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Original Article

The Effect of Implementation of the National Early Warning Scoring System 2 on the Outcomes of COVID-19 Hospitalized Patients

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Abstract

Introduction It is crucial to have tools to predict the clinical deterioration of coronavirus disease 2019 (COVID-19) patients. We aimed to study the efficacy of the National Early Warning Scoring System (NEWS2) application in predicting the risk of clinical relapse and outcomes in hospitalized COVID-19 patients at Palestinian specialized centers for COVID-19.

Patients and Methods A quasi-experimental design was applied. A sample of 384 adult patients was divided into two groups. For the pre-NEWS phase (control group) and the post-NEWS phase (study group), all study participants were observed until death or hospital discharge.

Results Comparing the pre-NEWS phase with the post-NEWS phase, a significant decrease was found in the mean length of hospital stay from 8.1 ± 5.5 to 6.4 ± 5.3 days ($p = 0.002$) and a reduction in the mortality rate from 19.8% during the pre-NEWS phase to 12.5% during the post-NEWS phase ($p = 0.071$). The predictive value of NEWS was an excellent predictor of admission to the intensive care unit (ICU), as indicated by an area under the receiver operating characteristic curve of 0.91 (95% confidence interval: 0.87–0.96, $p < 0.001$). Also, a significant difference in the frequency of monitoring patients' vital signs was observed between the control group (pre-NEWS phase) and the study group (post-NEWS phase) following clinical deterioration (10.1 ± 7.8 [pre-NEWS phase] vs. 23.4 ± 0.7 [post-NEWS phase], $p < 0.001$).

Conclusion Implementation of NEWS2 showed a significant improvement in hospitalized COVID-19 patient outcomes (length of stay, predicted ICU admissions, mortality rate, and frequency of vital signs measurements), which indirectly raised the follow-up of those patients by the medical team and attributed to a significant prediction of their deterioration.

Keywords
- COVID-19
- NEWS2
- clinical deterioration
- patient outcomes
- early warning scores

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Introduction

In numerous areas of medicine, the development of clinical prediction models is prevalent.[1] In 2000, acute hospitals implemented early warning scores (EWSs) for the first time. Today, they are widely used in various clinical contexts as they provide extremely valuable information to help characterize the clinical risk of deterioration more precisely, thereby facilitating risk stratification. Although 99% of acute hospitals utilize EWS to monitor patients[2] (the National Confidential Enquiry into Patient Outcome and Death [NCEPOD], 2015), there has been little progress over the past decade in identifying and responding to deteriorating patients.[3]

EWS systems have been established and widely used in developed nations to identify clinical deterioration as soon as possible.[4] They are common in Australia, the United States, and the Netherlands.[5]

The present study aims to analyze the influence of applying the National Early Warning Score (NEWS) on coronavirus disease 2019 (COVID-19) patient outcomes, such as patient deterioration, admission to an intensive care unit (ICU), length of hospital stays, and patient mortality. We hypothesized that implementing NEWS2 would significantly improve hospitalized COVID-19 patient outcomes by decreasing the length of hospital stay, predicting ICU admissions, reducing the mortality rate, and increasing the frequency of vital sign measurements.

Patients and Methods

Design and Setting

Among hospitalized COVID-19 patients, a quasi-experimental research design was utilized. This study was performed at inpatient units in the COVID-19 Martyrs Medical Military Complex and the Palestinian Red Crescent Society Hospital, which also functioned as a certified testing and treatment facility for COVID-19 and is located in Nablus, Palestine.

Study Population

About 384 adult male and female patients who satisfied the inclusion criteria were divided into two groups: the study group (post-NEWS2) (192 patients) and the control group (pre-NEWS2) (192 patients).

By reverse transcriptase polymerase chain reaction, severe acute respiratory syndrome coronavirus-2 was detected in all adult patients admitted to our research with a confirmed diagnosis of COVID-19. Patients who were younger than 18 years, pregnant women, those with spinal cord injuries, non-COVID-19 patients, and patients who were readmitted to the unit during the trial were excluded from the study. The NEWS should not be applied to children or pregnant women since their physiological response to acute illness may be affected. Due to functional abnormalities in the autonomic nervous system, spinal cord injury patients may not be able to rely on the NEWS (especially tetraplegia and severe paralysis). These criteria were developed by the Royal College of Physicians' (RCP) 2017 standards.[6]

All adult COVID-19 patients admitted to both COVID-19 centers and those who satisfied the criteria for inclusion were enrolled in the study during the study periods: July to November 2021 for the pre-NEWS phase and December 2021 to March 2022 for the post-NEWS phase. These patients were observed daily for improvement or deterioration. The researcher categorized patient outcomes until death or discharge. The sample was selected using the following formula, with a 95% level of significance and a margin of error of 0.05:

$$n = z^2 \times p(1-p)/1 + z^2 \times p(1-p)\,/e^2 \times N;\ n = (1.96)\,2/4\,(0.05)\,2 = 384.16$$

Where p is the proportion of the population predicted to be 0.5, e is the margin of error, N is the size of the people, and z is the z-score associated with the selected significance level. The equation yielded a sample size of $n = 384$.

