**S2 Equation:**

**Dynamic transmission model**

These are difference equations of the dynamic model of the pneumococcal transmission between serogroups, vaccination efficacy parameters against colonisation of vaccine serogroups and a potential parameter () to describe the rapid increase in NVT IPD cases since 2014/15.

**Unvaccinated**:

**PCV7 partially protected**:

**PCV7 fully protected**:

**PCV7 waned**:

**PCV13 partially protected**:

**PCV13 fully protected:**

**PCV13 waned:**

for age cohorts (48 cohorts for each annual age cohort comprising 100 year cohorts between 0y and 99y) , where the initial values of Unvaccinated group is obtained from the pre-vaccination equilibrium from the static model result. The movement between vaccine protected groups depends on the monthly vaccine uptake and vaccine protection waning according to the duration of vaccine protection. is a reduction parameter on the FOI, which is 1- Competition parameter between serogroups, s are monthly vaccination rates for each dose (two primary and booster doses), d7 and d13 are reduction in FOIs due to PCV7 and PCV13 against acquisition of VT1 and VT2, is a waning parameter (1/duration of vaccine protection), and is a clearance rate, 1/ duration of colonisation.

The Nelder-Mead method finds the set of model parameters with the maximum Poisson likelihood:

for three serogroups and six age groups between 2005/06 and 2015/16.