Journal of Internal Medicine 2006; **260**: 93–101 doi:10.1111/j.1365-2796.2006.01657.x

CRB-65 predicts death from community-acquired pneumonia*

T. T. BAUER[1], S. EWIG[2], R. MARRE[3], N. SUTTORP[4], T. WELTE[5] & THE CAPNETZ STUDY GROUP

[1]*HELIOS Clinic Emil v. Behring, Respiratory Diseases Clinic Heckeshorn, Berlin;* [2]*Augusta-Krankenanstalt, Klinik für Pneumologie, Beatmungsmedizin und Infektiologie;* [3]*Department of Medical Microbiology and Hygiene, University of Ulm, Ulm;* [4]*Department of Internal Medicine/Infectious Diseases, Charité, Humboldt-University – Medicine Berlin, Berlin; and* [5]*Department of Pneumology, Hannover Medical School, University of Hannover, Hannover, Germany*

Abstract. Bauer TT, Ewig S, Marre R, Suttorp N, Welte T, The CAPNETZ Study Group (HELIOS Clinic Emil v. Behring, Respiratory Diseases Clinic Heckeshorn, Berlin; Augusta-Krankenanstalt, Klinik für Pneumologie, Beatmungsmedizin und Infektiologie; University of Ulm, Ulm; Charité, Humboldt-University – Medicine Berlin, Berlin; Hannover Medical School, Hannover; Germany) CRB-65 predicts death from community-acquired pneumonia. *J Intern Med* 2006; **260**: 93–101.

Objective. The study was performed to validate the CURB, CRB and CRB-65 scores for the prediction of death from community-acquired pneumonia (CAP) in both the hospital and out-patient setting.

Design. Data were derived from a large multi-centre prospective study initiated by the German competence network for community-acquired pneumonia (CAPNETZ) which started in March 2003 and were censored for this analysis in October 2004.

Setting. Out- and in-hospital patients in 670 private practices and 10 clinical centres.

Subjects. Analysis was done for $n = 1343$ patients ($n = 208$ out-patients and $n = 1135$ hospitalized) with all data sets completed for the calculation of CURB and repeated for $n = 1967$ patients ($n = 482$ out-patients and $n = 1485$ hospitalized) with complete data sets for CRB and CRB-65.

Intervention. None. 30-day mortality from CAP was determined by personal contacts or a structured interview.

Results. Overall 30-day mortality was 4.3% (0.6% in out-patients and 5.5% in hospitalized patients, $P < 0.0001$). Overall, the CURB, CRB and CRB-65 scores provided comparable predictions for death from CAP as determined by receiver–operator-characteristics (ROC) curves. However, in hospitalized patients, CRB misclassified 26% of deaths as low risk patients. Availability of the CRB-65 score (90%) was far superior to that of CURB (65%), due to missing blood urea nitrogen values ($P < 0.001$).

Conclusions. Both the CURB and CRB-65 scores can be used in the hospital and out-patients setting to assess pneumonia severity and the risk of death. Given that the CRB-65 is easier to handle, we favour the use of CRB-65 where blood urea nitrogen is unavailable.

Keywords: community-acquired pneumonia, hospitalization – mortality, prognosis, severity.

Introduction

All authoritative guidelines for the management of adult patients with community-acquired pneumonia (CAP) recommend a severity-based approach to the diagnosis and treatment [1–5] and important progress has been made to validate criteria for the estimation of pneumonia severity at presentation. Currently both, the pneumonia severity index (PSI) [6] and the score comprising confusion, blood-urea nitrogen, respiratory rate and blood pressure (CURB)

*A list of the CAPNETZ investigators is provided in the Acknowledgements section.

[7] have been prospectively validated [8–10]. Moreover, criteria for severe CAP requiring more than regular care and/or admission to the ICU have been settled [10–12].

The CURB score seems particularly attractive since it relies on mostly clinical criteria, is easy to calculate and thus cost-effective. Moreover, it could be shown that the predictions of the CURB score for mortality and the need for ICU-admission are at least comparable with those of the much more complex PSI [10]. As a consequence, the CURB score has been included into the British Thoracic Society (BTS) guidelines and is recommended to aid the decision where to treat a patient with CAP [4]. The vast majority of decision concerning treatment location is made outside the hospital without readily access to the results of blood urea nitrogen (BUN) (the 'U' in CURB). Therefore, either the omission of blood urea nitrogen (CRB) or replacement with age ≥65 years (CRB-65) has been advocated in the out-patient setting [4, 7].

