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Research Article

Evaluation of Outcome and Performance of COVID-19 ICUs in Imam Reza General Hospital, Tabriz, Iran

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ABSTRACT

Background: The performance and outcomes of intensive care units play a critical role in determining the overall success of a healthcare system's response to the pandemic.

Methods: In this prospective study conducted between December 2021 and December 2023, data on the number of hospitalized patients, bed occupancy rate, average length of stay in the ICU, average number of admissions to the ICU, average APACHE scores of the patients on admission to the ICU, number of successful CPRs, number of deaths and discharges, and predicted mortality rate were extracted from a questionnaire completed for all COVID-19 ICUs of Imam Reza Hospital in Tabriz, Iran. Data were analyzed using SPSS ver22 software.

Results: In this study, a total of 3188 COVID-19 patients were hospitalized in the ICUs of Imam Reza Hospital during the specified period, with 2342 patients in 2021 and 846 patients in 2022. The average number of hospitalized patients per month in Imam Reza Educational Medical Center during the study period was 132.08. The average APACHE score of COVID patients on admission to the center's ICUs was on average 6.31 points higher than the global average ($P < 0.001$). In addition, the average predicted mortality rate in the center's COVID ICUs was approximately 1.08 lower than the reported global rate ($P = 0.001$).

Conclusion: The results of this study demonstrate the significant management capabilities of the hospital. The high number of COVID-19 cases, the majority of which were patients with more severe disease, confirms good to excellent patient

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management outcomes.

Introduction

Coronavirus disease 2019 (COVID-19)-related pneumonia was first reported in late December 2019 in Wuhan, Hubei, China [1-4]. The virus spread rapidly throughout China and to other countries, becoming a global concern and public health emergency [5-7]. The pathogen responsible for COVID-19 is a beta-coronavirus, namely SARS-CoV-2, which causes severe acute respiratory syndrome [8]. Coronaviruses are enveloped, single-stranded RNA viruses known for their rapid mutation and recombination properties [9]. The clinical features of COVID-19 vary, ranging from mild respiratory symptoms to severe acute respiratory infection (SARI) and acute respiratory distress syndrome (ARDS), which often require intensive care [10-15].

With the global spread of the COVID-19 pandemic, most healthcare systems were faced with the immense burden of resource allocation, selection, and clinical decision-making. With the rapidly increasing number of patients requiring intensive care, a new global challenge emerged: providing intensive care unit (ICU) beds and maintaining the quality of care for these critically ill patients. It suddenly became imperative to consider the experiences and strategies of different health care systems to find proper solutions and implement them. Intensive care unit (ICU) performance and outcomes play a critical role in determining the overall success of a health system's response to the pandemic.

Numerous systems and criteria have been introduced to determine outcomes in critically ill patients. Magunia et al. introduced a strategic system called the "Explainable Boosting Machine" as a predictor of ECMO requirements and outcomes of COVID-19 patients [16]. Furthermore, numerous chronic comorbidities such as coronary artery disease, chronic kidney disease, hypertension, diabetes, and obesity; having concomitant tumors; and some paraclinical findings have been introduced as predictors of clinical outcomes in the critically ill COVID-19 patients [17-28]. Iran suffered immensely during the COVID-19 pandemic and its subsequent outbreak waves, in terms of both the total number of COVID-19 cases and its associated mortality [14-15]. The aim of this study was to evaluate the outcomes and performance of the COVID-specialized ICUs of Imam Reza Hospital in Tabriz, Iran, affiliated with Tabriz University of Medical Sciences, and to provide a comparison between the local and global responses to this pandemic.

Methods

The study excludes the early 2020 wave due to logistical constraints during the pandemic's peak. Vaccination status was not systematically recorded, though Iran's national vaccine rollout began in February 2021 [2].

