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Determinants of Hospitalization Costs among Moderate Cases of COVID-19

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Abstract

Objective: To estimate demographic predictors of medical expense in hospitalization of moderate COVID-19. **Methods:** From January to March 2020, a total of 39 patients were treated and recovered from COVID-19 in a tertiary medical center in East China. Detailed cost data were collected and we estimated the demographic predictors of both total hospital expense and daily hospital expense. **Results:** The mean medical expense for treating hospitalized moderate COVID-19 cases was $1177.81. Every additional year in the patient's age corresponds to .9% more in total hospital expense (Coef. = 0.009, 95% CI 0.002-0.017, $P < 0.01$). The difference in daily medical expense between age groups was not statistically significant. **Conclusions:** Hospitalization cost was significantly elevated among the older patients, and the age effect in cost was mainly driven by the longer length of stay in the hospital. From a cost-saving perspective, the elderly population might deserve priority consideration when COVID-19 vaccination programs are implemented.

Keywords

COVID-19, length of stay, medical expenditure, hospitalization, nursing

1 What do we already know about this topic
Older patients of COVID-19 are more likely to die from this disease.
2 How does your research contribute to the field?
We found that among moderate cases of COVID-19 hospitalization every additional year in the patient's age is associated with .9% increase of their hospital expense, driven by their longer stay in the hospital.
3 What are your research's implications towards theory, practice, or policy?
Our finding indicates that prioritizing the elderly population for vaccination could mean cost-saving in health care given this population's higher cost if they become infected and hospitalized.

The sudden appearance of a zoonotic coronavirus infection in Wuhan, China quickly escalated to a global pandemic,[1] with millions of infections cases confirmed across the world.[2] This global threat triggered by COVID-19 posed heavy burden on health care system and public finance around world.[3] The average direct cost for providing medical care for a single symptomatic COVID-19 patient is estimated to be over $3000 in United States.[4] Medical cost of care for COVID-19 patients is an important topic in health services research, since it is key to the planning of health care resources in preparation for waves of infections in the population. For example, when decisions are made as to which population to get vaccinated earlier than other, priorities can be given to those most likely to die from an infection, those most likely to spread the virus,

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those most likely to be exposed to the infection risk, and those who could consume the maximum amount of health care resources if infected. This study was aimed to provide a comprehensive estimate of the resources consumed and medical expenditure of hospitalization for moderate COVID-19 cases.

Methods

Medical care for patients with COVID-19 was provided by a tertiary hospital in Yongjia County of the Zhejiang Province in East China, a county with its GDP per capita about 15% lower than China's GDP per capita.[5] The first COVID-19 case was admitted on January 2nd whereas the last case was discharged from hospital on March 27th, 2020. No local COVID-19 cases have been identified thereafter. As directed by the government's COVID-19 response strategy, three severe cases of COVID-19 were transferred from this tertiary hospital to the designated COVID-19 hospital in the area. Patient-level demographic, clinical, and medical expense data were retrospectively collected. Demographic characteristics included age and gender. Patients with diabetes and/or hypertension were identified as cases with comorbidity, resulting in a binary variable of comorbidity (patients with comorbidity vs patients without). Smoking status was reported as smoker (active or previous) or nonsmoker. Under the national policy, all medical expense (medications, nursing care, general medicine, laboratory, and radiology) in treating COVID-19 was all covered by health care insurance in China.[6] Initial CT imaging of each patient showed bilateral pulmonary infiltration. CT scans was performed every 3 days during the hospitalization. No medical treatment was recorded prior to hospitalization. A combination of inhalable IFN α-2b (5 million U, BID), oral lopinavir tablets (500 mg, BID), and an oral viral endosomal membrane fusion inhibitor (umifenovir) granules (200 mg, TID) was initiated on each patient after admission. This triple combination of interferon, antiretroviral protease inhibitor, and antiviral has been commonly used to treat mild and moderate COVID-19 patients with some evidence of effectiveness.[7]

This study was approved by the research ethics committee of Yongjia County People's Hospital (approval number: 2020-L01), with waivers of informed consents.

