Define forcing functions:

In[•]:=
```
betaval[t_, amplitude_, baseline_, phival_, gammaval_] :=
 gammaval * (amplitude / 2 * Cos[2 * Pi * (t - phival) / 52] + (amplitude / 2 + baseline))

p1[t_, kappaval_, importtime1_, importlength_] :=
 If[t > importtime1 && t ≤ (importtime1 + importlength), kappaval, 0]

p2[t_, kappaval_, importtime2_, importlength_] :=
 If[t > importtime2 && t ≤ (importtime2 + importlength), kappaval, 0]

p3[t_, kappaval_, importtime3_, importlength_] :=
 If[t > importtime3 && t ≤ (importtime3 + importlength), kappaval, 0]
```

Define model functions:

In[•]:=
```
S1S2S3c1[t] :=
 betaval[t, amplitude, baseline, phival, gammaval] * (I1S2S3[t] + I1S2E3[t] +
     I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] +
     I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) *
   S1S2S3[t] + p1[t, kappaval, importtime1, importlength] * S1S2S3[t]

S1S2S3c2[t] :=
 betaval[t, amplitude, baseline, phival, gammaval] * (S1I2S3[t] + S1I2E3[t] +
     S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + I1I2S3[t] +
     I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) *
   S1S2S3[t] + p2[t, kappaval, importtime2, importlength] * S1S2S3[t]

S1S2S3c3[t] :=
 betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
   (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] +
     E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] +
     R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * S1S2S3[t] +
  p3[t, kappaval, importtime3, importlength] * S1S2S3[t]

S1S2E3c1[t] := (1 - chi31val) * betaval[t, amplitude, baseline, phival, gammaval] *
   (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] +
     I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
     I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1S2E3[t] +
  (1 - chi31val) * p1[t, kappaval, importtime1, importlength] * S1S2E3[t]

S1S2E3c2[t] := (1 - chi32val) * betaval[t, amplitude, baseline, phival, gammaval] *
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    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] +
      E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * S1S2E3[t] +
   (1 - chi32val) * p2[t, kappaval, importtime2, importlength] * S1S2E3[t]

S1S2E3c3[t] := nuval * S1S2E3[t]

S1S2I3c1[t] := (1 - chi31val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] +
      I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1S2I3[t] +
   (1 - chi31val) * p1[t, kappaval, importtime1, importlength] * S1S2I3[t]

S1S2I3c2[t] := (1 - chi32val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] +
      E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * S1S2I3[t] +
   (1 - chi32val) * p2[t, kappaval, importtime2, importlength] * S1S2I3[t]

S1S2I3c3[t] := gammaval * S1S2I3[t]

S1S2R3c1[t] := (1 - chi31val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] +
      I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1S2R3[t] +
   (1 - chi31val) * p1[t, kappaval, importtime1, importlength] * S1S2R3[t]

S1S2R3c2[t] := (1 - chi32val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] +
      E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * S1S2R3[t] +
   (1 - chi32val) * p2[t, kappaval, importtime2, importlength] * S1S2R3[t]

S1S2R3c3[t] := sigma3val * S1S2R3[t]

S1E2S3c1[t] := (1 - chi21val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] +
      I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1E2S3[t] +
   (1 - chi21val) * p1[t, kappaval, importtime1, importlength] * S1E2S3[t]

S1E2S3c2[t] := nuval * S1E2S3[t]
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S1E2S3c3[t] :=
 (1 - chi23val) * betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival,
    gammaval] * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] +
     E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] +
     I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * S1E2S3[t] +
  (1 - chi23val) * p3[t, kappaval, importtime3, importlength] * S1E2S3[t]

S1E2E3c1[t] :=
 (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
     I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
     I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1E2E3[t] + (1 - Max[chi21val, chi31val]) *
   p1[t, kappaval, importtime1, importlength] * S1E2E3[t]

S1E2E3c2[t] := nuval * S1E2E3[t]

S1E2E3c3[t] := nuval * S1E2E3[t]

S1E2I3c1[t] :=
 (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
     I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
     I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1E2I3[t] + (1 - Max[chi21val, chi31val]) *
   p1[t, kappaval, importtime1, importlength] * S1E2I3[t]

S1E2I3c2[t] := nuval * S1E2I3[t]

S1E2I3c3[t] := gammaval * S1E2I3[t]

S1E2R3c1[t] :=
 (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
     I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
     I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1E2R3[t] + (1 - Max[chi21val, chi31val]) *
   p1[t, kappaval, importtime1, importlength] * S1E2R3[t]

S1E2R3c2[t] := nuval * S1E2R3[t]

S1E2R3c3[t] := sigma3val * S1E2R3[t]

S1I2S3c1[t] := (1 - chi21val) * betaval[t, amplitude, baseline, phival, gammaval] *
   (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] +
     I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
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      I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1I2S3[t] +
   (1 - chi21val) * p1[t, kappaval, importtime1, importlength] * S1I2S3[t]

S1I2S3c2[t] := gammaval * S1I2S3[t]

S1I2S3c3[t] :=
  (1 - chi23val) * betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival,
     gammaval] * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] +
      E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] +
      I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * S1I2S3[t] +
   (1 - chi23val) * p3[t, kappaval, importtime3, importlength] * S1I2S3[t]

S1I2E3c1[t] :=
  (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
      I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
      I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1I2E3[t] + (1 - Max[chi21val, chi31val]) *
    p1[t, kappaval, importtime1, importlength] * S1I2E3[t]

S1I2E3c2[t] := gammaval * S1I2E3[t]

S1I2E3c3[t] := nuval * S1I2E3[t]

S1I2I3c1[t] :=
  (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
      I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
      I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1I2I3[t] + (1 - Max[chi21val, chi31val]) *
    p1[t, kappaval, importtime1, importlength] * S1I2I3[t]

S1I2I3c2[t] := gammaval * S1I2I3[t]

S1I2I3c3[t] := gammaval * S1I2I3[t]

S1I2R3c1[t] :=
  (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
      I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
      I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1I2R3[t] + (1 - Max[chi21val, chi31val]) *
    p1[t, kappaval, importtime1, importlength] * S1I2R3[t]

S1I2R3c2[t] := gammaval * S1I2R3[t]
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S1I2R3c3[t] := sigma3val * S1I2R3[t]

S1R2S3c1[t] := (1 - chi21val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] +
      I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1R2S3[t] +
   (1 - chi21val) * p1[t, kappaval, importtime1, importlength] * S1R2S3[t]

S1R2S3c2[t] := sigma2val * S1R2S3[t]

S1R2S3c3[t] :=
  (1 - chi23val) * betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival,
     gammaval] * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] +
      E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] +
      I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * S1R2S3[t] +
   (1 - chi23val) * p3[t, kappaval, importtime3, importlength] * S1R2S3[t]

S1R2E3c1[t] :=
  (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
      I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
      I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1R2E3[t] + (1 - Max[chi21val, chi31val]) *
    p1[t, kappaval, importtime1, importlength] * S1R2E3[t]

S1R2E3c2[t] := sigma2val * S1R2E3[t]

S1R2E3c3[t] := nuval * S1R2E3[t]

S1R2I3c1[t] :=
  (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
      I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
      I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1R2I3[t] + (1 - Max[chi21val, chi31val]) *
    p1[t, kappaval, importtime1, importlength] * S1R2I3[t]

S1R2I3c2[t] := sigma2val * S1R2I3[t]

S1R2I3c3[t] := gammaval * S1R2I3[t]

S1R2R3c1[t] :=
  (1 - Max[chi21val, chi31val]) * betaval[t, amplitude, baseline, phival, gammaval] *
    (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] + I1E2S3[t] + I1E2E3[t] + I1E2I3[t] +
      I1E2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + I1R2S3[t] +
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      I1R2E3[t] + I1R2I3[t] + I1R2R3[t]) * S1R2R3[t] + (1 - Max[chi21val, chi31val]) *
   p1[t, kappaval, importtime1, importlength] * S1R2R3[t]

S1R2R3c2[t] := sigma2val * S1R2R3[t]

S1R2R3c3[t] := sigma3val * S1R2R3[t]

E1S2S3c1[t] := nuval * E1S2S3[t]

E1S2S3c2[t] := (1 - chi12val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] +
      E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * E1S2S3[t] +
  (1 - chi12val) * p2[t, kappaval, importtime2, importlength] * E1S2S3[t]

E1S2S3c3[t] :=
 (1 - chi13val) * betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival,
    gammaval] * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] +
      E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] +
      I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * E1S2S3[t] +
  (1 - chi13val) * p3[t, kappaval, importtime3, importlength] * E1S2S3[t]

E1S2E3c1[t] := nuval * E1S2E3[t]

E1S2E3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
     E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
     R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * E1S2E3[t] + (1 - Max[chi12val, chi32val]) *
   p2[t, kappaval, importtime2, importlength] * E1S2E3[t]

E1S2E3c3[t] := nuval * E1S2E3[t]

E1S2I3c1[t] := nuval * E1S2I3[t]

E1S2I3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
     E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
     R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * E1S2I3[t] + (1 - Max[chi12val, chi32val]) *
   p2[t, kappaval, importtime2, importlength] * E1S2I3[t]

E1S2I3c3[t] := gammaval * E1S2I3[t]
```

```
E1S2R3c1[t] := nuval * E1S2R3[t]

E1S2R3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
     E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
     R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * E1S2R3[t] + (1 - Max[chi12val, chi32val]) *
   p2[t, kappaval, importtime2, importlength] * E1S2R3[t]

E1S2R3c3[t] := sigma3val * E1S2R3[t]

E1E2S3c1[t] := nuval * E1E2S3[t]

E1E2S3c2[t] := nuval * E1E2S3[t]

E1E2S3c3[t] := (1 - Max[chi13val, chi23val]) *
   betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
   (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
     E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
     R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * E1E2S3[t] + (1 - Max[chi13val, chi23val]) *
   p3[t, kappaval, importtime3, importlength] * E1E2S3[t]

E1E2E3c1[t] := nuval * E1E2E3[t]

E1E2E3c2[t] := nuval * E1E2E3[t]

E1E2E3c3[t] := nuval * E1E2E3[t]

E1E2I3c1[t] := nuval * E1E2I3[t]

E1E2I3c2[t] := nuval * E1E2I3[t]

E1E2I3c3[t] := gammaval * E1E2I3[t]

E1E2R3c1[t] := nuval * E1E2R3[t]

E1E2R3c2[t] := nuval * E1E2R3[t]

E1E2R3c3[t] := sigma3val * E1E2R3[t]

E1I2S3c1[t] := nuval * E1I2S3[t]
```

```
E1I2S3c2[t] := gammaval * E1I2S3[t]

E1I2S3c3[t] := (1 - Max[chi13val, chi23val]) *
   betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
   (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
     E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
     R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * E1I2S3[t] + (1 - Max[chi13val, chi23val]) *
   p3[t, kappaval, importtime3, importlength] * E1I2S3[t]

E1I2E3c1[t] := nuval * E1I2E3[t]

E1I2E3c2[t] := gammaval * E1I2E3[t]

E1I2E3c3[t] := nuval * E1I2E3[t]

E1I2I3c1[t] := nuval * E1I2I3[t]

E1I2I3c2[t] := gammaval * E1I2I3[t]

E1I2I3c3[t] := gammaval * E1I2I3[t]

E1I2R3c1[t] := nuval * E1I2R3[t]

E1I2R3c2[t] := gammaval * E1I2R3[t]

E1I2R3c3[t] := sigma3val * E1I2R3[t]

E1R2S3c1[t] := nuval * E1R2S3[t]

E1R2S3c2[t] := sigma2val * E1R2S3[t]

E1R2S3c3[t] := (1 - Max[chi13val, chi23val]) *
   betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
   (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
     E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
     R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * E1R2S3[t] + (1 - Max[chi13val, chi23val]) *
   p3[t, kappaval, importtime3, importlength] * E1R2S3[t]

E1R2E3c1[t] := nuval * E1R2E3[t]

E1R2E3c2[t] := sigma2val * E1R2E3[t]

E1R2E3c3[t] := nuval * E1R2E3[t]
```

```
E1R2I3c1[t] := nuval * E1R2I3[t]

E1R2I3c2[t] := sigma2val * E1R2I3[t]

E1R2I3c3[t] := gammaval * E1R2I3[t]

E1R2R3c1[t] := nuval * E1R2R3[t]

E1R2R3c2[t] := sigma2val * E1R2R3[t]

E1R2R3c3[t] := sigma3val * E1R2R3[t]

I1S2S3c1[t] := gammaval * I1S2S3[t]

I1S2S3c2[t] := (1 - chi12val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] +
      E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * I1S2S3[t] +
  (1 - chi12val) * p2[t, kappaval, importtime2, importlength] * I1S2S3[t]

I1S2S3c3[t] :=
 (1 - chi13val) * betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival,
    gammaval] * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] +
      E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] +
      I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * I1S2S3[t] +
  (1 - chi13val) * p3[t, kappaval, importtime3, importlength] * I1S2S3[t]

I1S2E3c1[t] := gammaval * I1S2E3[t]

I1S2E3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
     E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
     R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * I1S2E3[t] + (1 - Max[chi12val, chi32val]) *
   p2[t, kappaval, importtime2, importlength] * I1S2E3[t]

I1S2E3c3[t] := nuval * I1S2E3[t]

I1S2I3c1[t] := gammaval * I1S2I3[t]

I1S2I3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
```

```
    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
      E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
      R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * I1S2I3[t] + (1 - Max[chi12val, chi32val]) *
    p2[t, kappaval, importtime2, importlength] * I1S2I3[t]

I1S2I3c3[t] := gammaval * I1S2I3[t]

I1S2R3c1[t] := gammaval * I1S2R3[t]

I1S2R3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
      E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
      R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * I1S2R3[t] + (1 - Max[chi12val, chi32val]) *
    p2[t, kappaval, importtime2, importlength] * I1S2R3[t]

I1S2R3c3[t] := sigma3val * I1S2R3[t]

I1E2S3c1[t] := gammaval * I1E2S3[t]

I1E2S3c2[t] := nuval * I1E2S3[t]

I1E2S3c3[t] := (1 - Max[chi13val, chi23val]) *
    betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
    (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
      E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
      R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * I1E2S3[t] + (1 - Max[chi13val, chi23val]) *
    p3[t, kappaval, importtime3, importlength] * I1E2S3[t]

I1E2E3c1[t] := gammaval * I1E2E3[t]

I1E2E3c2[t] := nuval * I1E2E3[t]

I1E2E3c3[t] := nuval * I1E2E3[t]

I1E2I3c1[t] := gammaval * I1E2I3[t]

I1E2I3c2[t] := nuval * I1E2I3[t]

I1E2I3c3[t] := gammaval * I1E2I3[t]

I1E2R3c1[t] := gammaval * I1E2R3[t]
```

```
I1E2R3c2[t] := nuval * I1E2R3[t]

I1E2R3c3[t] := sigma3val * I1E2R3[t]

I1I2S3c1[t] := gammaval * I1I2S3[t]

I1I2S3c2[t] := gammaval * I1I2S3[t]

I1I2S3c3[t] := (1 - Max[chi13val, chi23val]) *
   betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
   (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
     E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
     R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * I1I2S3[t] + (1 - Max[chi13val, chi23val]) *
   p3[t, kappaval, importtime3, importlength] * I1I2S3[t]

I1I2E3c1[t] := gammaval * I1I2E3[t]

I1I2E3c2[t] := gammaval * I1I2E3[t]

I1I2E3c3[t] := nuval * I1I2E3[t]

I1I2I3c1[t] := gammaval * I1I2I3[t]

I1I2I3c2[t] := gammaval * I1I2I3[t]

I1I2I3c3[t] := gammaval * I1I2I3[t]

I1I2R3c1[t] := gammaval * I1I2R3[t]

I1I2R3c2[t] := gammaval * I1I2R3[t]

I1I2R3c3[t] := sigma3val * I1I2R3[t]

I1R2S3c1[t] := gammaval * I1R2S3[t]

I1R2S3c2[t] := sigma2val * I1R2S3[t]

I1R2S3c3[t] := (1 - Max[chi13val, chi23val]) *
   betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
   (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
     E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
     R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * I1R2S3[t] + (1 - Max[chi13val, chi23val]) *
   p3[t, kappaval, importtime3, importlength] * I1R2S3[t]
```

```
I1R2E3c1[t] := gammaval * I1R2E3[t]

I1R2E3c2[t] := sigma2val * I1R2E3[t]

I1R2E3c3[t] := nuval * I1R2E3[t]

I1R2I3c1[t] := gammaval * I1R2I3[t]

I1R2I3c2[t] := sigma2val * I1R2I3[t]

I1R2I3c3[t] := gammaval * I1R2I3[t]

I1R2R3c1[t] := gammaval * I1R2R3[t]

I1R2R3c2[t] := sigma2val * I1R2R3[t]

I1R2R3c3[t] := sigma3val * I1R2R3[t]

R1S2S3c1[t] := sigma1val * R1S2S3[t]

R1S2S3c2[t] := (1 - chi12val) * betaval[t, amplitude, baseline, phival, gammaval] *
    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] +
      E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] +
      R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * R1S2S3[t] +
  (1 - chi12val) * p2[t, kappaval, importtime2, importlength] * R1S2S3[t]

R1S2S3c3[t] :=
 (1 - chi13val) * betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival,
    gammaval] * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] +
      E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] +
      I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * R1S2S3[t] +
  (1 - chi13val) * p3[t, kappaval, importtime3, importlength] * R1S2S3[t]

R1S2E3c1[t] := sigma1val * R1S2E3[t]

R1S2E3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
    (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
      E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
      R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * R1S2E3[t] + (1 - Max[chi12val, chi32val]) *
   p2[t, kappaval, importtime2, importlength] * R1S2E3[t]
```

```
R1S2E3c3[t] := nuval * R1S2E3[t]

R1S2I3c1[t] := sigma1val * R1S2I3[t]

R1S2I3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
     E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
     R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * R1S2I3[t] + (1 - Max[chi12val, chi32val]) *
   p2[t, kappaval, importtime2, importlength] * R1S2I3[t]

R1S2I3c3[t] := gammaval * R1S2I3[t]

R1S2R3c1[t] := sigma1val * R1S2R3[t]

R1S2R3c2[t] :=
 (1 - Max[chi12val, chi32val]) * betaval[t, amplitude, baseline, phival, gammaval] *
   (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] + E1I2I3[t] +
     E1I2R3[t] + I1I2S3[t] + I1I2E3[t] + I1I2I3[t] + I1I2R3[t] + R1I2S3[t] +
     R1I2E3[t] + R1I2I3[t] + R1I2R3[t]) * R1S2R3[t] + (1 - Max[chi12val, chi32val]) *
   p2[t, kappaval, importtime2, importlength] * R1S2R3[t]

R1S2R3c3[t] := sigma3val * R1S2R3[t]

R1E2S3c1[t] := sigma1val * R1E2S3[t]

R1E2S3c2[t] := nuval * R1E2S3[t]

R1E2S3c3[t] := (1 - Max[chi13val, chi23val]) *
   betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
   (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
     E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
     R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * R1E2S3[t] + (1 - Max[chi13val, chi23val]) *
   p3[t, kappaval, importtime3, importlength] * R1E2S3[t]

R1E2E3c1[t] := sigma1val * R1E2E3[t]

R1E2E3c2[t] := nuval * R1E2E3[t]

R1E2E3c3[t] := nuval * R1E2E3[t]

R1E2I3c1[t] := sigma1val * R1E2I3[t]
```

```
R1E2I3c2[t] := nuval * R1E2I3[t]

R1E2I3c3[t] := gammaval * R1E2I3[t]

R1E2R3c1[t] := sigma1val * R1E2R3[t]

R1E2R3c2[t] := nuval * R1E2R3[t]

R1E2R3c3[t] := sigma3val * R1E2R3[t]

R1I2S3c1[t] := sigma1val * R1I2S3[t]

R1I2S3c2[t] := gammaval * R1I2S3[t]

R1I2S3c3[t] := (1 - Max[chi13val, chi23val]) *
   betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
   (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
     E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
     R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * R1I2S3[t] + (1 - Max[chi13val, chi23val]) *
   p3[t, kappaval, importtime3, importlength] * R1I2S3[t]

R1I2E3c1[t] := sigma1val * R1I2E3[t]

R1I2E3c2[t] := gammaval * R1I2E3[t]

R1I2E3c3[t] := nuval * R1I2E3[t]

R1I2I3c1[t] := sigma1val * R1I2I3[t]

R1I2I3c2[t] := gammaval * R1I2I3[t]

R1I2I3c3[t] := gammaval * R1I2I3[t]

R1I2R3c1[t] := sigma1val * R1I2R3[t]

R1I2R3c2[t] := gammaval * R1I2R3[t]

R1I2R3c3[t] := sigma3val * R1I2R3[t]

R1R2S3c1[t] := sigma1val * R1R2S3[t]

R1R2S3c2[t] := sigma2val * R1R2S3[t]
```

```
R1R2S3c3[t] := (1 - Max[chi13val, chi23val]) *
    betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, gammaval] *
    (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] + E1S2I3[t] + E1E2I3[t] + E1I2I3[t] +
      E1R2I3[t] + I1S2I3[t] + I1E2I3[t] + I1I2I3[t] + I1R2I3[t] + R1S2I3[t] +
      R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) * R1R2S3[t] + (1 - Max[chi13val, chi23val]) *
    p3[t, kappaval, importtime3, importlength] * R1R2S3[t]

R1R2E3c1[t] := sigma1val * R1R2E3[t]

R1R2E3c2[t] := sigma2val * R1R2E3[t]

R1R2E3c3[t] := nuval * R1R2E3[t]

R1R2I3c1[t] := sigma1val * R1R2I3[t]

R1R2I3c2[t] := sigma2val * R1R2I3[t]

R1R2I3c3[t] := gammaval * R1R2I3[t]

R1R2R3c1[t] := sigma1val * R1R2R3[t]

R1R2R3c2[t] := sigma2val * R1R2R3[t]

R1R2R3c3[t] := sigma3val * R1R2R3[t]
```

Set default parameter values:

```
sigma1val = 1 / 40; (*Waning immunity rate, strain 1, weeks; default 1/40*)
sigma2val = 1 / 38; (*Waning immunity rate, strain 1, weeks; default 1/40*)
sigma3val = 1 / 104; (*Waning immunity rate, strain 1, weeks; default 1/40*)
nuval = 1 / (5 / 7);  (*Rate of progression to infection, weeks; default 1/1*)
gammaval = 1 / (4.9 / 7); (*Rate of recovery, weeks; default 1/1*)
chi12val = 0.74;
chi21val = 0.5;
chi13val = 0.0;
chi31val = 0.7;
chi23val = 0.0;
chi32val = 0.7;
amplitude = 0.66;
baseline = 1.4;
phival = -3.8;
kappaval = 0.01; (*Boost from importations*)
importtime1 = 0;
importtime2 = 52;
importtime3 = 52 * 100(*52*24+12*);
importlength = 0.5;
(*How long does an importation boost transmission, in weeks?*)
muval = 1 / (80 * 52); (* birth rate, in weeks *)
f = 1;
```

In[•]:=
```
scalingfactor = 0.075;
```

In[•]:=
```
tmax = 52 * 30; (*Simulation timespan, weeks*)
```

In[•]:=
```
plotwindow = {52 * 20.5, 52 * 27.5};
plotrangemax = 0.8;
importbarchar = {Black, Thick};
yearbarchar = {Gray, Thin};
fs = 18;
imsz = 400;
oc43char = {Blue, Thickness[0.008], Opacity[0.5]};
hku1char = {Red, Thickness[0.008], Opacity[0.5]};
ncovchar = {Black, Thickness[0.008], Opacity[0.5]};
totalchar = {Black, Thickness[0.004], Opacity[0.5], Dashed};
```

Run some scenarios:

70/0 | 104 | w4:

Define parameter values:

In[•]:=
```
chi31val = 0.7;
chi32val = 0.7;
chi13val = 0;
chi23val = 0;
sigma3val = 1 / 104;
importtime3 = 52 * 22 + 4;
```

Run the model:

