

# Insurer Costs of COVID-19 by Disease Severity and Duration

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In the US, the COVID-19 respiratory illness caused by SARS-CoV-2 has affected approximately 94 million patients and caused more than 1 million deaths as of September 7, 2022.<sup>1</sup> The actual direct health care costs of treating COVID-19 from the perspective of the American commercial payers are not well understood.

A characteristic of COVID-19 is its heterogeneous presentation: Individuals with SARS-CoV-2 infection can experience asymptomatic disease or develop symptoms ranging in severity from mild to deadly; therefore, health care costs and utilization vary greatly.<sup>2</sup> Sheinson et al published a cost-effectiveness framework for COVID-19 treatments for hospitalized patients in the US.<sup>3</sup> This study's findings suggested that bundled payments for patients with COVID-19 who had inpatient admissions without respiratory support or inpatient admissions with nonmechanical respiratory support averaged \$8767 and \$13,282, respectively, and reached \$49,631 for patients requiring mechanical ventilation.<sup>3</sup> Another study used a microcosting approach to estimate COVID-19-related costs, individually listing each payment for every visit and care.<sup>4</sup> Most recently, results of a study evaluating health care costs of patients with outpatient-diagnosed COVID-19 (with and without subsequent COVID-19-related inpatient admission) suggested that patients may incur median costs of \$208 for outpatient and \$39,187 for inpatient care.<sup>5</sup> Additional research has been published focusing on inpatient care only or on models of potential costs.<sup>6-9</sup> The actual paid amounts associated with the treatment of COVID-19 in both inpatient and outpatient settings from the perspective of the US private payer—including patient co-pays/coinsurance and deductibles—are not well documented.

Differentiating costs by case severity is key, as some asymptomatic patients may incur no costs at all. In addition, hospitalized patients may present with a primary diagnosis of COVID-19 or may be admitted for other causes and subsequently present with COVID-19. We did not include societal and non-health care costs in this analysis because our study focused on the perspective of the US private insurer. Because co-pay, coinsurance, and deductible represent a proportion of the negotiated rates between insurers and providers and vary significantly across patients based on their

## ABSTRACT

**OBJECTIVES:** To analyze US commercial insurance payments associated with COVID-19 as a function of severity and duration of disease.

**STUDY DESIGN:** Retrospective database analysis.

**METHODS:** Patients with COVID-19 between April 1, 2020, and June 30, 2021, in the Merative MarketScan Commercial database were identified and stratified as having asymptomatic, mild, moderate (with and without lower respiratory disease), or severe/critical (S/C) disease based on the severity of the acute COVID-19 infection. Duration of disease (DOD) was estimated for all patients. Patients with DOD longer than 12 weeks were defined as having post-COVID-19 condition (PCC). Outcomes were all-cause payments (ACP) and disease-specific payments (DSP) for the entire DOD. Variables included demographic and comorbidities at the time of acute disease. Adjusted payments by disease severity were estimated using generalized linear models ( $\gamma$  distribution with log link).

**RESULTS:** A total of 738,339 patients were included (374,401 asymptomatic, 156,220 mild, 180,213 moderate, and 27,505 S/C cases). DSP increased from \$217 [95% CI, \$214-221] for asymptomatic cases to \$2744 [95% CI, \$2678-\$2811] for moderate cases with lower respiratory disease and \$28,250 [95% CI, \$26,963-\$29,538] for S/C cases. ACP increased from \$505 [95% CI, \$497-\$512] for asymptomatic cases to \$46,538 [95% CI, \$44,096-\$48,979] for S/C cases. The DSP and ACP further increased by \$50,736 [95% CI, \$45,337-\$56,136] and \$94,839 [95% CI, \$88,029-\$101,649], respectively, in S/C cases with PCC vs a DOD of fewer than 4 weeks.

**CONCLUSIONS:** COVID-19 payments for S/C cases were more than 10-fold greater than those of moderate cases and further increased by nearly \$95,000 in S/C cases with PCC vs a DOD of fewer than 4 weeks.

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insurance plans or prior health care utilization during the same year, those payments were included in our analysis, allowing us to evaluate the total payments for care. Payments in our analysis thus include all monies paid by private insurance companies to health care providers for the treatment of COVID-19, including patient out-of-pocket costs.

The challenges associated with calculating payment for the treatment of COVID-19 are multiple—for example, case identification and cost attribution. Identification of cases was facilitated after April 2020 with the introduction of diagnosis codes specific to COVID-19. For cost attribution, we used 2 approaches: We identified disease-specific payments (DSPs), which were made for services with a diagnosis typically associated with COVID-19, and all-cause payments (ACPs), which include all services provided during the entire duration of the COVID-19 disease. The latter are important outcomes because some treatment associated with COVID-19, such as imaging or laboratory testing, may not have an associated COVID-19 diagnosis. These services would therefore be excluded from a DSP calculation, which would underestimate total cost of care. The use of both DSPs and ACPs thus provides a meaningful range of payments associated with the disease.

## METHODS

### Data Sources

The Merative MarketScan Commercial Claims and Encounters database was used. This database comprises enrollment information, demographics, and adjudicated inpatient medical, outpatient medical, and outpatient pharmacy claims data collected from more than 300 large self-insured US employers and more than 25 US health plans for individuals younger than 65 years and their dependents.

### Study Population

Patients with a COVID-19 *International Classification of Diseases, Tenth Edition, Clinical Modification* diagnosis code (U071-U072, B34.2, B97.29, J12.81) from April 1, 2020, to June 30, 2021, were identified in the database. For each patient, the date of earliest diagnosis was defined as the index date. When patients had multiple diagnoses of COVID-19, the first instance was used as the index date and index site of care. All patients in the study also required at least 7 months of continuous medical enrollment preindex and 6 months of continuous enrollment post index.