Validity and Reliability

The NEWS2 is the standard track and trigger early warning system used in the United Kingdom and provides a uniform observation system for patient care continuity. Ambulance services, general practice, and community assessments also use it.[7] In this study, NEWS2 was superior in its area under the receiver operating characteristic (AUROC) curve when predicting ICU admission, and the cutoff point for NEWS2 to predict in-hospital mortality was higher.

Study Protocol

For 2 weeks, using lectures, group discussions, and clinical scenarios, the researcher taught and monitored an educational program where nurses practiced using and implementing the NEWS system. The researcher educated nurses for 2 weeks on how to apply the NEWS system through lectures, group discussions, and clinical situations. The program's goals were to create a framework for communication among health care professionals and aid in knowing the physiological measurements, the rationale behind the size, and vital sign abnormalities. The program covered the advantages of NEWS, how it works, the reasons for its use, the score of physiological parameters, its thresholds and triggers, and its clinical response. The score consists of six physiological measures, including respiratory rate, oxygen saturation, pulse rate, systolic blood pressure, body temperature, and consciousness or new confusion. The study instruments are detailed in ►**Appendix 1**.

A score is assigned to each observation. When all six scores are combined, the overall NEWS is generated and configured to activate when a patient is seriously ill or has abnormal physiology. Each physiological parameter is assigned a score, with the value of the score representing how much the parameter deviates from the norm. A NEWS2 score of 5 or 6 is regarded as a critical threshold that may signal clinical worsening and should necessitate an immediate reaction by a physician or team with expertise in assessing and treating severely ill patients. An increased NEWS does not establish a diagnosis, but it does assist in identifying the risky patient who systematically requires immediate clinical assessment. The risk levels are classified as low, low-medium, medium, or high, with suggestions for appropriate clinical responses and more intensive treatment. It also provides a consistent monitoring system and continuity of treatment for patients between wards. Trends in a patient's clinical response can be monitored by regularly recording the score and providing early notifications of clinical deterioration. When early warning systems are used in close collaboration with the medical team, the patients are identified as needing special consideration. A specialist team can treat them immediately, lowering the potential adverse outcomes.[8]

Statistical Analysis

Application version 25 of the Statistical Package for the Social Sciences (SPSS) was used to tabulate and analyze the data after data collection. The quantitative data were reported using means and standard deviations. The independent sample *t*-test was used to assess group homogeneity and compare the mean frequency of patient monitoring in both groups. The significance level was established at 5% ($p = 0.05$). The homogeneity of the two groups in terms of patient outcomes and NEWS escalation categories was assessed using the chi-square proportional test. Using a post hoc chi-square test, it was determined which groups were substantially distinct.

Results

Characteristics of Patients

Patients in the control (pre-NEWS2) group were slightly but not significantly older than those in the study (post-NEWS2) group, as shown in ►**Tables 1** and **2**. The mean age of patients in the pre-NEWS phase was 62.1 ± 13.9 years, and the mean age in the post-NEWS phase was 58.1 ± 17.7 years ($p = 0.015$). On the other hand, more patients were 60 years and older ($p = 0.040$) in the pre-NEWS phase compared with those admitted during the post-NEWS phase. Patients in both groups did not differ significantly ($p > 0.05$) in terms of gender, chronic kidney diseases, chronic liver diseases, chronic lung diseases, or cardiovascular diseases.

The distribution of vaccinated and unvaccinated patients was also similar in both phases. However, more patients were 60 years and older ($p = 0.040$), had diabetes mellitus ($p = 0.010$), hypertension ($p = 0.010$), and autoimmune diseases ($p = 0.008$) in the pre-NEWS phase compared with those admitted during the post-NEWS phase.

During the pre-NEWS phase, 38 (19.8%) patients died, compared with 24 (12.5%) during the post-NEWS phase ($p = 0.071$). Of the patients admitted during the pre-NEWS phase, 49 (25.5%) required admission to the ICU, compared with 57 (29.7%) during the post-NEWS phase ($p = 0.424$). In the pre-NEWS phase, more patients received low-flow oxygen (LFO) than those admitted during the post-NEWS phase ($p < 0.001$). However, patients in both phases did not differ in terms of receiving a high-flow nasal cannula ($p = 0.060$), noninvasive positive pressure ventilation (NIPPV) ($p = 1.000$), or mechanical ventilation ($p = 0.354$). Nonetheless, more patients stayed in the hospital for 6 days or more in the pre-NEWS phase than those admitted during the post-NEWS phase ($p = 0.002$). The mean duration of hospital stay in the pre-NEWS phase was 8.1 ± 5.5 days, and the mean hospital stay in the post-NEWS phase was 6.4 ± 5.3 days ($p = 0.002$).

