

**Article:** How can a community pursue equitable health and well-being after a severe shock?  
Ideas from an explanatory model

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**Date:** September 13, 2022

## SUPPLEMENT 1 Equation List

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.Active

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### Active Equations

- (001) Adequacy of USC =  $\text{MIN}(1, \text{XIDZ}(\text{Urgent services capacity}, \text{Urgent need fraction}, 1))$   
*0-1 fraction*
  
- (002) Adequacy of USC at end of shock =  $\text{SAMPLE IF TRUE}(\text{Time} = \text{End year of shock}, \text{Adequacy of USC}, \text{Adequacy of USC})$   
*0-1 fraction*
  
- (003) Adequacy of USC initial = 0.6  
*0-1 fraction*
  
- (004) Asset gathering index = 0.5  
*1/year*
  
- (005) Asset threshold for outsourcing = 0.5  
*0-1 fraction*
  
- (006) Average of 4 indices =  $(\text{Vital conditions index} + \text{Equity index} + \text{Adequacy of USC} + \text{Civic muscle index}) / 4$   
*0-1 fraction*
  
- (007) Avg life eval =  $\text{Thriving fraction} * \text{Avg life eval of thriving} + \text{Struggling fraction} * \text{Avg life eval of struggling} + \text{Suffering fraction} * \text{Avg life eval of suffering}$   
*0-10 Cantril measure*
  
- (008) Avg life eval of struggling = 5  
*0-10 Cantril measure*
  
- (009) Avg life eval of suffering = 2  
*0-10 Cantril measure*

- (010) Avg life eval of thriving=8  
*0-10 Cantril measure*
- (011) Avg to date change in popn life years = -Avg to date change in popn YLL  
*years\*popn*
- (012) Avg to date change in popn YLL = Avg to date popn YLL - Popn YLL initial  
*years\*popn*
- (013) Avg to date popn YLL=XIDZ(Cumul popn YLL, Time, Popn YLL)  
*years\*popn*
- (014) Avg to date YLL since end of shock = XIDZ(Cumul YLL since end of shock, MAX(0, Time-End year  
of shock), Avg YLL at end of shock)  
*years*
- (015) Avg YLL=Struggling fraction\*Avg YLL of struggling + Suffering fraction\*Avg YLL of suffering  
*years*
- (016) Avg YLL at end of shock=SAMPLE IF TRUE(Time=End year of shock, Avg YLL, Avg YLL)  
*years*
- (017) Avg YLL initial=INITIAL(Avg YLL)  
*years*
- (018) Avg YLL of struggling=3  
*years*
- (019) Avg YLL of suffering=20  
*years*
- (020) Avg YLL since end of shock=IF THEN ELSE(Time<End year of shock, 0, Avg YLL)  
*years*
- (021) Change in avg life expectancy = -Change in avg YLL  
*years*
- (022) Change in avg YLL = Avg YLL - Avg YLL initial  
*years*
- (023) Civic muscle index= INTEG (CM building-CM loss from erosion-CM loss from shock, Civic muscle  
index initial)  
*0-1 fraction*
- (024) Civic muscle index initial=0.5  
*0-1 fraction*

