Predict the hospitalization in covid-19: magic is in the air

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Abstract

Background

Although pathogenesis and pattern of disease are still not completely understood, tactical management of overcrowding of hospitals and rational usage of resources is the need of the hour.

Material & Methods

Retrospective data of 6918 COVID-19 positive cases from SCB Medical College & Hospital, India, were obtained from the hospital records from March 2020 to January 2021. The patients' age, gender, symptoms, and comorbidities were analyzed against their hospital stay using R software (version 4.0.2).

Results

Elderly patients (> 65 years) had a higher rate (91.22%) of prolonged hospital stay as compared to others (47.61%). Frequently observed symptoms (in decreasing order) were fever (73.93%), cough (67.52%), myalgia (62.11%), dyspnea (49.59%), dizziness (47.38%), and anosmia (44.10%). The risk of prolonged hospitalization was highest with dyspnea [odds ratio: 2.29 (95 % confidence interval: 2.07–2.52)], followed by diarrhea [OR 1.98 (CI 1.77–2.21)], fever [OR 1.89 (CI 1.69–2.10)], anosmia [OR 1.86 (CI 1.69–2.05)], and dizziness [OR 1.46 (CI 1.32–1.60)]. The rate of hospitalization for more than seven days was highest with diabetes (86.80%), followed by respiratory illnesses (71.85%) and hypertension (71.28%).

Conclusion

These findings can help manage patients based on their symptoms and comorbidities before admission.

Summary Box

"What is already known on this subject?"

In the last 18-19 months, we knew briefly about the symptoms, predisposing factors, and the pathogenesis of coronavirus disease. During this phase of the uncertain war, we have successfully found few potential drug targets and made those in our favor, which have already been discussed and mentioned in recent studies on the coronavirus. Some studies reported on the pattern of hospitalization due to COVID infection. There is a dearth of literature on the co-occurrence of symptoms of COVID and their impact on hospitalization.

"What does this study add?"

In our study, we have shown the correlation between various attributes of this infectious disease. We have mentioned the associations of common factors with the duration of hospital stay through the Sankey diagram. We have evaluated the co-occurrence of different symptoms of COVID by co-occurrence plots. With

the help of funnel plots, we have also calculated the hospitalization rate for various symptoms and comorbidities of the hospitalized individual.

Introduction

Since December 2019, our perceptions, thoughts, and visions have changed because of the domination of coronavirus over our world. Its impact has drastically affected billions of lives around the globe physically, mentally, socially, and most importantly, economically, and the counts are still uprising. The clinical symptoms of COVID-19 infection vary from asymptomatic mild respiratory infection to multi-organ dysfunction syndrome (MODS) and even to acute respiratory distress syndrome (ARDS). The most common symptoms observed in the patients are fever, cough, breathing difficulties, loss of smell and taste, dizziness, muscle pain, fatigue, abdominal pain, and loose motion. The severity of disease proportionately increases with age and the presence of comorbidities(1,2).

Neglected and untreated diseases can lead to complications like myocardial infarction, coagulopathies, lung fibrosis, renal dysfunction, hypoxia, respiratory failure, and even death. According to some previous studies(3–5), the median length of hospital stay of the COVID-19 patients was 10-13 days. Therefore, it is essential to identify the risk factors associated with a prolonged hospital stay. COVID pandemic has heightened the necessity of long-term hospital stay, even the need for ventilatory support of severely ill patients. It has alarmed global emergency due to the immediate requirement of massive health infrastructure like hospitals with ICU set up and pharmaceutical companies to combat the nightmare(5–8).

Prediction of the hospitalization rate is the hour's call for the tactical management of rising disease burden and logical utilization of resources. Hence, we conducted a retrospective study to assess the attributes and predictors of prolonged hospitalization of COVID-19 disease in a tertiary care hospital.

Material And Methods

We performed a retrospective analysis of the duration of hospitalization in 6918 individuals, who were tested positive for SARS-COVID-19 infection and admitted to SCB Medical College, Cuttack, Odisha, India, within the period of 25th March 2020 to 31st January 2021. Individuals of 15-90 years of age, of either gender, with COVID-19 disease admitted to the study site, were included in the study. Exclusion criteria were: persons hospitalized for less than 24 hours; persons referred from and to another hospital; pregnant or lactating women; persons with heart failure, myocardial infection, cerebrovascular accident or thromboischemic attacks, chronic kidney disease (serum creatinine value of more than 1.5 mg/dl), and benign/malignant tumors, burn injury, persons requiring dialysis, persons hospitalized with any bone fractures; persons on total parenteral nutrition or any immunosuppressant drugs; persons who got themselves discharged against the medical advice of doctors; any hospital deaths; and persons reinfected with COVID-19 infection. We got ethical approval from the Institutional Ethics Committee of SCB Medical College, Cuttack, Odisha, India, before collecting and analyzing the data.

