

Dysphagia

© Springer-Verlag New York Inc. 2002

10.1007/s00455-002-0072-1

Predictors of Aspiration Pneumonia in Nursing Home Residents

Susan E. Langmore PhD¹, Kimberly A. Skarupski PhD, MPH² [Contact Information](#), Pil S. Park PhD³
and Brant E. Fries PhD³

(1) Department of Neurology, University of California San Francisco, San Francisco, California, USA

(2) Center for Organizational Research & Evaluation (CORE), Penn State Erie, The Behrend College,
Erie, Pennsylvania, USA

(3) Institute of Gerontology, The University of Michigan, Ann Arbor, Michigan, USA

[Contact Information](#) **Kimberly A. Skarupski**

Abstract Aspiration pneumonia is a serious problem for the elderly institutionalized person, often requiring transfer to a hospital and a lengthy stay there. It is associated with a high mortality rate and is very costly to the health care system. The current study sought to determine the key predictors of aspiration pneumonia in a nursing home population with the hope that health care providers could identify those residents at highest risk and focus more efforts on prevention of this serious disease. A cross-sectional, retrospective analysis was done, using the Minimum Data Set (MDS) nursing home assessment data for three states (New York, Mississippi, Maine) from 1993 to 1994 ($N = 102,842$). Nursing home residents were aged 65+. Standardized MDS summary scales and their component items were used, including: the Activities of Daily Living (ADL) scale, the cognitive performance scale (CPS), and the Resource Utilization Groups (RUGs). Results of these analyses showed the prevalence of pneumonia among this population was 3% ($n = 3118$). Results from the logistic regression models indicated 18 significant predictors of aspiration pneumonia. The strongest to weakest predictors of pneumonia were, respectively, suctioning use, COPD, CHF, presence of feeding tube, bedfast, high case mix index, delirium, weight loss, swallowing problems, urinary tract infections, mechanically altered diet, dependence for eating, bed mobility, locomotion, number of medications, and age, while both CVA and tracheotomy care were inversely predictive of pneumonia. The emergence of these significant predictors suggested a different pathogenesis of pneumonia in the elderly nursing home resident from the acute care patient or the outpatient. Nursing home residents have chronic medical conditions that gradually lead to “decompensation” in functional status, nutritional status, and pulmonary clearance. Dysphagia and aspiration are common complications of their medical conditions and may slowly worsen as their status deteriorates. Alternatively, a sudden adverse event may dramatically increase the amount aspirated or the ability to resist infection and lead to sudden decompensation. Clinical staff must identify residents with dysphagia and aspiration and work to prevent decline in functional status in all residents.

They must be aware of the dangers of adverse events that lead to sudden inactivity or illness and increase the risk of aspiration pneumonia. Prevention of this disease whenever possible will reduce costs, improve health outcomes, and improve our quality of care.

Keywords Nursing home residents - Pneumonia - Aspiration - Functional status - Dysphagia - Deglutition - Deglutition disorders

The majority of the work for this project was completed at the Institute of Gerontology, University of Michigan. This project was funded by a grant from the Department of Veterans Affairs, Ann Arbor Health Services Research & Development (HSR&D) Field Program.

Aspiration pneumonia is a serious problem for the elderly institutionalized person. Pneumonia and other respiratory tract infections are the second most common infections in nursing home patients, following urinary tract infections and accounting for about 21% of all infections [1]. The cumulative incidence of new cases of pneumonia in nursing homes is about 18% over one year, but figures go as high as 48% [2,3]. More importantly, pneumonia has the highest mortality rate of any nosocomial infection [1,4] and is the most frequent reason for hospitalization [5]. Once in hospital, pneumonia is associated with an average length of stay of 21–40 days [6,7]. A recent report found that the incidence of hospitalizations for aspiration pneumonia has increased dramatically from 1991 to 1998, with a very high case-fatality rate. Aspiration pneumonia was described as an “epidemic” with unexpected trends and unexplained causes [8]. Hospitals are rarely reimbursed for their costs when patients have pneumonia. One study [7] done in 1991 estimated that at that time, it cost hospitals an average of \$9,460–\$33,430 per pneumonia episode; the latter needed if the patient required a stay in the ICU.

In this study, we sought to determine the key predictors of aspiration pneumonia in a nursing home population. The most commonly reported risk factors among nursing home residents with pneumonia include advanced age, male gender, institutionalization, reduced cognitive status, reduced functional status, tube feeding, dysphagia, difficulty with oropharyngeal secretions, frailty, incontinence, pulmonary disease, stroke, and sedative-hypnotic drug use [2,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23]. Reduced functional status and dysphagia may be especially important risk factors in this population, since they were associated with increased mortality following pneumonia in three recent reports [24,25,26]. On the other hand, two studies focusing exclusively on nursing home patients reported dysphagia was *not* a significant predictor of pneumonia [27,28]. Therefore, the importance of this risk factor is unclear. In a related note, nursing home patients who are not taking any food or liquid by mouth, but are tube fed, are reported to be at higher risk for pneumonia than patients who are eating orally [23,29,30]. While refluxed gastric contents can cause pneumonia, studies of the bacteriology of aspiration pneumonia suggest that the combination of colonization of the oropharynx with pathogenic bacteria and microaspiration of saliva containing these bacteria may be the most common source of aspiration pneumonia [31,32]. Multiple factors predispose to oropharyngeal colonization, including decreased saliva production, malnutrition, incontinence, debility, and respiratory disease [33,34].

It is critical that research on prevention of pneumonia be given the same priority as those investigations that have focused on treatment of pneumonia with antibiotics. If the cause of the pneumonia is not found, it is likely to recur. One problem with preventative studies is that so far there are literally hundreds of different risk factors that have been identified. Most studies have focused on a single category of risk, for example, dysphagia or medical diagnosis. While these help us to understand that risk category better, we cannot compare relative risk across categories. This becomes important when we are proposing intervention programs to reduce the incidence of pneumonia, since treatment will be most effective and efficient only when the most critical risk factors are targeted for treatment. A few studies have applied specific treatments such as swallowing therapy [[35](#),[36](#),[37](#),[38](#),[39](#)] but with mixed results. Perhaps therapy aimed only at the swallowing problem is sometimes ineffective because other factors such as dental status and feeding status overwhelm the effects of a dysphagia and lead to pneumonia.

