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A Second Breadth: Hospital-Acquired Pneumonia in Pennsylvania, Nonventilated versus Ventilated Patients

Authors

James Davis, MSN, RN, CIC, CCRN, HEM, FAPIC

Senior Infection Prevention Analyst

Edward Finley, BS

Data Analyst

Pennsylvania Patient Safety Authority

Corresponding Author

James Davis

Abstract

Research published in 2012 by Pennsylvania Patient Safety Authority analysts determined that nonventilator hospital-acquired pneumonia (NV-HAP) affected more people than ventilator-associated pneumonia (VAP) and was as lethal as, and more costly than, VAP. This article updates the Authority's original data set, using the same methods and outcome measures. Analysts queried the Centers for Disease Control and Prevention's National Healthcare Safety Network (NHSN) for complete nosocomial pneumonia data sets from January 1, 2013, through December 31, 2016, inclusive of the total inpatient population for Pennsylvania acute-care facilities. Data sets from the Authority's original data (from January 1, 2009, through December 31, 2012) are included for comparison. The analysis found not only that NV-HAP continues to be as lethal as VAP but that it demonstrates higher incidence and is more costly as a whole.

Introduction

Research published in 2012 by the Pennsylvania Patient Safety Authority determined that nonventilator hospital-acquired pneumonia (NV-HAP) affected more people than ventilator-associated pneumonia (VAP) and was as lethal as and wholly more costly than VAP. Furthermore, the incidence of NV-HAP was on the rise in patients in conventional wards and was likely to be underreported.[1]

Since the original Authority work identifying and defining the impact of NV-HAP on Pennsylvania residents and healthcare facilities was published, U.S. researchers interested in furthering the body of knowledge for NV-HAP have focused on the condition. Subsequent publications have validated the Authority's original findings and identified new areas of impact.

Examples of NV-HAP research findings include the following:

- Hospital-acquired pneumonia (HAP) accounts for about 21.8% of the burden of all hospital-associated infections meeting criteria of the Centers for Disease Control and Prevention's National Healthcare Safety Network (NHSN). Of these HAP cases, 60.9% can be attributed to NV-HAP, and 39.1% can be attributed to VAP.[2]
- Mortality attributed to NV-HAP ranges from 13.1% to 30%.[1-6]
- Additional length of stay associated with NV-HAP ranges from 4.0 to 15.9 days.[6]
- Estimated NV-HAP acute-care treatment costs range from $28,008 to $40,000 per case.[1,2,6,7]

This article updates the Authority's original data set, using the same methods and outcome measures. The authors include prevention strategies proposed by other investigators that complement the Authority's original targeted interventions.

Methods

Pennsylvania state law (Act 52 of 2007) requires that all acute-care healthcare-associated infections be reported through NHSN. Analysts queried NHSN for complete nosocomial pneumonia data sets from January 1, 2013, through December 31, 2016, inclusive of the total inpatient population for Pennsylvania acute-care facilities. Data sets from January 1, 2009, through December 31, 2012, are included for comparison. The original data set was expanded to include 2012[1] to provide equal time-series sets and to address changes to NHSN's VAP definition that occurred in January 2013.[8]

Analysts also extracted data for patients with nosocomial pneumonia who died during that period. The NHSN field "Died" was used to aggregate the number of patients with pneumonia who died, regardless of responses found in the "Contributed to death" field. Of those cases of NV-HAP and VAP, the number of patients who died was also extracted. Time-series data was aggregated into yearly subtotals.

Besides comparing NV-HAP versus VAP incidence and mortality, estimated costs of NV-HAP versus VAP cases are compared. The baseline estimated average cost per NV-HAP case (in 2010 dollars) is $28,008.[9] The estimated average cost per VAP case is $37,442.[9] Authority analysts accounted for inflation, adjusting yearly values to accurately present financial impact.[10] Another outcome, distribution of NV-HAP cases by NHSN unit type, is based on aggregate data expressed in rate per 1,000 patient-days for January 1, 2013, through December 31, 2016.

Results

Table 1 shows the number of NV-HAP and VAP cases for 2009 through 2016 from NHSN. Although NV-HAP is as lethal as VAP, NV-HAP demonstrates higher incidence.

The table also includes the percentages of patients with NV-HAP and VAP who died. The difference in mortality percentages for patients with NV-HAP and VAP are not statistically significant; see Figure 1.

