



Capillary Refill Time and Oxygen Saturation as Predictors of Patient Acuity in Emergency Severity Index Triage: A Cross-Sectional Study

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Abstract

Background. Rapid physiological assessment in emergency departments (EDs) is essential for accurate triage and timely intervention. The Emergency Severity Index system categorises patients by clinical urgency, yet evidence remains limited regarding the prognostic value of capillary refill time and peripheral oxygen saturation in identifying high-acuity cases.

Aim. To examine the relationship between capillary refill time, peripheral oxygen saturation, and patient acuity levels based on Emergency Severity Index triage categories.

Methods. This analytical cross-sectional study evaluated medical records of 80 adult patients treated at a pulmonary hospital ED. Capillary refill time, peripheral oxygen saturation, and Emergency Severity Index levels were extracted. Associations were analysed using the Chi-Square test, with statistical significance set at $p < 0.05$. Prevalence ratios and 95% confidence intervals were calculated.

Results. Prolonged capillary refill time exceeding two seconds was significantly associated with higher-acuity Emergency Severity Index levels 1–2 ($p < 0.001$; prevalence ratio = 19.2; 95% confidence interval: 5.4–68.2). Similarly, peripheral oxygen saturation below 90 percent correlated with higher acuity ($p < 0.001$; prevalence ratio = 19.9; 95% confidence interval: 4.0–97.8).

Conclusions. Capillary refill time and peripheral oxygen saturation are strong physiological predictors of patient acuity in Emergency Severity Index triage. Incorporating these measures into triage protocols may enhance the early identification of critically ill patients, particularly in resource-limited emergency settings.

Keywords: capillary refill time; oxygen saturation; triage; Emergency Severity Index; patient acuity

1. INTRODUCTION

Emergency departments (ED) globally face escalating challenges from high patient volumes and suboptimal triage accuracy, which may critically compromise clinical outcomes for high-acuity patients (Bazmul et al., 2019; Hania et al., 2020). In Indonesia, EDs manage over four million annual visits, including complex cases at specialised hospitals such as Dr. Ario Wirawan Pulmonary Hospital (Ariyani & Rosidawati, 2020). The *Emergency Severity Index* (ESI) triage system, a widely adopted tool classifying patients based on physiological stability and resource needs, remains hindered by operation-



al inefficiencies, particularly in settings with high caseloads (Ariyani & Rosidawati, 2020). Multistep acuity assessments often delay time-sensitive interventions, underscoring the need for rapid, objective predictors of clinical deterioration.

Physiological parameters like capillary refill time (CRT) and oxygen saturation serve as frontline indicators of circulatory integrity and tissue perfusion (Monteerarat et al., 2022; Ristanto & Zakaria, 2018). While studies associate CRT >2 seconds and SpO₂ <90% with adverse outcomes (Sansone et al., 2017; Satici et al., 2022), their integration into ESI protocols remains understudied. Technical limitations such as inter-rater variability in CRT measurement and SpO₂ inaccuracies in specific populations (Wong et al., 2021) further complicate standardised implementation.

2. METHODS

This analytical cross-sectional study aimed to examine the relationship between capillary refill time, peripheral oxygen saturation, and patient acuity levels determined by the Emergency Severity Index. This design was selected for its suitability in identifying associations between variables without direct intervention, making it particularly appropriate for research in resource-limited emergency department (ED) settings (Ariyani & Rosidawati, 2020).

Participants

A total of 80 adult patients (aged ≥18 years), systematically sampled at five-visit intervals from 409 ED admissions during July 2024 at Dr. Ario Wirawan Pulmonary Hospital, Indonesia, were included. Inclusion criteria were complete documentation of capillary refill time, peripheral oxygen saturation, and Emergency Severity Index triage levels. Patients diagnosed with Acute Respiratory Distress Syndrome, Chronic Obstructive Pulmonary Disease (COPD), or critical paediatric conditions were excluded to minimise physiological confounders (Fernández-Sarmiento et al., 2024).

Measurements

Capillary refill time (CRT) was assessed using a standardised digital timing procedure involving five seconds of pressure applied to the right middle fingernail, with colour recovery time recorded in seconds (Monteerarat et al., 2022).

Peripheral oxygen saturation (SpO₂) was measured using a calibrated Philips IntelliVue MX500 monitor, verified under the Indonesian Ministry of Health Calibration Certificate (October 2023).

