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Clinical characteristics and diagnostic accuracy of preliminary diagnoses in adults with infections in Danish emergency departments: a multicentre combined cross-sectional and diagnostic study

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ABSTRACT

Objective Rapid and accurate infection diagnosis is a prerequisite for appropriate antibiotic prescriptions in an ED. Accurately diagnosing acute infections can be difficult due to nonspecific symptoms and limitations of diagnostic testing. The accuracy of preliminary diagnoses, established on the initial clinical assessment, depends on a physician's skills and knowledge. It has been scarcely studied, and knowledge of how infected patients present at EDs today is needed to improve it. Based on expert reference diagnoses and a current ED population, this study aimed to characterise adults presenting at EDs with suspected infection to distinguish between infections and non-infections and to investigate the accuracy of the preliminary infection diagnoses.

Design This study was multicentre with a design that combined a cross-sectional study and a diagnostic study with a prospective enrolment.

Setting Multicenter study including EDs at three Danish hospitals.

Participants Adults admitted with a preliminary diagnosis of an infectious disease.

Outcome measures Data were collected from medical records and participant interviews. The primary outcome was the reference diagnosis made by two medical experts on chart review. Univariate logistic regression analysis was performed to identify factors associated with infectious diseases.

Results We included 954 patients initially suspected of having an infection, with 81% later having an infectious disease confirmed by experts. Parameters correlating to infection were fever, feeling unwell, male sex, high C-reactive protein, symptoms onset within 3 days, high heart rate, low oxygen saturation and abnormal values of neutrophilocytes and leucocytes. The three main conditions were community-acquired pneumonia (CAP) (34%), urinary tract infection (UTI) with systemic symptoms (21%) and cellulitis (10%). The sensitivity of the physician's preliminary infection diagnoses was 87% for CAP, 74% for UTI and 77% for other infections.

Conclusions Four out of five patients with a preliminary infection diagnosis, established on initial clinical assessment, were ultimately confirmed to have an infectious disease. The main infections included CAP, UTI with systemic symptoms and cellulitis. Physicians' preliminary infection diagnoses were moderately in accordance with the reference diagnoses.

Trial registration number NCT04661085, NCT04681963, NCT04667195.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The reference diagnosis was assigned to an expert panel instead of relying on the diagnostic code registered in the medical record.
⇒ A pragmatic approach was chosen to evaluate real-life conditions.
⇒ Only mentally competent patients able to consent were included in this study, so the results can only be generalised to this group of patients.
⇒ Patients with infectious diseases that were overlooked by the ED physician during the primary investigations were missed.

INTRODUCTION

Antimicrobial resistance is rising as a consequence of increasing and inappropriate use of antibiotics, making it an urgent global public health threat.[1–4] Appropriate use of antibiotics in hospitals requires rapid and accurate infection diagnosis. Diagnostic errors are a known patient safety concern in the EDs, and correct preliminary diagnoses can speed up the

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diagnosis.[5] However, incorrect diagnoses can have negative consequences on patient outcomes such as prolonged hospital stay, increased intensive care unit (ICU) admissions and increased mortality.[6 7] Accurate preliminary diagnoses are therefore crucial for avoiding delays in diagnosing and treating infectious diseases.[8] Typically, an emergency physician establishes a preliminary diagnosis immediately after an initial clinical assessment. The suspected origin of infection guides the subsequent diagnostic work-up.

For decades, respiratory and urinary tract infections have been the most common infections among hospitalised patients.[9 10] Knowledge of the characteristics of these patients is based on older studies that may not apply to the current ageing population with increased comorbidity and use of immunomodulating treatments.

Severity scores to predict clinical deterioration and mortality in patients with suspected infection[11] and identifying sepsis[12] exist. However, to a large degree, the diagnostic accuracy of general infections in the ED still depends on the physician's skills and knowledge.[13] Older patients pose substantial diagnostic challenges because of the frequent absence of typical signs and symptoms and the familiar presence of chronic bacterial colonisation.[14–18] Diagnosis is further complicated by inaccurate diagnostic tests and delayed test results.[18–22] Therefore, this subpopulation is often over- or underdiagnosed.[18 23 24] Determining the extent of misdiagnosis requires a well-established and validated reference diagnosis, which may not always be feasible in studies that rely on discharge diagnoses from registers.

Improving diagnostic accuracy requires a multifaceted approach, such as studies focusing on diagnostics using symptom- and disease-oriented designs. In addition, new systems such as checklists and computer-based clinical decision support have been suggested as valuable tools to help decrease harm from diagnostic errors.[25] Identifying specific factors from knowledge of patient history, clinical examination and basic laboratory tests will help improve the diagnostic accuracy.

This study aimed to characterise adults suspected of an infectious disease on arrival to an ED, to distinguish between infection and non-infection and to investigate the accuracy of the preliminary infection diagnoses using an expert panel. The objectives were (I) to describe the distribution of infection diagnoses among patients suspected of infection, (II) to evaluate the accuracy of the emergency physician's ability to identify the correct origin of infection preliminarily, (III) to identify which factors (symptoms, comorbidities and clinical findings) have the highest correlation with infection diagnoses among patients suspected of infection and (IV) to investigate the difference in treatment trajectories for patients suspected of infection.

METHOD

Study design

This pragmatic multicentre study, with prospective data collection, combined a cross-sectional study design and a diagnostic study design. It was part of the larger multifaceted diagnostic stewardship project INDEED (Infectious Diseases in Emergency Departments),[26] aiming to improve the diagnosis of infectious diseases in the ED. The INDEED study protocol was published before patient enrolment.[26]

Regional Committees on Health Research Ethics for Southern Denmark approved the study (S-20200188), and the Region of Southern Denmark approved the processing of personal data (no. 20/60508).

The manuscript was reported in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology statement[27] and conducted in agreement with the Declaration of Helsinki's statement of ethical principles for medical research involving human subjects.

Setting

The study recruited acute medical patients from the EDs at three Danish hospitals (Hospital Sønderjylland, Lillebælt Hospital and Odense University Hospital) serving a catchment area of approximately 775 000 citizens from rural and urban areas and are part of Denmark's tax-funded universal healthcare system. In Denmark, patients are typically admitted to the ED for up to 24 hours before discharge to other wards or homes. There are no private hospitals with ED in Denmark.

