1 Parameters and Variables of the Differential Equation System

Table S1: Parameters and variables of the differential equation system.

$\kappa_{i,j}$	Contact rate of age group i with age group j
$\pi_{AC1,i} - \pi_{AC5,i}$	1-Effectiveness of child vaccination against carriers of GS1-GS5 in age group i
$\pi_{IPD1,i} - \pi_{IPD5,i}$	1-Effectiveness of child vaccination against IPD by GS1-GS5 in age group i
$\pi_{NBPPi,i} - \pi_{NBPPi,i}$	1-Effectiveness of child vaccination against NBPPi by GS1-GS5 in age group i
$\pi_{NBPPo,i} - \pi_{NBPPo,i}$	1-Effectiveness of child vaccination against NBPPo by GS1-GS5 in age group i
$\rho_{AC1,i} - \rho_{AC5,i}$	1-Effectiveness of adult vaccination against carriers of GS1-GS5 in age group i
$\rho_{IPD1,i} - \rho_{IPD5,i}$	1-Effectiveness of adult vaccination against IPD by GS1-GS5 in age group i
$\rho_{NBPPi,i} - \rho_{NBPPi,i}$	1-Effectiveness of adult vaccination against NBPPi by GS1-GS5 in age group i
$\rho_{NBPPo,i} - \rho_{NBPPo,i}$	1-Effectiveness of adult vaccination against NBPPo by GS1-GS5 in age group i

1.1 Infant Vaccination

Susceptible:

$$VI_S_i' = -\left(\pi_{AC1,i} \cdot \lambda_{1,i} + \pi_{AC2,i} \cdot \lambda_{2,i} + \pi_{AC3,i} \cdot \lambda_{3,i} + \pi_{AC4,i} \cdot \lambda_{4,i} + \pi_{AC5,i} \cdot \lambda_{5,i}\right) \cdot VI_S_i + r_i \cdot \left(VI_SC_{1,i} + VI_SC_{2,i} + VI_SC_{3,i} + VI_SC_{4,i} + VI_SC_{5,i}\right)$$

Carriers of a single group of serotypes:

$$VI_SC_{1,i}' = -\left(\pi_{AC2,i} \cdot c_{21} \cdot \lambda_{2,i} + \pi_{AC3,i} \cdot c_{31} \cdot \lambda_{3,i} + \pi_{AC4,i} \cdot c_{41} \cdot \lambda_{4,i} + \pi_{AC5,i} \cdot c_{51} \cdot \lambda_{5,i} + r_i\right) \cdot VI_SC_{1,i} + \pi_{AC1,i} \cdot \lambda_{1,i} \cdot VI_S_i + r_i \cdot \left(VI_DC_{12,i} + VI_DC_{13,i} + VI_DC_{14,i} + VI_DC_{15,i}\right)$$

$$VI_SC_{2,i}' = -\left(\pi_{AC1,i} \cdot c_{12} \cdot \lambda_{1,i} + \pi_{AC3,i} \cdot c_{32} \cdot \lambda_{3,i} + \pi_{AC4,i} \cdot c_{42} \cdot \lambda_{4,i} + \pi_{AC5,i} \cdot c_{52} \cdot \lambda_{5,i} + r_i\right) \cdot VI_SC_{2,i} + \pi_{AC2,i} \cdot \lambda_{2,i} \cdot VI_S_i + r_i \cdot \left(VI_DC_{12,i} + VI_DC_{23,i} + VI_DC_{24,i} + VI_DC_{25,i}\right)$$

$$VI_SC_{3,i}' = -\left(\pi_{AC1,i} \cdot c_{13} \cdot \lambda_{1,i} + \pi_{AC2,i} \cdot c_{23} \cdot \lambda_{2,i} + \pi_{AC4,i} \cdot c_{43} \cdot \lambda_{4,i} + \pi_{AC5,i} \cdot c_{53} \cdot \lambda_{5,i} + r_i\right) \cdot VI_SC_{3,i} + \pi_{AC3,i} \cdot \lambda_{3,i} \cdot VI_S_i + r_i \cdot \left(VI_DC_{13,i} + VI_DC_{23,i} + VI_DC_{34,i} + VI_DC_{35,i}\right)$$

$$VI_SC_{4,i}' = -\left(\pi_{AC1,i} \cdot c_{14} \cdot \lambda_{1,i} + \pi_{AC2,i} \cdot c_{24} \cdot \lambda_{2,i} + \pi_{AC3,i} \cdot c_{34} \cdot \lambda_{3,i} + \pi_{AC5,i} \cdot c_{54} \cdot \lambda_{5,i} + r_i\right) \cdot VI_SC_{4,i} + \pi_{AC4,i} \cdot \lambda_{4,i} \cdot VI_S_i + r_i \cdot \left(VI_DC_{14,i} + VI_DC_{24,i} + VI_DC_{34,i} + VI_DC_{45,i}\right)$$

$$VI_SC_{5,i}' = -\left(\pi_{AC1,i} \cdot c_{15} \cdot \lambda_{1,i} + \pi_{AC2,i} \cdot c_{25} \cdot \lambda_{2,i} + \pi_{AC3,i} \cdot c_{35} \cdot \lambda_{3,i} + \pi_{AC4,i} \cdot c_{45} \cdot \lambda_{4,i} + r_i\right) \cdot VI_SC_{5,i} + \pi_{AC5,i} \cdot \lambda_{5,i} \cdot VI_S_i + r_i \cdot \left(VI_DC_{15,i} + VI_DC_{25,i} + VI_DC_{35,i} + VI_DC_{45,i}\right)$$

Carriers of double different groups of serotypes:

$$VI_DC'_{12,i} = -2 \cdot r_i \cdot VI_DC_{12,i} + \pi_{AC2,i} \cdot c_{21} \cdot \lambda_{2,i} \cdot VI_SC_{1,i} + \pi_{AC1,i} \cdot c_{12} \cdot \lambda_{1,i} \cdot VI_SC_{2,i}$$

$$VI_DC'_{13,i} = -2 \cdot r_i \cdot VI_DC_{13,i} + \pi_{AC,i3} \cdot c_{31} \cdot \lambda_{3,i} \cdot VI_SC_{1,i} + \pi_{AC1,i} \cdot c_{13} \cdot \lambda_{1,i} \cdot VI_SC_{3,i}$$

$$VI_DC'_{14,i} = -2 \cdot r_i \cdot VI_DC_{14,i} + \pi_{AC4,i} \cdot c_{41} \cdot \lambda_{4,i} \cdot VI_SC_{1,i} + \pi_{AC1,i} \cdot c_{14} \cdot \lambda_{1,i} \cdot VI_SC_{4,i}$$

$$VI_DC'_{15,i} = -2 \cdot r_i \cdot VI_DC_{15,i} + \pi_{AC5,i} \cdot c_{51} \cdot \lambda_{5,i} \cdot VI_SC_{1,i} + \pi_{AC1,i} \cdot c_{15} \cdot \lambda_{1,i} \cdot VI_SC_{5,i}$$

$$VI_DC'_{23,i} = -2 \cdot r_i \cdot VI_DC_{23,i} + \pi_{AC3,i} \cdot c_{32} \cdot \lambda_{3,i} \cdot VI_SC_{2,i} + \pi_{AC2,i} \cdot c_{23} \cdot \lambda_{2,i} \cdot VI_SC_{3,i}$$

$$VI_DC'_{24,i} = -2 \cdot r_i \cdot VI_DC_{24,i} + \pi_{AC4,i} \cdot c_{42} \cdot \lambda_{4,i} \cdot VI_SC_{2,i} + \pi_{AC2,i} \cdot c_{24} \cdot \lambda_{2,i} \cdot VI_SC_{4,i}$$

$$VI_DC'_{25,i} = -2 \cdot r_i \cdot VI_DC_{25,i} + \pi_{AC5,i} \cdot c_{52} \cdot \lambda_{5,i} \cdot VI_SC_{2,i} + \pi_{AC2,i} \cdot c_{25} \cdot \lambda_{2,i} \cdot VI_SC_{5,i}$$

$$VI_DC'_{34,i} = -2 \cdot r_i \cdot VI_DC_{34,i} + \pi_{AC4,i} \cdot c_{43} \cdot \lambda_{4,i} \cdot VI_SC_{3,i} + \pi_{AC3,i} \cdot c_{34} \cdot \lambda_{3,i} \cdot VI_SC_{4,i}$$

$$VI_DC'_{35,i} = -2 \cdot r_i \cdot VI_DC_{35,i} + \pi_{AC5,i} \cdot c_{53} \cdot \lambda_{5,i} \cdot VI_SC_{3,i} + \pi_{AC3,i} \cdot c_{35} \cdot \lambda_{3,i} \cdot VI_SC_{5,i}$$

$$VI_DC'_{45,i} = -2 \cdot r_i \cdot VI_DC_{45,i} + \pi_{AC5,i} \cdot c_{54} \cdot \lambda_{5,i} \cdot VI_SC_{4,i} + \pi_{AC4,i} \cdot c_{45} \cdot \lambda_{4,i} \cdot VI_SC_{5,i}$$