- (025)  $CM\ building = \text{MIN}(CM\ loss\ from\ erosion + (1 - Civic\ muscle\ index) / TIME\ STEP, CM\ building\ normal + CM\ rebuilding\ with\ gathered\ assets)$   
*1/year*
- (026)  $CM\ building\ normal = \text{Max\ possible\ CM\ building} * Civic\ muscle\ index * \text{Frac\ of\ CM\ allocated\ to\ CM\ building}$   
*1/year*
- (027)  $CM\ erosion\ multiplier\ from\ outsourcing = 4$   
*dimensionless*
- (028)  $CM\ erosion\ rate = CM\ erosion\ rate\ normal * (1 + (CM\ erosion\ multiplier\ from\ outsourcing - 1) * \text{Frac\ of\ CM\ underused\ due\ to\ outsourcing})$   
*1/year*
- (029)  $CM\ erosion\ rate\ normal = 0.03$   
*1/year*
- (030)  $CM\ index\ at\ end\ of\ shock = \text{SAMPLE\ IF\ TRUE}(Time = \text{End\ year\ of\ shock}, Civic\ muscle\ index, Civic\ muscle\ index)$   
*0-1 fraction*
- (031)  $CM\ loss\ from\ erosion = Civic\ muscle\ index * CM\ erosion\ rate$   
*1/year*
- (032)  $CM\ loss\ from\ shock = CM\ total\ loss\ from\ shock / \text{Duration\ of\ shock} * \text{PULSE}(\text{Start\ year\ of\ shock}, \text{Duration\ of\ shock})$   
*1/year*
- (033)  $CM\ rebuilding\ with\ gathered\ assets = \text{IF\ THEN\ ELSE}(Time > \text{Start\ year\ of\ shock} + \text{Duration\ of\ assets\ for\ rebuilding}, 0, \text{SMOOTHI}(\text{Asset\ gathering\ index} * \text{MIN}(\text{Cumul\ CM\ loss\ from\ shock}, 1 - Civic\ muscle\ index) * (Civic\ muscle\ index / 0.5) * \text{Frac\ of\ CM\ allocated\ to\ CM\ building}, \text{Time\ to\ ramp\ up\ assets\ for\ rebuilding}, 0))$   
*1/year*
- (034)  $CM\ total\ loss\ from\ shock = 0$   
*0-1 fraction*
- (035)  $\text{Coefficient\ for\ urgent\ need\ from\ nonthriving} = 0.5$   
*dimensionless*
- (036)  $\text{Cumul\ CM\ loss\ from\ shock} = \text{INTEG}(CM\ loss\ from\ shock, 0)$   
*0-1 fraction*
- (037)  $\text{Cumul\ equity\ loss\ from\ shock} = \text{INTEG}(\text{Equity\ loss\ from\ shock}, 0)$   
*0-1 fraction*

- (038) Cumul popn YLL= INTEG (Popn YLL,0)  
*years\*years\*popn*
- (039) Cumul USC loss from shock= INTEG (USC loss from shock,0)  
*0-1 fraction*
- (040) Cumul VC loss from shock= INTEG (VC loss from shock,0)  
*0-1 fraction*
- (041) Cumul YLL since end of shock= INTEG (Avg YLL since end of shock,0)  
*years\*years*
- (042) Duration of assets for rebuilding=11  
*years*
- (043) Duration of shock=1  
*years*
- (044) Effect of equity on CM building= (Equity index/Equity index initial)^Exponent for CM building  
from equity  
*dimensionless*
- (045) Effect of equity on thriving= (Equity index/Equity index initial)^Exponent for thriving from  
equity  
*dimensionless*
- (046) Effect of nonthriving on urgent need= 1 + (Nonthriving ratio to initial-1)\*Coefficient for urgent  
need from nonthriving  
*dimensionless*
- (047) Effect of social support on thriving= (Social support index/Social support index  
initial)^Exponent for thriving from social support  
*dimensionless*
- (048) Effect of VC on thriving= (Vital conditions index/Vital conditions index initial)^Exponent for  
thriving from VC  
*dimensionless*
- (049) End year of shock=Start year of shock + Duration of shock  
*year*
- (050) Equity building=MIN(Equity loss from erosion+(1-Equity index)/TIME STEP, Equity building  
normal+ Equity rebuilding with gathered assets)  
*1/year*
- (051) Equity building normal=Max possible equity building initial\*Civic muscle index\*Frac of CM  
allocated to equity building  
*1/year*

- (052) Equity erosion rate=0.03  
*1/year*
- (053) Equity index= INTEG (Equity building-Equity loss from erosion-Equity loss from shock, Equity index initial)  
*0-1 fraction*
- (054) Equity index at end of shock= SAMPLE IF TRUE(Time=End year of shock, Equity index, Equity index)  
*0-1 fraction*
- (055) Equity index initial=0.52  
*0-1 fraction*
- (056) Equity loss from erosion=Equity index \* Equity erosion rate  
*1/year*
- (057) Equity loss from shock=Equity total loss from shock/Duration of shock \* PULSE(Start year of shock, Duration of shock)  
*1/year*
- (058) Equity rebuilding with gathered assets= IF THEN ELSE(Time>Start year of shock + Duration of assets for rebuilding, 0, SMOOTH1 (Asset gathering index\*MIN(Cumul equity loss from shock, 1-Equity index)\* (Civic muscle index/0.5)\*Frac of CM allocated to equity building, Time to ramp up assets for rebuilding, 0))  
*1/year*
- (059) Equity total loss from shock=0.06  
*0-1 fraction*
- (060) Exponent for CM building from equity=1  
*dimensionless*
- (061) Exponent for social support from CM=ln(Social support index initial)/ln(Civic muscle index initial)  
*dimensionless*
- (062) Exponent for thriving from equity=0.55  
*dimensionless*
- (063) Exponent for thriving from social support=0.4  
*dimensionless*
- (064) Exponent for thriving from VC=0.95  
*dimensionless*