The population was a convenience sample with recruitment between March 2021 and February 2022, 8 a.m.–8 p.m. on weekdays, by six study staff with healthcare educations (three physicians, one physiotherapist and two final-year medical students).

Population

Participants were adults aged 18 or older presenting to a medical ED. Patients were eligible if the receiving emergency physician suspected infection on an initial clinical assessment based on symptoms, vital signs, history and clinical examination. The project staff invited eligible patients to participate.

Patients were excluded if the treating physician considered that participation would delay urgent, vital treatment, if they were severely immunocompromised (see the protocol for further elaboration),[26] not mentally competent (ie, not able to understand or make decisions because of the mental condition), unable to read and speak Danish or had been admitted to hospital within the last 14 days to avoid inclusion of patients with hospital-acquired infections. Since this study aimed at identifying an average ED population outside a pandemic, patients who had tested positive for SARS-CoV-2 within the previous 14 days were also excluded. Verbal and written consent was obtained. Further eligibility information is available from the published protocol.[26]

Variables, data assessment and outcomes

Study staff interviewed the emergency physician on patient enrolment, and the most likely infection assigned by the treating emergency physician (preliminary origin

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of infection) was registered: community-acquired pneumonia (CAP), urinary tract infection or other/unknown infection.

The included patients were interviewed immediately by the study staff, who used a detailed standardised collection tool developed for the study. Before use, the tool was tested in the ED and adapted so that collection was uniform across study staff and departments. Variables collected were basic activities of daily living (ADL) dependencies (eating, bathing, dressing, toileting, transferring and moving around)[28] as indicators of a person's functional status, living at a nursing home, prior pneumonia, prior cellulitis, prior urinary tract infection (UTI), onset and current symptoms such as feeling unwell, tired, fever/sensation of fever (feeling of fever such as night sweats and chills) at home, peripheral oedema, central nervous system symptoms (headache, dizziness or confusion), gastrointestinal symptoms (nausea, vomiting, diarrhoea, constipation or stomach pain), respiratory symptoms (dyspnoea, respiratory tract secretion, cough or having a cold), urinary tract symptoms (frequent urination, pain during urination, urine retention/incontinence, change of urine (appearance or smell) and musculoskeletal symptoms (myalgia and back pain). The number of days since the onset of symptoms was also noted as this information is used by the clinician to assess the stage of development and severity of many infections. The symptoms were chosen based on symptoms typically expressed by the patient on arrival, and all variables were selected in collaboration with the ED staff and based on existing literature. The variables were collected to investigate their correlation to the infection diagnosis.

From the medical record, the study staff noted the five-level Danish Emergency Process Triage assigned on arrival (a Danish adaption and modification of the Adaptive Process Triage,[29] available vital signs that can be affected by infection (respiratory frequency, heart rate, oxygen saturation, blood pressure, ear temperature), results of initial blood tests (level of C-reactive protein, leucocytes, neutrophilocytes, creatinine, bilirubin and platelets), current medications and comorbidities (neurological diseases, pulmonary diseases including chronic obstructive pulmonary disease, endocrinological diseases including diabetes, chronic kidney diseases, cardiovascular diseases including ischaemic heart disease and cardiac heart failure, gastrointestinal diseases and if a urinary catheter was present).

The primary outcome was the reference diagnosis, as assessed retrospectively by two medical experts: a specialist in infectious diseases and an emergency medicine specialist. Both experts had considerable experience in acute infections. Each patient file was assessed individually by both experts, and the two experts were blinded to each other. The experts' diagnoses were based on all available information within the first week after enrolment. They included access to the medical records (patient history, clinical examination, all laboratory results and diagnostic imaging). The experts registered the presence and location of the infection. No checklists or diagnostic criteria were applied. The experts were blinded to each other's diagnosis. They were only able to see if they agreed on the diagnosis. In case of disagreement, they contacted each other by phone and discussed the patient until consensus was reached. The number of disagreements was not calculated in this study. Eight experts were connected to the study. The template describing the expert panel assessment can be found in the appendix of the protocol.[26]

The secondary outcomes—measuring the treatment trajectories: transfer to intensive care during current admission, readmission within 30 days, mortality within 30 days and length of hospital stay (LOS)—were assessed from the medical record by the project staff during follow-up at 30 days and 90 days.

All data were registered electronically in real-time using the Research Electronic Data Capture (RedCap version 10.8.3 to version 12.2.1 by Vanderbilt University) software.[30]

Statistical method

Descriptive statistics for the characteristics of the patients were presented as means and SD, or medians and IQR for continuous variables and numbers (n) and percentages (%) for categorical variables.

Univariate logistic regression analysis was performed to identify factors correlating with infection. Cut-offs for blood samples and vital parameters were chosen based on what is routinely applied in Danish hospitals. The duration of symptoms was used to divide patients into two groups: symptom duration of less than 3 days and symptom duration of 3 days or above. This threshold was selected as inflammation usually escalates during the first 2 days of infection.[31 32] Multivariate analyses would have been possible but deemed out of scope for this study.

To investigate differences in treatment trajectories, negative binomial regression was performed for LOS, and univariate logistic regression analysis was conducted to analyse intensive care during current admission, readmission within 30 days and mortality within 30 days. Results were reported with OR or incidence rate ratio, 95% CI and p values.

The accuracy of the emergency physician's ability to identify the preliminary origin of infection among patients with suspected infection (index test) was assessed by estimating the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and likelihood ratio (LR). The reference standard was the reference diagnosis registered by the expert panel (primary outcome).