In[•]:=
```
sol = NDSolve[
    {S1S2S3'[t] == -S1S2S3c1[t] - S1S2S3c2[t] - S1S2S3c3[t] +
       R1S2S3c1[t] + S1R2S3c2[t] + S1S2R3c3[t] - muval * S1S2S3[t] + muval,
     S1S2E3'[t] == -S1S2E3c1[t] - S1S2E3c2[t] - S1S2E3c3[t] + R1S2E3c1[t] +
       S1R2E3c2[t] + S1S2S3c3[t] - muval * S1S2E3[t],
     S1S2I3'[t] == -S1S2I3c1[t] - S1S2I3c2[t] - S1S2I3c3[t] + R1S2I3c1[t] +
       S1R2I3c2[t] + S1S2E3c3[t] - muval * S1S2I3[t],
     S1S2R3'[t] == -S1S2R3c1[t] - S1S2R3c2[t] - S1S2R3c3[t] + R1S2R3c1[t] +
       S1R2R3c2[t] + S1S2I3c3[t] - muval * S1S2R3[t],
     S1E2S3'[t] == -S1E2S3c1[t] - S1E2S3c2[t] - S1E2S3c3[t] + R1E2S3c1[t] +
       S1S2S3c2[t] + S1E2R3c3[t] - muval * S1E2S3[t],
     S1E2E3'[t] == -S1E2E3c1[t] - S1E2E3c2[t] - S1E2E3c3[t] + R1E2E3c1[t] +
       S1S2E3c2[t] + S1E2S3c3[t] - muval * S1E2E3[t],
     S1E2I3'[t] == -S1E2I3c1[t] - S1E2I3c2[t] - S1E2I3c3[t] + R1E2I3c1[t] +
       S1S2I3c2[t] + S1E2E3c3[t] - muval * S1E2I3[t],
     S1E2R3'[t] == -S1E2R3c1[t] - S1E2R3c2[t] - S1E2R3c3[t] + R1E2R3c1[t] +
       S1S2R3c2[t] + S1E2I3c3[t] - muval * S1E2R3[t],
     S1I2S3'[t] == -S1I2S3c1[t] - S1I2S3c2[t] - S1I2S3c3[t] + R1I2S3c1[t] +
       S1E2S3c2[t] + S1I2R3c3[t] - muval * S1I2S3[t],
     S1I2E3'[t] == -S1I2E3c1[t] - S1I2E3c2[t] - S1I2E3c3[t] + R1I2E3c1[t] +
       S1E2E3c2[t] + S1I2S3c3[t] - muval * S1I2E3[t],
     S1I2I3'[t] == -S1I2I3c1[t] - S1I2I3c2[t] - S1I2I3c3[t] + R1I2I3c1[t] +
       S1E2I3c2[t] + S1I2E3c3[t] - muval * S1I2I3[t],
     S1I2R3'[t] == -S1I2R3c1[t] - S1I2R3c2[t] - S1I2R3c3[t] + R1I2R3c1[t] +
       S1E2R3c2[t] + S1I2I3c3[t] - muval * S1I2R3[t],
     S1R2S3'[t] == -S1R2S3c1[t] - S1R2S3c2[t] - S1R2S3c3[t] + R1R2S3c1[t] +
       S1I2S3c2[t] + S1R2R3c3[t] - muval * S1R2S3[t],
```

```
S1R2E3'[t] == -S1R2E3c1[t] - S1R2E3c2[t] - S1R2E3c3[t] + R1R2E3c1[t] +
  S1I2E3c2[t] + S1R2S3c3[t] - muval * S1R2E3[t],
S1R2I3'[t] == -S1R2I3c1[t] - S1R2I3c2[t] - S1R2I3c3[t] + R1R2I3c1[t] +
  S1I2I3c2[t] + S1R2E3c3[t] - muval * S1R2I3[t],
S1R2R3'[t] == -S1R2R3c1[t] - S1R2R3c2[t] - S1R2R3c3[t] + R1R2R3c1[t] +
  S1I2R3c2[t] + S1R2I3c3[t] - muval * S1R2R3[t],
E1S2S3'[t] == -E1S2S3c1[t] - E1S2S3c2[t] - E1S2S3c3[t] + S1S2S3c1[t] +
  E1R2S3c2[t] + E1S2R3c3[t] - muval * E1S2S3[t],
E1S2E3'[t] == -E1S2E3c1[t] - E1S2E3c2[t] - E1S2E3c3[t] + S1S2E3c1[t] +
  E1R2E3c2[t] + E1S2S3c3[t] - muval * E1S2E3[t],
E1S2I3'[t] == -E1S2I3c1[t] - E1S2I3c2[t] - E1S2I3c3[t] + S1S2I3c1[t] +
  E1R2I3c2[t] + E1S2E3c3[t] - muval * E1S2I3[t],
E1S2R3'[t] == -E1S2R3c1[t] - E1S2R3c2[t] - E1S2R3c3[t] + S1S2R3c1[t] +
  E1R2R3c2[t] + E1S2I3c3[t] - muval * E1S2R3[t],
E1E2S3'[t] == -E1E2S3c1[t] - E1E2S3c2[t] - E1E2S3c3[t] + S1E2S3c1[t] +
  E1S2S3c2[t] + E1E2R3c3[t] - muval * E1E2S3[t],
E1E2E3'[t] == -E1E2E3c1[t] - E1E2E3c2[t] - E1E2E3c3[t] + S1E2E3c1[t] +
  E1S2E3c2[t] + E1E2S3c3[t] - muval * E1E2E3[t],
E1E2I3'[t] == -E1E2I3c1[t] - E1E2I3c2[t] - E1E2I3c3[t] + S1E2I3c1[t] +
  E1S2I3c2[t] + E1E2E3c3[t] - muval * E1E2I3[t],
E1E2R3'[t] == -E1E2R3c1[t] - E1E2R3c2[t] - E1E2R3c3[t] + S1E2R3c1[t] +
  E1S2R3c2[t] + E1E2I3c3[t] - muval * E1E2R3[t],
E1I2S3'[t] == -E1I2S3c1[t] - E1I2S3c2[t] - E1I2S3c3[t] + S1I2S3c1[t] +
  E1E2S3c2[t] + E1I2R3c3[t] - muval * E1I2S3[t],
E1I2E3'[t] == -E1I2E3c1[t] - E1I2E3c2[t] - E1I2E3c3[t] + S1I2E3c1[t] +
  E1E2E3c2[t] + E1I2S3c3[t] - muval * E1I2E3[t],
E1I2I3'[t] == -E1I2I3c1[t] - E1I2I3c2[t] - E1I2I3c3[t] + S1I2I3c1[t] +
  E1E2I3c2[t] + E1I2E3c3[t] - muval * E1I2I3[t],
E1I2R3'[t] == -E1I2R3c1[t] - E1I2R3c2[t] - E1I2R3c3[t] + S1I2R3c1[t] +
  E1E2R3c2[t] + E1I2I3c3[t] - muval * E1I2R3[t],
E1R2S3'[t] == -E1R2S3c1[t] - E1R2S3c2[t] - E1R2S3c3[t] + S1R2S3c1[t] +
  E1I2S3c2[t] + E1R2R3c3[t] - muval * E1R2S3[t],
E1R2E3'[t] == -E1R2E3c1[t] - E1R2E3c2[t] - E1R2E3c3[t] + S1R2E3c1[t] +
  E1I2E3c2[t] + E1R2S3c3[t] - muval * E1R2E3[t],
E1R2I3'[t] == -E1R2I3c1[t] - E1R2I3c2[t] - E1R2I3c3[t] + S1R2I3c1[t] +
  E1I2I3c2[t] + E1R2E3c3[t] - muval * E1R2I3[t],
E1R2R3'[t] == -E1R2R3c1[t] - E1R2R3c2[t] - E1R2R3c3[t] + S1R2R3c1[t] +
  E1I2R3c2[t] + E1R2I3c3[t] - muval * E1R2R3[t],
I1S2S3'[t] == -I1S2S3c1[t] - I1S2S3c2[t] - I1S2S3c3[t] + E1S2S3c1[t] +
  I1R2S3c2[t] + I1S2R3c3[t] - muval * I1S2S3[t],
I1S2E3'[t] == -I1S2E3c1[t] - I1S2E3c2[t] - I1S2E3c3[t] + E1S2E3c1[t] +
  I1R2E3c2[t] + I1S2S3c3[t] - muval * I1S2E3[t],
I1S2I3'[t] == -I1S2I3c1[t] - I1S2I3c2[t] - I1S2I3c3[t] + E1S2I3c1[t] +
  I1R2I3c2[t] + I1S2E3c3[t] - muval * I1S2I3[t],
```

```
I1S2R3'[t] == -I1S2R3c1[t] - I1S2R3c2[t] - I1S2R3c3[t] + E1S2R3c1[t] +
  I1R2R3c2[t] + I1S2I3c3[t] - muval * I1S2R3[t],
I1E2S3'[t] == -I1E2S3c1[t] - I1E2S3c2[t] - I1E2S3c3[t] + E1E2S3c1[t] +
  I1S2S3c2[t] + I1E2R3c3[t] - muval * I1E2S3[t],
I1E2E3'[t] == -I1E2E3c1[t] - I1E2E3c2[t] - I1E2E3c3[t] + E1E2E3c1[t] +
  I1S2E3c2[t] + I1E2S3c3[t] - muval * I1E2E3[t],
I1E2I3'[t] == -I1E2I3c1[t] - I1E2I3c2[t] - I1E2I3c3[t] + E1E2I3c1[t] +
  I1S2I3c2[t] + I1E2E3c3[t] - muval * I1E2I3[t],
I1E2R3'[t] == -I1E2R3c1[t] - I1E2R3c2[t] - I1E2R3c3[t] + E1E2R3c1[t] +
  I1S2R3c2[t] + I1E2I3c3[t] - muval * I1E2R3[t],
I1I2S3'[t] == -I1I2S3c1[t] - I1I2S3c2[t] - I1I2S3c3[t] + E1I2S3c1[t] +
  I1E2S3c2[t] + I1I2R3c3[t] - muval * I1I2S3[t],
I1I2E3'[t] == -I1I2E3c1[t] - I1I2E3c2[t] - I1I2E3c3[t] + E1I2E3c1[t] +
  I1E2E3c2[t] + I1I2S3c3[t] - muval * I1I2E3[t],
I1I2I3'[t] == -I1I2I3c1[t] - I1I2I3c2[t] - I1I2I3c3[t] + E1I2I3c1[t] +
  I1E2I3c2[t] + I1I2E3c3[t] - muval * I1I2I3[t],
I1I2R3'[t] == -I1I2R3c1[t] - I1I2R3c2[t] - I1I2R3c3[t] + E1I2R3c1[t] +
  I1E2R3c2[t] + I1I2I3c3[t] - muval * I1I2R3[t],
I1R2S3'[t] == -I1R2S3c1[t] - I1R2S3c2[t] - I1R2S3c3[t] + E1R2S3c1[t] +
  I1I2S3c2[t] + I1R2R3c3[t] - muval * I1R2S3[t],
I1R2E3'[t] == -I1R2E3c1[t] - I1R2E3c2[t] - I1R2E3c3[t] + E1R2E3c1[t] +
  I1I2E3c2[t] + I1R2S3c3[t] - muval * I1R2E3[t],
I1R2I3'[t] == -I1R2I3c1[t] - I1R2I3c2[t] - I1R2I3c3[t] + E1R2I3c1[t] +
  I1I2I3c2[t] + I1R2E3c3[t] - muval * I1R2I3[t],
I1R2R3'[t] == -I1R2R3c1[t] - I1R2R3c2[t] - I1R2R3c3[t] + E1R2R3c1[t] +
  I1I2R3c2[t] + I1R2I3c3[t] - muval * I1R2R3[t],
R1S2S3'[t] == -R1S2S3c1[t] - R1S2S3c2[t] - R1S2S3c3[t] + I1S2S3c1[t] +
  R1R2S3c2[t] + R1S2R3c3[t] - muval * R1S2S3[t],
R1S2E3'[t] == -R1S2E3c1[t] - R1S2E3c2[t] - R1S2E3c3[t] + I1S2E3c1[t] +
  R1R2E3c2[t] + R1S2S3c3[t] - muval * R1S2E3[t],
R1S2I3'[t] == -R1S2I3c1[t] - R1S2I3c2[t] - R1S2I3c3[t] + I1S2I3c1[t] +
  R1R2I3c2[t] + R1S2E3c3[t] - muval * R1S2I3[t],
R1S2R3'[t] == -R1S2R3c1[t] - R1S2R3c2[t] - R1S2R3c3[t] + I1S2R3c1[t] +
  R1R2R3c2[t] + R1S2I3c3[t] - muval * R1S2R3[t],
R1E2S3'[t] == -R1E2S3c1[t] - R1E2S3c2[t] - R1E2S3c3[t] + I1E2S3c1[t] +
  R1S2S3c2[t] + R1E2R3c3[t] - muval * R1E2S3[t],
R1E2E3'[t] == -R1E2E3c1[t] - R1E2E3c2[t] - R1E2E3c3[t] + I1E2E3c1[t] +
  R1S2E3c2[t] + R1E2S3c3[t] - muval * R1E2E3[t],
R1E2I3'[t] == -R1E2I3c1[t] - R1E2I3c2[t] - R1E2I3c3[t] + I1E2I3c1[t] +
  R1S2I3c2[t] + R1E2E3c3[t] - muval * R1E2I3[t],
R1E2R3'[t] == -R1E2R3c1[t] - R1E2R3c2[t] - R1E2R3c3[t] + I1E2R3c1[t] +
  R1S2R3c2[t] + R1E2I3c3[t] - muval * R1E2R3[t],
R1I2S3'[t] == -R1I2S3c1[t] - R1I2S3c2[t] - R1I2S3c3[t] + I1I2S3c1[t] +
  R1E2S3c2[t] + R1I2R3c3[t] - muval * R1I2S3[t],
```

```
 R1I2E3'[t] == -R1I2E3c1[t] - R1I2E3c2[t] - R1I2E3c3[t] + I1I2E3c1[t] +
   R1E2E3c2[t] + R1I2S3c3[t] - muval * R1I2E3[t],
 R1I2I3'[t] == -R1I2I3c1[t] - R1I2I3c2[t] - R1I2I3c3[t] + I1I2I3c1[t] +
   R1E2I3c2[t] + R1I2E3c3[t] - muval * R1I2I3[t],
 R1I2R3'[t] == -R1I2R3c1[t] - R1I2R3c2[t] - R1I2R3c3[t] + I1I2R3c1[t] +
   R1E2R3c2[t] + R1I2I3c3[t] - muval * R1I2R3[t],
 R1R2S3'[t] == -R1R2S3c1[t] - R1R2S3c2[t] - R1R2S3c3[t] + I1R2S3c1[t] +
   R1I2S3c2[t] + R1R2R3c3[t] - muval * R1R2S3[t],
 R1R2E3'[t] == -R1R2E3c1[t] - R1R2E3c2[t] - R1R2E3c3[t] + I1R2E3c1[t] +
   R1I2E3c2[t] + R1R2S3c3[t] - muval * R1R2E3[t],
 R1R2I3'[t] == -R1R2I3c1[t] - R1R2I3c2[t] - R1R2I3c3[t] + I1R2I3c1[t] +
   R1I2I3c2[t] + R1R2E3c3[t] - muval * R1R2I3[t],
 R1R2R3'[t] == -R1R2R3c1[t] - R1R2R3c2[t] - R1R2R3c3[t] + I1R2R3c1[t] +
   R1I2R3c2[t] + R1R2I3c3[t] - muval * R1R2R3[t],
 cuminf'[t] == E1S2S3c1[t] + E1S2E3c1[t] + E1S2I3c1[t] + E1S2R3c1[t] +
   E1E2S3c1[t] + E1E2E3c1[t] + E1E2I3c1[t] + E1E2R3c1[t] + E1I2S3c1[t] +
   E1I2E3c1[t] + E1I2I3c1[t] + E1I2R3c1[t] + E1R2S3c1[t] + E1R2E3c1[t] +
   E1R2I3c1[t] + E1R2R3c1[t] + S1E2S3c2[t] + S1E2E3c2[t] + S1E2I3c2[t] +
   S1E2R3c2[t] + E1E2S3c2[t] + E1E2E3c2[t] + E1E2I3c2[t] + E1E2R3c2[t] +
   I1E2S3c2[t] + I1E2E3c2[t] + I1E2I3c2[t] + I1E2R3c2[t] + R1E2S3c2[t] +
   R1E2E3c2[t] + R1E2I3c2[t] + R1E2R3c2[t] + S1S2E3c3[t] + S1E2E3c3[t] +
   S1I2E3c3[t] + S1R2E3c3[t] + E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] +
   E1R2E3c3[t] + I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
   R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
 S1S2S3[0] == 1, S1S2E3[0] == 0, S1S2I3[0] == 0, S1S2R3[0] == 0, S1E2S3[0] == 0,
 S1E2E3[0] == 0, S1E2I3[0] == 0, S1E2R3[0] == 0, S1I2S3[0] == 0, S1I2E3[0] == 0,
 S1I2I3[0] == 0, S1I2R3[0] == 0, S1R2S3[0] == 0, S1R2E3[0] == 0, S1R2I3[0] == 0,
 S1R2R3[0] == 0, E1S2S3[0] == 0, E1S2E3[0] == 0, E1S2I3[0] == 0, E1S2R3[0] == 0,
 E1E2S3[0] == 0, E1E2E3[0] == 0, E1E2I3[0] == 0, E1E2R3[0] == 0, E1I2S3[0] == 0,
 E1I2E3[0] == 0, E1I2I3[0] == 0, E1I2R3[0] == 0, E1R2S3[0] == 0, E1R2E3[0] == 0,
 E1R2I3[0] == 0, E1R2R3[0] == 0, I1S2S3[0] == 0, I1S2E3[0] == 0, I1S2I3[0] == 0,
 I1S2R3[0] == 0, I1E2S3[0] == 0, I1E2E3[0] == 0, I1E2I3[0] == 0, I1E2R3[0] == 0,
 I1I2S3[0] == 0, I1I2E3[0] == 0, I1I2I3[0] == 0, I1I2R3[0] == 0, I1R2S3[0] == 0,
 I1R2E3[0] == 0, I1R2I3[0] == 0, I1R2R3[0] == 0, R1S2S3[0] == 0, R1S2E3[0] == 0,
 R1S2I3[0] == 0, R1S2R3[0] == 0, R1E2S3[0] == 0, R1E2E3[0] == 0, R1E2I3[0] == 0,
 R1E2R3[0] == 0, R1I2S3[0] == 0, R1I2E3[0] == 0, R1I2I3[0] == 0, R1I2R3[0] == 0,
 R1R2S3[0] == 0, R1R2E3[0] == 0, R1R2I3[0] == 0, R1R2R3[0] == 0, cuminf[0] == 0},
{S1S2S3, S1S2E3, S1S2I3, S1S2R3, S1E2S3, S1E2E3, S1E2I3, S1E2R3, S1I2S3,
 S1I2E3, S1I2I3, S1I2R3, S1R2S3, S1R2E3, S1R2I3, S1R2R3, E1S2S3, E1S2E3, E1S2I3,
 E1S2R3, E1E2S3, E1E2E3, E1E2I3, E1E2R3, E1I2S3, E1I2E3, E1I2I3, E1I2R3, E1R2S3,
 E1R2E3, E1R2I3, E1R2R3, I1S2S3, I1S2E3, I1S2I3, I1S2R3, I1E2S3, I1E2E3,
 I1E2I3, I1E2R3, I1I2S3, I1I2E3, I1I2I3, I1I2R3, I1R2S3, I1R2E3, I1R2I3,
 I1R2R3, R1S2S3, R1S2E3, R1S2I3, R1S2R3, R1E2S3, R1E2E3, R1E2I3, R1E2R3,
 R1I2S3, R1I2E3, R1I2I3, R1I2R3, R1R2S3, R1R2E3, R1R2I3, R1R2R3, cuminf},
```

```
 {t, 0, tmax}
];
```

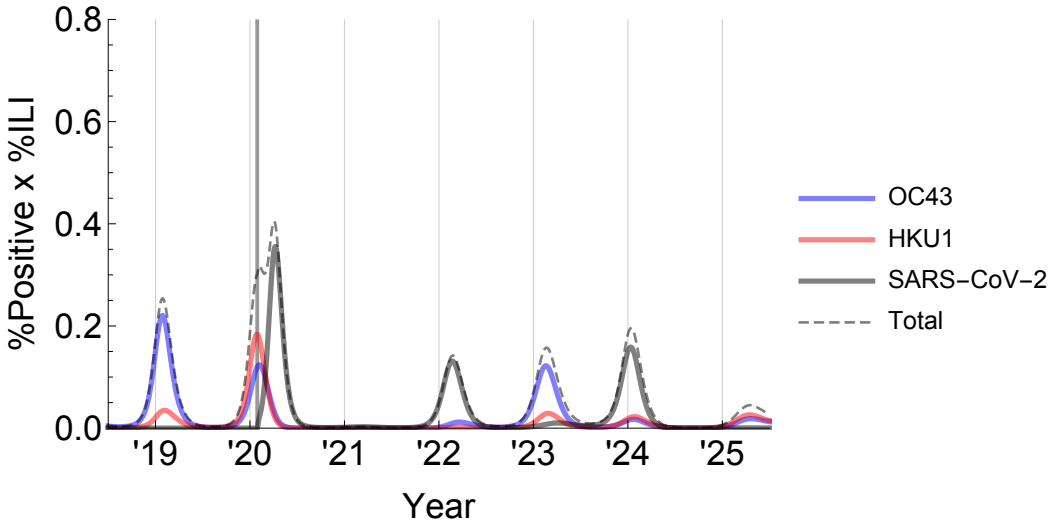
Plot output:

In[•]:=
```
figinvasion =
  Plot[{Evaluate[{{100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t])},
       {100 * scalingfactor * (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] +
          E1I2S3[t] + E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t])},
       {100 * scalingfactor * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] +
          E1S2I3[t] + E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] +
          I1I2I3[t] + I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t])},
       {100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t] +
          S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] +
          E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] +
          R1I2R3[t] + S1S2I3[t] + S1E2I3[t] + S1R2I3[t] + E1S2I3[t] +
          E1E2I3[t] + E1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1R2I3[t])
       }} /. sol]}, Join[{t}, plotwindow], PlotRange → {0, plotrangemax},
  GridLines → {Join[Table[{i, yearbarchar}, {i, 0, tmax, 52}],
     {{importtime3, importbarchar}}], None},
  Frame → {True, True, False, False}, PlotRangePadding → None,
  BaseStyle → FontSize → fs,
  FrameTicks → {Table[{i, "'" <> ToString[i / 52 - 2]}, {i, 0, tmax, 52}], Automatic},
  FrameLabel → {"Year", "%Positive x %ILI"}, ImageSize → imsz,
  PlotLegends → {"OC43", "HKU1", "SARS-CoV-2", "Total"},
  PlotStyle → {oc43char, hku1char, ncovchar, totalchar}];
```

Save output:

In[•]:=
```
figinvasion
```

Out[•]=



70/0 | 104 | w26:

Define parameter values:

In[•]:=
```
chi31val = 0.7;
chi32val = 0.7;
chi13val = 0;
chi23val = 0;
sigma3val = 1 / 104;
importtime3 = 52 * 22 + 26;
```

Run the model:

