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ORIGINAL ARTICLE

# Analysis of Direct Costs of COVID-19 Treatment at Imam Sajjad Hospital in Shahriar

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**A B S T R A C T**

**Background**: The COVID-19 virus (Corona) is recognized as one of the greatest global health challenges in the 21st century. In addition to its unwanted effects on individual health, this disease has also had significant financial and economic impacts. Hospitals, as the most important centers for providing health services, play a very vital role.

**Methods**: This study investigated and analyzed direct costs of treating COVID-19 in Imam Sajjad (AS) State Hospital in Shahriar. To this end, after performing the Kolmogorov-Smirnov test and confirming the non-normality of data distribution, non-parametric Wilcoxon signed-rank test was used.

**Results**: The results showed that the hypothesis of normality of the data distribution for the age parameter was rejected. Also, comparisons showed that gender and age variables had an impact on treatment costs, while having an underlying disease and disease severity had no significant impact on costs. In regression analyses, costs of testing, medication, CT scan, radiology, and echocardiography had an impact on the total cost of treatment. Moreover, the cost paid by insurance was strongly correlated with the total cost of treatment.

**Conclusion**: The analyses showed that some factors such as gender, age, and specific costs such as testing and medications had an impact on treatment costs. These findings can help improve financial resource management in dealing with similar diseases.

**Keywords**: COVID-19, Treatment Costs, Hospital, Wilcoxon, Regression

## Introduction

In recent years, the COVID-19 virus has been recognized as one of the greatest global health challenges, not only having negative effects on the physical and mental health of individuals, but also causing widespread economic and social crises (1). This global crisis has created major challenges, especially in the health and treatment systems of many countries. Hospitals, as the main centers for providing health services, play a key role in dealing with this crisis, and a detailed examination of the costs associated with the treatment of this disease in hospitals is of great importance (2). While all hospitals have undertaken extensive activities to combat the COVID-19 pandemic, the lack of financial and human resources has prevented many hospitals from managing their resources properly and effectively (3). Meanwhile, public hospitals have faced more difficulties than other hospitals due to high treatment costs and the need to allocate limited resources to different departments. Economic assessments are necessary to determine the health care resources and costs required to treat patients with this new disease (4). Available data indicate that 5-20% of patients with COVID-19 require hospitalization and between 14% and 20% of them require admission to the

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intensive care unit (5-7). In this regard, analyzing direct costs of treating COVID-19 in public hospitals is an important and necessary issue. Imam Sajjad Hospital (AS) in Shahriar, one of the most important medical centers in this region, is trying to improve the quality of medical services and optimize its financial management and resources by providing medical services to patients with COVID-19. Analysis of medical costs can help identify resources used, the efficiency of the medical system, and management solutions. Previous studies have shown that the costs of treating COVID-19 at different levels of hospitals vary significantly depending on the type of services, medical equipment, and the number of personnel (8). In addition, research shows that public hospitals face more management and cost challenges than other hospitals due to limited financial resources (9). Some studies also point to the need for cost analysis to optimally allocate resources in order to improve the quality of services (10). This study aimed to analyze and evaluate the direct costs of COVID-19 treatment in Imam Sajjad (AS) Shahriar State Hospital. This analysis includes collecting accurate data on various treatment costs and examining their impact on the financial management and performance of the hospital. Given the current state of the COVID-19 crisis, the present study seeks to provide solutions to improve and optimize treatment costs and processes in public hospitals. Analyzing the direct costs of COVID-19 treatment in public hospitals can help policymakers, hospital managers, and health officials allocate limited financial resources in the best possible way. It can also be effective in improving the financial performance of hospitals and helping with strategic decision-making.

## Materials and Methods

The present study was applied in terms of purpose and post-event in terms of data collection process. The statistical population of the study was 4240 outpatients and inpatients referring to Imam Sajjad (AS) Shahriar Hospital during the first 3 months of 2022, with a total of 480 hospitalized patients. After reviewing the available data, 132 files were found in the hospital HIS system, which were used in this study. The data collection method was library and field, and the data collection tool was databases that included hospital financial records, invoices, and financial reports related to COVID-19, which included direct medical costs, and these costs were based on these eight categories:

• **Bed Charges**: Includes general ward bed costs, ICU, private rooms.

