

Neutralizing Monoclonal Antibody Treatment Reduces Hospitalization for Mild and Moderate COVID-19: A Real-World Experience

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Summary

In a real-life clinical setting, we found that the receipt of NmAb treatment significantly reduced hospital utilization among COVID-19 patients with mild to moderate disease, especially if NmAb treatment was received ≤ 4 days after symptom onset.

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ABSTRACT

Background: Neutralizing monoclonal antibody (NmAb) treatments have received emergency use authorization to treat patients with mild or moderate COVID-19 infection. To date, no real-world data about the efficacy of NmAb has been reported from clinical practice. We assessed the impact of NmAb treatment given in the outpatient clinical practice setting on hospital utilization.

Methods: Electronic medical records were used to identify adult COVID-19 patients who received NmAbs [bamlanivimab (BAM) or casirivimab and imdevimab (REGN-COV2)] and historic COVID-19 controls. Post-index hospitalization rates were compared.

Results: 707 confirmed COVID-19 patients received NmAb and 1709 historic COVID-19 controls were included; 553 (78%) received BAM, 154 (22%) received REGN-COV2. Patients receiving NmAb infusion had significantly lower hospitalization rate (5.8% vs. 11.4%, $p < 0.0001$); a shorter length of stay if hospitalized (mean 5.2 days vs. 7.4 days, $p = 0.02$), and fewer ED visits within 30 days post-index (8.1% vs 12.3%, $p = 0.003$) than controls. Hospitalization-free survival was significantly longer in NmAb patients compared to controls ($p < 0.0001$). There was a trend towards a lower hospitalization rate among patients who received NmAb within 2-4 days after symptom onset. In multivariate analysis, having received a NmAb transfusion was independently associated with a lower risk of hospitalization after adjustment for age, sex, race, BMI and referral source: adjusted hazard ratio (95% CI) = 0.54 (0.38 – 0.79), $p = 0.0012$. Overall mortality was not different between the two groups.

Conclusions and Relevance: NmAb treatment reduced hospital utilization especially when received within a few days of symptom onset. Further study is needed to validate these findings.

Key Words: SARS-CoV-2, inpatient care, resource utilization, immunotherapy, multimorbidity.

Abbreviations: SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; BMI, body mass index; CCI, Charlson's comorbidity index; NmAb, neutralizing monoclonal antibody.

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INTRODUCTION

Since severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative virus of COVID-19, was first reported out of Wuhan, China in late December 2019, treatment for this potentially deadly infection has rapidly emerged. One of the most recent treatment options given an emergency use authorization (EUA) by the Federal Drug Administration (FDA) in the United States was the use of neutralizing monoclonal antibodies (NmAbs). These treatments were developed to prevent hospitalization and emergency room use for those with mild to moderate COVID-19 who met prespecified criteria based on age and medical history. Briefly, to receive NmAb-based treatment for COVID-19 under EUA, adult patients need to be ≥ 65 years, or ≥ 55 with a chronic cardiovascular or pulmonary disease, or to have a body mass index (BMI) ≥ 35 kg/m², diabetes, chronic kidney disease, or a comorbidity associated with reduced immune function regardless of age [2,3]. Patients also must have a mild- to moderate COVID-19 infection not on supplemental oxygen, not hospitalized, and be fewer than 10 days since the first onset of symptoms.

Monoclonal antibodies are laboratory-made proteins that mimic naturally occurring antibodies to target the immune system to treat a wide range of diseases from cancer and autoimmune disease to harmful pathogens. In the case of COVID-19, NmAbs are made to fight off SARS-CoV-2 spike protein which then blocks the virus's ability to attach and enter human cells (**Figure 1**) [4-5]. Several randomized controlled trials are evaluating the efficacy of NmAbs treatment among non-hospitalized patients with mild to moderate symptoms who were within three days of a test confirming a positive COVID-19 diagnosis and at high risk for progressing to severe COVID-19 [6-7]. The Blocking Viral Attachment and Cell Entry with SARS-CoV-2 Neutralizing Antibodies (BLAZE-1) trial is evaluating the efficacy of

bamlanivimab (BAM). In addition, the REGN-COV2 study is now investigating an antibody cocktail containing two SARS-CoV-2–neutralizing antibodies, casirivimab and imdevimab. The interim analyses from both studies demonstrated that administration of NmAbs reduced viral load when administered within 8 days from symptom onset and that patients who received treatment also reported slightly lower symptom scores 2 to 6 days after diagnosis. Based on these interim results, the FDA in November 2020 granted EUAs as treatment for mild to moderate COVID-19 in those 12 years and older who weigh at least 40 kgs (88 pounds) as well as meeting the prespecified criteria based on clinical data as described above [6-7].