In[•]:=
```
sol = NDSolve[
    {S1S2S3'[t] == -S1S2S3c1[t] - S1S2S3c2[t] - S1S2S3c3[t] +
       R1S2S3c1[t] + S1R2S3c2[t] + S1S2R3c3[t] - muval * S1S2S3[t] + muval,
     S1S2E3'[t] == -S1S2E3c1[t] - S1S2E3c2[t] - S1S2E3c3[t] + R1S2E3c1[t] +
       S1R2E3c2[t] + S1S2S3c3[t] - muval * S1S2E3[t],
     S1S2I3'[t] == -S1S2I3c1[t] - S1S2I3c2[t] - S1S2I3c3[t] + R1S2I3c1[t] +
       S1R2I3c2[t] + S1S2E3c3[t] - muval * S1S2I3[t],
     S1S2R3'[t] == -S1S2R3c1[t] - S1S2R3c2[t] - S1S2R3c3[t] + R1S2R3c1[t] +
       S1R2R3c2[t] + S1S2I3c3[t] - muval * S1S2R3[t],
     S1E2S3'[t] == -S1E2S3c1[t] - S1E2S3c2[t] - S1E2S3c3[t] + R1E2S3c1[t] +
       S1S2S3c2[t] + S1E2R3c3[t] - muval * S1E2S3[t],
     S1E2E3'[t] == -S1E2E3c1[t] - S1E2E3c2[t] - S1E2E3c3[t] + R1E2E3c1[t] +
```

```
  S1S2E3c2[t] + S1E2S3c3[t] - muval * S1E2E3[t],
S1E2I3'[t] == -S1E2I3c1[t] - S1E2I3c2[t] - S1E2I3c3[t] + R1E2I3c1[t] +
  S1S2I3c2[t] + S1E2E3c3[t] - muval * S1E2I3[t],
S1E2R3'[t] == -S1E2R3c1[t] - S1E2R3c2[t] - S1E2R3c3[t] + R1E2R3c1[t] +
  S1S2R3c2[t] + S1E2I3c3[t] - muval * S1E2R3[t],
S1I2S3'[t] == -S1I2S3c1[t] - S1I2S3c2[t] - S1I2S3c3[t] + R1I2S3c1[t] +
  S1E2S3c2[t] + S1I2R3c3[t] - muval * S1I2S3[t],
S1I2E3'[t] == -S1I2E3c1[t] - S1I2E3c2[t] - S1I2E3c3[t] + R1I2E3c1[t] +
  S1E2E3c2[t] + S1I2S3c3[t] - muval * S1I2E3[t],
S1I2I3'[t] == -S1I2I3c1[t] - S1I2I3c2[t] - S1I2I3c3[t] + R1I2I3c1[t] +
  S1E2I3c2[t] + S1I2E3c3[t] - muval * S1I2I3[t],
S1I2R3'[t] == -S1I2R3c1[t] - S1I2R3c2[t] - S1I2R3c3[t] + R1I2R3c1[t] +
  S1E2R3c2[t] + S1I2I3c3[t] - muval * S1I2R3[t],
S1R2S3'[t] == -S1R2S3c1[t] - S1R2S3c2[t] - S1R2S3c3[t] + R1R2S3c1[t] +
  S1I2S3c2[t] + S1R2R3c3[t] - muval * S1R2S3[t],
S1R2E3'[t] == -S1R2E3c1[t] - S1R2E3c2[t] - S1R2E3c3[t] + R1R2E3c1[t] +
  S1I2E3c2[t] + S1R2S3c3[t] - muval * S1R2E3[t],
S1R2I3'[t] == -S1R2I3c1[t] - S1R2I3c2[t] - S1R2I3c3[t] + R1R2I3c1[t] +
  S1I2I3c2[t] + S1R2E3c3[t] - muval * S1R2I3[t],
S1R2R3'[t] == -S1R2R3c1[t] - S1R2R3c2[t] - S1R2R3c3[t] + R1R2R3c1[t] +
  S1I2R3c2[t] + S1R2I3c3[t] - muval * S1R2R3[t],
E1S2S3'[t] == -E1S2S3c1[t] - E1S2S3c2[t] - E1S2S3c3[t] + S1S2S3c1[t] +
  E1R2S3c2[t] + E1S2R3c3[t] - muval * E1S2S3[t],
E1S2E3'[t] == -E1S2E3c1[t] - E1S2E3c2[t] - E1S2E3c3[t] + S1S2E3c1[t] +
  E1R2E3c2[t] + E1S2S3c3[t] - muval * E1S2E3[t],
E1S2I3'[t] == -E1S2I3c1[t] - E1S2I3c2[t] - E1S2I3c3[t] + S1S2I3c1[t] +
  E1R2I3c2[t] + E1S2E3c3[t] - muval * E1S2I3[t],
E1S2R3'[t] == -E1S2R3c1[t] - E1S2R3c2[t] - E1S2R3c3[t] + S1S2R3c1[t] +
  E1R2R3c2[t] + E1S2I3c3[t] - muval * E1S2R3[t],
E1E2S3'[t] == -E1E2S3c1[t] - E1E2S3c2[t] - E1E2S3c3[t] + S1E2S3c1[t] +
  E1S2S3c2[t] + E1E2R3c3[t] - muval * E1E2S3[t],
E1E2E3'[t] == -E1E2E3c1[t] - E1E2E3c2[t] - E1E2E3c3[t] + S1E2E3c1[t] +
  E1S2E3c2[t] + E1E2S3c3[t] - muval * E1E2E3[t],
E1E2I3'[t] == -E1E2I3c1[t] - E1E2I3c2[t] - E1E2I3c3[t] + S1E2I3c1[t] +
  E1S2I3c2[t] + E1E2E3c3[t] - muval * E1E2I3[t],
E1E2R3'[t] == -E1E2R3c1[t] - E1E2R3c2[t] - E1E2R3c3[t] + S1E2R3c1[t] +
  E1S2R3c2[t] + E1E2I3c3[t] - muval * E1E2R3[t],
E1I2S3'[t] == -E1I2S3c1[t] - E1I2S3c2[t] - E1I2S3c3[t] + S1I2S3c1[t] +
  E1E2S3c2[t] + E1I2R3c3[t] - muval * E1I2S3[t],
E1I2E3'[t] == -E1I2E3c1[t] - E1I2E3c2[t] - E1I2E3c3[t] + S1I2E3c1[t] +
  E1E2E3c2[t] + E1I2S3c3[t] - muval * E1I2E3[t],
E1I2I3'[t] == -E1I2I3c1[t] - E1I2I3c2[t] - E1I2I3c3[t] + S1I2I3c1[t] +
  E1E2I3c2[t] + E1I2E3c3[t] - muval * E1I2I3[t],
E1I2R3'[t] == -E1I2R3c1[t] - E1I2R3c2[t] - E1I2R3c3[t] + S1I2R3c1[t] +
```

```
  E1E2R3c2[t] + E1I2I3c3[t] - muval * E1I2R3[t],
E1R2S3'[t] == -E1R2S3c1[t] - E1R2S3c2[t] - E1R2S3c3[t] + S1R2S3c1[t] +
  E1I2S3c2[t] + E1R2R3c3[t] - muval * E1R2S3[t],
E1R2E3'[t] == -E1R2E3c1[t] - E1R2E3c2[t] - E1R2E3c3[t] + S1R2E3c1[t] +
  E1I2E3c2[t] + E1R2S3c3[t] - muval * E1R2E3[t],
E1R2I3'[t] == -E1R2I3c1[t] - E1R2I3c2[t] - E1R2I3c3[t] + S1R2I3c1[t] +
  E1I2I3c2[t] + E1R2E3c3[t] - muval * E1R2I3[t],
E1R2R3'[t] == -E1R2R3c1[t] - E1R2R3c2[t] - E1R2R3c3[t] + S1R2R3c1[t] +
  E1I2R3c2[t] + E1R2I3c3[t] - muval * E1R2R3[t],
I1S2S3'[t] == -I1S2S3c1[t] - I1S2S3c2[t] - I1S2S3c3[t] + E1S2S3c1[t] +
  I1R2S3c2[t] + I1S2R3c3[t] - muval * I1S2S3[t],
I1S2E3'[t] == -I1S2E3c1[t] - I1S2E3c2[t] - I1S2E3c3[t] + E1S2E3c1[t] +
  I1R2E3c2[t] + I1S2S3c3[t] - muval * I1S2E3[t],
I1S2I3'[t] == -I1S2I3c1[t] - I1S2I3c2[t] - I1S2I3c3[t] + E1S2I3c1[t] +
  I1R2I3c2[t] + I1S2E3c3[t] - muval * I1S2I3[t],
I1S2R3'[t] == -I1S2R3c1[t] - I1S2R3c2[t] - I1S2R3c3[t] + E1S2R3c1[t] +
  I1R2R3c2[t] + I1S2I3c3[t] - muval * I1S2R3[t],
I1E2S3'[t] == -I1E2S3c1[t] - I1E2S3c2[t] - I1E2S3c3[t] + E1E2S3c1[t] +
  I1S2S3c2[t] + I1E2R3c3[t] - muval * I1E2S3[t],
I1E2E3'[t] == -I1E2E3c1[t] - I1E2E3c2[t] - I1E2E3c3[t] + E1E2E3c1[t] +
  I1S2E3c2[t] + I1E2S3c3[t] - muval * I1E2E3[t],
I1E2I3'[t] == -I1E2I3c1[t] - I1E2I3c2[t] - I1E2I3c3[t] + E1E2I3c1[t] +
  I1S2I3c2[t] + I1E2E3c3[t] - muval * I1E2I3[t],
I1E2R3'[t] == -I1E2R3c1[t] - I1E2R3c2[t] - I1E2R3c3[t] + E1E2R3c1[t] +
  I1S2R3c2[t] + I1E2I3c3[t] - muval * I1E2R3[t],
I1I2S3'[t] == -I1I2S3c1[t] - I1I2S3c2[t] - I1I2S3c3[t] + E1I2S3c1[t] +
  I1E2S3c2[t] + I1I2R3c3[t] - muval * I1I2S3[t],
I1I2E3'[t] == -I1I2E3c1[t] - I1I2E3c2[t] - I1I2E3c3[t] + E1I2E3c1[t] +
  I1E2E3c2[t] + I1I2S3c3[t] - muval * I1I2E3[t],
I1I2I3'[t] == -I1I2I3c1[t] - I1I2I3c2[t] - I1I2I3c3[t] + E1I2I3c1[t] +
  I1E2I3c2[t] + I1I2E3c3[t] - muval * I1I2I3[t],
I1I2R3'[t] == -I1I2R3c1[t] - I1I2R3c2[t] - I1I2R3c3[t] + E1I2R3c1[t] +
  I1E2R3c2[t] + I1I2I3c3[t] - muval * I1I2R3[t],
I1R2S3'[t] == -I1R2S3c1[t] - I1R2S3c2[t] - I1R2S3c3[t] + E1R2S3c1[t] +
  I1I2S3c2[t] + I1R2R3c3[t] - muval * I1R2S3[t],
I1R2E3'[t] == -I1R2E3c1[t] - I1R2E3c2[t] - I1R2E3c3[t] + E1R2E3c1[t] +
  I1I2E3c2[t] + I1R2S3c3[t] - muval * I1R2E3[t],
I1R2I3'[t] == -I1R2I3c1[t] - I1R2I3c2[t] - I1R2I3c3[t] + E1R2I3c1[t] +
  I1I2I3c2[t] + I1R2E3c3[t] - muval * I1R2I3[t],
I1R2R3'[t] == -I1R2R3c1[t] - I1R2R3c2[t] - I1R2R3c3[t] + E1R2R3c1[t] +
  I1I2R3c2[t] + I1R2I3c3[t] - muval * I1R2R3[t],
R1S2S3'[t] == -R1S2S3c1[t] - R1S2S3c2[t] - R1S2S3c3[t] + I1S2S3c1[t] +
  R1R2S3c2[t] + R1S2R3c3[t] - muval * R1S2S3[t],
R1S2E3'[t] == -R1S2E3c1[t] - R1S2E3c2[t] - R1S2E3c3[t] + I1S2E3c1[t] +
```

```
  R1R2E3c2[t] + R1S2S3c3[t] - muval * R1S2E3[t],
R1S2I3'[t] == -R1S2I3c1[t] - R1S2I3c2[t] - R1S2I3c3[t] + I1S2I3c1[t] +
  R1R2I3c2[t] + R1S2E3c3[t] - muval * R1S2I3[t],
R1S2R3'[t] == -R1S2R3c1[t] - R1S2R3c2[t] - R1S2R3c3[t] + I1S2R3c1[t] +
  R1R2R3c2[t] + R1S2I3c3[t] - muval * R1S2R3[t],
R1E2S3'[t] == -R1E2S3c1[t] - R1E2S3c2[t] - R1E2S3c3[t] + I1E2S3c1[t] +
  R1S2S3c2[t] + R1E2R3c3[t] - muval * R1E2S3[t],
R1E2E3'[t] == -R1E2E3c1[t] - R1E2E3c2[t] - R1E2E3c3[t] + I1E2E3c1[t] +
  R1S2E3c2[t] + R1E2S3c3[t] - muval * R1E2E3[t],
R1E2I3'[t] == -R1E2I3c1[t] - R1E2I3c2[t] - R1E2I3c3[t] + I1E2I3c1[t] +
  R1S2I3c2[t] + R1E2E3c3[t] - muval * R1E2I3[t],
R1E2R3'[t] == -R1E2R3c1[t] - R1E2R3c2[t] - R1E2R3c3[t] + I1E2R3c1[t] +
  R1S2R3c2[t] + R1E2I3c3[t] - muval * R1E2R3[t],
R1I2S3'[t] == -R1I2S3c1[t] - R1I2S3c2[t] - R1I2S3c3[t] + I1I2S3c1[t] +
  R1E2S3c2[t] + R1I2R3c3[t] - muval * R1I2S3[t],
R1I2E3'[t] == -R1I2E3c1[t] - R1I2E3c2[t] - R1I2E3c3[t] + I1I2E3c1[t] +
  R1E2E3c2[t] + R1I2S3c3[t] - muval * R1I2E3[t],
R1I2I3'[t] == -R1I2I3c1[t] - R1I2I3c2[t] - R1I2I3c3[t] + I1I2I3c1[t] +
  R1E2I3c2[t] + R1I2E3c3[t] - muval * R1I2I3[t],
R1I2R3'[t] == -R1I2R3c1[t] - R1I2R3c2[t] - R1I2R3c3[t] + I1I2R3c1[t] +
  R1E2R3c2[t] + R1I2I3c3[t] - muval * R1I2R3[t],
R1R2S3'[t] == -R1R2S3c1[t] - R1R2S3c2[t] - R1R2S3c3[t] + I1R2S3c1[t] +
  R1I2S3c2[t] + R1R2R3c3[t] - muval * R1R2S3[t],
R1R2E3'[t] == -R1R2E3c1[t] - R1R2E3c2[t] - R1R2E3c3[t] + I1R2E3c1[t] +
  R1I2E3c2[t] + R1R2S3c3[t] - muval * R1R2E3[t],
R1R2I3'[t] == -R1R2I3c1[t] - R1R2I3c2[t] - R1R2I3c3[t] + I1R2I3c1[t] +
  R1I2I3c2[t] + R1R2E3c3[t] - muval * R1R2I3[t],
R1R2R3'[t] == -R1R2R3c1[t] - R1R2R3c2[t] - R1R2R3c3[t] + I1R2R3c1[t] +
  R1I2R3c2[t] + R1R2I3c3[t] - muval * R1R2R3[t],
cuminf'[t] == E1S2S3c1[t] + E1S2E3c1[t] + E1S2I3c1[t] + E1S2R3c1[t] +
  E1E2S3c1[t] + E1E2E3c1[t] + E1E2I3c1[t] + E1E2R3c1[t] + E1I2S3c1[t] +
  E1I2E3c1[t] + E1I2I3c1[t] + E1I2R3c1[t] + E1R2S3c1[t] + E1R2E3c1[t] +
  E1R2I3c1[t] + E1R2R3c1[t] + S1E2S3c2[t] + S1E2E3c2[t] + S1E2I3c2[t] +
  S1E2R3c2[t] + E1E2S3c2[t] + E1E2E3c2[t] + E1E2I3c2[t] + E1E2R3c2[t] +
  I1E2S3c2[t] + I1E2E3c2[t] + I1E2I3c2[t] + I1E2R3c2[t] + R1E2S3c2[t] +
  R1E2E3c2[t] + R1E2I3c2[t] + R1E2R3c2[t] + S1S2E3c3[t] + S1E2E3c3[t] +
  S1I2E3c3[t] + S1R2E3c3[t] + E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] +
  E1R2E3c3[t] + I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
  R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
S1S2S3[0] == 1, S1S2E3[0] == 0, S1S2I3[0] == 0, S1S2R3[0] == 0, S1E2S3[0] == 0,
S1E2E3[0] == 0, S1E2I3[0] == 0, S1E2R3[0] == 0, S1I2S3[0] == 0, S1I2E3[0] == 0,
S1I2I3[0] == 0, S1I2R3[0] == 0, S1R2S3[0] == 0, S1R2E3[0] == 0, S1R2I3[0] == 0,
S1R2R3[0] == 0, E1S2S3[0] == 0, E1S2E3[0] == 0, E1S2I3[0] == 0, E1S2R3[0] == 0,
E1E2S3[0] == 0, E1E2E3[0] == 0, E1E2I3[0] == 0, E1E2R3[0] == 0, E1I2S3[0] == 0,
```

```
  E1I2E3[0] == 0, E1I2I3[0] == 0, E1I2R3[0] == 0, E1R2S3[0] == 0, E1R2E3[0] == 0,
  E1R2I3[0] == 0, E1R2R3[0] == 0, I1S2S3[0] == 0, I1S2E3[0] == 0, I1S2I3[0] == 0,
  I1S2R3[0] == 0, I1E2S3[0] == 0, I1E2E3[0] == 0, I1E2I3[0] == 0, I1E2R3[0] == 0,
  I1I2S3[0] == 0, I1I2E3[0] == 0, I1I2I3[0] == 0, I1I2R3[0] == 0, I1R2S3[0] == 0,
  I1R2E3[0] == 0, I1R2I3[0] == 0, I1R2R3[0] == 0, R1S2S3[0] == 0, R1S2E3[0] == 0,
  R1S2I3[0] == 0, R1S2R3[0] == 0, R1E2S3[0] == 0, R1E2E3[0] == 0, R1E2I3[0] == 0,
  R1E2R3[0] == 0, R1I2S3[0] == 0, R1I2E3[0] == 0, R1I2I3[0] == 0, R1I2R3[0] == 0,
  R1R2S3[0] == 0, R1R2E3[0] == 0, R1R2I3[0] == 0, R1R2R3[0] == 0, cuminf[0] == 0},
 {S1S2S3, S1S2E3, S1S2I3, S1S2R3, S1E2S3, S1E2E3, S1E2I3, S1E2R3, S1I2S3,
  S1I2E3, S1I2I3, S1I2R3, S1R2S3, S1R2E3, S1R2I3, S1R2R3, E1S2S3, E1S2E3, E1S2I3,
  E1S2R3, E1E2S3, E1E2E3, E1E2I3, E1E2R3, E1I2S3, E1I2E3, E1I2I3, E1I2R3, E1R2S3,
  E1R2E3, E1R2I3, E1R2R3, I1S2S3, I1S2E3, I1S2I3, I1S2R3, I1E2S3, I1E2E3,
  I1E2I3, I1E2R3, I1I2S3, I1I2E3, I1I2I3, I1I2R3, I1R2S3, I1R2E3, I1R2I3,
  I1R2R3, R1S2S3, R1S2E3, R1S2I3, R1S2R3, R1E2S3, R1E2E3, R1E2I3, R1E2R3,
  R1I2S3, R1I2E3, R1I2I3, R1I2R3, R1R2S3, R1R2E3, R1R2I3, R1R2R3, cuminf},
 {t, 0, tmax}
];
```

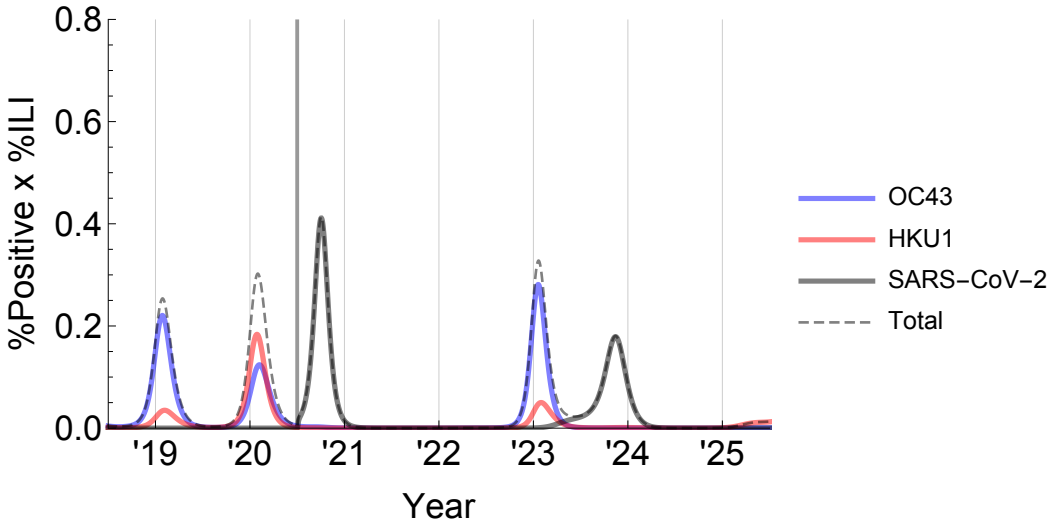
Plot output:

```
In[•]:= figinvasion =
  Plot[{Evaluate[{{100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t])},
       {100 * scalingfactor * (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] +
          E1I2S3[t] + E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t])},
       {100 * scalingfactor * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] +
          E1S2I3[t] + E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] +
          I1I2I3[t] + I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t])},
       {100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t] +
          S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] +
          E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] +
          R1I2R3[t] + S1S2I3[t] + S1E2I3[t] + S1R2I3[t] + E1S2I3[t] +
          E1E2I3[t] + E1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1R2I3[t])
       }} /. sol]}, Join[{t}, plotwindow], PlotRange → {0, plotrangemax},
    GridLines → {Join[Table[{i, yearbarchar}, {i, 0, tmax, 52}],
       {{importtime3, importbarchar}}], None},
    Frame → {True, True, False, False}, PlotRangePadding → None,
    BaseStyle → FontSize → fs,
    FrameTicks → {Table[{i, "'" <> ToString[i / 52 - 2]}, {i, 0, tmax, 52}], Automatic},
    FrameLabel → {"Year", "%Positive x %ILI"}, ImageSize → imsz,
    PlotLegends → {"OC43", "HKU1", "SARS-CoV-2", "Total"},
    PlotStyle → {oc43char, hku1char, ncovchar, totalchar}];
```

Save output:

In[•]:=
```
figinvasion
```

Out[•]=



70/0 | ∞ | w12:

Define parameter values:

In[•]:=
```
chi31val = 0.7;
chi32val = 0.7;
chi13val = 0;
chi23val = 0;
sigma3val = 1 / Infinity;
importtime3 = 52 * 22 + 12;
```

Run the model:

In[•]:=
```
sol = NDSolve[
    {S1S2S3'[t] == -S1S2S3c1[t] - S1S2S3c2[t] - S1S2S3c3[t] +
       R1S2S3c1[t] + S1R2S3c2[t] + S1S2R3c3[t] - muval * S1S2S3[t] + muval,
     S1S2E3'[t] == -S1S2E3c1[t] - S1S2E3c2[t] - S1S2E3c3[t] + R1S2E3c1[t] +
       S1R2E3c2[t] + S1S2S3c3[t] - muval * S1S2E3[t],
     S1S2I3'[t] == -S1S2I3c1[t] - S1S2I3c2[t] - S1S2I3c3[t] + R1S2I3c1[t] +
       S1R2I3c2[t] + S1S2E3c3[t] - muval * S1S2I3[t],
     S1S2R3'[t] == -S1S2R3c1[t] - S1S2R3c2[t] - S1S2R3c3[t] + R1S2R3c1[t] +
       S1R2R3c2[t] + S1S2I3c3[t] - muval * S1S2R3[t],
     S1E2S3'[t] == -S1E2S3c1[t] - S1E2S3c2[t] - S1E2S3c3[t] + R1E2S3c1[t] +
       S1S2S3c2[t] + S1E2R3c3[t] - muval * S1E2S3[t],
     S1E2E3'[t] == -S1E2E3c1[t] - S1E2E3c2[t] - S1E2E3c3[t] + R1E2E3c1[t] +
```

```
  S1S2E3c2[t] + S1E2S3c3[t] - muval * S1E2E3[t],
S1E2I3'[t] == -S1E2I3c1[t] - S1E2I3c2[t] - S1E2I3c3[t] + R1E2I3c1[t] +
  S1S2I3c2[t] + S1E2E3c3[t] - muval * S1E2I3[t],
S1E2R3'[t] == -S1E2R3c1[t] - S1E2R3c2[t] - S1E2R3c3[t] + R1E2R3c1[t] +
  S1S2R3c2[t] + S1E2I3c3[t] - muval * S1E2R3[t],
S1I2S3'[t] == -S1I2S3c1[t] - S1I2S3c2[t] - S1I2S3c3[t] + R1I2S3c1[t] +
  S1E2S3c2[t] + S1I2R3c3[t] - muval * S1I2S3[t],
S1I2E3'[t] == -S1I2E3c1[t] - S1I2E3c2[t] - S1I2E3c3[t] + R1I2E3c1[t] +
  S1E2E3c2[t] + S1I2S3c3[t] - muval * S1I2E3[t],
S1I2I3'[t] == -S1I2I3c1[t] - S1I2I3c2[t] - S1I2I3c3[t] + R1I2I3c1[t] +
  S1E2I3c2[t] + S1I2E3c3[t] - muval * S1I2I3[t],
S1I2R3'[t] == -S1I2R3c1[t] - S1I2R3c2[t] - S1I2R3c3[t] + R1I2R3c1[t] +
  S1E2R3c2[t] + S1I2I3c3[t] - muval * S1I2R3[t],
S1R2S3'[t] == -S1R2S3c1[t] - S1R2S3c2[t] - S1R2S3c3[t] + R1R2S3c1[t] +
  S1I2S3c2[t] + S1R2R3c3[t] - muval * S1R2S3[t],
S1R2E3'[t] == -S1R2E3c1[t] - S1R2E3c2[t] - S1R2E3c3[t] + R1R2E3c1[t] +
  S1I2E3c2[t] + S1R2S3c3[t] - muval * S1R2E3[t],
S1R2I3'[t] == -S1R2I3c1[t] - S1R2I3c2[t] - S1R2I3c3[t] + R1R2I3c1[t] +
  S1I2I3c2[t] + S1R2E3c3[t] - muval * S1R2I3[t],
S1R2R3'[t] == -S1R2R3c1[t] - S1R2R3c2[t] - S1R2R3c3[t] + R1R2R3c1[t] +
  S1I2R3c2[t] + S1R2I3c3[t] - muval * S1R2R3[t],
E1S2S3'[t] == -E1S2S3c1[t] - E1S2S3c2[t] - E1S2S3c3[t] + S1S2S3c1[t] +
  E1R2S3c2[t] + E1S2R3c3[t] - muval * E1S2S3[t],
E1S2E3'[t] == -E1S2E3c1[t] - E1S2E3c2[t] - E1S2E3c3[t] + S1S2E3c1[t] +
  E1R2E3c2[t] + E1S2S3c3[t] - muval * E1S2E3[t],
E1S2I3'[t] == -E1S2I3c1[t] - E1S2I3c2[t] - E1S2I3c3[t] + S1S2I3c1[t] +
  E1R2I3c2[t] + E1S2E3c3[t] - muval * E1S2I3[t],
E1S2R3'[t] == -E1S2R3c1[t] - E1S2R3c2[t] - E1S2R3c3[t] + S1S2R3c1[t] +
  E1R2R3c2[t] + E1S2I3c3[t] - muval * E1S2R3[t],
E1E2S3'[t] == -E1E2S3c1[t] - E1E2S3c2[t] - E1E2S3c3[t] + S1E2S3c1[t] +
  E1S2S3c2[t] + E1E2R3c3[t] - muval * E1E2S3[t],
E1E2E3'[t] == -E1E2E3c1[t] - E1E2E3c2[t] - E1E2E3c3[t] + S1E2E3c1[t] +
  E1S2E3c2[t] + E1E2S3c3[t] - muval * E1E2E3[t],
E1E2I3'[t] == -E1E2I3c1[t] - E1E2I3c2[t] - E1E2I3c3[t] + S1E2I3c1[t] +
  E1S2I3c2[t] + E1E2E3c3[t] - muval * E1E2I3[t],
E1E2R3'[t] == -E1E2R3c1[t] - E1E2R3c2[t] - E1E2R3c3[t] + S1E2R3c1[t] +
  E1S2R3c2[t] + E1E2I3c3[t] - muval * E1E2R3[t],
E1I2S3'[t] == -E1I2S3c1[t] - E1I2S3c2[t] - E1I2S3c3[t] + S1I2S3c1[t] +
  E1E2S3c2[t] + E1I2R3c3[t] - muval * E1I2S3[t],
E1I2E3'[t] == -E1I2E3c1[t] - E1I2E3c2[t] - E1I2E3c3[t] + S1I2E3c1[t] +
  E1E2E3c2[t] + E1I2S3c3[t] - muval * E1I2E3[t],
E1I2I3'[t] == -E1I2I3c1[t] - E1I2I3c2[t] - E1I2I3c3[t] + S1I2I3c1[t] +
  E1E2I3c2[t] + E1I2E3c3[t] - muval * E1I2I3[t],
E1I2R3'[t] == -E1I2R3c1[t] - E1I2R3c2[t] - E1I2R3c3[t] + S1I2R3c1[t] +
```

```
  E1E2R3c2[t] + E1I2I3c3[t] - muval * E1I2R3[t],
E1R2S3'[t] == -E1R2S3c1[t] - E1R2S3c2[t] - E1R2S3c3[t] + S1R2S3c1[t] +
  E1I2S3c2[t] + E1R2R3c3[t] - muval * E1R2S3[t],
E1R2E3'[t] == -E1R2E3c1[t] - E1R2E3c2[t] - E1R2E3c3[t] + S1R2E3c1[t] +
  E1I2E3c2[t] + E1R2S3c3[t] - muval * E1R2E3[t],
E1R2I3'[t] == -E1R2I3c1[t] - E1R2I3c2[t] - E1R2I3c3[t] + S1R2I3c1[t] +
  E1I2I3c2[t] + E1R2E3c3[t] - muval * E1R2I3[t],
E1R2R3'[t] == -E1R2R3c1[t] - E1R2R3c2[t] - E1R2R3c3[t] + S1R2R3c1[t] +
  E1I2R3c2[t] + E1R2I3c3[t] - muval * E1R2R3[t],
I1S2S3'[t] == -I1S2S3c1[t] - I1S2S3c2[t] - I1S2S3c3[t] + E1S2S3c1[t] +
  I1R2S3c2[t] + I1S2R3c3[t] - muval * I1S2S3[t],
I1S2E3'[t] == -I1S2E3c1[t] - I1S2E3c2[t] - I1S2E3c3[t] + E1S2E3c1[t] +
  I1R2E3c2[t] + I1S2S3c3[t] - muval * I1S2E3[t],
I1S2I3'[t] == -I1S2I3c1[t] - I1S2I3c2[t] - I1S2I3c3[t] + E1S2I3c1[t] +
  I1R2I3c2[t] + I1S2E3c3[t] - muval * I1S2I3[t],
I1S2R3'[t] == -I1S2R3c1[t] - I1S2R3c2[t] - I1S2R3c3[t] + E1S2R3c1[t] +
  I1R2R3c2[t] + I1S2I3c3[t] - muval * I1S2R3[t],
I1E2S3'[t] == -I1E2S3c1[t] - I1E2S3c2[t] - I1E2S3c3[t] + E1E2S3c1[t] +
  I1S2S3c2[t] + I1E2R3c3[t] - muval * I1E2S3[t],
I1E2E3'[t] == -I1E2E3c1[t] - I1E2E3c2[t] - I1E2E3c3[t] + E1E2E3c1[t] +
  I1S2E3c2[t] + I1E2S3c3[t] - muval * I1E2E3[t],
I1E2I3'[t] == -I1E2I3c1[t] - I1E2I3c2[t] - I1E2I3c3[t] + E1E2I3c1[t] +
  I1S2I3c2[t] + I1E2E3c3[t] - muval * I1E2I3[t],
I1E2R3'[t] == -I1E2R3c1[t] - I1E2R3c2[t] - I1E2R3c3[t] + E1E2R3c1[t] +
  I1S2R3c2[t] + I1E2I3c3[t] - muval * I1E2R3[t],
I1I2S3'[t] == -I1I2S3c1[t] - I1I2S3c2[t] - I1I2S3c3[t] + E1I2S3c1[t] +
  I1E2S3c2[t] + I1I2R3c3[t] - muval * I1I2S3[t],
I1I2E3'[t] == -I1I2E3c1[t] - I1I2E3c2[t] - I1I2E3c3[t] + E1I2E3c1[t] +
  I1E2E3c2[t] + I1I2S3c3[t] - muval * I1I2E3[t],
I1I2I3'[t] == -I1I2I3c1[t] - I1I2I3c2[t] - I1I2I3c3[t] + E1I2I3c1[t] +
  I1E2I3c2[t] + I1I2E3c3[t] - muval * I1I2I3[t],
I1I2R3'[t] == -I1I2R3c1[t] - I1I2R3c2[t] - I1I2R3c3[t] + E1I2R3c1[t] +
  I1E2R3c2[t] + I1I2I3c3[t] - muval * I1I2R3[t],
I1R2S3'[t] == -I1R2S3c1[t] - I1R2S3c2[t] - I1R2S3c3[t] + E1R2S3c1[t] +
  I1I2S3c2[t] + I1R2R3c3[t] - muval * I1R2S3[t],
I1R2E3'[t] == -I1R2E3c1[t] - I1R2E3c2[t] - I1R2E3c3[t] + E1R2E3c1[t] +
  I1I2E3c2[t] + I1R2S3c3[t] - muval * I1R2E3[t],
I1R2I3'[t] == -I1R2I3c1[t] - I1R2I3c2[t] - I1R2I3c3[t] + E1R2I3c1[t] +
  I1I2I3c2[t] + I1R2E3c3[t] - muval * I1R2I3[t],
I1R2R3'[t] == -I1R2R3c1[t] - I1R2R3c2[t] - I1R2R3c3[t] + E1R2R3c1[t] +
  I1I2R3c2[t] + I1R2I3c3[t] - muval * I1R2R3[t],
R1S2S3'[t] == -R1S2S3c1[t] - R1S2S3c2[t] - R1S2S3c3[t] + I1S2S3c1[t] +
  R1R2S3c2[t] + R1S2R3c3[t] - muval * R1S2S3[t],
R1S2E3'[t] == -R1S2E3c1[t] - R1S2E3c2[t] - R1S2E3c3[t] + I1S2E3c1[t] +
```

```
  R1R2E3c2[t] + R1S2S3c3[t] - muval * R1S2E3[t],
R1S2I3'[t] == -R1S2I3c1[t] - R1S2I3c2[t] - R1S2I3c3[t] + I1S2I3c1[t] +
  R1R2I3c2[t] + R1S2E3c3[t] - muval * R1S2I3[t],
R1S2R3'[t] == -R1S2R3c1[t] - R1S2R3c2[t] - R1S2R3c3[t] + I1S2R3c1[t] +
  R1R2R3c2[t] + R1S2I3c3[t] - muval * R1S2R3[t],
R1E2S3'[t] == -R1E2S3c1[t] - R1E2S3c2[t] - R1E2S3c3[t] + I1E2S3c1[t] +
  R1S2S3c2[t] + R1E2R3c3[t] - muval * R1E2S3[t],
R1E2E3'[t] == -R1E2E3c1[t] - R1E2E3c2[t] - R1E2E3c3[t] + I1E2E3c1[t] +
  R1S2E3c2[t] + R1E2S3c3[t] - muval * R1E2E3[t],
R1E2I3'[t] == -R1E2I3c1[t] - R1E2I3c2[t] - R1E2I3c3[t] + I1E2I3c1[t] +
  R1S2I3c2[t] + R1E2E3c3[t] - muval * R1E2I3[t],
R1E2R3'[t] == -R1E2R3c1[t] - R1E2R3c2[t] - R1E2R3c3[t] + I1E2R3c1[t] +
  R1S2R3c2[t] + R1E2I3c3[t] - muval * R1E2R3[t],
R1I2S3'[t] == -R1I2S3c1[t] - R1I2S3c2[t] - R1I2S3c3[t] + I1I2S3c1[t] +
  R1E2S3c2[t] + R1I2R3c3[t] - muval * R1I2S3[t],
R1I2E3'[t] == -R1I2E3c1[t] - R1I2E3c2[t] - R1I2E3c3[t] + I1I2E3c1[t] +
  R1E2E3c2[t] + R1I2S3c3[t] - muval * R1I2E3[t],
R1I2I3'[t] == -R1I2I3c1[t] - R1I2I3c2[t] - R1I2I3c3[t] + I1I2I3c1[t] +
  R1E2I3c2[t] + R1I2E3c3[t] - muval * R1I2I3[t],
R1I2R3'[t] == -R1I2R3c1[t] - R1I2R3c2[t] - R1I2R3c3[t] + I1I2R3c1[t] +
  R1E2R3c2[t] + R1I2I3c3[t] - muval * R1I2R3[t],
R1R2S3'[t] == -R1R2S3c1[t] - R1R2S3c2[t] - R1R2S3c3[t] + I1R2S3c1[t] +
  R1I2S3c2[t] + R1R2R3c3[t] - muval * R1R2S3[t],
R1R2E3'[t] == -R1R2E3c1[t] - R1R2E3c2[t] - R1R2E3c3[t] + I1R2E3c1[t] +
  R1I2E3c2[t] + R1R2S3c3[t] - muval * R1R2E3[t],
R1R2I3'[t] == -R1R2I3c1[t] - R1R2I3c2[t] - R1R2I3c3[t] + I1R2I3c1[t] +
  R1I2I3c2[t] + R1R2E3c3[t] - muval * R1R2I3[t],
R1R2R3'[t] == -R1R2R3c1[t] - R1R2R3c2[t] - R1R2R3c3[t] + I1R2R3c1[t] +
  R1I2R3c2[t] + R1R2I3c3[t] - muval * R1R2R3[t],
cuminf'[t] == E1S2S3c1[t] + E1S2E3c1[t] + E1S2I3c1[t] + E1S2R3c1[t] +
  E1E2S3c1[t] + E1E2E3c1[t] + E1E2I3c1[t] + E1E2R3c1[t] + E1I2S3c1[t] +
  E1I2E3c1[t] + E1I2I3c1[t] + E1I2R3c1[t] + E1R2S3c1[t] + E1R2E3c1[t] +
  E1R2I3c1[t] + E1R2R3c1[t] + S1E2S3c2[t] + S1E2E3c2[t] + S1E2I3c2[t] +
  S1E2R3c2[t] + E1E2S3c2[t] + E1E2E3c2[t] + E1E2I3c2[t] + E1E2R3c2[t] +
  I1E2S3c2[t] + I1E2E3c2[t] + I1E2I3c2[t] + I1E2R3c2[t] + R1E2S3c2[t] +
  R1E2E3c2[t] + R1E2I3c2[t] + R1E2R3c2[t] + S1S2E3c3[t] + S1E2E3c3[t] +
  S1I2E3c3[t] + S1R2E3c3[t] + E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] +
  E1R2E3c3[t] + I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
  R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
S1S2S3[0] == 1, S1S2E3[0] == 0, S1S2I3[0] == 0, S1S2R3[0] == 0, S1E2S3[0] == 0,
S1E2E3[0] == 0, S1E2I3[0] == 0, S1E2R3[0] == 0, S1I2S3[0] == 0, S1I2E3[0] == 0,
S1I2I3[0] == 0, S1I2R3[0] == 0, S1R2S3[0] == 0, S1R2E3[0] == 0, S1R2I3[0] == 0,
S1R2R3[0] == 0, E1S2S3[0] == 0, E1S2E3[0] == 0, E1S2I3[0] == 0, E1S2R3[0] == 0,
E1E2S3[0] == 0, E1E2E3[0] == 0, E1E2I3[0] == 0, E1E2R3[0] == 0, E1I2S3[0] == 0,
```

```
  E1I2E3[0] == 0, E1I2I3[0] == 0, E1I2R3[0] == 0, E1R2S3[0] == 0, E1R2E3[0] == 0,
  E1R2I3[0] == 0, E1R2R3[0] == 0, I1S2S3[0] == 0, I1S2E3[0] == 0, I1S2I3[0] == 0,
  I1S2R3[0] == 0, I1E2S3[0] == 0, I1E2E3[0] == 0, I1E2I3[0] == 0, I1E2R3[0] == 0,
  I1I2S3[0] == 0, I1I2E3[0] == 0, I1I2I3[0] == 0, I1I2R3[0] == 0, I1R2S3[0] == 0,
  I1R2E3[0] == 0, I1R2I3[0] == 0, I1R2R3[0] == 0, R1S2S3[0] == 0, R1S2E3[0] == 0,
  R1S2I3[0] == 0, R1S2R3[0] == 0, R1E2S3[0] == 0, R1E2E3[0] == 0, R1E2I3[0] == 0,
  R1E2R3[0] == 0, R1I2S3[0] == 0, R1I2E3[0] == 0, R1I2I3[0] == 0, R1I2R3[0] == 0,
  R1R2S3[0] == 0, R1R2E3[0] == 0, R1R2I3[0] == 0, R1R2R3[0] == 0, cuminf[0] == 0},
 {S1S2S3, S1S2E3, S1S2I3, S1S2R3, S1E2S3, S1E2E3, S1E2I3, S1E2R3, S1I2S3,
  S1I2E3, S1I2I3, S1I2R3, S1R2S3, S1R2E3, S1R2I3, S1R2R3, E1S2S3, E1S2E3, E1S2I3,
  E1S2R3, E1E2S3, E1E2E3, E1E2I3, E1E2R3, E1I2S3, E1I2E3, E1I2I3, E1I2R3, E1R2S3,
  E1R2E3, E1R2I3, E1R2R3, I1S2S3, I1S2E3, I1S2I3, I1S2R3, I1E2S3, I1E2E3,
  I1E2I3, I1E2R3, I1I2S3, I1I2E3, I1I2I3, I1I2R3, I1R2S3, I1R2E3, I1R2I3,
  I1R2R3, R1S2S3, R1S2E3, R1S2I3, R1S2R3, R1E2S3, R1E2E3, R1E2I3, R1E2R3,
  R1I2S3, R1I2E3, R1I2I3, R1I2R3, R1R2S3, R1R2E3, R1R2I3, R1R2R3, cuminf},
 {t, 0, tmax}
];
```

