

Original Investigation

I COUGH

Reducing Postoperative Pulmonary Complications With a Multidisciplinary Patient Care Program

Michael R. Cassidy, MD; Pamela Rosenkranz, RN, BSN, MEd; Karen McCabe, RN, BSN; Jennifer E. Rosen, MD; David McAneny, MD

IMPORTANCE Postoperative pulmonary complications can be a devastating consequence of surgery. Validated strategies to reduce these adverse outcomes are needed.

OBJECTIVES To design, implement, and determine the efficacy of a suite of interventions for reducing postoperative pulmonary complications.

DESIGN A before-after trial comparing our National Surgical Quality Improvement Program (NSQIP) pulmonary outcomes before and after implementing I COUGH, a multidisciplinary pulmonary care program.

SETTING An urban, academic, safety-net hospital.

PARTICIPANTS All patients who underwent general or vascular surgery at our institution during a 1-year period before and after implementation of I COUGH.

INTERVENTIONS A multidisciplinary team developed a strategy to reduce pulmonary complications based on comprehensive patient and family education and a set of standardized electronic physician orders to specify early postoperative mobilization and pulmonary care. Designated by the acronym I COUGH, the program emphasizes incentive spirometry, coughing and deep breathing, oral care (brushing teeth and using mouthwash twice daily), understanding (patient and family education), getting out of bed at least 3 times daily, and head-of-bed elevation. Nursing and physician education promoted a culture of mobilization and I COUGH interventions. I COUGH was implemented for all general surgery and vascular surgery patients at our institution in August 2010.

MAIN OUTCOMES AND MEASURES The NSQIP-reported incidence and risk-adjusted ratios of postoperative pneumonia and unplanned intubation, which NSQIP reports as observed-expected (OE) ratios for the 1-year period before implementing I COUGH and as odds ratios (ORs, statistically comparable to OE ratios) for the period after its implementation.

RESULTS Before implementation of I COUGH, our incidence of postoperative pneumonia was 2.6%, falling to 1.6% after its implementation, and risk-adjusted outcomes fell from an OE ratio of 2.13 to an OR of 1.58. The incidence of unplanned intubations was 2.0% before I COUGH and 1.2% after I COUGH, with risk-adjusted outcomes decreasing from an OE ratio of 2.10 to an OR of 1.31.

CONCLUSIONS AND RELEVANCE I COUGH, a standardized postoperative care program emphasizing patient education, early mobilization, and pulmonary interventions, reduced the incidence of postoperative pneumonia and unplanned intubation among our patients.

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Author Affiliations: Section of Surgical Oncology and Endocrine Surgery, Department of Surgery, Boston University Medical Center, Boston, Massachusetts (Rosen, McAneny); Department of Surgery, Boston University Medical Center, Boston, Massachusetts (Cassidy, Rosenkranz, McCabe).

Corresponding Author: David McAneny, MD, Section of Surgical Oncology and Endocrine Surgery, Department of Surgery, Boston University Medical Center, 820 Harrison Ave, FGH Ste 5008, Boston, MA 02118 (david.mcAneny@bmc.org).

Postoperative pulmonary complications are relatively common and costly. Estimated to occur in 2.7% to 3.4% of patients who undergo noncardiac surgery,^{1,2} postoperative respiratory problems, as defined by the National Surgical Quality Improvement Program (NSQIP), may include pneumonia, unplanned intubation, and failure to wean from mechanical ventilation after 48 hours. A 2004 analysis² of NSQIP data from a single institution estimated the attributable cost of respiratory complications to be \$52 466 per patient. Compared with other adverse outcomes, including thromboembolic, cardiovascular, and infectious complications, pulmonary complications were the most costly and were associated with an increased length of stay of 14 days compared with costs and length of stay in patients with no complications.

Despite the prevalence and cost of pulmonary complications, there is a paucity of best-practice guidelines for postoperative pulmonary care in general. Ventilator-associated pneumonia (VAP) is an often-discussed entity, including recommendations for its prevention; however, strategies to avoid pulmonary complications among nonventilated patients are less studied.

Data from the NSQIP revealed that our medical center, the largest safety-net hospital in New England and an academic urban hospital, was a high outlier for all measured postoperative pulmonary complications. Boston Medical Center is a merged entity of the former University Hospital and Boston City Hospital, with 509 licensed beds. More than half its patients have an annual income below \$20 420. About one-quarter of the patients do not speak English, and racial and ethnic minorities constitute 70% of all patients. Recognizing an opportunity for improvement, we envisioned a standardized suite of postoperative pulmonary care guidelines to reduce the incidence of adverse pulmonary outcomes, and we sought to demonstrate its efficacy.