Recently, Langmore et al., at the Ann Arbor VA Medical Center and University of Michigan, published results of a 5-year prospective study which sought to determine the predictors of aspiration pneumonia in elderly veterans [[29](#)]. The GOSP study (Geriatric Oral Science Project) enrolled 189 elderly veterans at the Ann Arbor VAMC from the outpatient clinics, acute care hospital, and nursing home care unit (NHCU) who had various medical problems. Extensive swallowing and dental examinations were performed on each subject, functional status and medical condition were rated, and each subject was followed prospectively until the end of the project or development of pneumonia. The highest incidence of pneumonia over the duration of the study occurred in the NH population (18/41 = 44%) compared with 19% of the hospitalized patients and 9% of the outpatients. Bivariate analyses showed the risk factors significantly associated with pneumonia in all patients included the presence of chronic obstructive pulmonary disease (COPD), congestive heart failure, GI disease, multiple diagnosis, number of medications, presence of dysphagia on an instrumental examination, aspiration of liquid or food or severe dysphagia on the examination, tube feeding, dependent for feeding, bedbound for part or all of the day, reduced level of alertness, dependent for oral care, brush teeth occasionally or never, number of decayed teeth, and dry or excess secretions in the mouth. When analyzed separately, factors that were significant for nursing home patients in this study were COPD, presence of dysphagia, and dependent for feeding. Multivariate logistic regression analyses determined that the best independent predictors for pneumonia for all patients were dependent for feeding, dependent for oral care, tube feeding, currently smoking, multiple medical diagnoses, number of medications, and number of decayed teeth. Unfortunately, there were not enough nursing home patients to perform the logistic regression analysis on specific subgroups, e.g., edentulous patients and tube-fed patients. In summary, the results suggested that colonization of the mouth and pharynx and subsequent aspiration of saliva, sometimes mixed with food or liquid, and reduced pulmonary clearance led to pneumonia in this group of veteran patients.

While results from the GOSP project were important, that study was limited by the small sample overall ($n = 189$) and in the group of nursing home patients ($n = 41$). This made it difficult to examine particular risk factors or interactions within different subgroups. The specialized sample of patients—all male, all patients at the same facility (Ann Arbor VAMC), and most with neurologic or pulmonary disease—precluded generalizations to the larger geriatric population. Different risk factors may operate in the three populations examined—the nursing home, hospital, and outpatient populations—but this

could not be determined.

The current study sought to examine a much larger database of institutionalized elderly patients to see if the findings of GOSP are supported by the larger data set. We also attempted to fill in missing variables, especially in the area of functional status, which define the high-risk patient. Since nursing homes experience the highest rate of pneumonia and represent the largest growing medical setting for older persons who require medical care, it was decided to focus on that setting. One of the primary risk factors of interest in this study was dysphagia. Because dysphagia was not a significant predictor in the GOSP study and its association with pneumonia has not been clearly established in the literature, we were interested in finding out whether it would emerge as a significant predictor in the large sample being analyzed in the current study.

Methods

By means of a cross-sectional study, we sought to determine which factors are key predictors of aspiration pneumonia in nursing home residents.

Data Source

The current study was feasible due to the availability of an extensive and rich database describing nursing home residents. In its efforts to improve care in the nation's nursing homes, Congress mandated in 1987 that a uniform assessment be performed of every resident for the purposes of improved care planning. The National Nursing Home Resident Assessment Instrument (RAI) was implemented in 1990 in virtually all nursing homes outside the Department of Veterans Affairs (DVA) [40]. One component of the RAI is the standardized data collection form known as the Minimum Data Set (MDS). The MDS comprises more than 350 variables and covers a comprehensive set of domains. MDS assessments are done within seven days of admission, annually thereafter, and at any significant change in status; a shorter version is conducted quarterly. The MDS can be completed by various members of the professional staff at each facility, but a registered professional nurse is responsible for certifying completion and accuracy of the entire assessment. Diagnoses and other conditions are checked as present after reading the patient's medical record and consulting with the physician and other professionals involved in the resident's care.

This retrospective study analyzed MDS assessments available in an archive of multistate data describing nursing home residents. The University of Michigan Assessment Archive Project (UMAAP) is a database of over 4 million assessments of nursing home residents from 14 states. The data are kept strictly confidential; all resident identification numbers are encrypted upon receipt of the data from each state. The data have been proven in multiple studies to have excellent reliability [41], including a test done within VA nursing homes (Fries, unpublished data).

Measures

Because the MDS has over 350 different assessment items, making comparisons of populations is difficult and potentially spurious. To that end, the authors of the MDS developed several scales that summarize assessment domains of importance to nursing home care. We employed three of these summary scales for these analyses: the Activities of Daily Living (ADL) scale, the cognitive performance scale (CPS), and the Resource Utilization Groups (RUGs). This yielded 55 total variables for consideration in this study.

ADL Hierarchy Index [42,43] is a scale that succinctly summarizes the effects of resident functionality. The measure of physical function consists of the mean value for a composite Activity of Daily Living (ADL) Index that combines self-performance in late-loss ADLs: bed mobility, bed–chair transfer, eating, and toileting. This scale has been shown to predict well the cost of care in nursing homes. In this scale, a value of 4 represents independence in all four ADLs, a value of 18 represents total dependence in all four. Research has shown that these ADLs are the most important in understanding differences in cost of care, and that for this application, the scale is interval (i.e., values can be considered numeric, with a “8” representing approximately twice the cost of a “4”). It follows that averaging the index is an appropriate measure for a population.

