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(Research Article)

Evaluate how daily collective physiological parameter monitoring affects medically admitted patient outcomes

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Abstract

Aim: This study aimed to analyze the prognostic significance of vital signs in patients, focusing on trending patterns rather than actual assessments. It assessed the relationship between monitored vital signs and adverse outcomes.

Methods: This study examines the prognostic performance of three trending vital signs in patients admitted to the ICU between January 2023 and May 2024. The three primary vital signs were mean arterial blood pressure (MAP), heart rate (HR), and core body temperature (Temp). The study used the Binary Logistic Regression test and sensitivity analyses to determine the best sensitivity and specificity for the predictors. The sensitivity indices included true positive rate (TPR), true negative rate (TNR), positive predictive value (PPV), negative predictive value (NPV), and accuracy indices (AI). The study used SPSS Statistics Version 25 for analysis, with a P-value below 0.05 considered statistically significant. The study adhered to the principles of the Helsinki Declaration and adhered to the principles of the Helsinki Declaration.

Results: The study used Binary Logistic Regression models to analyze patients' vital signs and overall critical illness mortality. The models identified variations in dependent variables and accurately classified 77.6%, 79.6%, and 79.4% of cases. Sensitivity analysis revealed that increased values of Temp_Trending and HR_Trending indicate a positive actual state, while diminished values of MAP_Trending suggest a favorable condition. The optimal cut-off points, sensitivities, specificities, positive and negative predictive values, likelihood ratios, and Youden and accuracy indices were found for the six evaluated patients' vital signs.

Conclusion: Utilising dynamic tracking for vital signs in hospitalised patients with a tendency for rapid fluctuations may enhance prognostic performance and utility in predicting adverse outcomes, including prolonged length of stay and mortality.

Keywords: Vital signs; Poor Clinical Outcomes; Medically admitted patients; Risk stratification.

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1. Introductions

Vital signs are utilised daily across all healthcare departments to assess and diagnose newly admitted patients, identify those at highest risk for prioritisation, monitor patients experiencing rapid deterioration, and forecast the outcomes of their care [1-2]. Prompt triaging and risk stratification facilitate the immediate transfer of patients to advanced critical intervention upon arrival at the emergency department, potentially yielding favourable clinical outcomes and reducing the exacerbation of adverse effects, including prolonged hospital stays, failure of mechanical ventilation extubation, biochemical laboratory abnormalities, haemodynamic instabilities, and overall mortality, including early mortality [3-4].

There is insufficient data demonstrating a definitive correlation between a patient's vital signs and their general health, with most findings focussing on individual haemodynamic parameters rather than examining them collectively [5-6]. Utilising haemodynamics as a sole discriminative threshold in clinical practice for assessing a patient's haemodynamic status has a significant risk of both overestimation and underestimating [7-8]. For instance, adopting an optimal cutoff point for mean arterial pressure (MAP) of 65 mmHg for triaging and diagnosing septic shock presents several drawbacks in haemodynamically unstable patients, particularly within the critical care cohort, as the MAP value may be misinterpreted above and below this predefined threshold, leading to erroneous interventional outcomes [9-10].

Furthermore, many of these monitored vital signs of relevance may exhibit non-linear correlations and could follow exponential or U-shaped patterns associated with poor bad outcomes and patient prognosis [11-12]. Nevertheless, integrating these highly variable vital signs with other more stable indices and scores, particularly the systemic inflammatory response syndrome (SIRS) criteria, systemic immune-inflammation index (SII), systemic inflammatory response index (SIRI), and either the standard sequential organ failure assessment (SOFA) score or its abbreviated version (qSOFA), may enhance prognostic potential and performance [13-14].

Indeed, these intriguing vital signs are typically influenced by physiological changes associated with ageing, comorbidities, and the utilizing medication. For example, artery walls stiffen with age, stress-induced compensatory heart rates become less sensitive, and reactive core body temperatures may be reduced in more advanced clinical circumstances [15-16]. This is why ageing potential confounders were incorporated into the conventional comorbidity burden typically represented by the composite tool of the Charlson Comorbidity Index (CCI) in a more effective modified comorbidity burden assessment tool known as the Age-Adjusted Charlson Comorbidity Index (AACCI) [17-18]. It is crucial that the vital signs of attending or admitted patients be assessed and altered according to their age-adjusted comorbidity burden indexes [19].