1.2 Adult Vaccination

Susceptible:

$$VA_S'_i = -\left(\rho_{AC1,i} \cdot \lambda_{1,i} + \rho_{AC2,i} \cdot \lambda_{2,i} + \rho_{AC3,i} \cdot \lambda_{3,i} + \rho_{AC4,i} \cdot \lambda_{4,i} + \rho_{AC5,i} \cdot \lambda_{5,i}\right) \cdot VA_S_i + r_i \cdot \left(VA_SC_{1,i} + VA_SC_{2,i} + VA_SC_{3,i} + VA_SC_{4,i} + VA_SC_{5,i}\right)$$

Carriers of a single group of serotypes:

$$VA_SC'_{1,i} = -\left(\rho_{AC2,i} \cdot c_{21} \cdot \lambda_{2,i} + \pi_{AC3}(t_{VI}) \cdot c_{31} \cdot \lambda_{3,i} + \pi_{AC4}(t_{VI}) \cdot c_{41} \cdot \lambda_{4,i} + \pi_{AC5}(t_{VI}) \cdot c_{51} \cdot \lambda_{5,i} + r_i\right) \cdot VA_SC_{1,i} + \rho_{AC1,i} \cdot \lambda_{1,i} \cdot VA_S_i + r_i \cdot \left(VA_DC_{12,i} + VA_DC_{13,i} + VA_DC_{14,i} + VA_DC_{15,i}\right)$$

$$VA_SC'_{2,i} = -\left(\rho_{AC1,i} \cdot c_{12} \cdot \lambda_{1,i} + \pi_{AC3}(t_{VI}) \cdot c_{32} \cdot \lambda_{3,i} + \pi_{AC4}(t_{VI}) \cdot c_{42} \cdot \lambda_{4,i} + \pi_{AC5}(t_{VI}) \cdot c_{52} \cdot \lambda_{5,i} + r_i\right) \cdot VA_SC_{2,i} + \rho_{AC2,i} \cdot \lambda_{2,i} \cdot VA_S_i + r_i \cdot \left(VA_DC_{12,i} + VA_DC_{23,i} + VA_DC_{24,i} + VA_DC_{25,i}\right)$$

$$VA_SC'_{3,i} = -\left(\rho_{AC1,i} \cdot c_{13} \cdot \lambda_{1,i} + \pi_{AC2}(t_{VI}) \cdot c_{23} \cdot \lambda_{2,i} + \pi_{AC4}(t_{VI}) \cdot c_{43} \cdot \lambda_{4,i} + \pi_{AC5}(t_{VI}) \cdot c_{53} \cdot \lambda_{5,i} + r_i\right) \cdot VA_SC_{3,i} + \rho_{AC3,i} \cdot \lambda_{3,i} \cdot VA_S_i + r_i \cdot \left(VA_DC_{13,i} + VA_DC_{23,i} + VA_DC_{34,i} + VA_DC_{35,i}\right)$$

$$VA_SC'_{4,i} = -\left(\rho_{AC1,i} \cdot c_{14} \cdot \lambda_{1,i} + \pi_{AC2}(t_{VI}) \cdot c_{24} \cdot \lambda_{2,i} + \pi_{AC3}(t_{VI}) \cdot c_{34} \cdot \lambda_{3,i} + \pi_{AC5}(t_{VI}) \cdot c_{54} \cdot \lambda_{5,i} + r_i\right) \cdot VA_SC_{4,i} + \rho_{AC4,i} \cdot \lambda_{4,i} \cdot VA_S_i + r_i \cdot \left(VA_DC_{14,i} + VA_DC_{24,i} + VA_DC_{34,i} + VA_DC_{45,i}\right)$$

$$VA_SC'_{5,i} = -\left(\rho_{AC1,i} \cdot c_{15} \cdot \lambda_{1,i} + \pi_{AC2}(t_{VI}) \cdot c_{25} \cdot \lambda_{2,i} + \pi_{AC3}(t_{VI}) \cdot c_{35} \cdot \lambda_{3,i} + \pi_{AC4}(t_{VI}) \cdot c_{45} \cdot \lambda_{4,i} + r_i\right) \cdot VA_SC_{5,i} + \rho_{AC5,i} \cdot \lambda_{5,i} \cdot VA_S_i + r_i \cdot \left(VA_DC_{15,i} + VA_DC_{25,i} + VA_DC_{35,i} + VA_DC_{45,i}\right)$$

Carriers of double different groups of serotypes:

$$VA_DC'_{12,i} = -2 \cdot r_i \cdot VA_DC_{12,i} + \rho_{AC2,i} \cdot c_{21} \cdot \lambda_{2,i} \cdot VA_SC_{1,i} + \rho_{AC1,i} \cdot c_{12} \cdot \lambda_{1,i} \cdot VA_SC_{2,i}$$

$$VA_DC'_{13,i} = -2 \cdot r_i \cdot VA_DC_{13,i} + \rho_{AC3,i} \cdot c_{31} \cdot \lambda_{3,i} \cdot VA_SC_{1,i} + \rho_{AC1,i} \cdot c_{13} \cdot \lambda_{1,i} \cdot VA_SC_{3,i}$$

$$VA_DC'_{14,i} = -2 \cdot r_i \cdot VA_DC_{14,i} + \rho_{AC4,i} \cdot c_{41} \cdot \lambda_{4,i} \cdot VA_SC_{1,i} + \rho_{AC1,i} \cdot c_{14} \cdot \lambda_{1,i} \cdot VA_SC_{4,i}$$

$$VA_DC'_{15,i} = -2 \cdot r_i \cdot VA_DC_{15,i} + \rho_{AC5,i} \cdot c_{51} \cdot \lambda_{5,i} \cdot VA_SC_{1,i} + \rho_{AC1,i} \cdot c_{15} \cdot \lambda_{1,i} \cdot VA_SC_{5,i}$$

$$VA_DC'_{23,i} = -2 \cdot r_i \cdot VA_DC_{23,i} + \rho_{AC3,i} \cdot c_{32} \cdot \lambda_{3,i} \cdot VA_SC_{2,i} + \rho_{AC2,i} \cdot c_{23} \cdot \lambda_{2,i} \cdot VA_SC_{3,i}$$

$$VA_DC'_{24,i} = -2 \cdot r_i \cdot VA_DC_{24,i} + \rho_{AC4,i} \cdot c_{42} \cdot \lambda_{4,i} \cdot VA_SC_{2,i} + \rho_{AC2,i} \cdot c_{24} \cdot \lambda_{2,i} \cdot VA_SC_{4,i}$$

$$VA_DC'_{25,i} = -2 \cdot r_i \cdot VA_DC_{25,i} + \rho_{AC5,i} \cdot c_{52} \cdot \lambda_{5,i} \cdot VA_SC_{2,i} + \rho_{AC2,i} \cdot c_{25} \cdot \lambda_{2,i} \cdot VA_SC_{5,i}$$

$$VA_DC'_{34,i} = -2 \cdot r_i \cdot VA_DC_{34,i} + \rho_{AC4,i} \cdot c_{43} \cdot \lambda_{4,i} \cdot VA_SC_{3,i} + \rho_{AC3,i} \cdot c_{34} \cdot \lambda_{3,i} \cdot VA_SC_{4,i}$$

$$VA_DC'_{35,i} = -2 \cdot r_i \cdot VA_DC_{35,i} + \rho_{AC5,i} \cdot c_{53} \cdot \lambda_{5,i} \cdot VA_SC_{3,i} + \rho_{AC3,i} \cdot c_{35} \cdot \lambda_{3,i} \cdot VA_SC_{5,i}$$

$$VA_DC'_{45,i} = -2 \cdot r_i \cdot VA_DC_{45,i} + \rho_{AC5,i} \cdot c_{54} \cdot \lambda_{5,i} \cdot VA_SC_{4,i} + \rho_{AC4,i} \cdot c_{45} \cdot \lambda_{4,i} \cdot VA_SC_{5,i}$$

