1. Recovered to Susceptible jump permitted (currently 0):

**"rToS\_YoungRate": 0.0,**

**"rToS\_AdultRate": 0.0,**

**"rToS\_ElderlyRate": 0.0**

1. Dedicated reader for historical recovered – set to work at **IZ** level – normally should match first timestep:

File name configured with:

**"area-with-recovered": "initialiseToRecovered.csv",**

File format looks like:

**Timestep,Area,NumberRecovered**

**37500,10,20**

**37500,20,30**

**37500,30,40**

**37500,40,50**

1. Variant functionality:

Compartmental model exactly matches standard variant.

* 1. New reader to seed for variant – at **CA** level:

File name configured with:

**"area-to-seed-with-variant": "variantSeedsPerCA.csv"**

File format looks like:

**Timestep,Area,NumberSeeds**

**37500,10,20**

**37500,20,30**

**37500,30,40**

**37500,40,50**

* 1. New variant rates:

Note: Betas (or other fitted params) are not automatically related to sampled fitted betas/params – i.e. the relationship/factor must be precalculated and entered manually.

**"covidVariant": {**

**"comment": "Used for covid variant scenarios",**

**"rates": {**

**"sToE\_Mild\_YoungRate\_Day": 0.55,**

**"sToE\_Mild\_AdultRate\_Day": 0.55,**

**"sToE\_Mild\_ElderlyRate\_Day": 0.55,**

**"sToE\_Mild\_YoungRate\_Night": 0.55,**

**"sToE\_Mild\_AdultRate\_Night": 0.55,**

**"sToE\_Mild\_ElderlyRate\_Night": 0.55,**

**"sToE\_Severe\_YoungRate\_Day": 1.0,**

**"sToE\_Severe\_AdultRate\_Day": 1.0,**

**"sToE\_Severe\_ElderlyRate\_Day": 1.0,**

**"sToE\_Severe\_YoungRate\_Night": 1.0,**

**"sToE\_Severe\_AdultRate\_Night": 1.0,**

**"sToE\_Severe\_ElderlyRate\_Night": 1.0,**

**"eToMI\_YoungRate": 0.333,**

**"eToMI\_AdultRate": 0.333,**

**"eToMI\_ElderlyRate": 0.333,**

**"eToR\_YoungRate": 0.0,**

**"eToR\_AdultRate": 0.0,**

**"eToR\_ElderlyRate": 0.0,**

**"eToT\_YoungRate": 0.0,**

**"eToT\_AdultRate": 0.0,**

**"eToT\_ElderlyRate": 0.0,**

**"miToR\_YoungRate": 0.235,**

**"miToR\_AdultRate": 0.235,**

**"miToR\_ElderlyRate": 0.235,**

**"miToSI\_YoungRate": 0.196,**

**"miToSI\_AdultRate": 0.286,**

**"miToSI\_ElderlyRate": 0.286,**

**"miToT\_YoungRate": 0.0,**

**"miToT\_AdultRate": 0.0,**

**"miToT\_ElderlyRate": 0.0,**

**"siToR\_YoungRate": 0.053,**

**"siToR\_AdultRate": 0.048,**

**"siToR\_ElderlyRate": 0.046,**

**"siToH\_YoungRate": 0.25,**

**"siToH\_AdultRate": 0.25,**

**"siToH\_ElderlyRate": 0.25,**

**"siToD\_YoungRate": 0.063,**

**"siToD\_AdultRate": 0.063,**

**"siToD\_ElderlyRate": 0.063,**

**"siToT\_YoungRate": 0.0,**

**"siToT\_AdultRate": 0.0,**

**"siToT\_ElderlyRate": 0.0,**

**"hToR\_YoungRate": 0.081,**

**"hToR\_AdultRate": 0.081,**

