Outcome of Nursing Home-Acquired Pneumonia: Derivation and Application of a Practical Model to Predict 30 Day Mortality

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OBJECTIVES: To derive a prediction model of 30 day mortality for nursing home-acquired pneumonia (NHAP) based on factors that can be readily identified by nursing home staff at the time of diagnosis and to apply the model to management issues related to NHAP including clarifying the importance of prepneumonia functional status as a predictor of outcome of NHAP.

DESIGN: This was a retrospective chart review of 378 episodes of NHAP treated in the nursing home or hospital during two periods: November 1997 to April 1998 and November 1998 to April 1999.

SETTING: Eleven nursing homes in the greater Buffalo, NY region.

PARTICIPANTS: Nursing home residents with radiographically proven pneumonia who had at least one of the following signs/symptoms: cough, fever, purulent sputum, respiratory rate ≥25 breaths/minute, localized auscultatory findings, or pleuritic pain.

MEASUREMENTS: Status (alive or dead) of each resident at 30 days (30 day mortality) after diagnosis of NHAP was the dependent variable. Factors predicting 30 day mortality were identified by logistic regression analysis. A scoring system was developed based on the results of the logistic model. Each episode of NHAP in the derivation cohort was scored using the model and the cohort was stratified by the model score into six categories or risk for mortality (0–5). The predictability of the model in the derivation cohort was measured using receiver operator characteristics curve analysis.

RESULTS: Of 378 episodes of NHAP, 74% were treated initially in the nursing home and 26% were hospitalized initially for treatment. The overall 30 day mortality was 21.4%; however, the mortality rate was significantly higher for those treated initially in the hospital (29.6% vs 16.6%; $P = .012$). Logistic regression analysis identified four predictors of 30 day mortality: (1) respiratory rate >30 breaths/minute (2 points), (2) pulse >125 beats/minute (1 point), (3) altered mental status (1 point), and (4) a history of dementia (1 point). Applying the scoring system to each episode in the derivation cohort demonstrated increasing mortality with increasing score. The c statistic for the model in the derivation cohort was .74. Based on the severity of NHAP, model episodes treated initially in the hospital were more acutely ill than those who were treated initially in the nursing home, and episodes treated with a parenteral antibiotic in the nursing home were more acutely ill than those who were treated with an oral agent. Functional status was not a predictor of 30 day mortality although there was a trend of higher mortality in the most dependent group ($P = .065$). The severity of NHAP model was able to define low and high risk mortality groups within a functional status category.

CONCLUSIONS: A severity of NHAP model was derived from a large cohort of episodes in multiple facilities. The model had reasonable discriminatory power in the derivation cohort. The model may aid clinicians in making treatment decisions in the nursing home setting and in making hospitalization decisions. Although prepneumonia functional status provides a reasonable estimate of NHAP severity and prognosis, the severity of NHAP model permitted further refinement of these estimates. The severity of NHAP model requires validation before it can be recommended for general use. **J Am Geriatr Soc 48:1292–1299, 2000.**

Key words: nursing home-acquired pneumonia; functional status; mortality; prediction models

Several recent studies of nursing home-acquired pneumonia (NHAP)[1–3] and lower respiratory tract infection in nursing home residents[4,5] have identified predictors of mortality. In these studies,[1–5] preinfection functional status was identified consistently as one of the most important predictors of mortality. However, none of these studies adequately accounted for acute severity of pneumonia using a quantitative measurement in the analysis.

Recently, we[6] validated the pneumonia prognosis index (PPI) in a group of patients with NHAP. The PPI represents a quantitative assessment of severity of pneumonia and prognostic information.[7] Requisite laboratory testing is a limitation of the PPI for NHAP. Such testing is not always done in nursing home residents with pneumonia, especially those who are treated in the nursing home. There is a need, therefore, for a simple and accurate severity of NHAP model that

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is available at the bedside to nurses within nursing homes and that does not require laboratory tests.