- (065)  $\text{Frac change in adequacy of USC since end of shock} = \text{IF THEN ELSE}(\text{Time} < \text{End year of shock}, 0, \text{ZIDZ}(\text{Adequacy of USC} - \text{Adequacy of USC at end of shock}, \text{Adequacy of USC at end of shock}))$   
*dimensionless*
- (066)  $\text{Frac change in civic muscle since end of shock} = \text{IF THEN ELSE}(\text{Time} < \text{End year of shock}, 0, \text{ZIDZ}(\text{Civic muscle index} - \text{CM index at end of shock}, \text{CM index at end of shock}))$   
*dimensionless*
- (067)  $\text{Frac change in equity since end of shock} = \text{IF THEN ELSE}(\text{Time} < \text{End year of shock}, 0, \text{ZIDZ}(\text{Equity index} - \text{Equity index at end of shock}, \text{Equity index at end of shock}))$   
*dimensionless*
- (068)  $\text{Frac change in struggling since end of shock} = \text{IF THEN ELSE}(\text{Time} < \text{End year of shock}, 0, \text{ZIDZ}(\text{Struggling fraction} - \text{Struggling frac at end of shock}, \text{Struggling frac at end of shock}))$   
*dimensionless*
- (069)  $\text{Frac change in suffering since end of shock} = \text{IF THEN ELSE}(\text{Time} < \text{End year of shock}, 0, \text{MIN}(1, \text{ZIDZ}(\text{Suffering fraction} - \text{Suffering frac at end of shock}, \text{Suffering frac at end of shock})))$   
*dimensionless*
- (070)  $\text{Frac change in thriving since end of shock} = \text{IF THEN ELSE}(\text{Time} < \text{End year of shock}, 0, \text{ZIDZ}(\text{Thriving fraction} - \text{Thriving frac at end of shock}, \text{Thriving frac at end of shock}))$   
*dimensionless*
- (071)  $\text{Frac change in vital conditions since end of shock} = \text{IF THEN ELSE}(\text{Time} < \text{End year of shock}, 0, \text{ZIDZ}(\text{Vital conditions index} - \text{Vital conditions index at end of shock}, \text{Vital conditions index at end of shock}))$   
*dimensionless*
- (072)  $\text{Frac change to date in adequacy of USC} = \text{ZIDZ}(\text{Adequacy of USC} - \text{Adequacy of USC initial}, \text{Adequacy of USC initial})$   
*dimensionless*
- (073)  $\text{Frac change to date in CM} = \text{ZIDZ}(\text{Civic muscle index} - \text{Civic muscle index initial}, \text{Civic muscle index initial})$   
*dimensionless*
- (074)  $\text{Frac change to date in equity} = \text{ZIDZ}(\text{Equity index} - \text{Equity index initial}, \text{Equity index initial})$   
*dimensionless*
- (075)  $\text{Frac change to date in struggling} = \text{ZIDZ}(\text{Struggling fraction} - \text{Struggling fraction initial}, \text{Struggling fraction initial})$   
*dimensionless*
- (076)  $\text{Frac change to date in suffering} = \text{ZIDZ}(\text{Suffering fraction} - \text{Suffering fraction initial}, \text{Suffering fraction initial})$   
*dimensionless*