**"hToR\_ElderlyRate": 0.081,**

**"hToD\_YoungRate": 0.103,**

**"hToD\_AdultRate": 0.103,**

**"hToD\_ElderlyRate": 0.103,**

**"tToR\_YoungRate": 0.0,**

**"tToR\_AdultRate": 0.0,**

**"tToR\_ElderlyRate": 0.0,**

**"tToH\_YoungRate": 0.0,**

**"tToH\_AdultRate": 0.0,**

**"tToH\_ElderlyRate": 0.0,**

**"tToD\_YoungRate": 0.0,**

**"tToD\_AdultRate": 0.0,**

**"tToD\_ElderlyRate": 0.0,**

**"rToS\_YoungRate": 0.0,**

**"rToS\_AdultRate": 0.0,**

**"rToS\_ElderlyRate": 0.0**

**}**

* 1. New variant specific output measures added to output modules – for example:

**EXPOSED\_VARIANT,**

**INFECTIOUS\_VARIANT,**

**MILD\_INFECTIOUS\_VARIANT,**

**SEVERE\_INFECTIOUS\_VARIANT,**

**RECOVERED\_VARIANT,**

**HOSPITALISED\_VARIANT,**

**DEAD\_VARIANT,**

**EXPOSED\_YOUNG\_VARIANT,**

**EXPOSED\_ADULT\_VARIANT,**

**EXPOSED\_ELDERLY\_VARIANT,**

**MILD\_INFECTIOUS\_YOUNG\_VARIANT,**

**MILD\_INFECTIOUS\_ADULT\_VARIANT,**

**MILD\_INFECTIOUS\_ELDERLY\_VARIANT,**

**SEVERE\_INFECTIOUS\_YOUNG\_VARIANT,**

**SEVERE\_INFECTIOUS\_ADULT\_VARIANT,**

**SEVERE\_INFECTIOUS\_ELDERLY\_VARIANT,**

**RECOVERED\_YOUNG\_VARIANT,**

**RECOVERED\_ADULT\_VARIANT,**

**RECOVERED\_ELDERLY\_VARIANT,**

**HOSPITALISED\_YOUNG\_VARIANT,**

**HOSPITALISED\_ADULT\_VARIANT,**

**HOSPITALISED\_ELDERLY\_VARIANT,**

**DEAD\_YOUNG\_VARIANT,**

**DEAD\_ADULT\_VARIANT,**

**DEAD\_ELDERLY\_VARIANT;**

1. Vaccine functionality:

The stats involved in recording vaccinations in the model are:

VACCINATED\_SUSCEPTIBLE, VACCINATED\_SUSCEPTIBLE\_YOUNG, VACCINATED\_SUSCEPTIBLE\_ADULT, VACCINATED\_SUSCEPTIBLE\_ELDERLY

VACCINATED\_NOT\_SUSCEPTIBLE, VACCINATED\_NOT\_SUSCEPTIBLE\_YOUNG, VACCINATED\_NOT\_SUSCEPTIBLE\_ADULT and VACCINATED\_NOT\_SUSCEPTIBLE\_ELDERLY.

Vaccinations are read in from file. There is a **fitted parameter** for the proportion of the vaccinated population that are divided into PARTIAL or FULL protection. FULL protection means individuals are pushed into the recovered state – with an efficacy label FULL. They do not take part in any transmission events. PARTIAL vaccination means that rather than making individuals ‘Recovered’ an efficacy/protection is used during transmission events and the time when they were ‘first’ vaccinated comes into play. With that in mind the model is now configurable for different 3 ‘phases’ of efficacies for these PARTIAL protected people. The time in each phase (for example first/second dose, waning efficacy, booster dose efficacy) can be configured. All of this is possible at the ‘age’ group level – i.e. the three different phases and their efficacies can be configured differently for young, adult and elderly.

