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SARS-CoV-2 variants and vaccination in Belgium

Modelling results by the SIMID consortium

This document contains model estimates of hospital admissions and ICU load by a stochastic dynamic transmission model using observational data up to December 3th, 2021. This analysis focuses on potential impacts of vaccination of 5-11 year old children and increase in vaccine uptake for adults. All previous reports are available via simid.be and the covid-en-wetenschap blog.

Preliminary conclusions

- The stochastic transmission model for Belgium shows that vaccination of children between 5 and 11 years of age can have an important impact on waves of COVID-19 infections, hospital admissions and ICU load, by delaying the rise of such a wave, and flattening its peak, or in certain circumstances even eliminating it. We demonstrate this for (1) a future scenario in which a fifth wave would occur in the first quarter of 2022, and (2) a counterfactual scenario with regard to the vaccination strategy in the past, i.e., assuming that we vaccinated (a large fraction of all) children between 5 and 11 years old prior to the fourth wave in Belgium (i.e., vaccination starting from July 2021).

- The number of hospital admissions in the youngest age group is low in our age-structured model, hence the added benefit of vaccine uptake in children is mainly a consequence of its capacity to reduce transmission to and therefore between older age groups in the community. This might change if properties of future VOCs change with regards to immunity and infectivity.

- For a hypothetical wave in 2022, with specified risk behaviour, VOC and vaccine assumptions in place, simulations with vaccination coverage of 95% in the complete Belgian population over the age of 18 years would prevent at least 30% of hospitalisations. Improving vaccination coverage to at least 90% in each age cohort for 18+ has similar potential compared to introducing widespread vaccination of children between 5 and 11 years old, through adapted social contact behaviour and/or modified viral or vaccine characteristics could substantially impact this finding. A combined strategy, through which both universal vaccination of children is introduced and vaccine uptake in adults is increased has substantial added benefit relative to either strategy by itself. Furthermore, such a combined strategy is likely to reduce uncertainty related to modified transmission dynamics associated with the rise of a new VOC.

- A retrospective scenario, in which children between 5 and 11 years old would have been vaccinated in July and August 2021, shows a relative constant level of hospital admissions and ICU load from September until December 2021.

- Two important counterbalancing limitations have to be borne in mind when interpreting these results: (1) these simulations explicitly account for waning vaccine-induced immunity, but not for waning immunity of persons previously infected by the virus. Clearly, this implies that the potential impact of vaccinating children is underestimated in this respect, as young children are not universally vaccinated but have often acquired infection; (2) if the omicron VOC evades vaccine induced protection against infection more than against (severe) disease, the potential impact of childhood vaccination may be overestimated relative to the impact of adult vaccination. This second aspect is currently unknown.

- The goal of this note is to highlight the potential effect of vaccination of 5-11-years-old in selected scenarios. It contains what-if scenarios with regard to previous uptake and a future wave in 2022. They are *not* intended as predictions to compare with (updated) reported burden of disease.

- Current data on the Omicron VOC is insufficient to inform the model projections. Therefore the Delta VOC remains the dominant strain throughout the simulations. We do explore a resurgence of COVID-19 in the first quarter of 2022 due to increased transmission, without defining the specific cause, but under the assumption that vaccines continue to protect at currently observed levels (i.e. implicitly accounting for the currently still dominating delta variant).
- Updated transmission modelling features: we account for waning of vaccine-induced immunity and booster doses.

Dynamic Transmission Model

Summary: The stochastic model as described by Abrams et al. (2021) has been adapted to include vaccination and the emergence of one VOC from December 2020 (i.e. B.1.1.7 or "Alpha") and another VOC from May 2021 (i.e. B.1.617.2 or "Delta"). The model is calibrated on early sero-prevalence data, genomic surveillance data, hospital admission data, hospital surge data, mortality data and social contact data from the Belgian CoMiX survey.