- (077)  $\text{Frac change to date in thriving} = \text{ZIDZ}(\text{Thriving fraction} - \text{Thriving fraction initial}, \text{Thriving fraction initial})$   
*dimensionless*
- (078)  $\text{Frac change to date in VC} = \text{ZIDZ}(\text{Vital conditions index} - \text{Vital conditions index initial}, \text{Vital conditions index initial})$   
*dimensionless*
- (079)  $\text{Frac of CM allocated to CM building} = \text{GAME}(\text{Frac of CM allocated to CM building initial})$   
*0-1 fraction*
- (080)  $\text{Frac of CM allocated to CM building initial} = 0.15$   
*0-1 fraction*
- (081)  $\text{Frac of CM allocated to equity building} = \text{GAME}(\text{Frac of CM allocated to equity building initial})$   
*0-1 fraction*
- (082)  $\text{Frac of CM allocated to equity building initial} = 0.15$   
*0-1 fraction*
- (083)  $\text{Frac of CM allocated to USC building} = \text{MAX}(0, 1 - \text{Frac of CM allocated to VC building} - \text{Frac of CM allocated to CM building} - \text{Frac of CM allocated to equity building})$   
*0-1 fraction*
- (084)  $\text{Frac of CM allocated to USC building initial} = \text{INITIAL}(\text{Frac of CM allocated to USC building})$   
*0-1 fraction*
- (085)  $\text{Frac of CM allocated to VC building} = \text{GAME}(\text{Frac of CM allocated to VC building initial})$   
*0-1 fraction*
- (086)  $\text{Frac of CM allocated to VC building initial} = 0.3$   
*0-1 fraction*
- (087)  $\text{Frac of CM underused due to outsourcing} = \text{IF THEN ELSE}(\text{VC rebuilding with gathered assets} = 0, 0, \text{Frac of CM allocated to VC building} * \text{Outsourced frac of asset use}) + \text{IF THEN ELSE}(\text{USC rebuilding with gathered assets} = 0, 0, \text{Frac of CM allocated to USC building} * \text{Outsourced frac of asset use}) + \text{IF THEN ELSE}(\text{Equity rebuilding with gathered assets} = 0, 0, \text{Frac of CM allocated to equity building} * \text{Outsourced frac of asset use}) + \text{IF THEN ELSE}(\text{CM rebuilding with gathered assets} = 0, 0, \text{Frac of CM allocated to CM building} * \text{Outsourced frac of asset use})$   
*0-1 fraction*
- (088)  $\text{Game interval} = 2$   
*years*
- (089)  $\text{Max possible CM building} = \text{Max possible CM building initial} * \text{Effect of equity on CM building}$   
*1/year*

- (090) Max possible CM building initial= (Civic muscle index initial\*CM erosion rate normal)/(Civic muscle index initial\*Frac of CM allocated to CM building initial)  
*1/year*
- (091) Max possible equity building initial= (Equity index initial\*Equity erosion rate)/(Civic muscle index initial\*Frac of CM allocated to equity building initial)  
*1/year*
- (092) Max possible USC building initial= (Urgent services capacity initial\*USC erosion rate)/(Civic muscle index initial\*Frac of CM allocated to USC building initial)  
*1/year*
- (093) Max possible VC building initial= (Vital conditions index initial\*VC erosion rate)/(Civic muscle index initial\*Frac of CM allocated to VC building initial)  
*1/year*
- (094) Nonthriving ratio to initial= Struggling or suffering fraction/(1-Thriving fraction initial)  
*dimensionless*
- (095) Outsourced frac of asset use=ZIDZ(MAX(0,Asset gathering index-Asset threshold for outsourcing), Asset gathering index)  
*0-1 fraction*
- (096) Penalty multiplier for negative score= 2  
*dimensionless*
- (097) Popn YLL= Population size\*Avg YLL  
*popn\*years*
- (098) Popn YLL initial=Avg YLL initial \* Population size  
*years\*popn*
- (099) Population size=330000  
*popn*
- (100) Recovery ratio= MAX(0, ZIDZ(Avg YLL at end of shock-Avg to date YLL since end of shock, Avg YLL at end of shock-Avg YLL initial))  
*dimensionless*
- (101) Score from suffering= IF THEN ELSE(Frac change in suffering since end of shock>0, Penalty multiplier for negative score, 1) \* MIN(1, -Frac change in suffering since end of shock) \* 100  
*dimensionless*
- (102) Score from thriving= IF THEN ELSE(Frac change in thriving since end of shock<0, Penalty multiplier for negative score, 1) \* MIN(1, Frac change in thriving since end of shock) \* 100  
*dimensionless*

- (103) Score to date= IF THEN ELSE(Time<End year of shock, 0, MIN(100,MAX(-100, 2 \* (MIN(50,Score from thriving\*Score weight on thriving) + MIN(50,Score from suffering\*Score weight on suffering)) / (Score weight on thriving + Score weight on suffering))))  
*dimensionless*
- (104) Score weight on suffering=0.85  
*dimensionless*
- (105) Score weight on thriving= 1  
*dimensionless*
- (106) Shock has occurred=IF THEN ELSE(Cumul VC loss from shock + Cumul USC loss from shock>0, 1, 0)  
*dimensionless*
- (107) Social support index=Civic muscle index^Exponent for social support from CM  
*0-1 fraction*
- (108) Social support index initial=0.8  
*0-1 fraction*
- (109) Start year of shock=1  
*year*
- (110) Struggling frac at end of shock=SAMPLE IF TRUE(Time=End year of shock, Struggling fraction, Struggling fraction)  
*0-1 fraction*
- (111) Struggling fraction= Struggling or suffering fraction - Suffering fraction  
*0-1 fraction*
- (112) Struggling fraction initial= 1-Thriving fraction initial-Suffering fraction initial  
*0-1 fraction*
- (113) Struggling or suffering fraction= 1-Thriving fraction  
*0-1 fraction*
- (114) Suffering frac at end of shock=SAMPLE IF TRUE(Time=End year of shock, Suffering fraction, Suffering fraction)  
*0-1 fraction*
- (115) Suffering fraction= Urgent need fraction \* (1-Adequacy of USC)  
*0-1 fraction*
- (116) Suffering fraction initial= 0.035  
*0-1 fraction*