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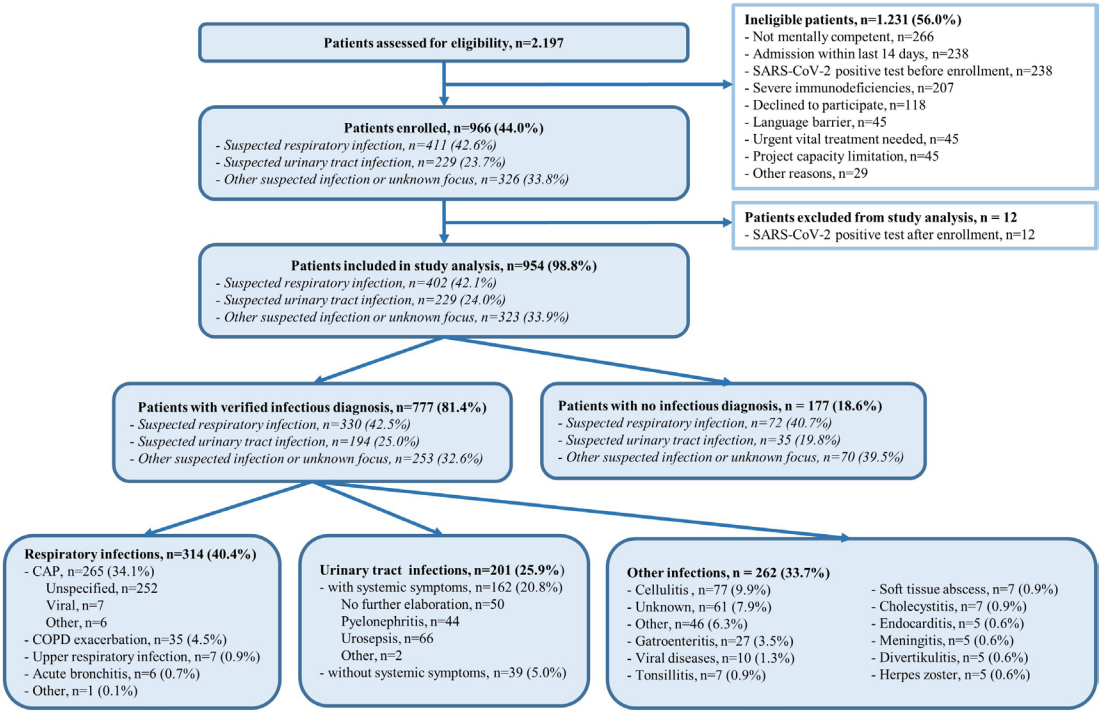

Figure 1 Patient flow.

All statistical analyses were completed using Stata (StataCorp. 2021. Stata Statistical Software: Release 17. College Station, TX, USA: StataCorp LLC).

RESULTS

Patient flow

We identified 2197 eligible patients; of these 966 patients (44.0%) were included in the study (figure 1). After enrolment, 12 patients were diagnosed with SARS-CoV-2 and excluded from the study analysis. We found no differences in sex or age between the final 954 included patients and the 1243 excluded patients.

Distribution of infectious diagnoses

Of the 954 included patients, 777 (81.4%) had an infection diagnosis, according to the expert assessment. The three main diagnoses were CAP (265 patients, 34.1%), UTI with systemic symptoms (162 patients, 20.8%) and cellulitis (77 patients, 9.9%). Among patients with an infection diagnosis, 61 (7.9%) had an infection of unknown origin. The distribution of the diagnoses can be seen in figure 1.

The diagnoses of patients without infection were very heterogeneous. The main disease groups were (presented according to ICD-10 chapters): 'symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified' (60 patients, 34%), diseases of the respiratory system (28 patients, 16%), 'diseases of the musculoskeletal system and connective tissue' (20 patients, 11%), 'diseases of the circulatory system' (15 patients, 9%) and 'diseases of the digestive system' (12 patients, 7%).

Accuracy

Table 1 shows the diagnostic accuracy of the physician's ability to identify the origin of infection preliminarily. The sensitivity was highest for CAP (86.5%, CI: 84.8 to 89.1) and lowest for UTIs (74.1%, CI: 71.4 to 76.9). Conversely, for specificity the highest value was for UTIs (89.4%, CI: 87.4–91.3) and lowest for CAP (79.8%, CI: 77.3–82.4). PPVs were between 57.0 and 65.1%, while all NPVs were above 90%. LR for positive test results (LR+) were highest for UTIs (7.0 (5.6–8.7)), while LR for negative test results (LR−) were lowest for CAP (0.18 (0.13–0.25)).

Characteristics and identification of factors associated with an infectious diagnosis

The characteristics of patients with and without infection diagnoses are listed in table 2. There were no significant differences in triage, comorbidities and age (median age was 74 (IQR 61–81) for patients with infection diagnoses and 71 (IQR 55–80) for patients without infection diagnoses).

A significantly larger proportion of patients with infection diagnoses were men (55.5%, OD: 1.4 (1.0–2.0)), had a sensation of fever or measured fever at home (71.1% vs 50.0%, OD: 2.5 (1.8–3.4)), felt unwell (63.0% vs 53.3%, OD: 1.5 (1.1–2.1)) and had gastrointestinal symptoms (72.1% vs 61.8%, OD: 1.6 (1.1–2.3)). No difference was observed in the typical pulmonary and urinary symptoms between those with and without infection diagnoses. The median time between the symptom onset and hospitalisation was 4 (IQR 2–8) and 7 (IQR 3–12) days for patients with and without infectious diagnoses, respectively. The time between symptom onset and hospitalisation is

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Table 1 Diagnostic accuracy of the emergency physician's ability to preliminarily identify the origin of infection if infection was suspected

Preliminary origin of infection	TP	FP	FN	TN	LR+ (95% CI)	LR– (95% CI)	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)
CAP	229	173	36	516	3.4 (3.0–4.0)	0.18 (0.13.0.25)	86.4 (81.7–90.3	74.9 (71.5–78.1)	57.0 (53.8–60.1)	93.5 (91.9–95.0)
Urinary tract infection	149	80	52	673	7.0 (5.6–8.7)	0.29 (0.23–0.37)	74.1 (71.4–76.9)	89.4 (87.4–91.3)	65.1 (62.0–68.1)	92.8 (91.2–94.5)
Other/ unknown infections	201	122	61	570	4.6 (3.7–5.2)	0.28 (0.23–0.35)	76.7 (74.0–79.4)	82.4 (80.0–84.8)	62.2 (59.2–65.3)	90.3 (88.5–92.2)

CAP, Community-acquired pneumonia; FN, False Negative; FP, False Positive; LR+, Likelihood ratio for positive test results; LR-, Likelihood ratio for negative test results; NPV, Negative Predictive value; PPV, Positive predictive value; TN, True negative; TP, True positive.

illustrated in figure 2, indicating no significant differences in the distribution of symptoms days, except for an increase in the first 2 days for patients diagnosed with an infection—the peaks at day 7 and 14 correspond to weeks 1 and 2, respectively.