The study objectives were: finding of a correlation between various attributes of COVID; evaluation of the association of common characteristics with hospital stay; prediction of co-occurrence of different symptoms;

calculation of odds ratio of prolonged hospitalization due to various symptoms; estimation of the rate of prolonged hospitalization due to symptoms and comorbidities. We collected the demographic and clinical data from hospital records with permission from the hospital in charge. A total of 390,732 patients were admitted to the hospital during the stipulated time duration. Out of which 6,918 patients met the inclusion and exclusion criteria of the study and were included for analysis. All the statistical analyses for this study were done using R software (version 4.0.2).

Results

For this retrospective study, we collected data of all the patients admitted to SCB medical college, Cuttack, India, from 25th March 2020 to 31st January 2021. A total of 390,732 patients were admitted to the study site during this period. Out of those patients, 6,918 [4916 (71.06%) male and 2002 (28.94%) female] patients infected with SARS-nCov2 met the study criteria and were included for the analysis. Demographic and clinical parameters have been provided in **Table 1**. The common comorbidities in the study population (in decreasing order) were diabetes [4127 (59.7%)], hypertension [4031 (58.3%)], and respiratory diseases [3211 (46.4%)]. Before their diagnosis and hospitalization, the common symptoms experienced by the patients before their diagnosis and hospitalization (in decreasing order of frequency) were fever, cough, myalgia, dyspnea, dizziness, anosmia, diarrhea, and hoarseness. The median age of the patients was 52 (39-64) years [male: 53 (40-64) years; female: 50 (37-63) years]. The median duration of hospital stay of patients was 9 (5-13) days [male: 10 (5-14) days; female: 7 (4-12) days] **Figure 1(a)**. Most of the female patients had shorter (< 7 days) duration of hospital stay, and male patients had longer (> 7 days) hospital stay **Figure 1(b)**. There was an increased duration of hospital stay with increased age and number of symptoms. Patients with bronchial asthma or chronic obstructive pulmonary disease were admitted for a longer duration than those without respiratory illnesses **Figure 1(c)**. The duration of hospitalization was prolonged with the presence of respiratory conditions. **Supplementary Figure 1 (a)** shows that most patients with no respiratory conditions were discharged within ten days of hospitalization. Patients with bronchial asthma had a longer hospital stay in comparison to COPD cases. There was an inclining trend of the duration of hospitalization with the advancing age of the individual, as shown in **Supplementary Figure 1 (b)**. Most patients of age < 35 years had been discharged within ten days of admission. All the patients with > 5 symptoms had to stay for a longer duration (i.e., more than seven days) as compared to those with less symptom complex, as shown in **Supplementary Figure 1 (c)**.

The correlation matrix had been plotted in **Figure 2**. We found significant correlation of duration of hospital stay with following variables: duration of diabetes ($r = 0.78, p < 0.001$), age of the person ($r = 0.62, p < 0.001$), number of symptoms ($r = 0.56, p < 0.001$), duration of hypertension ($r = 0.53, p < 0.001$), duration of asthma or COPD ($r = 0.52, p < 0.001$), and duration of fever prior to hospitalization ($r = 0.44, p < 0.001$). Other significant correlations were between following variables: duration of dyspnea and number of symptoms ($r = 0.58, p < 0.001$), duration of diabetes and age of the person ($r = 0.55, p < 0.001$), duration of dyspnea and duration of diabetes ($r = 0.47, p < 0.001$), duration of hypertension and age of the person ($r = 0.47, p < 0.001$), duration of diabetes and number of symptoms ($r = 0.45, p < 0.001$), duration of asthma and number of symptoms ($r = 0.44, p < 0.001$), duration of asthma and age of the person ($r = 0.43, p < 0.001$), and duration

of fever and duration of diabetes ($r = 0.42$, $p < 0.001$). There was a single negative (non-significant) correlation of duration of hospital stay with duration of alcoholism ($r = -0.07$, $p = 0.921$).