Although neither CURB nor CRB or CRB-65 has been generated nor validated in the out-patients, it would be desirable to have such a easy tool in this setting. Therefore, the important contribution of age (e.g. CRB-65) has to be investigated systematically. However, most data about the applicability of severity scores have been generated within one type of health care system (e.g. Great Britain) and may not be accepted in another. The German competence network for community-acquired pneumonia (CAPNETZ) which is funded by the German Ministry of Education and Research (BMBF) recruits nationwide prospectively CAP-patients with the goal to study and eventually to improve patient care. Due to its pivotal importance one of the primarily goals of this network was the prospective assessment of CURB, CRB and CRB-65 scores for predicting death from CAP not only in the hospital, but also in the out-patient.

Methods

Setting

Data derive from a multi-centre prospective study initiated by the German Competence network for community acquired pneumonia (CAPNETZ; http://www.capnetz.de). The network has been described in detail elsewhere [13]. In brief, the network comprises 10 clinical centres throughout Germany. These centres represent hospitals and out-patient departments at all levels of health-care provision involved in research and therapy of CAP. A total of 670 private practitioners, physicians and respiratory specialists as well as >30 hospitals cooperate within CAPNETZ. The decision where to treat the patient with pneumonia was left to the discretion of the attending physician. No attempt was made to implement standardized criteria or rules neither for the assessment of pneumonia severity nor for the decision to hospitalize.

Data collection started in March 2003 and was censored for this analysis on October 2004 (19 months). All consecutive and nonselected patients presenting with CAP were prospectively recorded. The study design was approved by the local Ethical Committee. All patients gave written informed consent and received a pseudonym from an independent third party to ensure data safety.

Study population

Patients presenting with a new pulmonary infiltrate on chest radiograph together with at least one symptom or sign of lower respiratory tract infection (fever, cough, purulent sputum, focal chest signs, dyspnoea and/or pleuritic pain) were eligible. Exclusion criteria were

1 acquisition of pneumonia after hospital admission;
2 presence of severe immunosuppression associated with a relevant risk for opportunistic infections;
  - chemotherapy and/or neutropenia <1000 μL^{-1} during the last 28 days,
  - therapy with corticosteroids >20 mg for >14 days,
  - known HIV infection,
  - immunosuppressive therapy after organ or bone marrow transplant;
3 pneumonia as an expected terminal event of a severe chronic disabling comorbidity;
4 an alternative diagnosis evolving during follow-up.

Data collection and evaluation

All patients were assessed at first presentation and during follow-up according to a standardized data sheet. In this study, the following parameters were recorded: date of presentation, age, gender, alcohol habits, comorbidity, residence in nursing home;

duration of symptoms, clinical symptoms (body temperature, respiratory rate, heart rate, arterial systolic and diastolic blood pressure, pneumonia-associated confusion, i.e. disorientation with regard to person, place or time that is not known to be chronic); blood gas analysis (pH, PaO_2, $PaCO_2$ and FIO_2); chest radiograph (number of lobes affected, pleural effusion); laboratory parameters (haemoglobin, haematocrit, leukocyte count, band forms, serum-creatinine, BUN, sodium and blood glucose). After 14 days all patients or relatives were contacted either personally or via telephone for a structured interview on outcome parameters (e.g. resolution of symptoms, length of antibiotic therapy and death). This interview was repeated for patients without improvement to assess 30 day mortality and for all patients after 180 days. Data validity and consistency checks were performed by an independent party before the analyses.

Definitions

For comparison of the distribution of pneumonia severity with other populations, the CURB, the CRB and the CRB-65 scores were computed. These scores are defined as follows:

1 The CURB index proposed by Lim and Macfarlane [7, 14] is derived from the four variables of the BTS rules; 'CURB' is the acronym of four core severity criteria identified in the original BTS study [15]: confusion, BUN (>7 mmol L^{-1}), respiratory rate (>30 min^{-1}) and blood pressure (diastolic pressure ≤60 mmHg). Alternatively, to the diastolic blood pressure, systolic blood pressure <90 mmHg was also included. CURB ranges from 0 to 4.
2 The CRB score applies the criteria mentioned above except BUN. CRB ranges from 0 to 3.
3 The CRB-65 adds age ≥65 years to the CRB. CRB-65 ranges from 0 to 4.

Accordingly, lowest risk is represented by 0 (all scores) and highest risk by either 3 (CRB) or 4 (CURB and CRB-65).

Statistical analysis

First, this study compared the predictive power of CURB, CRB and CRB-65 for death in patients with community-acquired pneumonia. Secondly, the performance of these scores for the prediction of mortality and the decision to hospitalize was compared between out-patients and hospitalized patients.