In patients with an infection diagnosis compared with patients without infection diagnosis, the heart rate was significantly higher (50.0% vs 35.0%, OD: 1.9 (1.3–2.6); >90 beats/min), oxygen saturation was significantly lower (44.2% vs 29.0%, OD: 1.9 (1.4–2.8); ≤96), fever (>38°C) was significantly more frequent (28.5% vs 7,4%, OD: 5.0 (2.8–9.0)), CRP level was significant higher (56.6% vs 15.3%, OD: 15.3 (9.5–24.7); CRP ≥100 mg/L) and leucocyte (75.4% vs 47.5%, OD 3.4 (2.4–4.8) values were <3.5 and >8.8 10^9/L) and neutrophilocyte (64.9% vs 28.6%, OD: 4.6 (3.2–6.6) values <1.5 and >7.5 10^9/L) were significantly more abnormal. The mean CRP value was 134.0 ng/L (SD 102.1 ng/L) for patients with infection diagnoses and 46.7 ng/L (SD 65.8 ng/mL) for patients without infection diagnoses. It was observed that 13.0% of the patients with an infectious diagnosis had a low CRP level (<20 mg/L). Of the patients with infection, 15.3% had a high CRP level (≥100 mg/L). The reference diagnoses of these patients were very heterogeneous.

Treatment trajectories

Table 3 lists the treatment trajectories for patients with and without an infection diagnoses. No significant differences were observed in readmission, mortality and transfer to the ICU. LOS was higher for patients diagnosed with an infection (median of 3 days (IQR 1–6) vs 1 day (IQR 0–4).

DISCUSSION

Four out of five patients with suspected infection had a reference diagnosis of infectious diseases. The three main conditions were CAP (32%), UTI with systemic symptoms (21%) and cellulitis (10%). The physician's ability to identify the origin of infection preliminarily was equivalent to good accuracy. Factors correlating with infection diagnosis were male sex, CRP level ≥21 mg/L), heart rate >90 beats/min, oxygen saturation ≤96, time between ED visit and symptom onset below 3 days, abnormal values of neutrophilocytes and leukocytes, feeling unwell, sensation of fever or fever measured at home, and fever >38°C. There was no significant difference in treatment trajectories, except for LOS, where patients not diagnosed with an infection were discharged faster (3 days vs 1 day).

Our results support older findings that CAP and UTIs are the most common infection diagnoses in ED populations and, together with cellulitis, encompass two-thirds of all ED infectious disease diagnoses.[33 34] Our study shows that when an ED physician suspects an infection, the probability that the patient has an infection is high even before the physician accesses any investigations or laboratory results. The preliminary origin of infection was also often diagnosed correctly, showing that the physicians' preliminary suspicion benefits clinical practice. The high NPVs and the lower PPVs indicate that the probability of identifying patient with the right preliminary origin of infection was lower than ruling out the infection in question. The sensitivity was highest for CAP illustrating that it is easier for the physician to preliminary identify CAP patients compared with, for example, UTI patients. On the other hand, the higher specificity for UTI patients shows that the physicians have a high ability to rule out UTI. In contrast, an American study[24] demonstrated poor sensitivity of the ED physicians to diagnose an infection and the type of infection when comparing to inhospital physician diagnosis. However, they included only patients above 65 years of age (no median age was specified), who often lack typical symptoms and signs.[35] Another American study also found low sensitivity for identifying acute bacterial infections in elderly patients and concluded that infections are often under- or overdiagnosed by the ED physicians.[24] A French study reported a similar accuracy level to our study when investigating acute respiratory failure in older patients using an expert panel as reference standard.[36] A Dutch study reported a high level of diagnostic agreement for patient with infectious diseases when comparing prehospital preliminary diagnosis with

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Table 2 Characteristics of patients suspected of infection and the association with the experts' reference diagnosis

