care from the CPGs, when the CPGs were available), and tailoring to local practice. Though the ideal level of concordance is unknown, we suggest that finding a moderate degree of concordance supports the overall effectiveness of protocols. The observed variation among protocols regarding the indications for care points out opportunities to further enhance uniformity of practice and to study clinical issues that need more and better evidence to guide practice.

Our analysis indicates that, with both the manual and computer-aided approaches, the level of concordance varies by modality; there was a high degree of agreement for aerosol, oxygen, and pulse oximetry, and less agreement for bronchopulmonary hygiene and hyperinflation. To the extent that the 4 protocols we examined used quantitative criteria as indications for oxygen and pulse oximetry monitoring, but more subjective criteria for bronchopulmonary hygiene and hyperinflation (eg, productive cough, volume of mucus produced), the subjectivity of the criteria may partially explain the observed variation.

Another source of variation in the care plans appears to be discordance among the protocols regarding indications for therapy. For example, the high degree of discordance regarding bronchopulmonary hygiene may relate to the fact that variance from indications in the AARC CPG was greatest for bronchopulmonary hygiene, and that few of the protocols agreed on indications for bronchopulmonary hygiene. Also, as with aerosolized bronchodilator therapy and oxygen, variation among the care plans may relate to the lack of a CPG to provide standard indications for therapy. This line of reasoning suggests that interventions to lessen geographic variation in respiratory care might include developing CPGs for modalities that currently have none available, objectifying the criteria as much as possible, and encouraging adoption of standard respiratory care protocols across hospitals. However, because specific protocols are often affected by local factors (eg, staffing, equipment, and local experience), and because physicians may be averse to adopting others' protocols or practice guidelines,[18] it seems unlikely that standard protocols would be widely adopted without local variation.

These impediments invite consideration of other ways to encourage adoption of standardized approaches to assure optimal allocation of respiratory care services and

optimal respiratory care. Possibilities include linking adoption of specific respiratory care protocols to reimbursement (eg, in a "pay for performance" strategy) or including use of specific respiratory care protocols in audits by the Joint Commission (formerly the Joint Commission on Accreditation of Healthcare Organizations). Clearly, just as the uniformity of care plans was tested in the present study, so too would endorsement of a specific approach require study to demonstrate efficacy in providing optimal respiratory care.

In assessing concordance in this study, we elected to compare agreement on consensus care plans between protocols from different hospitals rather than inter-evaluator variation with individual protocols. Though evaluating inter-rater variation can clarify the ease and uniformity of using individual protocols, we reasoned that using only 3 evaluators would provide an incomplete assessment of inter-rater variability. Rather, because the main focus of this research was variation across the 4 protocols, we elected to compare respiratory care plans that represented the consensus ratings of all 3 evaluators.

Our finding of similar concordance with the manual versus the computer-aided approach warrants additional comment. Specifically, one potential benefit of computer-aided care plan development is that inter-observer variation in care plans can be decreased. Because our analytic approach compared the computer-aided care plan with the consensus care of those developed manually by the 3 evaluators, we purposefully eliminated inter-observer variation for manually generated care plans, which could obscure a potential benefit of the computer-aided approach. On this basis, our results should not be construed to demonstrate the equivalence of manual versus computer-aided approaches. Fuller appreciation of the potential benefit of a computer-aided approach would require analysis of inter-observer variation among manually generated care plans from a larger number of evaluators than the three used in this study.

Though this study is, to our knowledge, the first to assess concordance of respiratory care protocols and care plans across different hospitals, several limitations of this study warrant comment. First, we considered protocols from only 4 hospitals, and our results may not generalize beyond the sample of hospitals represented here. On the other hand, to the extent that considering more protocols would probably introduce more variability, our estimates of discordance may be conservative.

A second limitation is that we used only 15 clinical vignettes. This relatively small number of vignettes decreased the precision with which we could measure concordance, as seen by the rather wide dispersion of the kappa values (ie, the 95% CIs for kappa ranged from 0.36 to 0.46). A larger number of vignettes might have allowed

us to detect further differences among modalities on the level of concordance.

Finally, our evaluation of agreement was based on applying the protocols to standardized vignettes, but not to actual patients. Though the vignettes were constructed to include all the elements needed to generate respiratory care plans with 4 the protocols, application to clinical practice remains uncertain. Because it was unfeasible to evaluate respiratory care plans generated for actual patients at geographically distant hospitals, the assessment with standardized vignettes seemed to be the best available approach to assess the concordance of different hospitals' protocols.

Conclusions

Overall, this comparison of respiratory care plans generated with 4 different hospitals' protocols and 15 standardized patient vignettes indicates moderate but incomplete agreement and suggests opportunities to enhance more uniform and presumably better respiratory care in different settings. Future research needs include replicating these findings with a larger, more representative sample of hospitals, evaluating whether clinical outcomes for patients vary because of protocol variation, and, if so, identifying strategies to drive more widespread adoption of optimal respiratory care practices.

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