MDS Cognitive Performance Scale (CPS) [44] summarizes the measures of cognition available in the MDS. Five selected MDS items are combined to create the single, functionally meaningful seven-category hierarchical Cognitive Performance Scale. In this scale, 0 represents a totally intact individual, while 6 represents an individual who is very severely impaired in cognitive functioning. Two of the items come from the cognitive domain: short-term memory and cognitive skills for decision-making. A third item represents the small proportion of residents in a coma or in a persistent vegetative state. The fourth item is from the communication domain (i.e., making self understood), and the last item represents an ADL performance indicator—full dependence in eating.

The CPS classifies all residents into seven categorical levels of cognitive performance: intact, borderline intact, mild impairment, moderate impairment, moderately severe impairment, severe impairment, and very severe impairment. Those with severe impairment in decision-making are assigned to the two severely impaired levels, based on whether they are totally dependent for eating or comatose. For other residents, low counts on the number of impairments (e.g., not independent in decision-making, not independent in being understood, and short-term memory problem) assign a resident to the two most intact groups. Other noncomatose residents are assigned to three impaired levels based on the second intermediate summarization representing those with more impairments in decision-making and being understood. The CPS scale corresponds closely with scores generated by the Mini-Mental State Examination and the Test for Severe Impairment, nursing judgments of disorientation, and neurological diagnoses of Alzheimer's disease and other dementias [44].

Resource Utilization Groups (RUGs) is a case-mix classification system whose main purpose is to identify patient characteristics associated with measured resource use. RUG-III comprises 44 groups that explain 55.5% of the variation in total nursing and therapy per diem costs and meets goals of clinical

validity and payment incentives [45,46]. The RUG-III system incorporates up to three dimensions in describing a resident:

- 1 One of seven major types of nursing home residents. The seven hierarchy categories include special rehabilitation, extensive care, special care, clinically complex, impaired cognition, behavioral problems, and reduced physical functions.
- 2 The ADL index is a summary measure of four ADL measures: toileting, eating, bed-to-chair transfer, and bed mobility.
- 3 Use of particular services such as nursing rehabilitation, speech therapy, or problems such as resident depression.

Setting and Sample Design

Data were drawn from three states, New York, Mississippi, and Maine, during 1993–1994 and were selected using the following criteria: most recent full (not quarterly) assessment, unduplicated, and age \geq 65. From these three states, we performed the analyses on 102,842 UMAAP MDS nursing home resident assessments. The sample size was considered sufficient to achieve meaningful results, considering the prevalence of pneumonia in this population is estimated at about 2–3% [47].

Data Analysis

The analyses began with bivariate statistical tests. A series of chi-squares were examined to assess the association of the 55 independent variables/suggested risk factors with the dependent variable, presence of pneumonia. The determination of pneumonia in the MDS is assessed via the ICD-9-CM code 486 for pneumonia. While this code is a general code used to identify the presence of any type of pneumonia, it was considered the best indicator of aspiration pneumonia. The other possible entry, “Recurrent lung aspirations in last 90 days,” was rarely checked and therefore was not considered in this analysis.

Risk factors were retained for further analyses if they met the criterion of $p \leq 0.05$ or if there was strong clinical reason to retain. Intercorrelations between the variables were investigated via a Pearson's correlation coefficient matrix. None of the bivariate relationships approached a level that indicated potential multicollinearity. Variables significantly associated at the bivariate level were then entered into a multivariate logistic regression model using a backward elimination procedure. In a backward elimination procedure, the computer begins the analysis with all variables in the equation and then removes the variable with the weakest correlation. The regression equation is reduced by one variable in each subsequent iteration until no further variables can be eliminated. The result is the most parsimonious model with the best fit. To validate our final model, we systematically divided our sample into two and attempted to fit the model. Results for both models showed the same statistically significant variables. Finally, interaction terms were calculated to account for any moderating effects on the dependent variable.

Results

Of the 102,842 nursing home resident assessments analyzed in Maine, Mississippi, and New York, most data were available for the parameters of interest. For our dependent variables—prevalence of pneumonia—data were available for 102,755 residents. The prevalence of pneumonia among this population was 3% ($n = 3118$).

[Table 1](#) lists the 55 independent variables that were significantly associated with pneumonia at the bivariate level ($p \leq 0.05$) and their prevalence rates in the population. Demographics of the population were as follows: 49% of the residents were 85 years or older, with the remainder between 65 and 85 years. Eighty-five percent (85.3) were white, 10.9% were African—American, and the remaining 3.8% were Hispanic, Native American, or Asian/Pacific Islander. Seventy-five percent (74.9) were female and 7.9% used tobacco products daily. Some of these variables have been previously reported to be associated with pneumonia, including certain medical diseases, reduced level of function for activities of daily living, lowered level of alertness, swallowing problems/dysphagia, feeding tube usage, increased number of medications, presence of other infection (e.g., urinary tract infection), daily use of tobacco, and daily cleaning of teeth/dentures.

Table 1 Variables significantly associated with pneumonia (3%) in the bivariate analyses ($N = 102,755$)

Independent variables		Prevalence (%)
Demographic information	Age 85+	49.4
	Female	74.9
	White	85.3
	Uses tobacco products daily	7.9
Cognitive status	Alzheimer's	12.9
	CPS—severe impairment	26.9
	Coma	0.3
	Indicators of delirium:	
	less alert	2.8

	changing awareness of environment	2.6
	incoherent speech	2.5
	Deteriorated change in cognitive status	12.8
	Speech clarity	19.0
	Deteriorated change in communication	8.9
Physical functioning	ADL Index (mean, SD)	11.1 (4.7)
	Total dependence for:	
	bed mobility	20.9
	transfer	31.0
	locomotion	35.8
	dressing	37.0
	eating	22.2
	toileting	41.6
	personal hygiene	42.9
	bathing	53.6
	Deteriorated change in ADL function	24.5
	Contractures	7.2