### Variable Creation

Patient demographics (age, sex, and geographic location within the US) at index date were captured. Thirty-one patient comorbidities as defined by Elixhauser, as well as the Elixhauser Comorbidity Index (ECI) score, were captured for all patients.<sup>10,11</sup> The ECI was selected instead of the Charlson Comorbidity Index because recent research

## TAKEAWAY POINTS

- ▶ Significant differences in commercial insurance payments were observed between asymptomatic, mild, moderate, and severe/critical COVID-19 cases, with asymptomatic cases incurring a mean of \$505 in all-cause health care payments and severe/critical cases averaging all-cause payments of \$46,538 per patient.
- ▶ Cost of care for severe/critical COVID-19 cases increased significantly with the duration of the disease.
- ▶ Severe/critical cases with post-COVID-19 condition, defined as more than 12 weeks of symptoms, incurred additional payments averaging \$94,839 compared with severe/critical cases with a disease duration of fewer than 4 weeks.

suggests that the former might be more predictive of frailty and mortality than the latter.<sup>12,13</sup> For the ECI calculation, 7 to 12 months of data preindex were analyzed up to 1 month prior to index (to avoid including morbidities related to the COVID-19 disease).

### Duration of Disease, Ongoing Symptomatic COVID-19, and Post-COVID-19 Condition

Duration of disease (DOD) was determined based on the presence of any 1 COVID-19 sign or symptom (CSS) or a COVID-19 diagnosis as per the codes listed earlier. A complete list of CSSs and corresponding diagnosis codes are shown in **eAppendix Table 1** (eAppendix available at [ajmc.com](http://ajmc.com)). For each patient with COVID-19, CSS diagnoses were identified starting 5 days before the COVID-19 code. Diagnoses listed prior to the index date were used because many patients presented with CSSs before being tested for and given a diagnosis of COVID-19. (For many patients with mild and moderate disease, most of the health care use happened prior to index.) COVID-19 was considered ongoing as long as the gap between distinct CSSs or COVID-19 diagnoses was shorter than 35 days. When a new diagnosis was identified after a 35-day gap, it was assumed that this might be a new condition. This rule was used because most CSSs are very generic in nature (eg, cough, headache), so their potential association with index COVID-19 may decline as the time gap in diagnosis dates increases. The decision to use a 35-day gap (vs a shorter or longer gap) was based on review of histograms of time gaps for CSS conditions for all patients. For patients with mild or moderate COVID-19 with no health care events in the database after their COVID-19 index code, it was assumed that they would have a DOD of 9 days following the COVID-19 diagnosis. The minimum DOD of any symptomatic patient in our study was 14 days. This was based on prior publications on disease duration.<sup>14,15</sup> Patients with no CSS diagnoses in the 5 days prior to and up to 35 days after index were considered asymptomatic, and for the purpose of calculating payments, their DOD was the single day when testing was performed. Ongoing symptomatic COVID-19 was defined as a DOD greater than 4 weeks ( $\geq 28$  days) but shorter than or equal to 12 weeks ( $\leq 84$  days). Post-COVID-19 condition (PCC) was defined as a DOD greater than 12 weeks ( $> 84$  days). These cutoffs were based on definitions from the United Kingdom National Institute for Health and Care Excellence, which to our

knowledge were the first published guidelines for characterization of potential “long COVID.”<sup>16</sup>

### Disease Severity

The classification of mild, moderate, and severe/critical (S/C) disease was made based on the Janssen trial definitions and the presence of CSS diagnoses. This classification was used for Janssen’s phase 3 ENSEMBLE clinical trial (NCT04505722) COVID-19 vaccine trial and described in protocols that were thoroughly reviewed and approved by the FDA and the Operation Warp Speed Team of Vaccine Phase 3 Clinical Trial Studies—hence the decision to use these definitions here. These definitions were also described in the trial publications.<sup>17,18</sup> **eAppendix Table 2** and **eAppendix Table 3** show the criteria for each severity classification and how these criteria link to CSSs and thus code lists (as per eAppendix Table 1).<sup>19,20</sup> Patients with mild disease were characterized as having only 1 symptom, as listed in eAppendix Table 2. Patients with moderate disease presented with either 2 symptoms or 1 symptom indicative of pneumonia or lower respiratory disease. Further stratification of the population with moderate disease was performed to create a group of moderate cases without lower respiratory disease (typically considered “mild,” as per the National Institutes of Health [NIH] definition<sup>20</sup> and as shown in the eAppendix) and another group of moderate cases with lower respiratory disease. Patients with S/C disease experienced at minimum severe respiratory conditions, such as acute respiratory distress or failure, along with other symptoms. All hospitalized patients had either moderate or S/C disease. All patients admitted to the intensive care unit or on ventilators were categorized as having S/C disease.

### Health Care Utilization and Payments

All payments for care in the inpatient or outpatient settings were analyzed for the entire DOD as defined earlier. Payments for visits or admissions with a CSS diagnosis were defined as a DSP so that 2 different total payments could be analyzed: an ACP, including all care encountered during the duration of the disease, and a DSP, a subset of ACP, including only care with CSS diagnoses.

### Statistical Analyses

Descriptive statistics were reported for all study variables as means and SDs for continuous variables and as frequencies and percentages for categorical variables. ACP and DSP by severity type were analyzed using generalized linear models with  $\gamma$  distribution and log links. Predictive models for DSP were developed. All demographics, comorbidities, and patient CSSs were used as features in the model development. Target was set as DSP to avoid including non-COVID-19 payments in the models. Models were developed using DataRobot 6.0.0. DataRobot is a machine learning platform that allows simultaneous use of a large library of models; it also allows automated ensembling of different distinct models to maximize predictive accuracy. A detailed explanation of the DataRobot platform has previously been published.<sup>21-23</sup>