Methods

Audit of Preintervention Nursing Practice

To understand the actual standards of care for postoperative patients at our institution before the development of the pulmonary care program, we audited pulmonary practices in the spring of 2010. We visited all patients who had undergone elective open abdominal or pelvic operations at 8 AM, 1 PM, and 6 PM on the day of surgery and during the 2 subsequent days. Nurses were unaware of these audits. Trained clinical staff noted whether each patient was in bed, sitting in a chair, or walking at the time of the visit. We also recorded whether an incentive spirometer was within reach of the patient. If patients were in bed at the time of the visit, we recorded whether the head of the bed was elevated more than 30°. We defined optimal practice as patients being out of bed (either sitting in a chair or walking) and having an incentive spirometer within reach. Although allowing the patient to remain in bed was considered less desirable, we defined favorable practice as head-of-bed elevation greater than 30° for patients who were in bed.

Composition of the Pulmonary Care Working Group

The effort to improve pulmonary care gained significant momentum when an author of this report (D.M.) established authority to develop quality improvement programs for the department of surgery. As a result, a multidisciplinary pulmonary care group convened, including representatives from the departments of surgery, nursing, and quality improvement; NSQIP; respiratory therapy; the Internal Medicine Preoperative Assessment Clinic; infection control; and physical therapy. The group was charged with reviewing the current literature about postoperative pulmonary care and developing a multidisciplinary strategy to reduce postoperative pulmonary complications. We focused efforts on establishing principles of education and creating simple standardized interventions. We first met in spring 2010 and then monthly thereafter until the implementation of the pulmonary care program on August 2, 2010.

Development of I COUGH Program

After reviewing the small body of literature about postoperative non-VAP pulmonary complications and their prevention,³⁻⁶ we aimed to create a simple, inexpensive pulmonary care program that could be easily understood and remembered by patients, their families, and our staff. The consensus of the Pulmonary Care Working Group was to include lung expansion exercises, early and frequent patient mobilization, oral hygiene, and education as key components of our strategy to reduce postoperative complications. For ease of recall, nursing representatives in the Pulmonary Care Working Group recommended an acronym to include the major components of the program, and we created I COUGH to describe

1. Incentive spirometry,
2. Coughing and deep breathing,
3. Oral care (brushing teeth and using mouthwash twice daily),
4. Understanding (patient and family education),
5. Getting out of bed frequently (at least 3 times daily), and
6. Head-of-bed elevation.

While not included in the I COUGH acronym, another important aspect of the program is postoperative pain control. Although not standardized in the same fashion as the pulmonary interventions, we recognized that adequate pain control is essential to our mobilization goals. Pain control options incorporated into the program include patient-controlled analgesia with narcotic and nonnarcotic agents. Specifics of pain control were tailored to individual patient needs.

Emphasis on Education

A major initiative of the I COUGH program is education of patients, their families, nurses, and physicians. Education of patients and families begins in the surgeons' clinics and the preoperative assessment clinic. We composed brochures, a video, and posters with instructions that describe the importance of postoperative pulmonary care. Proper use of incentive spirometry is demonstrated and taught in the preoperative setting. These principles are reinforced in the preoperative holding area immediately before the operation. Patients are again instructed about I COUGH elements after their operations by nursing staff and by surgeons and house staff during rounds. This institutional effort is predicated on patients and their fami-

Table. Orders Included in the Standardized Order Set

Orders
1. Educate patient about I COUGH protocol
2. Incentive spirometry: educate patient in use
3. Incentive spirometry: 10 times every hour (3-5 efforts each set) while awake until discharge
4. Keep incentive spirometer within reach
5. Document incentive spirometer volume every 4 h while awake
6. Head of bed elevated (>30°)
7. Out of bed to chair at least once on the day of the operation unless patient arrives from PACU late in evening
8. Walk at least once on day of operation if patient arrives from PACU by 4 PM if alert and safe to do so
9. Out of bed to chair at least 3 times/d, preferably at mealtimes, with assistance as needed
10. Progress activity to ambulate at least 3 times/d, with assistance as needed
11. Mouth care 8 AM and 8 PM, including brushing teeth and rinsing with mouthwash
12. Encourage patient to cough and deep breathe every 2 h

Abbreviations: I COUGH, incentive spirometry, coughing and deep breathing, oral care (brushing teeth and using mouthwash twice daily), understanding (patient and family education), getting out of bed at least 3 times daily, and head-of-bed elevation; PACU, postanesthesia care unit.

lies understanding, anticipating, and appreciating high standards of postoperative care, including early mobilization.