This article describes our recent studies of NHAP during two consecutive winter seasons among 11 nursing homes in the western New York State region. This study had three objectives. The first objective was to derive a prediction model of 30 day mortality or severity of NHAP based on factors that nursing home staff could readily identify at the time of diagnosis of NHAP. Secondly, the severity of NAHP model was utilized to evaluate management approaches such as the decision to prescribe parenteral therapy in the nursing home or to hospitalize a resident. Thirdly, the severity of NHAP model was utilized to evaluate the relationship between prepneumonia functional status and 30 day mortality.

MATERIALS AND METHODS

Nursing Homes

Eleven nursing homes located in the greater Buffalo, NY metropolitan area, participated in this study. Ten nursing homes were either proprietary or nonproprietary homes with 100 to 200 beds. The remaining home was a 630 bed public facility. Two different groups of geriatricians provided most of the care in these facilities.

Study Population

The study cohort consisted of all nursing home residents with radiographically confirmed pneumonia in the 11 study facilities during two 6 month periods: November 1997 to April 1998 and November 1998 to April 1999. The episodes of NHAP identified during the period of November 1997 to April 1998 were utilized previously to develop a treatment guideline.[8]

Design

Residents with NHAP were identified by review of infection control records and information available from the medical records department of each facility. Charts of residents with a diagnosis of NHAP during the two study periods were reviewed by one of three abstractors who were unaware of the study objectives. Data abstracted from the resident's charts included age, gender, do not resuscitate status, criteria for NHAP diagnosis, activities of daily living (ADL) score,[9] results of any laboratory tests, and antibiotic treatment. Underlying or comorbid diseases (diabetes, dementia, stroke, etc.) were abstracted from the principal diagnoses listed in the medical record of each resident. Hospital records of all residents admitted for treatment of NHAP were also reviewed and the same data were abstracted.

Definition of Pneumonia

A resident was considered to have NHAP if a chest X-ray demonstrated changes consistent with a diagnosis of pneumonia. In addition, residents were also required to have at least one of the following clinical signs or symptoms: cough, pleuritic chest pain, temperature $\geq$100.5° F, purulent sputum, tachypnea, or localized ausculatory findings suggesting pneumonia (rales, rhonci, or dullness to percussion).

Exclusions

During the two study periods, 452 episodes of NHAP were identified in the initial review of infection control surveillance data and data from the medical records department of the 11 nursing homes. Of these, 378 episodes met the definition for NHAP, were treated, and had at least a 30 day follow-up. The remaining 74 episodes were excluded from the study for the following reasons. In 27 episodes, a chest X-ray was not done to verify a clinical diagnosis of pneumonia. In 20 episodes, a chest X-ray did not demonstrate evidence of pneumonia. In 11 episodes, no outcome data were available. In nine episodes, no treatment data were available. In four episodes, treatment was withdrawn at the request of family or healthcare proxy. Finally, in three episodes, gastric content aspiration occurred within a few hours of the sudden onset of signs and symptoms suggestive of lower respiratory tract infection. At 30 days, there were 11 (18.6%) deaths among the 59 excluded episodes for which information was available. This was not significantly different from the 30 day mortality in the study cohort (81 deaths among 378 episodes or 21.4% 30 day mortality; $P = .75$). None of the residents included in the study cohort had "do not hospitalize orders" before onset of pneumonia.

Derivation of a Severity of NHAP Model

A severity of NHAP model was derived from the study cohort in the following manner. Logistic regression analysis was used to identify independent predictors of 30 day mortality. Only factors that would be readily available at the time of diagnosis or suspicion of NHAP were evaluated as potential predictors. These factors included vital signs, ADL score, underlying diseases, and symptoms such as cough. Based on the value of the regression coefficient in the logistic model, points were assigned to each significant predictor. This model was utilized to "score" each of the episodes in the study cohort. Episodes of NHAP were stratified into six groups based on the total score (0–5) and the probability of 30 day mortality was calculated for each group.

Outcome

Status (alive or dead) of each resident was assessed at 30 days (30 day mortality) after the diagnosis of pneumonia.