To complement this medical resource analysis, the total medical expense and the specific cost by categories (physician costs, medications, nursing care, laboratory, and radiology) of each participant was collected from the billing records that hospital sent to government. Medications charge was the cost of pharmaceutical treatment during the hospitalization. Physician costs and nursing fee were the payments for service provided by physician and nurses. Laboratory fee was the cost for various samples testing (blood, urine, mucus etc.). Radiology charge was the expenditure on radiological examinations (mainly chest CT scan). Medical expense was collected in Chinese yuan (CNY). The conversion to United States dollars (USD) was made basing on January 1st, 2020 exchange rate (1 USD = 6.56 CNY). Fees per day were calculated and reported as a proxy of medical expenditure on a daily basis. Difference in medical expense between gender groups was assessed using *t*-test. Categorical variables were presented as frequencies (%). Linear regression models with log-transformed expense variables were used to estimate medical expenditures (total and daily). Variables of age, gender, comorbidity (yes vs no), and smoking status (yes vs no) were included in each model. The length of hospital stay was included as an explanatory variable in the models of total expenditures. All statistical analyses were performed using Stata 16.0 (Stata Corp, College Station, TX, USA), with *P*-value < 0.05 defined as statistically significant.

Results

From January to March 2020, a total of 39 patients were treated from COVID-19. None of them received respiratory support. All smokers in our study population were male. Other characteristics had a similar distribution between gender groups (Table 1). Mean total medical expense in treating moderate COVID-19 with a combination of triple therapy was $1177.81 (standard deviation 415.78, Table 1). Medications accounted for one-third of the total medical expenditure (33.45%), while nursing expenses accounted for less than one-tenth of total cost (7.16%, Table 1). Although the expense increased with the length of stay, the age of these patients is the only significant predictor of total hospital expense of these COVID-19 patients (Coef. = 0.009, 95% CI 0.002-0.017, $P < 0.01$, Table 2), which means that every additional year in the patient's age corresponds to 0.9% more in total hospital expense. In physician costs, the increase of expenses associated with every additional year in patient's age was estimated to be 0.7% (Coef. = 0.007, 95% CI 0.000–0.015, Table 2).

When we use daily medical expense as the outcome variable, the associations between expense (in total or by categories) and age were consistently attenuated towards null (Coef. = 0.005, 95% CI −0.003–0.012 in total expense; Coef. = 0.004, 95% CI −0.002–0.010 in physician costs; Coef. = 0.009, 95% CI −0.001–0.019 in medications cost; Coef. = 0.001, 95% CI 0.000–0.002 in Nursing cost; Coef. = −0.001, 95% CI −0.012–0.009 in laboratory test cost; Coef. = 0.003, 95% CI −0.004–0.011 in radiological cost, Table 3).

Discussion

To the best of our knowledge, this is among the earliest attempts to document the total hospitalization expenditure for treating COVID-19 patients. We are aware that our estimation was drawn from an inpatient sample of moderate COVID-19 cases who were treated with a triple combination of IFN α-2b, lopinavir, and umifenovir. For these moderate COVID-19 cases,

Table 1. Clinical Characteristics and Detailed Medical Expenditure Between Gender Groups.

	Total (n = 39)	Male (n = 21)	Female (n = 18)	P-value
Age	43.33 (14.25)	46.14 (12.65)	40.06 (15.64)	0.19
Comorbidity	9 (23.1%)	7 (33.3%)	2 (11.1%)	0.14
Smoker	5 (12.8%)	5 (23.8%)	0 (0.0%)	0.05
Total expenditure	1177.81 (415.78)	1202.29 (427.84)	1149.24 (411.67)	0.70
Physician costs	278.59 (115.91)	279.43 (102.25)	277.62 (133.14)	0.96
Medications	393.94 (179.12)	399.28 (194.80)	387.70 (164.32)	0.84
Nursing care	52.53 (18.22)	51.52 (18.05)	53.71 (18.88)	0.71
Laboratory	315.61 (109.51)	336.88 (128.67)	290.79 (78.23)	0.19
Radiology	137.13 (50.38)	135.18 (47.72)	139.41 (54.63)	0.80
Length of stay	16.26 (5.74)	15.86 (5.68)	16.72 (5.94)	0.65

Table 2. Multivariate Analysis of Medical Expense.