## RESULTS

A total of 738,339 patients with a COVID-19 diagnosis or a positive COVID-19 test result were analyzed; this included 374,401 asymptomatic, 156,220 mild, 180,213 moderate (85,232 without and 94,981 with lower respiratory disease), and 27,505 S/C cases. Of the 156,220 mild cases, 129 had ongoing disease on November 30, 2021, with a mean (SD) DOD of 287.9 (74.8) days. Of the 180,213 moderate and 27,505 S/C cases, 575 moderate and 827 S/C cases had ongoing disease (mean [SD] DOD, 290.4 [85.7] and 282.2 [85.9] days, respectively). Key demographic, comorbidity, and disease duration findings are shown in **Table 1**. As expected, age and comorbidities increased with disease severity (mean [SD] age, 38.0 [16.0] years across all severity classes and 36.2 [16.1], 36.7 [16.2], 41.1 [15.0], and 50.3 [11.0] in the asymptomatic, mild, moderate, and S/C populations, respectively; mean [SD] ECI score, 0.70 [1.19] across all severity classes and 0.54 [0.99], 0.63 [1.07], 0.94 [1.36], and 1.75 [2.04] in the asymptomatic, mild, moderate, and S/C populations, respectively). The proportion of patients with an ECI score of 5 or greater also increased with disease severity, from 0.7% of the asymptomatic population to 9.1% of the S/C population. Patients with mild disease experienced COVID-19 for a mean of 19 days vs 57 days for patients with S/C disease. Female patients represented 53%, 55%, 57%, and 44% of the asymptomatic, mild, moderate, and S/C cohorts, respectively.

Across the entire cohort, the mean (SD) unadjusted total DSP and ACP for the treatment of COVID-19 for all patients were \$1713 (\$17,031) and \$3468 (\$27,930), respectively. **Table 2** shows adjusted DSP and ACP amounts for each severity. Mean DSP increased from \$217 (95% CI, \$214-\$221) for asymptomatic cases to \$28,250 (95% CI, \$26,963-\$29,538) for S/C cases (incremental payments from asymptomatic to mild, moderate without lower respiratory disease, moderate with lower respiratory disease, and S/C: \$197 [95% CI, \$189-\$206], \$515 [95% CI, \$496-\$534], \$2527 [95% CI, \$2461-\$2594], and \$28,033 [95% CI, \$26,746-\$29,321], respectively). ACP increased from \$505 (95% CI, \$497-\$512) for asymptomatic cases to \$46,538 (95% CI, \$44,096-\$48,979) for S/C cases.

Within the S/C cohort, the mean (SD) unadjusted DSP and ACP for the treatment of COVID-19, regardless of DOD, were \$30,079 (\$81,332) and \$56,277 (\$128,561), respectively. **Table 3** shows the adjusted payments for patients with S/C disease as a function of DOD: fewer than 4 weeks, 4 to 12 weeks (also described as ongoing symptomatic COVID-19), and more than 12 weeks (PCC). When comparing patients with a DOD fewer than 4 weeks vs those with a DOD more than 12 weeks, DSP and ACP increased by \$50,736 (95% CI, \$45,337-\$56,136) and \$94,839 (95% CI, \$88,029-\$101,649), respectively.

The most accurate predictive model evaluating patient characteristics (including diagnoses and treatments) associated with increased ACP was a blended generalized linear model. Not surprisingly, the most predictive features associated with increased payments were sepsis and ventilator use, followed by repeat inpatient admission and acute respiratory failure. The US region where the patient was

**TABLE 1.** Baseline Demographic Characteristics of Patients With COVID-19 Stratified by Disease Severity

	All patients	Asymptomatic <sup>a</sup>	Mild	Moderate			Severe/critical
				All moderate	Without lower respiratory disease	With lower respiratory disease	
n	738,339	374,401	156,220	180,213	85,232	94,981	27,505
Age in years, mean (SD)	38.00 (16.03)	36.16 (16.12)	36.74 (16.22)	41.05 (15.02)	37.81 (15.88)	43.95 (13.56)	50.27 (11.00)
Female, n (%)	397,710 (53.9)	197,466 (52.7)	85,944 (55.0)	102,282 (56.8)	47,901 (56.2)	54,381 (57.3)	12,018 (43.7)
Elixhauser Comorbidity Index score, mean (SD)	0.70 (1.19)	0.54 (0.99)	0.63 (1.07)	0.94 (1.36)	0.74 (1.16)	1.12 (1.49)	1.75 (2.04)
Elixhauser category, n (%)							
0: no comorbidities	461,176 (62.5)	254,974 (68.1)	100,199 (64.1)	96,167 (53.4)	51,103 (60.0)	45,064 (47.4)	9836 (35.8)
1-2	217,390 (29.4)	99,274 (26.5)	45,642 (29.2)	62,274 (34.6)	26,945 (31.6)	35,329 (37.2)	10,200 (37.1)
3-4	48,456 (6.6)	17,386 (4.6)	8809 (5.6)	17,282 (9.6)	6012 (7.1)	11,270 (11.9)	4979 (18.1)
≥5	11,317 (1.5)	2767 (0.7)	1570 (1.0)	4490 (2.5)	1172 (1.4)	3318 (3.5)	2490 (9.1)
Duration of disease in days, mean (SD)	12.96 (25.17)	N/A	18.65 (15.04)	27.43 (29.62)	22.98 (23.08)	31.42 (33.96)	56.99 (63.99)

N/A, not applicable.

<sup>a</sup>Asymptomatic refers to patients with no COVID-19–related signs or symptoms diagnoses in the database. These patients had only a positive test at index disease. It is possible, however, that some patients described here as having asymptomatic disease experienced signs or symptoms of COVID-19 that were not captured in the charts along with their positive test results.

treated was the fifth predictor of cost. Other predictors included presence of pneumonia and acute respiratory distress syndrome.

## DISCUSSION

Our study was designed to evaluate payments associated with COVID-19 from the US payer perspective based on disease severity. Asymptomatic, mild, and moderate cases of COVID-19 without lower respiratory disease required ACP of less than \$2000 per person, whereas patients with moderate COVID-19 with lower respiratory disease incurred mean costs exceeding \$5000. For patients with S/C disease, DSP ranged from \$17,333 to \$68,069 and ACP from \$31,255 to \$126,094 based on DOD.

