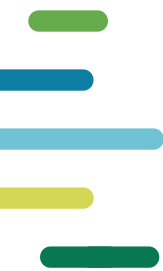**strata**

Analyzing the Effectiveness of Remdesivir with StrataSphere® Data

Key Considerations for Hospitals and Health Systems

Background

Remdesivir is currently the only anti–viral medication approved for treatment of hospitalized patients with COVID–19. It was approved by the FDA for emergency use in COVID–19 patients in May 2020 and fully approved for use in patients 12 and older in October 2020.

Initial clinical trials and research studies with small sample sizes had mixed results. While some studies showed Remdesivir had an impact on patient condition and survival rates, others showed no statistically significant impact on mortality and an increase in length of stay.

Due to these mixed results with small datasets and the medication's high costs (typically around $3,000 per treatment), Strata sought to use the power of our database of over 100 U.S. health systems participating in StrataSphere® to analyze the impacts of Remdesivir at scale and help our clients determine if the continued use of Remdesivir is justified.

Remdesivir is currently the only anti–viral medication approved for treatment of hospitalized patients with COVID–19.

Observed Effects of Remdesivir in StrataSphere Data
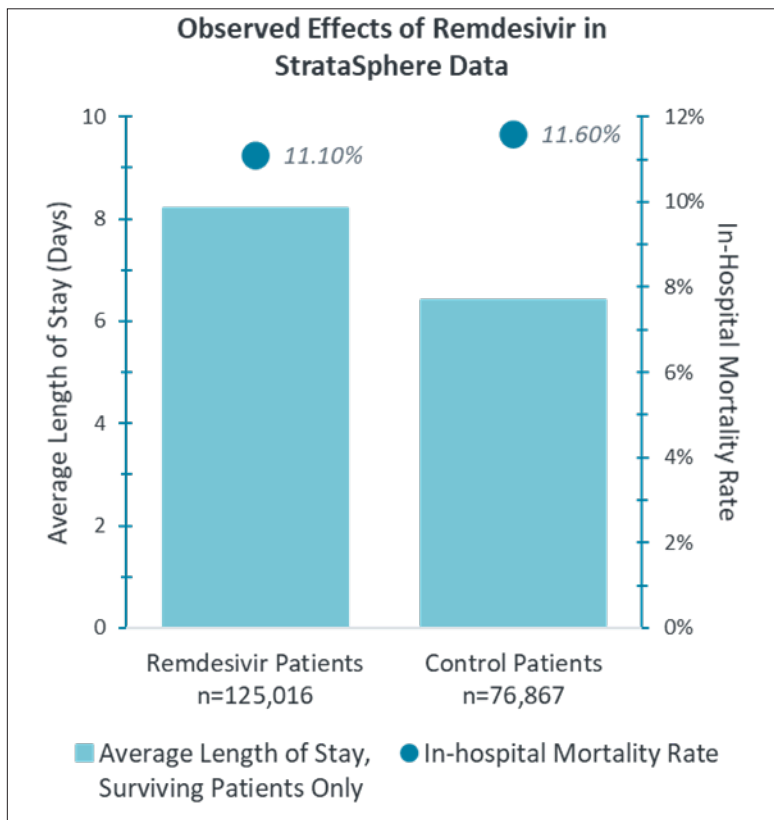
Using the StrataSphere database of hospital billing data, we identified 201,883 hospitalized patients with a primary diagnosis of COVID–19, including 125,016 who received Remdesivir treatment, from November 1, 2020, to September 30, 2021. We selected this time period so as not to include the early months of the COVID–19 pandemic, where significant variation in patient outcomes was seen due to the novelty of the illness and a need for clinicians to learn "on the fly" how best to treat it.

Key Findings

- More than 60% of all StrataSphere COVID-19 inpatients received Remdesivir, although there is significant variation between health systems.

- The use of Remdesivir in COVID-19 inpatients is associated with a limited improvement in overall in-hospital mortality (11.10% versus 11.60%) and a significant increase in length of stay (8.2 days versus 6.4 days, surviving patients only).