All data were analysed and processed with the Statistical Package for Social Sciences (SPSS) version 12.01 on a Windows XP operating system. Statistical analyses not provided by this software were calculated with EpiInfo 6.0 and/or MedCalc 7.0. Results are expressed as frequencies or as mean ± SD, unless indicated otherwise. The chi-square test was used to compare proportions and Fishers exact test was performed when appropriate. All continuous variables were compared by Student's *t*-test. The 95% confidence intervals are reported for all comparisons and exact intervals for single proportions were estimated according to Newcombe [16]. Effects on mortality of initial treatment setting (out-patients versus hospitalized) together with risk class assignment (CURB, CRB and CRB-65) were assessed by logistic regression analyses (stepwise forward, $P_{in} = 0.05$, $P_{out} = 0.10$). The odds ratio (OR), 95% confidence interval and level of significance are reported.

Receiver–Operator-Characteristics (ROC) curves were calculated for the CURB, CRB and CRB-65 score. Results of ROC statistics are reported as area under the curve (AUC) ± standard error of the mean (SEM). All tests were explorative and two-sided; the significance level was set at 5%.

Results

Patient population

Overall a total of 3973 patients were contacted during the study. The reasons for not entering the study protocol were the following: pneumonia not confirmed 470 of 1610 (29%), informed consent denied or withdrawn 309 of 1610 (19%), patients with pneumonia but at least one exclusion criterion 831 of 1610 (52%). The remaining 2363 of 3973 patients (59%) entered the study protocol (Fig. 1). The ratio of hospitalized to out-patients was 3 : 1. A total of 179 of 2363 patients could not be contacted 14 days after inclusion into the study (8%). The remaining study population included 1646 hospitalized and 538 out-patients ($n = 2184$ patients, 57% male, mean age 62.5 ± 18.3; range 18–99 years). Overall 30-day mortality was 94 of 2184 (4.3%). It was significantly higher in the hospitalized population (91/1646, 5.5%) compared

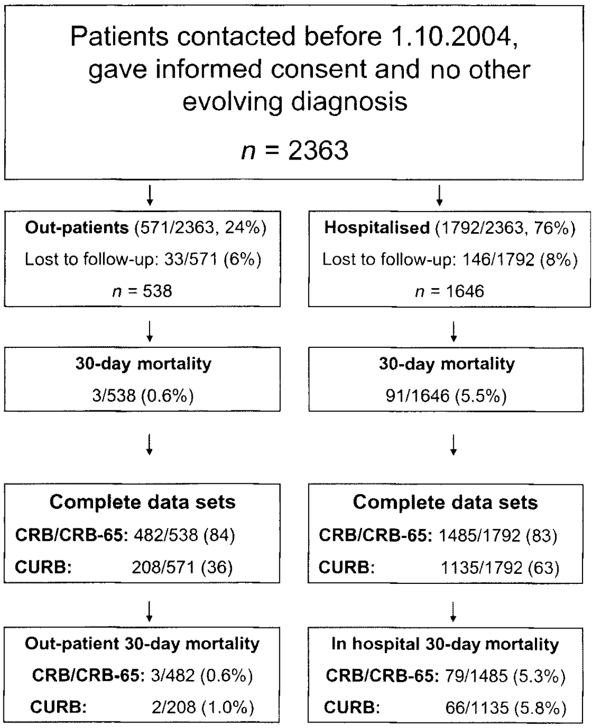


Fig. 1 Study population and selection criteria. Please see text for more details.

with out-patients (3/538, 0.6%; $P < 0.0001$, OR 10.5; 95% CI 3.3–33).

Table 1 displays baseline characteristics of out-patients and hospitalized patients. Patients with fever were more likely to be hospitalized. Comorbidity was higher in hospitalized patients. Values for respiratory rate, white blood cell counts, C-reactive protein and BUN were higher in hospitalized patients.

Blood gas analyses were rarely requested outside the hospital (19%), and no differences were found for the mean values in comparison with the hospital cohort. In contrast, blood pressure was assessed in 2153 of 2184 (99%) of the cases.

Incidence of score variables and availability of scores

A total of 1343 of 2184 (65%) data sets were complete for CURB with a significantly lower proportion in the out-patient cohort ($P < 0.0001$; OR 0.28; 95% CI 0.23–0.35) (Table 2). In contrast, the proportion of complete data sets for CRB and CRB-65 was not significantly different between out-patients and hospitalized patients ($P = 0.333$; OR 1.19; 95% CI 0.83–1.71). All score variables according to CURB, CRB and/or CRB-65 were more frequently reported in the hospitalized cohort. The proportion of patients who died did not change due to missing data neither for CURB nor for CRB-65/CRB.