To date, there is not enough data about the effect of early NmAb treatment on the risk of progression to severe COVID-19 in the form of hospital admission, emergency room use, and mortality outside of clinical trials. Therefore, the intent of this study was to assess the impact of neutralizing monoclonal antibody treatment for patients with an established diagnosis of COVID-19 on the outcomes of hospitalization, emergency room use, and mortality.

METHODS

Patient population

Inova Health System (IHS) is an integrated healthcare system which includes 5 acute care hospitals and emergency rooms in addition to multiple urgent care centers, primary care offices and specialty care practices. In order to deliver extended outpatient care to patients with mild to moderate COVID-19, IHS opened COVID-19 care clinics based on a “day hospital” concept. The clinics were chosen in convenient locations either as a part of an existing emergency department or as an outpatient clinic. In December 2020, these clinics started infusions of NmAbs to COVID-19 patients with mild to moderate symptoms. In order

to be eligible for an infusion with NmAbs at Inova, an individual must have had confirmed COVID-19 infection by a PCR or antigen test and fulfill all the EUA criteria for treatment with either BAM or REGN-COV2 as described above. It is important to note that the majority of clinic visits were taking place via telehealth so patients could be electronically referred for the NmAb treatment to an IHS facility. Once the referral was received at IHS, a follow-up telehealth visit was conducted by a physician to make sure all criteria were met and then, if a patient was deemed qualified for the NmAb treatment, the patient was immediately sent for treatment at one of the infusion centers.

For this study, data were collected from electronic medical records (EMRs) of adults (>18 years) with a diagnosis of COVID-19 who received a NmAb infusion between December 9, 2020 and February 4, 2021 in one of IHS COVID-19 clinics or emergency rooms. Both NmAb infusion regimens were given as described in their respective fact sheets as provided by the FDA [2-3]. Age-matched controls were randomly selected from historic COVID-19 patients who had been seen between June 1, 2020 and November 30, 2020 in any IHS outpatient clinic or ED; both in-person clinic or ED visits and telehealth visits were included. The diagnosis of acute COVID-19 infection was established using ICD-10 code U07.1.

Study definitions

The index date was the first recorded episode of care within IHS with a COVID-19 ICD-10 code for both NmAb patients and controls. In addition, 14 days of pre-infusion encounters at were extracted from EMRs in order to establish the source of referral for NmAb patients (ED vs. other). For controls, the source of care was the setting of their first episode of care with a COVID-19 ICD-10 code, similarly categorized as ED vs. other.

The primary outcome of the study was hospitalization with a COVID-19 diagnosis between 1 and 30 days after the index date. Patients who were hospitalized on the day of their first encounter with a COVID-19 diagnosis and NmAb patients who were hospitalized for COVID-19 on or before the day of infusion were excluded from the study. Secondary outcomes included the length of inpatient stay for patients who were hospitalized, post-index ER/clinic visits (1-30 days), and post-index death (at any time).

Race/ethnicity was classified into non-Hispanic white or Caucasian, non-Hispanic black or African-American, Hispanic, Asian, and other/biracial groups. Body mass index (BMI) was calculated using weight and height collected at any encounter with IHS during the study period (if multiple records then the one closest to the index date was chosen; multiple records for the same day were averaged). Because BMI was one of the eligibility criteria for NmAb infusion and the need to control for a potential difference in BMI between NmAb group and controls, patients without available BMI in their EMR were excluded. In addition, owing to a substantial difference in coding practices in inpatient and outpatient settings, Charlson comorbidity index (CCI) scores were calculated using ICD codes for patients who were and were never hospitalized separately.

