The CURB65 pneumonia severity score outperforms generic sepsis and early warning scores in predicting mortality in community-acquired pneumonia

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Abstract

Background

The performance of CURB65 in predicting mortality in community-acquired pneumonia (CAP) has been tested in two large observational studies. It has not been tested, however, against generic sepsis and early warning scores, which are increasingly being advocated for identification of high risk patients in acute medical wards.

Method

A retrospective analysis was performed of data prospectively collected for a CAP quality improvement study. The ability to stratify mortality and performance characteristics (sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and area under the receiver operating curve (AUC)) were calculated for stratifications of CURB65, CRB65, the systemic inflammatory response syndrome (SIRS) criteria and the Standardised Early Warning Score (SEWS).

Results

Four hundred and nineteen patients were included in the main analysis with a median age of 74 years (male sex = 47%). CURB65 and CRB65 stratified mortality in a more clinically useful way and had more favourable operating characteristics than SIRS or SEWS. For example, mortality in low risk patients was 2% when defined by CURB65, but 9% when defined by SEWS and 11% to 17% when defined by variations of the SIRS criteria. The sensitivity, specificity, PPV and NPV of CURB65 was 71%, 69%, 35% and 91%, respectively, versus 62%, 73%, 35% and 89% for the best performing version of SIRS and 52%, 67%, 27% and 86% for SEWS. CURB65 had the greatest AUC (0.78 versus 0.73 for CRB65, 0.68 for SIRS and 0.64 for SEWS).

Conclusions

CURB65 should not be supplanted by SIRS or SEWS for initial prognostic assessment in CAP. Further research to identify better generic prognostic tools is required.

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Introduction

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Community-acquired pneumonia (CAP) is an important quality improvement target in acute medicine[1]. Recent major national and specialist society CAP guidelines suggest the use of prognostic (severity) assessment in guiding clinical decisions about the level of intervention required[2-5]. The British Thoracic Society[2] (BTS), Infectious Diseases Society of America[3] (IDSA) and Canadian Thoracic Society[4] guidelines all recommend the use of validated prognostic tools[6,7] on admission to hospital as adjuncts to clinical judgement in guiding the management of patients with CAP. The Pneumonia Severity Index (PSI) has been used to identify low risk patients who can be managed equally effectively at home or as inpatients[8-10].

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In the United Kingdom (UK), the BTS guidelines promote the use of CURB65[7], which is based on four bedside and one laboratory based prognostic markers (see Table 1). This tool, which is an evolution of two previously validated prognostic rules[11,12], was shown to have 75% sensitivity and 75% specificity for predicting death at 30 days in CAP in the validation set of a large prospective multi-centre, multi-national derivation/validation study[7]. CRB65, which does not require a blood urea level, was shown to stratify mortality similarly, but had inferior performance characteristics. There is evidence that junior doctors, however, have poor awareness of the BTS recommendations. In a survey of 83 junior and middle grade doctors, only 4% could correctly state all four prognostic markers of the BTS CURB tool[13]. Woodhead suggested that the use of a generic rather than a pneumonia specific predictive tool might be easier for doctors to remember and use in the clinical management of patients[14].

Ewing et al have previously compared the performance of CURB, the precursor of CURB65, with that of the PSI, the modified American Thoracic Society (ATS) rule for predicting the need for intensive care unit admission, and the American College of Chest Physicians-Society of Critical Care Medicine's definition of sepsis[15]. The ATS rule performed the best with the PSI and CURB having similar performance characteristics. More recently, when compared to the PSI, CURB65 was shown to have equivalent

performance[16]. CURB65 has not been compared, however, with generic sepsis or early warning scores. The study reported in this paper compared the performance of CURB65 and CRB65 in predicting death with that of two commonly used generic scores, the systemic inflammatory response syndrome (SIRS) and the Standardised Early Warning Score (SEWS) (Table 1). SIRS is recognised worldwide as a component of the definition of sepsis[17]. It is often used to define and stratify sepsis in research[18], and has been incorporated in to our and other hospitals' sepsis guidelines. SEWS[19] is a modified version of an Early Warning Score (EWS)[20], which is increasingly been advocated for use in the acute medical environment to guide the intensity of nursing observation and medical management[20-22]. Our hypothesis was that SIRS and SEWS would perform at least as well, or better, than CURB65 and CRB65 in predicting mortality in CAP.