Distribution of score variables within scores

The number of criteria met within the three scores can be depicted from Fig. 2. None and one criterion was most often reported for all risk scores, the number of patients in the highest risk class (four for CURB and CRB-65, three for CRB) was <8% (Fig. 2).

Prediction of mortality

All three scores showed an increasing risk of death with increasing numbers of risk factors met (Table 3a). Mortality was significantly lower according to the treatment setting for out-patients (1.0%) compared with hospitalized patients (5.8%, $P = 0.002$). Accordingly, in multivariable analyses differences in mortality between out-patients and hospitalized patients were fully explained by differences in risk classes according to CURB (OR 3.0; 95% CI 2.3–4.0; $P < 0.0001$; treatment setting $P = 0.133$) and CRB-65 (OR 3.2; 95% CI 2.4–4.2; $P < 0.0001$; treatment setting $P = 0.133$). However, this was not the case for CRB (CRB: OR 3.0; 95% CI 2.2–4.1; $P < 0.0001$; treatment setting: OR 4.3; 95% CI 1.02–17.7; $P = 0.047$). This is due to the fact that 17 hospitalized patients with CRB class 0 died (Table 3a,b, Fig. 3). Thus, a considerable proportion of deaths (17/66, 26%) occurred in hospitalized patients classified as low risk patients by the CRB score (CRB class 0) and may be 'overlooked' by the CRB score.

Mortality remained clearly scaled regardless of whether CURB, CRB or CRB-65 was used when we grouped the number of criteria to enhance clinical applicability (0, 1–2, 3 or more) (Fig. 3). When we compared mortality within the groups, there was a significantly higher mortality in CRB class 0 compared with CRB-65 or CURB class 0.

Figure 4 summarizes the operative characteristics of CURB, CRB and CRB-65 for the prediction of death. All confidence intervals exclude 0.5 and thus

Table 1 Baseline characteristics and clinical presentation on evaluation for the scoring systems

	Out-patients (n = 538)	Hospitalized patients (n = 1646)	P-value
Age, years (mean ± SD)	53 ± 17	66 ± 18	<0.0001
Sex [male, n (%)]	250/538 (47)	986/1646 (60)	<0.0001
Current smoker, n (%)	179/536 (33)	477/1588 (30)	0.160
Body temperature >38.3 °C	229/535 (43)	871/1645 (53)	<0.0001
Comorbidity, n (%)			
Chronic heart failure	36/533 (7)	447/1629 (28)	<0.0001
Pulmonary	163/533 (31)	600/1625 (37)	0.008
Renal	11/534 (2)	172/1626 (11)	<0.0001
Hepatic	13/533 (2)	72/1629 (4)	0.041
Diabetes mellitus	45/534 (8)	347/1635 (21)	<0.0001
Cerebrovascular	22/533 (4)	275/1627 (17)	<0.0001
Neoplastic disease	39/538 (7)	189/1621 (12)	0.004
Blood gas analysis, n (%)	102/538 (19)	1121/1646 (68)	
PaO_2 (kPa, mean ± SD)	68.3 ± 13.2	65.7 ± 17.6	0.153
$PaCO_2$ (kPa, mean ± SD)	35.3 ± 5.4	36.0 ± 8.5	0.410
Blood pressure, n (%)	521/538 (97)	1632/1646 (99)	
Systolic (mmHg, mean ± SD)	126 ± 19	130 ± 24	<0.0001
Diastolic (mmHg, mean ± SD)	77 ± 11	74 ± 13	<0.0001
Respiratory rate, n (%)	491/538 (91)	1505/1646 (91)	
s^{-1}, mean ± SD	18 ± 6	21 ± 7	<0.0001
White blood cell count, n (%)	279/538 (52)	1580/1646 (96)	
nL^{-1}, mean ± SD	10.2 ± 4.7	13.5 ± 6.3	<0.0001
C-reactive protein, n (%)	273/538 (51)	1479/1646 (90)	
mg L^{-1}, mean ± SD	77 ± 87	155 ± 128	<0.0001
Blood urea nitrogen, n (%)	230/538 (43)	1249/1646 (76)	
mmol L^{-1}, mean ± SD	5.2 ± 2.5	8.1 ± 6.1	<0.0001