For highlighting the associations among age, respiratory illness, number of symptoms, and duration of hospital stay, a Sankey diagram was drawn in **Figure 3**. The columns (from left to right) represented the person's age, presence/absence of any respiratory disease, number of symptoms experienced before hospitalization, and duration of hospital stay after diagnosis of infection. The widths of the bands denote the association between the variables. Older adults were more affected by asthma or COPD than younger individuals. The patients with COPD had more symptoms than those with asthma and those without any respiratory diseases. The number of symptoms proportionately affects the duration of hospitalization. All individuals with more than five symptoms stayed in the hospital for more than seven days. Most of the patients with asthma & COPD were elderly and were more prone to present 4-5 symptoms at the time of hospitalization, which led them to prolonged hospitalization.

Figure 4 describes the co-occurrence plots of various symptoms of the participants. The up-left plot shows the symptoms in all participants. The up-right portion is meant for the participants hospitalized for 2-7 days. The down-left part depicts the co-occurrence of symptoms for patients hospitalized for more than seven days. The down-right plot shows participants who were hospitalized for more than 14 days. Fever was the most common symptom experienced among the study participants. It mainly co-occurred with cough, myalgia, dyspnea, and dizziness. Here, the size of the circle indicates the percentage of the participants, and the thickness of the line shows the degree of co-occurrence of the symptoms. The co-occurrence plots suggest the direct relationship of the number of symptoms with the hospital stay, which can otherwise be stated as; more the multi co-occurrence of symptoms, the longer is the hospital stay. Our study showed the strongest association with the following symptom complexes: fever - cough (70%) & fever - myalgia (67%). The most petite association was found between loose motions - hoarseness (10%) and dizziness - hoarseness (10%). This finding held good for hospitalization up to 7 days and for > 7 days. But in contrast to the above scenarios, prolonged hospitalization of more than 14 days was strongly associated with multiple symptom complexes, i.e., fever-cough, fever-myalgia, fever-breathlessness, and fever-hoarseness. So fever may be considered as the most crucial symptom associated with other symptoms.

In **Figure 5**, we analyzed the data to estimate the risk of prolonged hospitalization more than seven days by using the symptoms seen in the patients before the diagnosis of COVID-19. The symptoms (in decreasing order of risk of prolonged hospitalization) were: dyspnea [OR 2.29 (CI 2.07-2.52)], diarrhea [OR 1.98 (CI 1.77-2.21)], fever [OR 1.89 (CI 1.69-2.10)], anosmia [OR 1.86 (CI 1.69-2.05)], dizziness [OR 1.46 (CI 1.32-1.60)], myalgia [OR 1.31 (CI 1.18-1.44)], cough [OR 1.13 (CI 1.02-1.25)], and hoarseness [OR 1.12 (CI 1.00-1.25)]. Subgroup analyses had been done based on gender, shown in **Supplementary Figure 2 (a & b)**. These figures suggested that male patients with symptoms like dizziness, loose motion, dyspnea, and fever were approximately two times more likely to stay for > 7 days in the hospital. And female patients with symptoms like anosmia, hoarseness, dyspnea, and fever were approximately two to five times more likely to stay for > 7 days in the hospital. In contrast to males, females with dizziness were less likely to stay for a prolonged duration.

We analyzed the data to find the rate of prolonged hospital stay of the study participants with various symptoms, comorbidities, and addiction(s), and the number of signs and created funnel plots shown in **Supplementary Figures 3, 4, and 5**. Fever and dizziness are the two prominent symptoms that help predict the rate of hospitalization > 7 days, whereas dizziness and hoarseness are the two critical symptoms that indicate the rate of hospitalization > 14 days. When the numbers of symptoms are taken into account, a combination of 4 symptoms comes close to predict prolonged hospital stay (but outside the CI). Hypertension, asthma/COPD, smoking, and tobacco are the significant predictors for hospitalization > 7 days, but diabetes replaces as a decisive single factor for hospitalization > 14 days.

Discussion

Our study provides some insights into the clinical presentation of COVID-19 infection and hospitalization due to the disease. But, the generalization of this study should not be considered as it has limitations. Our study was limited by including patients diagnosed at, admitted to, and discharged from SCB Medical College, Cuttack, India. Patients not fitting into any one of these were not included for analysis because it would be difficult to trace their clinical records before and after their stay at the study site. Most patients admitted were males.

