

APPENDIX: MODEL EQUATIONS

{ The model has 51 (129) variables (array expansion in parens).

In root model and 0 additional modules with 0 sectors.

Stocks: 12 (34) Flows: 17 (49) Converters: 22 (46)

Constants: 19 (37) Equations: 20 (58) Graphicals: 1 (3) }

Top-Level Model:

Asymptomatic[AgeGroups](t) = Asymptomatic[AgeGroups](t - dt) +
(infectiousness[AgeGroups] - asym_recovering[AgeGroups]) * dt {NON-NEGATIVE}

INIT Asymptomatic[AgeGroups] = 0

UNITS: People

Exposed[AgeGroups](t) = Exposed[AgeGroups](t - dt) + (infection[AgeGroups] -
sickness[AgeGroups] - infectiousness[AgeGroups]) * dt {NON-NEGATIVE}

INIT Exposed[AgeGroups] = 1

UNITS: person

Hospitalized["0-19"](t) = Hospitalized["0-19"](t - dt) + (hospitalization["0-19"] - death_rate["0-19"] -
recovering_at_hospital["0-19"]) * dt {NON-NEGATIVE}

INIT Hospitalized["0-19"] = 0

UNITS: person

Hospitalized["20-64"](t) = Hospitalized["20-64"](t - dt) + (hospitalization["20-64"] -
death_rate["20-64"] - recovering_at_hospital["20-64"]) * dt {NON-NEGATIVE}

INIT Hospitalized["20-64"] = 0

UNITS: person

Hospitalized["65plus"](t) = Hospitalized["65plus"](t - dt) + (hospitalization["65plus"] -
death_rate["65plus"] - recovering_at_hospital["65plus"]) * dt {NON-NEGATIVE}

INIT Hospitalized["65plus"] = 0

UNITS: person

Immune["0-19"](t) = Immune["0-19"](t - dt) + (vaccination["0-19"] + asym_recovering["0-19"]
+ recovering_at_home["0-19"] + sym_recovering["0-19"] + recovering_at_hospital["0-19"]) * dt
{NON-NEGATIVE}

INIT Immune["0-19"] = 0

UNITS: person

Immune["20-64"](t) = Immune["20-64"](t - dt) + (vaccination["20-64"] + asym_recovering["20-64"]
+ recovering_at_home["20-64"] + sym_recovering["20-64"] + recovering_at_hospital["20-64"]) * dt
{NON-NEGATIVE}

INIT Immune["20-64"] = 0

UNITS: person

Immune["65plus"](t) = Immune["65plus"](t - dt) + (vaccination["65plus"] +
asym_recovering["65plus"] + recovering_at_home["65plus"] + sym_recovering["65plus"] +
recovering_at_hospital["65plus"]) * dt {NON-NEGATIVE}

INIT Immune["65plus"] = 845166

UNITS: person

Infected_at_Home["0-19"](t) = Infected_at_Home["0-19"](t - dt) + (isolation["0-19"] -
recovering_at_home["0-19"] - returning["0-19"]) * dt {NON-NEGATIVE}

INIT Infected_at_Home["0-19"] = 0

UNITS: person

$$\text{Infected_at_Home}["20-64"](t) = \text{Infected_at_Home}["20-64"](t - dt) + (\text{isolation}["20-64"] - \text{recovering_at_home}["20-64"] - \text{returning}["20-64"]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT Infected_at_Home}["20-64"] = 0$$
 UNITS: person

$$\text{Infected_at_Home}["65plus"](t) = \text{Infected_at_Home}["65plus"](t - dt) + (\text{isolation}["65plus"] - \text{recovering_at_home}["65plus"] - \text{returning}["65plus"]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT Infected_at_Home}["65plus"] = 0$$
 UNITS: person

$$\text{Susceptible}["0-19"](t) = \text{Susceptible}["0-19"](t - dt) + (- \text{infection}["0-19"] - \text{vaccination}["0-19"]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT Susceptible}["0-19"] = 21050220$$
 UNITS: People