Data Analysis

The unit of analysis for all the statistical evaluations was an episode of NHAP. Descriptive statistics for the study cohort are reported to provide an overview. Categorical variables were compared using chi-square or Fisher's exact test where appropriate. $P < .05$ was considered significant for all analyses. The severity of NHAP model was derived utilizing logistic regression analysis.

The discrimination and calibration of the model were assessed in the study cohort by receiver operating characteristics (ROC) curve analysis.[10] The ROC curve is a method to evaluate a prediction model in which more than one operating point or "cutoff" is possible.[11] Prediction models do not have just one sensitivity/specificity pair, but they have a spectrum of pairs associated with all possible selections of decision thresholds or cutoff points. The graphic representation of this spectrum for a particular model is called the ROC curve.[12] This curve is generated by changing the decision threshold over the entire range of possible prediction scores (in the present study from 0 to 5) and by calculating the sensitivity/specificity pairs of the decision matrix at each threshold. By convention, the y coordinate of the plot is the true-positive fraction (rate) or sensitivity and the x coordinate is the false-positive fraction (rate) [false positive rate =

1-specificity] associated with a particular threshold level. The ROC plot is an important component in the practical application of a prediction model; it relates the predicted outcome risk for an individual patient, at an established threshold level, with the classification accuracy achievable at that outcome risk level. However, despite the usefulness of ROC plots, one often needs to evaluate the performance of a model in different populations over the entire range of decision thresholds. Such comparisons require a quantitative index or measure of the ROC curve. The area under the ROC curve (AUC) has been found to be a useful quantitative measure of the ROC curve.[10,11] The total AUC of an ROC plot equals 1; an AUC = .5 (the diagonal of the ROC plot) means that the model is no better than chance (coin flip), whereas an AUC = 1.0 represents perfect performance. It has been demonstrated that for logistic regression models in which the outcome is dichotomous, as in the present study, the AUC is equal to the Mann-Whitney statistic[10] and it is also equal to the c statistic.[13] In the present study, the c statistic has been calculated as a quantitative measure of the ROC curve. Hanley and McNeil[10] have defined the AUC of the ROC plot as "the probability that a random pair [of patients with opposite outcomes, e.g., death or survival] will be correctly ranked as to their disease state." That is, for a mortality prediction model in which an increasing score is associated with increasing mortality (as in the present study), if the model has an AUC or c statistic = .80 in a sample population, this means that a randomly selected actual nonsurvivor will have a higher model score than a randomly selected survivor 80% of the time.

RESULTS

Clinical Characteristics

The clinical characteristics of the residents with 378 episodes of NHAP are listed in Table 1. Fifty percent of the study cohort was ≥85 years old and almost two thirds were females. Dementia was the most common underlying disease, whereas cancer was the least common. Over half of the study cohort was in the most dependent functional category of the Katz scoring system (ADL score of >15). Signs and symptoms of respiratory infection varied with the most common findings being fever and cough.

Table 1. Clinical Characteristics of 378 Episodes of Nursing Home-Acquired Pneumonia

Age (year)	
Mean ± SD	83 ± 10
Median	84
Range	36–101
Females, n (% of total episodes)	249 (65.9)
DNR order in chart, n (% of total)	305 (80.7)
Underlying diseases, n (% of total)	
Diabetes mellitus	82 (21.7)
Coronary artery disease	121 (32)
COPD	90 (23.8)
HF	95 (25.1)
Cancer	27 (7.1)
Stroke	83 (22)
Dementia	275 (72.8)
ADL category, n (% of total)	
<11 points	31 (8.2)
11–15 points	134 (35.5)
>15 points	213 (56.3)
Signs/symptoms, n (%)	
Temp >101°F	231/329 (70.2)
Resp rate >30 breaths/minute	86/371 (23.2)
Pulse >125 beats/minute	22/374 (5.9)
Systolic BP <90 mm Hg	14/358 (3.9)
Altered mental status	143/378 (37.8)
Cough	200/329 (60.8)

SD = standard deviation; DNR = do not resuscitate, COPD = chronic obstructive pulmonary disease; HF = heart failure; ADL = activities of daily living; Temp, temperature; Resp rate = respiratory rate; BP = blood pressure.