Table 1 Characteristics of patients included in the pre- and post-NEWS phases of the study

Variable	Pre-NEWS[a]	Post-NEWS[a]	Chi-square test	*p*-Value
Number	192	192	–	–
Age, y: $< 60/\geq 60$	78 (40.6%)/114 (59.4%)	99 (51.6%)/93 (48.4%)	4.62	0.04
Sex: female/male	98 (51%)/94 (50%)	105 (54.7%)/87 (45.3%)	0.51	0.54
Vaccination: none	101 (52.6%)	101 (52.6%)	0.0	1.0
Vaccination: one dose	67 (34.9%)	67 (34.9%)		
Vaccination: two doses	24 (12.5%)	24 (12.5%)		
Vaccination: two doses + a booster	0 (0.0%)	0 (0.0%)		
Diabetes mellitus: no/yes	89 (46.4%)/103 (53.6%)	115 (59.9%)/77 (40.1%)	7.07	0.01
Hypertension: no/yes	71 (37%)/121 (63%)	119 (62%)/73 (38%)	24.0	0.01
CKD: no/yes	172 (89.6%)/20 (10.4%)	183 (95.3%)/9 (4.7%)	4.51	0.052
Cancer: no/yes	180(93.8%)/12 (6.3%)	166 (86.5%)/26 (13.5%)	5.72	0.025
Chronic liver disease: no/yes	174 (90.6%)/18 (9.4%)	174 (90.6%)/18 (9.4%)	0	1.0
Autoimmune disease: no/yes	155 (80.7%)/37 (19.3%)	174 (90.6%)/18 (9.4%)	7.66	0.008
Chronic lung disease: no/yes	176 (91.7%)/16 (8.3%)	178 (92.7%)/14 (7.3%)	0.14	0.85
Cardiovascular disease: no/yes	132 (68.8%)/60 (31.3%)	130(67.7%)/62 (32.3%)	0.05	0.913

Abbreviations: CKD, chronic kidney disease; NEWS, National Early Warning Score.
[a]Values are expressed as number (percentage).

Table 2 COVID-19 features included in the pre- and post-NEWS phases of the study

Variable	Pre-NEWS	Post-NEWS	Chi-square test	p-Value
Number	192	192	–	–
Low-flow oxygen[a]: no/yes	10 (5.2%)/182 (94.8%)	42 (21.9%)/150 (78.1%)	22.78	< 0.001
High-flow nasal cannula no/yes	152 (79.2%)/40 (20.8%)	135 (70.3%)/57 (29.7%)	3.99	0.06
NIPPV: no/yes	166 (86.5%)/26 (13.5%)	167 (87.0%)/25 (13.0%)	0.02	1
Hospital LOS (d): $< 6/\geq 6$	80 (41.7%)/112 (58.3%)	112 (58.3%)/80 (41.7%)	10.67	0.002
Mechanical ventilation: no/yes	178 (92.7%)/14 (7.3%)	175 (91.1%)/17 (8.9%)	0.32	0.354
ICU admission: no/yes	143 (74.5%)/49 (25.5%)	135 (70.3%)/57 (29.7%)	0.83	0.424
Discharged alive: no/yes	38 (19.8%)/154 (80.2%)	24 (12.5%)/168 (87.5%)	3.77	0.071

Abbreviations: COVID-19, coronavirus disease 2019; ICU, intensive care unit; LOS, length of stay; NEWS, National Early Warning Score; NIPPV, noninvasive positive-pressure ventilation.
Note: Values are expressed as number (percentage).
[a]$SPO_2 < 94\%$.

Association between Patients Outcomes and Different Variables in the Pre-NEWS Phase

►**Table 3** shows associations between patient deterioration based on oxygen usage, admission to the ICU, and outcomes based on the length of hospitalization and hospital discharge status in the pre-NEWS phase. Receiving a high-flow nasal cannula, mechanical ventilation, and staying in the hospital for 6 days or more were not significantly associated with any of the variables such as age, gender, vaccination status, diabetes, cancer, hypertension, chronic liver disease, chronic kidney disease, autoimmune disease, or cardiovascular disease. However, receiving LFO was associated with having cancer ($p = 0.002$) and chronic liver disease ($p = 0.008$). Receiving NIPPV was not associated with chronic lung disease ($p = 0.047$). Admission to the ICU was significantly associated with having cancer ($p = 0.002$) and chronic liver disease ($p = 0.021$). Discharged dead were associated with older age ($p = 0.009$), autoimmune disease ($p = 0.020$), and cardiovascular disease ($p = 0.020$).

