

# The Nursing Home Pneumonia Risk Index: A Simple, Valid MDS-Based Method of Identifying 6-Month Risk for Pneumonia and Mortality

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## A B S T R A C T

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**Background:** Pneumonia is the leading infectious cause of hospitalization and death for nursing home (NH) residents; however, diagnosis is often delayed because classic signs of infection are not present. We sought to identify NH residents at high risk for pneumonia, to identify persons to target for more intensive surveillance and preventive measures.

**Methods:** Based on a literature review, we identified key risk factors for pneumonia and compiled them for use as prediction tool, limiting risk factors to those available on the Minimum Data Set (MDS). Next, we tested the tool's ability to predict 6-month pneumonia incidence and mortality rates in a sample of 674 residents from 7 NHs, evaluating it both as a continuous and a dichotomous variable, and applying both logistic regression and survival analysis to calculate estimates.

**Results:** NH Pneumonia Risk Index scores ranged from -1 to 6, with a mean of 2.1, a median of 2, and a mode of 2. For the outcome of pneumonia, a 1-point increase in the index was associated with a risk odds ratio of 1.26 ( $P = .038$ ) or a hazard ratio of 1.24 ( $P = .037$ ); using it as a dichotomous variable ( $\leq 2$  vs  $\geq 3$ ), the corresponding figures were a risk odds ratio of 1.78 ( $P = .045$ ) and a hazard ratio of 1.82 ( $P = .025$ ). For the outcome of mortality, a 1-point increase in the NH Pneumonia Risk Index was associated with a risk odds ratio of 1.58 ( $P = .002$ ) and a hazard ratio of 1.45 ( $P = .013$ ); using the index as a dichotomous variable, the corresponding figures were a risk odds ratio of 3.71 ( $P < .001$ ) and a hazard ratio of 3.29 ( $P = .001$ ).

**Conclusions:** The NH Pneumonia Risk Index can be used by NH staff to identify residents for whom to apply especially intensive preventive measures and surveillance. Because of its strong association with mortality, the index may also be valuable in care planning and discussion of advance directives.

Pneumonia is the leading infectious cause of hospitalization and death for nursing home (NH) residents.<sup>1,2</sup> Estimates of NH pneumonia incidence range from 0.3 to 2.5 cases per 1000 resident-days,<sup>3-5</sup> figures that are nearly 10 times the incidence rate for older persons living

in the community.<sup>4</sup> Related hospitalization rates are also much higher than for older adults living in the community; in fact, NH residents account for 10% to 18% of all people hospitalized for pneumonia.<sup>6</sup>

NH-acquired pneumonia has the highest mortality among NH-acquired infections. The case fatality rate is around 25%, in part because pneumonia differentially affects NH residents who are frail and have multiple comorbidities.<sup>2</sup> Furthermore, NH residents diagnosed with pneumonia have a 1-year all-cause mortality rate that is approximately twice that of a matched comparison group without pneumonia.<sup>7</sup> Unfortunately, in the high-risk, chronically ill NH population, a pneumonia diagnosis is often delayed because classic signs

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of infection, such as fever, cough, and mental status change, are frequently absent.<sup>8,9</sup>

A variety of risk factors for pneumonia have been identified. Prominent among these include advanced age, male gender, chronic pulmonary or cardiac disease, antipsychotic or other sedative medication use, advanced dementia, swallowing difficulties, impaired functional status, and poor oral health.<sup>1,7,10–15</sup> According to one review, the main risk factors for NH pneumonia tend to be fairly stable and uniform across multiple studies and to differ markedly from the risk factors for community-acquired pneumonia.<sup>4</sup>

As part of an intervention trial of the impact of enhanced oral hygiene on pneumonia incidence in NHs, we wanted to identify residents at high risk for pneumonia, thereby helping nursing staff prioritize the deployment of a dedicated oral care aide. A review of the literature found numerous studies identifying specific risk factors but no validated instrument to quantify pneumonia risk. Therefore, we sought to develop and validate a pneumonia risk scorecard using commonly available demographic and health status variables.

## Methods

Using the risk score development methods of Charlson et al,<sup>16</sup> Sloane et al,<sup>17</sup> and Berlowitz et al,<sup>18</sup> our study team, consisting of a geriatrician (P.D.S.), epidemiologist and NH health services researcher (S.Z.), infectious disease epidemiologist (D.W.), analyst (D.R.), and biostatistician (J.P.) reviewed the literature on pneumonia, including aspiration pneumonia, with the goal of developing a simple prediction tool to quantify each resident's pneumonia risk. To make the risk assessment tool feasible to calculate on all NH residents, we limited risk factors to those readily available on the Minimum Data Set (MDS), a standardized evaluation that is completed for all NH residents on an annual basis and updated at least quarterly.<sup>19–21</sup>