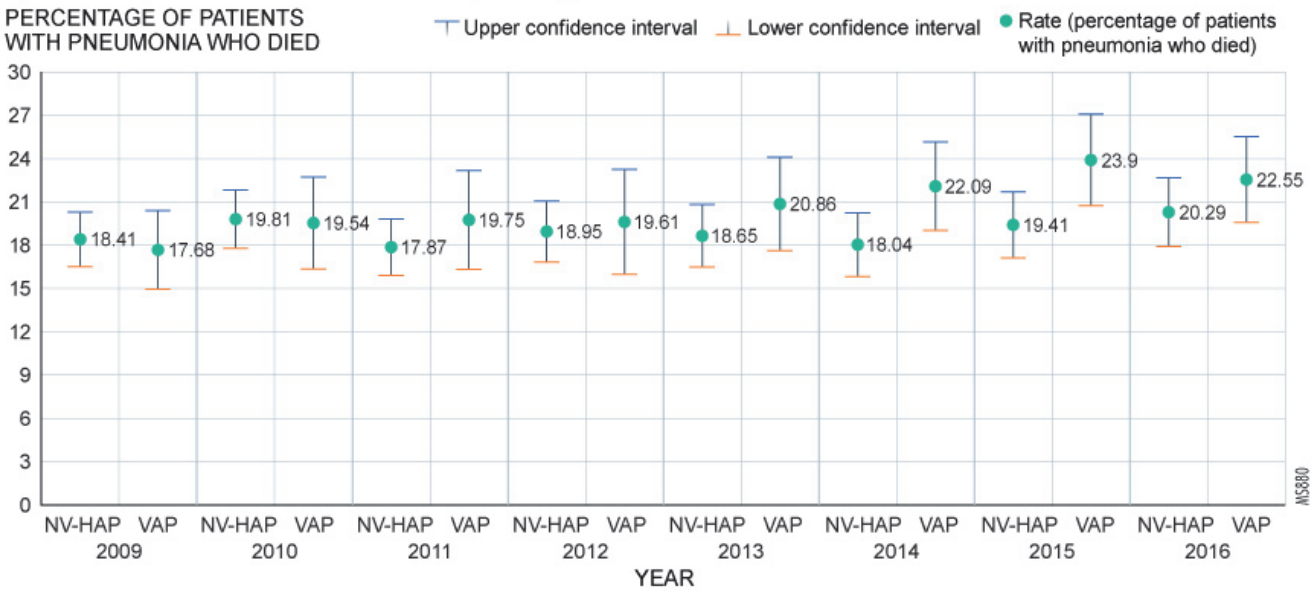
Table 1. Pennsylvania Nosocomial Pneumonia Incidence and Number of Patients with NV-HAP or VAP Who Died

Year	Number of NV-HAP Patients	Number of NV-HAP Patients Who Died	Percentage of Patients with NV-HAP Who Died (Confidence Interval)	Number of VAP Patients	Number of VAP Patients Who Died	Percentage of Patients with VAP Who Died (Confidence Limit)
2009	1,977	364	18.41 (16.52–20.3)	922	163	17.68 (14.96–20.39)
2010	1,848	366	19.81 (17.78–21.83)	737	144	19.54 (16.35–22.73)
2011	1,780	318	17.87 (15.9–19.83)	643	127	19.75 (16.32–23.19)
2012	1,620	307	18.95 (16.83–21.07)	571	112	19.61 (15.98–23.25)
2013	1,528	285	18.65 (16.49–20.82)	767	160	20.86 (17.63–24.09)
2014	1,419	256	18.04 (15.83–20.25)	901	199	22.09 (19.02–25.16)
2015	1,427	277	19.41 (17.13–21.7)	912	218	23.90 (20.73–27.08)
2016	1,380	280	20.29 (17.91–22.67)	980	221	22.55 (19.58–25.52)

Note: Data as reported to the National Healthcare Safety Network (NHSN). The NHSN field "Died" was used to aggregate the number of patients with NV-HAP or VAP who died regardless of responses found in the "Contributed to death" field.

NV-HAP, Nonventilator hospital-acquired pneumonia; VAP, ventilator-associated pneumonia.