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Methods

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A retrospective analysis of prospectively collected data was performed. The data used were collected as part of a controlled before and after study over two winter periods (November to April 2001/02 and 2002/03) to evaluate the implementation of a quality improvement programme to improve the delivery and appropriateness of antibiotic prescribing for hospitalised patients with CAP[23]. Potential subjects were identified by review of admission records from two hospitals, one a 1000-bed teaching hospital and the other a 500-bed district general hospital. Patients were included if they were receiving antibiotics for a suspected lower respiratory tract infection and had either a new infiltrate on the chest radiograph or been clinically diagnosed as having CAP by a specialist registrar or consultant physician. Patients were excluded if they had one or more of the following criteria: 1. a non-pneumonia diagnosis; 2. aspiration, hypostatic or hospital-acquired pneumonia; 3. the initial diagnosis of CAP was changed prior to discharge from hospital; 4. the patient was HIV-positive, neutropenic (<1.0 x 10^9/l) secondary to chronic illness or therapy, or significantly immunosuppressed (long term (>2 weeks) prednisolone (or equivalent) of ≥10mg or immunosuppressive therapy such as methotrexate, azathioprine, mycophenalate, etc.); 5. progressive malignancy;

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6, the patient had chronic respiratory disease other than asthma or chronic obstructive pulmonary disease; 7, age <16 years old.

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Demographic, clinical and outcomes data were collected using a pre-piloted data collection form. The criteria used to establish the CURB65, CRB65, SIRS and SEWS scores were taken from the earliest recorded reading/result in the patients medical/nursing records (i.e. on admission to hospital). Patients were reviewed on alternate days until discharge from hospital or death. Deaths after discharge, but within 30 days of admission to hospital were established by hospital computer database. Data were subsequently audited and double entered into an Epi-Info database (Centers for Disease Control (CDC), Atlanta and World Health Organisation (WHO), Geneva). Statistical analyses were performed using SPSS for Windows (version 10). Descriptive statistics are given as medians or percentages with 95% confidence intervals (CI) where appropriate. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated for stratifications of the four tools. A receiver operator curve (ROC) was produced for each tool. The area under the curve (AUC) for each of these and associated standard errors (SE) and 95% CI were also calculated. The definitions of the above performance characteristics are given in Table 2[24,25]

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The definitions of each of the four tools are shown in Table 1. Severity was defined according to how one would expect to use the tools in clinical practice. For CURB65, therefore, severe CAP was defined as a score of 3 or greater[7]. For CRB65, severe CAP was defined as a score of 3 or 4 as suggested by the findings of Lim et al[7]. For SEWS, severe CAP was defined as a score of 4 or greater as it is at this level of score that the SEWS chart recommends early intervention by a doctor[19]. We did not include a urine output score in the calculation of SEWS. SIRS was analysed in four different ways to establish the best performing variation of this tool and the most appropriate cut-offs to define severe CAP. For SIRS, hypotension was defined as a systolic blood pressure <90 mmHg. Organ hypo-perfusion was defined as new confusion (MSQ ≤8/10 or a 2 point drop in MSQ). We did not attempt to separate patients with severe sepsis from those with septic shock as, by

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definition, septic shock cannot be diagnosed on admission to hospital until the patient has received adequate intravenous fluid resuscitation. We have therefore assumed that patients who went on to be diagnosed with septic shock shortly after admission are embedded in the cohort of patients with severe sepsis.

Results

Of the 503 patients (a description of the whole cohort is provided in Appendix 1, Thorax website) included in the quality improvement study, full data for all four tools were available for 419 patients (83%). Descriptive statistics for this cohort of patients are shown in Table 3. Reasons for exclusion from the original quality improvement study have previously been published[23]. Most deaths occurred within the first week of admission (72%) with 14% occurring in the second week and the remainder (14%) between 15 and 30 days. Mortality for severity stratifications of the four tools and associated sensitivity, specificity, PPV and NPV are shown in Table 4. Based on the results of these analyses, for SIRS, we defined severe CAP as the presence of hypotension and/or organ hypo-perfusion without SIRS or severe sepsis/septic shock (Table 4).