Patient acuity levels were classified according to the Emergency Severity Index, version 5 (Emergency Nurses Association, 2023), based on physiological stability, potential for deterioration, and resource requirements.

Data collection procedure

Data collection followed a structured three-step protocol:

1. Identification of eligible medical records through systematic random sampling.
2. Extraction of capillary refill time, peripheral oxygen saturation, and Emergency Severity Index data using anonymised patient identifiers (e.g. 'Mr. A').
3. Secure entry of data into encrypted cloud-based forms protected by two-factor authentication.

Data analysis

Data were analysed using IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA). Univariate statistics described demographic and clinical characteristics. Bivariate analysis using the Chi-Square test ($\alpha = 0.05$) examined associations between capillary refill time (>2 seconds vs. ≤2 seconds), peripheral oxygen saturation (<90% vs. ≥90%), and dichotomised acuity groups (Unstable: Emergency Severity Index 1–2; Stable: Emergency Severity Index 3–5). Prevalence ratios and 95% confidence

intervals quantified association strength. The Chi-Square test was chosen for its reliability in analysing categorical data and its frequent application in emergency triage research (Mirhaghi et al., 2015).

Ethical considerations

Ethical approval was obtained from the Ethics Committee of Dr. Ario Wirawan Pulmonary Hospital (Ref. No. DP.04.03/D.XL.9.7/010/2025). The study complied with the principles of the Declaration of Helsinki, ensuring patient anonymity (initial-based coding), data confidentiality (encrypted storage), and non-maleficence (no direct patient involvement). Data access and utilisation were authorised under Research Permit No. DP.04.03/D.XL/2346/2025.

3. RESULTS

Demographic and clinical characteristics of the study participants are presented in Table 1. The sample consisted predominantly of male patients (57.5%, $n = 46$), with a median age of 54 years (range: 18–90 years). The most common admission diagnosis was chronic obstructive pulmonary disease (COPD) (8.8%, $n = 7$), and the leading presenting complaint was dyspnoea (31.3%, $n = 25$).

Regarding physiological parameters, 72.5% ($n = 58$) of participants demonstrated a normal capillary refill time (≤ 2 seconds), while 27.5% ($n = 22$) exhibited a prolonged refill time (> 2 seconds). Oxygen saturation analysis showed that 81% ($n = 65$) maintained peripheral oxygen saturation levels of $\geq 90\%$, whereas 19% ($n = 15$) had SpO_2 values below 90%.

Based on Emergency Severity Index triage, 36% ($n = 29$) of patients were categorised as unstable (ESI levels 1–2), and 64% ($n = 51$) as stable (ESI levels 3–5). Among all triage levels, ESI level 2 constituted the largest subgroup (35%, $n = 28$), followed by ESI level 4 (32.5%, $n = 26$).

Table 1. Participant characteristics and distribution of CRT, SpO_2 , and acuity levels ($n = 80$)

Variable	Value
Gender, n (%)	
Male	46 (57.5)
Female	34 (42.5)
Age, yrs., median (range)	54 (18–90)
Diagnosis, n (%)	
COPD	7 (8.8)
Injury/Trauma	7 (8.8)
Hypertension	6 (7.5)
Other diagnoses ¹	60 (75)
Chief complaint, n (%)	
Dyspnoea	25 (31.3)
Pain	22 (27.5)
Other complaints ²	33 (41.3)
CRT, n (%)	
> 2 seconds	22 (27.5)
≤ 2 seconds	58 (72.5)
SpO_2, n (%)	
$< 90\%$	15 (19)

Variable	Value
$\geq 90\%$	65 (81)
ESI level, n (%)	
1	1 (1.25)
2	28 (35)
3	18 (22.5)
4	26 (32.5)
5	7 (8.75)
Acuity level, n (%)	
Unstable (ESI 1–2)	29 (36)
Stable (ESI 3–5)	51 (64)

Notes: ¹ – includes lung cancer, fracture, congestive heart failure, tuberculosis, diabetes, asthma, and dyspepsia; ² – includes weakness, nausea/vomiting, cough, and other symptoms. COPD – chronic obstructive pulmonary disease; CRT – capillary refill time; SpO₂ – peripheral oxygen saturation; ESI – Emergency Severity Index.