Nursing education was similarly comprehensive. Nurse educators and physicians met with unit nurses, including those from the intensive care unit (ICU), to review baseline pulmonary outcome data and describe the importance of I COUGH principles. Expectations for care were articulated, including early mobilization, respiratory exercises, and oral hygiene, to establish a culture of an emphasis on postoperative pulmonary care. Attending physicians and house staff also were educated during quality improvement conferences about baseline pulmonary outcomes data and about the I COUGH principles and their importance.

Standardized Physician Order Sets

To support physician efforts, we created standardized electronic physician order sets that include specific and detailed orders for all elements of the I COUGH program. These orders are intended for all patients undergoing operations on the general surgery and vascular surgery services. The I COUGH orders are preselected in all order sets to ensure that every patient will have a standard level of postoperative pulmonary care. The intent of the specific orders (Table) is to mobilize patients out of bed as often as possible. Several options for postoperative pain control are included in the order sets and are tailored to each patient's needs.

Audits of Postintervention Nursing Practice

After the preintervention audits but before the implementation of I COUGH, we shared unit-specific audit data with the nurses. We used preintervention practice patterns as a basis for improvement while educating nurses on the importance of I COUGH principles. Eight weeks after the official implementation of I COUGH, we performed another audit of nurs-

ing practice as documented in medical records, and we compared those results with the original audit.

Outcome Measures

We used NSQIP data from our institution to determine the effect of I COUGH on postoperative pulmonary outcomes. All patients who underwent an operation on the general and vascular surgery services at our institution during the specified periods, including patients admitted to an ICU or a non-ICU, were captured in our analysis of the NSQIP data. The absolute incidence of postoperative pneumonia and of unplanned intubation during the first 30 postoperative days, as defined by the NSQIP, was compared between 1-year periods before and after the implementation of I COUGH (calendar year 2009 vs July 1, 2010-June 30, 2011, respectively) using χ^2 analysis. The NSQIP defines patients with pneumonia as having at least 1 definitive chest radiologic examination and at least 1 sign of pneumonia (fever, leukocytosis, or altered mental status with no other cause), as well as at least 1 microbiologic laboratory finding (positive cultures from blood, bronchoalveolar lavage, or pleural fluid specimens) or at least 2 symptoms (purulent sputum, worsening cough, dyspnea or tachypnea, rales or rhonchi, or worsening gas exchange). Unplanned intubation is defined as placement of a breathing tube that was not intended or planned, excluding instances of intubation during an unplanned return to the operating room. In addition, we queried the NSQIP database for the same outcomes in the same periods at comparable institutions, which we considered to be academic medical centers with more than 500 beds. We also compared our risk-adjusted pulmonary outcomes, which NSQIP reports as observed-expected (OE) ratios for periods before calendar year 2010 and as odds ratios (ORs) for calendar year 2010 and later. The OE ratio and OR values are considered to be statistically comparable for large sample sizes. This study was approved by the institutional review board of the Boston University School of Medicine.

Results

Effect of I COUGH on Nursing Practice

The pre-I COUGH nursing practice audit revealed that 80.4% of the 250 patients were in bed at the time of the visit, with only 19.6% of patients in a chair or walking. In contrast, post-I COUGH audits revealed a significant difference in practice, with 69.1% of 250 patients out of bed ($P < .001$). Prior to I COUGH, most patients (91.5%) had the heads of their beds elevated, and this figure remained similar post-I COUGH (82.7%; $P = .40$). Before I COUGH, only 52.8% of patients had an incentive spirometer within reach; post-I COUGH practice revealed the availability of an incentive spirometer and appropriate frequency of use among 77.2% of the patients ($P < .001$).

