Thorax Online First, published on January 31, 2006 as 10.1136/thx.2005.051326

A prospective comparison of severity scores for identifying patients with severe community acquired pneumonia. Reconsidering what is meant by severe pneumonia.

Authors

KL Buising[1], KA Thursky[12], JF Black F[1], L MacGregor[1], AC Street [1], MP Kennedy[3], GV Brown [12]

1. Victorian Infectious Diseases Service, The Royal Melbourne Hospital, Parkville, Victoria 3050, Australia
2. Centre for Clinical Research Excellence in Infectious Diseases, Department of Medicine, University of Melbourne, Parkville, Victoria 3050, Australia
3. Emergency Department, The Royal Melbourne Hospital, Parkville, Victoria 3050, Australia

Correspondents

#1 Dr Kirsty Buising, Victorian Infectious Diseases Service, 9th Floor Royal Melbourne Hospital, Grattan St, Parkville Victoria 3050 Australia Tel +61 3 9342 7212 Fax: +61 3 9342 7277 Email: Kirsty.Buising@mh.org.au

#2 Dr Karin Thursky, Address as above. Email: Karin.Thursky@mh.org.au

Short title

Pneumonia severity scores

Word Count

Text 3600

Key words

Community acquired pneumonia, Severity, Prediction, Adult,

Financial Support

The Centre for Clinical Research Excellence in Infectious Diseases based at the Royal Melbourne Hospital is funded by the National Health and Medical Research Council of Australia. The funding body had no role in the study design, data collection and analysis, or the interpretation and writing of this manuscript. The authors declare no competing interests with regard to the material published in this article.

Ethics Approval

Approval for this study was obtained from the Human Research Ethics Committee of Melbourne Health, situated at the Royal Melbourne Hospital, Parkville, Victoria AUSTRALIA

Abstract

Background: Several severity scores have been proposed to predict patient outcome and guide initial management of patients with community acquired pneumonia (CAP). Most have been derived as predictors of mortality. We aimed to compare the predictive value of these tools using different clinically meaningful outcomes as constructs for 'severe pneumonia'.

Patients and Setting: All patients presenting to the emergency department with an admission diagnosis of CAP from March 2003-March 2004

Study Design: Prospective cohort study. Clinical and laboratory features at presentation were used to calculate severity scores using the Pneumonia Severity Index (PSI), the revised American Thoracic Society score (rATS), the British Thoracic Society (BTS) severity scores: CURB (1996), modified BTS severity score (2001), and CURB65 (2004). The sensitivity, specificity, positive and negative predictive values were compared for four different outcomes (death, need for ICU admission, and combined outcomes of death and/or need for ventilatory or inotropic support).

Results: 392 patients were included in the analysis. 37 (9.4%) died and 26 (6.6%) required ventilatory and/or inotropic support. The modified BTS severity score performed best for all four outcomes. The PSI (class IV&V) and CURB had very similar performance as predictive tools for each outcome. The rATS identified the need for ICU well, but not mortality. CURB 65 predicted mortality well, but performed less well when requirement for ICU was included in the outcome of interest. When the combined outcome was evaluated (excluding patients > 90 years and those from nursing homes), the best predictors were the mod BTS (sensitivity 94.3%) and the PSI and CURB (sensitivity for both 83.3%)

Conclusions: Different severity scores have different strengths and weaknesses as prediction tools. Validation should be done in the most relevant clinical setting, and using more appropriate constructs of 'severe pneumonia' so that we ensure that these potentially useful tools truly deliver what clinicians expect of them.

Introduction

Severity scores have been promoted as useful tools to help clinicians predict the outcome of patients presenting with community acquired pneumonia (CAP). [1][2][3][4] For those patients identified as likely to have 'severe pneumonia', management strategies can be appropriately tailored to include hospitalisation, involvement of an experienced clinician in their care, early consideration of Intensive Care Unit (ICU) management, and the use of broad-spectrum empiric antibiotics.

Most severity scores for CAP are mortality prediction tools and therefore they identify many elderly patients and patients with complex co-morbidities, whose pneumonia may not have been particularly severe, but it serves as the final factor leading to death. For many of these patients, aggressive management strategies would not be clinically appropriate.

Requirement for ICU admission is an alternative definition for 'severe pneumonia' and some severity scores have been evaluated for their ability to predict this outcome. [5][6][7] Unfortunately ICU admission is an imperfect surrogate marker for the construct 'severe pneumonia' as it involves subjective judgement and the criteria for admission differ between institutions. Using this as a sole outcome of interest risks overlooking patients whose illness may have been underestimated clinically, and who died without reaching ICU.