• **Nursing Charges**: Includes general ward nursing costs, ICU nursing, private room nursing.

• **Pathology Charges**: Includes all laboratory tests (hematology, pathology, microbiology and biochemistry), COVID RT-PCR, and rapid antigen (RATs).

• **Radiology Charges**: Includes X-rays, CT scans, 2D echo, and MRI imaging.

• **Procedure Charges**: Intubation, Foley catheterization, catheterization, tracheostomy, and coronary angioplasty.

• **Medication and Hospitalization Charges**: Includes the cost of all medications and disposables consumed by the patient during the hospitalization.

• **Equipment Charges**: Ventilators, high flow nasal cannula (HFNC), non-invasive ventilation (NIV), monitors, mechanical ventilation (MV), oxygen machines, syringes and infusion sets, and defibrillators.

• **Inpatient Ward Costs**: including consultation costs, personal protective equipment (PPE) costs, biomedical waste, administrative costs, costs related to influenza isolation packages, dietary costs, and respiratory costs.

Logistic regression and Iviews software were used to analyze the data.

## Results

In this study, the total number of subjects was 132, 80 of whom were female and 52 were male. Information about gender is given in the table and

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chart of gender percentage distribution. In this study, 106 people were married and 26 were single, whose marital status is shown in the relevant table and chart. Also, the status of underlying diseases was considered in this study and it was found that out of 132 people, 92 people had no underlying disease and 40 people had underlying diseases (including obesity, blood pressure, and diabetes). In the field of insurance, 10 people from the entire population studied did not have insurance, while the rest of the people had various types of social security insurance and other insurance. Tables and charts related to the type of insurance and its relationship with gender are also given in the text.

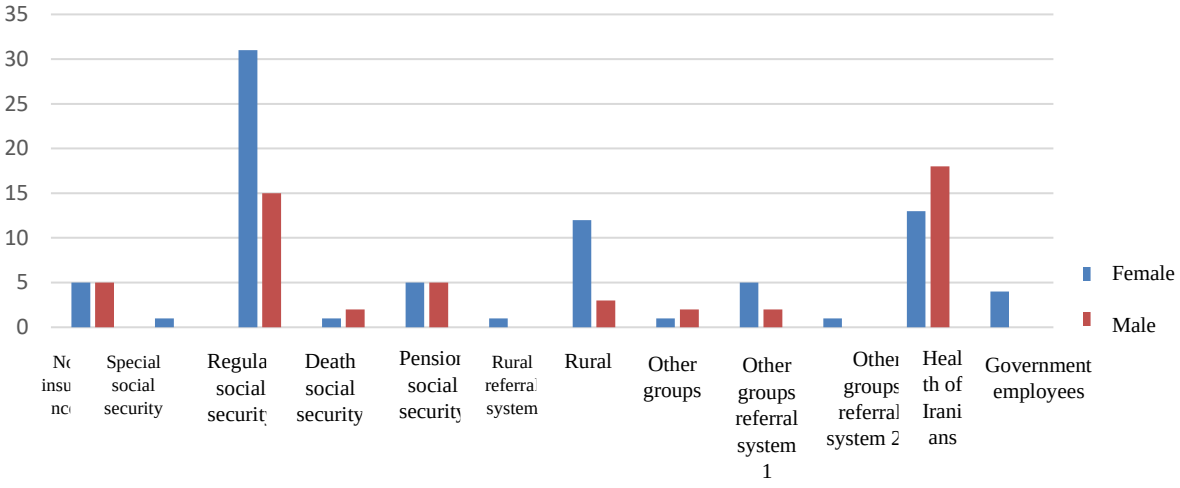



**Figure 1.** Type of insurance by gender

The investigation of the costs of testing and the total cost of treatment showed that the correlation coefficient was 0.37, indicating a lack of significant correlation between these two variables. In the regression analysis, the coefficient of determination was 0.14, which means that 14% of changes in the total cost of treatment can be predicted by the cost of testing. Also, the standard error of the regression was reported to be 0.001, indicating a high accuracy of the model. Finally, these results indicate that the regression model fits the data well and the values obtained from it are reliable