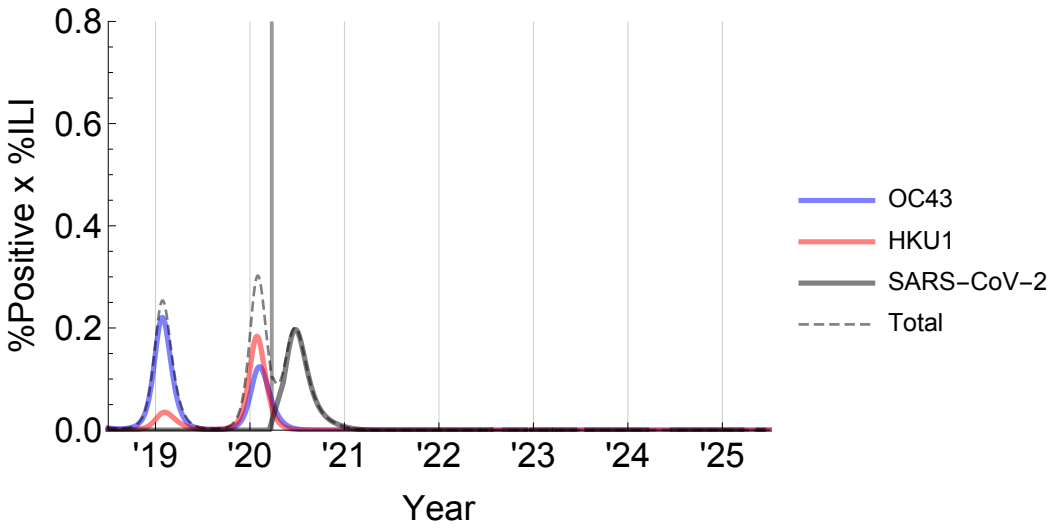
Plot output:

```
In[•]:= figinvasion =
  Plot[{Evaluate[{{100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t])},
       {100 * scalingfactor * (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] +
          E1I2S3[t] + E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t])},
       {100 * scalingfactor * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] +
          E1S2I3[t] + E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] +
          I1I2I3[t] + I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t])},
       {100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t] +
          S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] +
          E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] +
          R1I2R3[t] + S1S2I3[t] + S1E2I3[t] + S1R2I3[t] + E1S2I3[t] +
          E1E2I3[t] + E1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1R2I3[t])
       }} /. sol]}, Join[{t}, plotwindow], PlotRange → {0, plotrangemax},
    GridLines → {Join[Table[{i, yearbarchar}, {i, 0, tmax, 52}],
       {{importtime3, importbarchar}}], None},
    Frame → {True, True, False, False}, PlotRangePadding → None,
    BaseStyle → FontSize → fs,
    FrameTicks → {Table[{i, "'" <> ToString[i / 52 - 2]}, {i, 0, tmax, 52}], Automatic},
    FrameLabel → {"Year", "%Positive x %ILI"}, ImageSize → imsz,
    PlotLegends → {"OC43", "HKU1", "SARS-CoV-2", "Total"},
    PlotStyle → {oc43char, hku1char, ncovchar, totalchar}];
```

Save output:

In[•]:=
```
figinvasion
```

Out[•]=



30/0 | 40 | w12:

Define parameter values:

In[•]:=
```
chi31val = 0.3;
chi32val = 0.3;
chi13val = 0;
chi23val = 0;
sigma3val = 1 / 40;
importtime3 = 52 * 22 + 12;
```

Run the model:

In[•]:=
```
sol = NDSolve[
    {S1S2S3'[t] == -S1S2S3c1[t] - S1S2S3c2[t] - S1S2S3c3[t] +
       R1S2S3c1[t] + S1R2S3c2[t] + S1S2R3c3[t] - muval * S1S2S3[t] + muval,
     S1S2E3'[t] == -S1S2E3c1[t] - S1S2E3c2[t] - S1S2E3c3[t] + R1S2E3c1[t] +
       S1R2E3c2[t] + S1S2S3c3[t] - muval * S1S2E3[t],
     S1S2I3'[t] == -S1S2I3c1[t] - S1S2I3c2[t] - S1S2I3c3[t] + R1S2I3c1[t] +
       S1R2I3c2[t] + S1S2E3c3[t] - muval * S1S2I3[t],
     S1S2R3'[t] == -S1S2R3c1[t] - S1S2R3c2[t] - S1S2R3c3[t] + R1S2R3c1[t] +
       S1R2R3c2[t] + S1S2I3c3[t] - muval * S1S2R3[t],
     S1E2S3'[t] == -S1E2S3c1[t] - S1E2S3c2[t] - S1E2S3c3[t] + R1E2S3c1[t] +
       S1S2S3c2[t] + S1E2R3c3[t] - muval * S1E2S3[t],
     S1E2E3'[t] == -S1E2E3c1[t] - S1E2E3c2[t] - S1E2E3c3[t] + R1E2E3c1[t] +
```

```
  S1S2E3c2[t] + S1E2S3c3[t] - muval * S1E2E3[t],
S1E2I3'[t] == -S1E2I3c1[t] - S1E2I3c2[t] - S1E2I3c3[t] + R1E2I3c1[t] +
  S1S2I3c2[t] + S1E2E3c3[t] - muval * S1E2I3[t],
S1E2R3'[t] == -S1E2R3c1[t] - S1E2R3c2[t] - S1E2R3c3[t] + R1E2R3c1[t] +
  S1S2R3c2[t] + S1E2I3c3[t] - muval * S1E2R3[t],
S1I2S3'[t] == -S1I2S3c1[t] - S1I2S3c2[t] - S1I2S3c3[t] + R1I2S3c1[t] +
  S1E2S3c2[t] + S1I2R3c3[t] - muval * S1I2S3[t],
S1I2E3'[t] == -S1I2E3c1[t] - S1I2E3c2[t] - S1I2E3c3[t] + R1I2E3c1[t] +
  S1E2E3c2[t] + S1I2S3c3[t] - muval * S1I2E3[t],
S1I2I3'[t] == -S1I2I3c1[t] - S1I2I3c2[t] - S1I2I3c3[t] + R1I2I3c1[t] +
  S1E2I3c2[t] + S1I2E3c3[t] - muval * S1I2I3[t],
S1I2R3'[t] == -S1I2R3c1[t] - S1I2R3c2[t] - S1I2R3c3[t] + R1I2R3c1[t] +
  S1E2R3c2[t] + S1I2I3c3[t] - muval * S1I2R3[t],
S1R2S3'[t] == -S1R2S3c1[t] - S1R2S3c2[t] - S1R2S3c3[t] + R1R2S3c1[t] +
  S1I2S3c2[t] + S1R2R3c3[t] - muval * S1R2S3[t],
S1R2E3'[t] == -S1R2E3c1[t] - S1R2E3c2[t] - S1R2E3c3[t] + R1R2E3c1[t] +
  S1I2E3c2[t] + S1R2S3c3[t] - muval * S1R2E3[t],
S1R2I3'[t] == -S1R2I3c1[t] - S1R2I3c2[t] - S1R2I3c3[t] + R1R2I3c1[t] +
  S1I2I3c2[t] + S1R2E3c3[t] - muval * S1R2I3[t],
S1R2R3'[t] == -S1R2R3c1[t] - S1R2R3c2[t] - S1R2R3c3[t] + R1R2R3c1[t] +
  S1I2R3c2[t] + S1R2I3c3[t] - muval * S1R2R3[t],
E1S2S3'[t] == -E1S2S3c1[t] - E1S2S3c2[t] - E1S2S3c3[t] + S1S2S3c1[t] +
  E1R2S3c2[t] + E1S2R3c3[t] - muval * E1S2S3[t],
E1S2E3'[t] == -E1S2E3c1[t] - E1S2E3c2[t] - E1S2E3c3[t] + S1S2E3c1[t] +
  E1R2E3c2[t] + E1S2S3c3[t] - muval * E1S2E3[t],
E1S2I3'[t] == -E1S2I3c1[t] - E1S2I3c2[t] - E1S2I3c3[t] + S1S2I3c1[t] +
  E1R2I3c2[t] + E1S2E3c3[t] - muval * E1S2I3[t],
E1S2R3'[t] == -E1S2R3c1[t] - E1S2R3c2[t] - E1S2R3c3[t] + S1S2R3c1[t] +
  E1R2R3c2[t] + E1S2I3c3[t] - muval * E1S2R3[t],
E1E2S3'[t] == -E1E2S3c1[t] - E1E2S3c2[t] - E1E2S3c3[t] + S1E2S3c1[t] +
  E1S2S3c2[t] + E1E2R3c3[t] - muval * E1E2S3[t],
E1E2E3'[t] == -E1E2E3c1[t] - E1E2E3c2[t] - E1E2E3c3[t] + S1E2E3c1[t] +
  E1S2E3c2[t] + E1E2S3c3[t] - muval * E1E2E3[t],
E1E2I3'[t] == -E1E2I3c1[t] - E1E2I3c2[t] - E1E2I3c3[t] + S1E2I3c1[t] +
  E1S2I3c2[t] + E1E2E3c3[t] - muval * E1E2I3[t],
E1E2R3'[t] == -E1E2R3c1[t] - E1E2R3c2[t] - E1E2R3c3[t] + S1E2R3c1[t] +
  E1S2R3c2[t] + E1E2I3c3[t] - muval * E1E2R3[t],
E1I2S3'[t] == -E1I2S3c1[t] - E1I2S3c2[t] - E1I2S3c3[t] + S1I2S3c1[t] +
  E1E2S3c2[t] + E1I2R3c3[t] - muval * E1I2S3[t],
E1I2E3'[t] == -E1I2E3c1[t] - E1I2E3c2[t] - E1I2E3c3[t] + S1I2E3c1[t] +
  E1E2E3c2[t] + E1I2S3c3[t] - muval * E1I2E3[t],
E1I2I3'[t] == -E1I2I3c1[t] - E1I2I3c2[t] - E1I2I3c3[t] + S1I2I3c1[t] +
  E1E2I3c2[t] + E1I2E3c3[t] - muval * E1I2I3[t],
E1I2R3'[t] == -E1I2R3c1[t] - E1I2R3c2[t] - E1I2R3c3[t] + S1I2R3c1[t] +
```

```
  E1E2R3c2[t] + E1I2I3c3[t] - muval * E1I2R3[t],
E1R2S3'[t] == -E1R2S3c1[t] - E1R2S3c2[t] - E1R2S3c3[t] + S1R2S3c1[t] +
  E1I2S3c2[t] + E1R2R3c3[t] - muval * E1R2S3[t],
E1R2E3'[t] == -E1R2E3c1[t] - E1R2E3c2[t] - E1R2E3c3[t] + S1R2E3c1[t] +
  E1I2E3c2[t] + E1R2S3c3[t] - muval * E1R2E3[t],
E1R2I3'[t] == -E1R2I3c1[t] - E1R2I3c2[t] - E1R2I3c3[t] + S1R2I3c1[t] +
  E1I2I3c2[t] + E1R2E3c3[t] - muval * E1R2I3[t],
E1R2R3'[t] == -E1R2R3c1[t] - E1R2R3c2[t] - E1R2R3c3[t] + S1R2R3c1[t] +
  E1I2R3c2[t] + E1R2I3c3[t] - muval * E1R2R3[t],
I1S2S3'[t] == -I1S2S3c1[t] - I1S2S3c2[t] - I1S2S3c3[t] + E1S2S3c1[t] +
  I1R2S3c2[t] + I1S2R3c3[t] - muval * I1S2S3[t],
I1S2E3'[t] == -I1S2E3c1[t] - I1S2E3c2[t] - I1S2E3c3[t] + E1S2E3c1[t] +
  I1R2E3c2[t] + I1S2S3c3[t] - muval * I1S2E3[t],
I1S2I3'[t] == -I1S2I3c1[t] - I1S2I3c2[t] - I1S2I3c3[t] + E1S2I3c1[t] +
  I1R2I3c2[t] + I1S2E3c3[t] - muval * I1S2I3[t],
I1S2R3'[t] == -I1S2R3c1[t] - I1S2R3c2[t] - I1S2R3c3[t] + E1S2R3c1[t] +
  I1R2R3c2[t] + I1S2I3c3[t] - muval * I1S2R3[t],
I1E2S3'[t] == -I1E2S3c1[t] - I1E2S3c2[t] - I1E2S3c3[t] + E1E2S3c1[t] +
  I1S2S3c2[t] + I1E2R3c3[t] - muval * I1E2S3[t],
I1E2E3'[t] == -I1E2E3c1[t] - I1E2E3c2[t] - I1E2E3c3[t] + E1E2E3c1[t] +
  I1S2E3c2[t] + I1E2S3c3[t] - muval * I1E2E3[t],
I1E2I3'[t] == -I1E2I3c1[t] - I1E2I3c2[t] - I1E2I3c3[t] + E1E2I3c1[t] +
  I1S2I3c2[t] + I1E2E3c3[t] - muval * I1E2I3[t],
I1E2R3'[t] == -I1E2R3c1[t] - I1E2R3c2[t] - I1E2R3c3[t] + E1E2R3c1[t] +
  I1S2R3c2[t] + I1E2I3c3[t] - muval * I1E2R3[t],
I1I2S3'[t] == -I1I2S3c1[t] - I1I2S3c2[t] - I1I2S3c3[t] + E1I2S3c1[t] +
  I1E2S3c2[t] + I1I2R3c3[t] - muval * I1I2S3[t],
I1I2E3'[t] == -I1I2E3c1[t] - I1I2E3c2[t] - I1I2E3c3[t] + E1I2E3c1[t] +
  I1E2E3c2[t] + I1I2S3c3[t] - muval * I1I2E3[t],
I1I2I3'[t] == -I1I2I3c1[t] - I1I2I3c2[t] - I1I2I3c3[t] + E1I2I3c1[t] +
  I1E2I3c2[t] + I1I2E3c3[t] - muval * I1I2I3[t],
I1I2R3'[t] == -I1I2R3c1[t] - I1I2R3c2[t] - I1I2R3c3[t] + E1I2R3c1[t] +
  I1E2R3c2[t] + I1I2I3c3[t] - muval * I1I2R3[t],
I1R2S3'[t] == -I1R2S3c1[t] - I1R2S3c2[t] - I1R2S3c3[t] + E1R2S3c1[t] +
  I1I2S3c2[t] + I1R2R3c3[t] - muval * I1R2S3[t],
I1R2E3'[t] == -I1R2E3c1[t] - I1R2E3c2[t] - I1R2E3c3[t] + E1R2E3c1[t] +
  I1I2E3c2[t] + I1R2S3c3[t] - muval * I1R2E3[t],
I1R2I3'[t] == -I1R2I3c1[t] - I1R2I3c2[t] - I1R2I3c3[t] + E1R2I3c1[t] +
  I1I2I3c2[t] + I1R2E3c3[t] - muval * I1R2I3[t],
I1R2R3'[t] == -I1R2R3c1[t] - I1R2R3c2[t] - I1R2R3c3[t] + E1R2R3c1[t] +
  I1I2R3c2[t] + I1R2I3c3[t] - muval * I1R2R3[t],
R1S2S3'[t] == -R1S2S3c1[t] - R1S2S3c2[t] - R1S2S3c3[t] + I1S2S3c1[t] +
  R1R2S3c2[t] + R1S2R3c3[t] - muval * R1S2S3[t],
R1S2E3'[t] == -R1S2E3c1[t] - R1S2E3c2[t] - R1S2E3c3[t] + I1S2E3c1[t] +
```

```
  R1R2E3c2[t] + R1S2S3c3[t] - muval * R1S2E3[t],
R1S2I3'[t] == -R1S2I3c1[t] - R1S2I3c2[t] - R1S2I3c3[t] + I1S2I3c1[t] +
  R1R2I3c2[t] + R1S2E3c3[t] - muval * R1S2I3[t],
R1S2R3'[t] == -R1S2R3c1[t] - R1S2R3c2[t] - R1S2R3c3[t] + I1S2R3c1[t] +
  R1R2R3c2[t] + R1S2I3c3[t] - muval * R1S2R3[t],
R1E2S3'[t] == -R1E2S3c1[t] - R1E2S3c2[t] - R1E2S3c3[t] + I1E2S3c1[t] +
  R1S2S3c2[t] + R1E2R3c3[t] - muval * R1E2S3[t],
R1E2E3'[t] == -R1E2E3c1[t] - R1E2E3c2[t] - R1E2E3c3[t] + I1E2E3c1[t] +
  R1S2E3c2[t] + R1E2S3c3[t] - muval * R1E2E3[t],
R1E2I3'[t] == -R1E2I3c1[t] - R1E2I3c2[t] - R1E2I3c3[t] + I1E2I3c1[t] +
  R1S2I3c2[t] + R1E2E3c3[t] - muval * R1E2I3[t],
R1E2R3'[t] == -R1E2R3c1[t] - R1E2R3c2[t] - R1E2R3c3[t] + I1E2R3c1[t] +
  R1S2R3c2[t] + R1E2I3c3[t] - muval * R1E2R3[t],
R1I2S3'[t] == -R1I2S3c1[t] - R1I2S3c2[t] - R1I2S3c3[t] + I1I2S3c1[t] +
  R1E2S3c2[t] + R1I2R3c3[t] - muval * R1I2S3[t],
R1I2E3'[t] == -R1I2E3c1[t] - R1I2E3c2[t] - R1I2E3c3[t] + I1I2E3c1[t] +
  R1E2E3c2[t] + R1I2S3c3[t] - muval * R1I2E3[t],
R1I2I3'[t] == -R1I2I3c1[t] - R1I2I3c2[t] - R1I2I3c3[t] + I1I2I3c1[t] +
  R1E2I3c2[t] + R1I2E3c3[t] - muval * R1I2I3[t],
R1I2R3'[t] == -R1I2R3c1[t] - R1I2R3c2[t] - R1I2R3c3[t] + I1I2R3c1[t] +
  R1E2R3c2[t] + R1I2I3c3[t] - muval * R1I2R3[t],
R1R2S3'[t] == -R1R2S3c1[t] - R1R2S3c2[t] - R1R2S3c3[t] + I1R2S3c1[t] +
  R1I2S3c2[t] + R1R2R3c3[t] - muval * R1R2S3[t],
R1R2E3'[t] == -R1R2E3c1[t] - R1R2E3c2[t] - R1R2E3c3[t] + I1R2E3c1[t] +
  R1I2E3c2[t] + R1R2S3c3[t] - muval * R1R2E3[t],
R1R2I3'[t] == -R1R2I3c1[t] - R1R2I3c2[t] - R1R2I3c3[t] + I1R2I3c1[t] +
  R1I2I3c2[t] + R1R2E3c3[t] - muval * R1R2I3[t],
R1R2R3'[t] == -R1R2R3c1[t] - R1R2R3c2[t] - R1R2R3c3[t] + I1R2R3c1[t] +
  R1I2R3c2[t] + R1R2I3c3[t] - muval * R1R2R3[t],
cuminf'[t] == E1S2S3c1[t] + E1S2E3c1[t] + E1S2I3c1[t] + E1S2R3c1[t] +
  E1E2S3c1[t] + E1E2E3c1[t] + E1E2I3c1[t] + E1E2R3c1[t] + E1I2S3c1[t] +
  E1I2E3c1[t] + E1I2I3c1[t] + E1I2R3c1[t] + E1R2S3c1[t] + E1R2E3c1[t] +
  E1R2I3c1[t] + E1R2R3c1[t] + S1E2S3c2[t] + S1E2E3c2[t] + S1E2I3c2[t] +
  S1E2R3c2[t] + E1E2S3c2[t] + E1E2E3c2[t] + E1E2I3c2[t] + E1E2R3c2[t] +
  I1E2S3c2[t] + I1E2E3c2[t] + I1E2I3c2[t] + I1E2R3c2[t] + R1E2S3c2[t] +
  R1E2E3c2[t] + R1E2I3c2[t] + R1E2R3c2[t] + S1S2E3c3[t] + S1E2E3c3[t] +
  S1I2E3c3[t] + S1R2E3c3[t] + E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] +
  E1R2E3c3[t] + I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
  R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
S1S2S3[0] == 1, S1S2E3[0] == 0, S1S2I3[0] == 0, S1S2R3[0] == 0, S1E2S3[0] == 0,
S1E2E3[0] == 0, S1E2I3[0] == 0, S1E2R3[0] == 0, S1I2S3[0] == 0, S1I2E3[0] == 0,
S1I2I3[0] == 0, S1I2R3[0] == 0, S1R2S3[0] == 0, S1R2E3[0] == 0, S1R2I3[0] == 0,
S1R2R3[0] == 0, E1S2S3[0] == 0, E1S2E3[0] == 0, E1S2I3[0] == 0, E1S2R3[0] == 0,
E1E2S3[0] == 0, E1E2E3[0] == 0, E1E2I3[0] == 0, E1E2R3[0] == 0, E1I2S3[0] == 0,
```

```
  E1I2E3[0] == 0, E1I2I3[0] == 0, E1I2R3[0] == 0, E1R2S3[0] == 0, E1R2E3[0] == 0,
  E1R2I3[0] == 0, E1R2R3[0] == 0, I1S2S3[0] == 0, I1S2E3[0] == 0, I1S2I3[0] == 0,
  I1S2R3[0] == 0, I1E2S3[0] == 0, I1E2E3[0] == 0, I1E2I3[0] == 0, I1E2R3[0] == 0,
  I1I2S3[0] == 0, I1I2E3[0] == 0, I1I2I3[0] == 0, I1I2R3[0] == 0, I1R2S3[0] == 0,
  I1R2E3[0] == 0, I1R2I3[0] == 0, I1R2R3[0] == 0, R1S2S3[0] == 0, R1S2E3[0] == 0,
  R1S2I3[0] == 0, R1S2R3[0] == 0, R1E2S3[0] == 0, R1E2E3[0] == 0, R1E2I3[0] == 0,
  R1E2R3[0] == 0, R1I2S3[0] == 0, R1I2E3[0] == 0, R1I2I3[0] == 0, R1I2R3[0] == 0,
  R1R2S3[0] == 0, R1R2E3[0] == 0, R1R2I3[0] == 0, R1R2R3[0] == 0, cuminf[0] == 0},
 {S1S2S3, S1S2E3, S1S2I3, S1S2R3, S1E2S3, S1E2E3, S1E2I3, S1E2R3, S1I2S3,
  S1I2E3, S1I2I3, S1I2R3, S1R2S3, S1R2E3, S1R2I3, S1R2R3, E1S2S3, E1S2E3, E1S2I3,
  E1S2R3, E1E2S3, E1E2E3, E1E2I3, E1E2R3, E1I2S3, E1I2E3, E1I2I3, E1I2R3, E1R2S3,
  E1R2E3, E1R2I3, E1R2R3, I1S2S3, I1S2E3, I1S2I3, I1S2R3, I1E2S3, I1E2E3,
  I1E2I3, I1E2R3, I1I2S3, I1I2E3, I1I2I3, I1I2R3, I1R2S3, I1R2E3, I1R2I3,
  I1R2R3, R1S2S3, R1S2E3, R1S2I3, R1S2R3, R1E2S3, R1E2E3, R1E2I3, R1E2R3,
  R1I2S3, R1I2E3, R1I2I3, R1I2R3, R1R2S3, R1R2E3, R1R2I3, R1R2R3, cuminf},
 {t, 0, tmax}
];
```