This prospective observational study included COVID-19 patients admitted to the ICUs of Imam Reza Hospital from January 2021 to December 2022. All patients with severe acute respiratory illness, diagnosed based on WHO clinical criteria, were included: acute onset of any three or more of the following signs or symptoms: fever, cough, general weakness/fatigue, headache, myalgia, sore throat, coryza, dyspnea, nausea/diarrhea/anorexia [29]. A confirmatory nasopharyngeal swab PCR test was performed for all cases. No exclusion criteria were applied. Accordingly, the number of hospitalized patients, the average ICU stay, the mean APACHE score on admission, the number of successful CPRs, and the number of deceased and discharged patients, as well as the occurred-to-predicted mortality ratio, were extracted from the questionnaires designed for data collection from all COVID-19 ICUs of Imam Reza Hospital, Tabriz, Iran. Global average APACHE scores were sourced from multinational studies using the ISA, the RIC/WHO COVID-19 dataset. The length of stay data were derived from Armstrong et al. [27] and Richardson et al. [28]. The data were collected by some of the participating authors. This study was performed in accordance with the Helsinki Declaration. It was an observational study and was initiated after obtaining the Code of Ethics and approval from the Ethics Committee of Tabriz University of Medical Sciences under the code IR.TBZMED.REC.1402.301. No intervention was performed throughout the study phases. Due to a lack of access to the full database, single values were utilized. The data were analyzed using SPSS ver. 22, and the results were represented as frequency (distribution and percentage), mean±standard deviation, and median (interquartile range, considering the non-normal distribution). To test the normality of the data distribution, the Shapiro-Wilk test was used. To analyze the data, a one-sample t-test was used since our primary aim was to compare single-group ICU metrics (e.g., APACHE scores) to known global averages (parametric data). Graphs were designed using GraphPad Prism ver. 6. $P<0.05$ was considered statistically significant.

Results

A total of 3188 COVID-19 patients were admitted to the COVID ICU departments of Imam Reza Hospital. Of these, 2342 (73.46%) were hospitalized in 2021 and 846 (26.54%) in 2022. The highest incidence occurred in February, June, and July 2021 and 846 times in 2022. The highest incidents occurred in February, June, and July 2021. The distribution in relation to the population of COVID-19 patients is shown by year by month in (Figure 1). Detailed reports on patients with COVID-19 in the special care departments of the hospital are presented in monthly mean values in (Table 1); the mean ICU stay was 7.35±1.21 days with a mean length of mechanical ventilation of 6.27±3.41 days. The APACHE score on ICU admission was 18.31±2.40. An average bed occupancy rate of 88.97% (ranging from 77.94% to 96.54%) was observed.

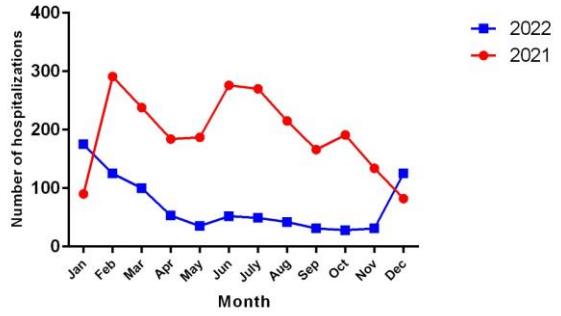

Figure 1- Admission number based on the months of the years

The hospital increased its intensive care unit capacity from 40 to 60 beds (150% capacity) during peak months (February–July 2021). Remdesivir was accessible, but because of its expensive cost, it was only used in extreme situations. Due to 12-hour nurse shifts and the redeployment of non-ICU staff, high occupancy put additional demand on medical staff and resources. A mean ratio of occurred to predicted deaths of 1.33 (1.04 - 1.95) was reported.

According to the COVID Center ICU performance analysis, based on the ratio of mortality to predicted death, the performance of the central ICU was assessed as excellent (ratio<1) in 14.3% of cases, good (ratio 1-2) in 57.1% of cases, average (ratio 2-3) in 19.5% of cases, and poor (ratio>3) in 9.1% of cases (Figure 2). When comparing the average patient length of stay in the COVID-19 Center ICUs with the global average, a statistically significant difference was observed (12.34 days), such that the median patient length of stay in the COVID-19 Center ICUs was on average 4.98 days lower than the global average (P<0.0001) (Figure 3, Table 2). When comparing the percentage of deaths in the COVID-19 Center ICUs to the global percentages, the average percentage of deaths in the COVID-19 Center ICUs was 4.24 percent lower than the global percentage but not statistically significantly different from the global average (41.6%) (P=0.129). Comparing the average APACHE score of patients entering the COVID Center ICUs with the global average revealed a statistically significant difference (score 12), such that the average APACHE score of patients entering the COVID Center ICUs was on average 6.31 points higher than the global average (P<0.0001). A statistically significant difference was observed regarding the ratio of the occurred to predicted mortality in the center's ICU with the global rate (2.77), such that the predicted mortality rate of COVID Center ICUs, on average, was about 1.08 lower than the global rate (P=0.001) (Figure 3, Table 2).