CURB65 and CRB65 were the only tools that identified a genuinely low risk group of patients (2% in CURB65 = 0 or 1 patients versus 0% in CRB65 = 0 patients versus 9% in the SEWS = 0 or 1 patients and 11% in patients without SIRS or hypotension or hypo-perfusion). The receiver operating curves are shown in Figure 1. The ROC for CURB65 had the greatest AUC (0.78, SE 0.025, 95% CI 0.73 to 0.83) followed by CRB65 (0.73, SE 0.029, 95% CI 0.67 to 0.79), SIRS (0.68, SE 0.035, 95% CI 0.61 to 0.75) and SEWS (0.64, SE 0.035, 95% CI 0.57 to 0.70). The overall accuracy of the four tools was 70% for CURB65, 79.5% for CRB65 (62% for a cut-off of ≥2 for severe CAP; see later discussion), 71% for SIRS and 64% for SEWS.

Sub-group analyses were performed on patients who had a chest radiograph reported by a consultant radiologist or seen by a consultant respiratory physician with associated documentation in the patient's case-notes (n = 218).

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The characteristics of this cohort are shown in Appendix 2, Thorax website. The operating characteristics of the four tools in this cohort of patients are shown in Appendix 3, Thorax website. The ROC is shown in Appendix 4, Thorax website. As for the main analyses, CURB65 and CRB65 were the only tools to identify a low risk cohort of patients. In contrast to the main analyses, SIRS (as defined above) performed better than CURB65 with respect to sensitivity, specificity, PPV, NPV and accuracy. The ROC for CURB65 still had the greatest AUC (0.79, SE 0.037, 95% CI 0.72 to 0.86), however, followed by CRB65 (0.75, SE 0.043, 95% CI 0.67 to 0.83), SIRS (0.70, SE 0.057, 95% CI 0.59 to 0.81) and SEWS (0.61, SE 0.059, 95% CI 0.49 to 0.72). The overall accuracy of the four tools in this new cohort was 69% for CURB65, 86% for CRB65 (62% for a cut-off of ≥2 for severe CAP; see later discussion), 76% for SIRS and 61% for SEWS. Table 5 compares the results of this study with two previously reported validation studies.

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Discussion

Severity assessment is the key to appropriately managing patients with CAP. The results of this study show that two potential generic prognostic tools, SIRS and SEWS, should not be used in preference to CURB65 or CRB65 for predicting mortality in adult patients who present to hospital with CAP. CURB65 and CRB65 outperform both of these tools in two ways. Firstly, and most importantly, their stratification of mortality is more clinically useful and identifies a genuinely low risk group of patients, whereas SIRS and SEWS do not. This means that CURB65 and CRB65 can be used to identify patients who do not require inpatient care unless they have additional co-morbidities or signs of respiratory failure[8-10]. Secondly, they performed better with regard to most of the other performance criteria (except when compared to our modified definition of SIRS in the chest radiograph defined cohort) and had the greatest AUC in all analyses. It is worth noting, however, that none of the tools performed particularly well and all were well below the standard required of population screening tests. This emphasises the importance of combining predictive tools with clinical judgement.

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The ease of using each tool in clinical practice should also be considered. CURB65 requires four bed-side and one laboratory criteria. Although the latter may delay a full assessment on admission to hospital, Lim et al have previously shown that CRB65 stratifies mortality similarly and can therefore be used whilst awaiting the urea result[7]. In contrast to the conclusions of Lim et al, however, the results of our study suggest that a CRB65 score of two or more would be a safer cut-off for defining CAP. SIRS requires three bed-side and one laboratory criteria plus an assessment of hypotension and hypo-perfusion. Although SEWS requires the most data, all criteria can be measured at the bed-side. It does require the availability of a pulse oximeter, however, and accurate measurement of urine output over a 3 hour period (see discussion later).

