Original Article

Validity of Pneumonia Severity Index and CURB-65 Severity Scoring Systems in Community Acquired Pneumonia in an Indian Setting

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ABSTRACT

Background. Little information is available from India regarding prognostic factors in patients with community acquired pneumonia (CAP).

Methods. Hospital-based prospective study to test the validity of pneumonia severity index (PSI) and the confusion, urea, respiratory rate, blood pressure, age over 65 years (CURB-65) risk scoring systems in patients with CAP (n=150).

Results. Although both CURB-65 class ≥III and PSI class ≥IV were 100% sensitive in predicting death, CURB-65 class ≥III had a higher specificity (74.6%) than PSI class ≥IV (52.2%) when used to predict death. In both PSI and CURB-65 risk scoring systems, mortality rate, need for intensive care unit (ICU) admission, prolonged need for intravenous (I.V.) antibiotics, prolonged duration of hospital stay and need for admission to ICU increased progressively with increasing scores. The PSI class ≥IV was more sensitive in predicting ICU admission than CURB-65. The duration of hospital stay was found to have a weak but significant correlation with PSI and CURB-65 criteria. Defervescence time also had a very weak but significant correlation with PSI and CURB-65 criteria. Duration of I.V. antibiotics had a moderately strong correlation with CURB-65 criteria but a weak correlation with PSI criteria.

Conclusions. Both PSI and CURB-65 were found to have equal sensitivity to predict death from CAP. Specificity of CURB-65 was higher than that of PSI. However, PSI was more sensitive in predicting ICU admission than CURB-65.

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Key words: Community acquired pneumonia, CURB-65, Pneumonia severity index.

INTRODUCTION

Community acquired pneumonia (CAP) is a common disorder with an incidence of about 20% to 30% in developing countries compared to an incidence of 3% to 4 % in developed countries.[1-3] The incidence varies markedly with age, being much higher in the very young and the elderly. It is estimated that India together with Bangladesh, Indonesia and Nepal account for 40% of global acute respiratory infection; 90% of mortality is due to pneumonia, mostly bacterial in origin.[2]

The cause of CAP is often difficult to establish and despite the recent progress it takes a few days to identify the causative micro-organism in the blood or sputum samples. The aetiology of CAP remains uncertain in many patients. Even with the use of extensive laboratory testing and invasive procedures; aetiological confirmation being achieved in no more than 45% to 70% of patients.[4,5] *Streptococcus pneumoniae* is the most commonly isolated pathogen responsible for 35% to 60% of cases.[6,7] Studies reported during the last two decades from India have also reported a higher prevalence of *Klebsiella pneumoniae* among culture-positive pneumonias.[8-10] In two Indian studies from New Delhi, the prevalence of *Mycoplasma pneumoniae* has been reported to be 35% in adults[11] and 27.4% in children.[12]

The reported mortality of adults admitted to hospital with CAP has varied widely (4%–21%).[13-15] While the British Thoracic Society (BTS) multi-centric study recorded a surprisingly low mortality of 5.7%,[16] a higher mortality (ranging from 21%-25%) has been reported in other studies.[17,18] Though definite statistics are lacking CAP remains a leading cause of death in India too.[7] The mortality in a study of CAP reported by Bansal *et al*[6] was 11 percent. In another Indian study,[19] a

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significantly higher mortality was noticed in patients aged 50 years or above and in those with underlying co-morbid conditions. The mortality of patients with severe CAP requiring admission to an intensive care unit (ICU) is high. This is likely to be particularly evident in health services where ICU beds are at a premium such that only critically ill patients in need of assisted ventilation can be admitted. In the UK, ICU based studies report mortality rates of over 50 percent.[14,15,20,21]

It is hoped that the knowledge of relevant prognostic factors might be useful for early identification of patients at high risk requiring intensive care treatment. Prognostic scoring systems for CAP have been developed to address these issues. The two prominent tools for this purpose are the pneumonia severity index (PSI), developed in the USA after pneumonia outcome research trial (PORT), and the BTS rule, which has recently been modified to the CURB-65 rule "confusion, elevated blood urea nitrogen, elevated respiratory rate, low systolic or diastolic blood pressure (BP), and age over 65 years (CURB-65)" rule.[22,23] The two scoring approaches are viewed as being complementary, as each has different strengths and weaknesses.