Treatment

Of the 378 episodes of NHAP, 280 (74.1%) were treated initially in the nursing home and 98 (25.9%) were treated initially in the hospital. Of the 280 treated initially in the nursing home, 175 (62.5%) were treated with an oral agent, whereas 105 (37.5%) were treated initially with a parenteral (intramuscular or intravenous) antibiotic. Forty-four (15.7%) of the 280 episodes treated initially in the nursing home were transferred to a hospital for further management. The treatment regimens prescribed in both the nursing homes and hospitals varied considerably. A summary of the most common regimens is shown in Table 2 by site of treatment. For episodes treated initially in the nursing home, eight treatment regimens were defined representing 87% of the 280 treatment courses prescribed. The remaining 13% of courses could not be easily grouped into any one class of agents or groups of agents. There was no significant difference in the 30 day mortality among the eight regimens listed (P = .85). For patients treated in the hospital, the most common regimens were an intravenous penicillin (most often ampicillin/sulbactam) or an intravenous cephalosporin (most often ceftriaxone) ± an oral agent to complete therapy. There was no significant difference in the 30 day mortality among the four hospital regimens listed in Table 2 (P = .59). A variety of other agents and combinations of agents were prescribed for the remaining 24 episodes of NHAP treated in the hospital (data not shown).

Outcome

Among the 378 episodes of NHAP, there were 81 (21.4%) deaths within 30 days of diagnosis. Among these 81 episodes, the median time to death was 12 days. Thirty day mortality rate was significantly higher among episodes of NHAP treated initially in the hospital (29 [29.6%] of 98) compared with those treated only in the nursing home (39 [16.6%] of 235; P = .012). Episodes of NHAP treated initially in the nursing home but eventually transferred to the hospital had a 30 day mortality identical to those treated initially in the hospital (13 [29.6%] of 44).

Predictors of 30 Day Mortality

An analysis was done to define predictors of 30 day mortality utilizing factors that would be readily available at the time the diagnosis of NHAP was considered. Table 3 lists the significant univariate predictors. Factors such as fever (temperature >100.5° F) of any level, very low (<96° F) or

Table 2. Summary of the Most Common Antibiotic Treatment Regimens for Nursing Home-Acquired Pneumonia by Site of Initial Treatment

Regimen	Nursing Home Treatment		Hospital Treatment	
	n Episodes	n Dying Within 30 Days (%)	n Episodes	n Dying Within 30 Days (%)
Oral betalactam* ± second agent	81	12 (14.8)		
Oral macrolide†	17	3 (17.6)		
Oral quinolone‡	29	4 (13.8)		
Oral TMP/SMZ	11	3 (27.2)		
IM cephalosporin§ ± second agent	86	17 (19.8)	6	3 (50)
IV penicillin ± oral agent	6	0	29	9 (31)
IV cephalosporin ± oral agent	9	1 (11.1)	31	9 (29)
IV quinolone ± second agent	4	2 (50)	8	1 (12.5)

*Oral betalactam = oral penicillin or cephalosporin.
†Oral macrolide = erythromycin, clarithromycin, or azithromycin.
‡Oral quinolone = ciprofloxacin, ofloxacin, levofloxacin, or trovafloxacin.
§IM cephalosporin = ceftriaxone or cefotaxime.
TMP/SMZ = trimethoprim/sulfamethoxazole; IM = intramuscular; IV = intravenous.