- The effect of Remdesivir on in-hospital mortality is stronger when given within the first four days of admission (10.85%, n=123,290) than for those who started on day 5 or later (28.39%, n=1,726).

- Remdesivir is associated with worse in-hospital mortality for patients over 70 but shows a meaningful positive impact in older patients who were admitted to the ICU and coded for an MS-DRG with a weight of 2.0+.

- The data suggests that, except in cases where there are other risk factors, Remdesivir likely provides minimal benefit to patients under 40, and may not even be warranted for otherwise healthy patients between 40-69.

The data included in this analysis comes from 102 U.S. health systems who participate in StrataSphere.

Data Profile

The data included in this analysis comes from 102 U.S. health systems who participate in StrataSphere. Key patient characteristics considered in the analysis include patient age, ICU status, and the weight assigned to the MS-DRG for the encounter, as a proxy for patient severity. The following tables provide additional context for the health system and patient characteristics included in the analysis.

Total Operating Expense	<$1B	>=$1B	Total
Health systems	51	51	102
Total hospitalized COVID Patients	51,411	150,472	201,883
COVID patients receiving Remdesivir	28,602	96,414	125,016

Health System Type	Academic	Children's	Multi-Site	Single Site
Health systems	16	5	47	24
Total hospitalized COVID Patients	38,101	15,598	130,526	17,658
COVID patients receiving Remdesivir	24,039	7,375	82,255	11,347

Census Region	Midwest	Northeast	South	West
Health systems	33	17	37	15
Total hospitalized COVID Patients	70,221	28,201	84,148	19,313
COVID patients receiving Remdesivir	42,005	17,588	52,519	12,904

Age	0–19	20–39	40–69	70+
Total hospitalized COVID Patients	2,514	11,726	93,334	94,309
COVID patients receiving Remdesivir	590	7,186	60,739	56,501

ICU Status	Non-ICU	ICU
Total hospitalized COVID Patients	114,521	87,362
COVID patients receiving Remdesivir	68,685	56,331

| MS-DRG Weight (Severity Proxy)	<2.0	2.0+
Total hospitalized COVID Patients	181,387	20,496
COVID patients receiving Remdesivir	111,872	13,144

Variation by Client

This graph shows the variation in the percentage of inpatients using Remdesivir by month and by health system; the size of each bubble represents the number of COVID–19 inpatients at that organization. There is wide variation between health systems, with larger organizations likely to administer Remdesivir in a higher percentage of cases and typical use remaining fairly constant since November 2020.

While some of this variation in use may be due to factors such as patient severity, there is likely additional variation unexplained by differences in patients. Organizations should consider how frequently they are administering Remdesivir, as there is a lot of variation in clinical protocols, and determine if additional clinical protocols are needed to ensure it is only used when appropriate and likely to improve patient outcomes.

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Percentage of COVID Patients Receiving Remdesivir by Month