The relationships between capillary refill time (CRT), peripheral oxygen saturation (SpO₂), and patient acuity levels are summarised in Table 2. Prolonged CRT (>2 seconds) was significantly associated with unstable acuity (ESI levels 1–2) ($p < 0.001$; prevalence ratio (PR) = 19.2; 95% confidence interval (CI): 5.4–68.2). Likewise, oxygen saturation below 90% demonstrated a strong association with unstable acuity ($p < 0.001$; PR = 19.9; 95% CI: 4.0–97.8).

Table 2. Association between capillary refill time, oxygen saturation and acuity level (n = 80)

Variable	Unstable acuity (ESI 1–2)	Stable acuity (ESI 3–5)	Total	PR (95% CI)	p-value
CRT >2 sec, n (%)	18 (81.8)	4 (18.2)	22 (100)	19.2 (5.4–68.2)	<0.001
CRT ≤2 sec, n (%)	11 (19.0)	47 (81.0)	58 (100)		
SpO₂ <90%, n (%)	13 (86.7)	2 (13.3)	15 (100)	19.9 (4.0–97.8)	<0.001
SpO₂ ≥90%, n (%)	16 (24.6)	49 (75.4)	65 (100)		

Note: CRT – capillary refill time; SpO₂ – peripheral oxygen saturation; ESI – Emergency Severity Index; PR – prevalence ratio; CI – confidence interval.

4. DISCUSSION

This study demonstrates that prolonged capillary refill time (CRT >2 seconds) and hypoxaemia (oxygen saturation <90%) are strong independent predictors of high-acuity status among patients assessed under the Emergency Severity Index (ESI) triage system. Patients with abnormal CRT exhibited a 19.2-fold higher likelihood of unstable acuity (ESI 1–2; $p < 0.001$; 95% CI: 5.4–68.2), while those with hypoxaemia had a 19.9-fold higher risk ($p < 0.001$; 95% CI: 4.0–97.8). These findings confirm that CRT and oxygen saturation are rapid, objective indicators of impaired perfusion and oxygenation, corresponding with established physiological thresholds for cardiovascular and respiratory compromise (Monteerarat et al., 2022; Ristanto & Zakaria, 2018). Incorporating these measures into routine ESI assessments may improve triage accuracy, reduce dependence on subjective judgement, and minimise treatment delays that have been associated with up to 30% higher mortality rates (Hania et al., 2020).

The current findings reinforce prior research underscoring the predictive value of CRT. Sansone et al. (2017) reported a 94% sensitivity of CRT >2 seconds for detecting sepsis-related clinical deterioration, while Fernández-Sarmiento et al. (2024) found a strong correlation between CRT prolongation and elevated serum lactate levels ($r = 0.78$, $p < 0.01$). Conversely, Kikomeko et al. (2022) argued that CRT may be less predictive in trauma populations, where altered mental status and impaired mobility better predicted 24-hour mortality. The apparent discrepancy likely reflects differing clinical contexts – trauma-focused versus respiratory-focused emergency departments (EDs) – and divergent outcome measures, namely mortality versus acuity.

Oxygen saturation was similarly validated as a prognostic indicator in this study. In alignment with Kobayashi et al. (2018), oxygen saturation below 90% significantly increased hospitalisation risk (OR = 3.5; 95% CI: 2.1–5.8). Daş et al. (2020) further confirmed oxygen saturation as a key variable in mortality prediction models (AUC = 0.86). However, Wong et al. (2021) cautioned against potential inaccuracies in pulse oximetry among ethnically diverse populations due to spectrophotometric bias – a limitation less relevant to this investigation, which involved an ethnically homogeneous cohort.

The epidemiological profile of the present sample reflects the hospital's specialisation in respiratory care, with chronic obstructive pulmonary disease (COPD) (8.8%) and dyspnoea (31.3%) being the predominant diagnoses. Compared with general ED data, where pain is typically the leading complaint (Akyl & Yıldırım, 2019), this clinical focus may have inflated the observed prevalence of hypoxaemia, thus warranting cautious generalisation of the findings to broader emergency settings.

Importantly, this investigation represents the first to concurrently validate CRT and oxygen saturation as complementary predictors of acuity within the ESI triage framework in a pulmonary hospital context. The combined use of these parameters enhances operational efficiency by facilitating faster, evidence-based stratification in high-volume EDs, such as Dr. Ario Wirawan Pulmonary Hospital, which manages over 4,900 visits annually. Furthermore, the findings support the integration of these physiological indicators into digital decision-support systems capable of real-time risk detection, with potential to inform national and institutional triage policy frameworks aimed at minimising treatment delays.