	Total expenditure	Physician costs	Medications	Nursing care	Laboratory	Radiology
Age	0.009 (0.002, 0.017)*	0.007 (0.000, 0.015)*	0.012 (0.000, 0.024)	0.002 (−0.001, 0.006)	0.008 (−0.001, 0.017)	0.005 (−0.003, 0.013)
Male vs female	−0.052 (−0.234, 0.13)	−0.048 (−0.222, 0.127)	−0.035 (−0.323, 0.254)	−0.027 (−0.11, 0.056)	−0.081 (−0.290, 0.127)	0.088 (−0.101, 0.277)
Comorbidity: no vs. yes	0.002 (−0.246, 0.25)	0.076 (−0.162, 0.314)	−0.037 (−0.431, 0.356)	−0.072 (−0.185, 0.041)	0.066 (−0.218, 0.350)	−0.072 (−0.325, 0.182)
Smoker: no vs yes	−0.072 (−0.347, 0.203)	−0.096 (−0.359, 0.167)	−0.186 (−0.622, 0.249)	0.035 (−0.089, 0.160)	−0.011 (−0.325, 0.304)	0.150 (−0.129, 0.429)
Length of hospital stay	0.049 (0.033, 0.065)*	0.057 (0.042, 0.073)*	0.062 (0.037, 0.088)*	0.070 (0.063, 0.077)*	0.023 (0.004, 0.041)*	0.048 (0.031, 0.065)*
Coefficient of determination	0.691	0.749	0.580	0.935	0.403	0.609

All figures were presented as Coefficient (95% Confidence Interval).
*: $P < 0.05$.

Table 3. Multivariate Analysis of Daily Medical Expense.

	Daily expenditure	Physician costs	Medications	Nursing care	Laboratory	Radiology
Age	0.004 (−0.002, 0.011)	0.004 (−0.002, 0.010)	0.009 (−0.001, 0.019)	0.001 (0.000, 0.002)	−0.001 (−0.012, 0.009)	0.003 (−0.004, 0.011)
Male vs female	−0.079 (−0.244, 0.087)	−0.059 (−0.214, 0.095)	−0.038 (−0.284, 0.208)	−0.016 (−0.042, 0.010)	−0.155 (−0.425, 0.114)	0.025 (−0.159, 0.210)
Comorbidity: no vs yes	0.064 (−0.165, 0.292)	0.134 (−0.080, 0.348)	0.019 (−0.320, 0.358)	−0.019 (−0.055, 0.016)	0.139 (−0.233, 0.511)	−0.048 (−0.301, 0.205)
Smoker: no vs yes	−0.114 (−0.367, 0.138)	−0.139 (−0.376, 0.097)	−0.229 (−0.605, 0.146)	−0.008 (−0.047, 0.031)	−0.052 (−0.463, 0.360)	0.096 (−0.182, 0.375)
Coefficient of determination	0.148	0.201	0.153	0.113	0.067	0.039

All figures were presented as Coefficient (95% Confidence Interval).

the average medical expense of hospitalization was around $1178, with medications contributing one-third of the total cost (this could be different in other countries where labor cost of health care professionals is considerably higher than that of China). It is important to note that our sample was 100% moderate cases who did not require respiratory support, which explains why our per patient cost estimate is notably lower than the per patient hospitalization cost of $2869.4 (Interquartile range: $3916.8) among COVID-19 inpatients of different levels of severity in Guangdong, China.[8] Although these cost estimates

from China are all much lower than the cost of treating COVID-19 inpatients in Europe (e.g., $1706.50 per patient per day in Geneva, Switzerland[9]), it is still evident that the hospitalization of COVID-19 patients is a formidable burden on China's fiscal system with its annual per capita health care expenditure of $222.4[10] (using the 2015 exchange rate) among urban residents. By revealing the direct cost to the health care system and insurance payers, our cost estimation illustrates the necessity of preventing COVID-19 infection from a financial perspective. To put the hospitalization expense of $1178 per moderate case under the broader context of COVID-19 control, the approved two-dose COVID-19 vaccines (SinoPharm and CoronaVac) in China were priced at $60 for each two-dose vaccination[11] for the government procurement, which was 5.1% of the per patient hospitalization expense we estimated here for moderate cases and 2.1% of the per patient hospitalization expense for all types of COVID-19 inpatients in Guangdong, China.[8]