$$\text{Susceptible}["20-64"](t) = \text{Susceptible}["20-64"](t - dt) + (- \text{infection}["20-64"] - \text{vaccination}["20-64"]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT Susceptible}["20-64"] = 51777664$$
 UNITS: People

$$\text{Susceptible}["65plus"](t) = \text{Susceptible}["65plus"](t - dt) + (- \text{infection}["65plus"] - \text{vaccination}["65plus"]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT Susceptible}["65plus"] = 5606503$$
 UNITS: People

$$\text{Symptomatic}[\text{AgeGroups}](t) = \text{Symptomatic}[\text{AgeGroups}](t - dt) + (\text{sickness}[\text{AgeGroups}] + \text{returning}[\text{AgeGroups}] - \text{hospitalization}[\text{AgeGroups}] - \text{sym_recovering}[\text{AgeGroups}] - \text{isolation}[\text{AgeGroups}]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT Symptomatic}[\text{AgeGroups}] = 0$$
 UNITS: People

$$\text{total_deaths}[\text{AgeGroups}](t) = \text{total_deaths}[\text{AgeGroups}](t - dt) + (\text{Flow_2}[\text{AgeGroups}]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT total_deaths}[\text{AgeGroups}] = 0$$

$$\text{total_hospitalization}[\text{AgeGroups}](t) = \text{total_hospitalization}[\text{AgeGroups}](t - dt) + (\text{Flow_5}[\text{AgeGroups}]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT total_hospitalization}[\text{AgeGroups}] = 0$$

$$\text{total_infection}(t) = \text{total_infection}(t - dt) + (\text{Flow_1}) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT total_infection} = 0$$

$$\text{total_sickness}[\text{AgeGroups}](t) = \text{total_sickness}[\text{AgeGroups}](t - dt) + (\text{Flow_4}[\text{AgeGroups}]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT total_sickness}[\text{AgeGroups}] = 0$$

$$\text{total_vaccinations}[\text{AgeGroups}](t) = \text{total_vaccinations}[\text{AgeGroups}](t - dt) + (\text{Flow_3}[\text{AgeGroups}]) * dt \{ \text{NON-NEGATIVE} \}$$

$$\text{INIT total_vaccinations}[\text{AgeGroups}] = 0$$

$$\text{asym_recovering}[\text{AgeGroups}] = \text{Asymptomatic/asym_recover_time} \{ \text{UNIFLOW} \}$$
 UNITS: person/Day

$$\text{death_rate}[\text{AgeGroups}] = \text{Hospitalized} * \text{mortality_fraction} / \text{mortal_time} \{ \text{UNIFLOW} \}$$
 OUTFLOW PRIORITY: 1