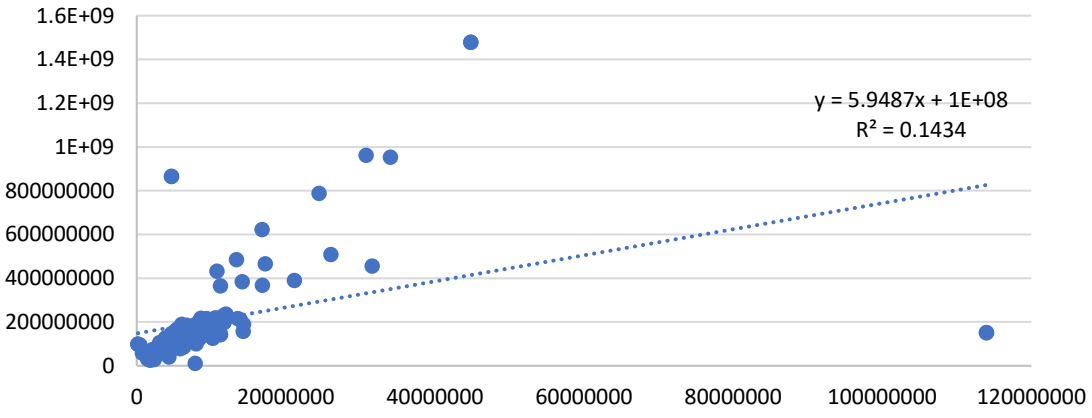



**Figure 2.** Line equation graph and correlation measure of test cost (independent variable) to total treatment cost (dependent variable)

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In the drug cost regression analysis, the correlation coefficient was 0.13, indicating no significant correlation between drug cost and total treatment cost. Also, the determinant coefficient was 0.01, indicating that only 1% of the changes in total treatment cost can be predicted by drug cost. The standard error of this regression was less than 0.001, indicating high accuracy of the model. In the analysis of variance (ANOVA), the research hypothesis was examined and the results showed that the calculated F value was 2.40 and the significance level was less than 0.12, and drug cost had an effect on total treatment cost.

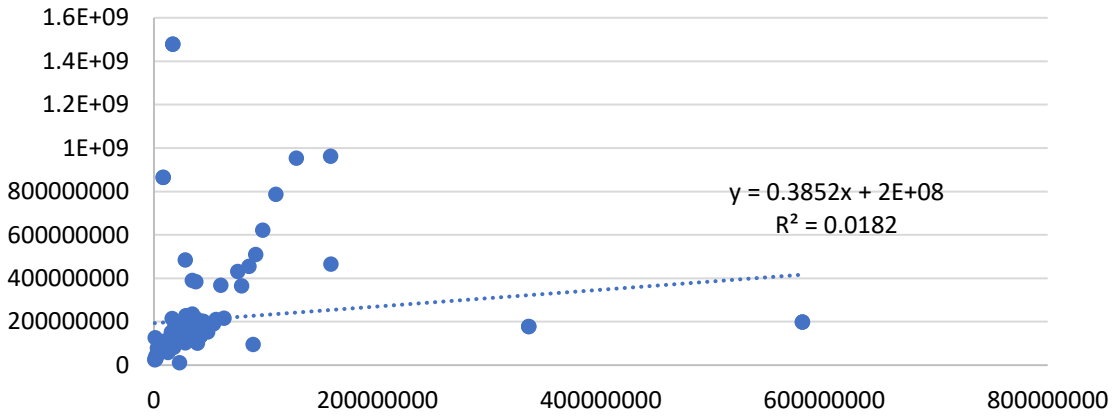



**Figure 3.** Line equation diagram and correlation measurement of drug cost (independent variable) to total treatment cost (dependent variable)

In the regression analysis of CT scan cost, the correlation coefficient was reported to be 0.13, indicating that there was no significant correlation between CT scan cost and total treatment cost. The coefficient of determination was 0.01, indicating that only 1% of changes in total treatment cost could be predicted by CT scan cost. The standard error of this regression was less than 0.001, indicating high accuracy of the model. In the analysis of variance (ANOVA), the results showed that the calculated F value was 13.99 and the significance level was less than 0.001, and CT scan cost had an effect on total treatment cost.