Our analysis was based on disease classification (asymptomatic, mild, moderate, and S/C), with the mild, moderate, and S/C characterizations defined by the Janssen phase 3 ENSEMBLE study protocol. All CSSs, as captured in the diagnosis fields of claims databases, were analyzed, and algorithms of severity were defined based on the Janssen trial disease severity definitions. These definitions are comparable to those suggested by the NIH (see eAppendix Table 3) but provide greater detail in terms of all diagnoses that make a mild, moderate, or S/C case, so they allow for a potentially better characterization of patients. We further stratified the population with moderate disease into 2 groups: patients without and patients with lower respiratory disease. Patients in the moderate group without lower respiratory disease are classified as having mild disease by the NIH, whereas those with lower respiratory disease meet the NIH criteria for moderate disease. As expected, increasing severity was associated with increased comorbidities, male sex (vs female), and increased age, which are characteristics shown in other studies to be

associated with increasing risks for severe COVID-19.<sup>24-27</sup> In addition, payments increased in a consistent manner with increased COVID-19 severity category, further highlighting the fact that our severity characterization was representative of increased clinical distress.

Two payment types, DSP and ACP, were evaluated in our study. DSPs were those associated with at least 1 diagnosis of a sign or symptom of COVID-19 or with COVID-19 testing, and they were potentially underestimates of total payments because they would not include related health care utilization (eg, testing, follow-up visits) that did not specifically mention those diagnoses. Because ACP did include all care received during the duration of the disease (or day of testing for asymptomatic cases), it may have included some unrelated emergency care, which was unavoidable during COVID-19; however, it is important to keep in mind that nonessential, nonurgent care during acute COVID-19 episodes was mostly postponed. It is therefore unlikely that significant unrelated, unessential care was provided during a patient's COVID-19 disease. In most US states, elective, expensive treatments (such as hip or knee arthroplasty) were postponed during the peak of the pandemic. Afterward, many states still required patients to present with a negative COVID-19 test to undergo such procedures. Therefore, the true payments associated with COVID-19 may be closer to that of the ACP than the DSP.<sup>28</sup>

Our findings are similar to those reported by Sheinson et al (who calculated \$8767 for inpatient care without oxygen, \$13,282 for inpatient care with oxygen, and \$49,631 for inpatient care with mechanical ventilation)<sup>3</sup> and those suggested by Scott et al, who found median payments of \$39,187 for patients requiring inpatient care.<sup>5</sup> Sheinson et al and Scott et al both used a bottom-up approach to evaluate cost.<sup>3,5</sup> In contrast, our study used all reported payments

## CLINICAL

**TABLE 2.** Adjusted Mean (95% CI) Payments for the Treatment of COVID-19 Stratified by Disease Severity<sup>a</sup>

Disease-specific payments	
Asymptomatic <sup>b</sup>	\$217 (\$214-\$221)
Mild	\$414 (\$406-\$422)
Moderate	
Without lower respiratory disease	\$733 (\$714-\$751)
With lower respiratory disease	\$2744 (\$2678-\$2811)
Severe/critical	\$28,250 (\$26,963-\$29,538)
Disease-specific incremental payments	
From asymptomatic to mild	\$197 (\$189-\$206)
From asymptomatic to moderate	
Without lower respiratory disease	\$515 (\$496-\$534)
With lower respiratory disease	\$2527 (\$2461-\$2594)
From asymptomatic to severe/critical	\$28,033 (\$26,746-\$29,321)
All-cause payments	
Asymptomatic <sup>b</sup>	\$505 (\$497-\$512)
Mild	\$957 (\$936-\$978)
Moderate	
Without lower respiratory disease	\$1372 (\$1331-\$1412)
With lower respiratory disease	\$5247 (\$5100-\$5394)
Severe/critical	\$46,538 (\$44,096-\$48,979)
All-cause incremental payments	
From asymptomatic to mild	\$452 (\$430-\$474)
From asymptomatic to moderate	
Without lower respiratory disease	\$867 (\$826-\$908)
With lower respiratory disease	\$4742 (\$4595-\$4889)
From asymptomatic to severe/critical	\$46,033 (\$43,591-\$48,475)

<sup>a</sup>Mean (SD) unadjusted total disease-specific and all-cause payments for all patients were \$1713 (\$17,031) and \$3468 (\$27,930), respectively. Adjusted payments were obtained using a generalized linear model, adjusting for patient age, sex, and comorbidities. Payments include all payments from payers and patients to health care providers for health care services as well as prescription drugs. Disease-specific payments include only health care events with diagnoses of COVID-19 signs and symptoms and antiviral prescriptions during the entire duration of COVID-19 disease. All-cause payments include all health care events and prescriptions during the entire duration of COVID-19 disease.

<sup>b</sup>Asymptomatic refers to patients with no COVID-19–related signs or symptoms diagnoses in the database. These patients had only a positive test at index disease. It is possible, however, that some patients described here as having asymptomatic disease experienced signs or symptoms of COVID-19 that were not captured in the charts along with their positive test results.

for analyses of both DSP and ACP. Importantly, at the time of our study, 129 mild, 575 moderate, and 827 S/C cases had ongoing disease, meaning that they would continue to incur payments; therefore, our analysis may show greater payments with longer follow-up time. (For those ongoing cases, the mean follow-up time was greater than 8 months, or 288, 290, and 282 days for patients with mild, moderate, and S/C disease, respectively.)