Even though most of the burden in terms of mortality and morbidity occurs in the developing world, little has been done to study the factors associated with an adverse prognosis in CAP in this region. Further, the scoring systems currently employed in the western world have not been validated in developing countries where population demographics and health-care delivery systems are totally different from the developed world. The aim of our study was to test the validity of PSI and CURB-65 severity scoring systems in CAP in an Indian setting.

MATERIAL AND METHODS

In this hospital-based prospective study, 150 patients with CAP attending the out-patient as well as in-patient departments of Sher-i-Kashmir Institute of Medical Sciences (SKIMS), a tertiary care Institute in an urban area of Kashmir, India, were studied. Patients presenting with any opacity on chest radiograph consistent with the diagnosis of acute pneumonia, associated with respiratory symptoms, infectious syndrome and lack of an alternate diagnosis, were diagnosed to have CAP.[24]

The following patients were excluded from the study: *(i)* patients known to be positive for human immunodeficiency virus (HIV); *(ii)* chronically immunosuppressed patients (defined as immunosuppression for solid organ transplantation, post-splenectomy, receiving >10mg/day of pre- dnisone or the equivalent for more than 30 days, treatment with other immunosuppressive agents, neutropenic patients with absolute neutrophil count <1000/mm^3); *(iii)* patients hospitalised within previous 14 days; and *(iv)* patients with an alternate diagnosis during follow-up.

At the time of initial evaluation, the selected patients underwent a complete clinical history and examination; chest radiograph (postero-anterior and lateral views) at presentation and repeated after 48 hours; electrocardiogram; arterial blood gas analysis and serum electrolyte measurement; sputum for gram staining and culture; blood cultures (in selected patients); complete blood counts, blood urea nitrogen and serum creatinine; fasting blood glucose, serum bilirubin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), total proteins, serum albumin; lactate dehydrogenase (LDH) levels, PSI scoring and CURB-65 scoring on the basis of the points (Tables 1 and 2).

Other investigations like pleural fluid analysis, computed tomography (CT) of the chest, broncho-

Table 1. Pneumonia severity index (PSI) scoring

Patient Characteristics	Points
Demographics	
Age(years): Male: age	—
Female: age	—
Nursing home resident	+10
Co-morbidities	
Neoplastic disease	+30
Liver disease	+20
Congestive heart failure	+10
Cerebrovascular disease	+10
Renal disease	+10
Examination findings	
Altered mental status	+20
Respiratory rate ³30/minute	+20
Systolic blood pressure <90 mmHg	+20
Temperature <35°C or ³40°C	+15
Pulse ³125/minute	+10
Laboratory findings	
pH <7.35 (do ABG only if hypoxic or COPD)	+30
BUN >10.7 mmol/ L	+20
Sodium <130 mEq/L	+20
Glucose ³13.9 mmol/L	+10
Hematocrit <0.30	+10
PaO_2 <60mmHg or oxygen saturation <90%	+10
Pleural effusion	+30

Risk	Class	Score
Low	I	<51
Low	II	51 - 70
Low	III	71 - 90
Medium	IV	90 - 130
High	V	>130

Hospitalisation is recommended for class IV and V. Class III is based on clinical judgement

Table 2. CURB-65 criteria scoring

Confusion
Blood urea >7 mmol/L at the time of admission.
Respiratory Rate of ≥30/minute
Systolic BP ≤90 mmHg or diastolic BP ≤60mmHg
Age ≥65 years

A score of 1 is given for presence of each of the variables
BP=Blood pressure

alveolar lavage (BAL) were done depending on the clinical scenario of the patient.

At the clinical end points (hospital discharge or death) the following parameters were recorded: *(i)* duration of antibiotics; *(ii)* time taken for defervescence; *(iii)* need for mechanical ventilation; *(iv)* need of admission to ICU; and *(v)* condition at 30 days after discharge from the hospital.

In the present study, in-hospital death or death within 30 days of discharge was the main outcome studied. Requirement for ICU admission was studied as a marker for "severe pneumonia". Factors associated with prolonged duration of antibiotic therapy (defined as need for antibiotics for more than five days), prolonged hospital stay (defined as hospital stay for more than seven days) and prolonged time to defervescence (more than three days) were also studied. Defervescence was defined as resolution of fever, chest pain; respiratory rate ≤ 24 per minute; arterial oxygen saturation (SaO_2) of ≥90% while breathing room air; and ability to perform basic daily activities without support.

Statistical Analysis

Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated for different PSI and CURB-65 grades with qualitative variables (death, ICU admissions) as an outcome. The relationship of quantitative variables with PSI and CURB-65 classes was assessed by Spearman's correlation co-efficient.