We suggest that alternative constructs for 'severe pneumonia' need to be considered.. In this study we evaluated the performance of many of the published severity scores for CAP, using different outcomes. The scores included modifications of the British Thoracic Society (BTS) severity score (CURB, CURB-65 and the modified BTS), the revised American Thoracic Society severity score (rATS), and the Pneumonia Severity Index (PSI). [2][3][5][6][7]

Aim

To evaluate the predictive value of severity scores for CAP in an Australian population, using different constructs for the outcome 'severe pneumonia'.

Method

Setting

This study was performed at the Royal Melbourne Hospital, an urban adult tertiary teaching hospital with 350 beds including 14 ICU beds. The emergency department assesses 50, 000 patients per year, leading to 16,000 admissions to hospital.

Patient recruitment and data collection

This study recruited consecutive patients presenting to the emergency department between 1st April 2003 and 30th March 2004 with a diagnosis of "pneumonia" made by the treating clinician within the first 24 hours of presentation (based upon clinical assessment, initial pathology results and chest x ray assessment by the clinician). All patients prospectively recorded in the emergency department database with symptoms or a diagnosis suggestive of a respiratory or infective illness were identified (this included pneumonia, chest infection, lower respiratory tract infection, etc.). Those for whom the medical record suggested that the treating doctor made a clinical diagnosis of pneumonia were included in the study. Exclusion criteria included: age <18 years; immunosuppression (acquired immune deficiency syndrome with CD4<200 per microlitre, chemotherapy within the last month, absolute neutrophil count $<0.5 \times 10^9$/L, transplant recipient with ongoing use of immunosuppressants, use of corticosteroids at a dose equivalent to prednisolone >15mg/day); chronic suppurative lung disease (bronchiectasis, cystic fibrosis) and nosocomial pneumonia (admitted to hospital for >48 hours within 2 weeks prior to presentation). Data on clinical features and pathology and radiology results available in the first 24 hours after presentation were collected by manual review of the medical record and the pathology computer database.

Data collected included: age, gender, residency in nursing home, respiratory rate, blood pressure, temperature, heart rate, presence of acute confusion, percutaneous oxygen saturation, co-morbid diseases, initial chest x-ray findings as assessed by the clinician and the radiologist (recorded separately), known antibiotic allergies, prior antibiotic use, tests ordered (and microbiology results obtained), and the site of initial management. The definition of acute confusion was based upon the clinician's assessment (that the patient's mental state was altered, and that this was a new phenomenon). If pre-existing dementia was known, then deterioration from the preceding usual state was required. A mini-mental state examination was not required. The pathology data collected included arterial blood gas (ABG) results, serum urea, creatinine, glucose, sodium, haematocrit, and white blood cell count. The clinical and pathology results collected represented the most abnormal result (highest and/or lowest) in the 24 hours from the time of emergency department arrival. This time period was deliberately chosen, as it most closely

resembled the time during which assessments are made in usual clinical practice. Missing values were assumed to be normal, in accord with methodology in past studies.

The antibiotics prescribed in the first 48 hours were recorded, as were all antibiotics subsequently prescribed. The patients' progress and outcome was monitored prospectively. This included the length of stay in hospital, requirement for ICU admission at any time during admission, length of stay in ICU, time to ICU admission, requirement for ventilatory assistance, need for inotropic support, in hospital mortality, and re-presentation within 2 weeks. If ABGs were not tested, then they were assumed to be within the normal range.

Severity scores including the Pneumonia Severity Index (PSI), the modified British Thoracic Society severity scores (BTS) and the revised American Thoracic Society (ATS) severity scores were calculated using collected data.
The severity scores were defined as follows:

- The PSI developed by Fine et al uses 20 clinical variables to determine a score. [5] These scores are then used to define 5 classes of increasing risk of mortality. We assessed the use of class V alone and class IV&V to define 'severe pneumonia' as other guidelines have previously suggested these two definitions. [4] [8] This prediction tool has been independently validated and widely endorsed.[2][3][9][10][11]
- The CURB index [6] was derived from the original BTS study [12] and uses four core clinical features: Confusion of new onset (or worsening of existing state for those with background cognitive impairment), serum urea >7mmol/L, respiratory rate >or equal to 30/minute, and blood pressure (systolic blood pressure <90mmHg or diastolic blood pressure < or equal to 60mmHg). The presence of 2 or more of these 4 criteria led to a classification as 'severe'. This tool has been validated independently [13][14][15]
- The CURB-65 index [7] is a further modification of the BTS prediction rules. Age >or equal to 65 years is added as a fifth variable to the four core variables mentioned above. To be classed as severe, a patient needed to meet 3 or more of the 5 variables. This tool has been endorsed in some guidelines [10][16].
- The modified British Thoracic Society severity score (mod BTS) (authors' own label) was suggested in the 2001 BTS guidelines for management of community-acquired pneumonia [2]. As a first step, the four core CURB variables are assessed, and if a patient has 2 or more out of 4 they are classed as severe. Then, if the patient has just one core criteria, or if they are aged greater than or equal to 50 years, or have one co-morbidity, then a second step is required. This step involves assessment for two additional variables; Oxygen saturations <92% and presence of bilateral or multilobar infiltrates on chest x-ray. If either of these additional criteria is met, then the patient was classed as 'severe'. To our knowledge, no independent validation of this tool has been published.
- The revised ATS (rATS) proposed by Ewig et al and incorporated in the ATS guidelines in 2001. [3][11][17][18][19] This predictive rule classed a patient as having 'severe pneumonia' if they met 1 out of 2 major criteria (requirement for mechanical ventilation or septic shock) or 2 out of 3 minor criteria (systolic blood pressure <90mmHg, multi-lobar chest x-ray changes, or PaO2/FiO2 <250).

The performance of the severity scores in predicting both death in hospital and need for ICU admission was evaluated. A variable that included all patients requiring either inotropic support or ventilatory assistance (non-invasive or invasive ventilation) within 48 hours of presentation where no other cause for circulatory or respiratory failure was clinically evident was also evaluated (as it was thought to represent a more objective outcome than ICU admission). Finally a combined outcome of interest was defined, which represented patients who died or required extraordinary interventions to keep them alive – that is, death and/ or requirement for ventilatory support or inotropic support. In a subsequent analysis, patients 90 years of age and over, those from nursing homes and those with advanced illness who were nominated as not for aggressive therapy (eg: not given antibiotics at all) were excluded, as this patient group was judged unlikely to be the group for whom a prediction tool would need to be applied.

The treating clinicians were unaware of the research being conducted. All decisions regarding diagnostic tests and therapeutics were made by clinicians without intervention by research staff. ICU assessment was based upon usual clinical evaluation. No specific guidelines were promoted at the time. Some clinicians may have been aware of, and used severity scores. The current Australian guidelines promoted the use of the PSI [21] and a computerised calculator was available to assist with PSI calculations at the point of care, but these were not specifically promoted.

Statistical Analysis

Descriptive analyses were used for patient characteristics. Sensitivity, specificity, positive predictive value, negative predictive value and 95% confidence intervals were calculated for each severity score, for each outcome of interest. A receiver operator characteristics curve was constructed using the performance criteria of each tool, and the area under these curves were reported. Statistical analysis was performed using Stata 8.0. [20]

Results

Population

Three hundred and ninety two patients with CAP were included in the analysis. Twenty-six patients (6.6%) required ICU admission. Of these, 65.3% (17/26) went directly to ICU, and of the remainder, 8 were admitted to ICU within 24 hours, and 1 was admitted on day 7 for another medical complication. No patients received non invasive ventilation, and this hospital did not have a separate high dependency unit at the time of the study. . Thirty-seven patients (9.4%) died in-hospital, and allowing for overlap between groups, 48.4% of these patients were either aged >90 years, resided in a nursing home, or were determined to be unsuitable for aggressive therapy within 24 hours of presentation due to complex irreversible co-morbidities. The median age of patients admitted to ICU was 62.5 years (range 25-85), compared with a median age of patients who died of 82 years (range 43-97) ($p<0.001$).

Patients were treated with an empiric antimicrobial regimen selected by the treating clinician, usually a beta lactam (either amoxycillin, penicillin or ceftriaxone) in combination with either a macrolide or doxycycline (as per local guidelines). [21] After excluding those patients who were not treated with antibiotics at all or had suspected aspiration pneumonia, 36% of patients did not receive a recommended antibiotic

regimen, the most common reason being treatment with a single antibiotic rather than combination therapy. Fourteen percent of patients (55/ 392) received solely oral antibiotic therapy and 82.4% received intravenous antibiotics initially. Fourteen patients (3.6%) received no antibiotic therapy and most of these were >90 years of age or from a nursing home. Documentation of the result of a PSI calculation was found in the notes of 6 patients. Further demographic and clinical data are presented in table1.

Data were missing for 20 patients who had no blood tests performed (hence serum urea, glucose, creatinine and white cell counts were unavailable). Only 141 (35.9%) patients had arterial blood gas testing done. Fourteen patients were transferred directly to a private hospital from the emergency department because the patient requested private care. Forty-five patients (11.5%) did not have a discharge diagnosis of pneumonia, despite being admitted with this clinical diagnosis. The majority of these patients had an upper respiratory tract infection (eg, acute bronchitis or an acute exacerbation of chronic obstructive pulmonary disease), and many of these also had evidence of pulmonary venous congestion on the formal reports of their chest x ray.