While adopting a binary threshold for the vital signs of attending patients may appear more practical, employing more sophisticated serial cutoff points for these assessed vital signs in a dynamic trending assessment could prove significantly more valuable in early triage, diagnosis, prognosis, pharmacotherapeutic intervention, and overall clinical management, facilitating a comprehensive and proactive plan for patients in emergency rooms and those admitted [20].

The objective of this study was to examine the prognostic significance of the vital signs of attended and admitted patients based on their trending patterns rather than their actual or average assessments and discriminative values. In this study, we aimed to assess the regression associations between the monitored vital signs—mean arterial blood pressure, heart rates, and core body temperature—and the likelihood of composited adverse outcomes, including prolonged length of stay, suspected oxygen desaturation on room air, transfer to critical care, haemodynamic and biochemical instability, and mortality.

2. Methods

This retrospective observational single-center study comprised patients who attended our institutional emergency room and were subsequently admitted to our medical departments at the King Hussein Medical Centre within the Royal Medical Services in Amman, Jordan. This study received initial approval from the Jordanian Royal Medical Services (JRMS) Institutional Review Board (IRB) at 4 February 2025 under registration number 6_2/2025. This sanctioned study received formal approval for publishing following evaluation by our institutional Directorate of Professional Training and Planning at 24 February 2025. This study rigorously adhered to the principles of the Helsinki Declaration. Data regarding all eligible patients will be obtained from Hakeem. Patients with significant missing data on the researched parameters or comparative variables will be excluded from our study. We examined all significant vital signs from the eligible patients admitted to the ICU between January 2023 and May 2024. The patients' mean arterial blood pressure (MAP), heart rate (HR), and core body temperature (Temp) were identified as the three primary vital signs of interest in the investigation. A trending score for the monitored vital signs was determined by evaluating the average changes in higher and lower values of these three vital signs of interest, followed by calculating their trending propensity and pattern using the equation: 100 – [100 / (1 + (Average of Upward Change / Average of Downward Change))]. The Binary Logistic Regression test was conducted for each predictor in relation to total mortality to obtain the coefficients necessary for the examined Binary Logistic Regression models. Furthermore, the associated variability in prediction quality and the importance of the chi-square statistics were also summarised correspondingly. Additionally, sensitivity analyses were undertaken to examine the thresholds that provide best sensitivity and specificity, yielding the greatest values of the Youden index. Furthermore, the pertinent sensitivity indices encompass the true positive rate (TPR) or sensitivity, true negative rate (TNR) or specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy indices (AI). The receiver operating characteristic (ROC) studies were conducted to derive the area under the generated curves, adjusted for standard errors and 95% confidence intervals. However, these abstractions are represented under ROC curves, and the sensitivity indices served as the standard metric for this study to assess the prognostic performance and utility of the three trending vital signs in predicting poorer composite outcomes, rather than the likelihood of naive adverse outcomes in the investigation. A P-value below 0.05 was considered statistically significant. Confidence intervals at a 95% level were calculated. Analyses were conducted using SPSS Statistics Version 25 (IBM).

3. Results

The Binary Logistic Regression models for patients' vital signs (Temp_Trending, MAP_Trending, and HR_Trending) and overall critical illness mortality were statistically significant, exhibiting χ2(df) values of (8) 79.879, (8) 985.175, and (6) 437.748, respectively, in comparative analysis. Our models elucidated variations in the dependent tested variables, which spanned from 27.9% to 43.8%, 1.1% to 1.8%, and 17.4% to 27.4%, contingent upon the utilisation of the Cox & Snell R2 or Nagelkerke R2 methodologies. They accurately classified 77.6%, 79.6%, and 79.4% of the cases, respectively. Table 1 presents the outcomes of the Binary Logistic Regression analysis for the patients' vital signs.

Table 1 Binary Logistic Regression results for the evaluated patients' vital signs about the likelihood of adverse composite outcomes of interest.