RESULTS

In our study (n=150), 89 (59.3%) were males. The mean age (±SD) of males [60.8 (±13.6) years] was higher than that of females [48.3 (±17.0) years]. Eighty-nine patients (59.3%) were smokers of which 74 (83.2%) were males. Clinical characteristics of patients who survived and died are given in table 3. Eighty-nine patients had one or more co-morbidities. The most common co-morbidity was hypertension, followed by diabetes mellitus and chronic obstructive pulmonary disease (COPD).

Sixteen patients (10.7%) died. [12 (8%) patients who died in-hospital and four (2.7%) within 30 days after discharge].

Table 3. Comparison of various clinical variables in patients who survived and died

Variable	Survived No. (%)	Died No. (%)
Patients	134 (89.3)	16 (10.7)
Mean age (±SD), years	54.3±16.6	67.2±4.5
Male sex	76 (56.7)	13 (81.3)
Smokers	73 (54.5)	16 (100)
Pre-hospitalisation antibiotics	79 (59)	16 (100)
Cough	119 (88.8)	16 (100)
Purulent sputum	101 (75.4)	15 (93.8)
Haemoptysis	19 (14.2)	0 (0)
Chest pain (pleuritic)	61 (45.5)	0 (0)
Confusion	33 (31.3)	14 (87.5)
Pleural effusion*	43 (24.6)	3* (18.8)
Temperature >100 °F	91 (67.9)	3 (18.8)
Pulse >100/min	73 (54.5)	5 (31.2)
Systolic BP £90mmHg	24 (18)	3 (18.75)
Diastolic BP £60mmHg	30 (22.4)	6 (37.5)
Respiratory rate ³30/min	77 (57.5)	16 (100)
D-Dimer positive	77 (57.5)	16 (100)
Hypertension	46 (34.3)	8 (50.0)
Diabetes mellitus	22 (16.4)	2 (12.5)
COPD	4 (3.0)	5 (31.3)

*=Two of these patients had transudative effusion because of congestive heart failure and only one had synpneumonic effusion
COPD=Chronic obstructive pulmonary disease; BP=Blood pressure

The number of patients in different PSI risk classes is given in table 4A. All the16 patients (100%) who died were in PSI class ≥IV. Mortality in PSI class I to III was 0%; in class IV, 14.1% and Class V, 34.8 percent. Table 4B represents the sensitivity, specificity, NPV and PPV of different levels of PSI classes for predicting death as an outcome. Sensitivity and specificity for PSI risk class ≥IV to predict death was 100% and 52.2% and PPV and NPV were 20% and 100%, respectively. Mortality in risk class 0 to II was 0%, in risk class III it was 9.5%, 47.8% in class IV and 50% in class V. The sensitivity and specificity were most favourable for a PSI class ≥IV. Though the specificity increased to 88.8% when PSI class V is chosen as the cut-off, there was an unfavourable drop in the sensitivity which decreases to 50 percent. The receiver-operating characteristic (ROC) curve for different PSI classes is shown in figure 1.

Table 4A. Mortality in different PSI classes

Variable	PSI Class					Total
	I	II	III	IV	V	
Number of patients	25 (16.7%)	27 (18%)	18 (12%)	57 (38%)	23 (15.3%)	150 (100%)
Deaths	0 (0%)	0 (0%)	0 (0%)	8 (50%)	8 (50%)	16 (100%)

PSI=Pneumonia severity index

The number and percentage of patients in different risk classes of CURB-65 scoring is given in table 5A. Table 5B represents the sensitivity, specificity, NPV and

Table 4B. Sensitivity, specificity, negative and positive predictive values for different PSI classes for predicting death

PSI Class	Sensitivity (%)	Specificity (%)	Negative Predictive Value (%)	Positive Predictive Value (%)
[3]II	100	18.7	100	12.8
[3]III	100	38.8	100	16.3
[3]IV	100	52.2	100	20
V	50	88.8	93.7	34.8

PSI=Pneumonia severity index

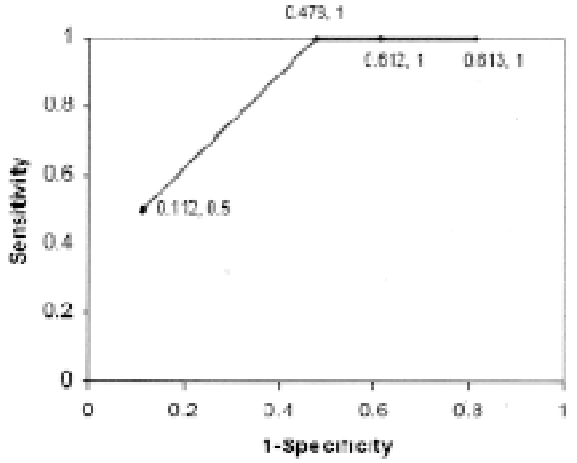

Figure 1. Receiver-operating characteristic curve for PSI with death as outcome. PSI=Pneumonia severity index.