Table 1- Detailed monthly report on patients in COVID-19 ICUs of the hospital

Variable	Median (interquartile) or Mean±SD
Number of hospitalized patients	132.08±85.73
Mean ICU stay (days)	7.35±1.21
Number of intubated patients in the ICU	15.62±6.19
Number of non-intubated patients in the ICU	28.46±9.69
Number of the discharged patients	80.5 (35.75 - 113)
Number of deceased patients	46.5 (14 - 83.5)
Length of mechanical ventilation (days)	6.27±3.41
APACHE score on ICU admission	18.31±2.40
Number of successful weaning	4 (2.25 - 13.75)
Number of CPR	47 (14 - 97)
Number of successful CPRs	12 (0 - 25)
Mortality rate	37.35±13.19
Ratio of occurred to predicted deaths	1.33 (1.04 - 1.95)
Bed occupation (%)	88.97 (77.94 - 96.54)

Table 2- Comparison of the performance of COVID-19 ICUs with global averages

	Mean (SD)	Test Value	Mean Difference	95% CI of the difference		P value*
				Lower	Upper	

Average length of stay in ICU	7.35 (1.21)	12.34	- 4.98	- 5.50	- 4.47	< 0.0001
Percentage of deaths	37.35 (13.19)	41.6	-4.24	- 9.81	1.33	0.129
APACHE score	18.31 (2.40)	12	6.31	5.29	7.32	< 0.0001
Ratio of actual to predicted mortality	1.68 (1.45)	2.77	- 1.08	- 1.70	- 0.47	0.001

* One – Sample t-test

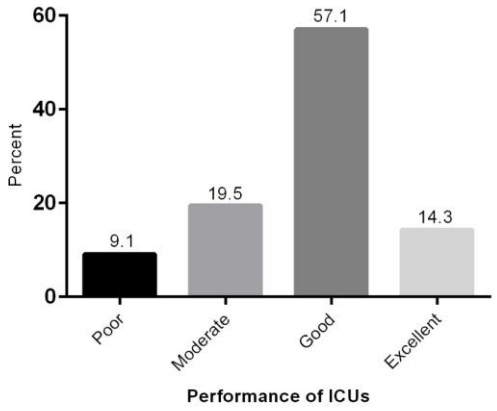

Figure 2- The performance of the COVID ICUs based on the ratio of occurred to predicted mortality

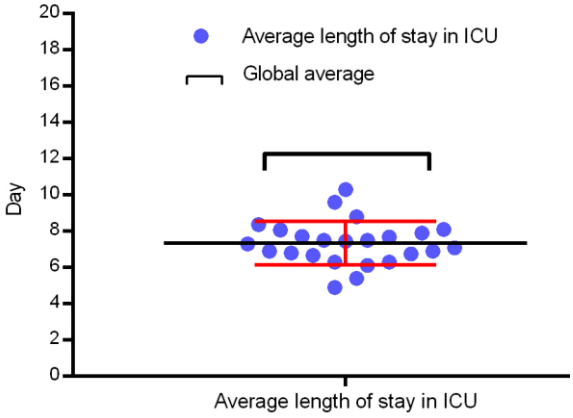

Figure 3- Distribution of the average ICU stay length in COVID central ICUs (days) compared to the global average

Discussion

Based on the data presented in the study, a total of 3188 patients with COVID-19 were hospitalized in the intensive care units of Imam Reza Hospital during the study period, which numbered 2342 people in 2021 and 846 people in 2022. This trend reflects the evolving nature of the disease in these years, with the majority of cases concentrated in 2021. These figures are also consistent with global outbreaks, where the initial wave in 2020 was accompanied by subsequent increases in cases in different regions [24]. The observation that the highest number of hospitalizations occurred in February, June, and July 2021 is consistent with the seasonal changes in COVID-19 documented in several studies. Periodicity in different regions has also been reported, with factors such as temperature, humidity, and human behavior playing a role in transmission changes [25-26].

Evaluation of ICU performance is an important aspect of health care, especially during a critical illness. We evaluated this performance by analyzing the ratio of occurred to predicted mortality. These results show that most patients received partially satisfactory care and experienced a significant proportion of excellent outcomes. When comparing these results to global standards, it is important to recognize that ICU performance can vary widely depending on region, healthcare infrastructure, and available resources. The performance of the hospital's special care unit, with a higher proportion of excellent outcomes, may indicate the effectiveness of local health care initiatives and interventions.