1.3 Quarterly Disease Incidence Per 100,000 Individuals

Invasive Pneumococcal diseases:

$$\begin{aligned} IPD'_{1,i} = \lambda_{1,i} \cdot \Big(& \big(S_i + c_{12} \cdot SC_{2,i} + c_{13} \cdot SC_{3,i} + c_{14} \cdot SC_{4,i} + c_{15} \cdot SC_{5,i}\big) + \pi_{IPD1,i} \\ & \cdot \big(VI_S_i + c_{12} \cdot VI_SC_{2,i} + c_{13} \cdot VI_SC_{3,i} + c_{14} \cdot VI_SC_{4,i} + c_{15} \cdot VI_SC_{5,i}\big) + \rho_{IPD1,i} \\ & \cdot \big(VI_S_i + c_{12} \cdot VI_SC_{2,i} + c_{13} \cdot VI_SC_{3,i} + c_{14} \cdot VI_SC_{4,i} + c_{15} \cdot VI_SC_{5,i}\big)\Big) \end{aligned}$$

$$\begin{aligned} IPD'_{2,i} = \lambda_{2,i} \cdot \Big(& \big(S_i + c_{21} \cdot SC_{1,i} + c_{23} \cdot SC_{3,i} + c_{24} \cdot SC_{4,i} + c_{25} \cdot SC_{5,i}\big) + \pi_{IPD2,i} \\ & \cdot \big(VI_S_i + c_{21} \cdot VI_SC_{1,i} + c_{23} \cdot VI_SC_{3,i} + c_{24} \cdot VI_SC_{4,i} + c_{25} \cdot VI_SC_{5,i}\big) + \rho_{IPD2,i} \\ & \cdot \big(VI_S_i + c_{21} \cdot VI_SC_{1,i} + c_{23} \cdot VI_SC_{3,i} + c_{24} \cdot VI_SC_{4,i} + c_{25} \cdot VI_SC_{5,i}\big)\Big) \end{aligned}$$

$$\begin{aligned} IPD'_{3,i} = \lambda_{3,i} \cdot \Big(& \big(S_i + c_{31} \cdot SC_{1,i} + c_{32} \cdot SC_{2,i} + c_{34} \cdot SC_{4,i} + c_{35} \cdot SC_{5,i}\big) + \pi_{IPD3,i} \\ & \cdot \big(VI_S_i + c_{31} \cdot VI_SC_{1,i} + c_{32} \cdot VI_SC_{2,i} + c_{34} \cdot VI_SC_{4,i} + c_{35} \cdot VI_SC_{5,i}\big) + \rho_{IPD3,i} \\ & \cdot \big(VI_S_i + c_{31} \cdot VI_SC_{1,i} + c_{32} \cdot VI_SC_{2,i} + c_{34} \cdot VI_SC_{4,i} + c_{35} \cdot VI_SC_{5,i}\big)\Big) \end{aligned}$$

$$\begin{aligned} IPD'_{4,i} = \lambda_{4,i} \cdot \Big(& \big(S_i + c_{41} \cdot SC_{1,i} + c_{42} \cdot SC_{2,i} + c_{43} \cdot SC_{3i} + c_{45} \cdot SC_{5,i}\big) + \pi_{IPD4,i} \\ & \cdot \big(VI_S_i + c_{41} \cdot VI_SC_{1,i} + c_{42} \cdot VI_SC_{2,i} + c_{43} \cdot VI_SC_{3,i} + c_{45} \cdot VI_SC_{5,i}\big) + \rho_{IPD4,i} \\ & \cdot \big(VI_S_i + c_{41} \cdot VI_SC_{1,i} + c_{42} \cdot VI_SC_{2,i} + c_{43} \cdot VI_SC_{3,i} + c_{45} \cdot VI_SC_{5,i}\big)\Big) \end{aligned}$$

$$\begin{aligned} IPD'_{5,i} = \lambda_{4,i} \cdot \Big(& \big(S_i + c_{51} \cdot SC_{1,i} + c_{52} \cdot SC_{2,i} + c_{53} \cdot SC_{3i} + c_{54} \cdot SC_{4,i}\big) + \pi_{IPD5,i} \\ & \cdot \big(VI_S_i + c_{51} \cdot VI_SC_{1,i} + c_{52} \cdot VI_SC_{2,i} + c_{53} \cdot VI_SC_{3,i} + c_{54} \cdot VI_SC_{4,i}\big) + \rho_{IPD5,i} \\ & \cdot \big(VI_S_i + c_{51} \cdot VI_SC_{1,i} + c_{52} \cdot VI_SC_{2,i} + c_{53} \cdot VI_SC_{3,i} + c_{54} \cdot VI_SC_{4,i}\big)\Big) \end{aligned}$$

Hospitalized community-acquired noninvasive pnemococcal pneumonia:

$$\begin{aligned} NBPPi'_{1,i} = \lambda_{1,i} \cdot \Big(& \big(S_i + c_{12} \cdot SC_{2,i} + c_{13} \cdot SC_{3,i} + c_{14} \cdot SC_{4,i} + c_{15} \cdot SC_{5,i}\big) + \pi_{NBPPi1,i} \\ & \cdot \big(VI_S_i + c_{12} \cdot VI_SC_{2,i} + c_{13} \cdot VI_SC_{3,i} + c_{14} \cdot VI_SC_{4,i} + c_{15} \cdot VI_SC_{5,i}\big) + \rho_{NBPPi1,i} \\ & \cdot \big(VI_S_i + c_{12} \cdot VI_SC_{2,i} + c_{13} \cdot VI_SC_{3,i} + c_{14} \cdot VI_SC_{4,i} + c_{15} \cdot VI_SC_{5,i}\big)\Big) \end{aligned}$$

$$NBPPi'_{2,i} = \lambda_{2,i} \cdot \Big(\big(S_i + c_{21} \cdot SC_{1,i} + c_{23} \cdot SC_{3,i} + c_{24} \cdot SC_{4,i} + c_{25} \cdot SC_{5,i}\big) + \pi_{NBPPi2,i} \cdot \big(VI_S_i + c_{21} \cdot VI_SC_{1,i} + c_{23} \cdot VI_SC_{3,i} + c_{24} \cdot VI_SC_{4,i} + c_{25} \cdot VI_SC_{5,i}\big) + \rho_{NBPPi2,i} \cdot \big(VI_S_i + c_{21} \cdot VI_SC_{1,i} + c_{23} \cdot VI_SC_{3,i} + c_{24} \cdot VI_SC_{4,i} + c_{25} \cdot VI_SC_{5,i}\big)\Big)$$

$$NBPPi'_{3,i} = \lambda_{3,i} \cdot \Big(\big(S_i + c_{31} \cdot SC_{1,i} + c_{32} \cdot SC_{2,i} + c_{34} \cdot SC_{4,i} + c_{35} \cdot SC_{5,i}\big) + \pi_{NBPPi3,i} \cdot \big(VI_S_i + c_{31} \cdot VI_SC_{1,i} + c_{32} \cdot VI_SC_{2,i} + c_{34} \cdot VI_SC_{4,i} + c_{35} \cdot VI_SC_{5,i}\big) + \rho_{NBPPi3,i} \cdot \big(VI_S_i + c_{31} \cdot VI_SC_{1,i} + c_{32} \cdot VI_SC_{2,i} + c_{34} \cdot VI_SC_{4,i} + c_{35} \cdot VI_SC_{5,i}\big)\Big)$$

$$NBPPi'_{4,i} = \lambda_{4,i} \cdot \Big(\big(S_i + c_{41} \cdot SC_{1,i} + c_{42} \cdot SC_{2,i} + c_{43} \cdot SC_{3i} + c_{45} \cdot SC_{5,i}\big) + \pi_{NBPPi4,i} \cdot \big(VI_S_i + c_{41} \cdot VI_SC_{1,i} + c_{42} \cdot VI_SC_{2,i} + c_{43} \cdot VI_SC_{3,i} + c_{45} \cdot VI_SC_{5,i}\big) + \rho_{NBPPi4,i} \cdot \big(VI_S_i + c_{41} \cdot VI_SC_{1,i} + c_{42} \cdot VI_SC_{2,i} + c_{43} \cdot VI_SC_{3,i} + c_{45} \cdot VI_SC_{5,i}\big)\Big)$$

$$NBPPi'_{5,i} = \lambda_{4,i} \cdot \Big(\big(S_i + c_{51} \cdot SC_{1,i} + c_{52} \cdot SC_{2,i} + c_{53} \cdot SC_{3i} + c_{54} \cdot SC_{4,i}\big) + \pi_{NBPPi5,i} \cdot \big(VI_S_i + c_{51} \cdot VI_SC_{1,i} + c_{52} \cdot VI_SC_{2,i} + c_{53} \cdot VI_SC_{3,i} + c_{54} \cdot VI_SC_{4,i}\big) + \rho_{NBPPi5,i} \cdot \big(VI_S_i + c_{51} \cdot VI_SC_{1,i} + c_{52} \cdot VI_SC_{2,i} + c_{53} \cdot VI_SC_{3,i} + c_{54} \cdot VI_SC_{4,i}\big)\Big)$$