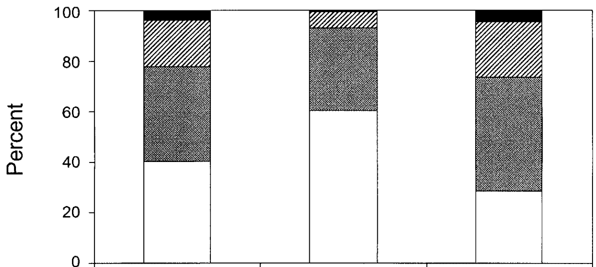
Table 2 Availability and prevalence of the single risk factors and the prognostic scores CURB, CRB and CRB-65

n (%)	Out-patients (n = 538)	Hospitalized patients (n = 1646)	P-value
Complete data sets for CURB	208/538 (37)	1135/1646 (69)	<0.0001
Compete data sets for CRB and CRB-65	482/538 (90)	1485/1646 (90)	0.672
Age ≥65 years	145/538 (27)	970/1646 (59)	<0.0001
Confusion	11/538 (2)	228/1630 (14)	<0.0001
Blood urea nitrogen (>7 mmol L^{-1})	36/230 (16)	538/1249 (44)	<0.0001
Respiratory rate >30 min^{-1}	32/491 (7)	178/1505 (12)	<0.0001
Blood pressure			
Systolic <90 mmHg	2/521 (0.4)	33/1632 (2)	<0.0001
Diastolic ≤60 mmHg	65/521 (13)	391/1632 (24)	<0.0001
Either or	65/521 (13)	391/1632 (24)	<0.0001

prediction according to the scores was better than random. No significant differences could be detected when the areas under the curve were compared between the scores.

Decisions about treatment setting

Although patients treated as out-patients had less risk factors according to the scores applied, a considerable number of patients at lower risk were hospitalized and *vice versa*. This was true for all three scores (Table 3a). In fact, patients with CURB 0 were hospitalized in 35% (339/1135), with CRB 0 in 57% (645/1135), and with CRB-65 0 in 24% (268/1135) of cases. Conversely, patients with CURB 1–4 were treated as out-patients in 32% (67/208), with CRB 1–3 in 21% (43/208), and with CRB-65 1–4 in 44% (92/208) of cases.



	CURB (*n*)	CRB (*n*)	CRB-65 (*n*)
■ 3–4	54	10	63
▨ 2	243	83	293
▩ 1	506	440	604
□ 0	540	810	383

Fig. 2 Proportion of all patients with risk classes 1, 2 and 3–4 for CURB, CRB and CRB-65. Stacked bars add up to 100% and total number of patients is reported (total $n = 1343$ for all bars).

Discussion

The main findings of this study comprise the following: (i) overall, the CURB, CRB and CRB-65 scores achieve comparable predictions of death in hospitalized patients with CAP; (ii) despite similar operative characteristics, the CRB may not be sensitive enough for predicting death in hospitalized patients; (iii) lower scores seem to identify patients with CAP at low risk for death also in the out-patients setting; (iv) CRB-65 should be preferred over the CURB because of higher availability and similar predictive value. The CRB seems to be oversimplified and does not identify low risk class patients correctly.

The present study confirms the ability of the CURB score to predict death from CAP. Lim *et al.* described the close relation of death rates with increasing numbers of CURB criteria fulfilled (including age >65 in addition), ranging from 0.7% for score 0–57% for score 5. Mortality rates also followed a scaled distribution when none (mortality 1%), one or two (mortality 8%), and three or four criteria of the CRB-65 were met (mortality 31%) [7]. Ewig *et al.* found a very similar pattern for the risk of death applying a scaled CURB score (mortality 1%, 8% and 34%) [10]. In this study, mortality was low in the absence of any CURB criterion (0.4%, 2/540), increased to 7% (52/749) when one or two, and to 26% (14/54) when three or four criteria were fulfilled.

When comparing CURB, CRB and CRB-65 in the present study, no statistically significant differences

Table 3 (a) Mortality at 30 days according to CURB, CRB and CRB-65 for patients with all data sets complete; (b) mortality at 30 days according to CURB, CRB and CRB-65 for patients with complete data for CRB and CRB-65