### Limitations

Our study has the following limitations. Our analysis included data from late 2020 to early 2021, describing outcomes with a COVID-19

**TABLE 3.** Adjusted Mean (95% CI) Payments for Patients With Severe/Critical Disease by Duration of Disease<sup>a</sup>

Disease-specific payments	
Duration < 4 weeks	\$17,333 (\$16,485-\$18,181)
Duration 4-12 weeks <sup>b</sup>	\$27,043 (\$25,711-\$28,376)
Duration > 12 weeks <sup>c</sup>	\$68,069 (\$62,739-\$73,400)
Disease-specific incremental payments	
From < 4 to 4-12 weeks	\$9711 (\$8133-\$11,288)
From < 4 to > 12 weeks	\$50,736 (\$45,337-\$56,136)
All-cause payments	
Duration < 4 weeks	\$31,255 (\$30,205-\$32,305)
Duration 4-12 weeks <sup>b</sup>	\$49,866 (\$48,181-\$51,550)
Duration > 12 weeks <sup>c</sup>	\$126,094 (\$119,373-\$132,814)
All-cause incremental payments	
From < 4 to 4-12 weeks	\$18,611 (\$16,635-\$20,586)
From < 4 to > 12 weeks	\$94,839 (\$88,029-\$101,649)

<sup>a</sup>The mean (SD) unadjusted disease-specific and all-cause payments for the treatment of COVID-19 in all severe/critical cases regardless of duration were \$30,079 (\$81,332) and \$56,277 (\$128,561), respectively. Adjusted payments were obtained using a generalized linear model, adjusting for patient age, sex, and comorbidities. Payments include all payments from payers and patients to health care providers for health care services as well as prescription drugs. Disease-specific payments only include health care events with diagnoses of COVID-19 signs and symptoms and antiviral prescriptions during the entire duration of COVID-19 disease. All-cause payments include all health care events and prescriptions during the entire duration of COVID-19 disease.

<sup>b</sup>Also referred to as ongoing symptomatic COVID-19.

<sup>c</sup>Also referred to as post-COVID-19 condition.

variant that may not be dominant anymore. However, our focus on disease severity and clinical presentation and our analysis of health care payments based thereof may provide a framework for understanding COVID-19 payments regardless of variant, simply based on patient disease severity. Our analysis period began in April 2020, when COVID-19 started to be identified in claims with specific codes, but it is possible that some patients with COVID-19 after April 2020 were miscoded and not represented herein. New COVID-19 codes introduced in 2021 were possibly missed, thus excluding some additional patients. An additional limitation is the lack of validation of diagnosis codes as found in claims databases. However, false diagnoses on claims constitute punishable fraud and, although possible, are unlikely on a large scale. The severity of disease (mild, moderate, and severe) was based on definitions that were thoroughly reviewed as part of a clinical trial but not validated. All signs and symptoms may not be exhaustively captured in this data set, as might be the case in a prospective clinical trial. This limitation may have affected our ability to accurately characterize some patients' disease severity. However, severity of disease was clearly associated with comorbidities and overall payments. Finally, a key limitation of our research was the determination of disease duration. A major assumption in our analysis was the maximum 35-day gap allowed between diagnoses or care associated with CSSs. Therefore, our analysis is possibly conservative, as patients returning for care due to PCC after a break of more than 35 days would not be

characterized in our research as having continued COVID-19 care. An additional limitation may be related to the generalizability of our findings because all payments were obtained from US-based commercial payers.

## CONCLUSIONS

Findings from our study of nearly 740,000 patients with COVID-19 highlight the heterogeneity in payments and show that payments for COVID-19 increased substantially with increasing disease severity and duration, thus reinforcing the economic importance of reducing the severity of COVID-19 through available technologies, including vaccines. ■

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**eAppendix Table 1: COVID-19 Signs and Symptoms (CSS) and Associated ICD-10 Codes.** For each CSS, the complete list of ICD codes was identified and used to search all claims.

COVID-19 Sign or Symptom Category	code (ICD10)	Short Code Description
Acute Respiratory Distress Syndrome	J80	Acute respiratory distress syndrome
Acute Respiratory Distress Syndrome	R0603	Acute respiratory distress syndrome
Acute Respiratory Failure	J9600	Acute respiratory failure unspecified whether with hypoxia or hypercapnia
Acute Respiratory Failure	J9601	Acute respiratory failure with hypoxia
Acute Respiratory Failure	J9602	Acute respiratory failure with hypercapnia
Acute Respiratory Failure	J9620	Acute and chronic respiratory failure unspecified whether with hypoxia or hypercapnia
Acute Respiratory Failure	J9621	Acute and chronic respiratory failure with hypoxia
Acute Respiratory Failure	J9690	Respiratory failure unspecified unspecified whether with hypoxia or hypercapnia
Acute Respiratory Failure	J9691	Respiratory failure unspecified with hypoxia
Chest Pain	J208	Acute bronchitis due to other specified organisms
Chest Pain	J209	Acute bronchitis unspecified
Chest Pain	J22	Unspecified acute lower respiratory infection
Chest Pain	J40	Bronchitis not specified as acute or chronic
Chest Pain	J9809	Other diseases of bronchus not elsewhere classified
Chest Pain	R071	Chest pain on breathing
Chest Pain	R072	Precordial pain
Chest Pain	R0781	Pleurodynia
Chest Pain	R0789	Other chest pain
Chest Pain	R079	Chest pain unspecified
Chills	R6883	Chills (without fever)
Coma	R4020	Unspecified coma
Coma	R402110	Coma scale eyes open never unspecified time
Coma	R402111	Coma scale eyes open never in the field [EMT or ambulance]
Coma	R402112	Coma scale eyes open never at arrival to emergency department
Coma	R402113	Coma scale eyes open never at hospital admission
Coma	R402114	Coma scale eyes open never 24 hours or more after hospital admission
Coma	R402120	Coma scale eyes open to pain unspecified time
Coma	R402121	Coma scale eyes open to pain in the field [EMT or ambulance]
Coma	R402122	Coma scale eyes open to pain at arrival to emergency department
Coma	R402123	Coma scale eyes open to pain at hospital admission
Coma	R402124	Coma scale eyes open to pain 24 hours or more after hospital admission
Coma	R402130	Coma scale eyes open to sound unspecified time
Coma	R402131	Coma scale eyes open to sound in the field [EMT or ambulance]
Coma	R402132	Coma scale eyes open to sound at arrival to emergency department
Coma	R402133	Coma scale eyes open to sound at hospital admission
Coma	R402134	Coma scale eyes open to sound 24 hours or more after hospital admission
Coma	R402140	Coma scale eyes open spontaneous unspecified time

