Alternative Pricing Models for Remdesivir and Other Potential Treatments for COVID-19

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ICER-COVID Model 1: Remdesivir Cost Recovery

Objective

The objective of this preliminary analysis was to estimate a price for remdesivir in the treatment of COVID-19 that would represent a "cost recovery" approach. This paradigm for pricing assumes that the goal is to set a price that compensates the manufacturer for the costs of production without additional profit.

Methods

The conceptual elements of the ICER model for a cost recovery pricing estimate include: 1) the marginal cost of producing the next course of remdesivir therapy; 2) research and development costs provided by the manufacturer; 3) research and development costs provided by the federal government; and 4) additional profits beyond the marginal cost. Importantly, the cost recovery pricing estimate does not include the remdesivir administration-related costs. The perspective of this framework is that of the manufacturer but may be expanded to include societal elements such as government investments in research and development as well as societal proceeds.

For remdesivir, we used evidence on the cost of producing the next course of therapy from an article by Hill et all in the Journal of Virus Eradication (2020). Their methods sought to determine the "minimum" costs of production by calculating the cost of active pharmaceutical ingredients, which is combined with costs of excipients, formulation, packaging and a small profit margin. Their analysis calculated a total cost of producing the "final finished product" of $9.32 US for a 10-day course of treatment. We rounded that amount up to $10 for a 10-day course. If a 5-day course of treatment becomes a recommended course of therapy, then the marginal cost would accordingly shrink to $5.

In our base-case cost recovery calculation, we set the costs of research and development to zero. There are important reasons to assume that sunk research and development costs should not be used to help justify the price of new drugs. For remdesivir, this perspective is strengthened by the fact that it was previously developed as part of a suite of agents for potential use in chronic Hepatitis C. Given that the manufacturer successfully launched other drugs for Hepatitis C, it seems reasonable that any sunk costs for research and development have already been recouped in the successful market experience of the manufacturer's other treatments in that area. For that reason and others, we are not currently including any research and development costs separate from the development costs already captured in the cost of production. As the manufacturer spends new money going forward on clinical trials for the COVID-19 population, consideration will be given to including these costs as a possible component of a cost recovery price estimate.

Preliminary Results and Conclusions

Table 1. Cost Recovery Model Results

	Marginal cost to produce one 10-day course for one patient	Manufacturer R&D Costs	Societal R&D Costs	Additional Profits Beyond Marginal Cost	Total Recovery Cost Pricing
$ per course of remdesivir treatment	$10	$0	$0	$0	$10

From the manufacturer perspective, the lowest cost to recover the marginal cost to produce one 10-day course of remdesivir is $10. A higher transaction price for one 10-day course of remdesivir would be necessary to achieve a profit over and above that of the cost to produce the next course of treatment. Policymakers and the public will need to debate the most appropriate development and pricing paradigms to be used to achieve rapid development and distribution of affordable treatments for a global pandemic.

ICER-COVID Model 2: Remdesivir Cost-Effectiveness Analysis

Objective

The objective of this preliminary analysis was to estimate the cost-effectiveness and corresponding health-based price benchmarks of remdesivir versus standard of care for hospitalized patients with advanced COVID-19 and lung involvement.

Methods

We used a decision tree model, populated by evidence from the Adaptive COVID-19 Treatment Trial (ACTT) and other sources, to estimate the costs and quality-adjusted life years (QALYs) gained through hospital recovery or death. In this application, quality-adjusted life years (QALYs) are equivalent to equal value of life-years gained (evLYGs). We estimated the lifetime costs and outcomes of remdesivir and standard of care by assigning the age-based average survival, health care costs, and utility for all those who recovered from the COVID-19 hospital event. We took the perspective of the health care sector for this preliminary and iterative analysis. Costs and outcomes were discounted at 3% per year. To aid in the interpretation of the findings, this analysis assumed that all potential societal costs and gains associated with remdesivir were borne by and are returned to society. Further, health system capacity measures and health care personnel impacts were not included in this analysis. Model inputs and assumptions may be viewed in a supporting table. Substantial clinical evidence uncertainty exists for remdesivir. In particular, the comparative remdesivir mortality benefit in the ACTT study did not reach statistical benefit, and the mortality benefit is by far the largest driver of the cost-effectiveness findings. To address this uncertainty, we performed a scenario analysis assuming no mortality benefit for remdesivir. ICER plans to request public comment and conduct peer-reviewed processes alongside updates to evidence sources in future iterations of this research.

Preliminary Results and Conclusions

Table 2. Value-Based Prices: lifetime horizon across different health-based prices and scenarios

Threshold	Base-Case Model (assuming mortality benefit)	Scenario Analysis assuming no mortality benefit
$50,000/QALY	**$4,460**	$390
$100,000/QALY	$28,670	$780
$150,000/QALY	$52,880	$1,170

In this preliminary modeling exercise, remdesivir extends life and improves quality of life versus standard of care. In public health emergencies, cost-effectiveness analysis thresholds are often scaled downward, and we feel the pricing estimate related to the threshold of $50,000 per incremental quality-adjusted life year (and equal value of a life-year gained) is the most policy-relevant consideration. In the case of remdesivir, the initial ICER-COVID model suggests a price of approximately $4,500 per treatment course, whether that course is 10 or 5 days.