PPV of choosing different levels of CURB-65 classes for predicting death as an outcome. The sensitivity and specificity of CURB-65 risk class ≥III to predict death was 100% and 74.6% and PPV and NPV were 32% and 100%, respectively. The sensitivity and specificity were most favourable for a CURB-65 class ≥III. Though the specificity increased to 88.8% when CURB-65 class ≥IV was chosen as the cut-off but there was an unfavourable drop in the sensitivity to 87.5 percent. The ROC curve for different CURB-65 classes is shown in figure 2.

Although both CURB-65 class ≥III and PSI class ≥IV were 100% sensitive in predicting death, CURB-65 class ≥III had a higher specificity (74.6%) than PSI class ≥IV

Table 5A. Mortality in different CURB-65 risk classes

Variable	CURB-65 Class						Total
	0	I	II	III	IV	V	
Number of patients	27 (18%)	31 (20.7%)	42 (28%)	21 (14%)	23 (15.3%)	6 (4%)	150 (100%)
Deaths	0 (0%)	0 (0%)	0 (0%)	2 (12.5%)	11 (68.75%)	3 (18.8%)	16 (100%)

CURB-65=Confusion, urea, respiratory rate, blood pressure, age over 65 years

(52.2%) when used to predict death.

Tables 6A and 6B represent the sensitivity, specificity, NPV and PPV of choosing different levels of PSI classes for predicting ICU admission as an outcome.

Table 5B. Sensitivity, specificity, and negative and positive predictive values for different CURB-65 classes for predicting death

CURB-65 class	Sensitivity (%)	Specificity (%)	Negative Predictive Value (%)	Positive Predictive Value (%)
[3]I	100	20.1	100	13
[3]II	100	43.3	100	17.4
[3]III	100	74.6	100	32
[3]IV	87.5	88.8	98.3	48.3
V	18.8	97.8	91	50

CURB-65=Confusion, urea, respiratory rate, blood pressure, age over 65 years

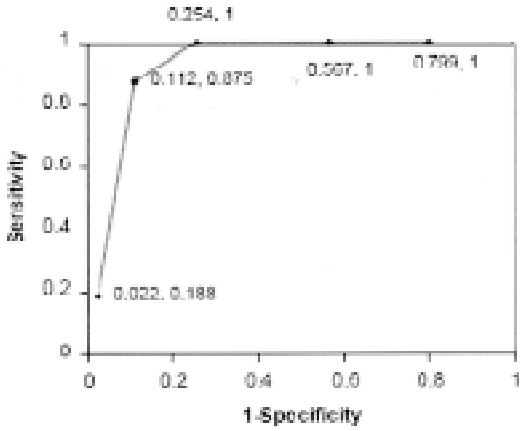

Figure 2. Receiver-operating characteristic curve for CURB-65 with death as outcome. CURB-65=Confusion, urea, respiratory rate, blood pressure, age over 65 years score.

The sensitivity and specificity were most favourable for a PSI class ≥IV. Though the specificity increases to 94.8% when PSI class V is chosen as the cut-off, there is an unfavourable drop in the sensitivity which decreases to 48.6 percent. The ROC curve for different PSI classes is shown in figure 3.

Tables 7A and 7B represent the sensitivity, specificity, NPV and PPV of choosing different levels of CURB-65 classes for predicting ICU admission as an

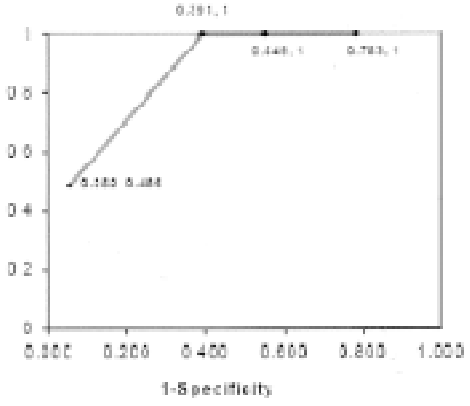

Figure 3. Receiver-operating characteristic curve for PSI with ICU admission as outcome. PSI=Pneumonia severity index, ICU=Intensive care unit.