	Involved in group activities	21.8
	No involvement patterns	21.0
	Passive range of motion therapy (1 + days>15 min)	32.7
	Trunk restraint	30.8
	Wheel self	26.1
Disease diagnoses	Arthritis	26.4
	Cancer	8.6
	Congestive heart failure	22.3
	Emphysema/asthma/COPD	13.1
	Stroke	23.2
Infections	Urinary tract infection	11.1
Health conditions	Shortness of breath in last 7 days	5.8
	Use of tobacco products daily	7.9
	Ventilator/respirator	0.1
	Vomiting	2.3
General medical condition	(RUGS) Case mix index (mean, SD)	1.1 (0.5)
Oral/nutritional status	Dehydration	2.7

	Eating/swallowing training (7 days/week)	3.5
	Feeding restrictions	5.9
	Feeding tube	7.7
	Mechanically altered diet	39.8
	Suctioning	1.2
	Swallowing problem	10.7
	Syringe feeding	0.7
	Tracheotomy care	0.4
	Weight loss	18.0
Oral/dental health	Chewing problem	16.3
	Daily cleaning of teeth/dentures	93.9
Number of medications	6 or more	50.7
Therapies	Occupational therapy (1 + days of >>10 min)	11.4
	Speech therapy (1 + days of >>10 min)	2.3

All of the variables significantly associated with pneumonia at the bivariate level were entered into a logistic regression model utilizing backward stepwise elimination. [Table 2](#) summarizes the results of the logistic regression analysis by listing the variables that were determined to be significant predictors of pneumonia. The logistic regression analysis eliminated some of the variables that were significant in the bivariate analyses, in all categories of interest. A number of interaction terms were calculated; for example, combinations of gender, feeding tube, swallowing problems, weight loss, bedfast, alertness, and eating dependence were constructed and none remained significant in the final reduced model. The

strongest to weakest predictors of pneumonia were, respectively, suctioning use, COPD, CHF, presence of feeding tube, bedfast, high case mix index, delirium, weight loss, swallowing problems, urinary tract infections, mechanically altered diet, dependence for eating, bed mobility, locomotion, number of medications, and age, while both CVA and tracheotomy care were inversely predictive of pneumonia.

Table 2 Predictors of aspiration pneumonia (logistic regression model with backward elimination procedure)

Independent variables	Odds ratio (95% CI)
Suctioning	2.55 (2.06,3.15)
COPD	2.49 (2.27,2.72)
CHF	1.75 (1.61,1.90)
Feeding tube	1.73 (1.51,1.98)
Bedfast	1.72 (1.53,1.92)
Case mix index	1.67 (1.55,1.79)
Indicators of delirium/less alert	1.63 (1.38,1.92)
Weight loss	1.60 (1.47,1.74)
Swallowing problem/dysphagia	1.46 (1.31,1.62)
Urinary tract infection	1.39 (1.25,1.53)
Mechanically altered diet	1.24 (1.14,1.36)
Dependence — eating	1.17 (1.05,1.31)
Dependence — bed	1.07 (0.96,1.19)

Dependence — locomotion	1.05 (0.94,1.17)
Number of medications	1.04 (1.03,1.04)
Age	1.01 (1.00,1.01)
CVA	0.83 (0.75,0.91)
Tracheotomy care	0.38 (0.25,0.60)

Discussion

In this study, there were 55 variables found to be significantly associated with pneumonia at the bivariate level ($p \leq 0.05$). Not surprisingly, nearly all variables reported in the literature on this topic were found somewhere on this list, including the three variables reported to be significantly associated with pneumonia in the nursing home veterans in the GOSP study (COPD, presence of dysphagia, and dependent for feeding). The current study added to the literature by extracting information from such a large database and by focusing on one setting.

After performing the logistic regression analysis, 18 variables remained that were significant predictors of aspiration pneumonia in nursing home residents. While this number was still quite high, it was expected, considering the large data set and the number of putative variables that were tested for significance. The significant predictors of aspiration pneumonia agreed, for the most part, with previous studies that have analyzed risk factors for pneumonia.

The significant predictors in this study were compared with the GOSP study results of Langmore et al. [29], where they looked at a smaller number of veteran patients, mostly male, in three settings: hospital, nursing home, and outpatient. Three variables were significant in both studies: dependent for eating (feeding), presence of a feeding tube, and manner of medications. This suggests that these variables are strong predictors of pneumonia regardless of the setting or gender of the patient.

Four variables were significant predictors of pneumonia in the GOSP study but not in the current one: multiple medical diagnoses, current smoker, dependent for oral care, and number of decayed teeth. Perhaps gender difference in the two studies accounted for some of the disparate results. For example, the prevalence of current smokers was surely less in the general population of nursing home residents, where females predominate, than in the veteran population which is nearly all male and former military. Other lifestyle differences probably existed as well, but how they might have accounted for the different results is not clear. The lack of significance for the dental/oral health variables was even more perplexing, since many studies have shown a relationship between oral health and pneumonia [48,49,50].

Dependent for feeding was the strongest predictor in the GOSP study, with an odds ratio of 19.9. In the current study, it did not achieve this startling level of significance, but it was still a significant predictor, suggesting that dependence for feeding is an important problem to address in the nursing home setting, where so many of the residents are fed by caregivers. Dependence for feeding is likely to increase the risk of pneumonia if poorly or inappropriately trained personnel feed patients, especially those with dysphagia or reduced cognitive status. In their ignorance, the feeders deliver food and liquid too quickly and in amounts too large for the patient to handle safely and the patients inadvertently aspirate. Dependence for feeding is also associated with an extremely dependent state [51], reinforcing the notion that overall functional status is an important predictor of pneumonia.

Presence of dysphagia, one of the significant risk factors for pneumonia in the current study, did not emerge as a significant predictor of pneumonia in the GOSP study, although it was a significant risk factor in the preliminary bivariate analysis. In the GOSP study, dysphagia was identified from instrumental swallowing examinations, whereas in this study, dysphagia was identified observationally, under the oral/nutritional status MDS category “swallowing problem” (“examples include frequent choking and coughing when eating or drinking, holding food in mouth for prolonged periods of time, or excessive drooling”) [52]. The difference in type of assessment may have some bearing on the different results of the two studies. Alternatively, the different populations in the two studies suggest that nursing home residents may be at particular risk for aspiration or that their events of aspiration are more deleterious.