Sharing immunopathological factors of cytokine storm, tissue damage, lymphopenia, and coagulation with influenza,[12] it is possible that the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) might evolve into a seasonal threat to global public health like influenza after the current pandemic. It is important to note, then, that in lower- and middle-income countries direct costs from respiratory infectious diseases such as influenza could be lower than in developed countries yet the former's indirect cost through productivity loss might be notably higher than the latter.[13] Therefore, in addition to the mission of achieving global health equity, it is important for the global community to help lower- and middle-income countries address the longer-term challenges of COVID-19 from the perspective of minimizing disease-related productivity loss.

In this study, 46.2% of hospitalized COVID-19 cases were over 65 years old, which was very similar to the COVID-19 data during February 12–March 16 reported to Centers for Disease Control and Prevention (CDC) in United States.[14] CDC reported that elderly patients comprise 45% of hospitalizations for COVID-19 infections in United States.[14] The medical expenditure increased with age in our study, suggesting that setting the senior citizens as a priority population for vaccination could be both ethically defensible but fiscally cost-saving (older COVID-19 inpatients incur significantly more cost than younger inpatients). This finding about the age pattern in inpatient cost bears relevance to the ongoing debate about whether the older adults should get the COVID-19 vaccines earlier than the younger adults[15] and countries like Indonesia did choose to start to vaccinate the younger adults first.[16] The high disease burden and financial burden of COVID-19 for elderly COVID-19 patients mean that countries might need to prioritize vaccinating the elderly population if health care cost is a substantial concern when planning for vaccine prioritization.

When we ran the model of daily medical expense, age was no longer a statistically significant predictor, indicating that the prolonged length of hospital stay in elderly patients was the main reason for the higher cost among the elderly population. The fact that elderly patients tend to have more comorbidities could be a reason why they tend to stay in the hospital for longer even though their COVID-19 infections belong to the moderate category.[17] Patients with comorbidity were substantially older than that of patients without (58.11 ± 15.24 vs 38.90 ± 10.67, $P < 0.01$), which may contribute to the higher mean expense of care for elderly patients, considering that comorbidity may increase the medical cost.[18]

One important limitation of this study was that the sample was limited to moderate cases, which reduce the external validity. Given the heterogeneity of local policy, health care regulations, and type of costs in each study about the economic perspective of the pandemic, this study only provides a descriptive overview of the medical expense of moderate COVID-19 cases. As this data collection was done at the early emergency phase of COVID-19 pandemic in China, we did not have the resources to document the more detailed information about the patients' medical history and sociodemographic characteristics nor did we have access to more detailed information such as unit costs and specific breakdown within nursing, labs, radiology, and medications. The absence of these variables limits the extent to which we can understand the patterns behind the cost variations between patients. On the other hand, while our small sample size could be the reason why the comorbidity did not show up as a significant predictor of hospital expenses in our models, the insignificant link between comorbidity and expenditure as found in our study was actually consistent with a study from South Korea with a much larger sample size ($N = 7590$).[19] So far, there has been little empirical evidence that shows a significant and positive link between comorbidities and COVID-19 hospital expenses.

To date, less attention has been paid to medical expenditure and resource utilization for hospitalized COVID-19 cases, and few (if any) studies have focused on the hospitalization expense of moderate COVID-19 cases, a subpopulation of COVID-19 inpatients that might become more salient with the world population increasingly vaccinated. Our study provides a relevant point estimate of the hospitalization expenditure for the moderate COVID-19 inpatients, while highlighting the role of age in economic burden of the COVID-19 pandemic. Future studies could look at the health care expenditure of COVID-19 patients of severe conditions as well as those treated with more recent approaches such as the cocktail monoclonal antibodies.[20]

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