"efficacy": {

"comment": "Note that 0 is full protection and 1.0 is no protection wrt vaccination",

"young": {

"standard": {

"standardStrainEfficacyFirstEfficacyChange\_young": 0.0,

"numberOfTimestepsInFirstEfficacyPhaseStandardStrain\_young": 1720,

"standardStrainEfficacySecondEfficacyChange\_young": 0.0,

"numberOfTimestepsInSecondEfficacyPhaseStandardStrain\_young": 1720,

"standardStrainEfficacyThirdEfficacyChange\_young": 0.0,

"numberOfTimestepsInThirdEfficacyPhaseStandardStrain\_young": 1720

},

"variant": {

"variantStrainEfficacyFirstEfficacyChange\_young": 0.8,

"numberOfTimestepsInFirstEfficacyPhaseVariantStrain\_young": 720,

"variantStrainEfficacySecondEfficacyChange\_young": 0.8,

"numberOfTimestepsInSecondEfficacyPhaseVariantStrain\_young": 720,

"variantStrainEfficacyThirdEfficacyChange\_young": 0.8,

"numberOfTimestepsInThirdEfficacyPhaseVariantStrain\_young": 720

}

},

"adult": {

"standard": {

"standardStrainEfficacyFirstEfficacyChange\_adult": 0.0,

"numberOfTimestepsInFirstEfficacyPhaseStandardStrain\_adult": 1720,

"standardStrainEfficacySecondEfficacyChange\_adult": 0.0,

"numberOfTimestepsInSecondEfficacyPhaseStandardStrain\_adult": 1720,

"standardStrainEfficacyThirdEfficacyChange\_adult": 0.0,

"numberOfTimestepsInThirdEfficacyPhaseStandardStrain\_adult": 1720

},

"variant": {

"variantStrainEfficacyFirstEfficacyChange\_adult": 0.8,

"numberOfTimestepsInFirstEfficacyPhaseVariantStrain\_adult": 720,

"variantStrainEfficacySecondEfficacyChange\_adult": 0.8,

"numberOfTimestepsInSecondEfficacyPhaseVariantStrain\_adult": 720,

"variantStrainEfficacyThirdEfficacyChange\_adult": 0.8,

"numberOfTimestepsInThirdEfficacyPhaseVariantStrain\_adult": 720

}

},

"elderly": {

"standard": {

"standardStrainEfficacyFirstEfficacyChange\_elderly": 0.0,

"numberOfTimestepsInFirstEfficacyPhaseStandardStrain\_elderly": 1720,

"standardStrainEfficacySecondEfficacyChange\_elderly": 0.0,

"numberOfTimestepsInSecondEfficacyPhaseStandardStrain\_elderly": 1720,

"standardStrainEfficacyThirdEfficacyChange\_elderly": 0.0,

"numberOfTimestepsInThirdEfficacyPhaseStandardStrain\_elderly": 1720

},

"variant": {

"variantStrainEfficacyFirstEfficacyChange\_elderly": 0.8,

"numberOfTimestepsInFirstEfficacyPhaseVariantStrain\_elderly": 720,

"variantStrainEfficacySecondEfficacyChange\_elderly": 0.8,

"numberOfTimestepsInSecondEfficacyPhaseVariantStrain\_elderly": 720,

"variantStrainEfficacyThirdEfficacyChange\_elderly": 0.8,

"numberOfTimestepsInThirdEfficacyPhaseVariantStrain\_elderly": 720

}

}

}

},

Historical vaccinations are also applied (to properly record the vaccination timestep). There is a configuration timestep that sets when these historical vaccinations should have started (Dec 2020). They are applied up to the model start time. And then the remainder are applied on the appropriate timestep during model run time.