Figure 1. Pennsylvania Nosocomial Pneumonia Cases, Percentage of Patients Who Died



Note: Data as reported to the National Healthcare Safety Network (NHSN). The NHSN field "Died" was used to aggregate the number of patients with pneumonia who died, regardless of responses found in the "Contributed to death" field.

NV-HAP, nonventilator hospital-acquired pneumonia; VAP, ventilator-associated pneumonia.

Table 2 compares the estimated total costs for NV-HAP and VAP cases. NV-HAP wholly is more costly than VAP.

Table 2. Estimated Total Yearly Cost of NV-HAP and VAP Cases in Pennsylvania

Year	NV-HAP Cases	Total Cost for NV-HAP Cases*	VAP Cases	Total Cost for VAP Cases*
2009	1,977	$53,955,118	922	$33,638,285

2010	1,848	$51,758,784	737	$27,594,754
2011	1,780	$50,667,789	643	$24,468,079
2012	1,620	$47,462,290	571	$22,363,860
2013	1,528	$45,480,874	767	$30,519,528
2014	1,419	$42,903,380	901	$36,417,564
2015	1,427	$43,106,716	912	$36,829,241
2016	1,380	$42,259,340	980	$40,118,681

Note: Cases identified in the National Healthcare Safety Network (NHSN) database.

The estimated average cost per NV-HAP case is $28,008. The estimated average cost per VAP case is $37,442.

NV-HAP, nonventilator hospital-acquired pneumonia; VAP, ventilator-associated pneumonia.

* Average costs are derived from Kalsekar I, Amsden J, Kothari S, et al. Economic and utilization burden of hospital-acquired pneumonia (HAP): a systematic review and meta-analysis. Chest. 2010 Oct;138 (4 Suppl):739A, and adjusted for inflation before and after 2010 based on the U.S. Department of Labor. Bureau of Labor Statistics. Consumer Price Index for All Urban Consumers (CPI-U) Inflation Calculator.

Table 3 shows the distribution of NV-HAP cases by NHSN unit type for years 2013 through 2016. This data is intended to identify and prioritize high-risk patient populations, to facilitate effective deployment of infection-prevention efforts and resources.

Table 3. Distribution of NV-HAP Cases, Pooled Mean per 1,000 Patient-Days (Based on Aggregate Data for Pennsylvania, 2013 through 2016)

Unit*	Facilities	NV-HAP Cases	Patient-Days	Pooled Mean†,‡
Acute/Critical Care				
Trauma	12	625	892,396	0.700
Surgery	11	477	908,216	0.525
Oncology medical/surgical	2	40	76,697	0.522
Neurosurgical	9	304	720,303	0.422
Medical	24	775	2,028,708	0.382
Cardiothoracic	30	562	1,550,793	0.362
Long-term acute care	3	50	189,497	0.264
Medical/surgical	117	1,883	7,212,260	0.261
Cardiac	19	222	963,748	0.230
Prenatal	1	2	11,566	0.173
Neurologic	4	18	106,348	0.169

Burn	4	27	194,824	0.139
Respiratory	2	6	59,180	0.101
Medical/surgical pediatric	5	36	693,549	0.052
Nursery	19	75	1,800,203	0.042
Step-down nursery	9	35	1,077,720	0.032
Cardiothoracic pediatric	3	9	331,409	0.027
Medical pediatric	0	0	25,322	0.000
Surgery pediatric	0	0	10,484	0.000
Ward				
Stroke	1	10	85,764	0.117
Pulmonary	6	61	698,634	0.087
Neurosurgical	3	24	452,944	0.053
Medical	53	612	11,976,937	0.051
Surgical	38	331	6,433,864	0.051
Genitourinary	1	5	103,484	0.048
Medical/surgical	122	1,285	29,471,925	0.044
Telemetry	24	118	2,824,988	0.042
Rehabilitation	41	129	3,982,174	0.032
Orthopedic	24	84	2,909,777	0.029
Gynecology	2	4	140,379	0.028
Neurologic	7	17	682,517	0.025
Gerontology	1	1	77,734	0.013
Behavioral	40	116	10,670,565	0.011
Surgical pediatric	1	1	115,905	0.009
Trauma orthopedic	1	3	334,186	0.009
Antenatal	1	1	117,704	0.008
Labor & delivery	4	4	546,418	0.007
Medical pediatric	2	5	838,051	0.006
Labor & delivery/postpartum	5	5	1,077,758	0.005
Rehabilitation pediatric	1	1	204,761	0.005
Behavioral health pediatric	1	1	261,356	0.004
Postpartum	10	11	2,740,931	0.004