Coma	R402141	Coma scale eyes open spontaneous in the field [EMT or ambulance]
Coma	R402142	Coma scale eyes open spontaneous at arrival to emergency department
Coma	R402143	Coma scale eyes open spontaneous at hospital admission
Coma	R402144	Coma scale eyes open spontaneous 24 hours or more after hospital admission
Coma	R402210	Coma scale best verbal response none unspecified time
Coma	R402211	Coma scale best verbal response none in the field [EMT or ambulance]
Coma	R402212	Coma scale best verbal response none at arrival to emergency department
Coma	R402213	Coma scale best verbal response none at hospital admission
Coma	R402214	Coma scale best verbal response none 24 hours or more after hospital admission
Coma	R402220	Coma scale best verbal response incomprehensible words unspecified time
Coma	R402221	Coma scale best verbal response incomprehensible words in the field [EMT or ambulance]
Coma	R402222	Coma scale best verbal response incomprehensible words at arrival to emergency department
Coma	R402223	Coma scale best verbal response incomprehensible words at hospital admission
Coma	R402224	Coma scale best verbal response incomprehensible words 24 hours or more after hospital admission
Coma	R402230	Coma scale best verbal response inappropriate words unspecified time
Coma	R402231	Coma scale best verbal response inappropriate words in the field [EMT or ambulance]
Coma	R402232	Coma scale best verbal response inappropriate words at arrival to emergency department
Coma	R402233	Coma scale best verbal response inappropriate words at hospital admission
Coma	R402234	Coma scale best verbal response inappropriate words 24 hours or more after hospital admission
Coma	R402240	Coma scale best verbal response confused conversation unspecified time
Coma	R402241	Coma scale best verbal response confused conversation in the field [EMT or ambulance]
Coma	R402242	Coma scale best verbal response confused conversation at arrival to emergency department
Coma	R402243	Coma scale best verbal response confused conversation at hospital admission
Coma	R402244	Coma scale best verbal response confused conversation 24 hours or more after hospital admission
Coma	R402250	Coma scale best verbal response oriented unspecified time
Coma	R402251	Coma scale best verbal response oriented in the field [EMT or ambulance]
Coma	R402252	Coma scale best verbal response oriented at arrival to emergency department
Coma	R402253	Coma scale best verbal response oriented at hospital admission
Coma	R402254	Coma scale best verbal response oriented 24 hours or more after hospital admission
Coma	R402310	Coma scale best motor response none unspecified time
Coma	R402311	Coma scale best motor response none in the field [EMT or ambulance]
Coma	R402312	Coma scale best motor response none at arrival to emergency department
Coma	R402313	Coma scale best motor response none at hospital admission
Coma	R402314	Coma scale best motor response none 24 hours or more after hospital admission
Coma	R402320	Coma scale best motor response extension unspecified time
Coma	R402321	Coma scale best motor response extension in the field [EMT or ambulance]
Coma	R402322	Coma scale best motor response extension at arrival to emergency department
Coma	R402323	Coma scale best motor response extension at hospital admission
Coma	R402324	Coma scale best motor response extension 24 hours or more after hospital admission



Coma	R402330	Coma scale best motor response abnormal unspecified time
Coma	R402331	Coma scale best motor response abnormal in the field [EMT or ambulance]
Coma	R402332	Coma scale best motor response abnormal at arrival to emergency department
Coma	R402333	Coma scale best motor response abnormal at hospital admission
Coma	R402334	Coma scale best motor response abnormal 24 hours or more after hospital admission
Coma	R402340	Coma scale best motor response flexion withdrawal unspecified time
Coma	R402341	Coma scale best motor response flexion withdrawal in the field [EMT or ambulance]
Coma	R402342	Coma scale best motor response flexion withdrawal at arrival to emergency department
Coma	R402343	Coma scale best motor response flexion withdrawal at hospital admission
Coma	R402344	Coma scale best motor response flexion withdrawal 24 hours or more after hospital admission
Coma	R402350	Coma scale best motor response localizes pain unspecified time
Coma	R402351	Coma scale best motor response localizes pain in the field [EMT or ambulance]
Coma	R402352	Coma scale best motor response localizes pain at arrival to emergency department
Coma	R402353	Coma scale best motor response localizes pain at hospital admission
Coma	R402354	Coma scale best motor response localizes pain 24 hours or more after hospital admission
Coma	R402360	Coma scale best motor response obeys commands unspecified time
Coma	R402361	Coma scale best motor response obeys commands in the field [EMT or ambulance]
Coma	R402362	Coma scale best motor response obeys commands at arrival to emergency department
Coma	R402363	Coma scale best motor response obeys commands at hospital admission
Coma	R402364	Coma scale best motor response obeys commands 24 hours or more after hospital admission
Coma	R40241	Glasgow coma scale score 13-15
Coma	R40242	Glasgow coma scale score 9-12
Coma	R40243	Glasgow coma scale score 3-8
Coma	R40244	Other coma without documented Glasgow coma scale score or with partial score reported
Confusion	R410	Disorientation unspecified
Confusion	R4182	Altered mental status unspecified
Confusion	R41840	Attention and concentration deficit
Confusion	R41841	Cognitive communication deficit
Confusion	R4189	Other symptoms and signs involving cognitive functions and awareness
Confusion	R419	Unspecified symptoms and signs involving cognitive functions and awareness
Confusion	R42	Dizziness and giddiness
Congestion	R0989	Other specified symptoms and signs involving the circulatory and respiratory systems
Cough	R05	Cough
Eye Disorders	H578	Other specified disorders of eye and adnexa
Eye Disorders	H579	Unspecified disorder of eye and adnexa
Fatigue	R5383	Other fatigue
Fever	R5081	Fever presenting with conditions classified elsewhere
Fever	R509	Fever unspecified
Gastrointestinal Symptoms	K529	Noninfective gastroenteritis and colitis unspecified
Gastrointestinal Symptoms	R1013	Epigastric pain