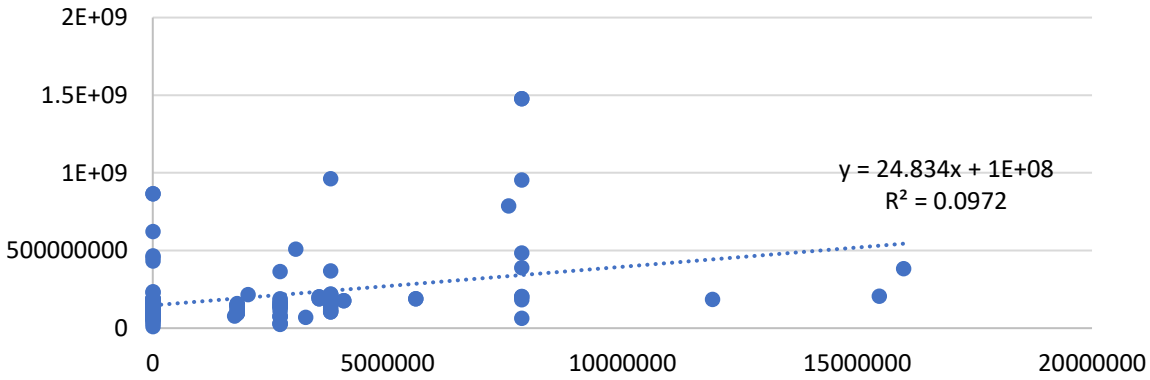



**Figure 4.** Line equation diagram and correlation measurement of CT scan cost (independent variable) to total treatment cost (dependent variable)

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In the regression analysis of radiology cost, the correlation coefficient was reported to be 0.40, indicating that there was no significant correlation between radiology cost and total treatment cost. The coefficient of determination was 0.16, indicating that 16% of the variation in total treatment cost could be predicted by radiology cost. The standard error of this regression was less than 0.001, indicating high accuracy of the model. In the analysis of variance (ANOVA), the results showed that the calculated F value was 25.76 and the significance level was less than 0.001; therefore, radiology cost had an effect on total treatment cost.

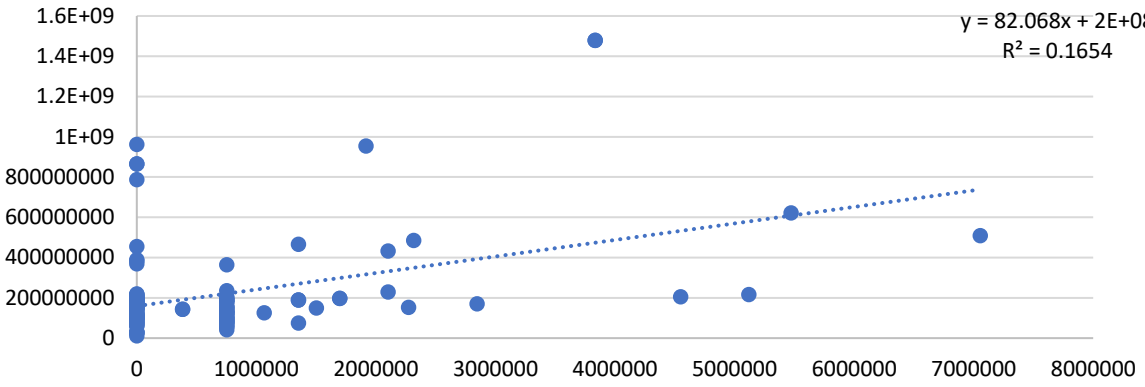



**Figure 5.** Line equation diagram and correlation measurement of radiology cost (independent variable) to total treatment cost (dependent variable)

In the regression analysis of echocardiography cost, the correlation coefficient was reported to be 0.24, indicating that there was no significant correlation between echocardiography cost and total treatment cost. The coefficient of determination was 0.06, indicating that only 6% of the changes in total treatment cost could be predicted by echocardiography cost. The standard error of this regression was less than 0.001, indicating a high accuracy of the model. In the analysis of variance (ANOVA), the results showed that the calculated F value was 8.66 and the significance level was less than 0.05, and echocardiography cost had an effect on total treatment cost. Therefore, the null hypothesis was rejected and the model was significant