Sensitivity/specificity of severity scores

Applying the severity scores to our entire population, the predictive value of the PSI for mortality was similar to that described in the original PORT (Pneumonia patient outcomes research team) cohort [5], that is class I: 0, class II: 0, class III: 2%, class IV: 8%, class V: 28%. [5] The performance of the tools in identifying patients who died is shown in table 2. If the group of elderly patients (>90 years of age, nursing home residents and patients identified as not for aggressive therapy at the time of admission) are excluded, then the sensitivity of the tools for mortality in the remaining patients was 94.7% (18/19) for both the PSI class IV&V and for CURB; 89.5% (17/19) for CURB-65; 100% for the mod BTS and 57.8% (11/19) for the rATS. Twenty-nine patients who died were not admitted to ICU prior to death. Eleven of these patients were not in the group aged >90 years, from a nursing home or identified as not for resuscitation within 24 hours of presentation. The CURB, PSI IV&V, and modBTS tools all identified 10/11 of these patients as 'severe'.

The rates of ICU admission in each of the classes of the PSI were class I:0, class II: 2%, class III; 5%, class IV: 7% and class V 14%. The rATS performed well to identify patients requiring ICU admission, as did the mod BTS, whereas CURB-65 had a sensitivity of just 57.7% for ICU admission. PSI class IV&V and CURB had similar predictive values for this outcome of interest (see table 3). Eight patients who required ICU admission were not admitted directly from the emergency department. Seven of these eight patients required transfer from the ward to ICU within 24 hours. In this cohort both the PSI class IV&V and the CURB definitions of severity correctly identified 7/8 of these patients (one patient was misclassified by both tools).

Table 4 gives details on the combined outcome of any patients who died and/ or required extraordinary interventions to keep them alive (ventilatory support or inotropes). The mod BTS performed well for all four outcomes used to define the construct of 'severe pneumonia'. The PSI class IV&V and CURB had comparable results for each of the four

outcomes, indeed for the combined outcome of death and/or ICU admission excluding the elderly group, the sensitivities were the same, with overlapping confidence intervals. The CURB was more specific than the PSI (although confidence intervals overlap), and this is reflected by a slightly higher area under the receiver operator characteristic curve. When the very elderly patients and nursing home residents were excluded, the sensitivity of the PSI and CURB 65 fell, whereas the other tools remained stable or increased in sensitivity, suggesting that this patient group were more often being categorised as severe by these tools compared with the other severity scores. The performance of the severity scores was separately assessed only for patients with both an admission and a discharge diagnosis of pneumonia (table 5). In this group, the discriminative ability of all the tools improved slightly (area under ROC curves; PSI (IV &V): 0.70, CURB: 0.74, CURB-65: 0.71, mod BTS: 0.78, rATS: 0.82).

Discussion

This is the first study to compare the performance of five published severity scores for community acquired pneumonia for different outcomes of interest. This study shows that different severity scores for community acquired pneumonia have different strengths and weaknesses depending upon which patients the clinician really wants to identify. CURB-65 predicted mortality well, but not the need for ICU admission or the combined outcomes. With this tool, younger patients were less likely to be identified as 'severe', as they needed to qualify for three of the remaining four criteria (after excluding age). The rATS was a sensitive tool for ICU admission, but not death, however the major criteria for this tool are not truly 'predictive' in that a requirement for inotropes or ventilatory support needs to already have been appreciated. The mod BTS showed good performance characteristics for ICU admission, death and the combined outcomes in this study. The PSI is a widely endorsed and well validated tool, and performed well for the different outcomes of interest. CURB is a simple tool, which showed comparable performance to the PSI. This study aimed to identify patients at the severe end of the spectrum of clinical illness for whom aggressive management strategies might be employed, such as early consultant review, ICU admission and administration of broad spectrum empiric antibiotics. In this cohort, the mod BTS, CURB and PSI had high sensitivities for the combined outcome of interest chosen to best represent this patient group.

We believe that pneumonia severity scores are likely to be useful for less experienced doctors, in order to alert them to a high risk group of patients for whom consultation with more experienced clinicians is required. For this purpose a tool needs a high sensitivity and good negative predictive value. Patients who are not identified as 'severe' by the severity score are unlikely to die or require ICU interventions. The decision about whether or not to admit patients in this lower risk group to hospital is likely to then be influenced by criteria such as social factors, age and general frailty, co-morbidities etc. A significant proportion of patients who fall in to low risk categories of severity scores still do require inpatient care due to factors not assessed by the severity score. [22][23] The low positive predictive value of these severity scores highlights the need for clinical judgement in guiding the management of those identified in the 'severe pneumonia' group. Not all patients in the high-risk group will require ICU management, but they should receive careful initial and ongoing assessment. No prediction tool is accurate

enough to determine appropriate management on its own, and these tools should always only be viewed as augmenting clinical judgement.