Gastrointestinal Symptoms	R1030	Lower abdominal pain unspecified
Gastrointestinal Symptoms	R1084	Generalized abdominal pain
Gastrointestinal Symptoms	R109	Unspecified abdominal pain
Gastrointestinal Symptoms	R110	Nausea
Gastrointestinal Symptoms	R111	Vomiting
Gastrointestinal Symptoms	R1110	Vomiting unspecified
Gastrointestinal Symptoms	R1111	Vomiting without nausea
Gastrointestinal Symptoms	R1112	Projectile vomiting
Gastrointestinal Symptoms	R1113	Vomiting of fecal matter
Gastrointestinal Symptoms	R1114	Bilious vomiting
Gastrointestinal Symptoms	R112	Nausea with vomiting unspecified
Gastrointestinal Symptoms	R197	Diarrhea unspecified
Headache	R51	Headache
Hepatic Failure	K7200	Acute and subacute hepatic failure without coma
Hepatic Failure	K7201	Acute and subacute hepatic failure with coma
Hepatic Failure	K7290	Hepatic failure unspecified without coma
Hepatic Failure	K7291	Hepatic failure unspecified with coma
Hypoxemia	R0902	Hypoxemia
Malaise	R531	Weakness
Malaise	R5381	Other malaise
Malaise	R55	Syncope and collapse
Malaise	R69	Illness unspecified
Myalgia	M791	Myalgia
Myalgia	M7910	Myalgia
Myalgia	M7912	Myalgia
Myalgia	M7918	Myalgia
Neurological Symptoms	R401	Stupor
Neurological Symptoms	R404	Transient alteration of awareness
Neurological Symptoms	R4701	Aphasia
Neurological Symptoms	R471	Dysarthria and anarthria
Neurological Symptoms	R4781	Slurred speech
Neurological Symptoms	R4789	Other speech disturbances
Neurological Symptoms	R479	Unspecified speech disturbances
Pain	R52	Pain unspecified
Pneumonia	J1281	Pneumonia due to SARS-associated coronavirus
Pneumonia	J1289	Other viral pneumonia
Pneumonia	J129	Pneumonia
Pneumonia	J181	Lobar pneumonia unspecified organism
Pneumonia	J188	Other pneumonia unspecified organism
Pneumonia	J189	Pneumonia unspecified organism
Pneumonia	R918	Other nonspecific abnormal finding of lung field

Rash	R21	Rash and other nonspecific skin eruption
Runny Nose	R0981	Nasal congestion
Sepsis	A4151	Sepsis due to Escherichia coli [E. coli]
Sepsis	A4189	Other specified sepsis
Sepsis	A419	Sepsis unspecified organism
Sepsis	R6520	Severe sepsis without septic shock
Sepsis	R6521	Severe sepsis with septic shock
Shortness of Breath	J9811	Atelectasis
Shortness of Breath	J988	Other specified respiratory disorders
Shortness of Breath	R0600	Dyspnea unspecified
Shortness of Breath	R0602	Shortness of breath
Shortness of Breath	R0609	Other forms of dyspnea
Somnolence	R400	Somnolence
Sore Throat	J029	Acute pharyngitis unspecified
Sore Throat	J069	Acute upper respiratory infection unspecified
Sore Throat	R070	Pain in throat
Sore Throat	R1310	Dysphagia unspecified
Sore Throat	R1312	Dysphagia oropharyngeal phase
Tachycardia	I471	Supraventricular tachycardia
Tachycardia	R000	Tachycardia unspecified
Taste and Smell Disturbances	R430	Anosmia
Taste and Smell Disturbances	R431	Parosmia
Taste and Smell Disturbances	R432	Parageusia
Taste and Smell Disturbances	R438	Other disturbances of smell and taste
Taste and Smell Disturbances	R439	Unspecified disturbances of smell and taste
Thrombosis	I82401	Acute embolism and thrombosis of unspecified deep veins of right lower extremity
Thrombosis	I82402	Acute embolism and thrombosis of unspecified deep veins of left lower extremity
Thrombosis	I82403	Acute embolism and thrombosis of unspecified deep veins of lower extremity bilateral
Thrombosis	I82409	Acute embolism and thrombosis of unspecified deep veins of unspecified lower extremity
Thrombosis	I82411	Acute embolism and thrombosis of right femoral vein
Thrombosis	I82412	Acute embolism and thrombosis of left femoral vein
Thrombosis	I82413	Acute embolism and thrombosis of femoral vein bilateral
Thrombosis	I82419	Acute embolism and thrombosis of unspecified femoral vein
Thrombosis	I82421	Acute embolism and thrombosis of right iliac vein
Thrombosis	I82422	Acute embolism and thrombosis of left iliac vein
Thrombosis	I82423	Acute embolism and thrombosis of iliac vein bilateral
Thrombosis	I82429	Acute embolism and thrombosis of unspecified iliac vein
Thrombosis	I82431	Acute embolism and thrombosis of right popliteal vein
Thrombosis	I82432	Acute embolism and thrombosis of left popliteal vein
Thrombosis	I82433	Acute embolism and thrombosis of popliteal vein bilateral
Thrombosis	I82439	Acute embolism and thrombosis of unspecified popliteal vein