Feeding tubes were significant predictors of pneumonia in this study as well as in the GOSP study. This relation is now established in the literature and clearly needs to be addressed [21,28,30,53]. Tube-fed patients who are not eating food or liquid by mouth may get pneumonia at increased rates over residents who eat orally. This relationship has been reported to be especially high in institutionalized patients with chronic dementia [30]. The source of the pneumonia is either refluxed gastric contents or oropharyngeal secretions, with both of these likely playing a part in many instances of pneumonia. Several recent studies have emphasized the role of reduced salivary flow and subsequent altered oropharyngeal colonization in tube-fed patients [29,54,55], but gastroesophageal reflux disease (GERD) has also been shown to be increased in tube-fed patients and to predispose them to pneumonia [19,31,32]. In the current study, there were no MDS variables that could directly identify patients as having gastroesophageal reflux disease (GERD) or altered colonization of the oropharynx. Therefore, the relative importance of two possible sources of aspiration in tube-fed patients could not be tested in this study.

Increased number of medications was a significant predictor in the current study as well as the GOSP study. There are several putative reasons for the appearance of this variable. First, many medications reduce salivary flow or create xerostomia as a side effect. This will create a favorable environment for growth of bacteria that are pathogenic to the lungs if aspirated [56,57]. Many medications also reduce level of alertness because of their sedative effect. This in turn might increase the propensity of the resident to aspirate or to react sluggishly to an event of aspiration. Finally, an increased number of

medications are generally a marker for a sick person, which might be associated with compromised immune function.

In order to summarize the data meaningfully, it might be useful to posit a model of how pneumonia develops and then relate our “best predictors” to this model. In brief, pneumonia develops when the following conditions are met: (1) the normal flora of bacteria in the mouth and throat or stomach is altered by overgrowth of certain bacteria which, if aspirated, are pathogenic to the lungs; (2) food, liquid, oropharyngeal secretions, and/or refluxed gastric material are aspirated in sufficient quantity or with bacteria that are harmful to the lungs; and (3) the lungs are unable to clear the aspirated material either by mechanical clearance or by systemic host/cellular defenses.

Two of our variables were directly related to altered colonization of the mouth and throat: *number of medications* and *feeding tubes*. As mentioned previously, multiple medications often have the side effect of reducing salivary flow, which, in turn, favors altered growth of bacterial pathogens in the oropharynx. Feeding tubes have multiple consequences, including a tendency to reduce salivary flow because there is no food or liquid to stimulate saliva production. This, in turn, alters the oropharyngeal flora. In addition, it is commonly observed by healthcare workers that tube-fed patients do not receive good oral hygiene, thus promoting tooth decay, periodontal disease, and build up of plaque, which also alter the oropharyngeal flora. Surprisingly, lack of good oral hygiene was not directly supported in the current study.

Several variables were associated with an increased predilection for aspiration. *Dependent for feeding* was discussed earlier as a factor that increases the likelihood that the person fed will aspirate more than if he/she could self-feed. Four other variables were strong markers for aspiration: *swallowing problem/dysphagia*, is often associated with aspiration. A *mechanically altered diet* may be thought of as a surrogate marker for dysphagia, as it is often given to these patients. *Indicators of delirium/less alert* suggests a predilection to aspirate because this condition renders the person less aware of material that needs to be swallowed. Finally, *suctioning*, our strongest predictor of pneumonia, is uniformly administered to patients who are actively aspirating their secretions.

One predictor, *trach care*, was inversely related to pneumonia. This was an unexplained finding, since tracheostomy tubes are often needed by persons who aspirate. Since it was our weakest predictor, we did not attempt to explain it.

Three predictors suggested pulmonary clearance was impaired in patients that developed pneumonia: *bedfast*, *dependence in bed* (i.e., for moving around, turning, etc.), and *dependence in locomotion*. These factors described patients who were not active, were dependent for activities of daily living, and were perhaps positioned supine in bed, which makes it difficult to expel secretions.

Three medical conditions in the final model were associated with impaired pulmonary clearance: *COPD*, *CHF*, and *CVA*. Curiously, *CVA* was inversely related to pneumonia in our study, in stark contradiction to most of the literature [[58](#),[59](#),[60](#)]. Our contrary results may have simply reflected a “categorization”

anomaly in the MDS data. That is, in the instructions for marking relevant medical problems or conditions, it specifically states not to mark old or inactive diagnoses. Many nursing home residents have “old” strokes or undiagnosed strokes, so this box may not have been marked consistently.

Finally, three significant predictors that were not identified in the previous GOSP study emerged as important risk factors for nursing home residents: *weight loss*, *urinary tract infections*, and *age*. This group of predictors suggests that impaired host resistance or a depressed immune system might be especially prevalent in nursing home residents and contribute to the development of pneumonia. Weight loss is frequently a clinical indicator of malnutrition. Malnutrition is very common in nursing home residents, especially in those with dysphagia. It depresses the immune system, and it is associated with an increased risk for pneumonia [61,62,63]. Residents with urinary tract infections (UTI) were also more likely to have pneumonia. UTIs are the most common infection found in nursing home residents [1] and the presence of one infection is known to weaken the ability to fight off a second one. Advanced age is also associated with reduced immunity. Many studies have found an increased incidence of pneumonia with advanced age [32,64,65]. Last, case mix index was predictive of pneumonia, suggesting that residents who required more nursing care were sicker and hence more vulnerable to pneumonia.

The findings of this study support the literature on risk factors for pneumonia, especially in highlighting the important role of dysphagia/aspiration, reduced functional status, and pulmonary disease. Many of the significant variables were multifaceted, meaning that they contribute to all three stages of development of pneumonia: altered colonization, aspiration, and reduced clearance.