Relationship between Patients' Outcomes and Variables in the Post-NEWS Phase

►**Table 4** shows associations between patient deterioration based on oxygen usage, admission to the ICU, outcomes based on length of stay in the hospital, and hospital discharge status with different variables in the post-NEWS phase. Receiving LFO was associated with older age ($p = 0.001$), diabetes ($p = 0.001$), and hypertension ($p = 0.006$). Receiving a high-flow nasal cannula was significantly associated with older age ($p = 0.011$), diabetes ($p = 0.004$), and hypertension ($p < 0.001$). Furthermore, receiving NIPPV was significantly associated with older patients ($p < 0.001$), male patients ($p = 0.018$), diabetes ($p = 0.047$), and hypertension ($p = 0.025$). Receiving mechanical ventilation was significantly associated with older age ($p < 0.001$). Staying 6 days or more was significantly associated with older age ($p = 0.041$), diabetes ($p = 0.004$), hypertension ($p < 0.001$), and cardiovascular disease ($p = 0.029$). Admission to the hospital was significantly associated with older age ($p < 0.001$), male patients ($p = 0.027$), diabetes ($p < 0.001$), hypertension ($p < 0.001$), chronic liver disease ($p = 0.005$), and cardiovascular disease ($p = 0.012$). Discharged dead were associated with older age ($p < 0.001$) and cancer ($p = 0.026$).

Relationship between NEWSs and Variables

Student's t-test and analysis of variance showed that the mean NEWSs were higher for patients who were 60 years and older ($p < 0.001$), had diabetes ($p < 0.001$), hypertension ($p < 0.001$), had cardiovascular disease ($p = 0.011$), received LFO ($p = 0.001$), NIPPV ($p < 0.001$), mechanical ventilation ($p < 0.001$), were admitted to the ICU ($p < 0.001$), and discharged dead ($p < 0.001$). There was a positive correlation between age and the NEWS (Pearson's $r = 0.473$, $p < 0.001$). Additionally, there was a positive correlation between NEWSs and length of hospital stay (Pearson's $r = 0.184$, $p < 0.001$) (►**Table 5**). A multiple linear regression model included the variables significantly associated with the student's t-tests to identify the significant predictors of high and low NEWSs. ►**Tables 6** and **7** show that high NEWSs were significantly predicted by the need to receive NIPPV ($p = 0.013$), stay in the hospital for 6 or more days ($p = 0.013$), be admitted to the ICU ($p = 0.006$), and be discharged dead ($p < 0.001$).

Discussion

To the best of our knowledge, most studies have yet to directly address the impact of NEWS systems in identifying clinical deterioration and outcomes in COVID-19 hospitalized patients.

In all fields of practice, it is vital to identify patients whose conditions are deteriorating. In this investigation, the NEWS2 showed strong discrimination in predicting the combined outcome of the patient's admission to the ICU, the patient's need for intensive respiratory support as an enormous sign of deterioration, a lengthening hospital stay, and in-hospital death.

Table 3 Associations between patient deterioration and outcomes with variables in the pre-NEWS phase ($N = 185$)

Variable		Low-flow oxygen			High-flow nasal cannula			NIPPV			Mechanical ventilation			Length of stay ≥ 6 d			ICU			Discharged alive		
		N	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value
Age (y)	< 60	75	0.49	0.533	17	0.07	0.857	8	1.21	0.293	3	2.31	0.163	39	3.75	0.073	14	3.96	0.063	70	7.52	0.009
	≥ 60	107			23			18			11			73			35			84		
Gender	Female	95	1.86	0.206	17	1.48	0.286	13	0.01	1.000	8	0.23	0.783	53	1.49	0.244	21	1.76	0.191	80	0.26	0.718
	Male	87			23			13			6			59			28			74		
Vaccine dose	None	93	3.50	0.171	21	1.36	0.490	16	1.15	0.531	7	0.06	0.971	64	3.50	0.168	27	0.18	0.945	81	3.65	0.160
	One	65			12			8			5			33			16			57		
	Two	24			7			2			2			15			6			16		
DM	Yes	96	1.17	0.344	21	0.03	1.000	13	0.16	0.833	9	0.69	0.579	64	1.32	0.304	31	2.45	0.137	78	2.81	0.105
Hypertension	Yes	115	0.04	1.000	24	0.20	0.714	19	1.31	0.283	8	0.22	0.775	70	0.03	0.881	34	1.14	0.309	96	0.16	0.713
ESRD	Yes	18	1.03	0.309	6	1.13	0.380	0	3.48	0.081	0	1.75	0.369	9	1.63	0.235	7	1.06	0.415	15	0.38	0.556
Cancer	Yes	8	20.40	0.002	3	0.13	1.000	2	0.11	1.000	1	0.02	1.000	12	9.14	0.004	8	11.34	0.002	8	1.47	0.259
Chronic liver	Yes	14	11.59	0.008	7	3.91	0.065	2	0.10	1.000	1	0.09	1.000	15	5.11	0.042	9	6.23	0.021	12	2.28	0.209
Autoimmune	Yes	35	0.00	1.000	7	0.10	0.826	3	1.16	0.309	1	1.42	0.312	20	0.35	0.582	5	3.48	0.091	35	5.98	0.020
Chronic lung	Yes	14	1.87	0.198	5	1.14	0.333	5	4.65	0.047	1	0.03	1.000	10	0.13	0.796	5	0.30	0.765	14	0.58	0.537
CVD	Yes	58	0.62	0.511	15	0.92	0.444	10	0.73	0.495	6	0.94	0.373	38	0.90	0.430	18	0.92	0.374	42	5.73	0.020

Abbreviations: CVD, cardiovascular disease; DM, diabetes mellitus; ESRD, end-stage renal disease; ICU, intensive care unit; NEWS, National Early Warning Score; NIPPV, noninvasive positive pressure ventilation.