Table 3. Univariate and Multivariate Predictors of 30 Day Mortality Among Residents with Nursing Home-Acquired Pneumonia

Predictor	Univariate		Multivariate			
	n Died/Total (%)	*P*	Regress Coeff	OR	95% CI OR	*P*
RR >30 breaths/minute						
Yes	38/86 (44.2)	< .001	.628	3.51	1.89–6.56	< .001
No	42/285 (14.7)					
Pulse >125 beats/minute						
Yes	13/22 (59.1)	< .001	.566	3.10	1.10–8.93	.032
No	68/352 (19.3)					
Altered MS						
Yes	96/143 (32.2)	< .001	.390	2.18	1.23–3.91	.008
No	35/235 (14.9)					
ADL >14						
Yes	58/232 (25)	.033	.068	1.15	0.61–2.21	.67
No	23/146 (15.8)					
Cancer						
Yes	10/27 (37)	.04	.430	2.36	0.83–6.43	.095
No	71/351 (20.2)					
Dementia						
Yes	66/275 (24)	.047	.461	2.51	1.21–5.58	.017
No	15/103 (14.6)					
DNR						
Yes	72/305 (23.6)	.039	.326	1.92	0.85–4.72	.13
No	9/73 (12.3)					
Cough						
Yes	35/200 (17.5)	.004	−.265	0.589	0.33–1.06	.076
No	40/129 (31.1)					

Regress Coeff = regression coefficient; OR = odds ratio; 95% CI = 95% confidence interval; RR = respiratory rate: MS = mental status; ADL = activities of daily living; DNR = do not resuscitate.

high temperature (>104° F), hypotension (systolic BP <90 mm Hg), or underlying diseases such as diabetes, coronary artery disease, and chronic lung disease were not significant univariate predictors of 30 day mortality (data not shown). Cough was associated with a significantly lower 30 day mortality compared with those without this symptom. The results of the logistic regression analysis to define independent predictors of 30 day mortality are also shown in Table 3. Respiratory rate >30 breaths/minute, pulse >125 beats/minute, altered mental status (compared with usual status or baseline), and a diagnosis of dementia were independent predictors of 30 day mortality.

Table 4. Performance of the Severity of Nursing Home-Acquired Pneumonia (NHAP) Model for Predicting 30 Day Mortality in the Derivation Cohort with NHAP

Outcome*	Total n Episodes	Severity of NHAP Model Risk Score					
		0	1	2	3	4	5
Alive	297	50	139	68	25	14	1
Dead	81	4	16	24	15	18	4
% dead	21.4	7.4	10.3	26.1	37.5	56.3	80

*Outcome = status 30 days after diagnosis of pneumonia.

Derivation of a Severity of Pneumonia Model

Points were assigned to the independent predictors of 30 day mortality identified by logistic regression analysis based on the regression coefficient and overall significance in the model as follows: (1) respiratory rate >30 breaths/minute (2 points), (2) pulse >125 beats/minute (1 point), (3) altered mental status (1 point), and (4) history of dementia (1 point). Using this scoring system, each of the 378 episodes of NHAP in the study cohort was evaluated for the presence of each predictor and given a point total (0–5). Results of the application of the model to the study cohort are shown in Table 4. As the risk score increased, the probability of 30 day mortality increased. The c statistic for the ROC curve of the derivation cohort was .74.

Application of the Severity of Pneumonia Model

The severity of pneumonia model can be utilized to evaluate different aspects of NHAP. One question has been whether or not the residents who are admitted to the hospital for initial treatment of NHAP are more acutely ill than those who are treated initially in the hospital. Insight into the answer to this question might be gained by evaluating the distribution of episodes of NHAP treated initially in the nursing home versus hospital initially stratified by the severity of NHAP model score (Table 5). Significantly more episodes of NHAP treated initially in the hospital had a severity score of ≥3 (30.6%) compared with episodes treated initially in the nursing home (16.8%; $P = .005$). However, 40% of the episodes of NHAP that were hospitalized were in low risk mortality groups with severity scores of 0 to 1.

Table 5. Relationship Between Severity of Nursing Home-Acquired Pneumonia Model Score and Initial Site of Treatment

Severity of Pneumonia Model Score	Initial Treatment Site	
	Nursing Home	Hospital
0	47 (16.8)*	7 (7.1)
1	123 (43.9)	32 (32.7)
2	63 (22.5)	29 (29.6)
3	23 (8.2)	17 (17.4)
4	22 (7.9)	10 (10.2)
5	2 (0.7)	3 (3.1)
Total	280	98

*n of episodes (% of column total).
$P = .005$ for the comparison of the proportion of episodes in each of the severity of pneumonia model groups by treatment site.