The data from this study can be compared with previous studies. The areas under the ROC curve for the CURB and PSI scores were similar to those calculated by Ewig *et al* for the outcome of ICU admission (0.665 v 0.65 and 0.725 v 0.70) [17]. Similarly, the areas under the ROC curve for the CURB and CURB-65 were very close to those obtained by Aujesky *et al* when assessing the outcome of mortality (0.74 v 0.74 and 0.76 v 0.74), however the area under the ROC curve for the PSI was smaller in our study (0.81 v 0.73). [8] We note that Aujesky et al assessed 30 day mortality, whereas this study focused only on death in hospital, and this may account for some of the difference. A change from CURB to CURB-65 (as suggested in recently [15]) improved specificity, but at the expense of sensitivity for all outcomes with poorer discriminative value. Our data support the suggestion that CURB offers a simple valuable alternative to the PSI, as noted by Ewig *et al*.[17]

Tools derived to predict mortality are likely to be skewed by elderly patients and patients with complex co-morbidities. For many of these patients aggressive interventions may not be appropriate. For this reason, we chose to evaluate the performance of the tool both including and excluding very elderly patients, those from nursing homes, and those with advanced debilitating co-morbidities. The PSI and CURB-65 have scoring systems that are heavily influenced by patient age. This might explain why they perform better when death is the outcome of interest, rather than ICU admission, given the clear difference in age between patients who died and patients admitted to ICU in this cohort. Similarly, in this cohort, most patients requiring ICU had respiratory or circulatory failure, thus satisfying a major criterion of the rATS tool. However, this tool performed poorly for predicting death in this cohort since most patients who died were not admitted to ICU. Our analysis of patients admitted to the ward and then transferred emergently to ICU within 24 hours was intended to identify patients whose severity of illness was possibly underestimated initially. The severity scores correctly identified the majority of these patients as 'severe'. Similarly, in the analysis of patients who died without being admitted to ICU (excluding the very elderly, nursing home patients, and those identified as not for aggressive therapies) it is conceivable that the severity of their illness may have been underestimated. These cases illustrate situations in which a severity score may have predicted a poor outcome and identified the need for intensive measures.

A major strength of this study was that patients were assessed using only the data readily available at the point of care when usual management decisions are being made. In some patients the diagnosis of pneumonia was later excluded on the basis of further investigation results, but it is important to include this group in the evaluation of the prediction tools as it best reflects the context in which they will be used. We must be sure that the tools are safe to use in the face of diagnostic uncertainty that accompanies early patient assessments (similar to intention to treat analysis of drug trials). The precision of discharge diagnoses of pneumonia can be poor [24][25], hence we have chosen to focus on initial clinical diagnosis to validate these tools. Our data, therefore, differs from previous studies that used the discharge or final diagnosis to define inclusion.The clinical data collected reflected the most abnormal result in the first 24 hours, which differs from other studies that have used the most abnormal result in the first 48 hours, or the first

result recorded (at triage). [5][6][7] We believe the strategy we employed best reflects the decision making process of clinicians at this institution.

In summary, consideration of alternative outcomes to define 'severe pneumonia' is important when evaluating severity scores for CAP. In addition, validation studies should reflect, as closely as possible, the context in which the tool is likely to be employed. They should use only the data likely to be readily and practically available in real time, avoid retrospective exclusion of cases due to recruitment based on discharge diagnosis, and apply the tool only to patients for whom it would be likely to be used in routine practice. Different severity scores for CAP have different strengths and weaknesses, which need to be recognised. The PSI (class IV&V), CURB and mod BTS severity score provide comparable information with regard to identifying high risk patients for whom more aggressive management strategies may be required

Table 1: Patient characteristics

Patient Characteristics	(n)	(%)
Age (years)		
Median 74		
Range 18-96		
Age group (years)		
18-38	47	11.9
39-58	56	14.3
59-78	137	34.9
> 78	152	38.7
Sex Female	158	40.3
Current smokers	83	21.1
Alcohol abuse	38	9.6
Nursing home resident	55	14.0
Previous presentation within 2 weeks	19	4.8
Antibiotics prior to presentation	99	25.2
Comorbidities		
Congestive cardiac failure	80	20.4
Chronic liver disease	10	2.5
Neoplasia	54	13.7
Chronic renal failure	47	11.9
Cerebrovascular disease	74	18.8
Chronic obstructive pulmonary disease	92	23.4
PEG/Tracheostomy	19	4.8
Dementia/ Neurological disease	52	13.2
Diabetes	87	22.1
Aspiration clinically suspected	39	9.9