Table 4 Associations between patient deterioration and outcomes with variables in the post-NEWS phase

Variable		Low-flow oxygen			High-flow nasal cannula			NIPPV			Mechanical ventilation			Length of stay $\geq$ 6 d			ICU			Discharged alive		
		N	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value	*N*	Chi-square test	*p*-Value
Age (y)	< 60	68	10.65	0.001	21	7.03	0.011	4	14.55	0.000	0	19.86	0.000	34	4.51	0.041	19	10.79	0.001	98	24.67	0.000
	≥ 60	82			36			21			17			46			38			70		
Gender	Female	79	1.13	1.130	27	1.75	0.206	8	5.97	0.018	6	2.83	0.126	41	0.65	0.463	24	5.18	0.027	96	3.27	0.082
	Male	71			30			17			11			39			33			72		
Vaccine dose	None	84	3.83	0.162	30	0.00	1.000	15	1.69	0.469	11	1.16	0.588	44	0.37	0.856	32	0.45	0.814	84	4.42	0.110
	One	50			20			6			4			27			18			63		
	Two	16			7			4			2			9			7			21		
DM	Yes	70	12.29	0.001	32	8.68	0.004	15	4.74	0.047	10	2.72	0.122	42	8.77	0.004	37	20.77	0.000	63	3.79	0.073
Hypertension	Yes	65	8.21	0.006	34	16.09	0.000	15	5.89	0.025	9	1.76	0.200	45	19.34	0.000	38	28.23	0.000	60	3.03	0.114
ESRD	Yes	8	0.64	0.687	3	0.06	1.000	1	0.03	1.000	0	0.91	0.610	4	0.03	1.000	4	0.98	0.454	7	0.81	0.605
Cancer	Yes	22	0.74	0.457	8	0.02	1.000	5	1.02	0.345	4	1.58	0.256	12	0.25	0.672	8	0.02	1.000	19	5.69	0.026
Chronic liver	Yes	15	0.31	0.768	2	3.28	0.102	0	2.96	0.136	0	1.92	0.233	7	0.06	1.000	0	8.39	0.005	18	2.82	0.135
Autoimmune	Yes	16	1.34	0.371	4	0.53	0.593	2	0.06	1.000	2	0.13	1.000	8	0.06	1.000	3	1.61	0.282	16	0.04	1.000
Chronic lung	Yes	13	1.91	0.203	3	0.49	0.561	1	0.46	0.699	1	0.06	1.000	4	1.07	0.403	2	1.71	0.238	13	0.39	0.702
CVD	Yes	53	2.90	0.096	22	1.47	0.240	9	0.18	0.819	6	0.08	0.790	33	5.03	0.029	26	6.58	0.012	54	0.01	1.000

Abbreviations: CVD, cardiovascular diseases; DM, diabetes mellitus; ESRD, end-stage renal disease; ICU, intensive care unit; NEWS, National Early Warning Score; NIPPV, noninvasive positive pressure ventilation.

Table 5 Relationship between mean NEWSs and variables

Variables	*N* (%)	Mean (SD)	*p*-Value
Age (y): < 60/≥ 60	99 (51.6%)/93 (48.4%)	3.3 (1.5)/5.0 (2.7)	< 0.001
Sex: Female/male	105 (54.7%)/87 (45.3)	3.9 (2.2)/4.5 (2.4)	0.083
Vaccination status: none	101 (52.6%)	4.5 (0.2)	0.052
Vaccination status: one dose	67 (34.9%)	3.6 (0.2)	
Vaccination status: two doses	24 (12.5%)	4.2 (0.5)	
Vaccination status: two doses + a booster	0 (0.0%)	NA	
Diabetes mellitus: no/yes	115 (59.9%)/77 (40.1%)	3.6 (2.0)/4.9 (2.5)	< 0.001
Hypertension: no/yes	119 (62.0%)/73 (38.0%)	3.6 (2.1)/5.0 (2.4)	< 0.001
CKD: no/yes	183 (95.3%)/9 (4.7%)	4.1 (2.3)/5.2 (3.0)	0.145
Cancer: no/yes	166 (86.5%)/26 (13.5%)	4.1 (2.3)/4.6 (2.3)	0.332
Chronic liver disease: no/yes	174 (90.6%)/18 (9.4%)	4.3 (2.4)/3.1 (1.0)	0.043
Autoimmune disease: no/yes	174 (90.6%)/18(9.4%	4.2 (2.3)/3.7 (2.4)	0.418
Chronic lung disease: no/yes	178 (92.7%)/14 (7.3%)	4.1 (2.4)/4.6 (1.5)	0.466
Cardiovascular disease: no/yes	130 (67.7%)/62 (32.3%)	3.9 (2.2)/4.8 (2.4)	0.011
Use of low-flow oxygen[a]: no/yes	42 (21.9%)/150 (78.1%)	3.2 (2.7)/4/4 (2.1)	0.001
Use of high-flow nasal cannula: no/yes	135 (70.3%)/57 (29.7%)	3.3 (1.7)/6.2 (2.4)	< 0.001
Use of NIPPV: no/yes	167 (87.0%)/25 (13.0%)	3.6(1.6)/8.1/2.4)	< 0.001
Hospital LOS (d): < 6/≥ 6	112 (58.3%)/80 (41.7%)	3.2(1.5)/5.4 (2.6)	< 0.001
Mechanical ventilation: no/yes	175 (91.0%)/17 (8.9%)	3.7 (1.8)/8.6 (2.5)	< 0.001
ICU admission: no/yes	135 (70.3%)/57 (29.7%)	3.2 (1.3)/6.5 (2.4)	< 0.001
Discharged alive: no/yes	24 (12.5%)/168 (87.5%)	3.2 (1.3)/6.5 (2.4)	< 0.001