Table 6A. Number of ICU admission in different PSI classes

Variable	PSI Class					Total
	I	II	III	IV	V	
Number of patients	25 (16.7%)	27 (18%)	18 (12%)	57 (38%)	23 (15.3%)	150 (100%)
ICU admissions	0 (0%)	0 (0%)	0 (0%)	18 (51.4%)	17 (48.6%)	35 (100%)

ICU=Intensive care unit; PSI=Pneumonia severity index

Table 6B. Sensitivity, specificity, negative and positive predictive values for different PSI classes in predicting ICU admission

PSI Class	Sensitivity (%)	Specificity (%)	Negative Predictive Value (%)	Positive Predictive Value (%)
[3]II	100	21.7	100	28
[3]III	100	45.2	100	35.7
[3]IV	100	60.9	100	43.8
V	48.6	94.8	85.8	73.9

PSI=Pneumonia severity index

outcome. The sensitivity and specificity were most favourable for a CURB-65 class ≥III. Though the specificity increased to 97.3% when CURB-65 class ≥IV was chosen as the cut-off, there was an unfavourable drop in the sensitivity which decreases to 74.3 percent. The ROC curve for different CURB-65 classes is shown in figure 4.

The PSI class ≥IV is more sensitive in predicting ICU admission than CURB-65 class ≥III; as CURB-65 class ≥III has a higher specificity (84.4%) than PSI class

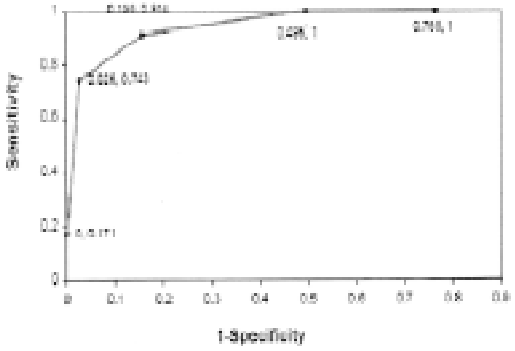

Figure 4. Receiver-operating characteristic curve for CURB-65 with ICU admission as outcome. CURB-65=Confusion, urea, respiratory rate, blood pressure, age over 65 years score, ICU=Intensive care unit.

Table 7A. Number of ICU admissions in different CURB-65 risk classes

Variable	CURB-65 Class						Total
	0	I	II	III	IV	V	
No. of patients	**27 (18%)**	**31 (20.7%)**	**42 (28%)**	**21 (14%)**	**23 (15.3%)**	**6 (4%)**	**150 (100%)**
ICU admissions	**0 (0%)**	**0 (0%)**	**3 (8.6%)**	**6 (17.1%)**	**20 (57.1%)**	**6 (17.1%)**	**35 (100%)**

ICU=Intensive care unit; CURB-65=Confusion, urea, respiratory rate, blood pressure, age over 65 years

Table 7B. Sensitivity, specificity, negative and positive predictive values for different CURB-65 classes for predicting ICU admission

CURB-65 Class	Sensitivity (%)	Specificity (%)	Negative Predictive Value (%)	Positive Predictive Value (%)
≥I	**100**	**23.5**	**100**	**28.5**
≥II	**100**	**50.4**	**100**	**38.0**
≥III	**91.4**	**84.4**	**97**	**64.0**
≥IV	**74.3**	**97.4**	**92.6**	**89.7**
V	**17.1**	**100**	**79.9**	**100**

ICU=Intensive care unit; CURB-65=Confusion, urea, respiratory rate, blood pressure, age over 65 years

≥IV (60.9%).

The PSI risk class was also significantly associated with the admission to ICU ($p<0.001$), prolonged duration of antibiotics ($p<0.001$), time to defervescence ($p=0.007$) and prolonged duration of hospital stay ($p<0.001$) (Table 8). Similarly, CURB-65 score was also significantly associated with the need for ICU admission ($p<0.001$), prolonged need for antibiotics ($p<0.001$) and prolonged duration of hospital stay ($p<0.001$) (Table 8).

The duration of hospital stay was found to have a weak but significant correlation with PSI and CURB-65 criteria. Defervescence time also had a very weak but significant correlation with PSI and CURB-65 criteria. Duration of IV antibiotics had a moderately strong correlation with CURB-65 criteria but a weak correlation with PSI criteria (Table 8).