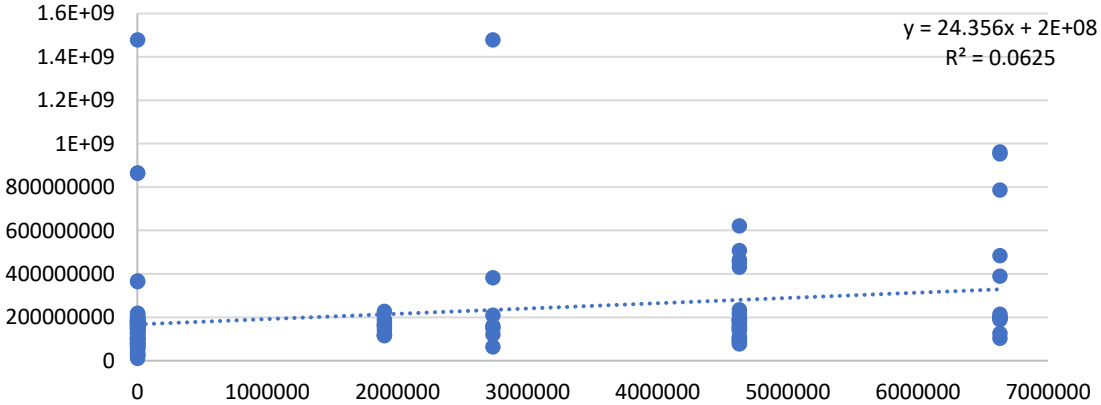



**Figure 6.** Line equation diagram and correlation measurement of echocardiography cost (independent variable) to total treatment cost (dependent variable)

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In the regression analysis of the cost paid by insurance, the correlation coefficient was reported to be 0.78, indicating a strong correlation between these two variables. Also, the coefficient of determination was 0.61, indicating that 61% of changes in the total cost of treatment can be predicted by the cost paid by insurance. The standard error of this regression was less than 0.001, indicating a high accuracy of the model. In the analysis of variance (ANOVA), the results showed that the calculated F value was 206.40 and the significance level was less than 0.001, so the null hypothesis was rejected and the model was significant, and the cost paid by insurance had an effect on the total cost of treatment.

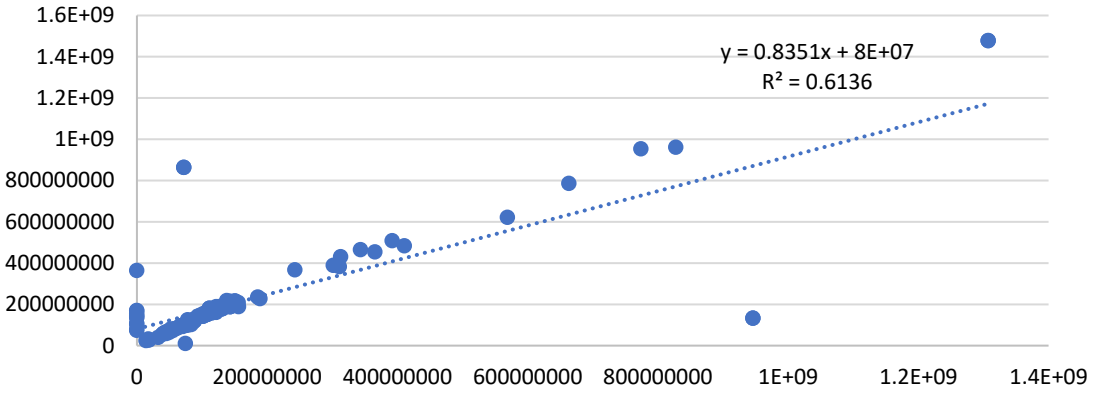



**Figure 7.** Line equation diagram and correlation measurement of cost paid by insurance to total treatment cost

In order to better compare the clinical costs of a patient, we can make comparisons based on gender, age, underlying disease, and severity of the disease. For this purpose, the average cost and standard deviation along with the significance level have been obtained. Table 1 shows the clinical management costs of patients (in million rials). The clinical management costs of patients were affected by gender, age, underlying diseases, and the severity of the patient's condition (discharge or death). Factors such as older age and death status have the greatest impact on increasing costs. This analysis can help make better decisions in managing financial resources in the field of treatment.