Abbreviations: CKD, chronic kidney disease; ICU, intensive care unit; LOS, length of stay; NEWS, National Early Warning Score; NIPPV, noninvasive positive-pressure ventilation; SD, standard deviation.
[a] $SPO_2 < 94\%$.

Table 6 Use of NEWSs to predict deterioration and outcomes of patients using both multiple linear regression and ROC curve analysis

Variable	Unstandardized coefficients	SE	Standardized coefficients	*T*	*p*-Value
Age	0.25	0.24	0.06	1.07	0.287
Diabetes	0.14	0.25	0.03	0.58	0.565
Hypertension	−0.06	0.26	−0.01	−0.24	0.813
Chronic liver disease	−0.15	0.36	−0.02	−0.41	0.681
Cardiovascular disease	0.34	0.25	0.07	1.39	0.167
Low-flow oxygen	0.46	0.25	0.08	1.84	0.068
High-flow nasal cannula	0.29	0.33	0.06	0.90	0.368
NIPPV	1.35	0.54	0.20	2.52	0.013
Mechanical ventilation	−0.79	0.66	−0.10	−1.20	0.231
Length of hospital stay	0.60	0.24	0.13	2.51	0.013
ICU	1.03	0.38	0.21	2.75	0.006
Discharged alive	−3.20	0.48	−0.46	−6.73	< 0.001

Abbreviations: ICU, intensive care unit; NEWS, National Early Warning Score; NIPPV, noninvasive positive pressure ventilation; ROC, receiver operating characteristic; SE, standard error.

Table 7 Use of NEWSs to predict deterioration and outcomes of patients using ROC curve analysis

Variable	AUC	*p*-Value	Lower	Upper	Sensitivity	Specificity
Low-flow oxygen	0.74	< 0.001	0.64	0.84	0.527	0.810
High-flow nasal cannula	0.87	< 0.001	0.82	0.92	0.561	0.904
NIPPV	0.95	< 0.001	0.90	0.99	0.920	0.904
Hospital stay $\geq$ 6 d	0.78	< 0.001	0.72	0.85	0.550	0.812
ICU	0.91	< 0.001	0.87	0.96	0.702	0.896
Mechanical ventilation	0.94	< 0.001	0.88	1.00	0.882	0.897
Mortality	0.96	< 0.001	0.92	1.00	0.875	0.911

Abbreviations: AUC, area under the curve; ICU, intensive care unit; NEWS, National Early Warning Score; NIPPV, noninvasive positive pressure ventilation; ROC, receiver operating characteristic.

The overall mean length of hospital stay after implementing the score was decreased, from 8.1 ± 5.5 days in pre-NEWS phase to 6.4 ± 5.3 days in post-NEWS phase which in line with those obtained in studies in countries other than China, which revealed that the median length of stay in hospitals varied from 4 to 21 days, but in China, the median length of stay in hospitals ranged from 4 to 53 days. However, an Egyptian quasi-experimental study found that there were no statistically significant changes in the total duration of hospital stays before or after the adoption of NEWS.[9]

Furthermore, the present study not only found a nonsignificant decrease in mortality rate in the study group compared with the control groups but also less than the reported mortality for all hospitalized COVID-19 patients in some European, American, and Chinese studies, with a percentage ranging between 17 and 23.4%.[10–15]

Additionally, the present study's conclusion supports Farenden et al, who found nonsignificant differences between deaths and outcomes before and after NEWS implementation.[16] But in contrast, Moon et al showed a substantial reduction in in-hospital mortality following the deployment of the NEWS system.[17]