Patients below 35 years and above 65 years were underrepresented, which could over or underestimate our duration of hospitalization and rate of prolonged hospitalization. Therefore, for extrapolation of these results into smaller population subgroups, caution is advised. During the early stages, PCR testing was restricted only to those persons who were severely ill, which could have inflated the estimates of the study. Persons with mild symptoms under home isolation, demanding medical supervision, and visiting the study site were tested again with a rapid antigen kit, and those with positive reports were admitted, which could have reduced the accurate estimates of the study as they were mildly infected and therefore discharged sooner than those with multiple, severe symptoms and comorbidities.

We excluded patients with heart disease, neurological disorder, malignancy since these might prolong their hospital stay. Many patients referred from different government health care centers, private clinics, and hospitals across the state were excluded because the data regarding the onset and severity of symptoms before their diagnosis could not be retrieved. Moreover, literacy and language were essential barriers to obtain the symptom history and other clinical data regarding the study, mainly for patients from other states and remote areas of the Odisha state, who only knew their vernacular language. All of these could have increased or decreased the estimate of hospitalization.

It is essential to quantify the hospitalization rate due to COVID-19 to evaluate its impact on the resources, staffing, and the total healthcare system. In our study, admission of patients with a wide range and various combinations of symptoms allowed us to state that most people with multiple symptoms and uncontrolled comorbidities are males of the elderly age group. Some studies had not reported bronchial asthma as a risk factor for hospitalization, but its association with prolonged hospitalization demands further investigation.

Our study found that symptoms before hospital admission were predictive of the duration of hospital stay. With the number of symptoms before diagnosis, age, and gender, we designed a model to differentiate short (≤ 7 days) and long (≥ 14 days) hospitalization due to COVID-19. The model was generalized with the same performance to the population that reported antibody testing. This information could feature in targeted education material for both affected individuals and healthcare providers, and we present decision curve analysis for use in clinical settings, with model results at different thresholds.

Declarations

Ethics approval and consent to participate: We got the ethical approval (IEC application no: 601 dated 11.02.2021) from the Institutional Ethics Committee of SCB Medical College and Hospital, Cuttack, Odisha, India, before collecting and analyzing the data. Since the data for this retrospective study were collected from the hospital record, consent for participation in the study was not applicable for this study.

Consent for publication: Not applicable

Availability of data and materials: The datasets generated during and analyzed during this study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: JPS and S.G. wrote the protocol. JPS got ethical approval for the study. M.P., S.S., and S.G. collected the data. JPS analyzed the data and was a major contributor in writing the manuscript. All the authors read and approved the final manuscript.

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Tables

Table 1: Patient characteristics

	Total [n = 6918]	Short duration (≤ 7 days) [n = 2972]	Intermediate duration (8-14 days) [n = 2627]	Long duration (> 14 days) [n = 1319]
Males; n (%)	4916 (71.06%)	1859 (62.55%)	2041 (77.69%)	1016 (77.02%)
Age in years; median (IQR)	52 (39-64)	40 (31-51)	55 (46-69)	63 (53-76)
Age group (16-35/36- 50/51- 65/ >65); n	1131/1834/2427/1526	1076/998/764/134	55/768/978/826	0/68/685/566
Age group (16-35/36- 50/51- 65/ >65); %	16.3/26.6/35.1/22.1	36.2/33.6/25.7/4.5	2.1/29.2/37.3/31.4	0/5.2/51.9/42.9
Respiratory diseases; n (%)	3211 (46.4)	911 (30.7)	1183 (45.0)	1117 (84.7)
Diabetes; n (%)	4127 (59.7)	549 (18.5)	2360 (89.8)	1218 (92.3)
Hypertension; n (%)	4031 (58.3)	1158 (39.0)	1851 (70.5)	1022 (77.5)
Smokers, n (%)	1854 (26.8)	531 (17.9)	755 (28.7)	568 (43.1)
Tobacco chewers, n (%)	1601 (23.1)	477 (16.0)	594 (22.6)	530 (40.2)
Alcoholics, n (%)	1800 (26.1)	818 (27.5)	634 (24.1)	348 (26.4)
Number of symptoms at diagnosis; median(IQR)	4 (3-4)	4 (3-4)	4 (3-4)	5 (4-6)

Figures

Figure 1

The median duration of hospital stay of patients was 9 (5-13) days [male: 10 (5-14) days; female: 7 (4-12) days] Figure 1(a). Most of the female patients had shorter (< 7 days) duration of hospital stay, and male patients had longer (> 7 days) hospital stay Figure 1(b). There was an increased duration of hospital stay with increased age and number of symptoms. Patients with bronchial asthma or chronic obstructive pulmonary disease were admitted for a longer duration than those without respiratory illnesses Figure 1(c).