Significant risk factors for NH-acquired pneumonia identified in prior reports included aspiration (odds risk [OR] 13.9), inability to take oral medication (OR 8.3), sedative medication use (OR 2.6), bedbound (OR 2.5), swallowing difficulty (OR 2.0), male gender (OR 1.9), older age (OR 1.7 per 10 years), and increased morbidity (OR 1.2). Independent predictors of aspiration pneumonia in NH residents include suctioning (OR 2.6), chronic obstructive pulmonary disease (OR 2.5), congestive heart failure (OR 1.8), feeding tube (OR 1.7), bedfast (OR 1.7), delirium/less alertness (OR 1.6), weight loss (OR 1.6), swallowing problem/dysphagia (OR 1.5), urinary tract infection (OR 1.4), mechanically altered diet (OR 1.2), dependence in eating (OR 1.2), and the following factors that were identified as risk factors for infection without an identified odds or risk ratio: poor oral hygiene, tracheostomy care, number of comorbid conditions, Alzheimer disease, behavioral symptoms of dementia, and a history of gastroesophageal reflux.<sup>1,7,10–15,22,23</sup>

Risk factors that are readily available in the MDS 3.0 were compiled into the NH Pneumonia Risk Index (see Table 1). Because of varying reports regarding relative strength of many items, each was assigned a score of +1 or –1. Characteristics included as increasing risk are male gender; age >85 years; a diagnosis of dementia, chronic lung disease, and chronic renal disease; requiring extensive or total assistance in eating; coughing or choking during meals (a marker for swallowing problems); behavior interfering with care; dental problems (a marker of poor oral hygiene); and current use of a sedative or antipsychotic medication. The single factor decreasing risk was edentulous status (a protective factor for oral hygiene). These items generate an overall risk score ranging from –1 to +10, with higher scores indicating greater risk.

The NH Pneumonia Risk Index was field tested in 7 NHs in North Carolina, each of which was participating as a control site in an

**Table 1**  
The Nursing Home Pneumonia Risk Index

Resident Characteristic	Minimum Data Set (MDS) 3.0 Item	Points
Male gender	A0800	+1
Age ≥85 y	A0900	+1
Diagnosis: Alzheimer disease/dementia	I14200 or I14800	+1
Chronic lung disease	I6200	+1
Chronic renal disease	K0100C	+1
Requires extensive or total assistance in eating	G0110H	+1
Noted to have coughing or choking during meals	K0100C	+1
Behavior interferes with care	E0500B or E0800	+1
Dental problems	L0200 (not B or Z)	+1
No teeth	L0200B	–1
On a sedative or antipsychotic medication	N0400 A, B, or D	+1

intervention study. Among the sample NHs, 5 (71%) were for-profit, the mean bed size was 106 (range 62–134), and the mean score on the overall NH quality score in Nursing Home Compare (which ranges from 0 to 5) was 3.1.<sup>24</sup> Medical records were audited on all 720 residents during site visits conducted between October 2014 and April 2016, and each resident was followed for 6 months or until death or discharge from the NH; incident pneumonia or mortality were recorded for all residents for up to 6 months. Of the cases audited, 46 were excluded from analysis because MDS data used to calculate the NH Pneumonia Risk Index were unavailable or more than 4 months out of date, yielding a final sample size of 674. All study procedures were approved by the Institutional Review Board of the University of North Carolina at Chapel Hill.

A positive case of pneumonia was identified based on written documentation of the diagnosis by a physician, nurse practitioner, physician assistant, or licensed nurse in the NH record or a hospital discharge summary, a method found to be highly sensitive when compared to detecting pneumonia based on recorded signs and symptoms or prescription of an antibiotic.<sup>9</sup> Mortality was confirmed based on a written note in the medical record with the date of death.

Data were double-entered using Microsoft Access and analyses conducted in SPSS, version 24. Descriptive statistics were used to calculate measures of central tendency, Cronbach alpha, and distributions of the variables of interest. To explore the relationship between NH Pneumonia Risk Index scores and 6-month pneumonia incidence and mortality, risk scores were examined as both a continuous variable and as a dichotomous variable ( $\leq 2$  and  $\geq 3$ ), applying both logistic regression (GENLIN command) and survival analysis (COXREG command) to estimate *P* values. NH site was added as a covariate to adjust for variation among sites.

## Results

The NH Pneumonia Risk Index scores among the 674 NH residents in the study sample ranged from –1 to 6, with a mean of 2.1 (standard deviation 1.3), a median of 2, and a mode of 2. As shown in Table 2, scores of 1, 2, and 3 were documented for 25%, 30%, and 21% of the sample, respectively; 65% of the sample scored  $\leq 2$ , and 35% scored  $\geq 3$ . Cronbach alpha for the measure was 0.1, confirming that it functions more as an index than as a scale.