Understanding patient characteristics and ICU care criteria is essential to optimizing health care delivery during an all-repressive epidemic. The study provided insights into several key criteria, including average length of stay, piping rate, and mortality and morbidity rate. The average length of ICU stay at Imam Reza Hospital (7.35 days) was significantly lower than the global average in studies through 2020, often ranging from 10 to 14 days. This difference may reflect differences in patient populations, disease severity, treatment approaches, and healthcare infrastructure. The average number of intubated patients on admission or within the first 24 hours of ICU admission and the average number of non-intubated patients provide insight into the specific care needs of COVID-19 patients in this setting. Our findings are consistent with similar studies regarding the need for ventilatory support in COVID-19 patients, with some studies reporting respiratory failure rates ranging from 12% to 88% [24]. When comparing the percentage of deaths in COVID-centered ICUs with the global rate, the average percentage in COVID-centered ICUs was lower than the global percentage. Nevertheless, this difference

was statistically insignificant. It is important to note that the mortality rate can vary significantly depending on the availability of health care resources and the severity of cases admitted to the ICU [27].

The severity of illness after admission to the ICU is a key factor in patient outcome. In this study, the mean APACHE score for patients admitted to our COVID-19 ICUs was significantly higher than the global average in studies up to 2020 [28,19]. This difference suggests that patients admitted to our ICUs suffered a higher initial severity of disease, probably due to late admission or more severe cases in the area. Regarding mortality rates, our study found that the ratio of occurred to predicted deaths in COVID-19 ICUs of our center was, on average, lower than the global ratio. This indicates that the ICU's ability to manage and reduce mortality is relatively better than the global average. However, it is important to consider various factors that may influence mortality rates, including treatment protocols, patient demographics, health care capacity, and access to critical care resources.

High ICU bed occupancy rates can pose significant challenges to healthcare systems and affect the ability to provide timely care to critically ill patients. Our study found a high bed occupancy in more than 50 percent of the months studied.

Medical personnel and resources were severely strained as a result of the high ICU occupancy rate. Due to financial constraints, Remdesivir was only used for severe patients, and the number of intensive care unit beds was raised from 40 to 60 during busy months. Burnout among staff members was also exacerbated by 12-hour shifts and the redeployment of non-ICU professionals to help.

This high occupancy rate underscores the pressure on ICU resources and the importance of efficient resource management during an all-invasive illness. Resource allocation and capacity planning are critical components in managing patient growth. Several studies conducted through 2020 emphasize the need for proactive planning, including expanding ICU capacity, ensuring an adequate supply of ventilators and other critical equipment, and implementing strategies to optimize resource utilization [30].

Comparison of the study results with global averages provides valuable insights. While the average mortality rate in the COVID-19 ICU was lower than the global percentage, this difference was not statistically significant. This shows that the ICUs of Imam Reza Hospital, despite performing well in terms of mortality, are generally in line with global trends in mortality and morbidity. The predicted mortality rate was significantly lower in our COVID Center ICUs than the overall rate. On the other hand, the significant differences observed in the average length of stay and APACHE scores between the hospital and global averages show the unique characteristics of the patient population and health care delivery in this setting. A shorter average length of stay might indicate effective care processes and resource allocation strategies.

Limitations

No follow-up was performed for this study. Confounding variables such as age, comorbidities, and vaccination status were not accounted for in this study, which should be considered in future research to provide a more comprehensive understanding of ICU outcomes due to the importance of comorbidities in COVID-19 outcomes [19].

Conclusion

The results of this study demonstrate the significant management capacity of the ICUs in our hospital. The Covid-19 cases, the majority of which were patients with higher initial severity of illness, benefited from good to excellent patient management. While ICUs at Imam Reza Hospital are generally in line with global rounds in terms of mortality rates, the shorter average stay and higher APACHE scores require further research to understand the attributing factors. Findings from our study contribute to a better understanding of the management of COVID-19 in the ICU and can serve as a foundation for future research and plans to improve healthcare in the region. As the disease continues to evolve, continued evaluation and implementation of healthcare strategies will be essential to optimize patient care and outcomes. The results of this study show a significant management capacity of the ICUs at Imam Reza Hospital, with performance comparable to global trends in mortality rates. However, notable differences were observed in ICU length of stay and APACHE scores.

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Ethics approval and consent to participate

Before participation, all individuals provided informed consent via an electronic consent form. All experimental protocols were approved by the regional ethics committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.1402.301). The study was done anonymously in accordance with the World Medical Association's Declaration of Helsinki.

Authors' contributions

Conceptualization: HS, MML, SEJG, MFD, and AM. Methodology: HS, MML, ATA, MS, and SN. Formal analysis: RME. Investigation: NJ, HS. Data curation: NJ, ATA. Writing—original draft preparation: SEJG and ATA. Writing—review and editing: HS and MS. Visualization: SEJG and MML. Supervision: HS. Submission: HS. All authors have read and agreed to the last version of this manuscript.

Data availability

The datasets used and/or analyzed during the present study are available from the corresponding author upon request.

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