

workforce. The per capita RN supply in the Western and North-east regions of the United States has fallen behind that in the rest of the country because these regions are home to a greater number of older RNs who are retiring. Per capita RN supply is expected to decrease further in these regions over the next decade, whereas the per capita supply is projected to grow at double-digit rates in the Midwest and the South.<sup>4</sup>

A third uncertainty is the lingering effect of the recession. The slow jobs recovery swelled the ranks of the nursing workforce, as many RNs chose to work additional hours or delay retirement to bolster their household's economic security.<sup>5</sup> This temporary swelling of the workforce is expected to subside as the jobs recovery accelerates. The danger is that in the meantime, employers, educators, and policymakers will reduce their investments in nursing when they observe that there's a healthy workforce, and people who might otherwise be interested in nursing may choose other career paths because there are fewer available jobs or temporarily depressed wages.

A final uncertainty concerns

the demand for RNs. The ACA may stimulate additional demand for RNs, with its increase in insurance coverage, expansion of nurse-managed health centers, and reform of the care delivery system, in which payment is to be linked to quality. However, it is unclear to what extent RNs, nurse practitioners, or other advanced-practice nurses will take the lead in these new models of care delivery and preventive care approaches championed by the ACA. It is also unclear whether RNs will be prepared with the skills needed for emerging roles in leading and managing teams, implementing patient-centered care, and adapting to other inevitable changes in RN responsibilities.

Despite the projections of severe shortages made just 10 years ago, a combination of policy efforts, a responsive education system, private-sector initiatives, and the effects of the recession has led to unexpected growth in the nursing workforce. If this growth continues, the nursing workforce will be better able to respond to the health care needs of Americans, including retiring baby boomers, and to the many challenges and consequences of the implementation of health care reform. This outcome is not cer-

tain, however, and is less likely if the surge in younger people entering nursing stalls, the workforce continues to grow unevenly across the country, or the nursing workforce is ill prepared to meet the challenges of the fast-changing health care delivery system.

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## Complications of Mechanical Ventilation — The CDC's New Surveillance Paradigm

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Earlier this year, the Centers for Disease Control and Prevention (CDC) rolled out new surveillance definitions for patients receiving mechanical ventilation that promise to dramatically improve hospitals' capacity to track

clinically significant complications in this population.<sup>1</sup> The new definitions replace the CDC's previous definition of ventilator-associated pneumonia (VAP) and are designed to achieve two primary goals: to broaden the focus of

surveillance beyond pneumonia to encompass other common complications of ventilator care, and to make surveillance as objective as possible in order to facilitate automation, improve comparability, and minimize gaming.

Benchmarking the quality of care for ventilated patients has been an elusive goal for regulators and quality advocates for many years. The VAP rate is the usual metric proposed for this purpose, given the frequency of the condition and its related morbidity and preventability. In practice, however, surveillance for VAP has proven highly problematic. The clinical criteria for VAP are subjective and nonspecific. They include nuanced and changeable signs such as “worsening oxygenation,” “change in the quality or quantity of sputum production,” and “new or progressive infiltrates.” They leave ample room for reasonable clinicians and infection surveyors to disagree. Many observers fear that strong pressures on hospitals to minimize their VAP rates have been prompting surveyors to apply subjective criteria more and more strictly, which in turn is leading to lower and lower VAP rates.

Indeed, more than 50% of non-teaching medical intensive care units (ICUs) in the United States are reporting VAP rates of zero.<sup>2</sup> Mean rates are 1.0 case of VAP per 1000 ventilator-days in medical units and 2.5 cases per 1000 ventilator-days in surgical units. It is unclear, however, to what extent these figures reflect bona fide improvements in care rather than artifacts of surveillance. Three lines of evidence point to a large contribution of a surveillance artifact: VAP rates in Europe are an order of magnitude higher than U.S. rates, despite similarly sophisticated prevention and care programs; cross-sectional surveys of ICUs consistently show that about 15% of patients are receiving antibiotics for nosocomial pneumonia; and clinicians who track VAP in parallel with their

hospitals' infection preventionists consistently find many more cases than do the preventionists. Subjectivity and interobserver variability are compounded by inaccuracy: autopsy series reveal that one third to one half of patients who met clinical criteria for VAP did not in fact have pneumonia.

Caught between the unsuitability of VAP for benchmarking and the national movement toward increasing use of quality measures, the CDC convened leaders of professional societies in critical care, infectious diseases, health care epidemiology, and respiratory therapy to develop a more tenable set of metrics. Building on exploratory work by the CDC's Prevention Epicenters, the group (of which I was a member) proposed shifting the focus of surveillance from pneumonia alone to complications of mechanical ventilation in general. Such a change would have three major benefits: it would broaden the focus of prevention from pneumonia alone to all important complications of mechanical ventilation, it would provide a more accurate description of what can reliably be determined with the use of routinely collected clinical data, and it would enable the development of quantitative, and hence objective, surveillance definitions based on changes in patients' ventilator settings.

The new framework includes a hierarchy of surveillance targets (see table). The first target, called ventilator-associated conditions, or VACs, identifies patients whose respiratory status has deteriorated after a period of stability or improvement. More specifically, a VAC is defined as at least 2 calendar days of stable or decreasing ventilator settings (daily minimum

positive end-expiratory pressure or fraction of inspired oxygen) followed by consistently higher settings for at least 2 additional calendar days. This tier of the new definitions is intentionally nonspecific and designed to capture all manner of pulmonary and nonpulmonary complications serious enough to result in persistently higher ventilator settings. Some of these events may be unavoidable consequences of caring for critically ill patients, so zero may no longer be a realistic goal.