The particular variables that emerged as predictive in this study suggest a different pathogenesis of pneumonia in the elderly nursing home resident than that of the acute care patient or the outpatient. Whereas the acute care patient has experienced a sudden event that either compromises his/her ability to swallow or to clear aspirated material, the nursing home patient has chronic disease that slowly progresses and eventually leads to “decompensation” in functional status, nutritional status, pulmonary clearance, and immune status. Aspiration of secretions, food, liquid, or refluxed gastric material is a common complication of several of the chronic medical conditions faced by this population and the severity and frequency of aspiration may gradually increase or become more “dangerous” as a consequence of worsening functional status.

Alternatively, aspiration or pulmonary clearance of aspiration may dramatically worsen as a consequence of being suddenly bedfast (as a result of a fall or urinary tract infection), put on a feeding tube, or given medications that reduce sensorium. As the immune system weakens, pneumonia becomes more and more difficult to resist.

This pattern of slow decline, sometimes triggered by an adverse event, suggests that prevention must be multifaceted as well. Healthcare providers must try to prevent decline in functional status with exercise, daily outings, and encouraging independence in ADLs. Weight gain must be facilitated by offering tasty and attractive meals and holding off on tube feedings as long as it is safe. Identification of dysphagia is critical and appropriate feeding techniques must be taught to feeders if the resident cannot feed himself.

If the immune system is bolstered by preventative strategies, a sudden period of inactivity or illness might not be as catastrophic as it otherwise would be.

Conclusions

The findings of this project support the literature and our previous research on risk factors for pneumonia. The variables that emerged in this study as significant predictors in nursing home residents reflected a variety of conditions that increase the likelihood of aspiration and reduce the ability of the host to fight off an impending infection. *Dependent for feeding, mechanically altered diet, weight loss, tube fed, suctioning, and swallowing problem* all emphasized that this population is especially prone to aspiration. We were unable to determine whether contaminated oropharyngeal secretions or refluxed gastric contents played a bigger role as the source of aspiration, along with food and liquid in the oral feeders. Until further studies clarify this issue, we believe that they should all be considered as a potential cause of the pneumonia in any given resident. *COPD, CHF, bedfast, indicators of delirium/less alert, advanced age, multiple medications, urinary tract infection, and dependent ADL status* highlighted the fragile state of pulmonary clearance and host resistance in these elderly persons. Many of these same variables are risk factors for altered oropharyngeal colonization, making an event of aspiration even more treacherous. The combination of any of the above risk factors makes the nursing home resident much more vulnerable to the threat of pneumonia.

In order to prevent pneumonia in nursing home residents, the variables that are identified as “best predictors” need to be targeted to reduce their ability to cause infection. Clinical staff in nursing homes need to identify patients at highest risk and work aggressively with these patients to try to minimize oropharyngeal colonization, eliminate aspiration, promote better pulmonary clearance, and strengthen the patient's immune function. By reducing the occurrences of aspiration pneumonia, we will reduce costs, improve health outcomes, and improve our quality of care.

Although this project was able to examine many variables by benefit of the MDS data set available to us, it did not complete the profile of all possible risk factors. Potentially important variables still need to be identified and, more importantly, the relationship between variables needs to be better understood. The identification of aspiration pneumonia was, by necessity, based on nonspecific information from the MDS which may have overestimated the prevalence of this disease. A smaller study with more patient-specific medical information available to the investigators would undoubtedly yield more accurate counts. Similarly, the identification of dysphagia was based on observation and not formal assessment, so the presumed importance of this variable was somewhat diminished. The current study included only nursing home residents; therefore, one cannot generalize our findings to persons in other settings such as home or hospital. Also, since most nursing home residents are elderly, the findings cannot be generalized to younger persons in nursing homes. Finally, it is important to remember that correlation of certain variables with pneumonia does not prove causality, but it can set the stage for a longitudinal study and, eventually, an interventional study.

References

Farber, BF, Brennen, C, Puntereri, AJ, Brody, JP (1984) "A prospective study of nosocomial infections in a chronic care facility." *J Am Geriatr Soc* 32: 234-238 [PubMed](#)

Loeb, J, McGeer, A, McArthur, M, Walter, S, Simor, AE (1999) "Risk factors for pneumonia and other lower respiratory tract infections in elderly residents of long-term care facilities." *Arch Intern Med* 159: 2058-2064 [PubMed](#)

Crossley, KB, Thurn, JR (1989) "Nursing home-acquired pneumonia." *Semin Respir Infect* 4: 64-72 [PubMed](#)

Gross, PA, New, HC, Aswapokee, P, Van Antwerpen, C, Aswapokee, N (1980) "Deaths from nosocomial infections: experience in a university hospital and a community hospital." *Am J Med* 68: 219-223 [PubMed](#)

Beck-Sague, C, Banerjee, S, Jarvis, WR (1993) "Infectious diseases and mortality among US nursing home residents." *Am J Public Health* 83: 1739-1742 [PubMed](#)

Zimmer, JG, Eggert, GM, Treat, A, Brodows, B (1988) "Nursing homes as acute care providers: a pilot study of incentives to reduce hospitalizations." *J Am Geriatr Soc* 36: 124-129 [PubMed](#)

Boyce, JM, Potter-Bynoe, G, Dziobek, L, Solomon, SL (1991) "Nosocomial pneumonia in Medicare patients: hospital costs and reimbursement patterns under the prospective payment system." *Arch Intern Med* 151: 1109-1114 [PubMed](#)

Baine, WB, Yu, W, Summe, JP (2001) "Epidemiologic trends in the hospitalization of elderly Medicare patients for pneumonia, 1991-1998." *Am J Public Health* 91: 1121-1123 [PubMed](#)

Alvarez, S, Shell, CG, Woolley, TW, Berk, SL, Smith, JK (1988) "Nosocomial infections in long-term facilities." *J Gerontol A Biol Sci Med Sci* 43: 9-17 [PubMed](#)