Medical/surgical pediatric	4	5	1,530,652	0.003
Behavioral health adolescent	1	1	681,088	0.001
Nursery	1	2	1,908,707	0.001
Ear/nose/throat	0	0	736	0.000
Orthopedic pediatric	0	0	113,178	0.000
Vascular surgery	0	0	31,926	0.000
Jail	0	0	155,176	0.000
Ward—Oncology				
Leukemia/lymphoma	2	14	110,550	0.127
Hematology/oncology	17	343	2,865,683	0.120
Hematopoietic stem cell transplant	2	37	317,854	0.116
Hematology/oncology pediatrics	0	0	551,696	0.000
Specialty Care Area				
Solid organ transplant pediatric	1	4	128,615	0.031
Long-term acute care pediatric	0	0	22,860	0.000
Step-down Unit				
Adult	60	555	8,272,644	0.067
Pediatric	1	1	415,707	0.002
Nursery	0	0	71,542	0.000
Long-term acute care	22	184	3,867,389	0.048

Note: Data as reported to the National Healthcare Safety Network (NHSN).

NV-HAP, nonventilator hospital-acquired pneumonia.

* Units are based on NHSN classifications.

† Pooled mean = total cases ÷ total patient-days x 1,000.

‡ Per 1,000 patient-days.

Discussion

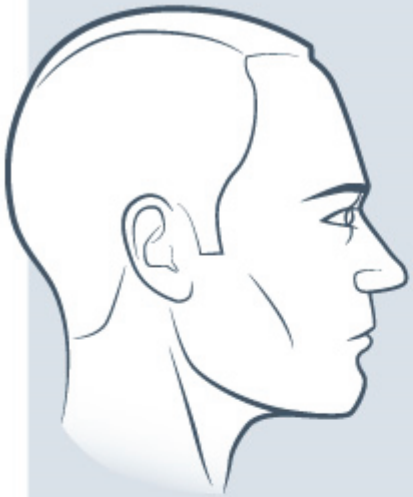
Both NV-HAP and HAP continue to be problematic for acute-care patients in Pennsylvania. Many healthcare providers are unaware of the importance of good dental care in preventing both NV-HAP and HAP. Li and co-authors noted that "the teeth are the only nonshedding surfaces in the body, and bacterial levels can reach more than 10^{11} microorganisms per mg of dental plaque [biofilm]."[11] The presence of subgingival biofilm serves as a continual and enormous bacterial load.[11] Poor oral hygiene increases plaque load, increasing enzyme levels in saliva.[11] As a

consequence of the plaque load, increased levels of oral proteolytic enzymes change the lining of the mouth, increasing attachment and colonization by exogenous and/or endogenous pathogenic bacteria.[12] The oral cavity is a source as well as a reservoir for pathogenic bacteria in both planktonic and biofilm states.

Dental-biofilm removal is mainly accomplished by using dentifrice-containing compounds, such as detergents, abrasives, and antimicrobials, which require mechanical tooth brushing to be effective.[13] Given the characteristics of dental biofilm, part of a comprehensive NV-HAP prevention program includes tooth and tongue brushing with toothpaste.

Other preventive measures include protecting the patient from macro and micro aspiration and strengthening host defenses to infection.[1,6,7,14] Figure 2 provides selected interventions to prevent NV-HAP. Figure 3 provides the Hospital-Acquired Pneumonia Prevention Initiative (HAPPI) oral care protocol designed by researchers at Sutter Medical Center and California State University, Sacramento, and approved by the American Dental Association Board of Trustees in 2017. The HAPPI research developed a targeted oral-care protocol that specifies patient type, equipment, procedure, and frequency for oral care.