All cost-effectiveness results will evolve as further data are released and as the context for the patient population treated evolves. Cost-effectiveness modeling is but one of several approaches to consider reasonable pricing. Particularly in the setting of a public health emergency on the scale of that associated with COVID-19, public and policymakers should consider a broad range of approaches.

APPENDIX: Model Description and Initial Key Assumptions

CEA Model Settings:

- Perspective: Health System
- Time Horizon: Lifetime
- Outcomes: Incremental costs, incremental QALYs=evLYG
- Structure: short-term decision tree (models duration in highest healthcare setting and probability of death from highest healthcare setting) with long-term Markov model (health states of alive and dead with average age-based costs and consequences)
- Population: hospitalized patients with advanced COVID-19 and lung involvement
- Discount rate of 3% for costs and outcomes

CEA Model Assumptions:

- For all those who recover in either the standard of care or remdesivir treatment, we assigned age- and gender-based probability of death, quality of life, and average healthcare costs
    - Future related and unrelated healthcare costs based on average age-adjusted healthcare costs
    - Future quality of life based on age-adjusted utility
    - Future death based on all-cause age- and sex-adjusted mortality
- Death prior to discharge occurred at the halfway point of the duration of the tree (at day 15 within the first 30 days)
- Treatment costs for remdesivir are in addition to a bundled hospital payment. We assumed no cost or disutility for potential adverse events separate from the cost and disutility of the admission.

Table 3. CEA Model Inputs

Model-Wide Inputs	Value	Source	Notes
Probability of inpatient visit as highest healthcare setting	66%	Petrilli et al., 2020	
Probability of ICU visit without ventilation as highest healthcare setting	6%	Petrilli et al., 2020	
Probability of ICU visit with ventilation as highest healthcare setting	28%	Petrilli et al., 2020	
Disutility of COVID symptoms	-0.19	Assumption & Smith & Roberts, 2002	For duration of admission
Disutility of COVID inpatient visit as highest healthcare setting	-0.30	Assumption & Barbut et al., 2019	For duration of admission; additive onto disutility of COVID symptoms
Disutility of COVID ICU visit without ventilation as highest healthcare setting	-0.50	Assumption & Barbut et al., 2019	For duration of admission; additive onto disutility of COVID symptoms

Disutility of COVID ICU visit with ventilation as highest healthcare setting	-0.60	Assumption & Barbut et al., 2019	For duration of admission; additive onto disutility of COVID symptoms
Healthcare resource cost when inpatient visit was highest healthcare setting	$12,692	Rae et al., 2020	Median total cost for larger employer plans for Pneumonia inpatient stay
Healthcare resource cost when ICU visit with no ventilation was highest healthcare setting	$34,223	Rae et al., 2020 & Assumption that short ventilator stays in ICU represent ICU stay costs without ventilator	Median total cost for larger employer plans for Respiratory system diagnosis with ventilator support for less than 96 hours
Healthcare resource cost when ICU visit with ventilation was highest healthcare setting	$61,169	Rae et al., 2020	Average of the median total cost for larger employer plans for Respiratory system diagnosis with ventilator support for less than 96 hours and for 96 hours or more
Average age of population	62	Petrilli et al., 2020	
Percent female	0.37	Petrilli et al., 2020	
Remdesivir-Specific Inputs			
Relative reduction in time to recovery	0.69	NIAID Statement	Applied to symptom days from placebo-specific inputs (31% reduction)
Relative reduction in mortality	0.69	NIAID Statement	Applied to mortality from placebo-specific inputs (=8.0/11.6)
Probability of discontinuing treatment	10%	Gilead active arm study (no control group)	
Percent of treatment regimen completed prior to discontinuation	50%	Gilead active arm study (no control group) & Assumption	
Placebo-Specific Inputs			
Probability of recovering given inpatient visit as highest healthcare setting	96%	Petrilli et al., 2020 & NIAID Statement	Probability of death was from Petrilli et al., 2020 and calibrated to NIAID

			observed death risk. Recovering was assumed to be 1 – death risk.
Probability of recovering given ICU visit without ventilation as highest healthcare setting	90%	Petrilli et al., 2020 & NIAID Statement	Probability of death was from Petrilli et al., 2020 and calibrated to NIAID observed death risk. Recovering was assumed to be 1 – death risk.
Probability of recovering given ICU visit with ventilation as highest healthcare setting	69%	Petrilli et al., 2020 & NIAID Statement	Probability of death was from Petrilli et al., 2020 and calibrated to NIAID observed death risk. Recovering was assumed to be 1 – death risk.
Symptom days given inpatient visit as highest healthcare setting	10.25	Petrilli et al., 2020 & NIAID Statement	Median days reported by Petrilli et al., 2020 and calibrated to NIAID observed days to recovery.
Symptom days given ICU visit with no ventilation as highest healthcare setting	24.33	Petrilli et al., 2020 & NIAID Statement	Median days reported by Petrilli et al., 2020 and calibrated to NIAID observed days to recovery.
Symptom days given ICU visit with ventilation as highest healthcare setting	24.33	Petrilli et al., 2020 & NIAID Statement	Median days reported by Petrilli et al., 2020 and calibrated to NIAID observed days to recovery.