Noninvasive community-acquired pneumococcal pneumonias treated in an outpatient setting:

$$NBPPo'_{1,i} = \lambda_{1,i} \cdot \Big(\big(S_i + c_{12} \cdot SC_{2,i} + c_{13} \cdot SC_{3,i} + c_{14} \cdot SC_{4,i} + c_{15} \cdot SC_{5,i}\big) + \pi_{NBPPo1,i} \cdot \big(VI_S_i + c_{12} \cdot VI_SC_{2,i} + c_{13} \cdot VI_SC_{3,i} + c_{14} \cdot VI_SC_{4,i} + c_{15} \cdot VI_SC_{5,i}\big) + \rho_{NBPPo1,i} \cdot \big(VI_S_i + c_{12} \cdot VI_SC_{2,i} + c_{13} \cdot VI_SC_{3,i} + c_{14} \cdot VI_SC_{4,i} + c_{15} \cdot VI_SC_{5,i}\big)\Big)$$

$$NBPPo'_{2,i} = \lambda_{2,i} \cdot \Big(\big(S_i + c_{21} \cdot SC_{1,i} + c_{23} \cdot SC_{3,i} + c_{24} \cdot SC_{4,i} + c_{25} \cdot SC_{5,i}\big) + \pi_{NBPPo2,i} \cdot \big(VI_S_i + c_{21} \cdot VI_SC_{1,i} + c_{23} \cdot VI_SC_{3,i} + c_{24} \cdot VI_SC_{4,i} + c_{25} \cdot VI_SC_{5,i}\big) + \rho_{NBPPo2,i} \cdot \big(VI_S_i + c_{21} \cdot VI_SC_{1,i} + c_{23} \cdot VI_SC_{3,i} + c_{24} \cdot VI_SC_{4,i} + c_{25} \cdot VI_SC_{5,i}\big)\Big)$$

$$NBPPo'_{3,i} = \lambda_{3,i} \cdot \Big(\big(S_i + c_{31} \cdot SC_{1,i} + c_{32} \cdot SC_{2,i} + c_{34} \cdot SC_{4,i} + c_{35} \cdot SC_{5,i}\big) + \pi_{NBPPo3,i} \cdot \big(VI_S_i + c_{31} \cdot VI_SC_{1,i} + c_{32} \cdot VI_SC_{2,i} + c_{34} \cdot VI_SC_{4,i} + c_{35} \cdot VI_SC_{5,i}\big) + \rho_{NBPPo3,i} \cdot \big(VI_S_i + c_{31} \cdot VI_SC_{1,i} + c_{32} \cdot VI_SC_{2,i} + c_{34} \cdot VI_SC_{4,i} + c_{35} \cdot VI_SC_{5,i}\big)\Big)$$

$$NBPPo'_{4,i} = \lambda_{4,i} \cdot \Big(\big(S_i + c_{41} \cdot SC_{1,i} + c_{42} \cdot SC_{2,i} + c_{43} \cdot SC_{3i} + c_{45} \cdot SC_{5,i} \big) + \pi_{NBPPo4,i} \cdot \big(VI_S_i + c_{41} \cdot VI_SC_{1,i} + c_{42} \cdot VI_SC_{2,i} + c_{43} \cdot VI_SC_{3,i} + c_{45} \cdot VI_SC_{5,i} \big) + \rho_{NBPPo4,i} \cdot \big(VI_S_i + c_{41} \cdot VI_SC_{1,i} + c_{42} \cdot VI_SC_{2,i} + c_{43} \cdot VI_SC_{3,i} + c_{45} \cdot VI_SC_{5,i} \big) \Big)$$

$$NBPPo'_{5,i} = \lambda_{4,i} \cdot \Big(\big(S_i + c_{51} \cdot SC_{1,i} + c_{52} \cdot SC_{2,i} + c_{53} \cdot SC_{3i} + c_{54} \cdot SC_{4,i} \big) + \pi_{NBPPo5,i} \cdot \big(VI_S_i + c_{51} \cdot VI_SC_{1,i} + c_{52} \cdot VI_SC_{2,i} + c_{53} \cdot VI_SC_{3,i} + c_{54} \cdot VI_SC_{4,i} \big) + \rho_{NBPPo5,i} \cdot \big(VI_S_i + c_{51} \cdot VI_SC_{1,i} + c_{52} \cdot VI_SC_{2,i} + c_{53} \cdot VI_SC_{3,i} + c_{54} \cdot VI_SC_{4,i} \big) \Big)$$

The ratio of pneumococcal diseases to pneumococcal carriers (case carrier ratio; CCR) is used outside the differential equation model in order to be able to carry out sensitivity analyzes on these parameters more efficiently.

1.4 Projection Analyses: Fatal IPD & CAP, Mean Hospitalization Trends (2001-2050)

Figures S1 to S8 showcase the mean projection of fatal IPD and CAP cases, figures S9 to S16 illustrate the mean hospitalization projection while figure S17 to S24 illustrate the mean hospitalization projection by serotype group, each with 75%-prediction intervals spanning from 2001 to 2050 across different age groups, both with and without vaccination.

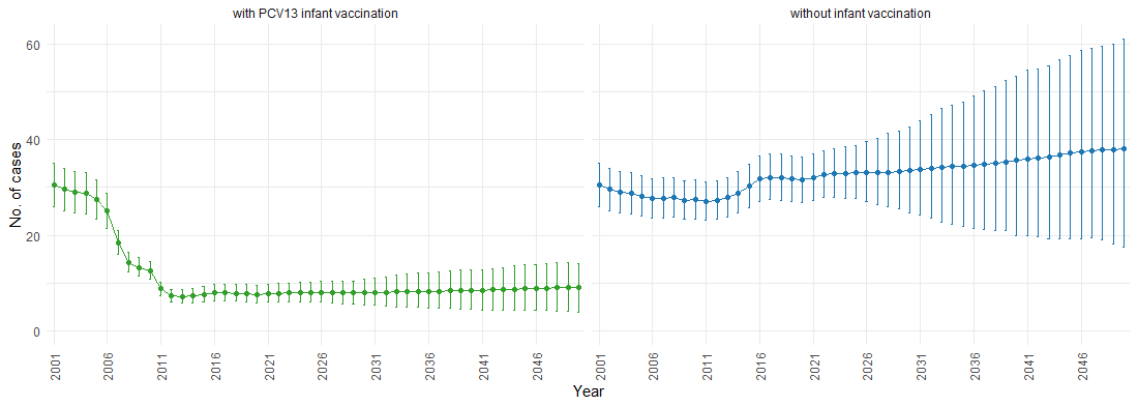


Figure S1: Mean projection of fatal IPD and CAP cases with 75%-prediction intervals (2001-2050) for ages 0-1, with and without infant vaccination.

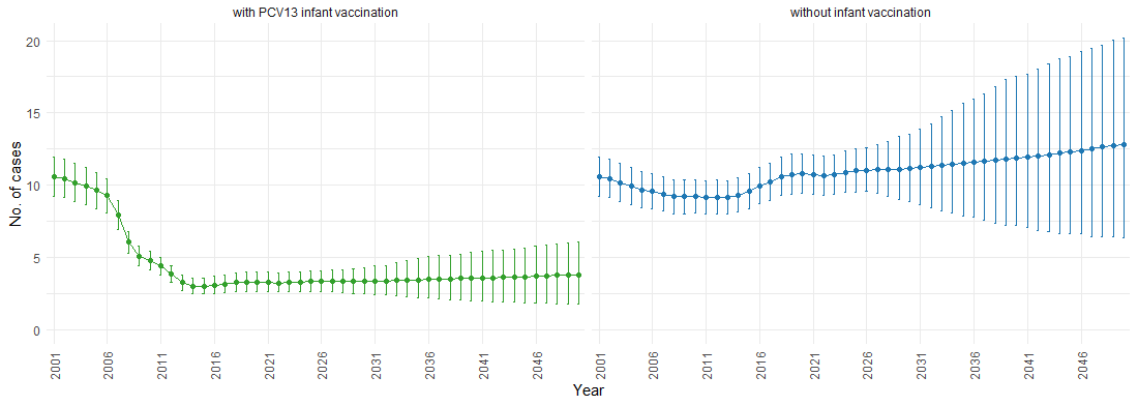


Figure S2: Mean projection of fatal IPD and CAP cases with 75%-prediction intervals (2001-2050) for ages 2-4, with and without infant vaccination.