Statistical Analysis

Patients' parameters were summarized as N (%) or mean (\pm SD) in NmAb group and controls separately. Parameters were compared between groups using χ^2 or Kruskal-Wallis tests for categorical or continuous parameters, respectively. Time from the index date to hospitalization was summarized in the form of Kaplan-Meier curves which were compared between NmAb group and controls using a log-rank test. In addition, factors that could be independently associated with time to hospitalization (age, sex, race, BMI, ED referral, and

having received NmAb treatment) were assessed using a Cox proportional hazard model.

SAS 9.4 (SAS Institute, Cary, NC) was used for all analyses. The study was approved by the Inova Health System's Institutional Review Board.

RESULTS

The study included 707 COVID-19 patients who received a NmAb infusion and 1709 historic COVID-19 controls. Patients in NmAb group received BAM (n=553, or 78%) or REGN-COV2 (n=154). Patients in NmAb group were slightly older than controls (mean age 60 vs. 58 years, $p=0.0044$), were more commonly male, white, and obese (**Table 1**). Of NmAb recipients, 42% were eligible for an infusion based on their age (≥ 65 years), another 28% based on $BMI \geq 35$ kg/m², and 30% met other eligibility criteria (**Table 1**). The mean time from the onset of symptoms to infusion was 6 days (SD 3 days); 35% were referred to the infusion from an ED (**Table 1**).

Of all included patients who received a NmAb infusion, 5.8% (n=41) were hospitalized for COVID-19 at least one day after the infusion but within 30 days after receiving the diagnosis (**Table 1**). The mean time to hospitalization was 5.3 days (SD 4.0 days) from the index date and 3.6 (SD 3.5) days from the date of infusion. The last hospitalization for COVID-19 among NmAb patients happened 17 days after the diagnosis. The mean length of inpatient stay among those who were hospitalized for COVID-19 after receiving NmAbs was 5.2 days (SD 4.5 days) (**Table 1**).

In comparison to controls, NmAb patients had a significantly lower crude hospitalization rate: 5.8% vs. 11.4% ($p<0.0001$). Among those who were hospitalized, NmAb patients had a shorter length of inpatient stay (mean 5.2 days vs. 7.4 days, $p=0.019$). Additionally, ED visits

within 30 days post-index were lower in those who received NmAb (8.1% vs 12.3%, $p=0.003$). There was no difference in CCI between NmAb and non-NmAb patients who were never hospitalized ($p>0.10$) while NmAb patients who were hospitalized had a higher baseline CCI score than hospitalized controls (mean (SD) = 4.6 (2.9) vs. 3.7 (2.9), $p=0.039$). The cumulative mortality rate for COVID-19 patients receiving NmAbs was not significantly different from that seen in controls ($p>0.05$) (**Table 1**).

Hospitalization-free survival was found to be significantly longer in NmAb patients in comparison to controls ($p<0.0001$ by a log-rank test) (**Figure 2**). In addition, for a subgroup of NmAb patients who had the duration of symptoms or the date of symptom onset recorded in their EMRs ($n=358$), we found that there was a trend towards a lower risk of hospitalization among patients who received their infusion sooner, especially in those who received it within 2-4 days after the onset of symptoms (**Figure 3**).

With the aim to identify a patient group which would likely benefit the most from NmAb treatment, we compared hospitalization rates between NmAb patients and controls in different BMI- and age-based subgroups (**Table 2**). As a result, we found that a trend towards lower hospitalization rate was observed across the spectrum of patient demographics with only a few exceptions (**Table 2**). In this context, it is interesting to note that the relative risk reduction was more pronounced in younger patients regardless of their BMI while the absolute risk reduction was greater in older patients; importantly, it is the latter that would translate into a smaller number needed to be treated (**Table 2**). At the same time, lean patients (BMI<25) who received NmAb did not seem to experience lower hospitalization regardless of age (**Table 2**).