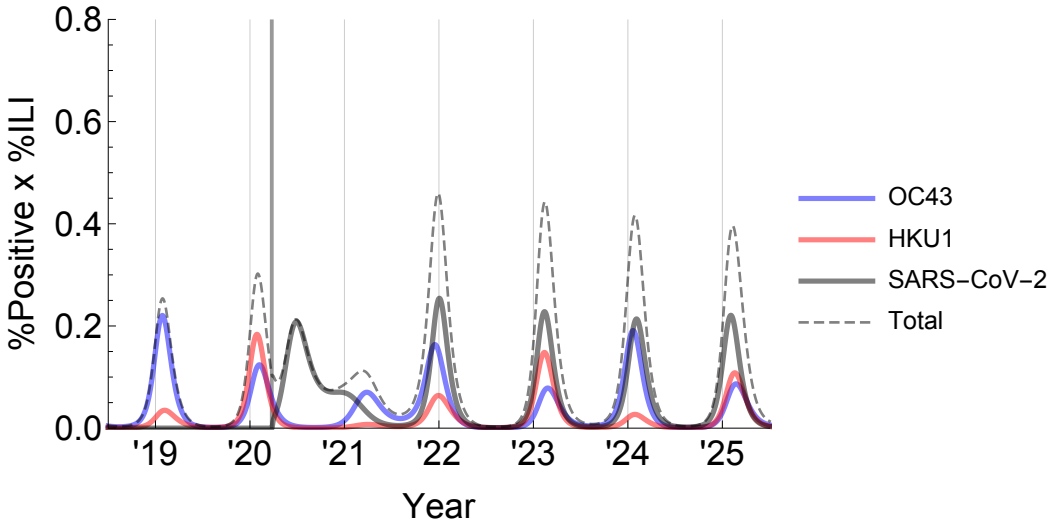
Plot output:

```
In[•]:= figinvasion =
  Plot[{Evaluate[{{100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t])},
       {100 * scalingfactor * (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] +
          E1I2S3[t] + E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t])},
       {100 * scalingfactor * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] +
          E1S2I3[t] + E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] +
          I1I2I3[t] + I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t])},
       {100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t] +
          S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] +
          E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] +
          R1I2R3[t] + S1S2I3[t] + S1E2I3[t] + S1R2I3[t] + E1S2I3[t] +
          E1E2I3[t] + E1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1R2I3[t])
       }} /. sol]}, Join[{t}, plotwindow], PlotRange → {0, plotrangemax},
    GridLines → {Join[Table[{i, yearbarchar}, {i, 0, tmax, 52}],
       {{importtime3, importbarchar}}], None},
    Frame → {True, True, False, False}, PlotRangePadding → None,
    BaseStyle → FontSize → fs,
    FrameTicks → {Table[{i, "'" <> ToString[i / 52 - 2]}, {i, 0, tmax, 52}], Automatic},
    FrameLabel → {"Year", "%Positive x %ILI"}, ImageSize → imsz,
    PlotLegends → {"OC43", "HKU1", "SARS-CoV-2", "Total"},
    PlotStyle → {oc43char, hku1char, ncovchar, totalchar}];
```

Save output:

In[•]:=
```
figinvasion
```

Out[•]=



30/0 | 40 | w36:

Define parameter values:

In[•]:=
```
chi31val = 0.3;
chi32val = 0.3;
chi13val = 0;
chi23val = 0;
sigma3val = 1 / 40;
importtime3 = 52 * 22 + 36;
```

Run the model:

In[•]:=
```
sol = NDSolve[
    {S1S2S3'[t] == -S1S2S3c1[t] - S1S2S3c2[t] - S1S2S3c3[t] +
       R1S2S3c1[t] + S1R2S3c2[t] + S1S2R3c3[t] - muval * S1S2S3[t] + muval,
     S1S2E3'[t] == -S1S2E3c1[t] - S1S2E3c2[t] - S1S2E3c3[t] + R1S2E3c1[t] +
       S1R2E3c2[t] + S1S2S3c3[t] - muval * S1S2E3[t],
     S1S2I3'[t] == -S1S2I3c1[t] - S1S2I3c2[t] - S1S2I3c3[t] + R1S2I3c1[t] +
       S1R2I3c2[t] + S1S2E3c3[t] - muval * S1S2I3[t],
     S1S2R3'[t] == -S1S2R3c1[t] - S1S2R3c2[t] - S1S2R3c3[t] + R1S2R3c1[t] +
       S1R2R3c2[t] + S1S2I3c3[t] - muval * S1S2R3[t],
     S1E2S3'[t] == -S1E2S3c1[t] - S1E2S3c2[t] - S1E2S3c3[t] + R1E2S3c1[t] +
       S1S2S3c2[t] + S1E2R3c3[t] - muval * S1E2S3[t],
     S1E2E3'[t] == -S1E2E3c1[t] - S1E2E3c2[t] - S1E2E3c3[t] + R1E2E3c1[t] +
```

```
  S1S2E3c2[t] + S1E2S3c3[t] - muval * S1E2E3[t],
S1E2I3'[t] == -S1E2I3c1[t] - S1E2I3c2[t] - S1E2I3c3[t] + R1E2I3c1[t] +
  S1S2I3c2[t] + S1E2E3c3[t] - muval * S1E2I3[t],
S1E2R3'[t] == -S1E2R3c1[t] - S1E2R3c2[t] - S1E2R3c3[t] + R1E2R3c1[t] +
  S1S2R3c2[t] + S1E2I3c3[t] - muval * S1E2R3[t],
S1I2S3'[t] == -S1I2S3c1[t] - S1I2S3c2[t] - S1I2S3c3[t] + R1I2S3c1[t] +
  S1E2S3c2[t] + S1I2R3c3[t] - muval * S1I2S3[t],
S1I2E3'[t] == -S1I2E3c1[t] - S1I2E3c2[t] - S1I2E3c3[t] + R1I2E3c1[t] +
  S1E2E3c2[t] + S1I2S3c3[t] - muval * S1I2E3[t],
S1I2I3'[t] == -S1I2I3c1[t] - S1I2I3c2[t] - S1I2I3c3[t] + R1I2I3c1[t] +
  S1E2I3c2[t] + S1I2E3c3[t] - muval * S1I2I3[t],
S1I2R3'[t] == -S1I2R3c1[t] - S1I2R3c2[t] - S1I2R3c3[t] + R1I2R3c1[t] +
  S1E2R3c2[t] + S1I2I3c3[t] - muval * S1I2R3[t],
S1R2S3'[t] == -S1R2S3c1[t] - S1R2S3c2[t] - S1R2S3c3[t] + R1R2S3c1[t] +
  S1I2S3c2[t] + S1R2R3c3[t] - muval * S1R2S3[t],
S1R2E3'[t] == -S1R2E3c1[t] - S1R2E3c2[t] - S1R2E3c3[t] + R1R2E3c1[t] +
  S1I2E3c2[t] + S1R2S3c3[t] - muval * S1R2E3[t],
S1R2I3'[t] == -S1R2I3c1[t] - S1R2I3c2[t] - S1R2I3c3[t] + R1R2I3c1[t] +
  S1I2I3c2[t] + S1R2E3c3[t] - muval * S1R2I3[t],
S1R2R3'[t] == -S1R2R3c1[t] - S1R2R3c2[t] - S1R2R3c3[t] + R1R2R3c1[t] +
  S1I2R3c2[t] + S1R2I3c3[t] - muval * S1R2R3[t],
E1S2S3'[t] == -E1S2S3c1[t] - E1S2S3c2[t] - E1S2S3c3[t] + S1S2S3c1[t] +
  E1R2S3c2[t] + E1S2R3c3[t] - muval * E1S2S3[t],
E1S2E3'[t] == -E1S2E3c1[t] - E1S2E3c2[t] - E1S2E3c3[t] + S1S2E3c1[t] +
  E1R2E3c2[t] + E1S2S3c3[t] - muval * E1S2E3[t],
E1S2I3'[t] == -E1S2I3c1[t] - E1S2I3c2[t] - E1S2I3c3[t] + S1S2I3c1[t] +
  E1R2I3c2[t] + E1S2E3c3[t] - muval * E1S2I3[t],
E1S2R3'[t] == -E1S2R3c1[t] - E1S2R3c2[t] - E1S2R3c3[t] + S1S2R3c1[t] +
  E1R2R3c2[t] + E1S2I3c3[t] - muval * E1S2R3[t],
E1E2S3'[t] == -E1E2S3c1[t] - E1E2S3c2[t] - E1E2S3c3[t] + S1E2S3c1[t] +
  E1S2S3c2[t] + E1E2R3c3[t] - muval * E1E2S3[t],
E1E2E3'[t] == -E1E2E3c1[t] - E1E2E3c2[t] - E1E2E3c3[t] + S1E2E3c1[t] +
  E1S2E3c2[t] + E1E2S3c3[t] - muval * E1E2E3[t],
E1E2I3'[t] == -E1E2I3c1[t] - E1E2I3c2[t] - E1E2I3c3[t] + S1E2I3c1[t] +
  E1S2I3c2[t] + E1E2E3c3[t] - muval * E1E2I3[t],
E1E2R3'[t] == -E1E2R3c1[t] - E1E2R3c2[t] - E1E2R3c3[t] + S1E2R3c1[t] +
  E1S2R3c2[t] + E1E2I3c3[t] - muval * E1E2R3[t],
E1I2S3'[t] == -E1I2S3c1[t] - E1I2S3c2[t] - E1I2S3c3[t] + S1I2S3c1[t] +
  E1E2S3c2[t] + E1I2R3c3[t] - muval * E1I2S3[t],
E1I2E3'[t] == -E1I2E3c1[t] - E1I2E3c2[t] - E1I2E3c3[t] + S1I2E3c1[t] +
  E1E2E3c2[t] + E1I2S3c3[t] - muval * E1I2E3[t],
E1I2I3'[t] == -E1I2I3c1[t] - E1I2I3c2[t] - E1I2I3c3[t] + S1I2I3c1[t] +
  E1E2I3c2[t] + E1I2E3c3[t] - muval * E1I2I3[t],
E1I2R3'[t] == -E1I2R3c1[t] - E1I2R3c2[t] - E1I2R3c3[t] + S1I2R3c1[t] +
```

```
  E1E2R3c2[t] + E1I2I3c3[t] - muval * E1I2R3[t],
E1R2S3'[t] == -E1R2S3c1[t] - E1R2S3c2[t] - E1R2S3c3[t] + S1R2S3c1[t] +
  E1I2S3c2[t] + E1R2R3c3[t] - muval * E1R2S3[t],
E1R2E3'[t] == -E1R2E3c1[t] - E1R2E3c2[t] - E1R2E3c3[t] + S1R2E3c1[t] +
  E1I2E3c2[t] + E1R2S3c3[t] - muval * E1R2E3[t],
E1R2I3'[t] == -E1R2I3c1[t] - E1R2I3c2[t] - E1R2I3c3[t] + S1R2I3c1[t] +
  E1I2I3c2[t] + E1R2E3c3[t] - muval * E1R2I3[t],
E1R2R3'[t] == -E1R2R3c1[t] - E1R2R3c2[t] - E1R2R3c3[t] + S1R2R3c1[t] +
  E1I2R3c2[t] + E1R2I3c3[t] - muval * E1R2R3[t],
I1S2S3'[t] == -I1S2S3c1[t] - I1S2S3c2[t] - I1S2S3c3[t] + E1S2S3c1[t] +
  I1R2S3c2[t] + I1S2R3c3[t] - muval * I1S2S3[t],
I1S2E3'[t] == -I1S2E3c1[t] - I1S2E3c2[t] - I1S2E3c3[t] + E1S2E3c1[t] +
  I1R2E3c2[t] + I1S2S3c3[t] - muval * I1S2E3[t],
I1S2I3'[t] == -I1S2I3c1[t] - I1S2I3c2[t] - I1S2I3c3[t] + E1S2I3c1[t] +
  I1R2I3c2[t] + I1S2E3c3[t] - muval * I1S2I3[t],
I1S2R3'[t] == -I1S2R3c1[t] - I1S2R3c2[t] - I1S2R3c3[t] + E1S2R3c1[t] +
  I1R2R3c2[t] + I1S2I3c3[t] - muval * I1S2R3[t],
I1E2S3'[t] == -I1E2S3c1[t] - I1E2S3c2[t] - I1E2S3c3[t] + E1E2S3c1[t] +
  I1S2S3c2[t] + I1E2R3c3[t] - muval * I1E2S3[t],
I1E2E3'[t] == -I1E2E3c1[t] - I1E2E3c2[t] - I1E2E3c3[t] + E1E2E3c1[t] +
  I1S2E3c2[t] + I1E2S3c3[t] - muval * I1E2E3[t],
I1E2I3'[t] == -I1E2I3c1[t] - I1E2I3c2[t] - I1E2I3c3[t] + E1E2I3c1[t] +
  I1S2I3c2[t] + I1E2E3c3[t] - muval * I1E2I3[t],
I1E2R3'[t] == -I1E2R3c1[t] - I1E2R3c2[t] - I1E2R3c3[t] + E1E2R3c1[t] +
  I1S2R3c2[t] + I1E2I3c3[t] - muval * I1E2R3[t],
I1I2S3'[t] == -I1I2S3c1[t] - I1I2S3c2[t] - I1I2S3c3[t] + E1I2S3c1[t] +
  I1E2S3c2[t] + I1I2R3c3[t] - muval * I1I2S3[t],
I1I2E3'[t] == -I1I2E3c1[t] - I1I2E3c2[t] - I1I2E3c3[t] + E1I2E3c1[t] +
  I1E2E3c2[t] + I1I2S3c3[t] - muval * I1I2E3[t],
I1I2I3'[t] == -I1I2I3c1[t] - I1I2I3c2[t] - I1I2I3c3[t] + E1I2I3c1[t] +
  I1E2I3c2[t] + I1I2E3c3[t] - muval * I1I2I3[t],
I1I2R3'[t] == -I1I2R3c1[t] - I1I2R3c2[t] - I1I2R3c3[t] + E1I2R3c1[t] +
  I1E2R3c2[t] + I1I2I3c3[t] - muval * I1I2R3[t],
I1R2S3'[t] == -I1R2S3c1[t] - I1R2S3c2[t] - I1R2S3c3[t] + E1R2S3c1[t] +
  I1I2S3c2[t] + I1R2R3c3[t] - muval * I1R2S3[t],
I1R2E3'[t] == -I1R2E3c1[t] - I1R2E3c2[t] - I1R2E3c3[t] + E1R2E3c1[t] +
  I1I2E3c2[t] + I1R2S3c3[t] - muval * I1R2E3[t],
I1R2I3'[t] == -I1R2I3c1[t] - I1R2I3c2[t] - I1R2I3c3[t] + E1R2I3c1[t] +
  I1I2I3c2[t] + I1R2E3c3[t] - muval * I1R2I3[t],
I1R2R3'[t] == -I1R2R3c1[t] - I1R2R3c2[t] - I1R2R3c3[t] + E1R2R3c1[t] +
  I1I2R3c2[t] + I1R2I3c3[t] - muval * I1R2R3[t],
R1S2S3'[t] == -R1S2S3c1[t] - R1S2S3c2[t] - R1S2S3c3[t] + I1S2S3c1[t] +
  R1R2S3c2[t] + R1S2R3c3[t] - muval * R1S2S3[t],
R1S2E3'[t] == -R1S2E3c1[t] - R1S2E3c2[t] - R1S2E3c3[t] + I1S2E3c1[t] +
```

```
  R1R2E3c2[t] + R1S2S3c3[t] - muval * R1S2E3[t],
R1S2I3'[t] == -R1S2I3c1[t] - R1S2I3c2[t] - R1S2I3c3[t] + I1S2I3c1[t] +
  R1R2I3c2[t] + R1S2E3c3[t] - muval * R1S2I3[t],
R1S2R3'[t] == -R1S2R3c1[t] - R1S2R3c2[t] - R1S2R3c3[t] + I1S2R3c1[t] +
  R1R2R3c2[t] + R1S2I3c3[t] - muval * R1S2R3[t],
R1E2S3'[t] == -R1E2S3c1[t] - R1E2S3c2[t] - R1E2S3c3[t] + I1E2S3c1[t] +
  R1S2S3c2[t] + R1E2R3c3[t] - muval * R1E2S3[t],
R1E2E3'[t] == -R1E2E3c1[t] - R1E2E3c2[t] - R1E2E3c3[t] + I1E2E3c1[t] +
  R1S2E3c2[t] + R1E2S3c3[t] - muval * R1E2E3[t],
R1E2I3'[t] == -R1E2I3c1[t] - R1E2I3c2[t] - R1E2I3c3[t] + I1E2I3c1[t] +
  R1S2I3c2[t] + R1E2E3c3[t] - muval * R1E2I3[t],
R1E2R3'[t] == -R1E2R3c1[t] - R1E2R3c2[t] - R1E2R3c3[t] + I1E2R3c1[t] +
  R1S2R3c2[t] + R1E2I3c3[t] - muval * R1E2R3[t],
R1I2S3'[t] == -R1I2S3c1[t] - R1I2S3c2[t] - R1I2S3c3[t] + I1I2S3c1[t] +
  R1E2S3c2[t] + R1I2R3c3[t] - muval * R1I2S3[t],
R1I2E3'[t] == -R1I2E3c1[t] - R1I2E3c2[t] - R1I2E3c3[t] + I1I2E3c1[t] +
  R1E2E3c2[t] + R1I2S3c3[t] - muval * R1I2E3[t],
R1I2I3'[t] == -R1I2I3c1[t] - R1I2I3c2[t] - R1I2I3c3[t] + I1I2I3c1[t] +
  R1E2I3c2[t] + R1I2E3c3[t] - muval * R1I2I3[t],
R1I2R3'[t] == -R1I2R3c1[t] - R1I2R3c2[t] - R1I2R3c3[t] + I1I2R3c1[t] +
  R1E2R3c2[t] + R1I2I3c3[t] - muval * R1I2R3[t],
R1R2S3'[t] == -R1R2S3c1[t] - R1R2S3c2[t] - R1R2S3c3[t] + I1R2S3c1[t] +
  R1I2S3c2[t] + R1R2R3c3[t] - muval * R1R2S3[t],
R1R2E3'[t] == -R1R2E3c1[t] - R1R2E3c2[t] - R1R2E3c3[t] + I1R2E3c1[t] +
  R1I2E3c2[t] + R1R2S3c3[t] - muval * R1R2E3[t],
R1R2I3'[t] == -R1R2I3c1[t] - R1R2I3c2[t] - R1R2I3c3[t] + I1R2I3c1[t] +
  R1I2I3c2[t] + R1R2E3c3[t] - muval * R1R2I3[t],
R1R2R3'[t] == -R1R2R3c1[t] - R1R2R3c2[t] - R1R2R3c3[t] + I1R2R3c1[t] +
  R1I2R3c2[t] + R1R2I3c3[t] - muval * R1R2R3[t],
cuminf'[t] == E1S2S3c1[t] + E1S2E3c1[t] + E1S2I3c1[t] + E1S2R3c1[t] +
  E1E2S3c1[t] + E1E2E3c1[t] + E1E2I3c1[t] + E1E2R3c1[t] + E1I2S3c1[t] +
  E1I2E3c1[t] + E1I2I3c1[t] + E1I2R3c1[t] + E1R2S3c1[t] + E1R2E3c1[t] +
  E1R2I3c1[t] + E1R2R3c1[t] + S1E2S3c2[t] + S1E2E3c2[t] + S1E2I3c2[t] +
  S1E2R3c2[t] + E1E2S3c2[t] + E1E2E3c2[t] + E1E2I3c2[t] + E1E2R3c2[t] +
  I1E2S3c2[t] + I1E2E3c2[t] + I1E2I3c2[t] + I1E2R3c2[t] + R1E2S3c2[t] +
  R1E2E3c2[t] + R1E2I3c2[t] + R1E2R3c2[t] + S1S2E3c3[t] + S1E2E3c3[t] +
  S1I2E3c3[t] + S1R2E3c3[t] + E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] +
  E1R2E3c3[t] + I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
  R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
S1S2S3[0] == 1, S1S2E3[0] == 0, S1S2I3[0] == 0, S1S2R3[0] == 0, S1E2S3[0] == 0,
S1E2E3[0] == 0, S1E2I3[0] == 0, S1E2R3[0] == 0, S1I2S3[0] == 0, S1I2E3[0] == 0,
S1I2I3[0] == 0, S1I2R3[0] == 0, S1R2S3[0] == 0, S1R2E3[0] == 0, S1R2I3[0] == 0,
S1R2R3[0] == 0, E1S2S3[0] == 0, E1S2E3[0] == 0, E1S2I3[0] == 0, E1S2R3[0] == 0,
E1E2S3[0] == 0, E1E2E3[0] == 0, E1E2I3[0] == 0, E1E2R3[0] == 0, E1I2S3[0] == 0,
```

```
  E1I2E3[0] == 0, E1I2I3[0] == 0, E1I2R3[0] == 0, E1R2S3[0] == 0, E1R2E3[0] == 0,
  E1R2I3[0] == 0, E1R2R3[0] == 0, I1S2S3[0] == 0, I1S2E3[0] == 0, I1S2I3[0] == 0,
  I1S2R3[0] == 0, I1E2S3[0] == 0, I1E2E3[0] == 0, I1E2I3[0] == 0, I1E2R3[0] == 0,
  I1I2S3[0] == 0, I1I2E3[0] == 0, I1I2I3[0] == 0, I1I2R3[0] == 0, I1R2S3[0] == 0,
  I1R2E3[0] == 0, I1R2I3[0] == 0, I1R2R3[0] == 0, R1S2S3[0] == 0, R1S2E3[0] == 0,
  R1S2I3[0] == 0, R1S2R3[0] == 0, R1E2S3[0] == 0, R1E2E3[0] == 0, R1E2I3[0] == 0,
  R1E2R3[0] == 0, R1I2S3[0] == 0, R1I2E3[0] == 0, R1I2I3[0] == 0, R1I2R3[0] == 0,
  R1R2S3[0] == 0, R1R2E3[0] == 0, R1R2I3[0] == 0, R1R2R3[0] == 0, cuminf[0] == 0},
 {S1S2S3, S1S2E3, S1S2I3, S1S2R3, S1E2S3, S1E2E3, S1E2I3, S1E2R3, S1I2S3,
  S1I2E3, S1I2I3, S1I2R3, S1R2S3, S1R2E3, S1R2I3, S1R2R3, E1S2S3, E1S2E3, E1S2I3,
  E1S2R3, E1E2S3, E1E2E3, E1E2I3, E1E2R3, E1I2S3, E1I2E3, E1I2I3, E1I2R3, E1R2S3,
  E1R2E3, E1R2I3, E1R2R3, I1S2S3, I1S2E3, I1S2I3, I1S2R3, I1E2S3, I1E2E3,
  I1E2I3, I1E2R3, I1I2S3, I1I2E3, I1I2I3, I1I2R3, I1R2S3, I1R2E3, I1R2I3,
  I1R2R3, R1S2S3, R1S2E3, R1S2I3, R1S2R3, R1E2S3, R1E2E3, R1E2I3, R1E2R3,
  R1I2S3, R1I2E3, R1I2I3, R1I2R3, R1R2S3, R1R2E3, R1R2I3, R1R2R3, cuminf},
 {t, 0, tmax}
];
```

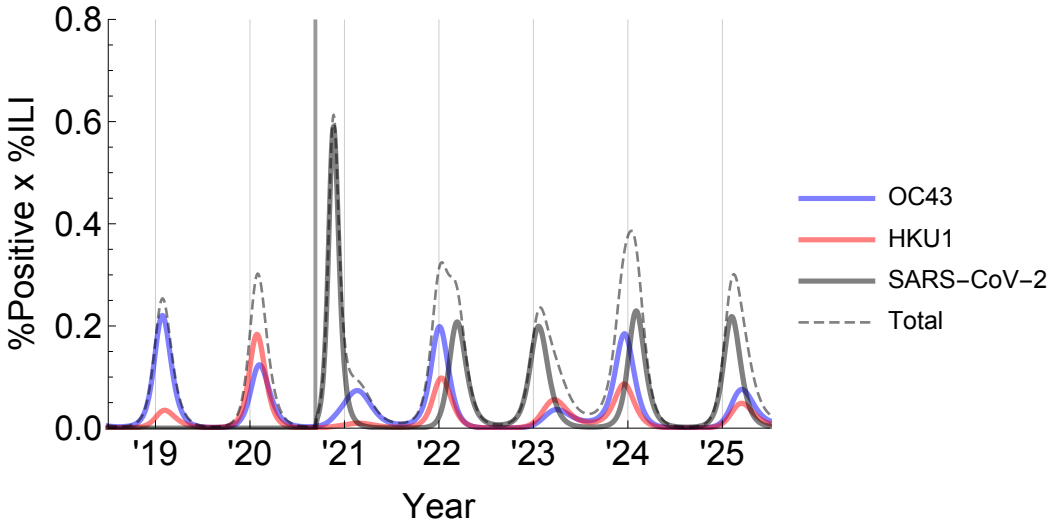
Plot output:

```
In[•]:= figinvasion =
  Plot[{Evaluate[{{100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t])},
       {100 * scalingfactor * (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] +
          E1I2S3[t] + E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t])},
       {100 * scalingfactor * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] +
          E1S2I3[t] + E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] +
          I1I2I3[t] + I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t])},
       {100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t] +
          S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] +
          E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] +
          R1I2R3[t] + S1S2I3[t] + S1E2I3[t] + S1R2I3[t] + E1S2I3[t] +
          E1E2I3[t] + E1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1R2I3[t])
       }} /. sol]}, Join[{t}, plotwindow], PlotRange → {0, plotrangemax},
    GridLines → {Join[Table[{i, yearbarchar}, {i, 0, tmax, 52}],
       {{importtime3, importbarchar}}], None},
    Frame → {True, True, False, False}, PlotRangePadding → None,
    BaseStyle → FontSize → fs,
    FrameTicks → {Table[{i, "'" <> ToString[i / 52 - 2]}, {i, 0, tmax, 52}], Automatic},
    FrameLabel → {"Year", "%Positive x %ILI"}, ImageSize → imsz,
    PlotLegends → {"OC43", "HKU1", "SARS-CoV-2", "Total"},
    PlotStyle → {oc43char, hku1char, ncovchar, totalchar}];
```

Save output:

In[•]:=
```
figinvasion
```

Out[•]=



30/30 | 104 | w32:

Define parameter values:

In[•]:=
```
chi31val = 0.3;
chi32val = 0.3;
chi13val = 0.3;
chi23val = 0.3;
sigma3val = 1 / 104;
importtime3 = 52 * 22 + 32;
```

Run the model:

In[•]:=
```
sol = NDSolve[
    {S1S2S3'[t] == -S1S2S3c1[t] - S1S2S3c2[t] - S1S2S3c3[t] +
       R1S2S3c1[t] + S1R2S3c2[t] + S1S2R3c3[t] - muval * S1S2S3[t] + muval,
     S1S2E3'[t] == -S1S2E3c1[t] - S1S2E3c2[t] - S1S2E3c3[t] + R1S2E3c1[t] +
       S1R2E3c2[t] + S1S2S3c3[t] - muval * S1S2E3[t],
     S1S2I3'[t] == -S1S2I3c1[t] - S1S2I3c2[t] - S1S2I3c3[t] + R1S2I3c1[t] +
       S1R2I3c2[t] + S1S2E3c3[t] - muval * S1S2I3[t],
     S1S2R3'[t] == -S1S2R3c1[t] - S1S2R3c2[t] - S1S2R3c3[t] + R1S2R3c1[t] +
       S1R2R3c2[t] + S1S2I3c3[t] - muval * S1S2R3[t],
     S1E2S3'[t] == -S1E2S3c1[t] - S1E2S3c2[t] - S1E2S3c3[t] + R1E2S3c1[t] +
       S1S2S3c2[t] + S1E2R3c3[t] - muval * S1E2S3[t],
     S1E2E3'[t] == -S1E2E3c1[t] - S1E2E3c2[t] - S1E2E3c3[t] + R1E2E3c1[t] +
```

```
  S1S2E3c2[t] + S1E2S3c3[t] - muval * S1E2E3[t],
S1E2I3'[t] == -S1E2I3c1[t] - S1E2I3c2[t] - S1E2I3c3[t] + R1E2I3c1[t] +
  S1S2I3c2[t] + S1E2E3c3[t] - muval * S1E2I3[t],
S1E2R3'[t] == -S1E2R3c1[t] - S1E2R3c2[t] - S1E2R3c3[t] + R1E2R3c1[t] +
  S1S2R3c2[t] + S1E2I3c3[t] - muval * S1E2R3[t],
S1I2S3'[t] == -S1I2S3c1[t] - S1I2S3c2[t] - S1I2S3c3[t] + R1I2S3c1[t] +
  S1E2S3c2[t] + S1I2R3c3[t] - muval * S1I2S3[t],
S1I2E3'[t] == -S1I2E3c1[t] - S1I2E3c2[t] - S1I2E3c3[t] + R1I2E3c1[t] +
  S1E2E3c2[t] + S1I2S3c3[t] - muval * S1I2E3[t],
S1I2I3'[t] == -S1I2I3c1[t] - S1I2I3c2[t] - S1I2I3c3[t] + R1I2I3c1[t] +
  S1E2I3c2[t] + S1I2E3c3[t] - muval * S1I2I3[t],
S1I2R3'[t] == -S1I2R3c1[t] - S1I2R3c2[t] - S1I2R3c3[t] + R1I2R3c1[t] +
  S1E2R3c2[t] + S1I2I3c3[t] - muval * S1I2R3[t],
S1R2S3'[t] == -S1R2S3c1[t] - S1R2S3c2[t] - S1R2S3c3[t] + R1R2S3c1[t] +
  S1I2S3c2[t] + S1R2R3c3[t] - muval * S1R2S3[t],
S1R2E3'[t] == -S1R2E3c1[t] - S1R2E3c2[t] - S1R2E3c3[t] + R1R2E3c1[t] +
  S1I2E3c2[t] + S1R2S3c3[t] - muval * S1R2E3[t],
S1R2I3'[t] == -S1R2I3c1[t] - S1R2I3c2[t] - S1R2I3c3[t] + R1R2I3c1[t] +
  S1I2I3c2[t] + S1R2E3c3[t] - muval * S1R2I3[t],
S1R2R3'[t] == -S1R2R3c1[t] - S1R2R3c2[t] - S1R2R3c3[t] + R1R2R3c1[t] +
  S1I2R3c2[t] + S1R2I3c3[t] - muval * S1R2R3[t],
E1S2S3'[t] == -E1S2S3c1[t] - E1S2S3c2[t] - E1S2S3c3[t] + S1S2S3c1[t] +
  E1R2S3c2[t] + E1S2R3c3[t] - muval * E1S2S3[t],
E1S2E3'[t] == -E1S2E3c1[t] - E1S2E3c2[t] - E1S2E3c3[t] + S1S2E3c1[t] +
  E1R2E3c2[t] + E1S2S3c3[t] - muval * E1S2E3[t],
E1S2I3'[t] == -E1S2I3c1[t] - E1S2I3c2[t] - E1S2I3c3[t] + S1S2I3c1[t] +
  E1R2I3c2[t] + E1S2E3c3[t] - muval * E1S2I3[t],
E1S2R3'[t] == -E1S2R3c1[t] - E1S2R3c2[t] - E1S2R3c3[t] + S1S2R3c1[t] +
  E1R2R3c2[t] + E1S2I3c3[t] - muval * E1S2R3[t],
E1E2S3'[t] == -E1E2S3c1[t] - E1E2S3c2[t] - E1E2S3c3[t] + S1E2S3c1[t] +
  E1S2S3c2[t] + E1E2R3c3[t] - muval * E1E2S3[t],
E1E2E3'[t] == -E1E2E3c1[t] - E1E2E3c2[t] - E1E2E3c3[t] + S1E2E3c1[t] +
  E1S2E3c2[t] + E1E2S3c3[t] - muval * E1E2E3[t],
E1E2I3'[t] == -E1E2I3c1[t] - E1E2I3c2[t] - E1E2I3c3[t] + S1E2I3c1[t] +
  E1S2I3c2[t] + E1E2E3c3[t] - muval * E1E2I3[t],
E1E2R3'[t] == -E1E2R3c1[t] - E1E2R3c2[t] - E1E2R3c3[t] + S1E2R3c1[t] +
  E1S2R3c2[t] + E1E2I3c3[t] - muval * E1E2R3[t],
E1I2S3'[t] == -E1I2S3c1[t] - E1I2S3c2[t] - E1I2S3c3[t] + S1I2S3c1[t] +
  E1E2S3c2[t] + E1I2R3c3[t] - muval * E1I2S3[t],
E1I2E3'[t] == -E1I2E3c1[t] - E1I2E3c2[t] - E1I2E3c3[t] + S1I2E3c1[t] +
  E1E2E3c2[t] + E1I2S3c3[t] - muval * E1I2E3[t],
E1I2I3'[t] == -E1I2I3c1[t] - E1I2I3c2[t] - E1I2I3c3[t] + S1I2I3c1[t] +
  E1E2I3c2[t] + E1I2E3c3[t] - muval * E1I2I3[t],
E1I2R3'[t] == -E1I2R3c1[t] - E1I2R3c2[t] - E1I2R3c3[t] + S1I2R3c1[t] +
```

```
  E1E2R3c2[t] + E1I2I3c3[t] - muval * E1I2R3[t],
E1R2S3'[t] == -E1R2S3c1[t] - E1R2S3c2[t] - E1R2S3c3[t] + S1R2S3c1[t] +
  E1I2S3c2[t] + E1R2R3c3[t] - muval * E1R2S3[t],
E1R2E3'[t] == -E1R2E3c1[t] - E1R2E3c2[t] - E1R2E3c3[t] + S1R2E3c1[t] +
  E1I2E3c2[t] + E1R2S3c3[t] - muval * E1R2E3[t],
E1R2I3'[t] == -E1R2I3c1[t] - E1R2I3c2[t] - E1R2I3c3[t] + S1R2I3c1[t] +
  E1I2I3c2[t] + E1R2E3c3[t] - muval * E1R2I3[t],
E1R2R3'[t] == -E1R2R3c1[t] - E1R2R3c2[t] - E1R2R3c3[t] + S1R2R3c1[t] +
  E1I2R3c2[t] + E1R2I3c3[t] - muval * E1R2R3[t],
I1S2S3'[t] == -I1S2S3c1[t] - I1S2S3c2[t] - I1S2S3c3[t] + E1S2S3c1[t] +
  I1R2S3c2[t] + I1S2R3c3[t] - muval * I1S2S3[t],
I1S2E3'[t] == -I1S2E3c1[t] - I1S2E3c2[t] - I1S2E3c3[t] + E1S2E3c1[t] +
  I1R2E3c2[t] + I1S2S3c3[t] - muval * I1S2E3[t],
I1S2I3'[t] == -I1S2I3c1[t] - I1S2I3c2[t] - I1S2I3c3[t] + E1S2I3c1[t] +
  I1R2I3c2[t] + I1S2E3c3[t] - muval * I1S2I3[t],
I1S2R3'[t] == -I1S2R3c1[t] - I1S2R3c2[t] - I1S2R3c3[t] + E1S2R3c1[t] +
  I1R2R3c2[t] + I1S2I3c3[t] - muval * I1S2R3[t],
I1E2S3'[t] == -I1E2S3c1[t] - I1E2S3c2[t] - I1E2S3c3[t] + E1E2S3c1[t] +
  I1S2S3c2[t] + I1E2R3c3[t] - muval * I1E2S3[t],
I1E2E3'[t] == -I1E2E3c1[t] - I1E2E3c2[t] - I1E2E3c3[t] + E1E2E3c1[t] +
  I1S2E3c2[t] + I1E2S3c3[t] - muval * I1E2E3[t],
I1E2I3'[t] == -I1E2I3c1[t] - I1E2I3c2[t] - I1E2I3c3[t] + E1E2I3c1[t] +
  I1S2I3c2[t] + I1E2E3c3[t] - muval * I1E2I3[t],
I1E2R3'[t] == -I1E2R3c1[t] - I1E2R3c2[t] - I1E2R3c3[t] + E1E2R3c1[t] +
  I1S2R3c2[t] + I1E2I3c3[t] - muval * I1E2R3[t],
I1I2S3'[t] == -I1I2S3c1[t] - I1I2S3c2[t] - I1I2S3c3[t] + E1I2S3c1[t] +
  I1E2S3c2[t] + I1I2R3c3[t] - muval * I1I2S3[t],
I1I2E3'[t] == -I1I2E3c1[t] - I1I2E3c2[t] - I1I2E3c3[t] + E1I2E3c1[t] +
  I1E2E3c2[t] + I1I2S3c3[t] - muval * I1I2E3[t],
I1I2I3'[t] == -I1I2I3c1[t] - I1I2I3c2[t] - I1I2I3c3[t] + E1I2I3c1[t] +
  I1E2I3c2[t] + I1I2E3c3[t] - muval * I1I2I3[t],
I1I2R3'[t] == -I1I2R3c1[t] - I1I2R3c2[t] - I1I2R3c3[t] + E1I2R3c1[t] +
  I1E2R3c2[t] + I1I2I3c3[t] - muval * I1I2R3[t],
I1R2S3'[t] == -I1R2S3c1[t] - I1R2S3c2[t] - I1R2S3c3[t] + E1R2S3c1[t] +
  I1I2S3c2[t] + I1R2R3c3[t] - muval * I1R2S3[t],
I1R2E3'[t] == -I1R2E3c1[t] - I1R2E3c2[t] - I1R2E3c3[t] + E1R2E3c1[t] +
  I1I2E3c2[t] + I1R2S3c3[t] - muval * I1R2E3[t],
I1R2I3'[t] == -I1R2I3c1[t] - I1R2I3c2[t] - I1R2I3c3[t] + E1R2I3c1[t] +
  I1I2I3c2[t] + I1R2E3c3[t] - muval * I1R2I3[t],
I1R2R3'[t] == -I1R2R3c1[t] - I1R2R3c2[t] - I1R2R3c3[t] + E1R2R3c1[t] +
  I1I2R3c2[t] + I1R2I3c3[t] - muval * I1R2R3[t],
R1S2S3'[t] == -R1S2S3c1[t] - R1S2S3c2[t] - R1S2S3c3[t] + I1S2S3c1[t] +
  R1R2S3c2[t] + R1S2R3c3[t] - muval * R1S2S3[t],
R1S2E3'[t] == -R1S2E3c1[t] - R1S2E3c2[t] - R1S2E3c3[t] + I1S2E3c1[t] +
```

```
  R1R2E3c2[t] + R1S2S3c3[t] - muval * R1S2E3[t],
R1S2I3'[t] == -R1S2I3c1[t] - R1S2I3c2[t] - R1S2I3c3[t] + I1S2I3c1[t] +
  R1R2I3c2[t] + R1S2E3c3[t] - muval * R1S2I3[t],
R1S2R3'[t] == -R1S2R3c1[t] - R1S2R3c2[t] - R1S2R3c3[t] + I1S2R3c1[t] +
  R1R2R3c2[t] + R1S2I3c3[t] - muval * R1S2R3[t],
R1E2S3'[t] == -R1E2S3c1[t] - R1E2S3c2[t] - R1E2S3c3[t] + I1E2S3c1[t] +
  R1S2S3c2[t] + R1E2R3c3[t] - muval * R1E2S3[t],
R1E2E3'[t] == -R1E2E3c1[t] - R1E2E3c2[t] - R1E2E3c3[t] + I1E2E3c1[t] +
  R1S2E3c2[t] + R1E2S3c3[t] - muval * R1E2E3[t],
R1E2I3'[t] == -R1E2I3c1[t] - R1E2I3c2[t] - R1E2I3c3[t] + I1E2I3c1[t] +
  R1S2I3c2[t] + R1E2E3c3[t] - muval * R1E2I3[t],
R1E2R3'[t] == -R1E2R3c1[t] - R1E2R3c2[t] - R1E2R3c3[t] + I1E2R3c1[t] +
  R1S2R3c2[t] + R1E2I3c3[t] - muval * R1E2R3[t],
R1I2S3'[t] == -R1I2S3c1[t] - R1I2S3c2[t] - R1I2S3c3[t] + I1I2S3c1[t] +
  R1E2S3c2[t] + R1I2R3c3[t] - muval * R1I2S3[t],
R1I2E3'[t] == -R1I2E3c1[t] - R1I2E3c2[t] - R1I2E3c3[t] + I1I2E3c1[t] +
  R1E2E3c2[t] + R1I2S3c3[t] - muval * R1I2E3[t],
R1I2I3'[t] == -R1I2I3c1[t] - R1I2I3c2[t] - R1I2I3c3[t] + I1I2I3c1[t] +
  R1E2I3c2[t] + R1I2E3c3[t] - muval * R1I2I3[t],
R1I2R3'[t] == -R1I2R3c1[t] - R1I2R3c2[t] - R1I2R3c3[t] + I1I2R3c1[t] +
  R1E2R3c2[t] + R1I2I3c3[t] - muval * R1I2R3[t],
R1R2S3'[t] == -R1R2S3c1[t] - R1R2S3c2[t] - R1R2S3c3[t] + I1R2S3c1[t] +
  R1I2S3c2[t] + R1R2R3c3[t] - muval * R1R2S3[t],
R1R2E3'[t] == -R1R2E3c1[t] - R1R2E3c2[t] - R1R2E3c3[t] + I1R2E3c1[t] +
  R1I2E3c2[t] + R1R2S3c3[t] - muval * R1R2E3[t],
R1R2I3'[t] == -R1R2I3c1[t] - R1R2I3c2[t] - R1R2I3c3[t] + I1R2I3c1[t] +
  R1I2I3c2[t] + R1R2E3c3[t] - muval * R1R2I3[t],
R1R2R3'[t] == -R1R2R3c1[t] - R1R2R3c2[t] - R1R2R3c3[t] + I1R2R3c1[t] +
  R1I2R3c2[t] + R1R2I3c3[t] - muval * R1R2R3[t],
cuminf'[t] == E1S2S3c1[t] + E1S2E3c1[t] + E1S2I3c1[t] + E1S2R3c1[t] +
  E1E2S3c1[t] + E1E2E3c1[t] + E1E2I3c1[t] + E1E2R3c1[t] + E1I2S3c1[t] +
  E1I2E3c1[t] + E1I2I3c1[t] + E1I2R3c1[t] + E1R2S3c1[t] + E1R2E3c1[t] +
  E1R2I3c1[t] + E1R2R3c1[t] + S1E2S3c2[t] + S1E2E3c2[t] + S1E2I3c2[t] +
  S1E2R3c2[t] + E1E2S3c2[t] + E1E2E3c2[t] + E1E2I3c2[t] + E1E2R3c2[t] +
  I1E2S3c2[t] + I1E2E3c2[t] + I1E2I3c2[t] + I1E2R3c2[t] + R1E2S3c2[t] +
  R1E2E3c2[t] + R1E2I3c2[t] + R1E2R3c2[t] + S1S2E3c3[t] + S1E2E3c3[t] +
  S1I2E3c3[t] + S1R2E3c3[t] + E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] +
  E1R2E3c3[t] + I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
  R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
S1S2S3[0] == 1, S1S2E3[0] == 0, S1S2I3[0] == 0, S1S2R3[0] == 0, S1E2S3[0] == 0,
S1E2E3[0] == 0, S1E2I3[0] == 0, S1E2R3[0] == 0, S1I2S3[0] == 0, S1I2E3[0] == 0,
S1I2I3[0] == 0, S1I2R3[0] == 0, S1R2S3[0] == 0, S1R2E3[0] == 0, S1R2I3[0] == 0,
S1R2R3[0] == 0, E1S2S3[0] == 0, E1S2E3[0] == 0, E1S2I3[0] == 0, E1S2R3[0] == 0,
E1E2S3[0] == 0, E1E2E3[0] == 0, E1E2I3[0] == 0, E1E2R3[0] == 0, E1I2S3[0] == 0,
```

```
  E1I2E3[0] == 0, E1I2I3[0] == 0, E1I2R3[0] == 0, E1R2S3[0] == 0, E1R2E3[0] == 0,
  E1R2I3[0] == 0, E1R2R3[0] == 0, I1S2S3[0] == 0, I1S2E3[0] == 0, I1S2I3[0] == 0,
  I1S2R3[0] == 0, I1E2S3[0] == 0, I1E2E3[0] == 0, I1E2I3[0] == 0, I1E2R3[0] == 0,
  I1I2S3[0] == 0, I1I2E3[0] == 0, I1I2I3[0] == 0, I1I2R3[0] == 0, I1R2S3[0] == 0,
  I1R2E3[0] == 0, I1R2I3[0] == 0, I1R2R3[0] == 0, R1S2S3[0] == 0, R1S2E3[0] == 0,
  R1S2I3[0] == 0, R1S2R3[0] == 0, R1E2S3[0] == 0, R1E2E3[0] == 0, R1E2I3[0] == 0,
  R1E2R3[0] == 0, R1I2S3[0] == 0, R1I2E3[0] == 0, R1I2I3[0] == 0, R1I2R3[0] == 0,
  R1R2S3[0] == 0, R1R2E3[0] == 0, R1R2I3[0] == 0, R1R2R3[0] == 0, cuminf[0] == 0},
 {S1S2S3, S1S2E3, S1S2I3, S1S2R3, S1E2S3, S1E2E3, S1E2I3, S1E2R3, S1I2S3,
  S1I2E3, S1I2I3, S1I2R3, S1R2S3, S1R2E3, S1R2I3, S1R2R3, E1S2S3, E1S2E3, E1S2I3,
  E1S2R3, E1E2S3, E1E2E3, E1E2I3, E1E2R3, E1I2S3, E1I2E3, E1I2I3, E1I2R3, E1R2S3,
  E1R2E3, E1R2I3, E1R2R3, I1S2S3, I1S2E3, I1S2I3, I1S2R3, I1E2S3, I1E2E3,
  I1E2I3, I1E2R3, I1I2S3, I1I2E3, I1I2I3, I1I2R3, I1R2S3, I1R2E3, I1R2I3,
  I1R2R3, R1S2S3, R1S2E3, R1S2I3, R1S2R3, R1E2S3, R1E2E3, R1E2I3, R1E2R3,
  R1I2S3, R1I2E3, R1I2I3, R1I2R3, R1R2S3, R1R2E3, R1R2I3, R1R2R3, cuminf},
 {t, 0, tmax}
];
```

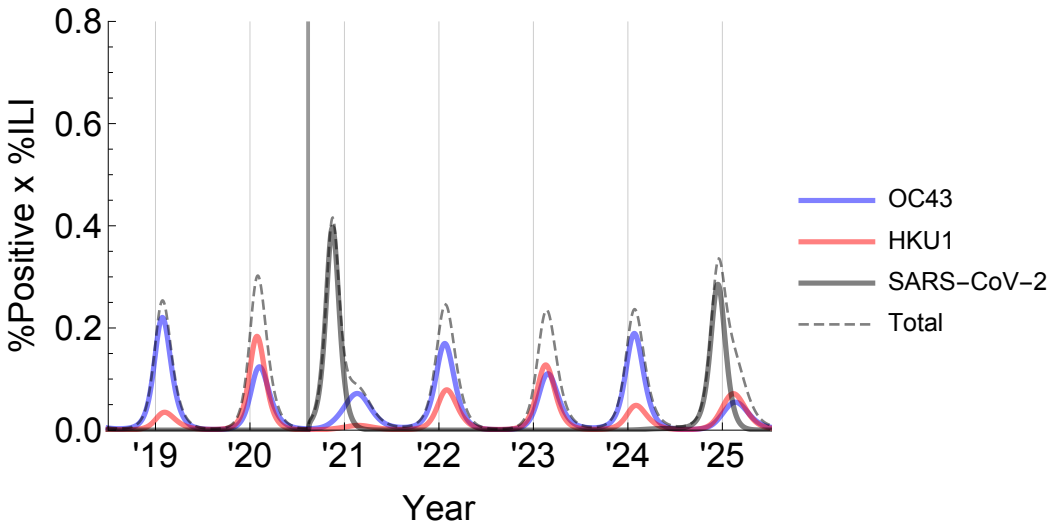
Plot output:

```
In[•]:= figinvasion =
  Plot[{Evaluate[{{100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t])},
       {100 * scalingfactor * (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] +
          E1I2S3[t] + E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t])},
       {100 * scalingfactor * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] +
          E1S2I3[t] + E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] +
          I1I2I3[t] + I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t])},
       {100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t] +
          S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] +
          E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] +
          R1I2R3[t] + S1S2I3[t] + S1E2I3[t] + S1R2I3[t] + E1S2I3[t] +
          E1E2I3[t] + E1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1R2I3[t])
       }} /. sol]}, Join[{t}, plotwindow], PlotRange → {0, plotrangemax},
    GridLines → {Join[Table[{i, yearbarchar}, {i, 0, tmax, 52}],
       {{importtime3, importbarchar}}], None},
    Frame → {True, True, False, False}, PlotRangePadding → None,
    BaseStyle → FontSize → fs,
    FrameTicks → {Table[{i, "'" <> ToString[i / 52 - 2]}, {i, 0, tmax, 52}], Automatic},
    FrameLabel → {"Year", "%Positive x %ILI"}, ImageSize → imsz,
    PlotLegends → {"OC43", "HKU1", "SARS-CoV-2", "Total"},
    PlotStyle → {oc43char, hku1char, ncovchar, totalchar}];
```

Save output:

In[•]:=
```
figinvasion
```

Out[•]=



Tables of cumulative infections and peak sizes:

In[•]:=
```
χ3Xvals = {{0.7, 0}, {0.7, 0.3}, {0.3, 0}, {0, 0}};
σ3vals = {{1/40}, {1/104}, {0}};
importtime3vals = {{52 * 22 + 4}, {52 * 22 + 16}, {52 * 22 + 28}, {52 * 22 + 40}};
fvals = {{0}, {0.5}, {1}};
```

In[•]:=
```
paramsets =
  Partition[Flatten[Table[Join[χ3X, σ3, importtime3, f], {χ3X, χ3Xvals},
     {σ3, σ3vals}, {importtime3, importtime3vals}, {f, fvals}]], 5];
```

In[•]:=
```
cuminfvec = {};
cuminfnCoVvec = {};
peakinfectedvec = {};
peakinfectednCoVvec = {};
```