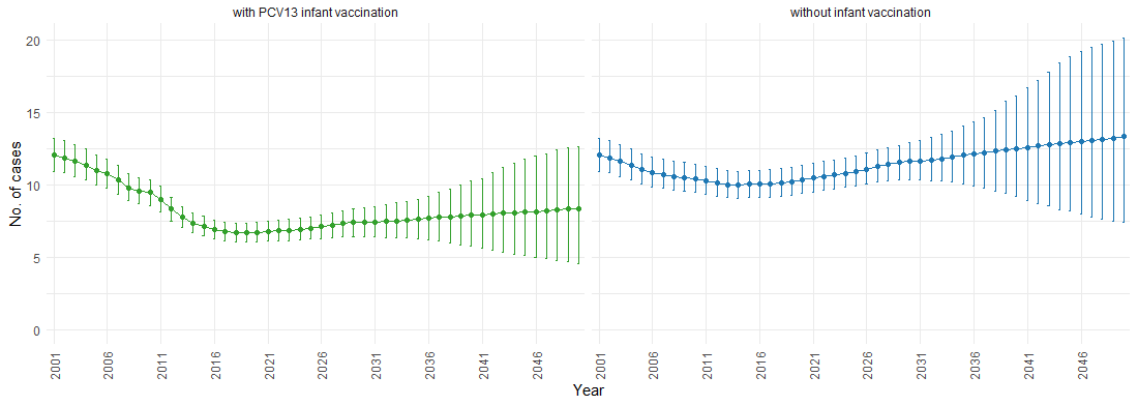


Figure S3: Mean projection of fatal IPD and CAP cases with 75%-prediction intervals (2001-2050) for ages 5-14, with and without infant vaccination.

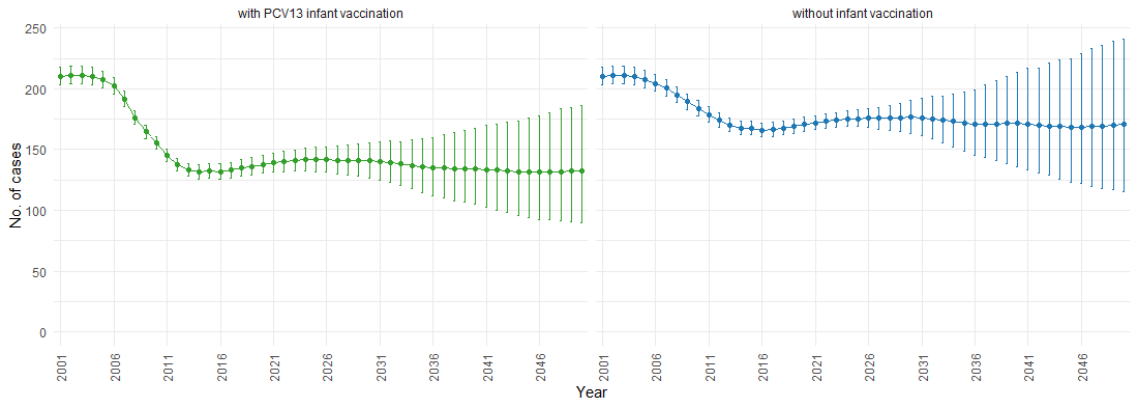


Figure S4: Mean projection of fatal IPD and CAP cases with 75%-prediction intervals (2001-2050) for ages 15-44, with and without infant vaccination.

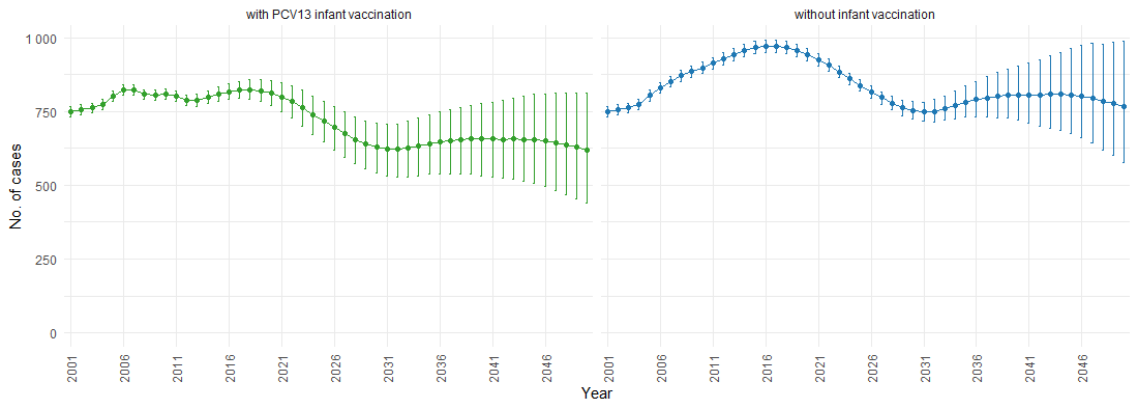


Figure S5: Mean projection of fatal IPD and CAP cases with 75%-prediction intervals (2001-2050) for ages 45-59, with and without infant vaccination.

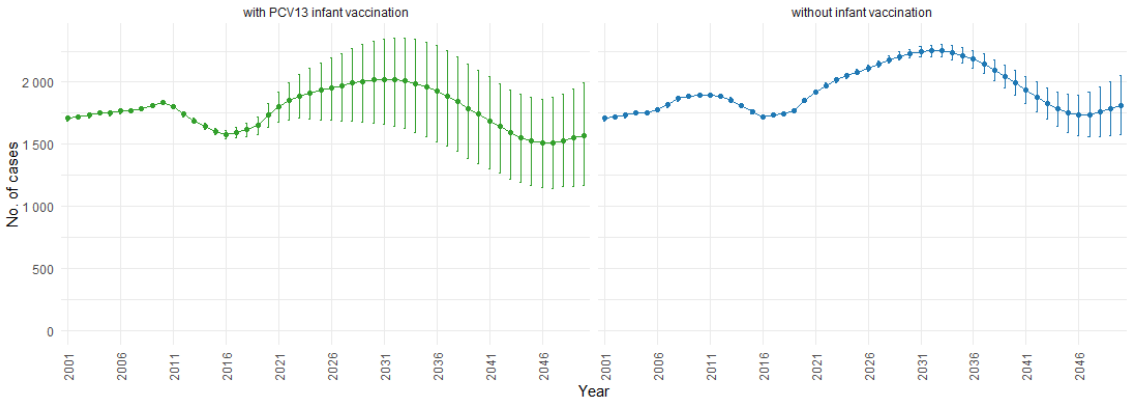


Figure S6: Mean projection of fatal IPD and CAP cases with 75%-prediction intervals (2001-2050) for ages 60-74, with and without infant vaccination.

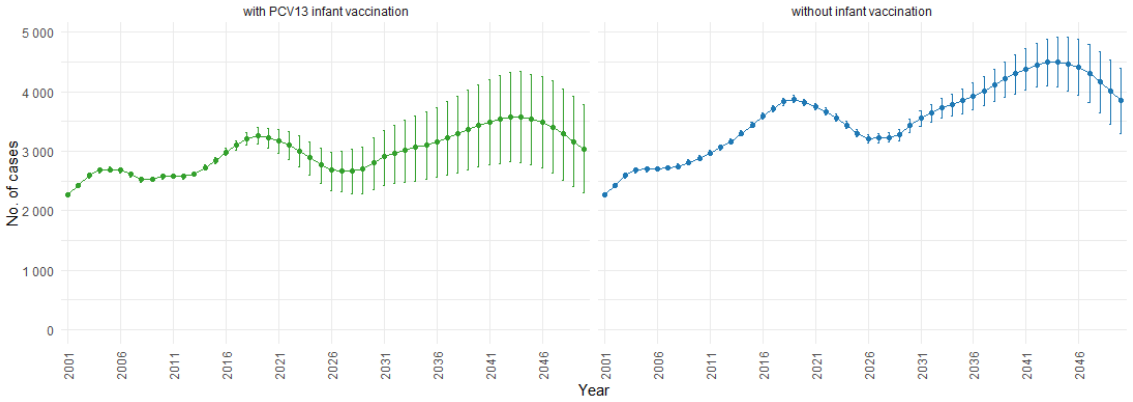


Figure S7: Mean projection of fatal IPD and CAP cases with 75%-prediction intervals (2001-2050) for ages 75-84, with and without infant vaccination.

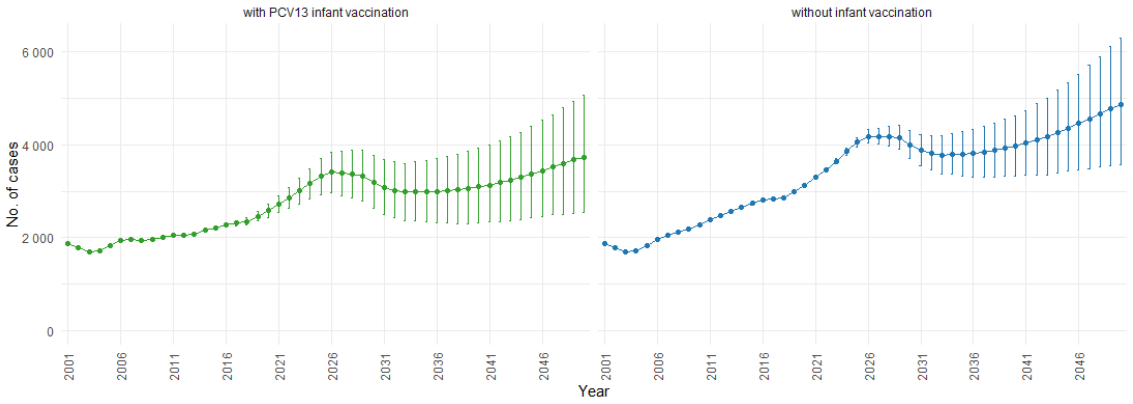


Figure S8: Mean projection of fatal IPD and CAP cases with 75%-prediction intervals (2001-2050) for ages 85-99, with and without infant vaccination.