This is now the third published study to assess the predictive performance of CURB65 in CAP[7,16]. CURB65 stratified mortality similarly across all three studies (Table 5). Importantly, mortality in the two least severe stratifications (i.e. 0 and 1) was similar (2%, 1.2% and 0.4%, respectively) thereby confirming that CURB65 can safely identify a low risk cohort of patients. The overall higher mortality seen in our study is likely to reflect the characteristics of the study cohort, in particular, the older median age (74 years versus 69 years in the derivation/validation study and the greater proportion of patients with severe CAP; 38% versus 29%[7]). The sensitivity, specificity, PPV and NPV were also similar. In our study these values were 71%, 69%, 35% and 91% versus 68%, 75%, 22% and 96% in the validation set and 75%, 75%, 23% and 97% in the derivation set of the validation/derivation study[7].

CURB65 has recently been found to have similar performance to the PSI (AUC 0.87 versus 0.89) in predicting 30-day mortality in CAP[16] but is yet to be compared to the modified ATS criteria[26]. Ewig et al recently compared both of these with the old BTS tool (CURB) and found that the modified ATS criteria performed the best in predicting mortality and the need for admission to an intensive care unit (ITU)[15]. The performance of CURB and the PSI were comparable. Interestingly, when severe sepsis was used as the cut-off for severity in this study, it had better sensitivity (89% versus 51%), PPV (20%

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versus 16%) and NPV (99% versus 96%), but worse specificity (70% versus 80%) and overall accuracy (71% versus 78%) than CURB in predicting mortality. One major caveat of this study is that 17% of patients (versus 3% in our study) were admitted to an ITU, which means that one may not be able to generalise these results to the NHS setting.

The definition of sepsis, which incorporates the systemic inflammatory response syndrome, was published in a consensus statement in 1992 and has since been widely adopted in research and clinical practice[17]. In our own hospitals, for example, the definitions given in Table 1 have been included in sepsis protocols to guide the intensity of antibiotic therapy. A North American study demonstrated that mortality due to infection increased with the number of SIRS criteria (7% with two criteria, 10% with three criteria and 17% with four criteria) and with severe sepsis (20%) and septic shock (40%)[27]. Jones et al also found a similar relationship in patients with bacteraemia (mortality in patients with no SIRS = 12%, SIRS 2 = 14%, SIRS 3 = 26%, SIRS 4 = 36%, severe sepsis = 38% and septic shock 56%) and it was suggested, on the basis of these studies, that SIRS was "of generalised use in predicting outcome from infection."[28] Interestingly, as with our study, Jones et al also found a cohort of patients with clinical evidence of hypotension and/or hypo-perfusion, but without the classical definition of SIRS. The mortality in this cohort of patients was 29% versus 28% in our study, which explains the higher mortality (17% when these patients were included versus 11% when they were classified as a separate cohort) for patients without SIRS (i.e. infection only patients).

Since then, the value of the SIRS criteria and the relationship between an increasing number of SIRS criteria and infection has been questioned. In a study of 300 internal medicine patients with new onset of fever at a university teaching hospital in The Netherlands, Bossink et al found that although there was a statistically significant association between the number of positive SIRS criteria and mortality (SIRS 1 = 0%, SIRS 2 = 3%, SIRS 3 = 8%, SIRS 4 = 17%), the performance of the definition of sepsis for predicting mortality was not as good as an alternative model proposed by the authors[29]. In our study,

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sepsis had a sensitivity of 73%, specificity of 30%, PPV of 20% and NPV of 83% for predicting mortality versus 63%, 60%, 13% and 94%, respectively, in the study by Bossink et al. A recent, multi-centred study using data from 3608 intensive care unit patients who had taken part in the European Sepsis Study found a gradation in mortality from uncomplicated infection or sepsis (25%) to severe sepsis (40%) to septic shock (60%)[30]. We found a similar association depending on how the sepsis definitions were used: from 13% (infection plus SIRS) to 38% (severe sepsis/septic shock) with the classical definition and from 11% (infection plus SIRS) to 28% (hypotension or hypo-perfusion without SIRS) to 38% (severe sepsis/septic shock) with our alternative definition. As with our study, they did not find any difference in mortality between patients with infection without SIRS and sepsis or an association between the number of SIRS criteria and mortality in these groups. The SIRS criteria may also have performed less well in our study because two of the criteria, heart rate and white cell count, have not been strongly associated with outcome in CAP[7,31]