In[•]:=
```
Do[
 chi31val = params[[1]];
 chi32val = params[[1]];
 chi13val = params[[2]];
 chi23val = params[[2]];
 sigma3val = params[[3]];
 importtime3 = params[[4]];
 f = params[[5]];

 sol = NDSolve[
   {S1S2S3'[t] == -S1S2S3c1[t] - S1S2S3c2[t] - S1S2S3c3[t] +
```

```
  R1S2S3c1[t] + S1R2S3c2[t] + S1S2R3c3[t] - muval * S1S2S3[t] + muval,
S1S2E3'[t] == -S1S2E3c1[t] - S1S2E3c2[t] - S1S2E3c3[t] + R1S2E3c1[t] +
  S1R2E3c2[t] + S1S2S3c3[t] - muval * S1S2E3[t],
S1S2I3'[t] == -S1S2I3c1[t] - S1S2I3c2[t] - S1S2I3c3[t] + R1S2I3c1[t] +
  S1R2I3c2[t] + S1S2E3c3[t] - muval * S1S2I3[t],
S1S2R3'[t] == -S1S2R3c1[t] - S1S2R3c2[t] - S1S2R3c3[t] + R1S2R3c1[t] +
  S1R2R3c2[t] + S1S2I3c3[t] - muval * S1S2R3[t],
S1E2S3'[t] == -S1E2S3c1[t] - S1E2S3c2[t] - S1E2S3c3[t] + R1E2S3c1[t] +
  S1S2S3c2[t] + S1E2R3c3[t] - muval * S1E2S3[t],
S1E2E3'[t] == -S1E2E3c1[t] - S1E2E3c2[t] - S1E2E3c3[t] + R1E2E3c1[t] +
  S1S2E3c2[t] + S1E2S3c3[t] - muval * S1E2E3[t],
S1E2I3'[t] == -S1E2I3c1[t] - S1E2I3c2[t] - S1E2I3c3[t] + R1E2I3c1[t] +
  S1S2I3c2[t] + S1E2E3c3[t] - muval * S1E2I3[t],
S1E2R3'[t] == -S1E2R3c1[t] - S1E2R3c2[t] - S1E2R3c3[t] + R1E2R3c1[t] +
  S1S2R3c2[t] + S1E2I3c3[t] - muval * S1E2R3[t],
S1I2S3'[t] == -S1I2S3c1[t] - S1I2S3c2[t] - S1I2S3c3[t] + R1I2S3c1[t] +
  S1E2S3c2[t] + S1I2R3c3[t] - muval * S1I2S3[t],
S1I2E3'[t] == -S1I2E3c1[t] - S1I2E3c2[t] - S1I2E3c3[t] + R1I2E3c1[t] +
  S1E2E3c2[t] + S1I2S3c3[t] - muval * S1I2E3[t],
S1I2I3'[t] == -S1I2I3c1[t] - S1I2I3c2[t] - S1I2I3c3[t] + R1I2I3c1[t] +
  S1E2I3c2[t] + S1I2E3c3[t] - muval * S1I2I3[t],
S1I2R3'[t] == -S1I2R3c1[t] - S1I2R3c2[t] - S1I2R3c3[t] + R1I2R3c1[t] +
  S1E2R3c2[t] + S1I2I3c3[t] - muval * S1I2R3[t],
S1R2S3'[t] == -S1R2S3c1[t] - S1R2S3c2[t] - S1R2S3c3[t] + R1R2S3c1[t] +
  S1I2S3c2[t] + S1R2R3c3[t] - muval * S1R2S3[t],
S1R2E3'[t] == -S1R2E3c1[t] - S1R2E3c2[t] - S1R2E3c3[t] + R1R2E3c1[t] +
  S1I2E3c2[t] + S1R2S3c3[t] - muval * S1R2E3[t],
S1R2I3'[t] == -S1R2I3c1[t] - S1R2I3c2[t] - S1R2I3c3[t] + R1R2I3c1[t] +
  S1I2I3c2[t] + S1R2E3c3[t] - muval * S1R2I3[t],
S1R2R3'[t] == -S1R2R3c1[t] - S1R2R3c2[t] - S1R2R3c3[t] + R1R2R3c1[t] +
  S1I2R3c2[t] + S1R2I3c3[t] - muval * S1R2R3[t],
E1S2S3'[t] == -E1S2S3c1[t] - E1S2S3c2[t] - E1S2S3c3[t] + S1S2S3c1[t] +
  E1R2S3c2[t] + E1S2R3c3[t] - muval * E1S2S3[t],
E1S2E3'[t] == -E1S2E3c1[t] - E1S2E3c2[t] - E1S2E3c3[t] + S1S2E3c1[t] +
  E1R2E3c2[t] + E1S2S3c3[t] - muval * E1S2E3[t],
E1S2I3'[t] == -E1S2I3c1[t] - E1S2I3c2[t] - E1S2I3c3[t] + S1S2I3c1[t] +
  E1R2I3c2[t] + E1S2E3c3[t] - muval * E1S2I3[t],
E1S2R3'[t] == -E1S2R3c1[t] - E1S2R3c2[t] - E1S2R3c3[t] + S1S2R3c1[t] +
  E1R2R3c2[t] + E1S2I3c3[t] - muval * E1S2R3[t],
E1E2S3'[t] == -E1E2S3c1[t] - E1E2S3c2[t] - E1E2S3c3[t] + S1E2S3c1[t] +
  E1S2S3c2[t] + E1E2R3c3[t] - muval * E1E2S3[t],
E1E2E3'[t] == -E1E2E3c1[t] - E1E2E3c2[t] - E1E2E3c3[t] + S1E2E3c1[t] +
  E1S2E3c2[t] + E1E2S3c3[t] - muval * E1E2E3[t],
E1E2I3'[t] == -E1E2I3c1[t] - E1E2I3c2[t] - E1E2I3c3[t] + S1E2I3c1[t] +
```

```
  E1S2I3c2[t] + E1E2E3c3[t] - muval * E1E2I3[t],
E1E2R3'[t] == -E1E2R3c1[t] - E1E2R3c2[t] - E1E2R3c3[t] + S1E2R3c1[t] +
  E1S2R3c2[t] + E1E2I3c3[t] - muval * E1E2R3[t],
E1I2S3'[t] == -E1I2S3c1[t] - E1I2S3c2[t] - E1I2S3c3[t] + S1I2S3c1[t] +
  E1E2S3c2[t] + E1I2R3c3[t] - muval * E1I2S3[t],
E1I2E3'[t] == -E1I2E3c1[t] - E1I2E3c2[t] - E1I2E3c3[t] + S1I2E3c1[t] +
  E1E2E3c2[t] + E1I2S3c3[t] - muval * E1I2E3[t],
E1I2I3'[t] == -E1I2I3c1[t] - E1I2I3c2[t] - E1I2I3c3[t] + S1I2I3c1[t] +
  E1E2I3c2[t] + E1I2E3c3[t] - muval * E1I2I3[t],
E1I2R3'[t] == -E1I2R3c1[t] - E1I2R3c2[t] - E1I2R3c3[t] + S1I2R3c1[t] +
  E1E2R3c2[t] + E1I2I3c3[t] - muval * E1I2R3[t],
E1R2S3'[t] == -E1R2S3c1[t] - E1R2S3c2[t] - E1R2S3c3[t] + S1R2S3c1[t] +
  E1I2S3c2[t] + E1R2R3c3[t] - muval * E1R2S3[t],
E1R2E3'[t] == -E1R2E3c1[t] - E1R2E3c2[t] - E1R2E3c3[t] + S1R2E3c1[t] +
  E1I2E3c2[t] + E1R2S3c3[t] - muval * E1R2E3[t],
E1R2I3'[t] == -E1R2I3c1[t] - E1R2I3c2[t] - E1R2I3c3[t] + S1R2I3c1[t] +
  E1I2I3c2[t] + E1R2E3c3[t] - muval * E1R2I3[t],
E1R2R3'[t] == -E1R2R3c1[t] - E1R2R3c2[t] - E1R2R3c3[t] + S1R2R3c1[t] +
  E1I2R3c2[t] + E1R2I3c3[t] - muval * E1R2R3[t],
I1S2S3'[t] == -I1S2S3c1[t] - I1S2S3c2[t] - I1S2S3c3[t] + E1S2S3c1[t] +
  I1R2S3c2[t] + I1S2R3c3[t] - muval * I1S2S3[t],
I1S2E3'[t] == -I1S2E3c1[t] - I1S2E3c2[t] - I1S2E3c3[t] + E1S2E3c1[t] +
  I1R2E3c2[t] + I1S2S3c3[t] - muval * I1S2E3[t],
I1S2I3'[t] == -I1S2I3c1[t] - I1S2I3c2[t] - I1S2I3c3[t] + E1S2I3c1[t] +
  I1R2I3c2[t] + I1S2E3c3[t] - muval * I1S2I3[t],
I1S2R3'[t] == -I1S2R3c1[t] - I1S2R3c2[t] - I1S2R3c3[t] + E1S2R3c1[t] +
  I1R2R3c2[t] + I1S2I3c3[t] - muval * I1S2R3[t],
I1E2S3'[t] == -I1E2S3c1[t] - I1E2S3c2[t] - I1E2S3c3[t] + E1E2S3c1[t] +
  I1S2S3c2[t] + I1E2R3c3[t] - muval * I1E2S3[t],
I1E2E3'[t] == -I1E2E3c1[t] - I1E2E3c2[t] - I1E2E3c3[t] + E1E2E3c1[t] +
  I1S2E3c2[t] + I1E2S3c3[t] - muval * I1E2E3[t],
I1E2I3'[t] == -I1E2I3c1[t] - I1E2I3c2[t] - I1E2I3c3[t] + E1E2I3c1[t] +
  I1S2I3c2[t] + I1E2E3c3[t] - muval * I1E2I3[t],
I1E2R3'[t] == -I1E2R3c1[t] - I1E2R3c2[t] - I1E2R3c3[t] + E1E2R3c1[t] +
  I1S2R3c2[t] + I1E2I3c3[t] - muval * I1E2R3[t],
I1I2S3'[t] == -I1I2S3c1[t] - I1I2S3c2[t] - I1I2S3c3[t] + E1I2S3c1[t] +
  I1E2S3c2[t] + I1I2R3c3[t] - muval * I1I2S3[t],
I1I2E3'[t] == -I1I2E3c1[t] - I1I2E3c2[t] - I1I2E3c3[t] + E1I2E3c1[t] +
  I1E2E3c2[t] + I1I2S3c3[t] - muval * I1I2E3[t],
I1I2I3'[t] == -I1I2I3c1[t] - I1I2I3c2[t] - I1I2I3c3[t] + E1I2I3c1[t] +
  I1E2I3c2[t] + I1I2E3c3[t] - muval * I1I2I3[t],
I1I2R3'[t] == -I1I2R3c1[t] - I1I2R3c2[t] - I1I2R3c3[t] + E1I2R3c1[t] +
  I1E2R3c2[t] + I1I2I3c3[t] - muval * I1I2R3[t],
I1R2S3'[t] == -I1R2S3c1[t] - I1R2S3c2[t] - I1R2S3c3[t] + E1R2S3c1[t] +
```

```
  I1I2S3c2[t] + I1R2R3c3[t] - muval * I1R2S3[t],
I1R2E3'[t] == -I1R2E3c1[t] - I1R2E3c2[t] - I1R2E3c3[t] + E1R2E3c1[t] +
  I1I2E3c2[t] + I1R2S3c3[t] - muval * I1R2E3[t],
I1R2I3'[t] == -I1R2I3c1[t] - I1R2I3c2[t] - I1R2I3c3[t] + E1R2I3c1[t] +
  I1I2I3c2[t] + I1R2E3c3[t] - muval * I1R2I3[t],
I1R2R3'[t] == -I1R2R3c1[t] - I1R2R3c2[t] - I1R2R3c3[t] + E1R2R3c1[t] +
  I1I2R3c2[t] + I1R2I3c3[t] - muval * I1R2R3[t],
R1S2S3'[t] == -R1S2S3c1[t] - R1S2S3c2[t] - R1S2S3c3[t] + I1S2S3c1[t] +
  R1R2S3c2[t] + R1S2R3c3[t] - muval * R1S2S3[t],
R1S2E3'[t] == -R1S2E3c1[t] - R1S2E3c2[t] - R1S2E3c3[t] + I1S2E3c1[t] +
  R1R2E3c2[t] + R1S2S3c3[t] - muval * R1S2E3[t],
R1S2I3'[t] == -R1S2I3c1[t] - R1S2I3c2[t] - R1S2I3c3[t] + I1S2I3c1[t] +
  R1R2I3c2[t] + R1S2E3c3[t] - muval * R1S2I3[t],
R1S2R3'[t] == -R1S2R3c1[t] - R1S2R3c2[t] - R1S2R3c3[t] + I1S2R3c1[t] +
  R1R2R3c2[t] + R1S2I3c3[t] - muval * R1S2R3[t],
R1E2S3'[t] == -R1E2S3c1[t] - R1E2S3c2[t] - R1E2S3c3[t] + I1E2S3c1[t] +
  R1S2S3c2[t] + R1E2R3c3[t] - muval * R1E2S3[t],
R1E2E3'[t] == -R1E2E3c1[t] - R1E2E3c2[t] - R1E2E3c3[t] + I1E2E3c1[t] +
  R1S2E3c2[t] + R1E2S3c3[t] - muval * R1E2E3[t],
R1E2I3'[t] == -R1E2I3c1[t] - R1E2I3c2[t] - R1E2I3c3[t] + I1E2I3c1[t] +
  R1S2I3c2[t] + R1E2E3c3[t] - muval * R1E2I3[t],
R1E2R3'[t] == -R1E2R3c1[t] - R1E2R3c2[t] - R1E2R3c3[t] + I1E2R3c1[t] +
  R1S2R3c2[t] + R1E2I3c3[t] - muval * R1E2R3[t],
R1I2S3'[t] == -R1I2S3c1[t] - R1I2S3c2[t] - R1I2S3c3[t] + I1I2S3c1[t] +
  R1E2S3c2[t] + R1I2R3c3[t] - muval * R1I2S3[t],
R1I2E3'[t] == -R1I2E3c1[t] - R1I2E3c2[t] - R1I2E3c3[t] + I1I2E3c1[t] +
  R1E2E3c2[t] + R1I2S3c3[t] - muval * R1I2E3[t],
R1I2I3'[t] == -R1I2I3c1[t] - R1I2I3c2[t] - R1I2I3c3[t] + I1I2I3c1[t] +
  R1E2I3c2[t] + R1I2E3c3[t] - muval * R1I2I3[t],
R1I2R3'[t] == -R1I2R3c1[t] - R1I2R3c2[t] - R1I2R3c3[t] + I1I2R3c1[t] +
  R1E2R3c2[t] + R1I2I3c3[t] - muval * R1I2R3[t],
R1R2S3'[t] == -R1R2S3c1[t] - R1R2S3c2[t] - R1R2S3c3[t] + I1R2S3c1[t] +
  R1I2S3c2[t] + R1R2R3c3[t] - muval * R1R2S3[t],
R1R2E3'[t] == -R1R2E3c1[t] - R1R2E3c2[t] - R1R2E3c3[t] + I1R2E3c1[t] +
  R1I2E3c2[t] + R1R2S3c3[t] - muval * R1R2E3[t],
R1R2I3'[t] == -R1R2I3c1[t] - R1R2I3c2[t] - R1R2I3c3[t] + I1R2I3c1[t] +
  R1I2I3c2[t] + R1R2E3c3[t] - muval * R1R2I3[t],
R1R2R3'[t] == -R1R2R3c1[t] - R1R2R3c2[t] - R1R2R3c3[t] + I1R2R3c1[t] +
  R1I2R3c2[t] + R1R2I3c3[t] - muval * R1R2R3[t],
cuminf'[t] == E1S2S3c1[t] + E1S2E3c1[t] + E1S2I3c1[t] + E1S2R3c1[t] +
  E1E2S3c1[t] + E1E2E3c1[t] + E1E2I3c1[t] + E1E2R3c1[t] + E1I2S3c1[t] +
  E1I2E3c1[t] + E1I2I3c1[t] + E1I2R3c1[t] + E1R2S3c1[t] + E1R2E3c1[t] +
  E1R2I3c1[t] + E1R2R3c1[t] + S1E2S3c2[t] + S1E2E3c2[t] + S1E2I3c2[t] +
  S1E2R3c2[t] + E1E2S3c2[t] + E1E2E3c2[t] + E1E2I3c2[t] + E1E2R3c2[t] +
```

```
      I1E2S3c2[t] + I1E2E3c2[t] + I1E2I3c2[t] + I1E2R3c2[t] + R1E2S3c2[t] +
      R1E2E3c2[t] + R1E2I3c2[t] + R1E2R3c2[t] + S1S2E3c3[t] + S1E2E3c3[t] +
      S1I2E3c3[t] + S1R2E3c3[t] + E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] +
      E1R2E3c3[t] + I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
      R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
    cuminfnCoV'[t] == S1S2E3c3[t] + S1E2E3c3[t] + S1I2E3c3[t] + S1R2E3c3[t] +
      E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] + E1R2E3c3[t] +
      I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
      R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
    S1S2S3[0] == 1, S1S2E3[0] == 0, S1S2I3[0] == 0, S1S2R3[0] == 0, S1E2S3[0] == 0,
    S1E2E3[0] == 0, S1E2I3[0] == 0, S1E2R3[0] == 0, S1I2S3[0] == 0,
    S1I2E3[0] == 0, S1I2I3[0] == 0, S1I2R3[0] == 0, S1R2S3[0] == 0,
    S1R2E3[0] == 0, S1R2I3[0] == 0, S1R2R3[0] == 0, E1S2S3[0] == 0,
    E1S2E3[0] == 0, E1S2I3[0] == 0, E1S2R3[0] == 0, E1E2S3[0] == 0, E1E2E3[0] == 0,
    E1E2I3[0] == 0, E1E2R3[0] == 0, E1I2S3[0] == 0, E1I2E3[0] == 0, E1I2I3[0] == 0,
    E1I2R3[0] == 0, E1R2S3[0] == 0, E1R2E3[0] == 0, E1R2I3[0] == 0, E1R2R3[0] == 0,
    I1S2S3[0] == 0, I1S2E3[0] == 0, I1S2I3[0] == 0, I1S2R3[0] == 0, I1E2S3[0] == 0,
    I1E2E3[0] == 0, I1E2I3[0] == 0, I1E2R3[0] == 0, I1I2S3[0] == 0, I1I2E3[0] == 0,
    I1I2I3[0] == 0, I1I2R3[0] == 0, I1R2S3[0] == 0, I1R2E3[0] == 0, I1R2I3[0] == 0,
    I1R2R3[0] == 0, R1S2S3[0] == 0, R1S2E3[0] == 0, R1S2I3[0] == 0, R1S2R3[0] == 0,
    R1E2S3[0] == 0, R1E2E3[0] == 0, R1E2I3[0] == 0, R1E2R3[0] == 0, R1I2S3[0] == 0,
    R1I2E3[0] == 0, R1I2I3[0] == 0, R1I2R3[0] == 0, R1R2S3[0] == 0, R1R2E3[0] == 0,
    R1R2I3[0] == 0, R1R2R3[0] == 0, cuminf[0] == 0, cuminfnCoV[0] == 0},
   {S1S2S3, S1S2E3, S1S2I3, S1S2R3, S1E2S3, S1E2E3, S1E2I3, S1E2R3, S1I2S3,
    S1I2E3, S1I2I3, S1I2R3, S1R2S3, S1R2E3, S1R2I3, S1R2R3, E1S2S3, E1S2E3, E1S2I3,
    E1S2R3, E1E2S3, E1E2E3, E1E2I3, E1E2R3, E1I2S3, E1I2E3, E1I2I3, E1I2R3, E1R2S3,
    E1R2E3, E1R2I3, E1R2R3, I1S2S3, I1S2E3, I1S2I3, I1S2R3, I1E2S3, I1E2E3, I1E2I3,
    I1E2R3, I1I2S3, I1I2E3, I1I2I3, I1I2R3, I1R2S3, I1R2E3, I1R2I3, I1R2R3,
    R1S2S3, R1S2E3, R1S2I3, R1S2R3, R1E2S3, R1E2E3, R1E2I3, R1E2R3, R1I2S3,
    R1I2E3, R1I2I3, R1I2R3, R1R2S3, R1R2E3, R1R2I3, R1R2R3, cuminf, cuminfnCoV},
   {t, 0, tmax}
  ];

cuminftags = Flatten[Table[Evaluate[scalingfactor * cuminf[t]
      /. sol], {t, plotwindow[[1]], plotwindow[[2]], 52}]];
cuminfnCoVtags = Flatten[Table[Evaluate[scalingfactor * cuminfnCoV[t]
      /. sol], {t, plotwindow[[1]], plotwindow[[2]], 52}]];

cuminfbyseason = Drop[cuminftags, 1] - Drop[cuminftags, -1];
cuminfnCoVbyseason = Drop[cuminfnCoVtags, 1] - Drop[cuminfnCoVtags, -1];

cuminfvec = Join[cuminfvec, {cuminfbyseason}];
cuminfnCoVvec = Join[cuminfnCoVvec, {cuminfnCoVbyseason}];
```

```
dailyinfected = Flatten[
  Table[Evaluate[scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
        I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
        I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t] +
        S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] + E1I2E3[t] +
        E1I2I3[t] + E1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] +
        R1I2R3[t] + S1S2I3[t] + S1E2I3[t] + S1R2I3[t] + E1S2I3[t] +
        E1E2I3[t] + E1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1R2I3[t]) /. sol],
   {t, plotwindow[[1]] + 1 / 7, plotwindow[[2]], 1 / 7}]];

dailyinfectednCoV = Flatten[
  Table[Evaluate[scalingfactor * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] +
        E1S2I3[t] + E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] +
        I1I2I3[t] + I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t]) /.
      sol], {t, plotwindow[[1]] + 1 / 7, plotwindow[[2]], 1 / 7}]];

peakinfected = Max[#] & /@ Partition[dailyinfected, Length[dailyinfected] / 7];
peakinfectedvec = Join[peakinfectedvec, {peakinfected}];

peakinfectednCoV =
 Max[#] & /@ Partition[dailyinfectednCoV, Length[dailyinfectednCoV] / 7];
peakinfectednCoVvec = Join[peakinfectednCoVvec, {peakinfectednCoV}];

(*Print[params];*)

, {params, paramsets}]
```

```
In[•]:= Join[{{"χ3X", "χX3", "σ3", "importtime3",
      "f", "19", "20", "21", "22", "23", "24", "25"}}, Table[
     Join[paramsets[[i]], 100 * cuminfvec[[i]]], {i, Length[paramsets]}]] // TableForm;

In[•]:= Join[{{"χ3X", "χX3", "σ3", "importtime3", "f", "19",
      "20", "21", "22", "23", "24", "25"}}, Table[Join[paramsets[[i]],
      100 * cuminfnCoVvec[[i]]], {i, Length[paramsets]}]] // TableForm;

In[•]:= Join[{{"χ3X", "χX3", "σ3", "importtime3", "19",
      "20", "21", "22", "23", "24", "25"}}, Table[Join[paramsets[[i]],
      100 * peakinfectedvec[[i]]], {i, Length[paramsets]}]] // TableForm;

In[•]:= Join[
   {{"χ3X", "χX3", "σ3", "importtime3", "19", "20", "21", "22", "23", "24", "25"}},
   Table[Join[paramsets[[i]], 100 * peakinfectednCoVvec[[i]]],
    {i, Length[paramsets]}]] // TableForm
```

Out[•]//TableForm=

χ3X	χX3	σ3	importtime3	19	20	21	22	23
0.7	0	$\frac{1}{40}$	1148	0	0.	0.627689	0.168377	0.0949357

0.7	0	$\frac{1}{40}$	1148	0.5	0.	0.501762	0.13517	0.130892
0.7	0	$\frac{1}{40}$	1148	1	0.	0.361707	0.157245	0.228484
0.7	0	$\frac{1}{40}$	1160	0	0.	0.627692	0.570488	0.168184
0.7	0	$\frac{1}{40}$	1160	0.5	0.	0.402484	0.421003	0.107093
0.7	0	$\frac{1}{40}$	1160	1	0.	0.142478	0.242761	0.2679
0.7	0	$\frac{1}{40}$	1172	0	0.	0.	0.627691	0.168379
0.7	0	$\frac{1}{40}$	1172	0.5	0.	0.	0.52876	0.222627
0.7	0	$\frac{1}{40}$	1172	1	0.	0.	0.462711	0.280515
0.7	0	$\frac{1}{40}$	1184	0	0.	0.	0.627692	0.168377
0.7	0	$\frac{1}{40}$	1184	0.5	0.	0.	0.623998	0.231831
0.7	0	$\frac{1}{40}$	1184	1	0.	0.	0.620668	0.163837
0.7	0	$\frac{1}{104}$	1148	0	0.	0.616921	0.00441861	0.159583
0.7	0	$\frac{1}{104}$	1148	0.5	0.	0.492546	0.00858174	0.0872222
0.7	0	$\frac{1}{104}$	1148	1	0.	0.355026	0.0153462	0.131092
0.7	0	$\frac{1}{104}$	1160	0	0.	0.616924	0.553492	0.0301463
0.7	0	$\frac{1}{104}$	1160	0.5	0.	0.395709	0.410487	0.0462721
0.7	0	$\frac{1}{104}$	1160	1	0.	0.141093	0.228565	0.00131126
0.7	0	$\frac{1}{104}$	1172	0	0.	0.	0.616923	0.00154747
0.7	0	$\frac{1}{104}$	1172	0.5	0.	0.	0.516717	0.000072068
0.7	0	$\frac{1}{104}$	1172	1	0.	0.	0.448219	2.9429×10^{-6}
0.7	0	$\frac{1}{104}$	1184	0	0.	0.	0.616924	0.000124427
0.7	0	$\frac{1}{104}$	1184	0.5	0.	0.	0.613078	0.000012031
0.7	0	$\frac{1}{104}$	1184	1	0.	0.	0.609609	2.78468×10
0.7	0	0	1148	0	0.	0.61042	0.00193274	6.61829×10
0.7	0	0	1148	0.5	0.	0.486868	0.00496388	2.84446×10
0.7	0	0	1148	1	0.	0.350969	0.0109242	9.05942×10
0.7	0	0	1160	0	0.	0.610423	0.542622	1.97728×10
0.7	0	0	1160	0.5	0.	0.391334	0.404049	2.62508×10
0.7	0	0	1160	1	0.	0.14019	0.220141	5.51129×10
0.7	0	0	1172	0	0.	0.	0.610423	7.35447×10
0.7	0	0	1172	0.5	0.	0.	0.509379	4.55693×10
0.7	0	0	1172	1	0.	0.	0.439062	9.17349×10
0.7	0	0	1184	0	0.	0.	0.610423	4.97025×10
0.7	0	0	1184	0.5	0.	0.	0.606339	1.55846×10
0.7	0	0	1184	1	0.	0.	0.60264	2.36753×10
0.7	0.3	$\frac{1}{40}$	1148	0	0.	0.353527	0.131491	0.0857325
0.7	0.3	$\frac{1}{40}$	1148	0.5	0.	0.228135	0.0951891	0.140042
0.7	0.3	$\frac{1}{40}$	1148	1	0.	0.115248	0.160267	0.236469
0.7	0.3	$\frac{1}{40}$	1160	0	0.	0.341116	0.399844	0.138853

0.7	0.3	$\frac{1}{40}$	1160	0.5	0.	0.132084	0.250163	0.147015
0.7	0.3	$\frac{1}{40}$	1160	1	0.	0.0359313	0.255535	0.243476
0.7	0.3	$\frac{1}{40}$	1172	0	0.	0.	0.449872	0.146356
0.7	0.3	$\frac{1}{40}$	1172	0.5	0.	0.	0.386047	0.217268
0.7	0.3	$\frac{1}{40}$	1172	1	0.	0.	0.363918	0.202837
0.7	0.3	$\frac{1}{40}$	1184	0	0.	0.	0.474388	0.152214
0.7	0.3	$\frac{1}{40}$	1184	0.5	0.	0.	0.471194	0.209889
0.7	0.3	$\frac{1}{40}$	1184	1	0.	0.	0.467915	0.119851
0.7	0.3	$\frac{1}{104}$	1148	0	0.	0.343278	0.0419317	0.109719
0.7	0.3	$\frac{1}{104}$	1148	0.5	0.	0.221242	0.0652818	0.092743
0.7	0.3	$\frac{1}{104}$	1148	1	0.	0.113044	0.09218	0.00591097
0.7	0.3	$\frac{1}{104}$	1160	0	0.	0.336689	0.38899	0.11933
0.7	0.3	$\frac{1}{104}$	1160	0.5	0.	0.131008	0.237828	0.0578016
0.7	0.3	$\frac{1}{104}$	1160	1	0.	0.0357518	0.229559	0.000103428
0.7	0.3	$\frac{1}{104}$	1172	0	0.	0.	0.439145	0.0447471
0.7	0.3	$\frac{1}{104}$	1172	0.5	0.	0.	0.373269	0.0010263
0.7	0.3	$\frac{1}{104}$	1172	1	0.	0.	0.347898	0.000012732
0.7	0.3	$\frac{1}{104}$	1184	0	0.	0.	0.464257	0.00243641
0.7	0.3	$\frac{1}{104}$	1184	0.5	0.	0.	0.460936	0.000074997
0.7	0.3	$\frac{1}{104}$	1184	1	0.	0.	0.457563	0.000018195
0.7	0.3	0	1148	0	0.	0.336901	0.032275	1.32169×10
0.7	0.3	0	1148	0.5	0.	0.217012	0.0554487	9.31212×10
0.7	0.3	0	1148	1	0.	0.111672	0.0447295	0.000382043
0.7	0.3	0	1160	0	0.	0.333823	0.382141	6.97171×10
0.7	0.3	0	1160	0.5	0.	0.130308	0.230296	2.94095×10
0.7	0.3	0	1160	1	0.	0.0356339	0.212667	1.58474×10
0.7	0.3	0	1172	0	0.	0.	0.432336	2.34241×10
0.7	0.3	0	1172	0.5	0.	0.	0.365294	4.2583×10^{-7}
0.7	0.3	0	1172	1	0.	0.	0.33776	2.86977×10
0.7	0.3	0	1184	0	0.	0.	0.457732	0.000011287
0.7	0.3	0	1184	0.5	0.	0.	0.4544	4.14521×10
0.7	0.3	0	1184	1	0.	0.	0.451026	1.33891×10
0.3	0	$\frac{1}{40}$	1148	0	0.	0.627689	0.168377	0.0949354
0.3	0	$\frac{1}{40}$	1148	0.5	0.	0.501762	0.135169	0.130892
0.3	0	$\frac{1}{40}$	1148	1	0.	0.361707	0.157246	0.228484
0.3	0	$\frac{1}{40}$	1160	0	0.	0.627692	0.570488	0.168185
0.3	0	$\frac{1}{40}$	1160	0.5	0.	0.402484	0.421003	0.107093
0.3	0	$\frac{1}{40}$	1160	1	0.	0.142478	0.242761	0.2679
0.3	0	$\frac{1}{40}$	1172	0	0.	0.	0.627691	0.168381

0.3	0	$\frac{1}{40}$	1172	0.5	0.	0.	0.52876	0.222636
0.3	0	$\frac{1}{40}$	1172	1	0.	0.	0.462711	0.280512
0.3	0	$\frac{1}{40}$	1184	0	0.	0.	0.627692	0.168381
0.3	0	$\frac{1}{40}$	1184	0.5	0.	0.	0.623998	0.231831
0.3	0	$\frac{1}{40}$	1184	1	0.	0.	0.620668	0.16381
0.3	0	$\frac{1}{104}$	1148	0	0.	0.616921	0.00441861	0.159731
0.3	0	$\frac{1}{104}$	1148	0.5	0.	0.492546	0.00858166	0.0872146
0.3	0	$\frac{1}{104}$	1148	1	0.	0.355026	0.0153462	0.131076
0.3	0	$\frac{1}{104}$	1160	0	0.	0.616924	0.553492	0.0295245
0.3	0	$\frac{1}{104}$	1160	0.5	0.	0.395709	0.410487	0.0462621
0.3	0	$\frac{1}{104}$	1160	1	0.	0.141093	0.228565	0.00131065
0.3	0	$\frac{1}{104}$	1172	0	0.	0.	0.616923	0.00149686
0.3	0	$\frac{1}{104}$	1172	0.5	0.	0.	0.516717	0.000072146
0.3	0	$\frac{1}{104}$	1172	1	0.	0.	0.448219	2.93646×10
0.3	0	$\frac{1}{104}$	1184	0	0.	0.	0.616924	0.000122775
0.3	0	$\frac{1}{104}$	1184	0.5	0.	0.	0.613078	0.000012013
0.3	0	$\frac{1}{104}$	1184	1	0.	0.	0.609609	2.77828×10
0.3	0	0	1148	0	0.	0.61042	0.00193275	2.71784×10
0.3	0	0	1148	0.5	0.	0.486868	0.00496389	2.50373×10
0.3	0	0	1148	1	0.	0.350969	0.0109243	9.88432×10
0.3	0	0	1160	0	0.	0.610423	0.542622	9.56257×10
0.3	0	0	1160	0.5	0.	0.391334	0.404049	4.37877×10
0.3	0	0	1160	1	0.	0.14019	0.220141	5.41256×10
0.3	0	0	1172	0	0.	0.	0.610423	7.92079×10
0.3	0	0	1172	0.5	0.	0.	0.509379	4.48971×10
0.3	0	0	1172	1	0.	0.	0.439062	8.81211×10
0.3	0	0	1184	0	0.	0.	0.610423	4.16856×10
0.3	0	0	1184	0.5	0.	0.	0.606339	1.5282×10^{-7}
0.3	0	0	1184	1	0.	0.	0.60264	5.27711×10
0	0	$\frac{1}{40}$	1148	0	0.	0.627689	0.168378	0.0949359
0	0	$\frac{1}{40}$	1148	0.5	0.	0.501762	0.13517	0.130892
0	0	$\frac{1}{40}$	1148	1	0.	0.361707	0.157246	0.228483
0	0	$\frac{1}{40}$	1160	0	0.	0.627692	0.570488	0.168188
0	0	$\frac{1}{40}$	1160	0.5	0.	0.402484	0.421003	0.107093
0	0	$\frac{1}{40}$	1160	1	0.	0.142478	0.242761	0.267899
0	0	$\frac{1}{40}$	1172	0	0.	0.	0.627691	0.168384
0	0	$\frac{1}{40}$	1172	0.5	0.	0.	0.52876	0.222636
0	0	$\frac{1}{40}$	1172	1	0.	0.	0.462711	0.280513
0	0	$\frac{1}{40}$	1184	0	0.	0.	0.627692	0.168383