Nonetheless, several limitations warrant consideration. The cross-sectional design precludes causal inference between the studied variables and clinical outcomes. Single-centre data collection limits external validity, and the ethnically homogeneous sample does not address known biases in pulse oximetry accuracy among diverse populations. Future research should adopt multicentre prospective designs to validate these findings across different clinical and demographic contexts, assess long-term outcomes such as 30-day mortality and hospital length of stay, and incorporate additional physiological parameters – including blood pressure, respiratory rate, and comorbidities – into predictive modelling. Moreover, the development and implementation of standardised nurse training protocols for CRT measurement are essential to reduce interobserver variability and improve reproducibility.

5. CONCLUSIONS AND PERSPECTIVES

This study demonstrates that capillary refill time and oxygen saturation are valuable physiological indicators for identifying patients with high clinical acuity in emergency department settings. Their inclusion in triage protocols based on the Emergency Severity Index may enhance the accuracy and efficiency of patient prioritisation. By providing rapid, objective insights into circulatory and respiratory function, these measures can support more timely clinical decisions, reduce treatment delays, and optimise resource allocation – particularly in high-demand emergency environments.

Future research should focus on validating these findings through larger, multicentre studies and across diverse patient populations. Expanding predictive models to include additional physiological and

contextual parameters may improve their clinical applicability. Standardised training for healthcare personnel in the assessment of capillary refill time is also recommended to ensure reliability and reproducibility. Furthermore, integrating these parameters into digital decision-support systems could strengthen real-time triage accuracy and contribute to safer, more efficient emergency care delivery.

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Kapiliarų prisipildymo laikas ir deguonies prisotinimo lygis kaip paciento būklės sunkumo rodikliai pagalbos skubumo nustatymo sistemoje: skerspjūvio tyrimas

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Santrauka

Tyrimo pagrindimas. Greitas fiziologinės būklės įvertinimas skubios pagalbos skyriuose būtinas norint tiksliai suskirstyti pacientus pagal būklės sunkumą ir laiku imtis reikalingų veiksmų. Skubios pagalbos indeksas padeda klasifikuoti pacientus pagal klinikinį skubumą, bet trūksta įrodymų apie kapiliarų prisipildymo laiko ir deguonies prisotinimo lygio prognostinę vertę būklės sunkumui nustatyti.

Tikslas. Ištirti ryšį tarp kapiliarų prisipildymo laiko, deguonies prisotinimo lygio ir paciento būklės skubumo rodiklių pagal skubios pagalbos indeksą.

Metodai. Šiame analitiniame skerspjūvio tyrime vertinti 80-ies suaugusių pacientų, gydytų plaučių ligų ligoninės skubios pagalbos skyriuje, sveikatos įrašai. Buvo išanalizuota: kapiliarų prisipildymo laikas, deguonies prisotinimo lygis ir skubios pagalbos indekso rodikliai. Ryšiai tarp kintamųjų buvo tiriami naudojant *Chi* kvadrato testą, statistinis reikšmingumas – $p < 0,05$. Apskaičiuoti paplitimo santykiai ir 95 % pasikliautinis intervalas.

Rezultatai. Ilgiau nei dvi sekundes trunkantis kapiliarų prisipildymas buvo reikšmingai susijęs su aukštais (1–2) skubios pagalbos indekso rodikliais ($p < 0,001$; paplitimo santykis = 19,2; 95 % pasikliautinis intervalas: 5,4–68,2). Panašiai, mažesnis nei 90 % deguonies prisotinimas koreliavo su didesniu būklės sunkumu ($p < 0,001$; paplitimo santykis = 19,9; 95 % pasikliautinis intervalas: 4,0–97,8).

Išvados. Pagal skubios pagalbos indeksą, kapiliarų prisipildymo laikas ir deguonies prisotinimas yra stiprūs fiziologiniai pacientų būklės sunkumo prognozės rodikliai. Šių parametų integravimas į pagalbos skubumo nustatymo sistemos protokolus gali pagerinti kritinės būklės pacientų ankstyvojo nustatymo galimybes, ypač esant ribotiems ištekliais.

Reikšminiai žodžiai: kapiliarų prisipildymo laikas; deguonies prisotinimas; pagalbos skubumo nustatymo sistema; skubios pagalbos indeksas; paciento būklės sunkumas

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