"vaccination": {

"time" : {

"startingTimeStep": 37200

},

1. Loss of immunity functionality:

Along with the FULL and PARTIAL protection labels a person can have based on a fitted parameter mentioned above which focused on vaccinated individuals - there are two more possible protection levels. They are PARTIAL\_AFTER\_LOSS\_OF\_VACCINATED\_IMMUNITY and PARTIAL\_AFTER\_LOSS\_OF\_NATURAL\_IMMUNITY. The former applies to vaccinated individuals that have made the jump back from Recovered to Susceptible and the later is for unvaccinated individuals that are Recovered from being infected and therefore have lost their natural immunity (i.e they didn’t have any immunity associated with vaccination). It is possible to configure 3 different phases of efficacy for these individuals (similar parameters to PARTIAL protection) – both labels are configured the same way currently. The first phase starts from the day a person makes the R->S jump (and loses their immunity) rather than time of vaccination (as before). In the configuration file the following parameters apply (note they are within the **afterImmunityLoss section)**:

"**afterImmunityLoss**": {

"young": {

"standard": {

"standardStrainEfficacyFirstEfficacyChange\_young": 0.1,

"numberOfTimestepsInFirstEfficacyPhaseStandardStrain\_young": 380,

"standardStrainEfficacySecondEfficacyChange\_young": 0.2,

"numberOfTimestepsInSecondEfficacyPhaseStandardStrain\_young": 380,

"standardStrainEfficacyThirdEfficacyChange\_young": 0.3,

"numberOfTimestepsInThirdEfficacyPhaseStandardStrain\_young": 380

},

"variant": {

"variantStrainEfficacyFirstEfficacyChange\_young": 0.5,

"numberOfTimestepsInFirstEfficacyPhaseVariantStrain\_young": 365,

"variantStrainEfficacySecondEfficacyChange\_young": 0.55,

"numberOfTimestepsInSecondEfficacyPhaseVariantStrain\_young": 370,

"variantStrainEfficacyThirdEfficacyChange\_young": 0.45,

"numberOfTimestepsInThirdEfficacyPhaseVariantStrain\_young": 375

}

},

"adult": {

"standard": {

"standardStrainEfficacyFirstEfficacyChange\_adult": 0.3,

"numberOfTimestepsInFirstEfficacyPhaseStandardStrain\_adult": 380,

"standardStrainEfficacySecondEfficacyChange\_adult": 0.2,

"numberOfTimestepsInSecondEfficacyPhaseStandardStrain\_adult": 380,

"standardStrainEfficacyThirdEfficacyChange\_adult": 0.3,

"numberOfTimestepsInThirdEfficacyPhaseStandardStrain\_adult": 380

},

"variant": {

"variantStrainEfficacyFirstEfficacyChange\_adult": 0.5,

"numberOfTimestepsInFirstEfficacyPhaseVariantStrain\_adult": 365,

"variantStrainEfficacySecondEfficacyChange\_adult": 0.55,

"numberOfTimestepsInSecondEfficacyPhaseVariantStrain\_adult": 370,

"variantStrainEfficacyThirdEfficacyChange\_adult": 0.45,

"numberOfTimestepsInThirdEfficacyPhaseVariantStrain\_adult": 375

}

},

"elderly": {

"standard": {

"standardStrainEfficacyFirstEfficacyChange\_elderly": 0.1,

"numberOfTimestepsInFirstEfficacyPhaseStandardStrain\_elderly": 380,

"standardStrainEfficacySecondEfficacyChange\_elderly": 0.2,

"numberOfTimestepsInSecondEfficacyPhaseStandardStrain\_elderly": 380,

"standardStrainEfficacyThirdEfficacyChange\_elderly": 0.3,

"numberOfTimestepsInThirdEfficacyPhaseStandardStrain\_elderly": 380

},

"variant": {

"variantStrainEfficacyFirstEfficacyChange\_elderly": 0.5,

"numberOfTimestepsInFirstEfficacyPhaseVariantStrain\_elderly": 365,

"variantStrainEfficacySecondEfficacyChange\_elderly": 0.55,

"numberOfTimestepsInSecondEfficacyPhaseVariantStrain\_elderly": 370,

"variantStrainEfficacyThirdEfficacyChange\_elderly": 0.45,

"numberOfTimestepsInThirdEfficacyPhaseVariantStrain\_elderly": 375

}

}

**Still to be implemented:**

Q. Should we also be allowing a factor (if a person is vaccinated) to reduce number of people jumping from mild to severe infectious?