Tested predictors		**B±SEM**	**Wald**	**Sig.**	**Exp(B)**	**95% C.I.for EXP(B)**		**χ2(df)**	**VR**	**%Cases**
						Lower	**Upper**			
Temp_Trending										
	Constant	-10.779±0.646	278.570	0.000	0.000			(8) 79.879	27.9%-43.8%	77.6%
		0.359±0.020	312.185	0.000	1.431	1.375	1.489			
MAP_Trending										
	Constant	3.148±0.374	70.951	.000	23.296			(8) 985.175	1.1%-1.8%	79.6%
		-0.048±0.010	23.890	.000	0.953	0.934	0.971			
HR_Trending										
	Constant	0.158±0.075	4.415	0.036	1.171			(6) 437.748	17.4%-27.4%	79.4%
		0.035±0.002	330.066	0.000	1.035	1.032	1.039			
The Binary Logistic Regression Test was performed to examine the extent of correlations, the proportion of total variations in the dependent variable explained by the independent factors, and the predictive quality of the dependent variable. This test was run to extract the requisite coefficients for the presented Binary Logistic Regression models.										
Temp_Trending: The relative trending index of Temperature. MAP_Trending: The relative trending index of mean arterial pressure.						VR: Variation range. HR_Trending: The relative trending index of heart rate.				

A sensitivity analysis was conducted on all 2155 cases: 1715 cases were classified as having a positive real state (Poorer outcomes of interest=1), 440 cases were classified as having a negative actual state (Better outcomes of interest=0), and 5 cases were classified as having missing data. Increased values of Temp_Trending and HR_Trending provide better evidence for a positive actual state. Conversely, diminished values of MAP_Trending provide greater evidence of a favourable actual condition. ROC analysis was performed on the three comparative vital signs to determine the area under the ROC curve for each (AUROC). The AUROC±SEM for Temp_RTI, MAP_RTI, and HR_RTI were 0.839±0.008 (95% CI: 0.823-0.855), 0.633±0.015 (95% CI: 0.604-0.661), and 0.788±0.010 (95% CI: 0.768-0.807), respectively. Table 1 presents Binary Logistic Regression models that elucidate the trending indices of the three examined variables.

The optimal cut-off points, sensitivities, specificities, positive and negative predictive values, likelihood ratios, and Youden and accuracy indices for the six evaluated patients' vital signs' relative trending indexes were [(36.750, 70.8%, 1.4%, 69.48%, 98.64%, 99.51%, 46.47%, 29.56%, 5195.34%, 76.52%), (36.4, 66.5%, 1.73%, 49.26%, 82.73%, 93.76%, 38.81%, 40.46%, 385.18%, 69.84%), and (57.065, 69.6%, 3.4%, 66.15%, 96.59%, 98.76%, 44.88%, 31.51%, 2040.51%, 75.08%), respectively]. Table 2 provided a comprehensive elucidation of the sensitivity analysis results for the performances of the three evaluated prognosticators concerning adverse outcomes of interest.

Table 2 The ideal cut-off points, sensitivities, specificities, positive and negative predictive values, likelihood ratios, Youden indices, accuracy indices, and %cOI for the trending indexes of temperature, mean arterial pressure, and heart rate in the evaluated patients.

Prognostic Indicator	Cutoff	TPR	FPR	YI	TNR	PPV	NPV	NLR	PLR	AI	%cOI
Temp_Trending	36.750	70.8%	1.4%	69.48%	98.64%	99.51%	46.47%	29.56%	5195.34%	76.52%	91.79%
MAP_Trending	36.400	66.5%	1.73%	49.26%	82.73%	93.76%	38.81%	40.46%	385.18%	69.84%	80.23%
HR_Trending	57.0650	69.6%	3.4%	66.15%	96.59%	98.76%	44.88%	31.51%	2040.51%	75.08%	89.62%

The area under the receiver operating characteristic (ROC) analysis was constructed for the tested patients' Temp_Trending, MAP_Trending, and HR_Trending regarding the composited outcomes of interest; Better composited outcomes of interest cohort (0) vs Poorer composited outcomes of interest cohort (1). The sensitivity analysis was thereafter processed on a total of 2155 processed cases; 1715-case were processed as positive actual state, 440-case were processed as negative actual state, and 5 cases were treated as missing data. Higher values of the Temp_Trending and HR_Trending indicate stronger evidence for a positive actual state. Oppositely, lower values of MAP_Trending indicate stronger evidence for a positive actual state.

TPR: True positive rate (sensitivity).
FPR: False positive rate.
YI: Youden index.
TNR: True negative ratio (specificity).
PPV: Positive predictive value.
NPV: Negative predictive value.
AI: Accuracy index.
PLR: Positive likelihood ratio.
NLR: Negative likelihood ratio.

cOI: Composited outcomes of inetrest.
Temp: The core body temperature.
HR: The heart rate.
MAP: Themean arterial pressure.