In multivariate analysis, factors independently associated with a higher risk of hospitalization after COVID-19 diagnosis were older age, male sex, non-white race, and having visited an ER which is a potential indicator of greater disease severity (**Table 3**). After adjustment for these, receiving NmAb transfusion was still independently associated with a lower risk of hospitalization: adjusted hazard ratio (aHR) (95% CI) = 0.54 (0.38 – 0.79), $p=0.0012$ (**Table 3**). Despite a bias in the value between hospitalized and non-hospitalized patients likely owing to varying coding practices, the association of having received NmAb with a lower risk of hospitalization remained significant after adjustment for CCI: aHR = 0.57 (0.38 – 0.84), $p=0.0045$ (**Table 3**). Similar trends were also observed in patients who received a specific type of antibody (vs. controls): aHR = 0.57 (0.39 – 0.84), $p=0.0049$ for BAM, aHR = 0.49 (0.20 - 1.21), $p=0.12$ for REGN-COV2.

DISCUSSION

In this study, we report the use of NmAb treatment for mild to moderate COVID-19 infection in real-life clinical practice settings. Our data show that patients who received treatment with either BAM or REGN-COV2 according to the EUA recommendations were less likely to be hospitalized for their COVID-19 infection with an adjusted hazard ratio of 0.54. The lower hospitalization rate in the NmAb group is especially noteworthy given that the NmAb group was studied during the peak of increased hospitalizations (December 2020-January 2021) [8]. We also noted a reduction in ER visits post infusion. Furthermore, for those who were hospitalized after their NmAb treatment, their inpatient stay was significantly shorter than that of the controls.

This improvement in outcomes was observed for both existing NmAb regimens and also across the spectrum of age and BMI-based subgroups of COVID-19 patients with only a few exceptions such that the reduction in hospitalization in the lean group (BMI<25) was not

observed, regardless of age. In this context, it is important to note that NmAb recipients with normal BMI included in our study experienced a relatively high hospitalization rate (nearly 10%, the highest of all BMI subgroups) which was likely driven by comorbidities that had made them eligible for NmAb treatment according to the current EUA guidelines. However, a potential benefit of the regimens for patients with a lean BMI and a low comorbidity burden cannot be appreciated from these data. In addition, there may be long-term benefits of the NmAb infusion such as reduction of post-COVID-19 chronic sequelae even among patients without a clear effect on their hospitalization risk although, given the design of our study, we were not able to show these potential benefits of NmAb infusions [9].

Interestingly, we noticed that the magnitude of relative improvement in outcomes was generally higher in patients less than 65 years of age in comparison to older NmAb recipients. This is in contrast to the present belief that it is older patients who would benefit the most owing to decreased immune function with age. Nonetheless, those 65 years and older did experience an absolute risk reduction for hospitalization that was slightly greater than that seen in younger patients; in the context of resource utilization, the latter potentially translates into a smaller number needed to treat in order to prevent one hospitalization. Taken together then, we believe that clinical trials should continue investigating efficacy of NmAbs in all patient populations with a potential aim to expand eligibility criteria to all SARS-COV2-infected patients regardless of their age or medical history.

Our study outcomes were also in line with clinical trial data in that NmAb recipients experienced significantly lower hospitalization rates and emergency room visits compared to controls [6-7]. Among the NmAb patients who were subsequently hospitalized, their length of stay was also significantly shorter than the controls. In the context of improved outcomes, it is important to note that although it was not statistically powered in this study, our data

suggest that the highest benefit of NmAb treatment can be achieved if administered early in the course of the disease, preferably within 4 days after the onset of symptoms. As such, a highly effective patient management pipeline is urgently needed for all healthcare systems which provide care to COVID-19 patients, in order to warrant timely access to treatment since this may result in the immediate benefit of reduced resource utilization.

Per internal records of COVID-19 care clinics, the rates of adverse events for NmAbs were similar to those reported from clinical trials. Overall, most patients tolerated the infusion well. The ordering provider was responsible for reporting any serious adverse events to the FDA Medwatch program per the EUAs; however, these reported events were not always readily available in patients' EMRs. The serious events that were collected and reported included one hypersensitivity reaction that improved with medical management, one patient reported an exacerbation of myasthenia gravis symptoms shortly post-infusion, and one patient with stable multiple sclerosis experienced a flare within a week post-infusion.