Thrombosis	I82441	Acute embolism and thrombosis of right tibial vein
Thrombosis	I82442	Acute embolism and thrombosis of left tibial vein
Thrombosis	I82443	Acute embolism and thrombosis of tibial vein bilateral
Thrombosis	I82449	Acute embolism and thrombosis of unspecified tibial vein
Thrombosis	I82491	Acute embolism and thrombosis of other specified deep vein of right lower extremity
Thrombosis	I82492	Acute embolism and thrombosis of other specified deep vein of left lower extremity
Thrombosis	I82493	Acute embolism and thrombosis of other specified deep vein of lower extremity bilateral
Thrombosis	I82499	Acute embolism and thrombosis of other specified deep vein of unspecified lower extremity
Thrombosis	I824Y1	Acute embolism and thrombosis of unspecified deep veins of right proximal lower extremity
Thrombosis	I824Y2	Acute embolism and thrombosis of unspecified deep veins of left proximal lower extremity
Thrombosis	I824Y3	Acute embolism and thrombosis of unspecified deep veins of proximal lower extremity bilateral
Thrombosis	I824Y9	Acute embolism and thrombosis of unspecified deep veins of unspecified proximal lower extremity
Thrombosis	I824Z1	Acute embolism and thrombosis of unspecified deep veins of right distal lower extremity
Thrombosis	I824Z2	Acute embolism and thrombosis of unspecified deep veins of left distal lower extremity
Thrombosis	I824Z3	Acute embolism and thrombosis of unspecified deep veins of distal lower extremity bilateral
Thrombosis	I824Z9	Acute embolism and thrombosis of unspecified deep veins of unspecified distal lower extremity
Wheezing	R062	Wheezing

**eAppendix Table 2: Definition of Disease Severity based on available COVID-19 Signs and Symptoms shown in eAppendix Table 1, admission type (inpatient, ICU) and treatment (ventilator use). The classification of disease is based on the Janssen ENSEMBLE Phase 3 clinical trial. The Definition for each severity type was described in terms of CSS, and concurrent presence of each type of CSS. These CSS were further identified for all patients using the codes listed in eAppendix Table 1.**

Severity	Definition	Identification using Database Variable (Signs and Symptoms, Admissions and Ventilator/ICU use)
Mild	<p><b>One of the following symptoms:</b> fever (<math>\geq 38.0^{\circ}\text{C}</math> or <math>\geq 100.4^{\circ}\text{F}</math>), sore throat, malaise (loss of appetite, generally unwell, fatigue, physical weakness), headache, muscle pain (myalgia), gastrointestinal symptoms, cough, chest congestion, runny nose, wheezing, skin rash, eye irritation or discharge, chills, new or changing olfactory or taste disorders, red or bruised looking feet or toes, or shaking chills or rigors.</p>	<p><b>At least 1 of:</b> Chills, cough, chest congestion, fever, eye irritation or discharge, headache, GS, malaise, myalgia, OTD, runny nose, skin rash, sore throat, wheezing - and:  <b>Do not qualify as moderate or severe</b></p>
Moderate	<p><b>Any 1 of the following new or worsening signs or symptoms:</b> Respiratory rate <math>\geq 20</math> breaths/minute, abnormal saturation of oxygen (SpO<sub>2</sub>) but still <math>&gt;93\%</math> on room air at sea level, clinical or radiologic evidence of pneumonia, radiologic evidence of deep vein thrombosis (DVT), shortness of breath or difficulty breathing</p> <p><b>Any 2 of the following new or worsening signs or symptoms:</b> Fever (<math>\geq 38.0^{\circ}\text{C}</math> or <math>\geq 100.4^{\circ}\text{F}</math>), heart rate <math>\geq 90</math> beats/minute, shaking chills or rigors, sore throat, cough, malaise as evidenced by 1 or more of the following: - Loss of appetite - Generally unwell - Fatigue - Physical weakness, headache, muscle pain (myalgia), Gastrointestinal symptoms (diarrhea, vomiting, nausea, abdominal pain), new or changing olfactory or taste disorders, red or bruised looking feet or toes</p>	<p><b>At least 1 of:</b> DVT, pneumonia, shortness of breath (may be coded as outpatient-only ARF/ARDS), tachypnea, hypoxemia, or:</p> <p><b>At least 2 of:</b> Chills or rigors, cough, fever, gastrointestinal symptoms, headache, malaise, myalgia, new or changing olfactory or taste disorders, skin rash, sore throat, tachycardia - and:  <b>Do not qualify as severe/critical</b></p>
Severe / Critical	<p><b>Clinical signs at rest indicative of severe systemic illness</b> (respiratory rate <math>\geq 30</math> breaths/minute, heart rate <math>\geq 125</math> beats/minute, oxygen saturation (SpO<sub>2</sub>) <math>\leq 93\%</math> on room air at sea level, or partial pressure of oxygen/fraction of inspired oxygen (PaO<sub>2</sub>/FiO<sub>2</sub>)- Respiratory failure (defined as needing high-flow oxygen, non-invasive ventilation, mechanical ventilation, or extracorporeal membrane oxygenation [ECMO]) - Evidence of shock</p>	<p><b>Severe systemic illness characterized by inpatient admission with at least 1 of:</b> hypoxemia, hepatic failure, neurological dysfunction, renal failure, shock, tachypnea, tachycardia, respiratory failure/distress</p>

	(defined as systolic blood pressure (defined as systolic blood pressure <90 mm Hg, diastolic blood pressure <60 mm Hg, or requiring vasopressors) - Significant acute renal, hepatic, or neurologic dysfunction - Admission to the ICU - Death	or mechanical ventilation or ECMO or ICU admission (death not identifiable in database)
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**eAppendix Table 3: NIH Classification of Disease**

<b>Severity</b>	<b>Definition</b>
Mild	<ul style="list-style-type: none"><li>• <i>Mild Illness:</i> Individuals who have any of the various signs and symptoms of COVID-19 (e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste and smell) but who do not have shortness of breath, dyspnea, or abnormal chest imaging.</li></ul>
Moderate	<ul style="list-style-type: none"><li>• <i>Moderate Illness:</i> Individuals who show evidence of lower respiratory disease during clinical assessment or imaging and who have an oxygen saturation (SpO<sub>2</sub>) ≥94% on room air at sea level.</li></ul>
Severe or critical	<ul style="list-style-type: none"><li>• <i>Severe Illness:</i> Individuals who have SpO<sub>2</sub> &lt;94% on room air at sea level, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO<sub>2</sub>/FiO<sub>2</sub>) &lt;300 mm Hg, a respiratory rate &gt;30 breaths/min, or lung infiltrates &gt;50%.</li><li>• <i>Critical Illness:</i> Individuals who have respiratory failure, septic shock, and/or multiple organ dysfunction.</li></ul>