Table 8. Correlation between some outcome parameters and PSI and CURB-65 criteria in 150 patients with community acquired pneumonia

	Spearman's rho	PSI	CURB-65
Duration of hospital stay	Correlation coefficient	0.401	0.487
	p-value	<0.001	<0.001
Defervescence time	Correlation coefficient	0.218	0.243
	p-value	0.007	0.003
Duration of IV antibiotics	Correlation coefficient	0.467	0.634
	p-value	<0.001	<0.001

PSI=Pneumonia severity index; CURB-65=Confusion, urea, respiratory rate, blood pressure, age over 65 years

DISCUSSION

In the initial management of patients with suspected CAP the clinician is faced with diagnostic and prognostic challenges, each challenge corresponding to a specific management decision. This emphasises the importance of prompt, accurate diagnosis and severity of illness which corresponds to decisions regarding the intensity of management. The decision regarding the

most appropriate site of care, including whether admission to hospital is warranted, is the first and single most important decision in the overall management of CAP. It has consequences both for the level of treatment received by the patient as well as the overall costs of treatment.[25]

An unchanged mortality of 4% to 21%[13,17] in-hospital treated CAP has renewed the interest in studying prognostic factors associated with fatal outcome.

The first landmark study to prognosticate patients of CAP was conducted by the Research Committee of the BTS in 1982.[26] In this study[26] comprising of 453 adults in 25 British hospitals, patients had a 21-fold increased risk of death if they had two of the following at admission: respiratory rate ≤30/min, diastolic BP ≤60mmHg, urea >7mmol/L. On the basis of these findings, BTS1 rule was constructed by selecting three factors, which were highly associated with death at admission, namely, respiratory rate ≥30/min at admission; diastolic blood pressure ≤60mmHg, and blood urea level >7mmol/L.

This rule yielded the highest value among any of the rules tested in the Youden index, a statistic combining sensitivity and specificity for selection of an optimal rule, assuming equal importance of sensitivity and specificity.[27] When the first rule was modified to use only three most predictive features ('confusion' replacing 'urea>7mmol/L), immediate application was possible with this second rule referred to as BTS2 rule. This modified rule had the highest overall accuracy (93%) and the highest specificity (94%) of any rule tested, but correctly identified only 39% of the patients who died; a positive rule was associated with a relative risk of death of 10.2. These two rules were compared with a more complicated one suggested by Macfarlane,[28] which required at least three of the following factors: *(i)* confusion on examination, *(ii)* white blood cell count $\geq 10 \times 10^9$/L or lymphocytes $\geq 1 \times 10^9$/L; *(iii)* arterial oxygen tension (PaO_2) ≤6.6KPa; and *(iv)* blood urea level ≥7mmol/L. It showed an overall accuracy of 87%, but identified only 50% of the patients who died, and was associated with a relative risk of death of 6.4.

Neill *et al*[29] derived a modified BTS rule (mBTSr) in which severe CAP was suggested by the presence of two or more of: *(i)* confusion, *(ii)* respiratory rate ≥30/minute, *(iii)* diastolic BP ≤60mmHg; and *(iv)* blood urea ≥7mmol/L at the time of admission. Those who satisfied mBTSr had a 36.5-fold greater risk of dying compared with 22 and 9.9 with BTS1 and BTS2, respectively.[29]

Subsequently, CURB criteria (confusion, urea, respiratory rate and blood pressure) were developed which were similar to mBTSr, but systolic BP <90mmHg was added (either systolic BP <90mmHg or diastolic BP <60mmHg scores 1). Authors[30] also suggested CURB-65 where an age ≥65 years was given additional score of 1, making a total score of 5.

A major breakthrough was achieved only after the transformation of these rules into a risk score, which resulted from adding one point for each of these parameters (CURB or for patients aged >65 years CURB-65) by Lim and co-workers.[23,31] The scoring system consists of a six-point score determined at the time of initial presentation. In the original study, mortality risk in the six separate groups was as follows: group 0, 0.7%; group 1, 3.2%; group 2, 3%; group 3, 17%; group 4, 42%; and group 5, 57 percent. These scores allowed for predictions very similar to those made by the PSI. In a subsequent study,[32] the absence of any CURB criterion was associated with a 30-day mortality of one percent, the presence of one or two with 8%, and the presence of three or four with 30% mortality.