4. Discussion

Most hospital departments globally have limited presentation resources, which serve as a constraining element. For example, when evaluating the ratio of workplace physicians to skilled nurses in relation to the number of admitted patients [21]. The ratio was notably lower across worldwide institutions, particularly in critical care facilities and in low-income nations such as ours. However, the care of hospitalised patients at an acceptable level may be enhanced by employing relevant, practical, bed red flag early alerting tools derived from subjective and objective data for stratifying severity and prioritising medical and therapeutic interventions [22].

This approach may assist the collaborative team in early prognostication of adverse outcomes, particularly concerning prolonged length of stay, the necessity for non-invasive and invasive ventilation in desaturated patients, haemodynamic and biochemical lab destabilisation, transfer to advanced care facilities such as intensive care units, expenditure on restrictive antibiotics like colistin, and mortality rates [23]. This study was conducted to address a critical issue in clinical practice by examining the clinical prognostic value of available parameters, such as the vital signs of attended and admitted patients, in order to enhance their predictive performance and utility by circumventing the limitations of binary thresholds for discrimination.

Various studies indicate that daily monitoring of a patient's vital signs, particularly in cases of significant fluctuations, can elucidate the patient's general health status, uncover associated underlying conditions, and assess the functionality of their organs [24]. Numerous studies examined the potential beneficial effects on patients' health of adhering to the

Vital Signs Directed Therapy (VSDT) protocol during their treatment in emergency departments or upon admission to various hospital departments, including critical care units [25]. As previously articulated, the correlation between patients' vital signs and outcomes is significantly evolving in clinical practice. Relying on a singular threshold for risk stratification, such as 90 mmHg for systolic blood pressure or 65 mmHg for mean arterial pressure, may overlook the increased risk associated with extreme vital sign levels, particularly in critical scenarios like traumatic brain injuries and septic shock. Therefore, employing a dynamic approach that monitors trends over an conversely, the VSDT possesses significant potential for favourable outcomes when utilised appropriately [26]. This study primarily examined the efficacy of three selected vital signs in predicting unfavourable outcome rates for patients screened and hospitalised in our emergency and medical departments. The trends of each assessed vital sign were utilised to monitor these fluctuating signs in real time. Tracking trends, rather than observing a singular discriminative point, serves as an effective dynamic assessment tool that enables the observation of how outcomes vary in relation to one another throughout interventions by analysing the average changes in the ascension and descension of the monitored vital signs that were evaluated. Currently, there is a paucity of studies addressing patient parameters and indicators in a more dynamic manner, which may be more suitable for hospitalised patients who are likely to experience quick fluctuations. Most studies indicate that the optimal mean arterial pressure (MAP) for maintaining organ perfusion in critically ill patients, including those with sepsis, ranges from 65 mmHg to 70 mmHg [27].

The study's findings indicated that the optimal MAP threshold for trending patterns was established at 36.4, exhibiting a sensitivity of 66.5% and a specificity of 82.73%. Other studies indicated that a heart rate of 130 beats per minute (bpm) was deemed equivalent in significance to unconsciousness, representing the maximum level of attention. Our research indicated that the optimal HR_Trending value was 57.07, exhibiting a sensitivity of 69.6% and a specificity of 96.59%. This study was limited by its retrospective methodology, single-center approach, and very small sample size. Future research will be necessary to examine the actual correlations between trends in numerous patient tools and indicators, including vital signs, and the likelihood of adverse outcomes, particularly concerning length of hospital stay and mortality.

5. Conclusion

Utilising dynamic tracking for vital signs in hospitalised patients with a tendency for rapid fluctuations may enhance prognostic performance and utility in predicting adverse outcomes, including prolonged length of stay and mortality.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest in this manuscript

Statement of ethical approval

This study received initial approval from the Jordanian Royal Medical Services (JRMS) Institutional Review Board (IRB) at 4 February 2025 under registration number 6_2/2025. This sanctioned study received formal approval for publishing following evaluation by our institutional Directorate of Professional Training and Planning at 24 February 2025.

Statement of informed consent

Owing to the retrospective design of this study, the informed consent form was waived.

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