Number of patients in each group of the severity scores:	**No**	**%**
PSI class		
I	47	11.9
II	57	14.5
III	68	17.3
IV	131	33.4
V	89	22.7
IV and V combined	220	56.1
rATS severe	70	17.8
CURB severe	182	46.4
CURB-65 severe (group 3)	161	41.0
ModBTS severe	214	54.6

PSI= Pneumonia Severity Index, rATS=revised American Thoracic Society, modBTS= modified British Thoracic Society

Management and outcomes	(n)	(%)
Length of stay (LOS), Median and range (days)	4 (1-76)	
Site of care		
Ward	243	62.0
ICU direct	17	4.3
Outpatient	53	13.5
Another hospital (not ICU)	14	3.6
Short stay unit	62	15.8
Died in emergency department	2	0.5
ICU admission	26	6.6
Mechanical ventilation	23	5.8
Inotropes	26	6.6
Died in ICU	8/ 26	30.7
Died outside ICU	29/366	7.9
Died (All sites)	37	9.4
Admitted to ICU	8/ 37	21.6
Nursing home residents	13/ 37	35.1
Aged >90 years	7/ 37	18.9
Not for aggressive therapy	4/ 37	10.8
Median LOS of those who died, days	6.5	
Discharge Diagnosis of Pneumonia	347	88.5
Readmitted within 2 weeks	32	8.3

Table 2: Predictive value of scores

OUTCOME = MORTALITY

Severity score	Sensitivity , 95% CI	Specificity, 95% CI	PPV 95% CI	NPV 95% CI (%)	Area under ROC
PSI class V	67.5 [50.2,81.9]	82.1 [77.6,85.9]	28.4 [19.3,39.0]	96.0 [93.1,97.9]	0.73
PSI class IV&V	97.3 [85.8,99.9]	47.9 [42.5,53.2]	16.4 [11.7,22.0]	99.4 [96.7,99.9]	0.73
CURB (≥2)	89.2 [74.5,96.9]	58.1 [52.7,63.3]	18.3 [12.9,24.7]	98.1 [95.1,99.4]	0.74
CURB65 (≥3)	81.0 [64.8,92.0]	67.9 [62.7,72.7]	20.8 [14.5,28.4]	97.2 [94.2,98.8]	0.74
ModBTS	91.9 [78.1,98.3]	49.8 [44.5,55.2]	16.2 [11.4,21.8]	98.3 [95.1,99.6]	0.71
rATS	40.5 [24.7,57.9]	84.6 [80.4,88.2]	21.7 [12.7,33.3]	93.1 [89.7,95.6]	0.63

Table 3: Predictive value of scores

OUTCOME = ICU admission

Severity score	Sensitivity , 95% CI	Specificity, 95% CI	PPV 95% CI	NPV 95% CI (%)	Area under ROC
PSI class V	48.0 [27.8-68.7]	79.0 [74.5,83.1]	13.6 [7.2,22.6]	95.6 [92.7,97.6]	0.65
PSI class IV&V	84.0 [63.9-95.4]	45.4 [40.2,50.7]	9.6 [6.0,14.3]	97.6 [94.0,99.3]	0.65
CURB (≥2)	84.0 [63.9-95.4]	56.2 [50.9,61.3]	11.7 [7.3,17.2]	98.1 [95.1,99.4]	0.70
CURB65 (≥3)	57.7 [36.9-76.6]	64.7 [59.6,69.6]	10.4 [5.9,16.6]	95.5 [92.2,97.7]	0.61
ModBTS	96.0 [79.6-99.9]	48.7 [43.5,54.0]	11.4 [7.4,16.5]	99.4 [96.9,99.9]	0.72
rATS	92.0 [73.9-99.0]	87.3 [83.4,90.5]	33.3 [22.4,45.7]	99.3 [97.7,99.4]	0.90

