

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

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SUPPLEMENT 1

Equation List

.Active

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) $CM\ building = MIN(CM\ loss\ from\ erosion + (1 - Civic\ muscle\ index) / TIME\ STEP, CM\ building\ normal + CM\ rebuilding\ with\ gathered\ assets)$
1/year
- (026) $CM\ building\ normal = Max\ possible\ CM\ building * Civic\ muscle\ index * Frac\ of\ CM\ allocated\ to\ CM\ building$
1/year
- (027) $CM\ erosion\ multiplier\ from\ outsourcing = 4$
dimensionless
- (028) $CM\ erosion\ rate = CM\ erosion\ rate\ normal * (1 + (CM\ erosion\ multiplier\ from\ outsourcing - 1) * Frac\ of\ CM\ underused\ due\ to\ outsourcing)$
1/year
- (029) $CM\ erosion\ rate\ normal = 0.03$
1/year
- (030) $CM\ index\ at\ end\ of\ shock = SAMPLE\ IF\ TRUE(Time = End\ year\ of\ shock, Civic\ muscle\ index, Civic\ muscle\ index)$
0-1 fraction
- (031) $CM\ loss\ from\ erosion = Civic\ muscle\ index * CM\ erosion\ rate$
1/year
- (032) $CM\ loss\ from\ shock = CM\ total\ loss\ from\ shock / Duration\ of\ shock * PULSE(Start\ year\ of\ shock, Duration\ of\ shock)$
1/year
- (033) $CM\ rebuilding\ with\ gathered\ assets = IF\ THEN\ ELSE(Time > Start\ year\ of\ shock + Duration\ of\ assets\ for\ rebuilding, 0, SMOOTHI(Asset\ gathering\ index * MIN(Cumul\ CM\ loss\ from\ shock, 1 - Civic\ muscle\ index) * (Civic\ muscle\ index / 0.5) * Frac\ of\ CM\ allocated\ to\ CM\ building, Time\ to\ ramp\ up\ assets\ for\ rebuilding, 0))$
1/year
- (034) $CM\ total\ loss\ from\ shock = 0$
0-1 fraction
- (035) $Coefficient\ for\ urgent\ need\ from\ nonthriving = 0.5$
dimensionless
- (036) $Cumul\ CM\ loss\ from\ shock = INTEG(CM\ loss\ from\ shock, 0)$
0-1 fraction
- (037) $Cumul\ equity\ loss\ from\ shock = INTEG(Equity\ loss\ from\ shock, 0)$
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) $\text{Frac of CM allocated to CM building} = \mathbf{GAME}(\text{Frac of CM allocated to CM building initial})$
0-1 fraction
- (080) $\text{Frac of CM allocated to CM building initial} = 0.15$
0-1 fraction
- (081) $\text{Frac of CM allocated to equity building} = \mathbf{GAME}(\text{Frac of CM allocated to equity building initial})$
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) $\text{Frac of CM allocated to VC building} = \mathbf{GAME}(\text{Frac of CM allocated to VC building initial})$
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

.Control

Simulation Control Parameters

(142) FINAL TIME = 12
year

(143) INITIAL TIME = 0
year

(144) SAVEPER = TIME STEP
year

(145) TIME STEP = 0.125
year