Figure 2. Selected Interventions to Prevent Nonventilator Hospital-Acquired Pneumonia

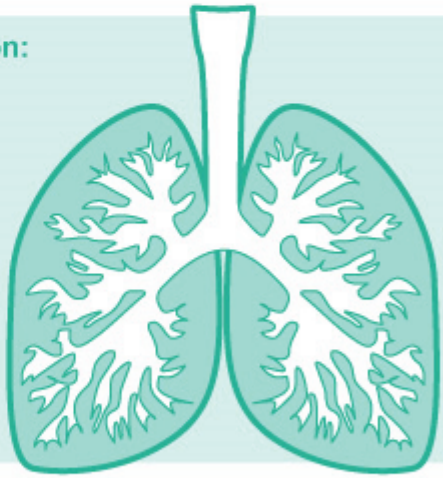


Selected interventions to prevent colonization:

- Provide information about optimal pulmonary state.
- Optimize functional reserve capacity.
- Strengthen patient's resistance to atelectasis.
- Maintain patient's resistance to infection:
  - —Perform hand hygiene.
  - —Institute a routine oral hygiene regimen.
  - —Eliminate oral bacterial reservoirs.
  - —Consult with a dental professional.
  - —Protect oral epithelial cells and nasal passages by providing moisture and avoiding large-bore nasogastric tubes.
  - —Avoid unnecessary antibiotics.
  - —Avoid unnecessary stress ulcer prophylaxis (if necessary, consider a cytoprotective agent).
  - —Consider chlorhexidine oral rinse or chlorhexidine bath for select patient populations.

Selected interventions to prevent aspiration:

- Teach techniques for optimizing cough and airway clearance.
- Avoid unnecessary medications that reduce level of consciousness.
- Maintain head of the bed at 30 degrees or greater unless contraindicated.
- Encourage ambulation.
- Provide subglottic suctioning.
- Consult with speech and/or swallowing professionals when appropriate.



Holistic prevention strategies:

- Administer vaccines and immunizations.
- Provide smoking cessation counseling.
- Institute environmental infection control measures.
- Encourage personal hygiene, including hand hygiene.
- Evaluate the patient's risk for aspiration.
- Provide dementia screening.
- Assess the patient's nutritional status.
- Encourage routine professional dental care.

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Figure 3. Oral Care Protocol to Prevent Hospital-Acquired Pneumonia

ORAL CARE PROTOCOL

- Complete oral care assessment that *includes swallow assessment first.* Determine if a bite block is required and if a swallow assessment is required.
- Always use Personal Protective Equipment (PPE) when assisting patients with mouth care, including gloves, mask, and face shield.
- Document oral care in the patient record.
- Disposable swabs should not replace tooth brushing. They are for comfort care, one-time use only; do not leave soaking in a cup for reuse later.

Maintain adequate oral hydration when possible to maximize salivary flow

PATIENT TYPE	EQUIPMENT	PROCEDURE	FREQUENCY
Self-care and staff-assist. Able to expectorate (spit).	▪ Soft toothbrush ▪ Toothpaste, plaque removing ▪ Antiseptic oral rinse, alcohol-free ▪ Mouth moisturizer ▪ 1-2 swabs ▪ If available, dental floss or interdental cleansers	1. Set patient up at sink or in bed with all equipment. 2. Instruct patient to brush teeth for 1-2 minutes. Brush the tongue. 3. Instruct patient to swish and spit antiseptic oral rinse. 4. If available, have patients use floss or interdental cleansers. 5. May moisturize interior of mouth and lips using a swab, PRN. 6. Discard disposable equipment/swab in appropriate receptacle.	After each meal and before bedtime. If patient is NPO, oral care should be done AM, mid-day, evening, and bedtime.
Dependent for oral care. Not able to expectorate (spit). At risk for aspiration.	▪ Suction toothbrush & swab ▪ Antiseptic oral rinse, alcohol-free ▪ Mouth moisturizer	1. Moisten suction toothbrush/swab in antiseptic oral rinse. 2. Connect suction toothbrush/swab to continuous suction. 3. Brush the teeth 1-2 minutes. Brush the tongue. 4. Suction debris from mouth. 5. Apply moisturizer, using a swab, to the interior of the oral cavity and the lips. 6. Discard disposable equipment/swab in appropriate receptacle.	Same as above.
Dependent on oral care. Patient on a ventilator.	▪ Suction toothbrush/swab ▪ Oral cleansing solution ▪ Mouth moisturizer ▪ Chlorhexidine oral rinse	1. Provide suction, PRN, to remove oropharyngeal secretions that can migrate down the tube and settle on top of the cuff. 2. Obtain suction toothbrush/swab and moisten with oral cleansing solution. 3. Connect suction toothbrush/swab to continuous suction. 4. Remove the debris and cleanse the gums, tongue, and inside of cheeks with the solution-saturated swab. 5. Suction debris from mouth. 6. Apply moisturizer, using a swab, to the interior of the oral cavity and the lips. 7. Discard disposable equipment/swab in appropriate receptacle.	Every 4 hours and PRN oral debris. Use chlorhexidine rinse as oral care solution AM and HS.
Denture care for patients with no teeth *Whenever patient is sleeping,* clean dentures and place in antiseptic solution.	▪ Denture cup, labeled ▪ Denture brush is preferred when available, otherwise soft toothbrush ▪ Denture cleanser (for soaking only) ▪ 2 swabs ▪ Antiseptic rinse, alcohol-free ▪ Optional: denture adhesive	1. After removing dentures, place in a labeled denture cup. 2. Brush the palate, buccal surfaces, gums, and tongue with the toothbrush or swab. 3. Patient can swish and spit antiseptic rinse, or use swab to apply. 4. Line the sink with paper towel and add water to cushion the dentures in case you drop them. Carefully brush dentures with warm water. DO NOT USE TOOTHPASTE as this may scratch the surface of the dentures. 5. Clean and dry equipment and return to patient's bedside table. 6. Assist patient in inserting dentures into mouth. 7. After HS mouth care, soak dentures in a commercial cleanser in the denture cup. 8. If patient needs denture adhesive to hold firmly in place, follow manufacturer directions.	After each meal and at bedtime.