Each bubble represents 1 health system; size of bubble represents number of COVID patients
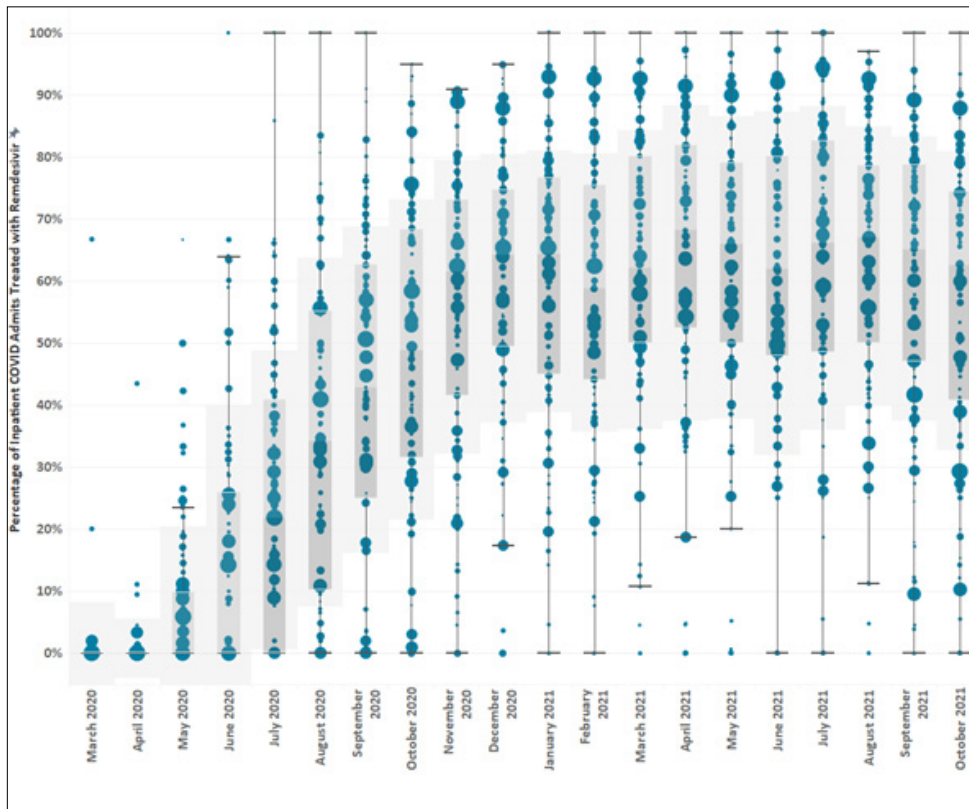
Detailed Analysis of Remdesivir's Impact on Patient Outcomes

	Age Grouping/ICU Status/DRG Weight											
	20–39				**40–69**				**70+**			
	Non–ICU		**ICU**		**Non–ICU**		**ICU**		**Non–ICU**		**ICU**	
	MS–DRG Weight <2.0	MS–DRG Weight >=2.0	MS–DRG Weight <2.0	MS–DRG Weight >=2.0	MS-DRG Weight <2.0	MS-DRG Weight >=2.0	MS-DRG Weight <2.0	MS-DRG Weight >=2.0	MS-DRG Weight <2.0	MS–DRG Weight >=2.0	MS-DRG Weight <2.0	MS-DRG Weight >=2.0
Total Inpatient COVID Patients	7,181	48	3,699	798	52,070	477	30,811	9,976	52,424	542	32,817	8,526
Remdesivir Patients	4,295	25	2,395	471	33,307	254	20,781	6,397	30,208	323	20,362	5,608
Control Patients	3	6	21	165	141	86	599	3,587	1,530	160	3,595	3,970
Remdesivir in–hospital mortality rate	0.07%	24.00%	0.88%	35.03%	0.42%	33.86%	2.88%	56.07%	5.06%	49.54%	17.66%	70.79%
Control in–hospital mortality rate	0.07%	30.43%	0.77%	40.06%	0.74%	35.87%	4.18%	60.30%	7.08%	50.23%	16.82%	74.71%
Difference in mortality rate between control and Remdesivir patients†	0.00%	6.43%	(0.11%)	5.03%	0.32%***	2.02%	1.30%***	4.22%***	2.02%***	0.69%	(0.83%)*	3.92%***
Remdesivir Avg. LOS (surviving patients only)	4.4	8	6.4	22.1	5.2	10.6	8.2	25.1	9.6	11.4	9.4	24.1
Control Avg. LOS (surviving patients only)	3.3	5.4	5.1	23.7	4.2	9.6	7	25.3	7.5	11.1	7.6	21.6
Remdesivir reduction (increase) in Avg. LOS	(1.1)***	(2.6)*	(1.3)***	1.6	(0.9)***	(1.0)***	(1.2)***	0.2***	(2.1)	(0.3)	(1.8)***	(2.5)***

†Calculated as the mortality rate of the control patients minus the mortality rate of the Remdesivir patients

Significance levels:

* p < .1 (somewhat significant)

** p < .05 (significant)

*** p < .01 (highly significant)

- The effect of Remdesivir on mortality varies somewhat between different groups of patients. For patients over age 70, we see an overall increase in mortality when Remdesivir is administered (16.38% v. 15.76%, $p<0.05$). However, when further stratifying these patients by ICU status and MS–DRG weight, Remdesivir is associated with a 3.9 percentage point reduction ($p<0.01$) in in–hospital mortality for patients admitted to the ICU with an MS–DRG weight >=2.0.