- (117) Thriving frac at end of shock=SAMPLE IF TRUE(Time=End year of shock, Thriving fraction, Thriving fraction)  
*0-1 fraction*
- (118) Thriving fraction=MIN(1, Thriving fraction initial \* Effect of VC on thriving \* Effect of equity on thriving\* Effect of social support on thriving)  
*0-1 fraction*
- (119) Thriving fraction initial=0.55  
*0-1 fraction*
- (120) Time to ramp up assets for rebuilding=1  
*years*
- (121) Urgent need fraction= MIN(Urgent need fraction initial\*Effect of nonthriving on urgent need, Struggling or suffering fraction)  
*0-1 fraction*
- (122) Urgent need fraction initial= Suffering fraction initial/(1-Adequacy of USC initial)  
*0-1 fraction*
- (123) Urgent services capacity= INTEG (USC building-USC loss from erosion-USC loss from shock, Urgent services capacity initial)  
*0-1 fraction*
- (124) Urgent services capacity initial= INITIAL(Urgent need fraction initial\*Adequacy of USC initial)  
*0-1 fraction*
- (125) USC building=USC building normal + USC rebuilding with gathered assets  
*1/year*
- (126) USC building normal= Max possible USC building initial\*Civic muscle index\*Frac of CM allocated to USC building  
*1/year*
- (127) USC erosion rate=0.25  
*1/year*
- (128) USC loss from erosion=Urgent services capacity \* USC erosion rate  
*1/year*
- (129) USC loss from shock=USC total loss from shock/Duration of shock \* PULSE(Start year of shock, Duration of shock)  
*1/year*

- (130) USC rebuilding with gathered assets= IF THEN ELSE(Time>Start year of shock + Duration of assets for rebuilding, 0, SMOOTHI (Asset gathering index\*MIN(Cumul USC loss from shock, 1-Urgent services capacity)\*(Civic muscle index/0.5)\*Frac of CM allocated to USC building, Time to ramp up assets for rebuilding, 0))  
*1/year*
- (131) USC total loss from shock=0.003  
*0-1 fraction*
- (132) VC building=MIN(VC loss from erosion+(1-Vital conditions index)/TIME STEP, VC building normal+ VC rebuilding with gathered assets)  
*1/year*
- (133) VC building normal=Max possible VC building initial\*Civic muscle index\*Frac of CM allocated to VC building  
*1/year*
- (134) VC erosion rate=0.03  
*1/year*
- (135) VC loss from erosion=Vital conditions index \* VC erosion rate  
*1/year*
- (136) VC loss from shock=VC total loss from shock/Duration of shock \* PULSE(Start year of shock, Duration of shock)  
*1/year*
- (137) VC rebuilding with gathered assets= IF THEN ELSE(Time>Start year of shock + Duration of assets for rebuilding, 0, SMOOTHI (Asset gathering index\*MIN(Cumul VC loss from shock, 1-Vital conditions index)\*(Civic muscle index/0.5)\*Frac of CM allocated to VC building, Time to ramp up assets for rebuilding, 0))  
*1/year*
- (138) VC total loss from shock=0.1  
*0-1 fraction*
- (139) Vital conditions index= INTEG (VC building-VC loss from erosion-VC loss from shock, Vital conditions index initial)  
*0-1 fraction*
- (140) Vital conditions index at end of shock=SAMPLE IF TRUE(Time=End year of shock, Vital conditions index, Vital conditions index)  
*0-1 fraction*
- (141) Vital conditions index initial=0.8  
*0-1 fraction*

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.Control

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Simulation Control Parameters

(142) FINAL TIME = 12  
*year*

(143) INITIAL TIME = 0  
*year*

(144) SAVEPER = TIME STEP  
*year*

(145) TIME STEP = 0.125  
*year*