Table 2 displays the relationship between baseline NH Pneumonia Risk Index scores and the 6-month incidence of pneumonia and mortality. The 6-month pneumonia incidence rate ranged from 3% for scores of –1 or 0, to 13% for scores of 4 or 5. Mortality rate ranged from 1% for scores of –1 or 0 to 19% for a score of 5. When index scores were dichotomized, a score of  $\leq 2$  was associated with a pneumonia

**Table 2**  
Rates of Pneumonia and Death Within 6 Months After Pneumonia Risk Assessment

Pneumonia Risk Score	Number (%) of Residents	Number of Cases of Pneumonia	Pneumonia Incidence Rate, %	Number of Deaths	Mortality Rate, %
-1 or 0	69* (10)	2	3	1	1
1	166 (25)	14	8	4	2
2	204 (30)	13	6	8	4
3	144 (21)	16	11	18	13
4	72 (11)	9	13	1	1
5	16 (2)	2	13	3	19
≥6	3 (<1)	0	0	0	0
≤2	439 (65)	29	6.6	13	3.0
≥3	235 (35)	27	11.5	22	9.4
Total	674	56	8	35	5

\*Three had a score of -1; 66 had a score of 0.

incidence rate of 6.6% and a mortality rate of 3.0%, whereas scores  $\geq 3$  were associated with a pneumonia incidence rate of 11.5% and a mortality rate of 9.4%.

For the outcome of pneumonia, using the NH Pneumonia Risk Index as a continuous variable, a 1-point increase in the index was associated with a risk odds ratio of 1.26 ( $P = .038$ ) or a hazard ratio of 1.24 ( $P = .037$ ) for pneumonia within 6 months; using it as a dichotomous variable ( $\leq 2$  vs  $\geq 3$ ), the corresponding figures were a risk odds ratio of 1.78 ( $P = .045$ ) and a hazard ratio of 1.82 ( $P = .025$ ). For the outcome of mortality, a 1-point increase in the NH Pneumonia Risk Index was associated with a risk odds ratio of 1.58 ( $P = .002$ ) and a hazard ratio of 1.45 ( $P = .013$ ); using the index as a dichotomous variable, the corresponding figures were a risk odds ratio of 3.71 ( $P < .001$ ) and a hazard ratio of 3.29 ( $P = .001$ ).

## Discussion

Nursing homes are under increasing pressure to prevent hospitalization due to pneumonia and other acute, potentially preventable health events.<sup>25</sup> However, because resources are limited, it is important to identify persons who are at particularly high risk, so that preventive interventions can be targeted toward those most likely to benefit. This research sought to develop and validate a simple method of identifying persons at increased risk for pneumonia who could benefit from such preventive efforts as mobilization, enhanced oral hygiene care, and additional medical scrutiny.<sup>26</sup>

Using variables obtained from the MDS—a routine nursing screening tool mandated by law for all federally certified NHs, the NH Pneumonia Risk Index identifies a subgroup of one-third of NH residents whose 6-month risk of pneumonia is nearly twice that of the others (Table 2). Thus, NH staff may wish to compute the index to identify residents who need especially aggressive management to prevent pneumonia and identify respiratory symptoms consistent with pneumonia early, so that incipient pneumonia can potentially be treated without requiring hospitalization.

Although the index was not developed to assess mortality, a serendipitous finding was that the NH Pneumonia Risk Index also estimates 6-month mortality, and that indeed its association with mortality is even greater than its association with pneumonia (Table 2). Therefore, the NH Pneumonia Risk Index may also be useful when applied to estimate mortality risk, a factor that can be valuable in care planning and discussion of advance directives.

A potential limitation of these results is the possibility of mislabeling. Despite the fact that the MDS has been extensively validated, errors or omissions are inevitable when such an extensive, standardized assessment tool is routinely collected on persons whose verbal and cognitive abilities are often limited.<sup>19,27</sup> Furthermore, pneumonia is difficult to diagnose and is likely misdiagnosed

frequently, even in hospital settings, as cases with the diagnosis may have negative chest radiographs, negative examinations, lack of cough or fever, and negative blood cultures.<sup>28</sup> Consequently, some diagnostic mislabeling may have been present in these data. That said, the data represent what is standard in NH practice, and what is available for regulatory, quality assurance, and quality improvement activities in community NH settings. Moreover, the score is easy to derive, and potential mislabeling notwithstanding, identifies residents at high risk of pneumonia and mortality.

Finally, additional validation of the NH Pneumonia Risk Index is indicated. Although the study NHs were typical of US NHs, more widespread field testing would help identify whether and to what extent there is variation in the index's predictive power in other NH settings. As part of these efforts, it may be useful to compare the index with the measure recently developed by Jackson and colleagues for pneumonia risk among community elderly.<sup>29</sup>

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