Another issue that requires clarification is the decision to utilize parenteral (intramuscular or intravenous) antibiotic treatment in the nursing home setting. In a recent study describing a treatment guideline for NHAP, we were unable to define factors predictive of prescribing parenteral antibiotic treatment in the nursing home.[8] Similar to the strategy used above in evaluating the hospitalization decision, 279 episodes of NHAP treated initially in the nursing home with either oral or parenteral antibiotic therapy were stratified by severity score (Table 6). Significantly more episodes of NHAP treated initially with parenteral antibiotics had a severity score of ≥ 3 (24%) compared with episodes treated initially with an oral agent (12%; $P = .049$). Nevertheless, almost 53% of the episodes treated with a parenteral antibiotic initially were in the low risk mortality scoring groups (scores of 0–1).

Functional Status, Severity of Pneumonia, and 30 Day Mortality

There was no significant relationship between prepneumonia functional status as measured by ADL score and 30 day mortality although there was a clear trend of increasing mortality with functional dependence (Table 7) ($P = .065$). To evaluate in greater depth the relationship between functional status and 30 day mortality, episodes of NHAP in each ADL category were stratified by the severity of NHAP model score and 30 day mortality was calculated for each model score-functional category pair (Table 8). Several findings in

Table 6. Relationship Between Severity of Nursing Home-Acquired Pneumonia Model Score and Route of Administration of Antibiotic Treatment Among 280 Episodes of Pneumonia Treated Initially in the Nursing Home

Severity of Pneumonia Model Score	Type of Initial Antibiotic Treatment	
	Oral	Parenteral
0	32 (18.3)*	14 (13.5)
1	83 (47.4)	41 (39.4)
2	39 (22.3)	24 (23.1)
3	13 (7.4)	9 (8.7)
4	7 (4)	15 (14.4)
5	1 (0.6)	1 (1)
Total episodes	175	104

*n of episodes (% of column total).
$P = .049$ for the comparison of the proportion of episodes in each of the severity of pneumonia model groups by treatment site.

Table 7. Relationship Between Prepneumonia Functional Status* and 30 Day Outcome Among 378 episodes of Nursing Home-Acquired Pneumonia

	ADL Category†		
30-Day Outcome	<11 Points	11–15 Points	>15 Points
Alive	28 (90.3)‡	110 (82.1)	159 (74.7)
Dead	3 (9.7)	24 (17.9)	54 (25.3)
Total	31	134	213

*Functional status was measured using Katz's ADL score.
†Three categories of functional status were created based on the ADL score.
‡n of episodes (% of column total).
$P = .065$ comparing the 30 day mortality among the three ADL categories.
ADL = activities of daily living.

Table 8. Relationship of Prepneumonia Functional Status,* Severity of Nursing Home-Acquired Pneumonia Model Score, and 30 Day Mortality

Severity of NHAP Model Score	ADL Category†		
	<11 Points	11–15 Points	>15 Points
0	9 (29) [0]‡	25 (18.7) [8]	20 (9.4) [10]
1	14 (45.2) [0]	59 (44) [6.8]	82 (38.5) [14.6]
2	7 (22.6) [28.6]	33 (24.6) [33]	52 (24.4) [21.2]
3	1 (3.2) [100]	9 (6.7) [22]	30 (14.1) [40]
4	0	7 (5.2) [57]	25 (11.7) [56]
5	0	1 (1) [100]	4 (1.9) [75]
Total	31 (100) [9.7]	134 (100) [17.9]	213 (100) [25.3]

*Functional status was measured using Katz's ADL score.
†Three categories of functional status were created based on the ADL score.
‡n of episodes (% of total episodes in that ADL category) [% 30 day mortality].
ADL = activities of daily living.