Although the NEWS2 method assesses supplemental oxygen as a binary variable, it cannot distinguish between oxygen supply rates. The RCP has verified this issue, stating that any increase in oxygen therapy among COVID-19 patients should prompt a physician assessment and increased monitoring.[17] While it has been established that oxygen supplementation is an independent risk factor for new coronavirus pneumonia escalating to a serious situation, no previous studies have shown an association between NEWS and supplemental oxygen therapy. Some studies have established a link between the oxygen saturation measures in the score and death as a predictive physiological parameter in patients with COVID-19 infection. Liu et al found that the oxygen saturation level had a good predictive performance for predicting death.[18]

Despite the lack of published statistics on NEWS2's effectiveness in controlling COVID-19 patients' clinical deterioration, this study showed that NEWS2 was good at predicting deteriorating patients based on their oxygen requirement, with an acceptable level of sensitivity and specificity for LFO, high-flow oxygen (HFO), and mechanical ventilation (intermittent mandatory ventilation [IMV]).

In El-Hamshari et al's study,[18] ICU admission was recommended if the patient met ICU admission criteria: hemodynamic instability or an increase in acute respiratory failure demanding an increase in oxygen therapy from LFO to a nasal cannula, a simple facemask, a nonrebreathe mask (NRB), or mechanical ventilation. Receiving ICU-level care depends mainly on patients' advanced requirements for oxygen, such as HFO therapy, NIPPV, or IMV, but some patients were monitored outside the ICU on medical floors due to a lack of ICU beds. Patients' oxygen treatment increased, from NRB to HFO therapy to NIPPV. With the patients' or family's consent, intubation and IMV were considered if none of these interventions raised oxygenation to $> 90\%$ and if the patient continued worsening breathing difficulties.

No reliable prognostic score can predict clinical outcomes in patients with COVID-19, regardless of whether they are treated in an inpatient or outpatient setting.[19] The present study found that the mean NEWS during the patient's hospital stay was a good predictor of staying in the hospital for 6 days or more and an excellent predictor of admission to the ICU. Like worldwide hospital policies, most ICU admissions were estimated to take 2.0 days from hospital admission. In this study, the mean NEWS during the patient's hospital stay was an excellent predictor of mortality. These findings aligned with a few small cohort studies that looked at the predictive value of baseline NEWS2 and other clinical scoring systems in predicting clinical outcomes in COVID-19 patients based on a single measurement at the time of hospital admission. In a Chinese study of 654 COVID-19 admissions, the baseline NEWS2 had a better prediction of mortality than CURB-65 and performed better than qSOFA.[20] In a Korean study of 110 COVID-19 inpatients, using a baseline threshold of NEWS more than or equal to 5 resulted in a poor predictive value of 0.98 but a positive predictive value of 0.59 for a future event.[21] The baseline (original) NEWS anticipated an event (defined as ICU admission and death) for qSOFA. The baseline NEWS2 in a Norwegian study of 66 inpatients predicted a composite adverse outcome of inpatient death and ICU admission. This was in comparison with qSOFA's AUROC of 0.62 and CURB-65's AUROC of 0.58.[22]

The prognostic qualities of NEWS2 for admission to the ICU were similarly established in 68 patients with severe COVID-19 in another study.[23] "Serious events" were classified as any of the following occurring while the patient was hospitalized: death, an unexpected transfer to an ICU, or the start of noninvasive ventilation. With equivalent AUROC scores for predicting serious events of 0.837 for admission NEWS and 0.846 for admission, NEWS is modified by age.[24]

According to Covino et al (2020), NEWS was the most reliable indicator of ICU admission within 48 hours and 7 days of emergency department entrance. The greatest AUROC values for predicting in-hospital death, according to the findings of Liu et al.[3] However, Knight et al. (2020)[25] found NEWS with in-hospital mortality as an outcome has a good, modest predictive value for ICU admissions, which would help prioritize a huge attribution number of patients with COVID-19 who subsequently deteriorate.

The NEWS risk categorization may exist because it provides a quick and easy approach to spotting deteriorating patients using a united surveillance system that directs medical personnel to patients according to priority. This opinion is consistent with Ludikhuize et al[26] who found that NEWS, based on the decline in vital signs noted at least once in 48 hours before an adverse event, might have identified more than 80% of patients with urgent cases.

The results of this study showed that there were statistically significant differences between the study post-NEWS group and the control pre-NEWS group for the frequency of vital sign measurements as the number of vital sign measurements varied, much like in the control group. In other words, before implementing the NEWS, the staff could take vital signs twice or once during a shift. They typically only measured two parameters. However, after implementing NEWS, the mean number of vital signs monitored in the study group increased noticeably as they measured all vital sign parameters by NEWS standards. Nevertheless, the fact that there is little or no high-quality data confirming trends in the myriads of scoring systems established to predict clinical deterioration should be an important contribution to evidence-based practice.

