Table 6. Learned rules.

Rule 1	IF	Inflamatory (M1) Alveolar Macrophages $>$ 16.289
	THEN	IL6 =
		0.1 $\times$ Inflamatory (M1) Alveolar Macrophages
		+ 0.0021 $\times$ Immunosupressed (M2) Alveolar macrophages
		- 0.1056 [763/0.931%]
Rule 2	IF	Inflamatory (M1) Alveolar Macrophages $\leq$ 1.381
	THEN	IL6 =
		-0.0001 $\times$ Viral Load
		+ 0.1025 $\times$ Inflamatory (M1) Alveolar Macrophages
		- 0.0101 $\times$ Delayed IL6 - 0.0001 $\times$ T-cell Interferon
		+ 0.0019 [410/1.095%]
Rule 3	IF	Inflamatory (M1) Alveolar Macrophages $>$ 10.592
	THEN	IL6 =
		-0.0002 $\times$ Time (Hour) - 0.0015 $\times$Viral Load
		+ 0.0833 $\times$ Inflamatory (M1) Alveolar Macrophages
		- 0 $\times$ Active Adaptive Immune System
		+ 0.0001 $\times$ Resting Alveolar Macrophages
		+ 0.1664 $\times$ Delayed IL6
		- 0.5716 [89/0.318%]
Rule 4	IF	Active Adaptive Immune System $>$ 9.922
		Inflamatory (M1) Alveolar Macrophages $>$ 6.424
	THEN	IL6 =
		-0.0001 $\times$ Time (Hour) - 0.0048 $\times$ Viral Load
		+ 0.1134 $\times$ Inflamatory (M1) Alveolar Macrophages
		- 0.0003 $\times$ Active Adaptive Immune System
		- 0.0008 $\times$ Immunosupressed (M2) Alveolar macrophages
		+ 0.0011 $\times$ Resting Alveolar Macrophages
		- 0.1284 $\times$ Delayed IL6 + 0.0015 $\times$ TcellInterferon
		- 5.0631 [69/0.096%]
Rule 5	IF	TcellInterferon $>$ 0.517
	THEN	IL6 =
		-0.0003 $\times$ Time (Hour) - 0.0019 $\times$ Viral Load
		+ 0.0992 $\times$ Inflamatory (M1) Alveolar Macrophages
		+ 0.0001 $\times$ Active Adaptive Immune System
		+ 0.1282 [79/2.143%]
Rule 6	IF	Time (Hour) $>$ 1.5 and Active Adaptive Immune System $\leq$ 7.841
	THEN	IL6 =
		-0.0003 $\times$ Time (Hour) - 0.0103 $\times$ Viral Load + 0.7211 [11/1.317%]
Rule 7	IF	Viral Load $\leq$ 0.999
	THEN	IL6 =
		+ 0.9887 [4/0%]
Rule 8	IF	Time (Hour) $>$ 1
	THEN	IL6 =
		+ 0.9597 [4/4.369%]
Rule 9	IF	
	THEN	IL6 =
		+ 3 [2]

1 APPENDIX: LEARNING CLASSIFICATION RULES AND RELEVANT ATTRIBUTES

2 APPENDIX: SYSTEM DYNAMICS MODEL: STOCKS, FLOWS AND VARIABLES

Table 7. Stocks.