**Table 1.** Comparison of clinical management costs for patients (in million Rials)

| Characteristics | | mean cost | standard deviation | P |
|---|---|---|---|---|
| Gender | Male | 220/460 | 201.571 | 0.035 |
| | Female | 204/005 | 248.985 | |
| Age | Between 0 and 34 | 144.118 | 971.188 | 0.000 |
| | Between 35 and 69 | 161.423 | 124.125 | |
| | Above 70 | 285.386 | 321.976 | |
| Underlying disease | Yes | 263.676 | 288.199 | 0.426 |
| | No | 186.873 | 199.862 | |
| Severity | Discharged | 186.791 | 192.682 | 0.083 |
| | Death | 529.340 | 436.643 | |

Initially, in the first step, costs were compared based on age.

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**Table 2.** Comparison of clinical management costs of patients based on age (in million Rials)

| Age range | Between 0 and 34 | Between 35 and 69 | Above 70 |
|---|---|---|---|
| Number of valid data | 8 | 71 | 53 |
| Average (in million Rials) | 144.118 | 161.423 | 285.386 |
| Median | 103.797 | 141.991 | 178.600 |
| Mode | 73.646[a] | [a]93.864 | [a]81.772 |
| Standard deviation | 97.118 | 125.124 | 321.976 |
| Variance | 9432077568.380 | 15407241867.898 | 103668712471.584 |
| Range | 290.562 | 776.478 | 1446.584 |
| Total | 1152.946 | 11461.057 | 15125.469 |

[a] There are multiple modes. The smallest value is shown

According to the findings, the significance level was (0.000), so age affected the cost. Therefore, it was accepted that there is a significant relationship between age and the cost of clinical management of patients. Then, costs were compared based on gender.

**Table 3.** Comparison of clinical management costs of patients based on gender (in million rials)

| Gender | Female | Male |
|---|---|---|
| Number of valid data | 81 | 52 |
| Average (in million Rials) | 204.005 | 220.460 |
| Median | 150.927 | 161.311 |
| Mode | 98.718[a] | 81.772[a] |
| Standard deviation | 248.985 | 201.571 |
| Variance | 61993693967.448 | 40631165220.920 |
| Range | 1453.544 | 943.203 |
| Total | 16524.472 | 11463.935 |

[a] There are multiple modes. The smallest value is shown

The findings showed a significance level of 0.035 and gender had an effect on cost, so there was a significant relationship between gender and the cost of clinical management of patients.

In the third step, costs were compared based on having/not having an underlying disease.

**Table 4.** Comparison of clinical management costs of patients based on having/not having an underlying disease (in million Rials)

| Health status | Not having underlying disease | Having underlying disease |
|---|---|---|
| Number of valid data | 92 | 40 |
| Average (in million Rials) | 186.873 | 263.676 |
| Median | 150.726 | 170.830 |
| Mode | 177.354 | 141.880[a] |
| Standard deviation | 199.862 | 288.199 |
| Variance | 39945153115.512 | 83059230608.084 |
| Range | 1467.975 | 1414.314 |
| Total | 17192.406 | 10547.067 |

[a] There are multiple modes. The smallest value is shown

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The results showed that having/not having an underlying disease did not affect the cost. The reason for this is that a series of treatment protocols were used for most patients (whether with or without an underlying disease), so it was accepted that "there is no significant relationship between having/not having an underlying disease and the cost of clinical management of patients." Finally, costs were compared based on the severity of the disease (death/discharge conditions)

**Table 5.** Comparison of clinical management costs of patients based on death/discharge conditions (in million rials)

| Discharge/death status | Death | Discharged |
|---|---|---|
| Number of valid data | 9 | 123 |
| Average (in million Rials) | 529.340 | 186.791 |
| Median | 431.138 | 151.701 |
| Mode | 74.711[a] | 81.772[a] |
| Standard deviation | 436.643 | 192.682 |
| Variance | 190657225210.723 | 37126675300.371 |
| Range | 1403.310 | 1467.975 |
| Total | 4764.067 | 22975.406 |

[a] There are multiple modes. The smallest value is shown

The results showed that the severity of the disease (discharge or death) did not affect the cost. The reason for this is that tests and medications were prescribed for most patients (whether acute or normal). The average hospitalization of deceased patients was also very low, so there was no significant relationship between the severity of the disease (death/discharge conditions) and the cost of clinical management of patients.