	Suspected infection (total) n=954	Missing information n (% of 954)	Infection diagnose n=777	No infection diagnoses n=177	Correlation (univariate analysis)	
					OR (95% CI)	P value
Demographic data						
Age group, n (%)		0 (0)				
18–40	83 (8.7)		63 (8.1)	20 (11.3)	ref	
41–60	167 (17.5)		131 (16.9)	36 (20.3)	1.2 (0.6 to 2.2)	0.65
61–70	165 (17.3)		135 (17.4)	30 (16.9)	1.4 (0.8 to 2.7)	0.28
71–80	286 (30.0)		236 (30.4)	50 (28.2)	1.5 (0.8 to 2.7)	0.18
≥81	253 (26.5)		212 (27.3)	41 (23.2)	1.6 (0.9 to 3.0)	0.11
Male, n (%)	513 (53.8)	0 (0)	431 (55.5)	82 (46.3)	**1.4 (1.0 to 2.0)**	**0.03**
Nursing home resident, n (%)	69 (7.0)	13 (1.4)	55 (7.2)	11 (6.3)	1.2 (0.6 to 2.3)	0.68
ADL dependency*, n (%)	260 (28.0)	25 (2.6)	215 (28.5)	45 (25.9)	1.1 (0.8 to 1.7)	0.49
Polypharmacy (>5 medications), n (%)	544 (57.0)	0 (0)	450 (57.9)	94 (53.1)	1.2 (0.9 to 1.7)	0.24
Comorbidities						
Neurological diseases, n (%)	172 (18.0)	0 (0)	133 (17.1)	39 (22.0)	0.7 (0.5 to 1.1)	0.13
Pulmonary diseases, n (%)	269 (28.2)	0 (0))	223 (28.7)	46 (26.0)	1.1 (0.8 to 1.7)	0.47
COPD, n (%)	190 (19.9)	0 (0)	159 (20.5)	31 (17.5)	1.2 (0.8 to 1.9)	0.38
Endocrinological diseases, n (%)	296 (31.0)	0 (0)	241 (31.0)	55 (31.1)	1.0 (0.7 to 1.4)	0.99
Diabetes mellitus II, n (%)	160 (16.8)	0 (0)	131 (16.9)	29 (16.4)	1.0 (0.7 to 1.6)	0.88
Chronic kidney diseases, n (%)	59 (6.2)	0 (0)	50 (6.4)	9 (5.1)	1.3 (0.6 to 2.7)	0.50
Urinary catheter, n (%)	62 (6.5)	0 (0)	55 (7.1)	7 (4.0)	1.9 (0.8 to 4.1)	0.13
Ischaemic heart disease, n (%)	134 (14.0)	0 (0)	108 (13.9)	26 (14.7)	0.9 (0.6 to 1.5)	0.79
Cardiac heart failure, n (%)	58 (6.1)	0 (0)	52 (6.7)	6 (3.4)	2.0 (0.9 to 4.8)	0.10
Gastrointestinal, n (%)	100 (10.5)	0 (0)	80 (10.3)	20 (11.3)	0.9 (0.5 to 1.5)	0.69
Rheumatic diseases, n(%)	118 (12.4)	0 (0)	97 (12.5)	21 (11.9)	1.1 (0.6 to 1.8)	0.8
Prior pneumonia, n (%)	444 (52.0)	100 (10.5)	368 (53.6)	76 (45.2)	1.4 (1.0 to 2.0)	0.05
Prior cellulitis, n (%)	123 (14.5)	106 (11.1)	104 (15.2)	19 (11.4)	1.4 (0.8 to 2.3)	0.61
Prior urine tract infection, n (%)	467 (53.6)	83 (8.7)	376 (53.6)	91 (53.5)	1.0 (0.7 to 1.4)	0.98
Subjective symptoms (current at admission and start of onset within the last 14 days)						
Feeling unwell, n (%)	559 (61.2)	41 (4.3%)	469 (63.0)	90 (53.3)	**1.5 (1.1 to 2.1)**	**0.02**
Tired, n (%)	657 (72.6)	49 (5.1%)	543 (73.8)	114 (67.5)	1.4 (0.9 to 1.9)	0.10
Fever/sensation of fever at home, n (%)	612 (67.1)	42 (4.4%)	526 (71.1)	86 (50.0)	**2.5 (1.8 to 3.4)**	**0.00**
Peripheral oedema, n (%)	79 (8.6)	40 (4.2%)	60 (8.1)	19 (11.0)	0.7 (0.4 to 1.2)	0.22
Cerebral, n (%)	570 (62.2)	37 (3.9%)	472 (63.3)	98 (57.3)	1.3 (0.9 to 1.8)	0.15
Gastrointestinal, n (%)	643 (70.2)	38 (4.0%)	536 (72.1)	107 (61.8)	**1.6 (1.1 to 2.3)**	**0.01**
Respiratory, n (%)	533 (58.3)	39 (4.1%)	439 (59.2)	94 (54.3)	1.2 (0.9 to 1.7)	0.25
Urinary tract, n (%)	342 (37.5)	42 (4.4%)	289 (39.0)	53 (31.0)	1.4 (1.0 to 2.0)	0.05
Musculoskeletal, n (%)	344 (37.8)	44 (4.6%)	277 (37.5)	67 (39.2)	0.9 (0.7 to 1.3)	0.68
Time to symptom onset<3 days	240 (25.2)	0 (0%)	209 (26.9)	31 (17.5)	**1.7 (1.1 to 2.6)**	**0.01**
Severity assessment and vital parameters						
Triage, n (%)		59 (6.2%)				
Resuscitation and emergent	233 (26.0)		192 (26.4)	41 (24.4)	ref	
Urgent	479 (53.5)		392 (53.9)	87 (51.8)	1.0 (0.6 to 1.5)	0.85
Less and non-urgent	183 (20.4)		143 (19.7)	40 (23.8)	0.8 (0.5 to 1.2)	0.28
Respiratory rate≥22/min, n (%)	274 (28.9)	5 (0.5%)	226 (29.3)	48 (27.1)	1.1 (0.8 to 1.6)	0.57
Heart rate >90 beats/min, n (%)	450 (47.2)	1 (0.1%)	388 (50.0)	62 (35.0)	**1.9 (1.3 to 2.6)**	**0.00**
Oxygen saturation ≤96, n (%)	393 (41.4)	4 (0.4%)	342 (44.2)	51 (29.0)	**1.9 (1.4 to 2.8)**	**0.00**
Systolic blood pressure ≤100, n (%)	62 (6.5)	3 (0.3%)	56 (7.2)	6 (3.4)	2.2 (0.9 to 5.2)	0.07
Fever>38°C†, n (%)	233 (24.6)	5 (0.5%)	220 (28.5)	13 (7.4)	**5.0 (2.8 to 9.0)**	**0.00**

Continued

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Table 2 Continued

	Suspected infection (total) n=954	Missing information n (% of 954)	Infection diagnose n=777	No infection diagnoses n=177	Correlation (univariate analysis)	
					OR (95% CI)	P value
Initial blood tests						
C-reactive protein, n (%)		0 (0%)				
Low <20 mg/L	196 (20.5)		101 (13.0)	95 (53.7)	ref	
Moderate 21–99 mg/L	291 (30.5)		236 (30.4)	55 (31.1)	**4.0 (2.7 to 6.1)**	**0.00**
High ≥100 mg/L	467 (49.0)		440 (56.6)	27 (15.3)	**15.3 (9.5 to 24.7)**	**0.00**
Leucocytes 10^9/L: < 3.5 and > 8.8, n (%)	670 (70.2)	0 (0%)	586 (75.4)	84 (47.5)	**3.4 (2.4 to 4.8)**	**0.00**
Neutrophilocytes 10^9/L: < 1.5 and >7.5, n (%)	549 (58.2)	10 (1.1%)	499 (64.9)	50 (28.6)	**4.6 (3.2 to 6.6)**	**0.00**
Creatinine ≥110 µmol/L, n (%)	255 (26.7)	0 (0%)	218 (28.1)	37 (20.9)	1.5 (1.0 to 2.2)	0.05
Bilirubin >20 µmol/L, n (%)	92 (9.8)	11 (1.2%)	80 (10.4)	12 (6.9)	1.6 (0.8 to 2.9)	0.16
Platelets <150 10^9/L, n (%)	78 (8.3)	10 (1.1%)	69 (9.0)	9 (5.2)	1.8 (0.9 to 3.7)	0.11