Effect of I COUGH on Postoperative Pulmonary Complications

During the year before the implementation of I COUGH, the incidence of postoperative pneumonia at our institution was 2.6% (1569 cases), and this was similar to the previously recorded period (Figure 1). The incidence of pneumonia fell to

1.6% in the year after the implementation of I COUGH (1542 cases; $P = .09$). Average incidences of pneumonia at comparable NSQIP hospitals (academic medical centers with >500 beds) during the same periods are presented in Figure 1 for purposes of comparison and range from 1.4% to 1.7%. In terms of risk-adjusted NSQIP data, before the implementation of I COUGH, our OE ratio for pneumonia was 2.13 (95% CI, 1.52-2.90), similar to preceding years, and decreased to an OR of 1.58 (95% CI, 1.06-2.36) after I COUGH institution (Figure 1).

The incidence of unplanned intubations at our institution was 2.0% before I COUGH (1569 cases), consistent with the preceding period, and became 1.2% after introduction of I COUGH (Figure 2) (1542 cases; $P = .09$). The same outcome at comparable NSQIP hospitals is demonstrated in Figure 2, ranging from 1.4% to 1.6%. Risk-adjusted NSQIP data showed that unplanned intubations fell from an OE ratio of 2.10 (95% CI, 1.42-2.98) before I COUGH to an OR of 1.31 (95% CI, 0.87-1.97) after I COUGH (Figure 2).

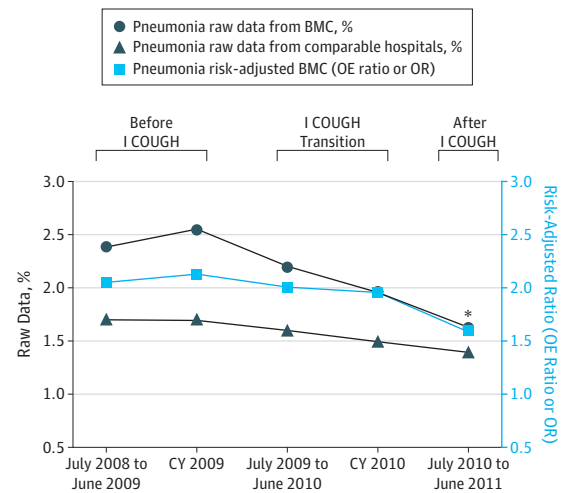
Discussion

Pneumonia and postoperative pulmonary insufficiency are relatively common among surgical patients, and it is clear that they are highly debilitating and costly. Nevertheless, there is a paucity of data regarding nonventilator pulmonary care. In the ICU, VAP is often discussed in the literature as an avoidable nosocomial infection,⁷⁻⁹ and VAP prevention “bundles” have been proposed, studied, and strongly endorsed.¹⁰⁻¹³ These sets of interventions to prevent VAP generally include simple strategies, such as head-of-bed elevation, oral hygiene, and sedation “vacations.”¹⁴ The philosophy of the bundle is to achieve synergistic prevention efficacy by implementing multiple interventions together. We adopted a similar idea in our attempt to create a simple postoperative pulmonary-complication prevention strategy for all postoperative patients.

Because practice guidelines for nonventilated postoperative pulmonary care are limited, a systematic review of strategies to reduce pulmonary complications was undertaken by the American College of Physicians but found the quality of evidence to be lacking for most interventions.³ Among the commonly used strategies, some evidence exists for postoperative lung expansion modalities, such as incentive spirometry, deep breathing exercises, and continuous positive airway pressure, suggesting that these interventions may reduce the risk of pulmonary morbidities.³ However, a Cochrane review⁴ of incentive spirometry did not demonstrate adequate evidence to recommend its routine use. In a small randomized trial,⁵ chest physiotherapy combined with deep breathing exercises and education about early postoperative mobilization reduced postoperative pulmonary complications after abdominal surgery.

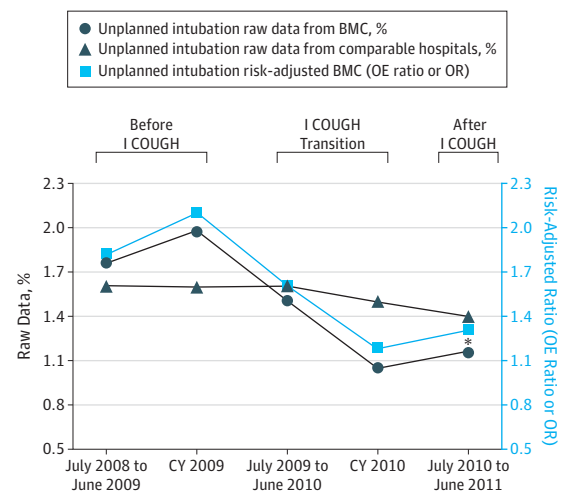
In 2010, Wren and colleagues⁶ described a pulmonary care program that helped reduce the incidence of postoperative pulmonary complications in a Veterans Affairs hospital population. Their program was based on postoperative