Figure 2

The correlation matrix had been plotted in Figure 2. We found significant correlation of duration of hospital stay with following variables: duration of diabetes ($r = 0.78$, $p < 0.001$), age of the person ($r = 0.62$, $p < 0.001$), number of symptoms ($r = 0.56$, $p < 0.001$), duration of hypertension ($r = 0.53$, $p < 0.001$), duration of asthma or COPD ($r = 0.52$, $p < 0.001$), and duration of fever prior to hospitalization ($r = 0.44$, $p < 0.001$). Other significant correlations were between following variables: duration of dyspnea and number of symptoms ($r = 0.58$, $p < 0.001$), duration of diabetes and age of the person ($r = 0.55$, $p < 0.001$), duration of dyspnea and duration of diabetes ($r = 0.47$, $p < 0.001$), duration of hypertension and age of the person ($r = 0.47$, $p < 0.001$), duration of diabetes and number of symptoms ($r = 0.45$, $p < 0.001$), duration of asthma and number of symptoms ($r = 0.44$, $p < 0.001$), duration of asthma and age of the person ($r = 0.43$, $p < 0.001$), and duration of fever and duration of diabetes ($r = 0.42$, $p < 0.001$). There was a single negative (non-significant) correlation of duration of hospital stay with duration of alcoholism ($r = -0.07$, $p = 0.921$).

Sankey diagram

Hospital stay based on age, asthma, and symptoms

Figure 3

For highlighting the associations among age, respiratory illness, number of symptoms, and duration of hospital stay, a Sankey diagram was drawn in Figure 3. The columns (from left to right) represented the person's age, presence/absence of any respiratory disease, number of symptoms experienced before hospitalization, and duration of hospital stay after diagnosis of infection. The widths of the bands denote the association between the variables. Older adults were more affected by asthma or COPD than younger individuals. The patients with COPD had more symptoms than those with asthma and those without any respiratory diseases. The number of symptoms proportionately affects the duration of hospitalization. All individuals with more than five symptoms stayed in the hospital for more than seven days. Most of the patients with asthma & COPD were elderly and were more prone to present 4-5 symptoms at the time of hospitalization, which led them to prolonged hospitalization.

Figure 4

Figure 4 describes the co-occurrence plots of various symptoms of the participants. The up-left plot shows the symptoms in all participants. The up-right portion is meant for the participants hospitalized for 2-7 days. The down-left part depicts the co-occurrence of symptoms for patients hospitalized for more than seven days. The down-right plot shows participants who were hospitalized for more than 14 days. Fever was the most common symptom experienced among the study participants. It mainly co-occurred with cough, myalgia, dyspnea, and dizziness. Here, the size of the circle indicates the percentage of the participants, and the thickness of the line shows the degree of co-occurrence of the symptoms. The co-occurrence plots suggest the direct relationship of the number of symptoms with the hospital stay, which can otherwise be stated as; more the multi co-occurrence of symptoms, the longer is the hospital stay. Our study showed the strongest association with the following symptom complexes: fever - cough (70%) & fever - myalgia (67%). The most petite association was found between loose motions - hoarseness (10%) and dizziness - hoarseness (10%). This finding held good for hospitalization up to 7 days and for > 7 days. But in contrast to the above scenarios, prolonged hospitalization of more than 14 days was strongly associated with multiple symptom complexes, i.e., fever-cough, fever-myalgia, fever-breathlessness, and fever-hoarseness. So fever may be considered as the most crucial symptom associated with other symptoms.

Figure 5

In Figure 5, we analyzed the data to estimate the risk of prolonged hospitalization more than seven days by using the symptoms seen in the patients before the diagnosis of COVID-19. The symptoms (in decreasing order of risk of prolonged hospitalization) were: dyspnea [OR 2.29 (CI 2.07-2.52)], diarrhea [OR 1.98 (CI 1.77-2.21)], fever [OR 1.89 (CI 1.69-2.10)], anosmia [OR 1.86 (CI 1.69-2.05)], dizziness [OR 1.46 (CI 1.32-1.60)], myalgia [OR 1.31 (CI 1.18-1.44)], cough [OR 1.13 (CI 1.02-1.25)], and hoarseness [OR 1.12 (CI 1.00-1.25)].

Supplementary Files

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