0	0	$\frac{1}{40}$	1184	0.5	0.	0.	0.623998	0.231831
0	0	$\frac{1}{40}$	1184	1	0.	0.	0.620668	0.16381
0	0	$\frac{1}{104}$	1148	0	0.	0.616921	0.00441861	0.159773
0	0	$\frac{1}{104}$	1148	0.5	0.	0.492546	0.00858173	0.0872111
0	0	$\frac{1}{104}$	1148	1	0.	0.355026	0.0153463	0.131077
0	0	$\frac{1}{104}$	1160	0	0.	0.616924	0.553492	0.0294537
0	0	$\frac{1}{104}$	1160	0.5	0.	0.395709	0.410486	0.0462616
0	0	$\frac{1}{104}$	1160	1	0.	0.141093	0.228565	0.00131069
0	0	$\frac{1}{104}$	1172	0	0.	0.	0.616923	0.00149523
0	0	$\frac{1}{104}$	1172	0.5	0.	0.	0.516717	0.000072150
0	0	$\frac{1}{104}$	1172	1	0.	0.	0.448219	2.93628×10
0	0	$\frac{1}{104}$	1184	0	0.	0.	0.616924	0.000122633
0	0	$\frac{1}{104}$	1184	0.5	0.	0.	0.613078	0.000012009
0	0	$\frac{1}{104}$	1184	1	0.	0.	0.609609	2.77615×10
0	0	0	1148	0	0.	0.61042	0.00193275	3.21074×10
0	0	0	1148	0.5	0.	0.486869	0.00496414	2.48934×10
0	0	0	1148	1	0.	0.350969	0.0109243	9.88881×10
0	0	0	1160	0	0.	0.610423	0.542622	1.48067×10
0	0	0	1160	0.5	0.	0.391334	0.404049	4.37054×10
0	0	0	1160	1	0.	0.14019	0.220141	5.40821×10
0	0	0	1172	0	0.	0.	0.610423	7.48245×10
0	0	0	1172	0.5	0.	0.	0.509379	4.48908×10
0	0	0	1172	1	0.	0.	0.439061	8.77975×10
0	0	0	1184	0	0.	0.	0.610423	4.0501×10^{-7}
0	0	0	1184	0.5	0.	0.	0.606339	1.52714×10
0	0	0	1184	1	0.	0.	0.60264	5.28399×10

Check the rows:

Define parameter values:

In[•]:=
```
chi31val = 0.7;
chi32val = 0.7;
chi13val = 0.0;
chi23val = 0.0;
sigma3val = 1 / 104;
importtime3 = 1160;
f = 1;
```

Run the model:

In[•]:=
```
sol = NDSolve[
    {S1S2S3'[t] == -S1S2S3c1[t] - S1S2S3c2[t] - S1S2S3c3[t] +
```

```
  R1S2S3c1[t] + S1R2S3c2[t] + S1S2R3c3[t] - muval * S1S2S3[t] + muval,
S1S2E3'[t] == -S1S2E3c1[t] - S1S2E3c2[t] - S1S2E3c3[t] + R1S2E3c1[t] +
  S1R2E3c2[t] + S1S2S3c3[t] - muval * S1S2E3[t],
S1S2I3'[t] == -S1S2I3c1[t] - S1S2I3c2[t] - S1S2I3c3[t] + R1S2I3c1[t] +
  S1R2I3c2[t] + S1S2E3c3[t] - muval * S1S2I3[t],
S1S2R3'[t] == -S1S2R3c1[t] - S1S2R3c2[t] - S1S2R3c3[t] + R1S2R3c1[t] +
  S1R2R3c2[t] + S1S2I3c3[t] - muval * S1S2R3[t],
S1E2S3'[t] == -S1E2S3c1[t] - S1E2S3c2[t] - S1E2S3c3[t] + R1E2S3c1[t] +
  S1S2S3c2[t] + S1E2R3c3[t] - muval * S1E2S3[t],
S1E2E3'[t] == -S1E2E3c1[t] - S1E2E3c2[t] - S1E2E3c3[t] + R1E2E3c1[t] +
  S1S2E3c2[t] + S1E2S3c3[t] - muval * S1E2E3[t],
S1E2I3'[t] == -S1E2I3c1[t] - S1E2I3c2[t] - S1E2I3c3[t] + R1E2I3c1[t] +
  S1S2I3c2[t] + S1E2E3c3[t] - muval * S1E2I3[t],
S1E2R3'[t] == -S1E2R3c1[t] - S1E2R3c2[t] - S1E2R3c3[t] + R1E2R3c1[t] +
  S1S2R3c2[t] + S1E2I3c3[t] - muval * S1E2R3[t],
S1I2S3'[t] == -S1I2S3c1[t] - S1I2S3c2[t] - S1I2S3c3[t] + R1I2S3c1[t] +
  S1E2S3c2[t] + S1I2R3c3[t] - muval * S1I2S3[t],
S1I2E3'[t] == -S1I2E3c1[t] - S1I2E3c2[t] - S1I2E3c3[t] + R1I2E3c1[t] +
  S1E2E3c2[t] + S1I2S3c3[t] - muval * S1I2E3[t],
S1I2I3'[t] == -S1I2I3c1[t] - S1I2I3c2[t] - S1I2I3c3[t] + R1I2I3c1[t] +
  S1E2I3c2[t] + S1I2E3c3[t] - muval * S1I2I3[t],
S1I2R3'[t] == -S1I2R3c1[t] - S1I2R3c2[t] - S1I2R3c3[t] + R1I2R3c1[t] +
  S1E2R3c2[t] + S1I2I3c3[t] - muval * S1I2R3[t],
S1R2S3'[t] == -S1R2S3c1[t] - S1R2S3c2[t] - S1R2S3c3[t] + R1R2S3c1[t] +
  S1I2S3c2[t] + S1R2R3c3[t] - muval * S1R2S3[t],
S1R2E3'[t] == -S1R2E3c1[t] - S1R2E3c2[t] - S1R2E3c3[t] + R1R2E3c1[t] +
  S1I2E3c2[t] + S1R2S3c3[t] - muval * S1R2E3[t],
S1R2I3'[t] == -S1R2I3c1[t] - S1R2I3c2[t] - S1R2I3c3[t] + R1R2I3c1[t] +
  S1I2I3c2[t] + S1R2E3c3[t] - muval * S1R2I3[t],
S1R2R3'[t] == -S1R2R3c1[t] - S1R2R3c2[t] - S1R2R3c3[t] + R1R2R3c1[t] +
  S1I2R3c2[t] + S1R2I3c3[t] - muval * S1R2R3[t],
E1S2S3'[t] == -E1S2S3c1[t] - E1S2S3c2[t] - E1S2S3c3[t] + S1S2S3c1[t] +
  E1R2S3c2[t] + E1S2R3c3[t] - muval * E1S2S3[t],
E1S2E3'[t] == -E1S2E3c1[t] - E1S2E3c2[t] - E1S2E3c3[t] + S1S2E3c1[t] +
  E1R2E3c2[t] + E1S2S3c3[t] - muval * E1S2E3[t],
E1S2I3'[t] == -E1S2I3c1[t] - E1S2I3c2[t] - E1S2I3c3[t] + S1S2I3c1[t] +
  E1R2I3c2[t] + E1S2E3c3[t] - muval * E1S2I3[t],
E1S2R3'[t] == -E1S2R3c1[t] - E1S2R3c2[t] - E1S2R3c3[t] + S1S2R3c1[t] +
  E1R2R3c2[t] + E1S2I3c3[t] - muval * E1S2R3[t],
E1E2S3'[t] == -E1E2S3c1[t] - E1E2S3c2[t] - E1E2S3c3[t] + S1E2S3c1[t] +
  E1S2S3c2[t] + E1E2R3c3[t] - muval * E1E2S3[t],
E1E2E3'[t] == -E1E2E3c1[t] - E1E2E3c2[t] - E1E2E3c3[t] + S1E2E3c1[t] +
  E1S2E3c2[t] + E1E2S3c3[t] - muval * E1E2E3[t],
E1E2I3'[t] == -E1E2I3c1[t] - E1E2I3c2[t] - E1E2I3c3[t] + S1E2I3c1[t] +
```

```
  E1S2I3c2[t] + E1E2E3c3[t] - muval * E1E2I3[t],
E1E2R3'[t] == -E1E2R3c1[t] - E1E2R3c2[t] - E1E2R3c3[t] + S1E2R3c1[t] +
  E1S2R3c2[t] + E1E2I3c3[t] - muval * E1E2R3[t],
E1I2S3'[t] == -E1I2S3c1[t] - E1I2S3c2[t] - E1I2S3c3[t] + S1I2S3c1[t] +
  E1E2S3c2[t] + E1I2R3c3[t] - muval * E1I2S3[t],
E1I2E3'[t] == -E1I2E3c1[t] - E1I2E3c2[t] - E1I2E3c3[t] + S1I2E3c1[t] +
  E1E2E3c2[t] + E1I2S3c3[t] - muval * E1I2E3[t],
E1I2I3'[t] == -E1I2I3c1[t] - E1I2I3c2[t] - E1I2I3c3[t] + S1I2I3c1[t] +
  E1E2I3c2[t] + E1I2E3c3[t] - muval * E1I2I3[t],
E1I2R3'[t] == -E1I2R3c1[t] - E1I2R3c2[t] - E1I2R3c3[t] + S1I2R3c1[t] +
  E1E2R3c2[t] + E1I2I3c3[t] - muval * E1I2R3[t],
E1R2S3'[t] == -E1R2S3c1[t] - E1R2S3c2[t] - E1R2S3c3[t] + S1R2S3c1[t] +
  E1I2S3c2[t] + E1R2R3c3[t] - muval * E1R2S3[t],
E1R2E3'[t] == -E1R2E3c1[t] - E1R2E3c2[t] - E1R2E3c3[t] + S1R2E3c1[t] +
  E1I2E3c2[t] + E1R2S3c3[t] - muval * E1R2E3[t],
E1R2I3'[t] == -E1R2I3c1[t] - E1R2I3c2[t] - E1R2I3c3[t] + S1R2I3c1[t] +
  E1I2I3c2[t] + E1R2E3c3[t] - muval * E1R2I3[t],
E1R2R3'[t] == -E1R2R3c1[t] - E1R2R3c2[t] - E1R2R3c3[t] + S1R2R3c1[t] +
  E1I2R3c2[t] + E1R2I3c3[t] - muval * E1R2R3[t],
I1S2S3'[t] == -I1S2S3c1[t] - I1S2S3c2[t] - I1S2S3c3[t] + E1S2S3c1[t] +
  I1R2S3c2[t] + I1S2R3c3[t] - muval * I1S2S3[t],
I1S2E3'[t] == -I1S2E3c1[t] - I1S2E3c2[t] - I1S2E3c3[t] + E1S2E3c1[t] +
  I1R2E3c2[t] + I1S2S3c3[t] - muval * I1S2E3[t],
I1S2I3'[t] == -I1S2I3c1[t] - I1S2I3c2[t] - I1S2I3c3[t] + E1S2I3c1[t] +
  I1R2I3c2[t] + I1S2E3c3[t] - muval * I1S2I3[t],
I1S2R3'[t] == -I1S2R3c1[t] - I1S2R3c2[t] - I1S2R3c3[t] + E1S2R3c1[t] +
  I1R2R3c2[t] + I1S2I3c3[t] - muval * I1S2R3[t],
I1E2S3'[t] == -I1E2S3c1[t] - I1E2S3c2[t] - I1E2S3c3[t] + E1E2S3c1[t] +
  I1S2S3c2[t] + I1E2R3c3[t] - muval * I1E2S3[t],
I1E2E3'[t] == -I1E2E3c1[t] - I1E2E3c2[t] - I1E2E3c3[t] + E1E2E3c1[t] +
  I1S2E3c2[t] + I1E2S3c3[t] - muval * I1E2E3[t],
I1E2I3'[t] == -I1E2I3c1[t] - I1E2I3c2[t] - I1E2I3c3[t] + E1E2I3c1[t] +
  I1S2I3c2[t] + I1E2E3c3[t] - muval * I1E2I3[t],
I1E2R3'[t] == -I1E2R3c1[t] - I1E2R3c2[t] - I1E2R3c3[t] + E1E2R3c1[t] +
  I1S2R3c2[t] + I1E2I3c3[t] - muval * I1E2R3[t],
I1I2S3'[t] == -I1I2S3c1[t] - I1I2S3c2[t] - I1I2S3c3[t] + E1I2S3c1[t] +
  I1E2S3c2[t] + I1I2R3c3[t] - muval * I1I2S3[t],
I1I2E3'[t] == -I1I2E3c1[t] - I1I2E3c2[t] - I1I2E3c3[t] + E1I2E3c1[t] +
  I1E2E3c2[t] + I1I2S3c3[t] - muval * I1I2E3[t],
I1I2I3'[t] == -I1I2I3c1[t] - I1I2I3c2[t] - I1I2I3c3[t] + E1I2I3c1[t] +
  I1E2I3c2[t] + I1I2E3c3[t] - muval * I1I2I3[t],
I1I2R3'[t] == -I1I2R3c1[t] - I1I2R3c2[t] - I1I2R3c3[t] + E1I2R3c1[t] +
  I1E2R3c2[t] + I1I2I3c3[t] - muval * I1I2R3[t],
I1R2S3'[t] == -I1R2S3c1[t] - I1R2S3c2[t] - I1R2S3c3[t] + E1R2S3c1[t] +
```

```
  I1I2S3c2[t] + I1R2R3c3[t] - muval * I1R2S3[t],
I1R2E3'[t] == -I1R2E3c1[t] - I1R2E3c2[t] - I1R2E3c3[t] + E1R2E3c1[t] +
  I1I2E3c2[t] + I1R2S3c3[t] - muval * I1R2E3[t],
I1R2I3'[t] == -I1R2I3c1[t] - I1R2I3c2[t] - I1R2I3c3[t] + E1R2I3c1[t] +
  I1I2I3c2[t] + I1R2E3c3[t] - muval * I1R2I3[t],
I1R2R3'[t] == -I1R2R3c1[t] - I1R2R3c2[t] - I1R2R3c3[t] + E1R2R3c1[t] +
  I1I2R3c2[t] + I1R2I3c3[t] - muval * I1R2R3[t],
R1S2S3'[t] == -R1S2S3c1[t] - R1S2S3c2[t] - R1S2S3c3[t] + I1S2S3c1[t] +
  R1R2S3c2[t] + R1S2R3c3[t] - muval * R1S2S3[t],
R1S2E3'[t] == -R1S2E3c1[t] - R1S2E3c2[t] - R1S2E3c3[t] + I1S2E3c1[t] +
  R1R2E3c2[t] + R1S2S3c3[t] - muval * R1S2E3[t],
R1S2I3'[t] == -R1S2I3c1[t] - R1S2I3c2[t] - R1S2I3c3[t] + I1S2I3c1[t] +
  R1R2I3c2[t] + R1S2E3c3[t] - muval * R1S2I3[t],
R1S2R3'[t] == -R1S2R3c1[t] - R1S2R3c2[t] - R1S2R3c3[t] + I1S2R3c1[t] +
  R1R2R3c2[t] + R1S2I3c3[t] - muval * R1S2R3[t],
R1E2S3'[t] == -R1E2S3c1[t] - R1E2S3c2[t] - R1E2S3c3[t] + I1E2S3c1[t] +
  R1S2S3c2[t] + R1E2R3c3[t] - muval * R1E2S3[t],
R1E2E3'[t] == -R1E2E3c1[t] - R1E2E3c2[t] - R1E2E3c3[t] + I1E2E3c1[t] +
  R1S2E3c2[t] + R1E2S3c3[t] - muval * R1E2E3[t],
R1E2I3'[t] == -R1E2I3c1[t] - R1E2I3c2[t] - R1E2I3c3[t] + I1E2I3c1[t] +
  R1S2I3c2[t] + R1E2E3c3[t] - muval * R1E2I3[t],
R1E2R3'[t] == -R1E2R3c1[t] - R1E2R3c2[t] - R1E2R3c3[t] + I1E2R3c1[t] +
  R1S2R3c2[t] + R1E2I3c3[t] - muval * R1E2R3[t],
R1I2S3'[t] == -R1I2S3c1[t] - R1I2S3c2[t] - R1I2S3c3[t] + I1I2S3c1[t] +
  R1E2S3c2[t] + R1I2R3c3[t] - muval * R1I2S3[t],
R1I2E3'[t] == -R1I2E3c1[t] - R1I2E3c2[t] - R1I2E3c3[t] + I1I2E3c1[t] +
  R1E2E3c2[t] + R1I2S3c3[t] - muval * R1I2E3[t],
R1I2I3'[t] == -R1I2I3c1[t] - R1I2I3c2[t] - R1I2I3c3[t] + I1I2I3c1[t] +
  R1E2I3c2[t] + R1I2E3c3[t] - muval * R1I2I3[t],
R1I2R3'[t] == -R1I2R3c1[t] - R1I2R3c2[t] - R1I2R3c3[t] + I1I2R3c1[t] +
  R1E2R3c2[t] + R1I2I3c3[t] - muval * R1I2R3[t],
R1R2S3'[t] == -R1R2S3c1[t] - R1R2S3c2[t] - R1R2S3c3[t] + I1R2S3c1[t] +
  R1I2S3c2[t] + R1R2R3c3[t] - muval * R1R2S3[t],
R1R2E3'[t] == -R1R2E3c1[t] - R1R2E3c2[t] - R1R2E3c3[t] + I1R2E3c1[t] +
  R1I2E3c2[t] + R1R2S3c3[t] - muval * R1R2E3[t],
R1R2I3'[t] == -R1R2I3c1[t] - R1R2I3c2[t] - R1R2I3c3[t] + I1R2I3c1[t] +
  R1I2I3c2[t] + R1R2E3c3[t] - muval * R1R2I3[t],
R1R2R3'[t] == -R1R2R3c1[t] - R1R2R3c2[t] - R1R2R3c3[t] + I1R2R3c1[t] +
  R1I2R3c2[t] + R1R2I3c3[t] - muval * R1R2R3[t],
cuminf'[t] == E1S2S3c1[t] + E1S2E3c1[t] + E1S2I3c1[t] + E1S2R3c1[t] +
  E1E2S3c1[t] + E1E2E3c1[t] + E1E2I3c1[t] + E1E2R3c1[t] + E1I2S3c1[t] +
  E1I2E3c1[t] + E1I2I3c1[t] + E1I2R3c1[t] + E1R2S3c1[t] + E1R2E3c1[t] +
  E1R2I3c1[t] + E1R2R3c1[t] + S1E2S3c2[t] + S1E2E3c2[t] + S1E2I3c2[t] +
  S1E2R3c2[t] + E1E2S3c2[t] + E1E2E3c2[t] + E1E2I3c2[t] + E1E2R3c2[t] +
```

```
    I1E2S3c2[t] + I1E2E3c2[t] + I1E2I3c2[t] + I1E2R3c2[t] + R1E2S3c2[t] +
    R1E2E3c2[t] + R1E2I3c2[t] + R1E2R3c2[t] + S1S2E3c3[t] + S1E2E3c3[t] +
    S1I2E3c3[t] + S1R2E3c3[t] + E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] +
    E1R2E3c3[t] + I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
    R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
  cuminfnCoV'[t] == S1S2E3c3[t] + S1E2E3c3[t] + S1I2E3c3[t] + S1R2E3c3[t] +
    E1S2E3c3[t] + E1E2E3c3[t] + E1I2E3c3[t] + E1R2E3c3[t] +
    I1S2E3c3[t] + I1E2E3c3[t] + I1I2E3c3[t] + I1R2E3c3[t] +
    R1S2E3c3[t] + R1E2E3c3[t] + R1I2E3c3[t] + R1R2E3c3[t],
  S1S2S3[0] == 1, S1S2E3[0] == 0, S1S2I3[0] == 0, S1S2R3[0] == 0, S1E2S3[0] == 0,
  S1E2E3[0] == 0, S1E2I3[0] == 0, S1E2R3[0] == 0, S1I2S3[0] == 0,
  S1I2E3[0] == 0, S1I2I3[0] == 0, S1I2R3[0] == 0, S1R2S3[0] == 0,
  S1R2E3[0] == 0, S1R2I3[0] == 0, S1R2R3[0] == 0, E1S2S3[0] == 0,
  E1S2E3[0] == 0, E1S2I3[0] == 0, E1S2R3[0] == 0, E1E2S3[0] == 0, E1E2E3[0] == 0,
  E1E2I3[0] == 0, E1E2R3[0] == 0, E1I2S3[0] == 0, E1I2E3[0] == 0, E1I2I3[0] == 0,
  E1I2R3[0] == 0, E1R2S3[0] == 0, E1R2E3[0] == 0, E1R2I3[0] == 0, E1R2R3[0] == 0,
  I1S2S3[0] == 0, I1S2E3[0] == 0, I1S2I3[0] == 0, I1S2R3[0] == 0, I1E2S3[0] == 0,
  I1E2E3[0] == 0, I1E2I3[0] == 0, I1E2R3[0] == 0, I1I2S3[0] == 0, I1I2E3[0] == 0,
  I1I2I3[0] == 0, I1I2R3[0] == 0, I1R2S3[0] == 0, I1R2E3[0] == 0, I1R2I3[0] == 0,
  I1R2R3[0] == 0, R1S2S3[0] == 0, R1S2E3[0] == 0, R1S2I3[0] == 0, R1S2R3[0] == 0,
  R1E2S3[0] == 0, R1E2E3[0] == 0, R1E2I3[0] == 0, R1E2R3[0] == 0, R1I2S3[0] == 0,
  R1I2E3[0] == 0, R1I2I3[0] == 0, R1I2R3[0] == 0, R1R2S3[0] == 0, R1R2E3[0] == 0,
  R1R2I3[0] == 0, R1R2R3[0] == 0, cuminf[0] == 0, cuminfnCoV[0] == 0},
 {S1S2S3, S1S2E3, S1S2I3, S1S2R3, S1E2S3, S1E2E3, S1E2I3, S1E2R3, S1I2S3,
  S1I2E3, S1I2I3, S1I2R3, S1R2S3, S1R2E3, S1R2I3, S1R2R3, E1S2S3, E1S2E3, E1S2I3,
  E1S2R3, E1E2S3, E1E2E3, E1E2I3, E1E2R3, E1I2S3, E1I2E3, E1I2I3, E1I2R3, E1R2S3,
  E1R2E3, E1R2I3, E1R2R3, I1S2S3, I1S2E3, I1S2I3, I1S2R3, I1E2S3, I1E2E3, I1E2I3,
  I1E2R3, I1I2S3, I1I2E3, I1I2I3, I1I2R3, I1R2S3, I1R2E3, I1R2I3, I1R2R3,
  R1S2S3, R1S2E3, R1S2I3, R1S2R3, R1E2S3, R1E2E3, R1E2I3, R1E2R3, R1I2S3,
  R1I2E3, R1I2I3, R1I2R3, R1R2S3, R1R2E3, R1R2I3, R1R2R3, cuminf, cuminfnCoV},
 {t, 0, tmax}
];
```

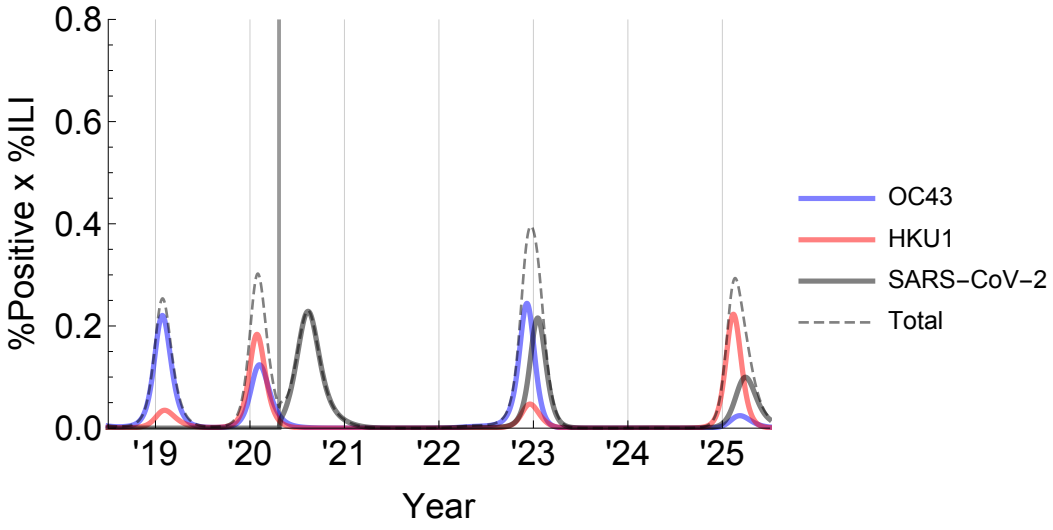
Plot output:

```
In[•]:= figinvasion =
  Plot[{Evaluate[{{100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t])},
       {100 * scalingfactor * (S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] +
          E1I2S3[t] + E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] + R1I2R3[t])},
       {100 * scalingfactor * (S1S2I3[t] + S1E2I3[t] + S1I2I3[t] + S1R2I3[t] +
          E1S2I3[t] + E1E2I3[t] + E1I2I3[t] + E1R2I3[t] + I1S2I3[t] + I1E2I3[t] +
          I1I2I3[t] + I1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1I2I3[t] + R1R2I3[t])},
       {100 * scalingfactor * (I1S2S3[t] + I1S2E3[t] + I1S2I3[t] + I1S2R3[t] +
          I1E2S3[t] + I1E2E3[t] + I1E2I3[t] + I1E2R3[t] + I1I2S3[t] + I1I2E3[t] +
          I1I2I3[t] + I1I2R3[t] + I1R2S3[t] + I1R2E3[t] + I1R2I3[t] + I1R2R3[t] +
          S1I2S3[t] + S1I2E3[t] + S1I2I3[t] + S1I2R3[t] + E1I2S3[t] +
          E1I2E3[t] + E1I2I3[t] + E1I2R3[t] + R1I2S3[t] + R1I2E3[t] + R1I2I3[t] +
          R1I2R3[t] + S1S2I3[t] + S1E2I3[t] + S1R2I3[t] + E1S2I3[t] +
          E1E2I3[t] + E1R2I3[t] + R1S2I3[t] + R1E2I3[t] + R1R2I3[t])
       }} /. sol]}, Join[{t}, plotwindow], PlotRange → {0, plotrangemax},
    GridLines → {Join[Table[{i, yearbarchar}, {i, 0, tmax, 52}],
       {{importtime3, importbarchar}}], None},
    Frame → {True, True, False, False}, PlotRangePadding → None,
    BaseStyle → FontSize → fs,
    FrameTicks → {Table[{i, "'" <> ToString[i / 52 - 2]}, {i, 0, tmax, 52}], Automatic},
    FrameLabel → {"Year", "%Positive x %ILI"}, ImageSize → imsz,
    PlotLegends → {"OC43", "HKU1", "SARS-CoV-2", "Total"},
    PlotStyle → {oc43char, hku1char, ncovchar, totalchar}];
```

Save output:

In[ ]:= `figinvasion`

Out[ ]=



In[ ]:=
```
Plot[Table[betaval[t, f * amplitude, baseline + (1 - f) * amplitude, phival, 1],
  {f, {0, 0.5, 1}}], {t, 0, 52}, PlotRange → {0, Automatic}]
```

Out[ ]=