Table 4: Predictive value of scores for Combined Outcomes

OUTCOME = Death and/or ICU admission**

Severity score	Sensitivity , 95% CI	Specificity, 95% CI	PPV 95% CI	NPV 95% CI (%)	Area under ROC
PSI class V	55.5 [41.4,69.1]	82.6 [78.1,86.5]	34.1 [24.3,44.9]	92.0 [88.3,94.8]	0.70
PSI class IV&V	90.7 [79.7,96.9]	49.1 [43.6,54.6]	22.3 [17.0,28.4]	97.0 [93.2,99.0]	0.70
CURB (≥2)	85.2 [72.8,93.0]	59.8 [54.4,65.0]	25.5 [19.3,32.5]	96.1 [92.5,98.3]	0.73
CURB65 (≥3)	70.9 [57.1,82.4]	68.8 [63.6,73.7]	27.1 [20.0,35.1]	93.5 [89.7,96.3]	0.69
ModBTS	94.4 [84.6,98.8]	52.4 [46.6,59.7]	24.3 [18.6,30.6]	98.3 [95.1,99.6]	0.73
rATS	57.4 [43.2,70.7]	88.6 [84.7,91.8]	44.9 [32.9,57.3]	92.8 [89.3,95.3]	0.73

OUTCOME = Death &/or ICU admission Excluding # (n=311)**

Severity score	Sensitivity , 95% CI	Specificity, 95% CI	PPV 95% CI	NPV 95% CI (%)	Area under ROC
PSI class V	47.2 [30.4,64.5]	79.8 [75.2,83.8]	19.1 [11.5,28.8]	93.7 [90.4,96.2]	0.65
PSI class IV&V	83.3 [67.2,93.6]	46.6 [41.3,51.9]	13.6 [9.4,18.9]	96.5 [92.6,98.7]	0.65
CURB (≥2)	83.3 [67.2,93.6]	57.8 [52.5,63.0]	16.7 [11.5,22.9]	97.2 [93.9,98.9]	0.71
CURB65 (≥3)	66.6 [49.0,81.3]	66.3 [61.1,71.2]	16.7 [10.9,23.8]	95.2 [91.7,97.8]	0.70
ModBTS	94.3 [81.3,99.3]	49.4 [44.1,54.7]	15.9 [11.2,21.5]	98.8 [96.0,99.8]	0.72
rATS	72.2 [54.8,85.8]	87.9 [84.9,91.1]	37.7 [26.3,50.1]	96.9 [94.4,98.5]	0.80

** Where ICU is defined as requirement for invasive or non-invasive ventilation and/ or inotropic support, not judged to be due to another cause

Excluding Nursing home residents, Patients Aged >90 years and patients nominated as Not for aggressive therapy at presentation (due to advanced irreversible co-morbidities)

Table 5
Predictive value of scores for combined outcomes using only those patients with an admission and a discharge diagnosis of pneumonia (n=347)

OUTCOME = Death &/or ICU* admission Excluding # if discharge diagnosis is pneumonia					
Severity score	**Sensitivity , 95% CI**	**Specificity, 95% CI**	**PPV 95% CI**	**NPV 95% CI (%)**	**Area under ROC**
PSI class V	54.5 [40.5, 68.0]	82.5 [78.0, 86.4]	33.7 [24.0, 44.5]	91.8 [88.0, 94.5]	0.50
PSI class IV&V	89.0 [77.7, 95.9]	49.2 [43.8, 54.7]	22.2 [16.9, 28.4]	96.5 [92.5, 98.7]	0.70
CURB (≥2)	80.0 [67.0, 89.6]	59.6 [54.2, 64.9]	24.4 [18.2, 31.4]	94.8 [90.9, 97.4]	0.74
CURB65 (≥3)	70.9 [57.1, 82.4]	68.8 [63.6, 73.8]	27.1 [20.0, 35.1]	93.6 [89.7, 96.3]	0.71
ModBTS	98.2 [90.3, 99.9]	51.9 [46.5, 57.4]	25.0 [19.3, 31.3]	99.4 [96.8, 99.9]	0.78
rATS	58.2 [44.4, 71.3]	88.7 [84.8, 91.9]	45.7 [33.7, 58.0]	92.8 [89.5, 95.4]	0.82

** Where ICU is defined as requirement for invasive or non-invasive ventilation and/ or inotropic support, not judged to be due to another cause

Excluding Nursing home residents, Patients Aged >90 years and patients nominated as Not for aggressive therapy at presentation (due to advanced irreversible co-morbidities)

References

1. Lim WS, Macfarlane JT. Importance of severity of illness assessment in management of lower respiratory infections. Curr opin infect dis 2004;17(2):121-5.

2. British Thoracic Society Standards of Care Committee. British Thoracic Society Guidelines for the Management of Community Acquired Pneumonia in adults. Thorax 2001;56 (Supp4):iv1-64.