- Garibaldi, RA, Brodine, S, Matsumiya, S (1981) "Infections among patients in nursing homes: policies, prevalence, and problems." *N Engl J Med* 305: 731-735 [PubMed](#)
- Irvine, PW, Van Buren, N, Crossley, K (1984) "Causes for hospitalization of nursing home residents: the role of infection." *J Am Geriatr Soc* 32: 103-107 [PubMed](#)
- Harkness, GA, Bentley, DW, Roghmann, KJ (1990) "Risk factors for nosocomial pneumonia in the elderly." *Am J Med* 89: 457-463 [PubMed](#)
- Mehr, DR, Foxman, B, Colombo, P (1992) "Risk factors for mortality from lower respiratory infections in nursing home patients." *J Fam Pract* 34: 585-591 [PubMed](#)
- Niederman, MS (1993) "Nosocomial pneumonia in the elderly patient." *Clin Chest Med* 14: 479-490 [PubMed](#)
- Degelau, J, Guay, D, Straub, K, Luxenberg, MG (1995) "Effectiveness of oral antibiotic treatment in nursing home-acquired pneumonia." *J Am Geriatr Soc* 43: 245-251 [PubMed](#)
- Siebens, H, Trupe, E, Siebens, A, Cook, R, Anshen, S, Hanauer, R, Oster, G (1986) "Correlates and consequences of eating dependency in institutionalized elderly." *J Am Geriatr Soc* 34: 192-198 [PubMed](#)
- Rudman, D, Feller, AG (1989) "Protein-calorie undernutrition in the nursing home." *J Am Geriatr Soc* 37: 173-183 [PubMed](#)
- Pingleton, SK (1989) "Enteral nutrition as a risk factor for nosocomial pneumonia." *Eur J Clin Microbiol Infect Dis* 8: 51-55 [PubMed](#)
- Ciocon, JO, Silverstone, FA, Graver, LM, Foley, CJ (1988) "Tube feedings in elderly patients." *Arch Intern Med* 148: 429-433 [PubMed](#)
- Sitzmann, JV (1990) "Nutritional support of the dysphagic patient: methods, risks, and complications of therapy." *J Parenter Enteral Nutr* 14: 60-63 [PubMed](#)

Marrie, TJ (2000) "Community-acquired pneumonia in the elderly." *Clin Infect Dis* 31: 1066-1078

[PubMed](#)

Medina-Walpole, A, Katz, PR (1999) "Nursing home-acquired pneumonia." *J Am Geriatr Soc* 47: 1005-1015

[PubMed](#)

Pick, N, McDonald, A, Bennett, B, Litsche, M, Dietsche, L, Legerwood, R, Spurgas, R, LaForce, FM (1996) "Pulmonary aspiration in a long-term care setting: clinical and laboratory observations and an analysis of risk factors." *J Am Geriatr Soc* 44: 763-768

[PubMed](#)

Mehr, DR, Zweig, SC, Kruse, RL, Popejoy, L, Horman, D, Willis, D, Doyle, E (1998) "Mortality from lower respiratory infection in nursing home residents: A pilot prospective community-based study." *J Fam Pract* 47: 298-304

[PubMed](#)

Medina-Walpole, AM, McCormick, WC (1998) "Provider practice patterns in nursing home-acquired pneumonia." *J Am Geriatr Soc* 46: 187-192

[PubMed](#)

Marrie, TJ, Blanchard, W (1997) "A comparison of nursing home-acquired pneumonia patients with patients with community-acquired pneumonia and nursing home patients without pneumonia." *J Am Geriatr Soc* 45: 50-55

[PubMed](#)

Croghan, JE, Burke, EM, Caplan, S, Denman, S (1994) "Pilot study of 12-month outcomes of nursing home patients with aspiration on videofluoroscopy." *Dysphagia* 9: 141-146

[PubMed](#)

Feinberg, MJ, Knebl, J, Tully, J (1996) "Prandial aspiration and pneumonia in an elderly population followed over 3 years." *Dysphagia* 11: 104-109

[PubMed](#)

Langmore, SE, Terpenning, MS, Schork, A, Chen, Y, Murray, JT, Lopatin, D, Loesche, WJ (1998) "Predictors of aspiration pneumonia: how important is dysphagia?" *Dysphagia* 13: 69-81

[PubMed](#)

Finucane, TE, Christmas, C, Travis, K (1999) "Tube feeding in patients with advanced dementia: a review of the evidence." *JAMA* 282: 1365-1370

[PubMed](#)

- Finegold, SM (1991) "Aspiration pneumonia." *Rev Infect Dis* 13: S737-S742 [PubMed](#)
- Verghese, A, Berk, SL (1983) "Bacterial pneumonia in the elderly." *Medicine* 62: 271-285 [PubMed](#)
- Valenti, WM, Trudell, RG, Bentley, DW (1978) "Factors predisposing to oropharyngeal colonization with gram-negative bacilli in the aged." *N Engl J Med* 298: 1108-1111 [PubMed](#)
- Terpenning, MS, Bradley, SF, Wan, JY, Chenoweth, CE, Jorgensen, KA, Kauffman, CA (1994) "Colonization and infection with antibiotic-resistant bacteria in a long-term care facility." *J Am Geriatr Soc* 42: 1062-1069 [PubMed](#)
- Horner, J, Massey, EW, Riski, JE, Lathrop, DL, Chase, KN (1988) "Aspiration following stroke: clinical correlates and outcome." *Neurology* 38: 1359-1362 [PubMed](#)
- Logemann, JA, Pauloski, BR, Rademaker, A, Cook, B, Graner, D, Milianti, F, Beery, Q, Stein, D, Bowman, J, Lazarus, C, Heiser, MA, Baker, T (1992) "Impact of the diagnostic procedure on outcome measures of swallowing rehabilitation in head and neck cancer patients." *Dysphagia* 7: 179-186 [PubMed](#)
- DePippo, KL, Holas, MA, Reding, MJ, Mandel, FS, Lesser, ML (1994) "Dysphagia therapy following stroke: a controlled trial." *Neurology* 44: 1655-1660 [PubMed](#)
- Neumann, S, Bartolome, G, Buchholz, D, Prosiegel, M (1995) "Swallowing therapy of neurologic patients: correlation of outcome with pretreatment variables and therapeutic methods." *Dysphagia* 10: 1-5 [PubMed](#)
- Crary, M (1995) "A direct intervention program for chronic neurogenic dysphagia secondary to brainstem stroke." *Dysphagia* 10: 6-18 [PubMed](#)
- Morris, JN, Hawes, C, Fries, BE, Phillips, CD, Mor, V, Katz, S, Murphy, K, Drugovich, ML, Friedlob, AS (1990) "Designing the national resident assessment instrument for nursing facilities." *Gerontologist* 30: 293-307 [PubMed](#)