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In contrast to SIRS, there is less data supporting the use of SEWS in infection. This is a concern given the increasing rate at which it is being implemented in acute medical admissions units in the UK. Indeed, implementation is being encouraged by major organisations interested in clinical effectiveness, such NHS Quality Improvement Scotland (QIS)[19]. SEWS is based on an Early Warning Score (EWS), which was validated for use in acute medical patients in 2001[20]. The AUC in the validation study was 0.67 compared to 0.62 in our study (versus 0.78 for CURB65 and 0.68 for SIRS). A subsequent study of 1695 acute medical patients, who were compared to a cohort of patients admitted to the same unit in the previous year, but prior to implementation of the EWS, did not demonstrate any change in mortality as a result of implementation[21]. A recent study, again from the UK, of 1047 ward patients assessed by an intensive care outreach service, found a strong statistical association between the EWS and the need for intervention or mortality[32]. As with SIRS, the EWS has been tested in different cohorts of patients in different contexts and it is debatable as to whether this evidence can be generalised to all patient populations. In our study, SEWS was better

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than SIRS at stratifying mortality. It is possible therefore, that it could still be used to identify patients at high risk of needing critical care, once the initial decisions about an appropriate site of care and antibiotic therapy have been made. Overall, however, SEWS performed less well than CURB65, CRB65 and SIRS with regard to other operating characteristics.

There are a number of caveats to the interpretation of the results of our study. Patients were included using a pragmatic, real-life definition of CAP. Sub-group analysis of a chest radiograph defined cohort of patients, however, confirmed the findings of our main analyses. Because the performance of all tests is context dependent, one may not be able to extrapolate our results to healthcare systems dissimilar to the NHS. We also used a limited definition of hypo-perfusion to define severe sepsis and septic shock. We feel this is justified given that the inclusion of acidosis in clinical practice would require an additional blood test, which is not performed in all patients with CAP. Indeed, the BTS guidelines recommend arterial blood gas measurement only when the patient's SaO_2 is <92% or other features of severe pneumonia are present[2]. Additionally, acidosis is only likely to affect a relatively small number of the most severely ill patients. As urine output cannot be measured accurately on admission to hospital and would therefore delay severity assessment and reduce the practicality of the tool, oliguria was also excluded as a criterion of hypo-perfusion and was not scored in SEWS. When using SEWS, it is recommended that 3+ hours of urine output be assessed. Given that there are six other SEWS criteria, and that oliguria would be an unusual isolated finding in severe CAP, it is unlikely that the omission of this would have resulted in poorer SEWS performance. Also, oliguria was not included in the validation study by Subbe et al[20]. Nevertheless, it is possible that the omission of these criteria, in particular for SIRS, may have altered performance characteristics.

In summary, CURB65 and CRB65 were better at stratifying mortality and outperformed SIRS and SEWS in predicting 30-day mortality in CAP. For the time being, other prognostic tools should not supplant CURB65 in the initial assessment of patients with CAP. There is clearly a need for corroboration of

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our results and the development of better generic predictive tools for use in acute medicine and sepsis.

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Table 1 Definitions of each of the four prognostic tools studied

Severity grade	**Score/definition**
CURB65 score	
Based on the presence or absence of the following criteria: new confusion, urea >7mmol/l, respiratory rate ≥30/minute, systolic blood pressure <90mmHg or diastolic blood pressure ≤60mmHg and age ≥65 years	
Severe	3 or more
Non-severe, moderate risk	2
Non-severe, low risk	0 or 1
CRB65 score	
Based on the presence or absence of the following criteria: new confusion, respiratory rate ≥30/minute, systolic blood pressure <90mmHg or diastolic blood pressure ≤60mmHg and age ≥65 years	
Severe	3 or 4
Non-severe, moderate risk	1 or 2
Non-severe, low risk	0
Systemic inflammatory response syndrome (SIRS)	
The diagnosis of SIRS is based on the presence of at least two of the following criteria: temperature <36ºC or >38ºC, pulse >90/minute, respiratory rate >20/minute and white cell count <4 or >12 cells per mm^3 The diagnosis of severe sepsis and septic shock is based on the presence of SIRS in infection plus the presence or absence of hypotension and/or organ hypo-perfusion and the patients response to adequate fluid resuscitation	
Septic shock (severe)	Severe sepsis plus hypotension and/or organ hypo-perfusion, which has failed to respond to adequate fluid resuscitation
Severe sepsis (severe)	SIRS plus hypotension and/or organ hypo-perfusion
SIRS (non-severe, intermediate risk)	≥2 of the SIRS criteria above
No SIRS (non-severe, low risk)	<2 of the SIRS criteria above
Standardised early warning system (SEWS)	
A complex scoring system based on the patient's respiratory rate, SaO_2, temperature, blood pressure, heart rate, neurological response and urine output. The SEWS chart is available at: http://www.nhshealthquality.org/nhsqis/files/Supplement%20to%20Final%20Report%20(SEWS%20Chart).pdf	
Inform nurse in charge and aim for doctor (at least senior house officer) review within 30 minutes (severe)	≥4
Hourly observations and inform nurse in charge (non-severe, intermediate risk)	2 or 3
Routine (4 hourly) observations (low risk)	0 or 1