In 1997, Fine *et al*[22] introduced the pneumonia severity index (PSI), a product of the Pneumonia PORT study of ambulatory and hospitalised patients with CAP. The rule stratifies patients into five classes of risk for death within 30 days of presentation. The lowest risk class (risk class I) comprises patients who are younger than 50 years of age, have none of the five important co-existing illnesses and have normal mental status and normal or only mildly abnormal vital signs at presentation. Assignment to the remaining risk classes depends on the presence or absence of a set of medical history, physical examination, and laboratory findings. Total point scores of 70 or less correspond to class II, 71 to 90 to class III, 91 to 130 to class IV, and more than 130 to class V. Mortality rates in risk classes I, II, and III are low (0.1% to 0.4% in class I and 0.9% to 2.8% in class III), with correspondingly higher mortality rates in risk classes IV and V. The cumulative mortality rate of patients in risk classes I to III is less than one percent.

The variables in PORT study were derived from and validated in more than 50,000 patients, the largest database ever studied in the history of CAP research. The original role of the PSI was to identify those patients at a low risk of mortality who, therefore, could safely be treated as out-patients. The PSI was subsequently confirmed to make valid predictions of mortality by several authors, although in some reports mortality rates were somewhat lower in the highest risk group.[32-34] Finally, the PSI was also shown to predict long-term outcomes of CAP.[35] A major limitation of the PSI is the unbalanced impact of age on the score, resulting in a potential underestimation of severe pneumonia, particularly in younger otherwise healthy individuals.[32] Nevertheless, the PSI is currently recommended as a tool of severity assessment in the Infectious Diseases Society of America (IDSA) guidelines.[36, 37]

Capelastegui *et al*[38] presented a comparative validation of the CURB-65, CRB-65 (which omits the blood urea measurement) and PSI scores in a

population of 1,776 patients including 676 outpatients. The 30-day mortality increased with increasing score, and predictions of 30-day mortality were equivalent for all scores as assessed by ROC analysis. This is in contrast to the study by Aujesky *et al*[39] comprising 3,181 patients and including 1,094 outpatients, showing a minor but significant advantage for the PSI score in predicting 30-day mortality using area under the curve (AUC) analysis. However, this population predominantly included less severely ill patients (only 6% PS IV as compared with 18% in the present study), thereby limiting the comparability of both populations studied.

The CURB-65 score has a major advantage in its simplicity. However, with blood urea nitrogen, it includes a variable that is not readily available in general practice and not even in some hospitals. Therefore, one of the most remarkable findings of the study by Capelastegui *et al*[38] is the equivalence of predictions made by the CURB and the CRB-65 score, the latter simply replacing blood urea nitrogen by the presence of age >65 years. This fits well into findings from the data generated by the German Competence Network for the study of community-acquired pneumonia *(CAPNETZ; unpublished data, T.T. Bauer, Medizinische Klinik III, Bergmannsheil Klinikum der Ruhr-Universität, Bochum, Germany).* In a population of 1,312 patients, which included 205 out-patients, CURB and CRB-65 had an equivalent predictive power for 14-day mortality. Taken together, there is growing evidence that CURB, CURB-65 and CRB-65 all allow for similar predictions of death from CAP as compared to the PSI, with the CRB-65 representing the only score that is also easily applicable in out-patients.

Overall, the CRB-65 and CURB-65 scores are an impressive example of the value of a simple clinical approach not requiring sophisticated biochemical, immunological or genetic data in the risk stratification of patients with an acute potentially life-threatening condition.

Capelastegui *et al*[38] have also identified several additional factors associated with the need for hospitalisation not necessarily related to mortality but requiring special attention, which should be assessed in all but the lowest risk classes, thereby extending previous experiences.[34] These factors comprise co-morbidities, severe hypoxaemia or hypercapnia, the extent of radiographic infiltrates, and pleural effusions.

Both CURB and CURB-65 include confusion and raised urea (>7mmol/L) in their severity criteria, which may be less useful in the elderly as both conditions are common in acutely unwell older people.[40,41] In this regard, Myint *et al*[42] examined the value of ventilation perfusion mis-match using the ratio of PaO_2 and fraction of inspired oxygen (FIO_2) for predicting mortality from CAP and to derive alternative severity score to circumvent the use of confusion and blood urea. From their analyses, low systolic BP (S) and poor oxygenation (PaO_2: FIO_2) (O), advancing age (A), high respiratory rate (R) were found to be significantly associated with death from CAP, and derived a new index (SOAR) using these criteria and assessed its usefulness. They defined severe pneumonia as the presence of ≥2 criteria out of four. A score of 1 was given for presence of each of the following (dichotomised variables): *(i)* systolic BP <90 mmHg; *(ii)* PaO_2:FIO_2 <250; *(iii)* age ≥65 years; and *(iv)* respiratory rate ≥30 per minute.