Hawes, C, Morris, JN, Phillips, CD, Mor, V, Fries, BE, Nonemaker, S (1995) "Reliability estimates for the Minimum Data Set for nursing home resident assessment and care screening (MDS)." *Gerontologist* 35: 172-178 [PubMed](#)

Morris, JN, Fries, BE, Morris, SA (1999) "Scaling ADLs within the MDS." *J Gerontol A Biol Sci Med Sci* 54A: M546-M553 [PubMed](#)

Williams, BC, Fries, BE, Foley, WJ, Schneider, D, Gavazzi, M (1994) "Activities of daily living and costs in nursing homes." *Health Care Financ Rev* 15: 117-135 [PubMed](#)

Morris, JN, Fries, BE, Mehr, DR, Hawes, C, Phillips, C, Mor, V, Lipsitz, LA (1994) "MDS Cognitive Performance Scale." *J Gerontol A Biol Sci Med Sci* 49: M174-M182 [PubMed](#)

Clauser, SB, Fries, BE (1992) "Nursing home resident assessment and case-mix classification: cross-national perspectives." *Health Care Financ Rev* 13: 135-155 [PubMed](#)

Fries, BE, Schneider, DP, Foley, WJ, Gavazzi, M, Burke, R, Cornelius, E (1994) "Refining a case-mix measure for nursing homes: resource utilization groups (RUG-III)." *Med Care* 32: 668-685 [PubMed](#)

Fein, AM, Niederman, MS (1994) "Severe pneumonia in the elderly." *Clin Geriatr Med* 10: 121-143 [PubMed](#)

Meguro, K, Yamagauchi, S, Doi, C, Nakamura, T, Sekizawa, K, Sasaki, H (1992) "Prevention of respiratory infections in elderly bed-bound nursing home patients." *Tohoku J Exp Med* 167: 135-142 [PubMed](#)

Simons, S, Kidd, EAM, Beighton, D (1999) "Oral health of elderly occupants in residential homes." *Lancet* 353: 1761- [PubMed](#)

Yoneyama, T, Yoshida, M, Matsui, T, Sasaki, H (1999) "Oral care and pneumonia. Oral Care Working Group." *Lancet* 354: 515- [PubMed](#)

Katz, S, Akpom, A (1976) "A measure of primary sociobiological functions." *Int J Health Serv* 114: 1129-1136 [PubMed](#)

Morris, JN, Hawes, C, Murphy, K, Nonemaker, S, Phillips, C, Fries, BE, Mor, V, 1991 *Resident Assessment Instrument training manual and resource guide*. Eliot Press Natick, MA

, MR (2000) "Rethinking the role of tube feeding in patients with advanced dementia." *N Engl J Med* 342: 206-210 [PubMed](#)

Johanson, WG, Woods, DE, Chaudhuri, T (1979) "Association of respiratory tract colonization with adherence of gram-negative bacilli to epithelial cells." *J Infect Dis* 139: 667-673 [PubMed](#)

Thompson, RS, Hall, NK, Szpiech, M, Reisenberg, LA (1997) "Treatments and outcomes of nursing-home acquired pneumonia." *J Am Board Fam Pract* 10: 82-87 [PubMed](#)

Loesche, WJ, Bromerg, J, Terpenning, MS, Bretz, WA, Dominguez, MS, Grossman, MA, Langmore, SE (1995) "Xerostomia, xerogenic medications and food avoidances in selected geriatric groups." *J Am Geriatr Soc* 43: 401-407 [PubMed](#)

Sreebny, LM, Valdini, A (1987) "Xerostomia, a neglected symptom." *Arch Intern Med* 147: 1333-1337 [PubMed](#)

Johnson, ER, McKenzie, SW, Sievers, A (1993) "Aspiration pneumonia in stroke." *Arch Phys Med Rehabil* 74: 973-976 [PubMed](#)

Holas, MA, DePippo, KL, Reding, MJ (1994) "Aspiration and relative risk of medical complications following stroke." *Arch Neurol* 51: 1051-1053 [PubMed](#)

Kidd, D, Lawson, J, Nesbitt, R, MacMahon, J (1995) "The natural history and clinical consequences of aspiration in acute stroke." *QJM* 88: 409-413 [PubMed](#)

Sandman, P, Adolfsson, R, Nygren, C, Hallmans, G, Winblad, B (1987) "Nutritional status and dietary intake in institutionalized patients with Alzheimer's disease and multiinfarct dementia." *J Am Geriatr Soc* 35: 31-38 [PubMed](#)

Sitzmann, JV (1990) "Nutritional support of the dysphagic patient: methods, risks, and complications of therapy." *J Parenter Enteral Nutr* 14: 60-63 [PubMed](#)

Chouinard, J, Lavigne, E, Vileneuve, C (1998) "Weight loss, dysphagia, and outcome in advanced dementia." *Dysphagia* 13: 151-155 [PubMed](#)

Koivula, I, Stenn, M, Makela, PH (1994) "Risk factors for pneumonia in the elderly." *Am J Med* 96: 313-320 [PubMed](#)

Jokinen, C, Heiskanen, L, Juvonen, H, Kallinen, S, Karkola, K, Korppi, M, Kurki, S, Rönberg, PR, Seppä, A, Soimakallio, S et al. (1993) "Incidence of community-acquired pneumonia in the population of four municipalities in eastern Finland." *Am J Epidemiol* 137: 977-988 [PubMed](#)