n (%)	Out-patients ($n = 208$)	Hospitalized patients ($n = 1135$)	*P*-value
(a)			
CURB			
0	0/141 (0)	2/399 (0.5)	1.0
1	0/56 (0)	23/450 (3.6)	0.095
2	1/9 (11.1)	28/234 (9.0)	1.0
3	1/2 (50)	11/45 (24.4)	0.450
4	–	2/7 (28.6)	n.a.
CRB			
0	0/165 (0)	17/645 (2.6)	0.031
1	1/37 (2.6)	30/402 (7.5)	0.502
2	1/5 (20.0)	16/78 (20.5)	1.0
3	–	3/10 (30.0)	n. a.
CRB-65			
0	0/115 (0)	0/268 (0)	n.a.
1	0/80 (0)	21/524 (4.0)	0.095
2	1/10 (10.0)	31/283 (11.0)	1.0
3	1/3 (33.3)	12/53 (22.6)	0.555
4	–	2/7 (28.6)	n.a.
	Out-patients ($n = 482$)	Hospitalized patients ($n = 1485$)	
(b)			
CRB			
0	1/385 (0.3)	22/867 (2.0)	0.005
1	1/88 (1.1)	37/511 (7.2)	0.031
2	1/8 (12.5)	17/96 (17.7)	1.0
3	–	3/11 (27.3)	n.a.
CRB-65			
0	0/284 (0)	0/375 (0)	n.a.
1	1/166 (0.6)	27/686 (3.9)	0.028
2	1/29 (3.4)	37/350 (10,6)	0.338
3	1/3 (33.3)	13/66 (19.7)	0.449

n.a., not applicable.

in predictions of mortality could be detected. However, CRB score failed to detect patients at increased risk of death in the hospital setting in a considerable amount of cases (26%). The CURB score failed only in three occasions (2/54, 4%), the CRB-65 did not fail in any. This observation may hint at a limitation of a score relying on only three variables at least in elderly and comorbid patients.

For the first time, we could demonstrate that the scores are also useful for the estimation of the risk of death from CAP in the out-patient setting. As expected, 95% of patients were classified as CURB class 0 or 1, 98% as CRB class 0 or 1, and 94% as CRB-65 class 0 or 1. Moreover, only two patients at

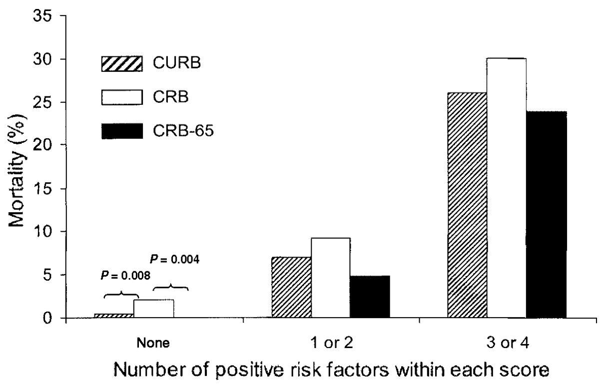


Fig. 3 Mortality according to CURB, CRB and CRB-65 for all patients (n = 1343). Percentages and absolute values are given. Table reproduces frequencies, proportions and exact confidence intervals (please see Methods section for details).

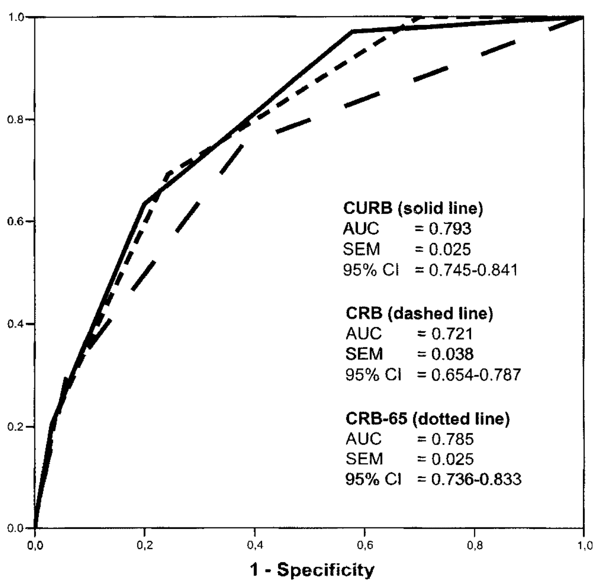


Fig. 4 Comparative receiver–operator characteristics (ROC) curve analysis for prediction of mortality (n = 68/1343). ROC curves for CURB, CRB and CRB-65 are given.

higher risk treated outside the hospital died. At first glance, it seems that out-patients had even lower mortality rates in all risk classes as compared with hospitalized patients. The number of patients treated as out-patients with high risk scores was low and the observed differences did not reach statistical significance. Multivariable analyses of our data suggest, however, that the lower average risk profile accounts for a large proportion of this observed difference in mortality between out-patients and those who were treated within the hospital. Nevertheless, this is an important issue, since lower mortality rates in identical risk scores but different treatment settings would hint at additional risk factors for death which may be detected by practitioners but not by the score (e.g. further comorbidity). Clearly, this issue deserves further investigations with very large numbers of patients included.