This evidence of effectiveness of NmAb treatment for COVID-19 in real-world clinical practice is important as the FDA on February 9, 2021 issued another EUA for a combination monoclonal antibody treatment (bamlanivimab and etesevimab) which was found to decrease the rate of hospitalization and mortality at 29 days of follow-up when compared to the placebo group [10]. With our findings and the continuance of these clinical trials, more data are now available for professional societies such as the Infection Diseases Society of America (IDSA) to update their guidelines on monoclonal antibody treatment which may be necessary when considering treatment access and payment options in the future [11].

The main limitation is that it is a retrospective observational study design with limited EMR data which only allowed testing a narrow range of hypotheses. Another limitation is use of administrative data for medical history which may have not been systematically collected for non-hospitalized patients. Similarly, no systematic assessment of adverse events data was available from EMRs. Duration of symptoms was available for a subset of patients only, resulting in a limited sample size. No events and outcomes were included if they happened outside of our health system such that a patient who received NmAb treatment and hospitalized outside of an IHS facility would not have been captured in our study outcomes. Similarly, for patients referred for a NmAb infusion from outside IHS, the index date would be potentially later than if that same patient were initially seen by an IHS provider. At the same time, there is no reason to believe that clinical events outside IHS would be imbalanced between NmAb patients and controls. In addition, while potential outcome undercount cannot be ruled out, it is important to note that IHS service area covers a large region of Northern Virginia. Another limitation is the use of the first episode of care as an index date rather than the day of symptom or illness onset. Despite this, the control sample may still be biased towards potentially sicker patients because NmAb infusion required waiting for, on average, 1.7 days without being hospitalized or put on supplemental oxygen. However, this limitation would be primarily applicable to the first few days post-index and would unlikely affect the overall trends and conclusions of the study especially since the CCI among the hospitalized group was significantly lower for the control group. Finally, our control group of patients was taken from a non-overlapping time period which could have introduced differences in evolving hospitalization practices. In this context, it is important to note that we excluded patients from the first few months of the pandemic when the changes in our practice were the most rapid. Rather, we used the period from June 2020 onwards when our practices had

largely stabilized as previously published [12].

In summary, our study provides real-world evidence that neutralizing monoclonal antibody treatment for mild to moderate COVID-19 infection, when applied using prespecified criteria, is effective in reducing hospitalizations and may also reduce hospital resource utilization. This effect was observed in most age- and BMI-based subgroups of patients. Additional studies are needed to confirm this in a more diverse and potentially expanded patient population.

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NOTES

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Figure Legends

Figure 1. Schematic depiction of the potential mechanism of mAb in COVID-19 infection (reprinted with permission from Taylor et al. Nat Rev Immunol, 2021 [5]).

Figure 2. Hospitalizations for COVID-19 in patients who received a NmAb infusion and controls (censored at 30 days).

Figure 3. Distribution of hospitalization rates based on the number of days between the first onset of symptoms and NmAb infusion (n=358).

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Table 1. Comparison of COVID-19 patients who received NmAb infusion to controls.