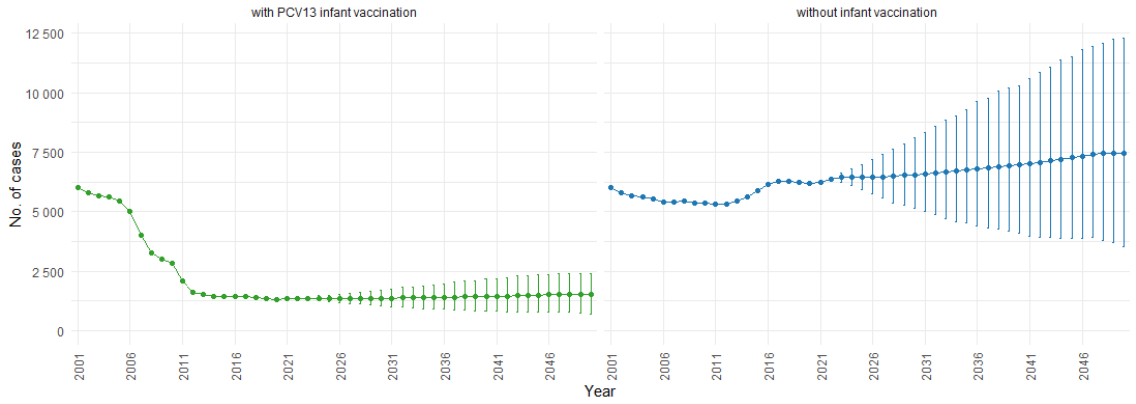


Figure S9: Mean hospitalization projection with 75%-prediction intervals (2001-2050) for ages 0-1, with and without infant vaccination.

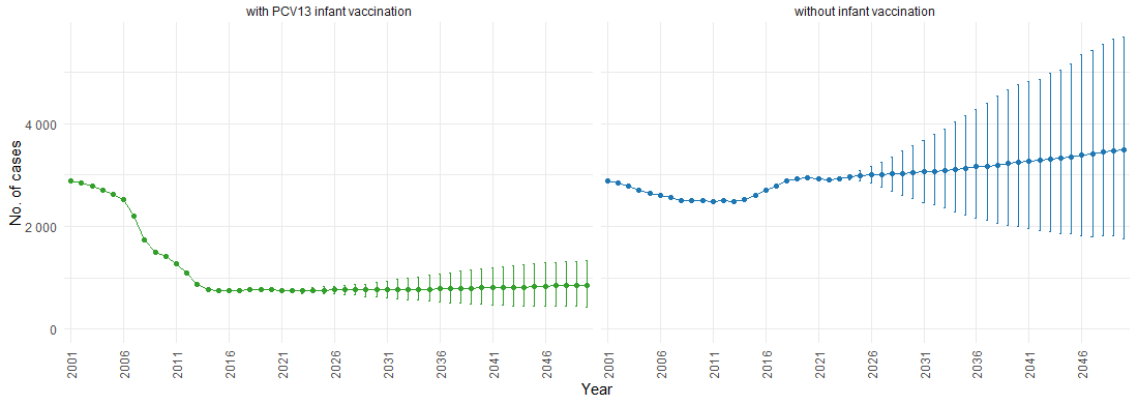


Figure S10: Mean hospitalization projection with 75%-prediction intervals (2001-2050) for ages 2-4, with and without infant vaccination.

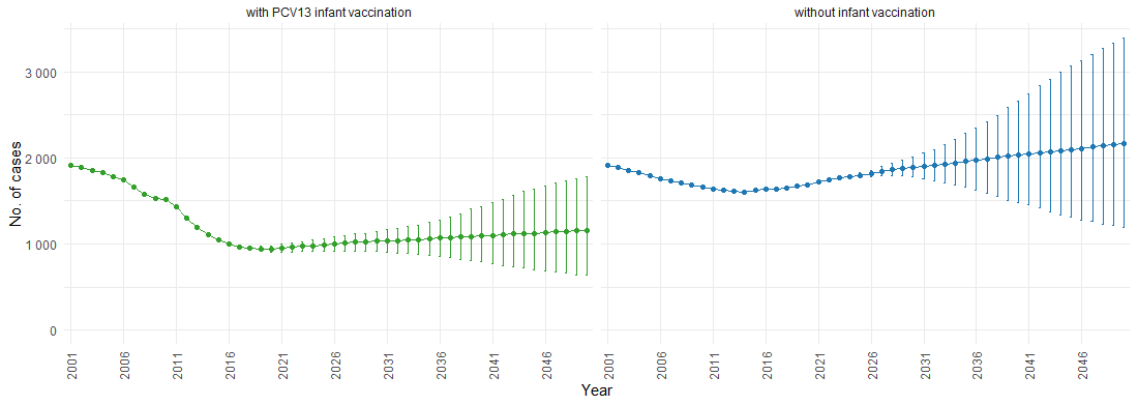


Figure S11: Mean hospitalization projection with 75%-prediction intervals (2001-2050) for ages 5-14, with and without infant vaccination

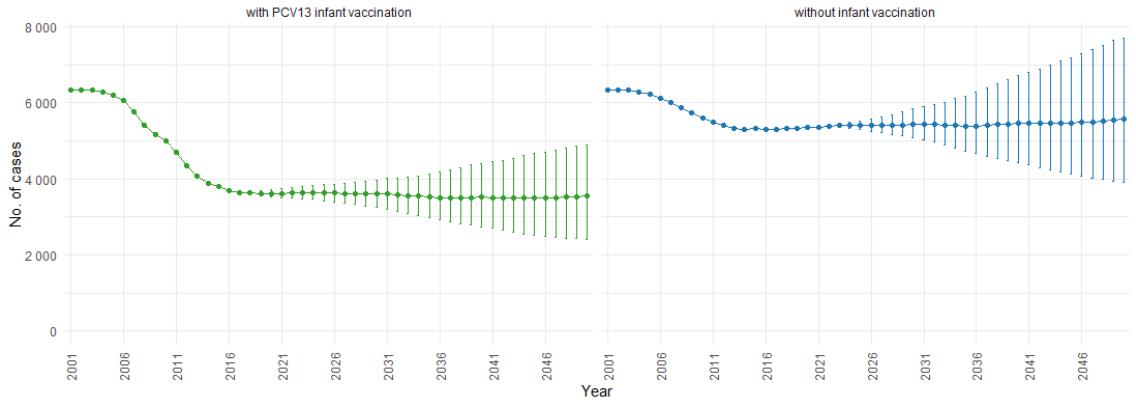


Figure S12: Mean hospitalization projection with 75%-prediction intervals (2001-2050) for ages 15-44, with and without infant vaccination.

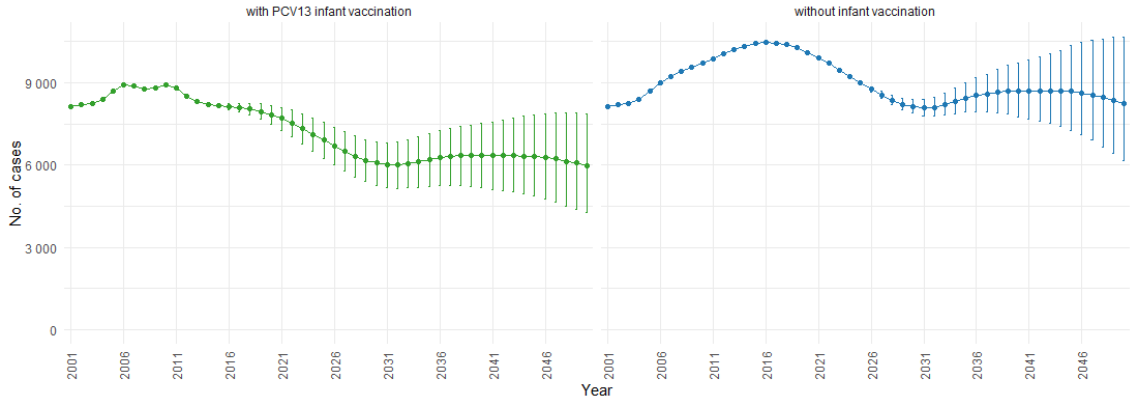


Figure S13: Mean hospitalization projection with 75%-prediction intervals (2001-2050) for ages 45-59, with and without infant vaccination.