UNITS: person/Day

$$\text{Flow_1} = \text{SUM}(\text{infection}) \{ \text{UNIFLOW} \}$$

$$\text{Flow_2}[\text{AgeGroups}] = \text{death_rate} \{ \text{UNIFLOW} \}$$

$\text{Flow_3[AgeGroups]} = \text{vaccination} * \text{VE_converter}$ {UNIFLOW}
 $\text{Flow_4[AgeGroups]} = \text{sickness}$ {UNIFLOW}
 $\text{Flow_5[AgeGroups]} = \text{hospitalization}$ {UNIFLOW}
 $\text{hospitalization[AgeGroups]} = \text{Symptomatic} * \text{hosp_fraction} / \text{hosp_del}$ {UNIFLOW}
 OUTFLOW PRIORITY: 1
 UNITS: person/Day
 $\text{infection[AgeGroups]} = \text{Susceptible} * (1 - \text{vaccination_fraction}) * \text{infectious_pressure}$ {UNIFLOW}
 OUTFLOW PRIORITY: 1
 UNITS: person/Day
 $\text{infectiousness[AgeGroups]} = \text{Exposed} * (1 - \text{sym_fraction}) / \text{incubation_period}$ {UNIFLOW}
 OUTFLOW PRIORITY: 2
 UNITS: person/Day
 $\text{isolation[AgeGroups]} = \text{Symptomatic} * \text{isolation_fraction} / \text{isolation_del}$ {UNIFLOW}
 OUTFLOW PRIORITY: 3
 UNITS: person/Day
 $\text{recovering_at_home[AgeGroups]} =$
 $(\text{Infected_at_Home} * \text{isolation_success_frac}) / \text{sym_recover_time}$ {UNIFLOW}
 OUTFLOW PRIORITY: 1
 UNITS: person/Day
 $\text{recovering_at_hospital[AgeGroups]} = \text{Hospitalized} * (1 - \text{mortality_fraction}) / \text{hosp_recover_time}$
 {UNIFLOW}
 OUTFLOW PRIORITY: 2
 UNITS: person/Day
 $\text{returning[AgeGroups]} = \text{Infected_at_Home} * (1 - \text{isolation_success_frac}) / \text{isolation_duration}$
 {UNIFLOW}
 OUTFLOW PRIORITY: 2
 UNITS: person/Day
 $\text{sickness[AgeGroups]} = (\text{Exposed} * \text{sym_fraction}) / \text{incubation_period}$ {UNIFLOW}
 OUTFLOW PRIORITY: 1
 UNITS: person/Day
 $\text{sym_recovering[AgeGroups]} = \text{Symptomatic} / \text{sym_recover_time}$ {UNIFLOW}
 OUTFLOW PRIORITY: 2
 UNITS: person/Day
 $\text{vaccination[AgeGroups]} =$
 $\text{Susceptible} * \text{vaccination_fraction} * \text{vaccine_effectiveness} / \text{vaccination_time}$ {UNIFLOW}
 OUTFLOW PRIORITY: 2
 UNITS: person/Day
 $\text{asym_recover_time} = 5$
 UNITS: Days
 $\text{contact_matrix["0-19", "0-19"]} = 12,0862063$
 UNITS: 1/day
 $\text{contact_matrix["0-19", "20-64"]} = 5,730541$
 UNITS: 1/day
 $\text{contact_matrix["0-19", "65plus"]} = 0,2075335$
 UNITS: 1/day
 $\text{contact_matrix["20-64", "0-19"]} = 3,4566133$

UNITS: 1/day
 contact_matrix["20-64", "20-64"] = 8,18603144
 UNITS: 1/day
 contact_matrix["20-64", "65plus"] = 0,20482167
 UNITS: 1/day
 contact_matrix["65plus", "0-19"] = 1,946813
 UNITS: 1/day
 contact_matrix["65plus", "20-64"] = 3,240805
 UNITS: 1/day
 contact_matrix["65plus", "65plus"] = 0,70370733
 UNITS: 1/day
 distancing_coefficient[Symptomatic] = 0,75
 UNITS: dmnl
 distancing_coefficient[Asymptomatic] = 0,9
 UNITS: dmnl
 hosp_del = 3
 UNITS: Days
 hosp_fraction["0-19"] = 0,0037
 UNITS: dmnl
 hosp_fraction["20-64"] = 0,007
 UNITS: dmnl
 hosp_fraction["65plus"] = 0,09
 UNITS: dmnl
 hosp_recover_time = 8
 UNITS: Days
 incubation_period = 2
 UNITS: Days
 infectious_pressure[AgeGroups] = SUM(contact_matrix[AgeGroups;]*
 (distancing_coefficient[Symptomatic] *Symptomatic *infectivity[Symptomatic]+
 distancing_coefficient[Asymptomatic]*Asymptomatic*infectivity[Asymptomatic])/total_mobile
)
 UNITS: 1/day
 infectivity[Symptomatic] = 0,076
 UNITS: dmnl
 infectivity[Asymptomatic] = 0,076/2
 UNITS: dmnl
 isolation_del = 1
 UNITS: Days
 isolation_duration = 2
 UNITS: Days
 isolation_fraction["0-19"] = 0,05
 UNITS: dmnl
 isolation_fraction["20-64"] = 0,025
 UNITS: dmnl
 isolation_fraction["65plus"] = 0,9
 UNITS: dmnl