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Table 2 Definitions of performance characteristics[24,25]

Performance characteristic	**Definition** **Equation**
Sensitivity	How good the test is at identifying patients who die True positives (i.e. tested positive and died) All deaths
Specificity	How good the test is at identifying patients who do not die True negatives (i.e. tested negative and lived) All alive
Positive predictive value (PPV)	In the event of a positive test, the probability that the patient will die True positives All positives
Negative predictive value (NPV)	In the event of a negative test, the probability that the patient will not die True negatives All negatives
Accuracy	The proportion of all tests that have given a correct result True positives and negatives All positives and negatives
Receiver operating curve (ROC)	A curve created by mapping sensitivity against 1 minus specificity. The area under the curve (AUC) is a marker of performance with higher values indicating better diagnostic ability. An AUC=1 indicates perfect performance whereas an AUC=0.5 indicates that there is a 50:50 chance that the test correctly identifies those who die
Comment	
Sensitivity and specificity are useful when considering the performance of a test at the population level. In contrast, PPV, NPV and accuracy are better when considering the performance of a test at the patient level (i.e. In the event of a positive test result, what is the probability that the patient in front of me will or will not die?). It is also important to consider how easy a test is to apply in clinical practice (see discussion).	

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Table 3 Demographic and clinical characteristics of the patients included

Numbers included	
Number included in the quality improvement project (Appendix 1, Thorax website gives data on full cohort)	503
Number of patients with full data for all four tools	419
Demographics	
Sex	47% male (n = 197)
Age	Median = 74 years (range 16 to 98)
	Age over 65 years = 70% (n = 292)
Living in own home	84% (n = 351)
Living alone	36% (n = 152)
Clinical characteristics	
Antibiotic from GP prior to admission	42% (n = 149/356)
CRP >50	76.5% (n = 286/374)
Chest radiograph consistent with pneumonia	95% (218/230)
Severity assessment on admission	
CURB65 score	
0 or 1	33.5% (n = 140)
2	28.5% (n = 119)
3 or more	38% (n = 160)
Respiratory rate ≥30/minute	22% (n = 91)
Systolic blood pressure <90mmHg	6% (n = 24)
Diastolic blood pressure ≤60mmHg	25% (n = 103)
Pulse ≥125/minute	10% (n = 43)
Pulse oximetry <92% (any FiO_2)	33% (n = 140)
Blood urea >7mmol/l	58% (n = 242)
New confusion	31% (n = 129)
% without co-morbidity	35% (n = 147)
% with asthma/COPD	35% (n = 146)
Initial antibiotic regimen	
Broad spectrum beta-lactam + macrolide	48% (n = 201)
Narrow spectrum beta-lactam + macrolide	31% (n = 130)
Beta-lactam monotherapy	10% (n = 42)
Macrolide monotherapy	3% (n = 13)
Levofloxacin	2% (n = 8)
Others	6% (n = 25)
Outcomes	
% of patients transferred to the intensive care unit	3% (n = 13)
30-day post admission mortality	19% (n = 79)
Length of hospital stay (excludes deaths)	Median = 5 days (range 0 to 116)

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Table 4 Operating characteristics of CURB65, CRB65, SIRS criteria used in four different ways and SEWS