- Remdesivir is also associated with a 2.0 percentage point reduction in mortality for patients not admitted to the ICU with an MS–DRG weight <2.0. On the other hand, there is a 0.83 percentage point increase in mortality for patients admitted to the ICU with an MS–DRG weight <2.0. This presents a paradox in the oldest patient group whereby the sickest and least sick patients may see some benefit from the medication, but for others the risks may outweigh the potential benefits. It is likely there are additional clinical considerations not captured in the StrataSphere data that would shed further light on this puzzle.

- For younger patients, the picture is somewhat clearer. For all patients 20–39 with meaningful sample sizes (ICU and non–ICU patients with an MS–DRG weight < 2.0), there is no difference in mortality rates between patients treated with Remdesivir and the control group. Similarly, the impact of Remdesivir on patients aged 40–69 with no ICU stay & an MS–DRG weight <2.0 is statistically significant but numerically very minimal. This data suggests that, except in cases where there are other risk factors, Remdesivir likely provides minimal benefit to patients under 40, and may not even be warranted for otherwise healthy patients between 40–69.

Guidance and Next Steps

- **Ensure Appropriate Protocols:** Because the medication is most effective when given in the first four days of hospitalization, organizations should ensure they have appropriate protocols in place to begin treatment quickly.

- **Study How Age Impacts Results:** Looking more closely at the mixed effects on mortality for older and younger patients can reveal a kind of paradox. Overall, Remdesivir has a negative effect on these patients' likelihood of survival. However, older patients who require ICU care or other intensive treatment resulting in a more severe MS–DRG are the most positively impacted by Remdesivir. We recommend that organizations consider other clinical data points available from their electronic medical record system and develop appropriate clinical protocols for the use of the medication.

- **Share Feedback and Ideas for Future Research:** We plan to do more research using the StrataSphere dataset in the future. Please share your feedback regarding this paper with us — as well as suggestions for future topics — by emailing us at StrataSphere@StrataDecision.com.

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Methodology

StrataSphere data is sourced from outbound hospital claims; as a result, additional clinical data such as lab values that could offer a more nuanced understanding of each patient's severity is not available. Additionally, we are unable to examine mortality rates beyond hospital discharge.

Based on input from clinical experts, we used age, ICU status, and the DRG weight as variables to control for patient severity and complexity. We used UB–04 Revenue Codes to identify ICU patients, defined as any patient with an ICU stay of any duration. We also used the "expired" patient discharge status to identify patient mortality.

Each data point represents a distinct patient. An individual patient may have more than one inpatient admission. In these cases, the patients are treated longitudinally, considering their final discharge status, the use at any time of Remdesivir, and their total length of stay. The MS–DRG weight used is for the first encounter, or if there are more than two encounters, the weight for the MS–DRG coded most frequently. A patient with any ICU days is treated as an ICU patient.

A z–test for proportions was used to test for significance for the stratified mortality data shown in page 5. A t–test was used to test for significance for the differences in length of stay. When measuring significance at the single group level (for example, comparing outcomes for all patients over 70), a Chi–Square test was used.

StrataSphere data is sourced from outbound hospital claims.

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Strata Decision Technology provides an innovative set of software and service solutions to help healthcare providers better analyze, plan and perform in support of caring for their community and reducing the cost of care. Our customer base includes over 2,000 hospitals and over 400 healthcare delivery systems. Founded in 1996, our mission is to Help Heal Healthcare™. For more information, visit www.stratadecision.com.