## Conclusions

The results of this study, which examined the direct costs of treating patients with COVID-19 at Imam Sajjad Shahriar Hospital, showed that various factors affect treatment costs. In particular, the findings indicate a significant effect of age on treatment costs, with patients over 70 years of age incurring significantly more costs compared to other age groups. These results are consistent with other studies worldwide that indicated increased treatment costs for older people. For example, a study in the United States showed that the costs of treating patients with COVID-19 increased significantly with age. This is due to the greater need for intensive care and complex medications, which are more common in older people (25). According to the findings of statistical analysis at Imam Sajjad Hospital (AS), the age of patients had a significant effect on the direct costs of treating COVID-19. The ANOVA results showed that the average treatment costs for different age groups differed significantly. Specifically, patients over 70 years of age incurred the highest average treatment costs (285.386 million rials), while patients in the age group 0 to 35 years of age incurred the lowest costs (144.118 million rials). These significant differences were confirmed with a significance level of less than 0.05 (0.000), indicate the importance of planning to allocate treatment resources according to age groups. In addition to age, gender is also known as another factor affecting costs. Medical costs have been reported to be higher for men than for women, which may be due to physiological differences as well as differences in access to medical services between the sexes. Similar studies have also shown that gender differences in medical costs can be due to medical differences as well as social and cultural attitudes (26). Another important finding of this study is the high impact of medical equipment and drug costs on overall medical costs. This result is similar to many other studies showing that drug and medical equipment costs constitute a major part of the financial burden of treating patients with COVID-19 (27, 28). Based on the analyses conducted at Imam Sajjad Hospital (AS), gender of

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patients had a significant impact on the direct costs of treating COVID-19. The average medical costs for male patients (220.460 million rials) was higher than that of female patients (204.005 million rials). Results of ANOVA test also confirmed this difference with a significance level of 0.035, which was lower than the significance level of 0.05. Therefore, the research hypothesis indicating the effect of gender on treatment costs was accepted. The average clinical management cost for patients with underlying disease was 263.676 million rials and for patients without underlying disease was 186.873 million rials. This difference indicated a higher cost for patients with underlying disease. ANOVA test showed that the significance level value was 0.426, which was higher than 0.05. This means that the observed difference between the groups (patients with and without underlying disease) was not statistically significant. The reason for lack of significance was stated to be the use of similar treatment protocols for most patients, regardless of the underlying disease status. As a result, although the average costs for patients with underlying diseases were higher, this difference was not statistically significant. The average cost for discharged patients was 186.791 million rials and for deceased patients was 529.340 million rials. This indicated a higher cost for patients with higher severity (death). ANOVA test showed that the significance level value was 0.083, which was higher than the usual significance level (0.05). This means that the observed difference in costs between deceased and discharged patients was not statistically significant. The reason for lack of statistical significance was that most patients (whether with high severity of disease or normal) were prescribed similar tests and medications. Moreover, the average length of stay for deceased patients was very short. Although the average costs for fatal patients were higher, this difference was not statistically significant, because similar treatment protocols and interventions were applied to patients with different severities. Previous studies on management and policy issues in the management of infectious diseases, especially COVID-19, have addressed various dimensions, including health policy, human resource management, and the impact of human development indicators on mortality.

## Discussion

Radan et al. (11) showed that sustainable value factors in the use of information technology can not only facilitate the management of pandemics, but also prevent their consequences for future generations. In this study, three environmental, social, and economic factors were introduced as key factors (11). Jamalov et al. (12) used FMOLS and DOLS methods to examine the impact of human development index and its components (such as life expectancy, literacy, per capita income, and employment) on COVID-19 mortality in developing countries. The results of this study showed that these indices have a negative and significant impact on COVID-19 mortality in the long term, and emphasized the importance of improving health, education, and the economy to reduce the effects of the pandemic (12). Shirazi and Panahi (13) suggested that strengthening support and welfare structures, along with adopting transparent management policies, can help improve job and psychological conditions of healthcare workers. This study emphasized that democratic management methods and increasing welfare services are among the most important measures to improve management structures of healthcare centers (13). Rasouli et al. (14) reported that 51.4% of participants were women, 55.6% were in the age group of 71-90 years, and 58.4% had multisystem diseases. All patients had a score below 6 on the treatment adherence questionnaire, indicating poor adherence to treatment. Statistical analyses showed that only age and education level had a significant relationship with treatment adherence (p=0.001)(14). Bagheri et al. (15) showed that the average direct non-medical costs of patients were 20,260,000 rials and their indirect costs were 28,300,000 rials. Several factors such as previous chronic diseases (pulmonary, asthma, diabetes), ICU admission, coma, and heart disease were significantly associated with direct non-medical costs. Also, variables such as age, gender,