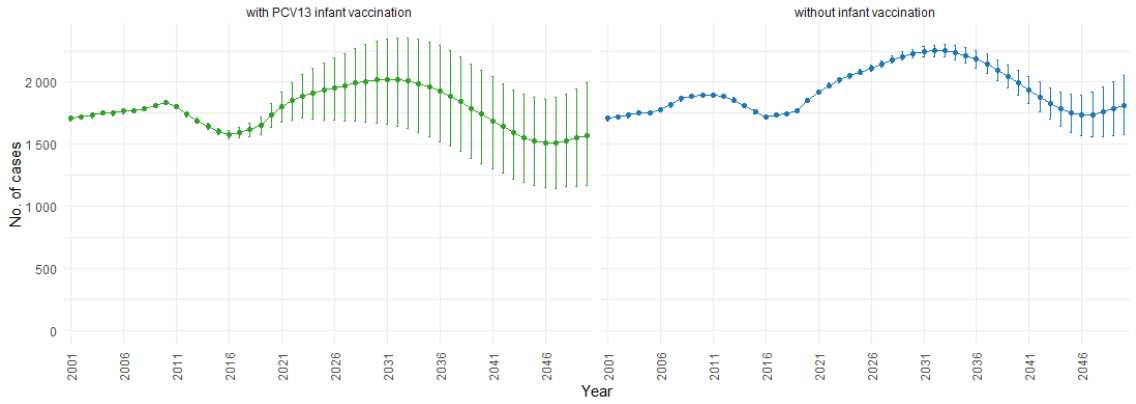


Figure S14: Mean hospitalization projection with 75%-prediction intervals (2001-2050) for ages 60-74, with and without infant vaccination.

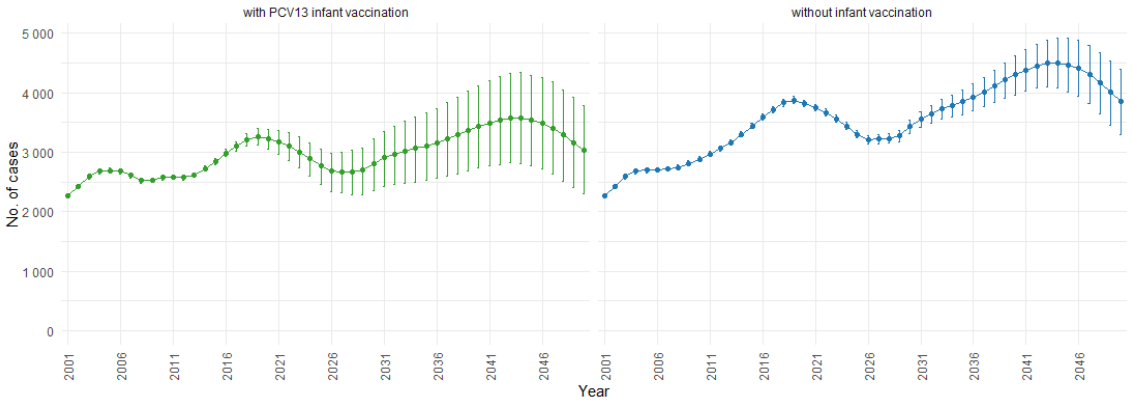


Figure S15: Mean hospitalization projection with 75%-prediction intervals (2001-2050) for ages 75-84, with and without infant vaccination.

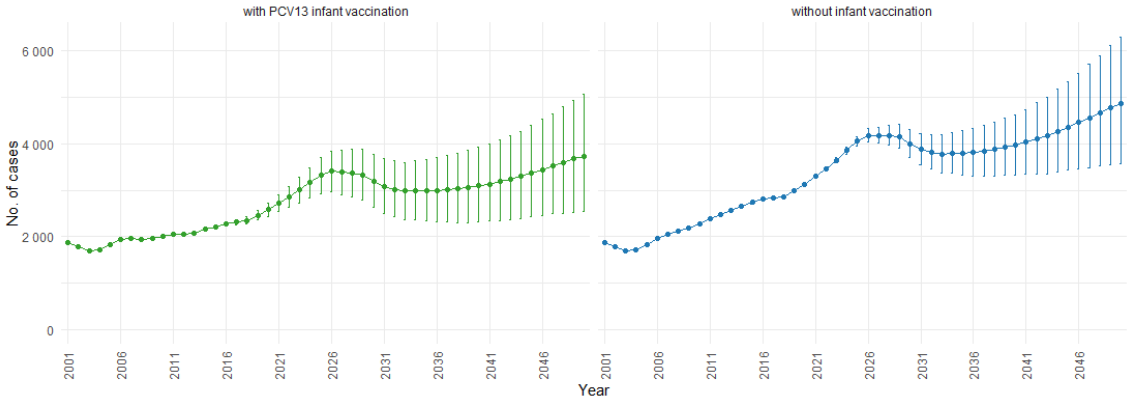


Figure S16: Mean hospitalization projection with 75%-prediction intervals (2001-2050) for ages 85-99, with and without infant vaccination.

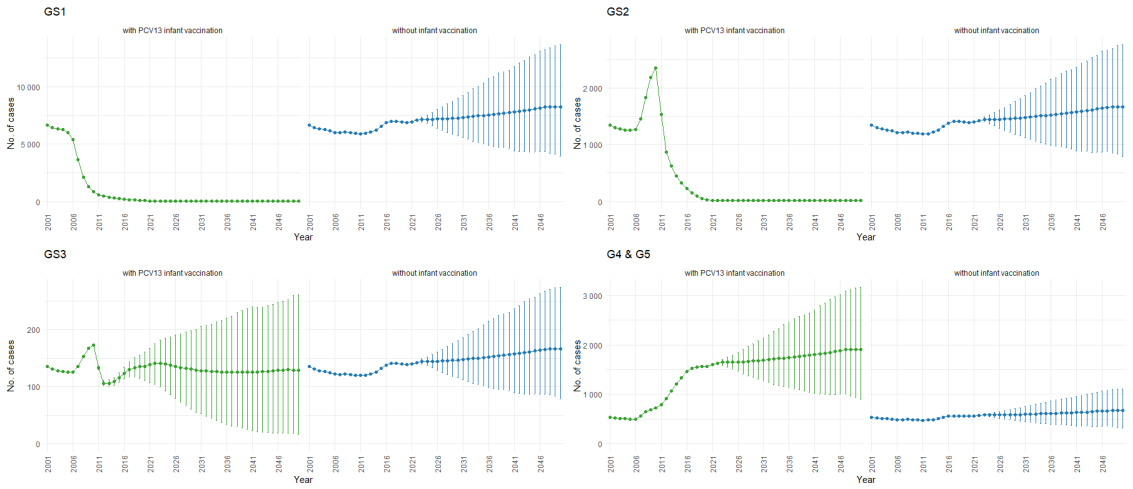


Figure S17: Mean hospitalizations with 75%-prediction intervals (2001-2050) for ages 0-1, with and without infant vaccination, by pneumococcal serotype group.

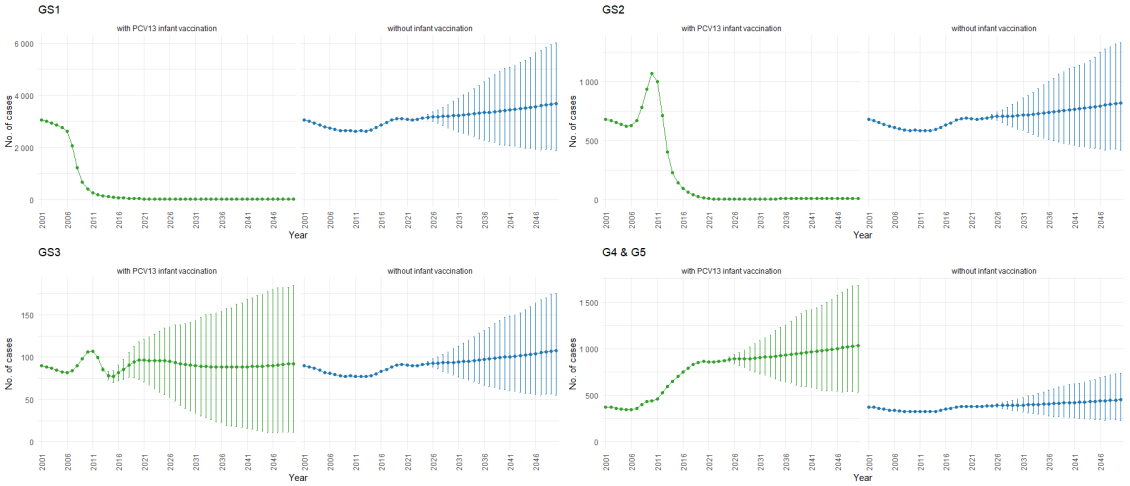


Figure S18: Mean hospitalizations with 75%-prediction intervals (2001-2050) for ages 2-4, with and without infant vaccination, by pneumococcal serotype group.