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isolation_success_frac["0-19"] = 1
UNITS: dmnl
isolation_success_frac["20-64"] = 1
UNITS: dmnl
isolation_success_frac["65plus"] = 1
UNITS: dmnl
mortal_time = 7
UNITS: Days
mortality_fraction["0-19"] = 0,0025
UNITS: dmnl
mortality_fraction["20-64"] = 0,002
UNITS: dmnl
mortality_fraction["65plus"] = 0,03
UNITS: dmnl
sym_fraction = 0,5
UNITS: dmnl
sym_recover_time = 7
UNITS: Days
total_mobile[AgeGroups] = Asymptomatic + Exposed + Immune + Susceptible + Symptomatic
{SUMMING CONVERTER}
UNITS: People
vaccination_fraction["0-19"] = GRAPH(TIME)
Points: (1,0, 0,0002), (2,42745098039, 0,0001923), (3,85490196078, 0,0001849),
(5,28235294118, 0,0001778), (6,70980392157, 0,000171), (8,13725490196, 0,0001644),
(9,56470588235, 0,0001581), (10,9921568627, 0,000152), (12,4196078431, 0,0001461),
(13,8470588235, 0,0001405), (15,2745098039, 0,0001351), (16,7019607843, 0,0001299),
(18,1294117647, 0,0001249), (19,5568627451, 0,0001201), (20,9843137255, 0,0001155),
(22,4117647059, 0,0001111), (23,8392156863, 0,0001068), (25,2666666667, 0,0001027),
(26,6941176471, 0,00009873), (28,1215686275, 0,00009493), (29,5490196078, 0,00009128),
(30,9764705882, 0,00008777), (32,4039215686, 0,0000844), (33,831372549, 0,00008115),
(35,2588235294, 0,00007803), (36,6862745098, 0,00007503), (38,1137254902, 0,00007214),
(39,5411764706, 0,00006937), (40,968627451, 0,0000667), (42,3960784314, 0,00006413),
(43,8235294118, 0,00006167), (45,2509803922, 0,00005929), (46,6784313725, 0,00005701),
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(52,3882352941, 0,00004874), (53,8156862745, 0,00004686), (55,2431372549, 0,00004506),
(56,6705882353, 0,00004333), (58,0980392157, 0,00004166), (59,5254901961, 0,00004006),
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(65,2352941176, 0,00003424), (66,662745098, 0,00003292), (68,0901960784, 0,00003166),
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(73,8, 0,00002706), (75,2274509804, 0,00002602), (76,6549019608, 0,00002502),
(78,0823529412, 0,00002405), (79,5098039216, 0,00002313), (80,937254902, 0,00002224),
(82,3647058824, 0,00002138), (83,7921568627, 0,00002056), (85,2196078431, 0,00001977),
(86,6470588235, 0,00001901), (88,0745098039, 0,00001828), (89,5019607843, 0,00001757),
(90,9294117647, 0,0000169), (92,3568627451, 0,00001625), (93,7843137255, 0,00001562),
(95,2117647059, 0,00001502), (96,6392156863, 0,00001444), (98,0666666667, 0,00001389),
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(103,776470588, 0,00001187), (105,203921569, 0,00001141), (106,631372549, 0,00001097),
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0,000002191), (166,584313725, 0,000002107), (168,011764706, 0,000002025),
(169,439215686, 0,000001947), (170,866666667, 0,000001872), (172,294117647,
0,000001799), (173,721568627, 0,00000173), (175,149019608, 0,000001663), (176,576470588,
0,000001599), (178,003921569, 0,000001537), (179,431372549, 0,000001477),
(180,858823529, 0,00000142), (182,28627451, 0,000001365), (183,71372549, 0,000001312),
(185,141176471, 0,000001262), (186,568627451, 0,000001213), (187,996078431,
0,000001166), (189,423529412, 0,000001121), (190,850980392, 0,000001077),
(192,278431373, 0,000001035), (193,705882353, 9,952e-7), (195,133333333, 9,566e-7),
(196,560784314, 9,194e-7), (197,988235294, 8,837e-7), (199,415686275, 8,494e-7),
(200,843137255, 8,164e-7), (202,270588235, 7,846e-7), (203,698039216, 7,541e-7),
(205,125490196, 7,247e-7), (206,552941176, 6,965e-7), (207,980392157, 6,694e-7),
(209,407843137, 6,433e-7), (210,835294118, 6,182e-7), (212,262745098, 5,941e-7),
(213,690196078, 5,709e-7), (215,117647059, 5,486e-7), (216,545098039, 5,271e-7),
(217,97254902, 5,065e-7), (219,4, 4,867e-7), (220,82745098, 4,676e-7), (222,254901961,
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(240,811764706, 2,662e-7), (242,239215686, 2,556e-7), (243,666666667, 2,455e-7),
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(262,223529412, 1,438e-7), (263,650980392, 1,379e-7), (265,078431373, 1,323e-7),
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(270,788235294, 1,117e-7), (272,215686275, 1,071e-7), (273,643137255, 1,026e-7),
(275,070588235, 9,834e-8), (276,498039216, 9,42e-8), (277,925490196, 9,023e-8),
(279,352941176, 8,641e-8), (280,780392157, 8,274e-8), (282,207843137, 7,921e-8),
(283,635294118, 7,581e-8), (285,062745098, 7,255e-8), (286,490196078, 6,941e-8),
(287,917647059, 6,639e-8), (289,345098039, 6,349e-8), (290,77254902, 6,07e-8), (292,2,