3. American Thoracic Society: Guidelines for the management of adults with community acquired pneumonia. Am j respir crit care med 2001;163:1730–1754

4. Johnson PD, Irving L, Turnidge J. Community acquired pneumonia Med j aust 2002;176:341-7

5. Fine MJ, Auble TE, Yealy DM, Hanusa BH, Weissfeld LA, Singer DE, Coley CM, Marrie TJ, Kapoor WN.A prediction rule to identify low-risk patients with community-acquired pneumonia.
N engl j med. 1997;336(4):243-50.

6. Neill AM, Martin IR, Weir R, Anderson R, Chereshsky A, Epton MJ, Jackson R, Schousboe M, Frampton C, Hutton S, Chambers ST, Town GI.Community acquired pneumonia: aetiology and usefulness of severity criteria on admission. Thorax 1996;51(10):1010-6.

7. Lim WS, van der Eerden MM, Laing R, Boersma WG, Karalus N, Town GI, Lewis SA, Macfarlane JT. Defining community acquired pneumonia severity on presentation to hospital: an international derivation and validation study. Thorax 2003;58(5):377-82.

8. Aujesky D, Auble TE, Yealy DM, Stone RA, Obrosky DS, Meehan TP, Graff LG, Fine JM, Fine MJ .Prospective comparison of three validated prediction rules for prognosis in community-acquired pneumonia. Am j med 2005;118(4):384-92

9 Atlas SJ, Benzer TI, Borowsky LH et al. Safely increasing the proportion of patients with community acquired pneumonia treated as outpatients: and interventional trial. Arch int med 1998;158:1350-1356

10 Mandell LA, Bartlett JG, Dowell SF, File TMJr, Musher DM, Whitney C. Update of practice guidelinesa for the management of community acquired pneumonia in immunocompetent adults. Clin inf dis 2003;37:243-50

11. Community-acquired pneumonia in adults in British hospitals in 1982-1983: a survey of aetiology, mortality, prognostic factors and outcome. The British Thoracic Society and the Public Health Laboratory Service. Q j med 1987;62(239):195-220.

12. Lim WS, Macfarlane JT, Boswell TC et al. Study of community acquired pneumonia aetiology (SCAPA) in adults admitted to hospital: implications for management guidelines. Thorax 2001;56: 296-301

13. Lim WS, Lewis S, Macfarlane JT. Severity prediction rules in community acquired pneumonia: a validation study. Thorax 2000;55(3):219-23

14. Lim WS, Macfarlane JT. Defining prognostic factors in the elderly with community acquired pneumonia: a case controlled study of patients aged > or = 75 yrs. Eur respir j 2001;17(2):200-5

15. Macfarlane JT, Boldy D. 2004 update of BTS pneumonia guidelines: what's new? Thorax 2004;59:364-366

16. Ewig S, Ruiz M, Mensa J, Marcos MA, Martinez JA, Arancibia F, Niederman MS, Torres A .Severe community-acquired pneumonia. Assessment of severity criteria.
Am j respir crit care med 1998;158(4):1102-8.

17.Ewig S, de Roux A, Bauer T, Garcia E, Mensa J, Niederman M, Torres A. Validation of predictive rules and indices of severity for community acquired pneumonia. Thorax 2004;59(5):421-7

18. Angus DC, Marrie TJ, Obrosky DS, Clermont G, Dremsizov TT, Coley C, Fine MJ, Singer DE, Kapoor WN. Severe community-acquired pneumonia: use of intensive care services and evaluation of American and British Thoracic Society Diagnostic criteria. Am j respir crit care med 2002;166(5):717-23.

19. Riley PD, Aronsky D, Dean NC. Validation of the 2001 American Thoracic Society criteria for severe community-acquired pneumonia.
Crit care med 2004;32(12):2398-402.

20. Stata 8.0 Stata Corp LP USA

21. Therapeutic Guidelines Antibiotic, version 12.. Therapeutic guidelines writing group. Therapeutic Guidelines, Melbourne Australia 2003.

22. Arnold FW, Ramirez JA, McDonald LC, Xia EL. Hospitalisation for community acquired pneumonia: Pneumonia severity index vs clinical judgement. Chest 2003; 124: 121-4

23.Goss GH, Rubenfeld GD, Park Dr et al. Cost and incidence of social comorbidities in low risk patients with community acquired pneumonia admitted to a public hospital. Chest 2003; 126: 2148-55

24. Aronsky D, Haug PJ, Lagor C, dean NC. Accuracy of administrative data for identifying patients with pneumonia. Am J Med Qual 2005 Nov-Dec; 20(6): 319-28

25. Goodpasture H, Nguyen-Dang CT, Lee TH, Ghazarian PG, Fulton MA. Miscoding as a cause of elevated simple pneumonia mortality. Jt Comm J Qual Saf. 2004 Jun: 30(6): 335-41