*Basic ADL dependencies: ≥ one dependency regarding bathing, dressing, toileting, transferring, eating, and moving around.
†All patients in this study had a temperature>36.5C.
COPD, chronic obstructive pulmonary disease.

discharge diagnosis.[37] However, only patients presented to the ED by ambulance were included, making this population more severe, homogeneous and different from our study. The development of future algorithms, including using artificial intelligence to support clinical decisions, may aid physicians in discriminating between patients with and without infections at an ED.[38 39]

There is a wide heterogeneity of diagnoses among patients without infection, reflecting how non-infections may mimic infections in early stages. This tend to reduce the diagnostic accuracy in the ED. It is remarkable that one-third of the patients who were considered not to have infection were not assigned a definite diagnosis. This indicates that for even an expert panel with access to all information in the medical record, it is not easy the assign an accurate diagnosis. This underlines the heterogeneity of the ED population. A notice is the short LOS of 1 (0–4) day, making the amount of information limited in the medical record.

Of the patients diagnosed with an infection by the expert panel, 8% had an infection of unknown origin after 1 week. This emphasises the difficulties in assigning an accurate diagnosis even though all information is available. It could be interesting to characterise these patients further and follow their treatment trajectories to improve the diagnostic setup and identify the origin of the infection more quickly.

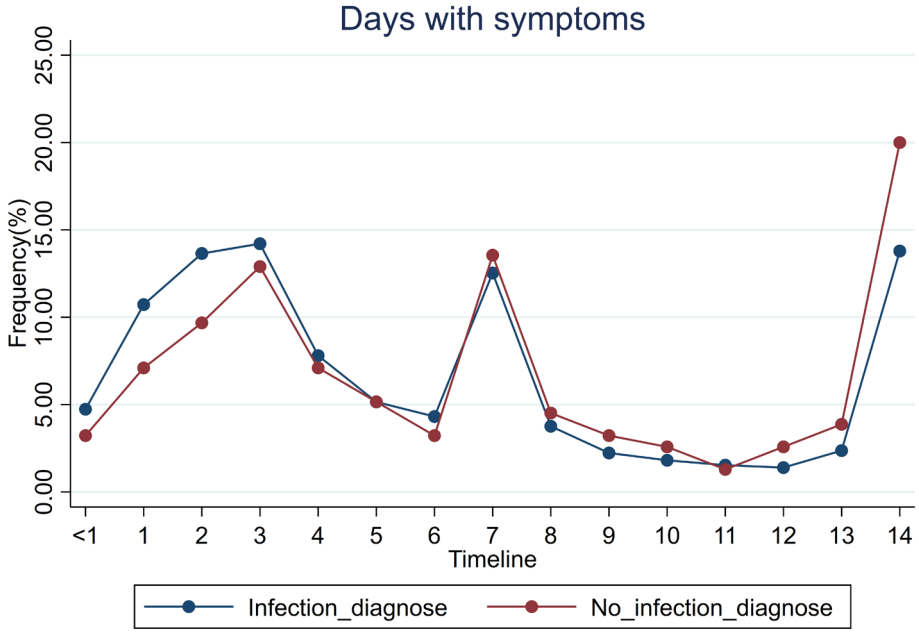

Figure 2 Time between symptom onset and hospitalisation for patients with suspected infection.

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Table 3 Treatment trajectories for patients with suspected infection and the association to the experts' reference diagnosis

	Suspected infection (total) n=954	Infection diagnose n=777	No infection diagnoses n=177	OR (95%CI)	p value
Transfer to intensive care unit during current admission, n (%)	17 (1.8)	16 (2.4)	1 (0.6)	0.39 (0.09 to 1.68)	0.21
Readmissions within 30 days, n(%)	131 (13.7)	108 (13.9)	23 (13.0)	1.08 (0.67 to 1.75)	0.75
Mortality within 30 days, n(%)	31 (3.2)	26 (3.3)	5 (2.8)	1.19 (0.45 to 3.15)	0.72
				IRR (95%CI)	
Length of hospital stay (in days), median (IQR)	3 (1-6)	3 (1-6)	1 (0–4)	1.58 (1.30 to 1.91)	0.00

IRR, incidence rate ratio.

Updated knowledge of symptoms of infection in ED is still vital as the current population has aged. Interestingly, there was no difference in pulmonary and UTI symptoms between infected and non-infected patients, demonstrating the challenge of an accurate preliminary diagnosis. Unsurprisingly, fever, high CRP level (≥100 mg/L) and abnormal levels of leucocytes and neutrophilocytes correlated with an infection diagnosis. However, only 28.5% of the patients with infection diagnoses had fever at arrival, though fever correlated with an infection diagnosis. It is well known that fever is not always present in infections, especially in immunocompromised and older patients.[40 41] Nevertheless, more than 70% of patients with an infection diagnosis reported fever sensations and/or measured an abnormal temperature prior to hospitalisation, indicating a history of fever might be more helpful for triage and preliminary diagnosis than temperature measured on ED arrival.

As 13.0% of the patients with infectious diagnoses had low CRP levels (<20 mg/L), physicians must be aware that a low CRP level cannot safely exclude the presence of infection, also supported by previous findings.[42 43] On the other hand, 15.3% of the patients without infections had high CRP levels. In this analysis, we did not divide the patients diagnosed with infection into bacterial or viral infections. This may explain the CRP levels, but this depth of information is rarely available on arrival at an ED. The inflammatory systemic response is dynamic; therefore, the CRP, leucocyte and neutrophilocyte levels must be interpreted in the context of the number of days since symptom onset. The biomarkers are not definitive for an infection and cannot stand alone but can be included in a diagnostic algorithm.

The significant lower LOS for patients without infectious diagnoses emphasises the fact that it is easier to rule out the patients not having the diagnosis in question. By excluding a severe infection requiring hospitalisation, the probability of being discharged after the initial investigation is high. There were no significant differences in mortality and ICU transfer. This result was expected as the most severe patients (those requiring urgent vital treatment, the severe immunocompromised patients and those not mentally able to consent) were excluded from the study.