Figure 1. Incidence of Pneumonia at Boston Medical Center (BMC) and at Comparable Institutions, Along With Risk-Adjusted Outcomes at BMC, During Consecutive National Surgical Quality Improvement Program (NSQIP) Reporting Periods Before, During, and After the Implementation of I COUGH



For reporting periods before calendar year (CY) 2010, NSQIP reports risk-adjusted data as observed-expected (OE) ratios. For CY 2010 and later, NSQIP reports risk-adjusted data as odds ratios (ORs). * $P = .09$ compared with CY 2009. See the Table footnote for the expansion of I COUGH.

Figure 2. Incidence of Unplanned Intubations at Boston Medical Center (BMC) and at Comparable Institutions, Along With Risk-Adjusted Outcomes at BMC, During Consecutive National Surgical Quality Improvement Program (NSQIP) Reporting Periods Before, During, and After the Implementation of I COUGH



For reporting periods before calendar year (CY) 2010, NSQIP reports risk-adjusted data as observed-expected (OE) ratios. For CY 2010 and later, NSQIP reports risk-adjusted data as odds ratios (ORs). * $P = .09$ compared with CY 2009. See the Table footnote for the expansion of I COUGH.

nursing interventions including incentive spirometry, oral hygiene, ambulation, head-of-bed elevation, and continuous education of physicians and ward staff. Together, these

strategies were successful, but this remains the only study to characterize and describe the outcome of a systematic and standardized postoperative pulmonary care program in non-ICU surgical ward patients. Other general guidelines have been proposed by the Centers for Disease Control and Prevention¹⁰; these and the guidelines of Wren and colleagues recommended lung expansion modalities and early mobilization. We based the principles of our I COUGH program on this small collected body of literature.

It was disturbing to discover that our hospital was a high outlier in all NSQIP-defined adverse pulmonary outcomes, but we regarded this as an opportunity to improve care. We sought to motivate multidisciplinary health care providers to understand the significance of quality outcomes and embrace a higher standard of care for patients. The result of these efforts was the I COUGH program, which built on previously described recommendations for postoperative pulmonary care and made education and standardization key elements.

A subjective review of I COUGH care patterns before implementation revealed inconsistent patient education regarding the importance of and instruction in incentive spirometry. There was no formal preoperative education, and patients' families usually were not included in the discussion. Physicians' orders for nurses regarding postoperative mobilization were irregular or absent. After the introduction of I COUGH, an established standardized order set, along with nursing documentation requirements, showed that patients and their families were being educated by nurses and by surgeons as routine practice in multiple settings (preoperative clinics, preoperative holding area, and postoperative units). Mobilization now occurs in a standardized fashion.

We have observed that the principles of I COUGH have begun to reduce the incidence of postoperative pulmonary complications among our patients. We have done so by involving a multidisciplinary team in all stages of planning and development. In this way, we have not imposed a standard of care by mandate but instead have involved nursing leadership and practicing ward and ICU nurses in the process of redefining the culture. We found that involvement of representatives of each discipline significantly increased acceptance of the I COUGH program and instilled a sense of commitment and pride that could not have been achieved by simply instituting and enforcing a policy without input from all parties involved. Nurse managers have been especially critical to the success of the program by driving it at the unit level. We appreciate that this pulmonary care program will be sustained by constant reinforcement of the I COUGH principles, continuous auditing of practices on the postoperative units, and redirection of care toward quality outcomes.

Fostering a culture of education and improvement has been essential to the I COUGH goals. Our efforts at education apply to both our staff and to patients and their families. We believe that understanding is crucial to the efficacy of this program and of similar programs in quality improvement. Preoperative educational materials, including pamphlets and a video provided to patients and their family

members, have enhanced patient adherence to our pulmonary care guidelines. The easy-to-remember acronym, I COUGH, helps patients, their families, and staff to remember these principles.

Another important aspect of success is standardization, such that each patient ideally receives optimal care regardless of operation or diagnosis (with a few exceptions for operations that require specific mobilization guidelines). In this way, practices promoting excellence become fundamental to the culture of the institution. Finally, the simplicity of the interventions described in the I COUGH program demonstrates that basic, inexpensive postoperative patient care can favorably affect outcomes.