In another prospective study from Hong Kong (n=1016), Man *et al*[37] compared the ability of three validated prediction rules for CAP to predict mortality: the 20 variable PSI, the 6-point CURB-65 scale adopted by the BTS and the simpler CRB-65. The patients were classified into three risk groups (low, intermediate and high) according to each rule and the ability of the three rules to predict 30-day mortality was compared. The overall mortality and ICU admission rates were 8.6% and 4.0%, respectively. The PSI, CURB-65 and CRB-65 performed similarly and the areas under the ROC curve were 0.736 (95% confidence interval (CI) 0.687 to 0.736), 0.733 (95% CI 0.679 to 0.787) and 0.694 (95% CI 0.634 to 0.753), respectively. All three rules had high negative predictive values but relatively low positive predictive values at all cut-off points. Larger proportions of patients were identified as low risk by PSI (47.2%) and CURB-65 (43.3%) than by CRB-65 (12.6%). The study concluded that all three predictive rules have a similar performance in predicting the severity of CAP, but CURB-65 was more suitable than the other two for use in the emergency department because of its simplicity of application and ability to identify low-risk patients.

In a study by Loh *et al*[43] conducted in Malaysia, BTS criteria fared poorly in predicting mortality compared with clinical assessment by attending clinicians (36-fold increased risk of death by 'clinical assessment' *vs* two-three-fold by 'BTS criteria'). These results have demonstrated the need for testing the validity of such scoring systems in Asian countries and other developing parts of the world that have different demographic characteristics as well as healthcare delivery systems than those where such prognostic scoring systems were developed and validated.

The comparison between mortality rates in different risk classes in our study and that of the previous studies[22,32,36,38] showed that in all the studies mortality rates progressively increase with increasing risk scores in both PSI and CURB-65 risk classes. Though in our study mortality rates in PSI risk class I to III were lower compared to other two studies by Fine *et al*[22] and Buising *et al*[36], mortality rates in classes IV to V were higher. The latter effect is because Buising *et al*[36] studied only in-hospital mortality while as in our study,

death group included patients who died within 30 days after discharge. Further, four patients who were severely sick and required admission to ICU left the hospital against medical advice on request and subsequently died at home within few days of leaving the hospital. Comparison of mortality rates in different CURB-65 risk classes in our study and that of Capelastegui *et al*[38] and Ewig *et al*[32] showed comparable results.

The comparison of PSI and CURB-65 with respect to sensitivity, specificity and predictive values have good sensitivity and NPV but specificity and PPV are less impressive. These results are comparable to those obtained by Man *et al*.[37] Specificity of CURB-65 was found to be better than PSI probably because a major limitation of the PSI is the unbalanced impact of age on the score, resulting in a potential underestimation of severe CAP particularly in younger otherwise healthy individuals.[32]

The two scoring CURB-65 and PSI approaches are viewed as being complementary, as each has different strengths and weaknesses. The PSI seems to have been developed, and best validated, as a way to identify low mortality risk patients, but the scoring system can occasionally underestimate severity of illness, especially in young patients without comorbid illness.[33,36] This is primarily because the PSI heavily weighs age and co-morbidity, and does not directly measure CAP-specific disease severity. In contrast, the CURB-65 approach may be ideal for identifying high mortality risk patients with severe illness due to CAP who might otherwise be overlooked without formal assessment of subtle aberrations in key vital signs.[34] However, one clear deficiency of the CURB-65 approach is that it does not generally account for comorbid illness, and thus may not be easily applied in older patients who may still have substantial mortality risk, even if a mild form of CAP destabilises a chronic, but compensated, disease process. Thus, both tools offer a valuable assessment of patient illness, but from different perspectives, and each is best at identifying patients at opposite ends of the disease severity spectrum.

In conclusion, both PSI and CURB-65 have equal sensitivity to predict death from CAP, however specificity of CURB-65 is higher than that of PSI. Mortality rates progressively increase with increasing risk class in both severity scoring systems. By using the knowledge of these criteria, patients of CAP can be better prognosticated as regards severity of their illness with consequently better triaging of patients, utilisation of resources and appropriate treatment to improve the outcome in this disease.

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