	NmAb group	Controls	P
N	707	1709	
Bamlanivimab	553 (78.2%)	0 (0.0%)	
Casirivimab and imdevimab (REGN-COV2)	154 (21.8%)	0 (0.0%)	
Age, years	59.8 ± 15.9	58.1 ± 15.2	0.0044
Male sex	31.7 ± 7.8	29.5 ± 6.2	<0.0001
Non-Hispanic white or Caucasian	357 (50.6%)	762 (44.6%)	0.0067
Non-Hispanic black or African-American	340 (56.2%)	644 (41.9%)	<0.0001
Hispanic	94 (15.5%)	263 (17.1%)	0.38
Asian	111 (17.8%)	507 (32.4%)	<0.0001
Other race/ethnicity	57 (9.4%)	118 (7.7%)	0.18
BMI, kg/m ²	3 (0.5%)	6 (0.4%)	0.73
Morbid obesity (BMI ≥ 40)	109 (15.4%)	99 (5.8%)	<0.0001
BMI ≥ 35	232 (32.8%)	306 (17.9%)	<0.0001
Age ≥ 65 and BMI ≥ 35	34 (4.8%)	76 (4.4%)	0.69
Age < 65 and BMI ≥ 35	197 (27.9%)	230 (13.5%)	<0.0001
Age ≥ 65 and BMI < 35	264 (37.4%)	508 (29.7%)	0.0002
Age < 65 and BMI < 35	210 (29.8%)	895 (52.4%)	<0.0001
Referred from Emergency Department (ED) *	244 (34.5%)	832 (48.7%)	<0.0001
Duration of symptoms before infusion, days (mean ± SD)	-6.15 ± 2.76		
Charlson's comorbidity index (CCI) and components:			
CCI in hospitalized patients	4.59 ± 2.91	3.70 ± 2.86	0.0391
CCI in non-hospitalized patients	2.26 ± 1.77	2.35 ± 2.28	0.19
Myocardial infarction	20 (2.8%)	66 (3.9%)	0.21
Congestive heart failure	22 (3.1%)	95 (5.6%)	0.0108
Peripheral vascular disease	8 (1.1%)	62 (3.6%)	0.0009
Cerebrovascular disease	9 (1.3%)	58 (3.4%)	0.0039
Dementia	14 (2.0%)	69 (4.0%)	0.0115
Chronic pulmonary disease	96 (13.6%)	240 (14.0%)	0.76
Connective tissue disease-rheumatic disease	11 (1.6%)	34 (2.0%)	0.47
Peptic ulcer disease	0 (0.0%)	7 (0.4%)	0.09
Mild liver disease	5 (0.7%)	61 (3.6%)	0.0001
Diabetes without complications	132 (18.7%)	278 (16.3%)	0.15
Diabetes with complications	27 (3.8%)	115 (6.7%)	0.0057
Paraplegia and Hemiplegia	0 (0.0%)	6 (0.4%)	0.11
Renal disease	40 (5.7%)	129 (7.5%)	0.10

Non-metastatic cancer	22 (3.1%)	53 (3.1%)	0.99
Moderate or Severe Liver Disease	1 (0.1%)	3 (0.2%)	0.85
Metastatic carcinoma	5 (0.7%)	18 (1.1%)	0.43
AIDS	0 (0.0%)	1 (0.1%)	0.52
Outcomes:			
Hospitalized with COVID-19 in 1-30 days post-index	41 (5.8%)	195 (11.4%)	<0.0001
Period from index to hospitalization, days (for hospitalized only)	5.29 ± 4.01	5.70 ± 4.95	0.83
Length of inpatient stay, days (for hospitalized only)	5.24 ± 4.55	7.44 ± 8.10	0.0186
Returned to ED in 1-30 days post-index	57 (8.1%)	210 (12.3%)	0.0026
Died in follow-up	4 (0.6%)	24 (1.4%)	0.08

* Visited ED with a diagnosis of COVID-19 before infusion for NmAb group; index visit to ED for controls.

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Table 2. Comparison of hospitalization rates by subgroups.

	NmAb group	Controls	P
By BMI:			
< 25 kg/m ²	13 (9.1%)	42 (10.1%)	0.72
25-30 kg/m ²	8 (3.8%)	69 (11.6%)	0.0011
30-35 kg/m ²	8 (6.5%)	47 (11.9%)	0.09
35-40 kg/m ²	5 (4.1%)	25 (12.1%)	0.0144
≥ 40 kg/m ²	7 (6.4%)	12 (12.1%)	0.15
By age:			
< 65 years	13 (3.2%)	98 (8.7%)	0.0002
≥ 65 years	28 (9.4%)	97 (16.6%)	0.0037
By BMI and age:			
Age ≥65, BMI ≥35	6 (17.6%)	10 (13.2%)	0.54
Age <65, BMI ≥35	6 (3.0%)	27 (11.7%)	0.0008
Age ≥65, BMI <35	22 (8.3%)	87 (17.1%)	0.0009
Age <65, BMI <35	7 (3.3%)	71 (7.9%)	0.0192