Table 8 should be emphasized. First, in all three ADL categories, a substantial proportion (45%–75%) of episodes were in the low risk mortality groups of the severity of NHAP model (scores = 0 or 1). However, the proportion of episodes in the high risk mortality groups (model scores of 3–5;) was significantly greater for ADL scores of >15 (most dependent group; 59 [28%] of 213) compared with the other two categories combined (18 [11%] of 165; $P < .001$). The 30 day mortality for each functional category-severity of NHAP model score pair is also shown in Table 8. There was an incremental increase in mortality as the severity score increased in each ADL category, thus indicating that at each level of dependency there were episodes of NHAP with a low and high risk for mortality. The difference in 30 day mortality among the three ADL categories resulted from a significantly higher proportion of episodes in the high risk mortality range (scores of 3–5) of the severity of NHAP model in the most dependent group (ADL scores of >15).

DISCUSSION

The case-fatality rate of NHAP is the highest of all the common infections occurring in the nursing home setting and has not changed over the past two decades.[14–16] In the past, experts have recommended hospitalization for most episodes of NHAP because of the high morbidity and mortality related to this infection.[17,18] However, a study by Fried and colleagues[3] found that treatment of NHAP in the nursing home resulted in significantly better outcomes (less loss of function and decreased mortality at 2 months after pneumonia) compared with treatment in the hospital. These findings led Zimmer and Hall[19] to suggest that there should be a more "individualized clinical approach to NHAP" than has previously been considered by expert panels.[20,21]

The first step in individualizing the approach to treatment of NHAP is having the capability to assess accurately the severity of pneumonia and prognosis. Since the early 1990s, several studies[1–5] of NHAP or lower respiratory infection have been published in which risk factors for mortality have been identified. In all of these studies,[1–5] prepneumonia functional status was an important predictor of outcome. However, these studies[1–5] all have limitations that make it difficult to determine the precise role of functional status in the outcome. First, none of these studies assessed adequately the acute severity of pneumonia in their analyses. Second, other than the one study by Mehr et al.,[5] most of the studies[1–4] have been done in one facility. Third, some studies have evaluated factors as predictors that are not readily available to staff and would require calculations that are not practical. For example, Muder et al.[2] and Fried et al.[1] used a comorbidity index to assess underlying disease severity. Mehr et al.[5] used a magnitude estimation ADL scale that would not be practical for use by nursing home staff. Fourth, the number of episodes of NHAP or lower respiratory tract infection evaluated in these studies has been relatively small except for the studies of Fried et al.[1,3]

Our study attempts to deal with some of the limitations of prior studies. First, we studied a large (n = 378) cohort of NHAP episodes that occurred among 11 nursing homes during two consecutive winter seasons. Second, only factors that would be readily available to nursing staff in the nursing home were evaluated as predictors of 30 day mortality. Third, we derived a practical severity of NHAP model from the multivariate predictors of 30 day mortality and applied the model to several management issues related to NHAP.

The predictors of 30 day mortality identified in this study were, in part, consistent with those identified in previous studies[1–5] and also had biological plausibility. An increased respiratory rate was the most important predictor which is consistent with the findings of other studies.[1,3,5] Tachycardia and altered mental status were also significant independent predictors in this study. These latter two factors plus increased respiratory rate represent acute physiological derangements that reflect the severity of pneumonia. Finally, a diagnosis of dementia was also an independent predictor of 30 day mortality. No attempt was made to define the severity of dementia because such information would not be readily available to nursing home staff in an acute situation. One other study[1] found that severe dementia was a univariate predictor of mortality among hospitalized residents with NHAP. The severity of NHAP model based on these predictors had reasonably good discriminatory power in the derivation cohort which is not surprising.[22] There may be other factors, e.g., oxygen saturation breathing room air, that may have value in predicting the severity of NHAP. However, in our study, oxygen saturation was not measured consistently to include it as a possible predictor.