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educational and occupational status, and having physical activity at work had a significant effect on indirect costs (*P-values* <0.05). This study emphasizes that Omicron has imposed heavy economic costs on patients and their families (15). Thaqafipour (16) stated that direct costs included costs of tests, treatment, protective equipment, and medications, while indirect costs included job loss, fear of going to the hospital, and psychological problems related to the economic situation. The study also noted the heavy economic impact of the disease on the health system, including the costs of hospitalization and the provision of protective equipment and medications (16). Kabir et al. (17) stated that the average direct medical cost was 214,926,500 rials and the average indirect cost was 959,577,714 rials. Hospitalization and medication services accounted for the largest share of the costs. This study showed that the widespread spread of COVID-19 has imposed a significant economic burden on society and the health system (17). Kugler et al. (18) showed that patients admitted to the ICU had higher costs and longer lengths of stay, especially among older patients.This study highlights the financial burden of COVID-19 treatment and the need for effective health planning during the pandemic (18). Using retrospective cost analysis, Witturapong et al. (19) estimated the costs of preparation, pandemic wave, and readiness to operate at US$0.6, US$3.9, and US$1.2 million, respectively. The treatment costs for COVID-19 patients were higher than the costs of infection control in the early stages, and public contributions accounted for 20.94% of the costs. (19). Al-Mateer et al. (20) reported that underlying diseases and disease severity can significantly increase treatment costs, indicating the need for optimal resource allocation (20). Mithaka Morais et al. (21) showed that the average cost per admission was US$12,637.42 and costs varied depending on clinical conditions and demographic factors. Older patients with underlying diseases had higher costs, mainly due to the need for intensive interventions such as mechanical ventilation. This study highlighted the importance of assessing costs in future health planning (21). Reddy et al. (22) showed that the average cost for a 13-day ICU stay was US$2,742.91. Patients with diabetes and sepsis and those requiring mechanical ventilation had higher costs. This study emphasized that the costs of ICU admission in resource-limited settings were high and depended on several factors, including length of stay and severity of illness (22). Shinson et al. (23) reported that effective treatments can help reduce disease burden and costs. Incremental cost-effectiveness ratios (ICERs) ranged from US$22,933 for public insurance to US$8,028 for social insurance (23). Thant et al. (24) showed that clinical management costs were US$717 for asymptomatic patients, US$869 for mild patients, and US$4,290 for severe patients. This study estimated the total costs for managing 124,630 COVID-19 patients in Myanmar up to December 2020, providing useful inputs for future health and economic planning (24)

The present study, from a scientific and practical perspective, can help health managers and policymakers to use findings to provide more optimal plans for managing medical costs in similar crises. Based on the findings, it is suggested that special attention be paid to age groups over 70 years old and men, and specific solutions be designed to reduce their medical costs. Also, developing resource management systems and improving the use of medical equipment and drugs can help reduce costs. This study clearly showed that various factors such as age and gender had a significant impact on the medical costs of patients with COVID-19. The results indicated that paying attention to these factors can help optimize costs. Despite the useful results of this study, there were limitations that should be noted. Among the most important limitations was the inability to generalize the results to other hospitals and geographical areas. This study was limited to only one specific hospital, and the specific conditions of this hospital may cause differences in costs compared to other hospitals and other areas. Also, due to data limitations, some factors affecting medical costs, such as patient's economic status

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and access to health insurance, were not fully examined. There were also limitations such as focusing on a specific hospital and not examining some economic variables that should be addressed in future research. Ultimately, these findings are of great importance to policymakers and health managers and can help with future planning in the field of health crisis management.

### Ethical Considerations

This article has an ethical code number IR.IAU.SRP.REC.1403.159. All confidential information is kept confidential by the researchers.

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### Authors' contributions

F. J, L. R, and S. BD designed research and wrote the manuscript. Also, the authors approved the final manuscript.

### Conflict of Interest

The authors declare no conflict of interests.

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Non Applicable.

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