5,802e-8), (293,62745098, 5,543e-8), (295,054901961, 5,295e-8), (296,482352941, 5,057e-8), (297,909803922, 4,827e-8), (299,337254902, 4,607e-8), (300,764705882, 4,395e-8), (302,192156863, 4,191e-8), (303,619607843, 3,995e-8), (305,047058824, 3,806e-8), (306,474509804, 3,625e-8), (307,901960784, 3,451e-8), (309,329411765, 3,283e-8), (310,756862745, 3,122e-8), (312,184313725, 2,967e-8), (313,611764706, 2,818e-8), (315,039215686, 2,675e-8), (316,466666667, 2,537e-8), (317,894117647, 2,404e-8), (319,321568627, 2,277e-8), (320,749019608, 2,154e-8), (322,176470588, 2,037e-8), (323,603921569, 1,923e-8), (325,031372549, 1,815e-8), (326,458823529, 1,71e-8), (327,88627451, 1,609e-8), (329,31372549, 1,512e-8), (330,741176471, 1,419e-8), (332,168627451, 1,33e-8), (333,596078431, 1,244e-8), (335,023529412, 1,161e-8), (336,450980392, 1,081e-8), (337,878431373, 1,005e-8), (339,305882353, 9,313e-9), (340,733333333, 8,606e-9), (342,160784314, 7,926e-9), (343,588235294, 7,272e-9), (345,015686275, 6,643e-9), (346,443137255, 6,038e-9), (347,870588235, 5,457e-9), (349,298039216, 4,898e-9), (350,725490196, 4,36e-9), (352,152941176, 3,843e-9), (353,580392157, 3,346e-9), (355,007843137, 2,868e-9), (356,435294118, 2,409e-9), (357,862745098, 1,967e-9), (359,290196078, 1,542e-9), (360,717647059, 1,134e-9), (362,145098039, 7,409e-10), (363,57254902, 3,632e-10), (365,0, 0)

UNITS: dmnl

vaccination_fraction["20-64"] = GRAPH(TIME)

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