**Appendix: Putting GRACE into Action**

There are two ways to employ GRACE. One, presented in Lakdawalla and Phelps (2020), employs Taylor Series expansions to approximate value. Herein, we present a different approach, using specific utility functions with known parameters that define risk preferences and diminishing returns.

 Two general functional forms are common in empirical estimation of risk preferences. One, hyperbolic absolute risk aversion (HARA), contains relative risk aversion (CRRA) as a special case. The other, Expo-Power (EP) utility function, contains exponential utility (EU). These functional forms, or any others, can be implemented in GRACE using the equations in Section II. To illustrate GRACE’s mechanics, we work with CRRA utility here.

Recall that in the simple two-period model,

 $TVMI\_{GRACE}=KDϕ\{μ\_{P}ρH\_{0}+μ\_{B}ϵω\_{H}R\}$ (A.1a)

This contrasts with traditional cost-effectiveness, for which:

 $TVMI=Kϕ\{μ\_{P}H\_{T}+μ\_{B}\}$ (A.1b)

The effect of GRACE turns on the implications of the parameters $D$, $R$, $ω\_{H}$, $ρ$, and $ϵ$.

Standard CEA assumes that each quality-adjusted life-year is worth $K=\frac{C}{ω\_{C}}.$ It is plausible to assume $K=2C,$ implying $ω\_{C}=0.5$ for the utility of consumption. For illustration, we assume similar curvature in $W$, the utility of HRQoL. Under CRRA, this implies $γ=0.5$

1. **Assessing disability.** With CRRA, equation (11b) implies the disability adjustment, *D*:

$D=\left[\frac{H\_{0}}{H\_{0}\left(1-d^{\*}\right)}\right]^{γ}=\left(\frac{1}{1-d^{\*}}\right)^{γ}$ (A.2)

For severe disabilities such as advanced Duchenne Muscular Dystrophy (DMD), Amyotrophic Lateral Sclerosis (ALS, also known as Lou Gehrig's Disease), or Alzheimer's Disease, it is plausible that $d^{\*}=0.8.$ Then, when $γ=0.5$, $D=\left[\frac{1}{1-0.8}\right]^{0.5}=2.236.$ With these parameters, GRACE magnifies the WTP for any health improvement by a factor of over 2 compared with standard CEA.

This adjustment varies with $γ$. If there were nearly constant returns to health, so that $γ=0.75$, then $D=3.34$ and if $γ=0.25,$ then $D=1.5$. Further, for a mild impairment, suppose that $d^{\*}=0.1, $ so that when $γ=0.5, $ then $D=1.05,$ a very small "bonus" for disability.

1. **Assessing Severity of Illness Effects.** Next, consider the illness severity multiplier, $R=\frac{W^{'}\left(μ\_{1S}\right)}{W^{'}\left(H\_{0}\right)}.$ With CRRA utility, from Equation (11a):

 $R=\left[\frac{1}{1-l^{\*}}\right]^{1-γ}$ (A.3)

Continuing to assume that $γ=0.5,$ *R* rises exponentially as the magnitude of untreated acute illness, $l^{\*},$ rises. If $l^{\*}=0.2,$ say, for a case of the flu or widespread poison ivy, then $R=\left[\frac{1}{.8}\right]^{0.5}=1.12$. For a more serious acute illness such as a herniated lumbar disc, suppose that $l^{\*}=0.5.$ Then, $R=1.414.$ For a very serious illness with $l^{\*}=0.8, $ $R=2.24.$ Notice that the effect of $γ$ is just the inverse of its effects on *D*. For $R,$ the exponential power is $(1-γ),$ whereas in the calculation for disability, $D,$ the power is $γ.$

1. **Assessing the Value of Improving HRQoL**. Consider a treatment with the deterministic (i.e., $ϵ=1$) improvement in HRQoL. Here, the total measure of value is:

 Value of improving HRQoL = $Kϕω\_{H}DRμ\_{B}$ (A.4)

In contrast, standard CEA values an HRQoL gain at $Kϕμ\_{B}$ per healthy beneficiary. Under CRRA utility, the GRACE value weakly exceeds the standard CEA value if and only if:

 $ω\_{H}DR=γ\left[\frac{1}{1-d^{\*}}\right]^{γ}\left[\frac{1}{1-l^{\*}}\right]^{1-γ}\geq 1$ (A.5)

The product $ωDR$ has components that both fall and rise with $γ$. Since $ω\_{H}=γ,$ reductions in $γ$ shrink $ω\_{H}.$ As the examples at Equation (A.2) show, smaller values of $γ$ also shrink the value of $D.$ Just the reverse is true for the acute illness multiplier, $\left(1-γ\right)=$ $r\_{H}^{\*}$. As $γ$ falls, $R $rises.