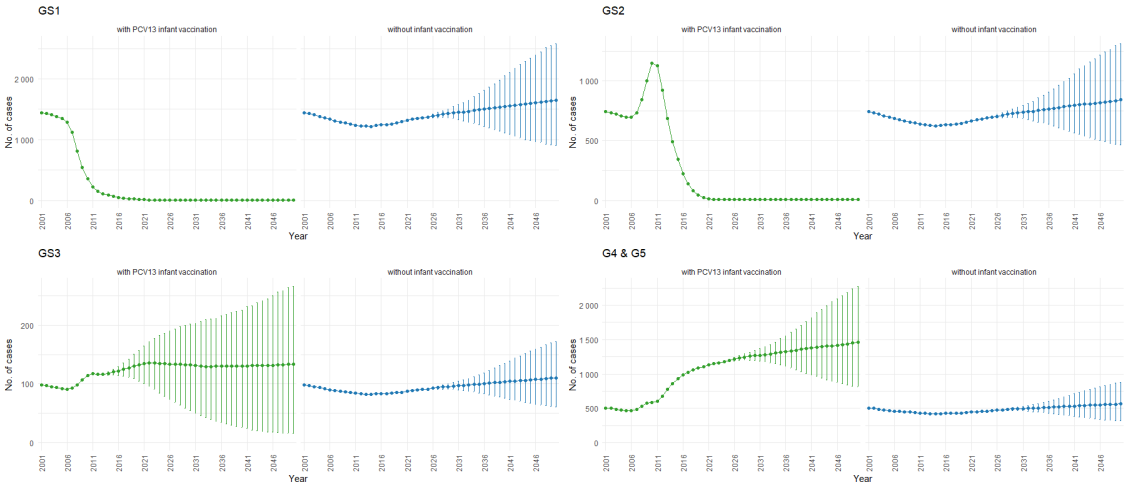


Figure S19: Mean hospitalizations with 75%-prediction intervals (2001-2050) for ages 5-14, with and without infant vaccination, by pneumococcal serotype group.

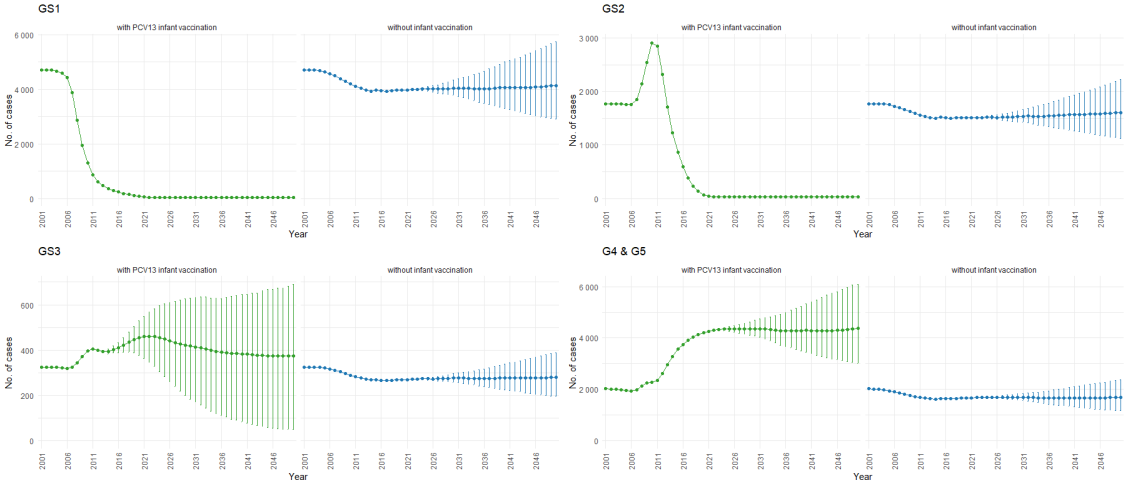


Figure S20: Mean hospitalizations with 75%-prediction intervals (2001-2050) for ages 15-44, with and without infant vaccination, by pneumococcal serotype group.



Figure S21: Mean hospitalizations with 75%-prediction intervals (2001-2050) for ages 45-59, with and without infant vaccination, by pneumococcal serotype group.



Figure S22: Mean hospitalizations with 75%-prediction intervals (2001-2050) for ages 60-74, with and without infant vaccination, by pneumococcal serotype group.

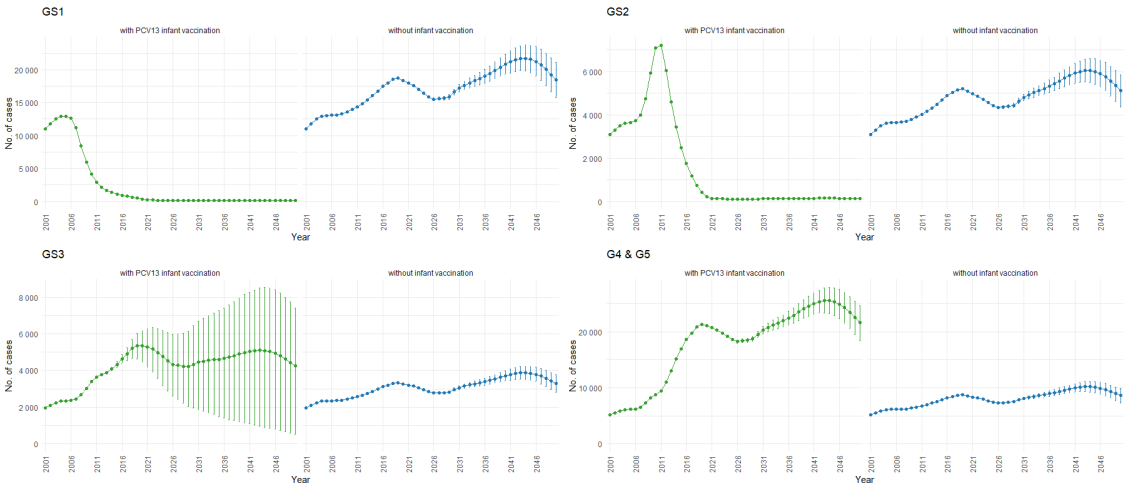


Figure S23: Mean hospitalizations with 75%-prediction intervals (2001-2050) for ages 75-84, with and without infant vaccination, by pneumococcal serotype group.

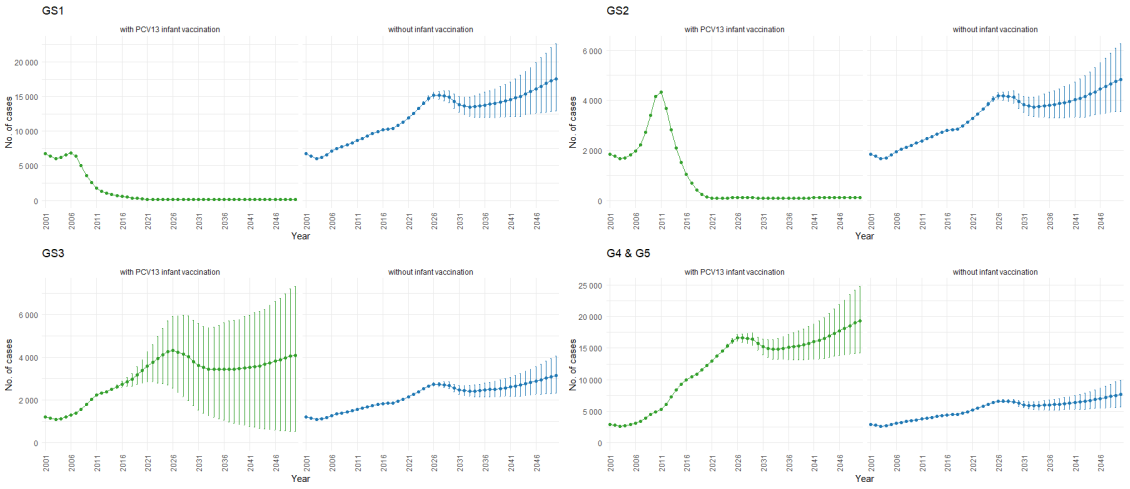


Figure S24: Mean hospitalizations with 75%-prediction intervals (2001-2050) for ages 85-99, with and without infant vaccination, by pneumococcal serotype group.