In this study, we have illustrated that the severity of NHAP model has the potential to be useful in evaluating several aspects of the management of this infection. First, it has been assumed that residents with NHAP treated in the hospital are more acutely ill than those treated in the nursing home.[4] Using the severity of NHAP model, we found that residents with pneumonia who were hospitalized tended to be more ill than those treated in the nursing home. However, a substantial proportion (almost 40%) of those hospitalized were in the low risk mortality groups. Other factors such as time of the day of evaluation, that have nothing to do with the severity of pneumonia, may also influence the decision to hospitalize a resident with NHAP.[1] This may explain why some residents who are not as ill as others are admitted to the hospital for initial treatment of NHAP. Thus, the severity of NHAP model may be useful in helping clinicians to identify residents who should be hospitalized. Whether such residents benefit from hospitalization remains unclear.[3,23] Second, it is unclear how physicians determine the route of administration (oral vs parenteral) of antibiotic therapy for residents treated initially in the nursing home.[8] Utilizing the severity of NHAP model, we found that episodes treated in the nursing home with a parenteral antibiotic were more often in the high risk mortality group compared with those treated with an oral agent. However, the proportion of episodes in the high risk group was only 24%. Over 50% of the patients who received parenteral antibiotic treatment in the nursing home were in the low risk mortality group. These findings suggest that other factors besides the severity of pneumonia play a role in the physician's decision to utilize parenteral antibiotic treatment in the nursing home setting. Nevertheless, the severity of NHAP model may be useful to clinicians as an aid in the decision to utilize parenteral antibiotic therapy in the nursing home setting.

In contrast to other studies,[1-5] we did not identify functional dependence as an independent predictor of 30 day mortality. Only one other study[24] of NHAP has found no significant relationship between functional dependency and mortality but multivariate analysis was not performed. We utilized the severity of NHAP model to evaluate the influence of prepneumonia functional status on 30 day mortality. When residents were stratified into three categories of dependency (low, moderate, and high) based on their ADL score, residents in the high dependency category had a significantly greater proportion of episodes with NHAP model scores of >3 (moderate to high mortality groups) compared with the two other ADL categories. Thus, nursing home residents who are most dependent as measured by the ADL score seem to have the highest probability of developing severe pneumonia and death. However, after controlling for functional dependence, the severity of NHAP model provided a refined estimate of both the severity of infection and prognosis in each ADL category.

Finally, the optimal antimicrobial regimen for NHAP treated in the nursing home or hospital has not been determined. We[8] have recently developed a treatment guideline for NHAP based on community practice. The recommendations in the guideline were liberal in terms of choices of agents, especially for oral agents prescribed in the nursing home. This study does not offer any new insights into the treatment approach to NHAP. The 30 day mortality did not differ significantly among regimens grouped by classes of antibiotics (oral or parenteral) in our study. However, this finding must be viewed cautiously because of the retrospective nature of the study. Also, the severity of illness was not accounted for in assessing outcome related to treatment regimen, and some agents, e.g., quinolones, were prescribed infrequently relative to other classes of agents. Recently, Gleason et al.[25] analyzed retrospectively 12,945 Medicare patients hospitalized with community-acquired pneumonia in the US; of 12,945 patients, 3,194 (25%) were living in long-term care facilities. The objective of the study was to evaluate the association between initial antimicrobial therapy and outcome and to control for confounding factors including the severity of pneumonia using the PPI.[7] Among those with NHAP who were hospitalized for treatment, there was a trend toward a lower 30 day mortality (compared with the reference regimen of a nonpseudomonal third-generation cephalosporin) for those treated with a second-generation cephalosporin plus a macrolide or a quinolone alone; there was a significantly higher rate of 30 day mortality with treatment with a betalactam/betalactamase inhibitor plus macrolide compared with the reference regimen. These provocative findings suggest that atypical pathogens may be a more common cause of NHAP than previously suspected; they also indicate the need for prospective studies to define the optimal treatment for NHAP.

In conclusion, we have described the results of a regional multifacility study of NHAP. The overall 30 day mortality rate of 21% was similar to that of other studies recently published.[1-5,23,24] A severity of NHAP model was derived from the study cohort that may be useful in management of this infection in the nursing home because the predictors utilized should all be readily available at the time of diagnosis of NHAP. After controlling for functional dependency, the model was still able to discriminate between low and high risk mortality groups. Examples of how the model may be useful in the management of NHAP were provided. Prospective validation of the severity of NHAP model is required before it can be recommended for general use.

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