 Note that if $ωDR>1$ then GRACE values a treatment more than standard CEA does. Conversely, if $ωDR<1$, GRACE says that standard CEA overvalues treatments. This is most likely to occur for low severity illnesses, where $l^{\*}$ is small, so $R≈1$. Then, particularly when disability is absent, so that $D=1$, we can say with assurance that $DR<1$ for any meaningful magnitude of diminishing returns to health, i.e., where $ω\_{H}\ll 1.$

 This also highlights the importance of distinguishing between CRRA, IRRA or DRRA. When utility is CRRA, $ω\_{H}+r\_{H}^{\*}=1$. If it is IRRA, then $ω\_{H}+r\_{H}^{\*}<1$; this will reduce GRACE estimates of the value of improving HRQoL compared with CRRA utility. Conversely, if utility is DRRA, then $ω\_{H}+r\_{H}^{\*}$ > 1, which makes $ω\_{H}R$ larger than it is under CRRA.

 Finally, we note that WTP for improvements in HRQoL is unambiguously greater for disabled people than for otherwise similar non-disabled people, since $D>1$ for disabled people, and grows exponentially with disability severity, whereas $D=1$ for people without disability.

1. **Assessing the Value of Improving LE.** This brings us to the value of extending LE. In GRACE, this is $ϕDρμ\_{P}$, where $μ\_{p}$ is the gain in the probability of survival. *D* depends upon $γ$. The multiplier $ρ$ also depends on the exact distribution of potential treated health outcomes.

 Under CRRA, where $π\_{n}^{T}$ is the probability of treated health outcome *n* and $H\_{n}^{T}=H\_{0}\left(1-t\_{n}^{\*}\right)$, and where $t^{\*}$ is the relative HRQoL loss in the treated state *n*:

 $ρ=\sum\_{n}^{}π\_{n}^{T}\left(\frac{H\_{0}(1-t\_{n}^{\*})}{H\_{0}}\right)^{γ}=\sum\_{n}^{}π\_{n}^{T}\left(1-t\_{n}^{\*}\right)^{γ}$ (A.6)

When the treated HRQoL falls, so does $ρ$, and with it, the value of extensions in LE. Further, since $t\_{n}^{\*}$ incorporates the effects of disability, $ρ$ is lower for disabled people than for otherwise similar non-disabled people.

1. **Assessing the Effects of Random Treatment Outcomes**. If treatment outcomes are stochastic, the value of HRQoL gains is given by:

$$KDϕ\{ω\_{H}R\}ETG$$

Equation (7c) in the main text states that the treatment gain, measured in units of health, is $ETG=\frac{EW(T)}{W^{'}\left(μ\_{H}\right)}$. Assuming for simplicity that treatment gains are perfectly correlated with the underlying health state, Equation (14b) gives a more-complete expression as:

$ETG=\frac{1}{γH\_{0}^{γ-1}}\{\sum\_{i}^{}π\_{i}^{T}H\_{T\_{i}}^{γ}-\sum\_{i}^{}π\_{i}^{U}H\_{1Sj}^{γ}$} (A.7)

For the mean HRQoL benefit, $μ\_{B}$, Jensen’s inequality implies that $\sum\_{i}^{}π\_{i}^{T}H\_{T\_{i}}^{γ}<\left(\overbar{H\_{T\_{i}1Sj}}+μ\_{B}\right)^{γ}$. Thus, GRACE discounts the value of risky treatments and multiplies the value of risk-reducing treatments. GRACE also discounts the value of a given health improvement more heavily when diminishing returns are greater – i.e., when $γ$ is smaller.

1. **Multiperiod Models.** The main text, Equation (20c) shows that in multiperiod models:

 $TVMI=ϕDKω\_{H}^{ }R\sum\_{j=0}^{\infty }β^{j}\{\frac{μ\_{pj}\left[EW\left(H\_{sj}+B\_{j}\right)\right]+p\_{j}^{U}\left[EW\_{j}\left(T\right)\right]}{W^{'}\left(H\_{sj}\right)}\}$ (A.8)

 Discounting occurs just as in standard CEA, with $β^{j}$. The GRACE-related WTP measure satisfies $K\_{GRACE}=DKω\_{H}^{ }R$. Therefore, the multiperiod model essentially involves careful bookkeeping.