Stock	Equation	Units
Resting alveolar macrophages	$\frac{d\text{Resting alveolar macrophages}}{dt} = -\text{Activation}(t)$ (1)	macrophages
Inflammatory alveolar macrophages	$\frac{d\text{Inflammatory alveolar macrophages}}{dt} = \text{Activation}(t) - \text{Immunoregulation}(t)$ (2)	macrophages
Immunosupressed alveolar macrophages	$\frac{d\text{Immunosupressed alveolar macrophages}}{dt} = \text{Immunoregulation}(t)$ (3)	macrophages
Delayed IL6	$\frac{d\text{Delayed IL6}}{dt} = \text{delayed IL6 net}(t) - \text{delayed IL6 degradation}(t)$ (4)	pg/mL
Viral Load	$\frac{d\text{Viral Load}}{dt} = \text{net new viruses}(t) - \text{Adaptive Immune System Net Effect}(t) - \text{Innate Immune System Net Effect}(t) - \text{virus net deaths}(t)$ (5)	viruses
IL6	$\frac{d\text{IL6}}{dt} = \text{IL6 production}(t) - \text{IL6 degradation}(t)$ (6)	pg/mL
PAMPS	$\frac{d\text{PAMPS}}{dt} = \text{PAMPs and RRS alarm}(t) - \text{Alarm decay}(t)$ (7)	pamps
Active Adaptive Immune System	$\frac{d\text{Active Adaptive Immune System}}{dt} = \text{Response And Activation}(t) - \text{net back off}(t)$ (8)	T-cells
Resting Adaptive Immune System	$\frac{d\text{Resting Adaptive Immune System}}{dt} = -\text{Response And Activation}(t)$ (9)	T-cells
Interferon Strength	$\frac{d\text{Interferon Strength}}{dt} = \text{Interferon Net}(t) - \text{Interferon Decay}(t)$ (10)	Interferon
Uninfected Lung Tissue	$\frac{d\text{Uninfected Lung Tissue}}{dt} = \text{Regeneration Rate}(t) - \text{Infection Rate}(t)$ (11)	lung cells
Infected Lung Tissue	$\frac{d\text{Infected Lung Tissue}}{dt} = \text{Infection Rate}(t) - \text{Destruction Net Rate}(t)$ (12)	lung cells
Destroyed Lung Tissue	$\frac{d\text{Destroyed Lung Tissue}}{dt} = \text{Destruction Net Rate}(t) - \text{Cleaning Rate}(t)$ (13)	lung cells
T-Cell interferon	$\frac{d\text{T-Cell interferon}}{dt} = \text{T-cell Interferon net}(t) - \text{T-cell Interferon Decay}(t)$ (14)	Interferon

Table 8. Flows.

Flow	Equation	Units
Infection Rate	(Rate by which a virus infects a lung cell per lung cell present × Viral Load × Uninfected Lung Tissue) − (success rate infected lung cells alert per interferon hour× Infected Lung Tissue × Interferon Strength) (15)	lung cells/Hour
Destruction Net Rate	Infected Lung Tissue × Infected Lung Tissue × Death Proportionality Constant (16)	lung cells/Hour
Regeneration Rate	regeneration fraction × Uninfected Lung Tissue + repair rate × Immunosupressed (M2) Alveolar macrophages (17)	lung cells/Hour
Interferon Net	Infected Lung Tissue × Interferon per hour per cell (18)	Interferon/Hour
IL6 production	Inflamatory (M1) Alveolar Macrophages × IL6 synthesis Rate (19)	(pc/mL)/Hour
IL6 degradation	IL6 × IL6 degradation rate (20)	(pc/mL)/Hour
delayed Il6 net	DELAY FIXED(IL6 production, IL6 delay time, IL6 production) (21)	(pc/mL)/Hour
Delayed IL6 degradation	Delayed IL6 × IL6 degradation rate (22)	(pc/mL)/Hour
virus net deaths	Viral Load × virus death proportionality constant (23)	viruses/Hour
net new viruses	Infected Lung Tissue × new viruses per hour per infected lung cell (24)	viruses/Hour
Innate Immune System Net Effect	Inflamatory (M1) Alveolar Macrophages×rate of macrophages phagocytosis × Viral Load (25)	viruses/Hour
rate of macrophages phagocytosis	$0.001/\text{virulence}^3$ (26)	(viruses/Hour) / (viruses × macrophages)
Interferon Decay	0 (27)	Interferon/Hour
Alarm Decay	Decay rate × PAMPs (28)	pamps/Hour
PAMPs and RRS alarm	sensitivity × Viral Load (29)	pamps/Hour
Adaptive Immune System Net Effect	Active Adaptive Immune System × virus elimination rate by adaptive immune system (30)	viruses/Hour
Activation	expected activation × Viral Load (31)	macrophages/ Hour
Immunoregulation	Inflamatory (M1) Alveolar Macrophages $\times \frac{\text{Immunomodulation Rate}}{\text{IL6 modulation factor}} \times \log(\max(3, \text{Delayed IL6}))^3$ (32)	macrophages/ Hour
net back off	Active Adaptive Immune System × back off rate (33)	T-cells/Hour
Response And Activation	Inflamatory (M1) Alveolar Macrophages × invocation rate × PAMPs (34)	T-cells/Hour
T-cell Interferon Decay	Interfeton Decay rate × T-cell interferon (35)	Interferon/Hour
T-cell interferon net	Active Adaptive Immune System × T-cell interferon Production by T-cell (36)	Interferon/Hour