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AM, *ante meridiem*, morning; HS, *hora sonni*, at bedtime; NPO, *nil per os*, nothing by mouth; PRN, *pro re nata*, as needed.

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For preventive interventions to be successful, they need to be performed at specified frequencies. In a large, multicenter, nationwide study, in regard to hospital care performed in the 24 hours before NV-HAP diagnosis, Baker and Quinn found evidence of limited compliance, as follows:[14]

- Oral care ≥2 times was not documented for 58.6% of patients.

- Most patients (64.5%) had documented head-of-bed elevation to 30 to 45 degrees, whereas 35.5% did not.
- If permitted, 28.7% of patients were out of bed twice in a 24-hour period, and 55.4% were out of bed fewer than two times (15.9% were not allowed mobility intervention).
- Incentive spirometry was not documented for 81.8%, nor were cough and deep breathing exercises (67.4%), in the 24-hour period before pneumonia diagnosis.

The poor performance of basic NV-HAP prevention methods is unfortunate and likely signals the need for improved workflows, systems, tools, and human resources to deliver the care that is needed to prevent the condition. The job of prevention should fall upon all care providers, not just nurses and patient care assistants. Perhaps enlisting respiratory therapists, speech and swallowing therapists, and dental professionals could help ensure prevention tasks are performed at appropriate intervals.

The dental professional's participation is of paramount importance. Adachi and co-authors correlated weekly dental cleaning by a hygienist with fewer cases of fever and fatal pneumonia in the nursing home setting.[15] Similarly, Abe and co-authors noted a reduction in influenza infection in older patients because of weekly professional dental cleaning.[16] Perhaps, for HAP prevention, the dental professional should play an active role in the hospital and other healthcare settings.

Limitations and Data Nuances

NHSN's VAP criteria-definition changes occurred in January 2013,[8] which, unfortunately, renders impossible direct comparisons between VAP and NV-HAP for the time periods before and after the change. Analysts did not calculate for analysis the pooled mean for NHSN events for the time periods before or after the criteria change, because the totals would be incomparable.

Analysis by patient-days may underestimate the true rate of NV-HAP because this metric potentially lowers rates because of extensions of length of stay related to NV-HAP. Authority analysts did not have access to unit-level-specific admissions by location type for this analysis—hence, the use of patient-days by location type.

Comparison of Table 1 from this article with Table 1 from the original Authority article[1] reveals few differences, likely due to institutional edits over time. Regardless, the outcomes are the same for this updated data compared with the original data.

Conclusion

Both NV-HAP and VAP continue to be problematic for acute-care patients in Pennsylvania. NV-HAP affects more patients, contributes to more deaths, and increases costs more than VAP. Focusing care on bacterial reservoirs and the oral portal of entry is the most realistic approach for preventing NV-HAP. Improving oral hygiene is essential in preventing NV-HAP (and VAP). Staff compliance with interventions, as noted herein, and helping all patients to get HAPPI care is likely to prevent extra lengths of stay, save money, and prevent premature deaths.

Notes

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