During the COVID-19 pandemic, the researcher included all patients diagnosed with COVID-19 and admitted to the hospital, except those who met RCP-recommended exclusion criteria. Since hospital admission, we have collected comprehensive data on vital signs, covering every aspect of the NEWS2. Also, the commitment from the medical team to using the score was high, which indicates that the implementation of the score was easy and applicable based on a physiological variable and enhanced the flow of patient monitoring in a cost-effective manner. However, it is important to spell out some of this study's limitations. First, because the sample was taken from a single geographic region in Palestine in a relatively short review time and the post-NEWS data were gathered only 3 months after the score's introduction, the research findings are less likely to be generalized. Also, this was a double-center study in the same geographical area, which limits its generalization. Second, not all ward patients required to be admitted to the ICU based on their NEWS were immediately admitted to the ICU. Third, the patient's nursing staff was called first, delaying some ICU admissions when the ICU team was not available or there was a shortage of ICU beds. Fourth, because patients were not followed up after being discharged from the hospital and the study's outcomes were restricted to a hospital stay, 28- and 90-day mortality rates were not provided. Finally, a potential problem with using a control group is the risk bias caused by other concurrent changes. It could be helpful to improve predictive performance by supplementing the score parameters with additional measures, such as blood tests. Instead of creating a new EWS, which would imply a larger sample size and an external validation cohort, the purpose was to investigate the utility of the existing NEWS2 rating system in the context of COVID-19, as it is already used in medical care. Therefore, this study is expected to add value to the body of research.

Conclusion

Adoption of NEWS2 was associated with a significant prediction of patient deterioration and showed a considerable improvement in hospitalized COVID-19 patient outcomes (decreased length of hospital stay, predicted ICU admissions, and modest decrease in mortality rate), an increase in the frequency of vital signs measurements, which indirectly raised the number of medical reviews following the patient's clinical deterioration, and also that the medical team's commitment to using the score was high. This indicates that the implementation of the score was easy, applicable, and based on a physiological variable, and it enhanced the flow of patient monitoring cost-effectively.

Authors' Contribution

I.M.T. and J.Q. contributed to literature search, preparation of the manuscript, and revision of the manuscript along with this they also initiated, conceptualized, designed, and organized the research, supervised and critically reviewed the manuscript and finalized the manuscript. All authors approved the final manuscript.

Ethical Approval

An Institutional Review Board approval was granted by the An-Najah National University Research Committee (March 2022/25). Informed consent was obtained from all participants before being enrolled. Ethics approval and consent to participate in this study were carried out in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of An-Najah National University and was also obtained for all participants who participated in the study. Instructions and voluntary participation statements were included. All data collected were confidential and used only for this study.

Availability of Data

The data sets used for the current study are available from the corresponding author upon reasonable requests.

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Conflict of Interest
None declared.

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Appendix 1 Description of the study instruments

Part 1. The patient's medical record, age, gender, admitting diagnosis, prior medical history, patient score, hospital stay duration, and admission date were extracted for the medical and demographic data sheets.
Part 2. NEWS2 is a scale that can "monitor and trigger." It is an aggregate scoring system with multiple factors that measure, from 0 to 3, the deviation from expected normal levels of respiratory rate, oxygen saturation, systolic blood pressure, heart rate, body temperature, and degree of awareness. This is how the AVPU concept evaluates awareness: A = alert, V = verbal stimulus reaction, P = pain stimulus response, and U = unresponsive. Three points are awarded for the possibility of consciousness-level alteration. Each of these features is assigned a score; the scores are tallied together, and the eventual addition of additional oxygen increases the score by two points. The correlation between the patient's clinical risk and the total score points is as follows: low-risk (aggregate scores 1–4): immediate assessment by the ward nurse within 6 h to determine a change in frequency of monitoring or escalation of clinical treatment; moderate-risk (score of more than 5 or 3 in any single parameter): urgent evaluation by ward-based nurse hourly and recheck with other nurse or doctor to discover the cause and to decide on modification in monitoring frequency or escalation of clinical care; and high-risk score (7 or more): indicates that the NEWS escalation protocol will be started when the nurse contacts the physician in charge of a patient who requires an immediate assessment by the critical care team, typically resulting in patient transfer to higher dependency care settings. The escalation procedure assists clinicians in making clinical decisions. Recommendations are forwarded regarding the level of qualifications required for the condition, the evaluation interval, the level of treatment, and the activation of a medical emergency team.
Part 3. A patient outcome observational checklist was subdivided into primary outcomes. Patient deterioration represented the physiological parameters that were included in the NEWS measures. The use of oxygen support therapy, vaccination status, and the frequency of monitoring or any added special concerns or medical reviews by the health care providers were secondary outcomes, including ICU admission, length of hospital stay, and mortality. Each patient in the trial group received it. These data were used daily after utilizing the NEWS compared with the documented patient's clinical condition, use of oxygen support therapy, vaccination status, frequency of monitoring, length of hospital stay, admission to the ICU, and discharge status of the patient (alive or dead) for the control pre-NEWS implementation phase group.

Abbreviations: ICU, intensive care unit; NEWS, National Early Warning Score.