Table 9. Auxiliary Variables.

Auxiliary variable	Equation	Units
activation rate by which a macrophage is activated per virus present per macrophage	$\min(\text{maximum activation rate}, \text{PAMPs} \times \text{detection factor})$ (37)	macrophages/ (viruses×Hour)
rate of macrophages phagocytosis	$\frac{0.001}{\text{virulence}^3}$ (38)	(viruses/Hour)/ (viruses×macrophages)
sensitivity	$0.2 - 0.8(\text{virulende} - 2)$ (39)	pamps/ (viruses×Hour)
expected activation	$\texttt{SMOOTH}\left(\begin{matrix}\text{activation rate by which a}\\ \text{macrophage is activated per}, \text{time to diffuse}\\ \text{virus present per macrophage}\end{matrix}\right)$ (40)	macrophages/ (viruses×Hour)
success rate infected lung cells alert per interferon hour	$\begin{matrix}\texttt{IF}\\ \texttt{THEN}\\ \texttt{ELSE}\end{matrix}\left(\begin{matrix}\text{Initial Viral Load}\\ \text{in Thousands}\end{matrix} > 1, \frac{\text{default rate}}{1000}, \text{default rate}\right)$ (41)	(1/Hour)/(interferon)

Table 10. Constants.

ID	Parameter	Value	Units
1	back off rate	0.005	1/Hour
2	Cleaning rate per destroyed lung cell	0.2	(lung cells/Hour) / lung cells
3	Decay rate	0.005	(pamps/Hour) / pamps
4	default rate	0.001	1/(Hour × interferon)
5	detection factor	1e-05	macrophages / (Hour × viruses × pamps))
6	feeedback rate	0.001	macrophages / (Hour × interferon))
7	final time	480	Hour
8	IL6 degradation rate	0.8	(pg / (Hour × mL)) / (pg / mL)
9	IL6 delay time	6	Hour
10	IL6 initial value	3	pg / mL
11	IL6 modulation factor	0.05	pg / mL
12	IL6 synthesis Rate	0.08	pg / (Hour × mL × macrophages)
13	Immunomodulation Rate	0.5	macrophages / (Hour × macrophages)
14	Infected Lung Tissue Death Proportionality Constant	0.5	(lung cells / Hour) / lung cells
15	Initial lung Cells in Thousands	15,000	lung cells
16	Initial time	0	Hour
17	Initial viral load in thousands	1	viruses
18	Interferon decay	0	interferon/Hour
19	Interferon per hour per cell	2	(interferon/Hour)/lung cells
20	Interferon decay rate	0.01	1/Hour
21	invocation rate	0.0001	T-cells/(Hour×pamps×macrophages)
22	maximum activation rate	0.07	T-cells/(Hour×pamps×macrophages)
23	new viruses per hour per infected lung cell	0.002	(viruses / Hour) / lung cells
24	patient precondition	{0, 1, 2}	Dmnl
25	time step	1	Hour
26	time to diffuse	6	Hour
27	virulence	{1,2}	Dmnl
28	virus death proportionality constant	0.001	(viruses / Hour) / viruses