Interpretation

As pneumonia, UTIs and cellulitis account for two-thirds of all ED infections, it is important to have guidelines for the diagnosis and treatment of these diseases. If rapid and accurate diagnostics is available, we can treat these infections with targeted antibiotic treatment, thus contributing to the reduction of broad-spectrum antibiotics for the majority of infections in the ED.

Even though the population has aged and changed over the past several years, same symptoms and signs are still an important part of the physician's preliminary infection diagnosis.

In the future, diagnostic algorithms, including artificial intelligence algorithms, may support the physician's preliminary infection diagnosis. This study summarises the factors that may be of greatest value to include in such diagnostic algorithms.

Strengths, limitations and generalisability

A strength of this study was the pragmatic approach, reflecting real-life routine practice conditions and the immediate transferability of these results in clinical practice. However, the pragmatic design means our results can only be compared with similar settings.

The diagnosis was assigned by an expert panel instead of using the diagnostic code registered in the medical record commonly used in register studies.[18] We believe using an expert panel makes the assigned diagnoses more credible since the expert panel reviewed all the notes in the medical record, the blood test results, the radiological examinations and other diagnostics tests and examinations. However, the expert panel did not use scoring systems or algorithms; only their experience and knowledge were used to determine the diagnoses, which challenges reproducibility and generalisability.

Convenience sampling was chosen based on what could succeed in practice (eg, presence of study staff for recruitment and data collection, presence of hospital staff informed about the project). This introduces selection bias and may affect generalisability. The results can therefore only be applied to mentally competent adults admitted on weekdays during the daytime. Patients hospitalised at night or during weekends could be systematically different, and the same applies to the excluded

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patients, such as the immunocompromised patients. A Danish study identified that patients hospitalised out-of-office hours were more often admitted to intensive care and had a higher mortality.[44] However, we do not consider these limitations to affect our results significantly. Future research should focus on patient selection. However, around-the-clock inclusion of patients for research can pose execution challenges due to the required extra resources and costs.

Another potential selection bias was the inclusion of patients with suspected infection only as opposed to all adults admitted to the ED. This weakness resulted in patients not initially identified as infected by the ED physician being missed. This may have resulted in a higher prevalence of infections and fewer true negatives and false negatives in our study compared with the general ED population. We also experienced that some emergency physicians were reluctant to suspect an infection if unsure, which might have resulted in less uncertain conditions and a higher sensitivity. However, this was not measured but only an experience. It reflects the work in the ED where the physicians need to be safe rather than sorry. Another weakness is that the study recruited patients during the coronavirus disease pandemic in 2019, which affected the distribution of infections.

We generally had low levels of missing data and classified missings as missing completely at random or at random. The statistical analyses performed in this study were sub-analyses of the main multifaceted study. Therefore, there is a risk of type II errors in relation to the power calculation.

CONCLUSION

Four out of five patients with a preliminary diagnosis of infection had a reference diagnosis of infection. The primary infections were CAP, UTI with systemic symptoms and cellulitis. Physicians' preliminary infection diagnoses were moderate in accordance with the reference expert diagnoses. Fever, male sex, high CRP level, heart rate of >90 beats/min, oxygen saturation of ≤96, symptom onset of less than 3 days and abnormal neutrophilocyte and leukocytes were correlated to an infection diagnosis.

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Contributors HS, OG, FSR and CBM conceptualised the study, and all authors designed the study and data collection in detail. HS, AH and MBC reviewed the literature. AH, MHL, MBC, MAH, FK and JJS were project staff recruiting the patients and collecting data. HS supervised data collection and analysis. CBM, MAH, MJHL, PAM, SN, JJ, BTR and SP constituted the expert panel. HS, AH and MBC conducted the data management and statistical analysis, and HS wrote the first manuscript, which was critically reviewed by all authors, who finally approved the manuscripts before submission. HS and CBM are responsible for the overall content as guarantors. The corresponding author attests that all listed authors meet authorship criteria and that all others meeting the criteria have been included.

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REFERENCES

1 Collaborators AR. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet* 2022;400.
2 World Health Organization. *Antimicrobial Resistance: Global Report on Surveillance*. Switzerland: World Health Organization, 2014.
3 Ho CS, Wong CTH, Aung TT, *et al*. Antimicrobial resistance: a concise update. *Lancet Microbe* 2024;2024:100947.
4 On J. Tackling Drug-Resistant Infections Globally: Final Report and Recommendations. London: Wellcome Trust and UK Department of Health, 2016.
5 Newman-Toker DP, Badihian S, *et al*. Diagnostic errors in the emergency department: a systematic review. Agency for Healthcare Research and Quality; 2022.
6 Hautz WE, Kämmer JE, Hautz SC, *et al*. Diagnostic error increases mortality and length of hospital stay in patients presenting through