The implementation of the CURB score amongst out-patients is hampered by the necessity for BUN. BUN is the only variable which cannot be readily assessed because it requires additional infrastructure and therefore introduces significant delay in clinical decision making [4, 7]. We could confirm this drawback, because BUN was only requested by 37%(!) of the participating physicians treating out-patients. The BTS guidelines have therefore recommended the use of the CRB score (CURB excluding BUN) as an alternative to the CURB score in the out-patients setting [4]. CRB, however, overlooks too many fatal courses with risk class 0, so that our data strongly suggest that the knowledge of increased BUN should be substituted by age ≥65 years in clinical practice (CRB-65). This finding further improves the applicability and provides a simple, rapid and cheap tool to estimate the risk of death from CAP. Nevertheless, we cannot exclude a type-II error for differences between these scores.

Out-patients had less risk factors according to the scores applied, and, accordingly, mortality was significantly lower amongst out-patients (1.0%) compared with hospitalized patients (5.8%, P = 0.002). The low number of death in association with CAP in these patients does limit the general conclusion, that CRB-65 and CURB will also work outside the hospital, however, since no effort was made to implement the knowledge about such a score at the beginning of the study, in fact these scores reflect a large part of the decisions where to treat a patient with CAP. However, a considerable number of patients at low risk with scores of 0 was nevertheless hospitalized, and a similar amount of patients with scores higher than 0 was treated as out-patients. Since the recording of the reasons behind clinical decisions about the treatment setting was not part of the study, we are unable to judge what these deviating decisions truly reflect. The fact that very few patients with low risk scores of 0 died (at least applying CURB and CRB-65) supports the notion that most admissions may not have been necessary in terms of pneumonia severity. Accordingly, the experience of Roson *et al.* when validating the pneumonia severity score (PSI) by Fine *et al.* in hospitalized patients suggests that morbid factors not reflected by the prognostic score, management and social factors all contribute to these deviations [9]. On the other hand, the favourable clinical courses of most patients with higher risk scores treated as out-patients support the clinical decisions made by the attending physicians. Therefore, the exact identification of the reasons behind hospitalization decisions remains an important area for further investigations.

Our study has two limitation which should be addressed. First, the physicians and thus the patients underlie a selection bias towards their interest in conducting and joining the study. Therefore, the observed mortality and the ratio of in- and out-patients may not be representative. Secondly, large databases suffer from the problem of missing data for many reasons. We have, however, provided separate analysis for the data sets with all CURB criteria completed and for that with all CRB and CRB-65 criteria completed. Results did not differ in a significant way. Thus, we are confident that the missing data do not devalue the main results gained from our analysis.

In conclusion, this study provides additional support for the use of simple scores for the estimation of the risk of death from CAP in both hospitalized and out-patients. CURB and CRB-65 can both be used in the out-patients and the hospital setting. Given that the CRB-65 is easier to handle, we favour the use of CRB-65 at least in the out-patient setting. The scores can be used as evidence based aid for the decision where to treat patients with CAP.

Acknowledgements

CAPNETZ is a multidisciplinary approach to better understand and treat patients with community-acquired pneumonia. The network has only been made possible by the contribution of many investigators. We are especially indebted to the work of the investigators in the local clinical centres (LCC) who established and kept contact to all practitioners, physicians, and respiratory specialists cooperating within the network: Hartmut Lode and Malina Schmidt-Ioanas (Berlin, Heckeshorn), Antje Kuhnke and Markus Becker (Berlin, Charité), Barbara Schlosser and Erna Marchel (Bochum), Matthias Pletz (Hannover), Klaus Dalhoff, Sven Pischke and Niels Schübel (Lübeck), Joachim Lorenz & Ingrid Huntemann (Luedenscheid), Thomas Klante (Magdeburg), Tom Schaberg and Konstanze Voigt (Rotenburg a.d.W.), Martin Hetzel and Philipp M. Lepper (Ulm), Berthold Jany and Uwe Ziegler (Wuerzburg),

In addition, we would like to acknowledge the work of the central computing unit (CSU) with Michael Weber, Torsten Illmann and Michael Wallner, the central service unit with Heike von Baum and Susanne Gonschior, Klaus Richter and Brunhilde Schweiger from the Robert-Koch Institute.

It is also our responsibility and pleasure to express our appreciation to all clinical physicians and physicians in private practice who saw and identified patients with community acquired pneumonia for their work dedicated to CAPNETZ.