Qualitative analyses suggest that in practice, however, most VACs are attributable to pneumonia, pulmonary edema, atelectasis, or acute respiratory distress syndrome.<sup>3,4</sup> These events appear to be highly meaningful: studies from the United States, Canada, Australia, and Italy have consistently shown strong associations between VACs and prolonged length of stay in the ICU and between VACs and higher mortality rates.<sup>3-5</sup> These events are also potentially actionable: there is a great deal of existing literature on how to prevent and manage these four conditions.

Subsequent tiers of ventilator-associated events are designed to identify the subset of VACs that are infection-related and those that might indeed be pneumonias. An “infection-related ventilator-associated complication,” or IVAC, is defined as a VAC in a patient who has a concurrent abnormal temperature or white-cell count and is given one or more new antibiotics that are continued for at least 4 days. A diagnosis of “possible pneumonia” or “probable pneumonia” further requires the presence of purulent respiratory secretions (as assessed according to quantitative Gram's

## The CDC's New Surveillance Paradigm for Ventilator-Associated Events.

Concept	Name	Definition
New respiratory deterioration	Ventilator-associated condition (VAC)	$\geq 2$ Calendar days of stable or decreasing daily minimum positive end-expiratory pressure or daily minimum fraction of inspired oxygen, followed by a rise in daily minimum positive end-expiratory pressure of $\geq 3$ cm of water or a rise in the daily minimum percentage of inspired oxygen by $>20$ points sustained for $\geq 2$ calendar days
New respiratory deterioration with evidence of infection	Infection-related ventilator-associated complication (IVAC)	VAC plus a temperature of $<36^{\circ}\text{C}$ or $>38^{\circ}\text{C}$ or a leukocyte count of $\leq 4000$ or $\geq 12,000$ per cubic millimeter, plus one or more new antibiotics continued for at least 4 days within 2 calendar days before or after onset of a VAC, excluding the first 2 days of mechanical ventilation
New respiratory deterioration with possible evidence of pulmonary infection	Possible pneumonia	IVAC plus Gram's staining of endotracheal aspirate or bronchoalveolar lavage showing $\geq 25$ neutrophils and $\leq 10$ epithelial cells per low-power field, or a positive culture for a potentially pathogenic organism, within 2 calendar days before or after onset of a VAC, excluding the first 2 days of mechanical ventilation
New respiratory deterioration with probable evidence of pulmonary infection	Probable pneumonia	IVAC plus Gram's staining of endotracheal aspirate or bronchoalveolar lavage showing $\geq 25$ neutrophils and $\leq 10$ epithelial cells per low-power field, plus endotracheal aspirate with $\geq 10^5$ colony-forming units per milliliter or bronchoalveolar-lavage culture with $\geq 10^4$ colony-forming units per milliliter, or endotracheal-aspirate or bronchoalveolar-lavage semiquantitative equivalent, within 2 calendar days before or after onset of a VAC, excluding the first 2 days of mechanical ventilation

staining criteria), pathogenic respiratory cultures, or both. Patients with an IVAC and purulence alone or pathogenic cultures alone have "possible pneumonia," and those with both purulence and positive quantitative or semiquantitative cultures have "probable pneumonia." Probable pneumonia can also be triggered by suggestive histopathological features, positive pleural-fluid cultures, or diagnostic tests for legionella and selected viruses.

The new definitions do not include radiographic criteria. This omission does not represent a denial of the central role that radiographs play in routine clinical care, but rather reflects the recognition that they are counterproductive in surveillance definitions because they introduce substantial complexity and subjectivity without increasing accuracy.

These new definitions constitute a radical shift from both the method and mind-set of traditional VAP surveillance, but I be-

lieve they promise three important benefits. Foremost is the opportunity to identify a population of patients who have serious complications that have previously not been acknowledged or attended to by quality-improvement programs. Flagging this population is the necessary first step toward elucidating these events and identifying opportunities to modify care so as to avert them.

Second, the new definitions will enable hospitals to benchmark their rates against peer institutions in a more meaningful way. The new definitions are based solely on quantitative criteria and hence are far more objective than those used in traditional VAP surveillance. Hospitals can now be more confident that differences in rates reflect differences in patients and processes of care rather than subjective and unquantifiable surveillance biases. The definitions will be most useful once they are paired with severity-of-illness scores for credible risk adjustment.

Third, the inclusion of an antibiotic criterion in the definition of IVAC will provide hospitals with a routine, widely reportable benchmark for the prescribing of antibiotics in their ICUs. Antibiotic-prescribing practices are known to vary widely among clinicians and among institutions, yet there has been no simple way for clinicians or hospitals to know where they stand relative to their peers. The IVAC metric has the potential to identify outlier prescribers. Antibiotic-stewardship programs will benefit from the opportunity to understand how their institution compares with peer institutions and who their outlier prescribers may be. This information may help individuals and institutions to minimize excessive prescribing and thereby reduce rates of antibiotic resistance and *Clostridium difficile* infections, as well as costs.

In sum, these new definitions promise to enrich the breadth and quality of information available to front-line clinicians, hos-

pital leaders, patients, and the public. New, credible, and comparable system-level insights into patients who have serious complications and into institutions' antibiotic-prescribing patterns are critical first steps toward further improving care for ventilated patients.

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