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the emergency room. *Scand J Trauma Resusc Emerg Med* 2019;27:54.
7 Bastakoti M, Muhailan M, Nassar A, *et al*. Discrepancy between emergency department admission diagnosis and hospital discharge diagnosis and its impact on length of stay, up-triage to the intensive care unit, and mortality. *Diagnosis (Berl)* 2021;9:107–14.
8 Newman-Toker DE, Schaffer AC, Yu-Moe CW, *et al*. Serious misdiagnosis-related harms in malpractice claims: The 'Big Three' - vascular events, infections, and cancers. *Diagnosis (Berl)* 2019;6:227–40.
9 The top 10 causes of death: world health organization. 2018. Available: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death
10 Kennedy M, Joyce N, Howell MD, *et al*. Identifying infected emergency department patients admitted to the hospital ward at risk of clinical deterioration and intensive care unit transfer. *Acad Emerg Med* 2010;17:1080–5.
11 Calle P, Cerro L, Valencia J, *et al*. Usefulness of severity scores in patients with suspected infection in the emergency department: a systematic review. *J Emerg Med* 2012;42:379–91.
12 Miller AC. What's new in critical illness and injury science? The use of risk stratification tools in patients with suspected sepsis in the acute care settings. *Int J Crit Illn Inj Sci* 2023;13:1–3.
13 Wachter RM, Holmboe ES. Diagnostic errors and patient safety. *JAMA* 2009;302:258.
14 Lee C-C, Chen S-Y, Chang I-J, *et al*. Comparison of clinical manifestations and outcome of community-acquired bloodstream infections among the oldest old, elderly, and adult patients. *Medicine (Baltimore)* 2007;86:138–44.
15 Trick WE, Weinstein RA, DeMarais PL, *et al*. Colonization of skilled-care facility residents with antimicrobial-resistant pathogens. *J Am Geriatr Soc* 2001;49:270–6.
16 Ducharme J, Neilson S, Ginn JL. Can urine cultures and reagent test strips be used to diagnose urinary tract infection in elderly emergency department patients without focal urinary symptoms? *CJEM* 2007;9:87–92.
17 Woodford HJ, George J. Diagnosis and management of urinary tract infection in hospitalized older people. *J Am Geriatr Soc* 2009;57:107–14.
18 Chandra A, Nicks B, Maniago E, *et al*. A multicenter analysis of the ED diagnosis of pneumonia. *Am J Emerg Med* 2010;28:862–5.
19 Cartuliares MB, Sundal LM, Gustavsson S, *et al*. Limited value of sputum culture to guide antibiotic treatment in a Danish emergency department. *Dan Med J* 2020;67:A11190641.
20 Reed WW, Byrd GS, Gates RH Jr, *et al*. Sputum gram's stain in community-acquired pneumococcal pneumonia. A meta-analysis. *West J Med* 1996;165:197–204.
21 Gentilotti E, De Nardo P, Cremonini E, *et al*. Diagnostic accuracy of point-of-care tests in acute community-acquired lower respiratory tract infections. A systematic review and meta-analysis. *Clin Microbiol Infect* 2022;28:13–22.
22 Arvig MD, Mogensen CB, Skjøt-Arkil H, *et al*. Chief Complaints, Underlying Diagnoses, and Mortality in Adult, Non-trauma Emergency Department Visits: A Population-based, Multicenter Cohort Study. *West J Emerg Med* 2022;23:855–63.
23 Gordon LB, Waxman MJ, Ragsdale L, *et al*. Overtreatment of presumed urinary tract infection in older women presenting to the emergency department. *J Am Geriatr Soc* 2013;61:788–92.
24 Caterino JM, Leininger R, Kline DM, *et al*. Accuracy of Current Diagnostic Criteria for Acute Bacterial Infection in Older Adults in the Emergency Department. *J Am Geriatr Soc* 2017;65:1802–9.
25 Newman-Toker DE, Pronovost PJ. Diagnostic errors--the next frontier for patient safety. *JAMA* 2009;301:1060–2.
26 Skjøt-Arkil H, Heltborg A, Lorentzen MH, *et al*. Improved diagnostics of infectious diseases in emergency departments: a protocol of a multifaceted multicentre diagnostic study. *BMJ Open* 2021;11:e049606.
27 Elm E von, Altman DG, Egger M, *et al*. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ* 2007;335:806–8.
28 Katz S. Assessing Self-maintenance: Activities of Daily Living, Mobility, and Instrumental Activities of Daily Living. *J American Geriatrics Society* 1983;31:721–7.
29 Nordberg M, Lethvall S, Castrén M. The validity of the triage system ADAPT. *Scand J Trauma Resusc Emerg Med* 2010;18:36.
30 Harris PA, Taylor R, Thielke R, *et al*. Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377–81.
31 Calbo E, Alsina M, Rodríguez-Carballeira M, *et al*. The impact of time on the systemic inflammatory response in pneumococcal pneumonia. *Eur Respir J* 2010;35:614–8.
32 Méndez R, Menéndez R, Cillóniz C, *et al*. Initial Inflammatory Profile in Community-acquired Pneumonia Depends on Time since Onset of Symptoms. *Am J Respir Crit Care Med* 2018;198:370–8.
33 Goto T, Yoshida K, Tsugawa Y, *et al*. Infectious Disease-Related Emergency Department Visits of Elderly Adults in the United States, 2011-2012. *J Am Geriatr Soc* 2016;64:31–6.
34 Zandam H, Mitra M, Akobirshoev I, *et al*. Infectious Diseases-Related Emergency Department Visits Among Non-Elderly Adults with Intellectual and Developmental Disabilities in the United States: Results from the National Emergency Department Sample, 2016. *Popul Health Manag* 2022;25:335–42.
35 Caterino JM, Stevenson KB. Disagreement between emergency physician and inpatient physician diagnosis of infection in older adults admitted from the emergency department. *Acad Emerg Med* 2012;19:908–15.
36 Ray P, Birolleau S, Lefort Y, *et al*. Acute respiratory failure in the elderly: etiology, emergency diagnosis and prognosis. *Crit Care* 2006;10:R82.
37 Veldhuis LI, Gouma P, Nanayakkara PWB, *et al*. Diagnostic agreement between emergency medical service and emergency department physicians, a prospective multicentre study. *BMC Emerg Med* 2024;24:120.
38 Heckerling PS, Gerber BS, Tape TG, *et al*. Prediction of community-acquired pneumonia using artificial neural networks. *Med Decis Making* 2003;23:112–21.
39 Chumbita M, Cillóniz C, Puerta-Alcalde P, *et al*. Can Artificial Intelligence Improve the Management of Pneumonia. *J Clin Med* 2020;9:248.
40 DeWitt S, Chavez SA, Perkins J, *et al*. Evaluation of fever in the emergency department. *Am J Emerg Med* 2017;35:1755–8.
41 Caterino JM, Kline DM, Leininger R, *et al*. Nonspecific Symptoms Lack Diagnostic Accuracy for Infection in Older Patients in the Emergency Department. *J Am Geriatr Soc* 2019;67:484–92.
42 Chan Y-L, Liao H-C, Tsay P-K, *et al*. C-reactive protein as an indicator of bacterial infection of adult patients in the emergency department. *Chang Gung Med J* 2002;25:437–45.
43 Ozger HS, Senol E. Use of infection biomarkers in the emergency department. *Turk J Emerg Med* 2022;22:169–76.
44 Vest-Hansen B, Riis AH, Sørensen HT, *et al*. Out-of-hours and weekend admissions to Danish medical departments: admission rates and 30-day mortality for 20 common medical conditions. *BMJ Open* 2015;5:e006731.

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