Contribution of all authors

Torsten T. Bauer helped planning the study, performed data processing and wrote parts of the manuscript, Santiago Ewig was involved with planning of the study and wrote parts of the manuscript, Reinhard Marre, Norbert Suttorp and Tobias Welte organized CAPNETZ and data processing, planed the study and helped with the manuscript.

Conflict of interest statements of the authors

None of the authors had a potential conflict of interest.

Supported by

German Ministry of Education and Research (BMBF), Dr Bauer was supported by official grants of the Ruhr-University Bochum, Germany (F 397-03).

References

1 Niederman MS, Mandell LA, Anzueto A, Bass JB, Broughton WA, Campbell GD *et al.* Guidelines for the Management of Adults with Community-acquired Pneumonia. Diagnosis, assessment of severity, antimicrobial therapy, and prevention. *Am J Respir Crit Care Med* 2001; **163:** 1730–54.

2 Mandell LA, Marrie TJ, Grossman RF, Chow AW, Hyland RH. Canadian guidelines for the initial management of community-acquired pneumonia: an evidence-based update by the Canadian Infectious Diseases Society and the Canadian Thoracic Society. The Canadian Community-Acquired Pneumonia Working Group. *Clin Infect Dis* 2000; **31:** 385–421.
3 Mandell LA, Bartlett JG, Dowell SF, File TM Jr, Musher DM, Whitney C. Update of practice guidelines for the management of community-acquired pneumonia in immunocompetent adults. *Clin Infect Dis* 2003; **37:** 1405–33.
4 British Thoracic Society Standards of Care Committee. BTS Guidelines for the Management of Community Acquired Pneumonia in Adults. *Thorax* 2001; **56:** 1iv–64.
5 Huchon G, Woodhead MA, Gialdroni Grassi G, Leophonte P, Manresa F, Schaberg T *et al.* Guidelines for management of adult community-acquired lower respiratory tract infections. *Eur Respir J* 1998; **11:** 986–91.
6 Fine MJ, Auble TE, Yealy DM, Hanusa BH, Weissfeld LA, Singer DE *et al.* A prediction rule to identify low-risk patients with community-acquired pneumonia. *N Engl J Med* 1997; **336:** 243–50.
7 Lim WS, van der Eerden MM, Laing R, Boersma WG, Karalus N, Town GI *et al.* Defining community acquired pneumonia severity on presentation to hospital: an international derivation and validation study. *Thorax* 2003; **58:** 377–82.
8 Ewig S, Kleinfeld T, Bauer TT, Seifert K, Schäfer H, Göke N. Comparative validation of prognostic rules for community-acquired pneumonia in an elderly population. *Eur Respir J* 1999; **14:** 370–5.
9 Roson B, Carratala J, Dorca J, Casanova A, Manresa F, Gudiol F. Etiology, reasons for hospitalization, risk classes, and outcomes of community-acquired pneumonia in patients hospitalized on the basis of conventional admission criteria. *Clin Infect Dis* 2001; **33:** 158–65.
10 Ewig S, de Roux A, Bauer T, Garcia E, Mensa J, Niederman M *et al.* Validation of predictive rules and indices of severity for community acquired pneumonia. *Thorax* 2004; **59:** 421–7.
11 Ewig S, Ruiz M, Mensa J, Marcos MA, Martinez JA, Arancibia F *et al.* Severe community-acquired pneumonia: assessment of severity criteria. *Am J Respir Crit Care Med* 1998; **158:** 1102–8.
12 Angus DC, Marrie TJ, Obrosky DS, Clermont G, Dremsizov TT, Coley C *et al.* 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:** 717–23.
13 Welte T, Suttorp N, Marre R. CAPNETZ-community-acquired pneumonia competence network. *Infection* 2004; **32:** 234–8.
14 Lim WS, Lewis S, Macfarlane JT. Severity prediction rules in community acquired pneumonia: a validation study. *Thorax* 2000; **55:** 219–23.
15 British Thoracic Society and the Public Health Laboratory Service. Community-acquired pneumonia in adults in British hospitals in 1982–1983: a survey of aetiology, mortality, prognostic factors and outcome. *Q J Med* 1987; **62:** 195–200.
16 Newcombe RG. Two-sided confidence intervals for the single proportion: comparison of seven methods. *Stat Med* 1998; **17:** 857–72.

Correspondence: Prof. Dr Tobias Welte, Department of Pneumology, University of Hannover, Carl-Neuberg-Str. 1, D-30625 Hannover, Germany.
(fax: +49-511-5323353; e-mail: welte.tobias@mh-hannover.de).