Severity	Mortality	Sensitivity	Specificity	PPV	NPV
CURB65					
CURB65 = 0	0/58 (0%)	100%	0%	19%	NC
CURB65 = 1	3/82 (4%)	100%	17%	22%	100%
CURB65 = 2	20/119 (17%)	96%	40%	27%	98%
CURB65 = 3	27/105 (26%)	71%	69%	35%	91%
CURB65 = 4	27/49 (55%)	37%	92%	53%	86%
CURB65 = 5	2/6 (33%)	2.5%	99%	33%	81%
CRB65					
CRB65 = 0	0/71 (0%)	100%	0%	19%	NC
CRB65 = 1	21/150 (14%)	100%	21%	23%	100%
CRB65 = 2	28/131 (21%)	73%	59%	29%	90.5%
CRB65 = 3	28/61 (46%)	38%	89%	45%	86%
CRB65 = 4	2/6 (33%)	2.5%	99%	33%	81%
SIRS used in four different ways					
No SIRS[1]	21/124 (17%)	100%	0%	19%	NC
SIRS	21/197 (11%)	73%	30%	20%	83%
Severe sepsis/septic shock	37/98 (38%)	47%	82%	38%	87%
SIRS = 0[2]	5/35 (14%)	100%	0%	19%	NC
SIRS = 1	16/89 (18%)	94%	9%	19%	86%
SIRS = 2	28/136 (21%)	73%	30%	20%	83%
SIRS = 3	27/113 (24%)	38%	62%	19%	81%
SIRS = 4	3/46 (6%)	4%	87%	6%	80%
SIRS = 0[3]	5/35 (14%)	100%	0%	19%	NC
SIRS = 1	16/89 (18%)	94%	9%	19%	86%
SIRS = 2	12/89 (13%)	73%	30%	20%	83%
SIRS = 3	8/75 (11%)	58%	53%	22%	84%
SIRS = 4	1/33 (3%)	48%	73%	29%	86%
Severe sepsis/septic shock	37/98 (38%)	47%	82%	38%	87%
No SIRS or hypotension/ organ hypo-perfusion[4]	9/81 (11%)	100%	0%	19%	NC
SIRS	21/197 (11%)	89%	21%	21%	89%
Hypotension and/or organ hypo-perfusion, but no SIRS	12/43 (28%)	62%	73%	35%	89%
Severe sepsis/septic shock	37/98 (38%)	47%	82%	38%	87%
SEWS					
SEWS = 0	4/41 (10%)	100%	0%	19%	NC
SEWS = 1	5/58 (9%)	95%	11%	20%	90%
SEWS = 2	41/153 (27%)	89%	26%	22%	91%
SEWS = 3	12/80 (15%)	67%	47%	23%	86%
SEWS = 4	10/57 (17.5%)	52%	67%	27%	86%
SEWS = 5	8/34 (23.5%)	39%	81%	32%	85%
SEWS ≥ 6	23/62 (37%)	29%	88%	38%	84%

NC = not calculable

1. Defined as in Table 1
2. Defined by presence or absence of: temperature <36ºC or >38ºC, pulse >90/minute, respiratory rate >20/minute and white cell count <4 or >12 cells per mm^3
3. Defined by above plus definition of severe sepsis/septic shock given in Table 1
4. New definition (see results section)

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Table 5 Comparison of the performance characteristics of CURB65 in three different validation studies

Study	Study reported here n = 419 %	Study reported here, CXR cohort* n = 218 %	Lim et al[7] n = 932 %	Capelastegui et al[21] n = 1100 inpatients, 676 outpatients %
CURB65 score				
0	0	0	0.6	0
1	3.7	2.1	1.7	1.1
2	16.8	14.8	9.0	7.6
3	25.7	19.6	16.1	21
4	55.1	37.5	36.9	41.9
5	33.3	50	20	60

* Patients with a chest radiograph that had been reported by a consultant radiologist or seen by a consultant respiratory physician with associated documentation in the case-notes.

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Contributors: GB had the initial study idea, collected and analysed the data and wrote the initial draft of the paper. PD and DN were involved in developing the initial idea and edited the initial and subsequent drafts of the paper. PD is the guarantor.

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Competing interests: None declared

Ethical approval: Collection of data was approved by both Tayside University Hospitals NHS Trust's medical ethics committee and Caldicot guardian

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