The I COUGH program was designed as a suite of postoperative interventions. As such, we cannot use these data to support any single element of the program as paramount. Even though the role of incentive spirometry is uncertain for postoperative pulmonary care,^{3,4} we have found exercise with the device to be valuable for conveying the concrete goals of deep inspiration to our patients, many of whom do not speak English. Ultimately, our aim was not to demonstrate the superior efficacy of a solitary intervention but rather to support the concept that a multidisciplinary standard of care, encompassing multiple interventions, can have a positive effect on patient outcomes.

There are several methodologic limitations of this study. Nursing audits conducted before implementation of I COUGH were observational, with actual practices documented by visiting patient rooms. Because of limited staff availability after I COUGH implementation, the later audits were performed by review of nursing documentation in the medical records. Nevertheless, there were substantial differences in nursing practice documented between the audits before and after I COUGH implementation, and we believe that a favorable change in practice occurred as a result of our program. In addition, because of changes in the way NSQIP reports risk-adjusted outcomes, these data are presented as OE ratios for periods before calendar year 2010 and as ORs for calendar year 2010 and later. As such, we are comparing an OE ratio for the periods before I COUGH with an OR for the periods after I COUGH. However, OE ratios and ORs are considered to be statistically comparable for large sample sizes. Finally, we do not yet have data to confirm sustained success of the I COUGH program over a protracted course of time, although early trends are favorable.

Quality improvement programs at the national level, such as NSQIP, have allowed surgeons and other physicians to reflect thoughtfully on current practices and redefine standards of care that are based on well-validated, risk-adjusted outcome measures. Any success that I COUGH or similar postoperative care programs can achieve must be sustained through constant education and reeducation of staff and patients, along with regular measurements of performance and analyses of data. We are eager to monitor our outcomes over a longer period, and we are stimulated by the possibility that postoperative complications may be diminished by adherence to simple, inexpensive, easily performed patient care strategies.

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Additional Information: I COUGH is a registered service mark of Boston Medical Center Corporation.

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Invited Commentary

Out of Bed With a Good COUGH, Just What the Doctor Ordered

Bruce J. Leavitt, MD

In this study, Cassidy and his colleagues¹ from Boston University Medical Center investigated the efficacy of a multidisciplinary team in reducing postoperative pulmonary complications by instituting a program called I COUGH. This program used incentive spirometry, cough and deep breathing, oral care, understanding and education, mobilization of the patient (getting out of bed ≥ 3 times daily), and head of bed elevation. This was an observational study looking at rates of postoperative



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pneumonia and unplanned intubation in patients undergoing general and vascular surgery. These outcome measures were determined using National Surgical Quality Improvement Program (NSQIP) measures. Prior to the study, their hospital was a high outlier for those pulmonary complications when compared with other similar institutions. A pulmonary care working group included surgeons, nurses, respiratory therapists, physical therapists, infectious disease personnel, and NSQIP data personnel. They compared the postoperative pulmonary complications after 1 year of institution

of the multidisciplinary program and compared the results with the year prior to the planned intervention.

Their results show a trend toward significance, with a less than 1% reduction in postoperative pneumonia and less than 1% rate of unplanned intubation when compared with their pre-intervention rates. There was a significant improvement in the percentages of patients being out of bed as well as the incentive spirometer being within reach.

This study involved nonintubated patients, whereas the literature mostly focuses on the prevention of ventilator-associated pneumonia. The Institute for Healthcare Improvement has documented a ventilator-associated pneumonia preventative bundle (<http://www.ihl.org/knowledge/Pages/Changes/ImplementtheVentilatorBundle.aspx>) that contains 2 of the I COUGH implementation strategies.

Despite not reaching clinical significance, this study has many positive outcomes. Cassidy and his colleagues have shown that creating a multidisciplinary team that implements simple measures involving the pulmonary care of the surgical patient can improve outcomes and lower medical costs.

ARTICLE INFORMATION

Author Affiliation: Department of Surgery, Fletcher Allen Health Care, Burlington, Vermont.

Corresponding Author: Bruce J. Leavitt, MD, Department of Surgery, Fletcher Allen Health Care, Fletcher 454, 111 Colchester Ave, Burlington, VT 05401 (bruce.leavitt@vtmednet.org).

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