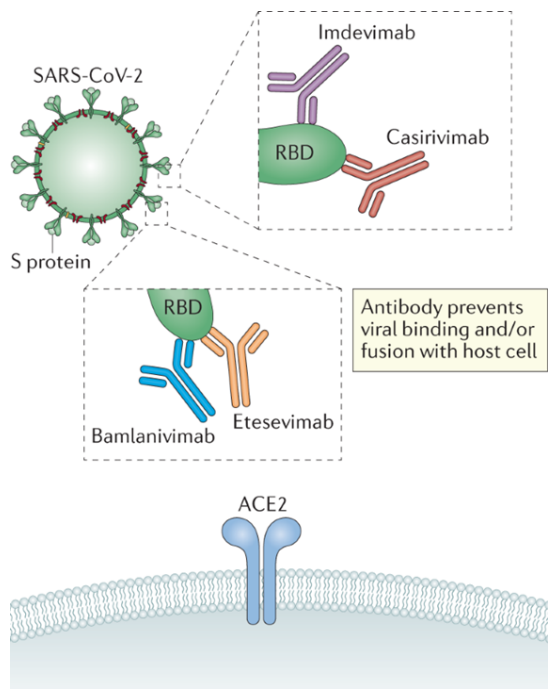
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Table 3. Independent predictors of time to hospitalization for COVID-19 patients.

predictor	Adjusted hazard ratio	P
<i>Model 1</i>		
Receiving NmAb infusion	0.54 (0.38 - 0.79)	0.0012
Age, per 5 years	1.18 (1.12 - 1.24)	<.0001
Male sex	1.53 (1.16 - 2.02)	0.0025
White race	0.55 (0.41 - 0.76)	0.0002
Referral from ED*	2.11 (1.57 - 2.82)	<.0001
BMI \geq 35 kg/m ²	1.10 (0.76 - 1.58)	0.62
<i>Model 2</i>		
Receiving NmAb infusion	0.57 (0.38 - 0.84)	0.0045
Age, per 5 years	1.04 (0.97 - 1.13)	0.26
Male sex	1.45 (1.07 - 1.95)	0.0150
White race	0.48 (0.34 - 0.68)	<.0001
Referral from ED*	2.11 (1.53 - 2.90)	<.0001
BMI \geq 35 kg/m ²	1.08 (0.74 - 1.58)	0.69
Charlson's comorbidity index, per 1 point	1.22 (1.10 - 1.36)	0.0003

*Referral from ED means a patient visited ED with a diagnosis of COVID-19 before infusion for NmAb group, the index visit was to ED for controls.

Figure 1



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Figure 2

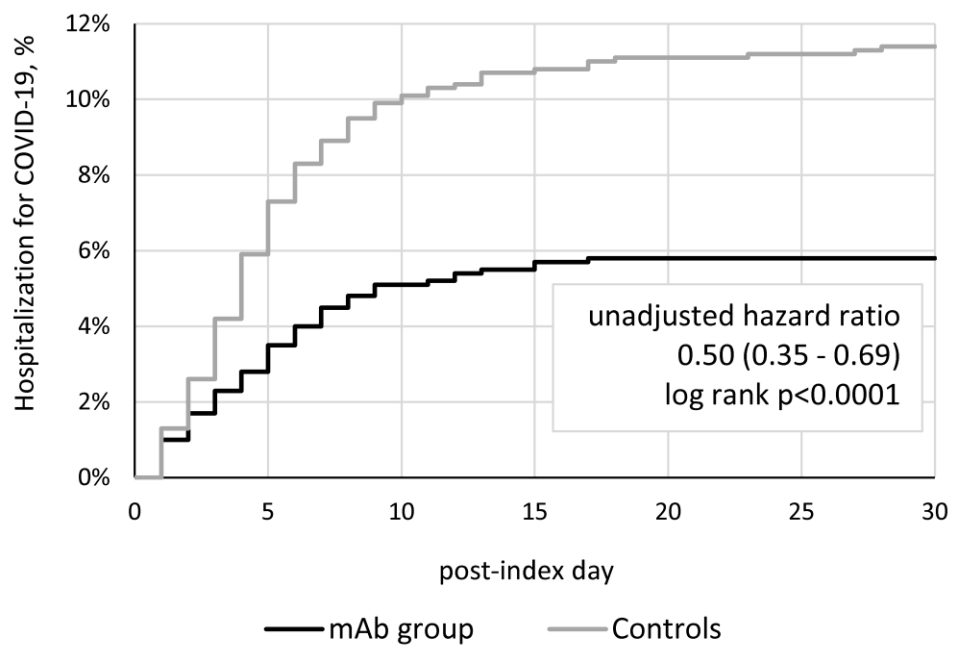


Figure 3