Model input and assumptions

1. **Gradually accumulating naturally-acquired immunity** in the population is accounted for, as well as immunity induced by vaccination. Immunity after infection is assumed to last till the end of the simulations.
2. The **introduction of VOCs in the Belgian population** is accounted for by using data from the baseline genomic surveillance of SARS-CoV-2 in Belgium at the National Reference Laboratory.
3. **Alpha VOC:** We aggregated the proportion of Alpha, Beta and Gamma VOC in the population to account for the replacement of the wild-type variant by more infectious and severe VOCs (for which increased transmissibility and severity is assumed to be equal). The additional transmissibility of the aggregated VOC, which we will denote in this report by the dominant VOC Alpha, is estimated by the model at 35% (95% credible interval (CrI): 29%-40%) relative to the wild-type variant. The model assumes no differential hospital admission probability with respect to the Alpha VOC. Upon infection, the model allows for a VOC-specific differential hospital length-of-stay and risk of ICU admission.
4. **Delta VOC:** The impact of the Delta VOC is modelled by the introduction of a second VOC from May 2021 onward with an average increase in transmissibility of 80% (95% CrI: 65%-99%) relative to the Alpha variant. This increase is estimated based on the baseline genomic surveillance data. We assume a hazard ratio for hospitalization of 2 for the Delta VOC relative to the Alpha VOC. Mean values of 1.8-2.6 have been reported in the UK (with 95% confidence interval up to 4.36, see PHE, Sheikh).
5. Our model results contain stochastic variation in the transmission process and parameter uncertainty based on 40 model parameter configurations. The calibration procedure relies on likelihood-based MCMC sampling resulting in 40 posterior samples of the joint distribution, each of which is used to generate a single stochastic realization within each social mixing and/or vaccine uptake scenario. The MCMC procedure is, in general, based on the adaptive Metropolis-within-Gibbs algorithm, and parameter configurations are updated starting from previous calibration results based on an additional number of iterations (100 iterations) with 10 realizations per iteration, periodicity of 10 iterations and leading to 40 different chains based on 40 initial starting configurations.
6. This model is **fully age-structured** but does not simulate the physical interactions of subgroups like nursing home residents and nursing home personnel or healthcare workers in general. Vaccine uptake for health care workers is therefore implemented at the level of the ages of the target group.
7. Since the report from October 2021, we complement the reported hospital admissions with the number of new positive cases in the Belgian hospitals in the last 24h that have been admitted for another pathology. Given that these positive cases contribute to the COVID-19 related hospital load, we include these new patients in our analysis. Hospital admission data is still the main source of information to inform and

calibrate the model given the frequent changes in the Belgian SARS-CoV-2 testing policy (and its impact on the daily number of confirmed COVID-19 cases).

8. The model is calibrated using the latest social contact data of the Belgian CoMiX survey. For each survey wave (with the latest included wave, the 36th conducted November 23-29th 2021), we estimate age-specific q-parameters (i.e., proportionality factors) to translate social contact data into transmission rates, with estimated social contact rates used as a proxy for effective contacts enabling disease transmission and proportionality factors adjusting for other factors that influence this relation. This captures, among other things, age-specific susceptibility and risk behavior during social contacts.

9. We designed different **scenarios** to explore the combination of social contact behaviour and vaccine uptake. None of the scenarios include the introduction of infected cases as a result of international travel. We started from the latest model calibration and applied different vaccine uptake schemes, as presented in Figures 1, S1, S2 and S3.

    - **Scenario A:** We assume an additional COVID-19 wave due to increased social contact behaviour after the planned winter school holiday. During the school closure period from December 18th, 2021, to January 8th, 2022, the dynamics estimated for December 2020 are re-used. From then on we gradually apply the contact frequencies and transmission dynamics of early October 2021, resulting in a hypothetical emergent 5th wave. Children aged 5-11 years are not universally offered vaccines in this scenario (Figure 1a). The uptake in this and all the other age groups is in line with the reported uptake for Belgium (Figure S1).
    - **Scenario B:** In line with scenario A, we assume an additional COVID-19 wave in 2022 due to increased social contact behaviour. Children aged 5-11 years are vaccinated with a first dose in December 2021 and a second dose in January 2022 at a vaccination coverage of 80% (Figure 1b).
    - **Scenario C:** In line with scenario A, we assume an additional COVID-19 wave in 2022 due to increased social contact behaviour. In this scenario we reach at least 90% vaccination coverage in each age group over the age of 18 years in January 2022. For the population up to 17y, we use the reported uptake (Figure S2).
    - **Scenario D:** In line with scenario A, we assume an additional COVID-19 wave in 2022 due to increased social contact behaviour. In this scenario we reach 95% vaccination coverage in each age group over the age of 18 years in January 2022. For the population up to 17y, we use the reported uptake (Figure S3).
    - **Combined scenarios (B+C) and (B+D) :** Additional scenarios are constructed by combining scenarios B and C on the one hand, and B and D on the other: **(B+C):** 80% vaccination coverage in 5-11-year olds and at least 90% vaccination coverage in $>$ 18 year olds; and **((B+D):** 80% vaccination coverage in 5-11-year olds and 95% vaccination coverage in $>$ 18 year olds.
    - **Scenario E:** We start from the latest model calibration and project the current fourth wave, without universally offering vaccines to children aged 5-11-years (a "factual" scenario) (Figure 1a).
    - **Scenario F:** In line with Scenario E, we start from the latest model calibration. Here, we focus on the hypothetical impact vaccinating 5-11-year-old children in July and August 2021 could have had on the fourth wave (a "counterfactual" scenario) (Figure 1c).

10. **Vaccine protection**

    - **Infection:** we use a "leaky" vaccination approach. For example, vaccination with 50% effectiveness, implies that for a vaccinated individual the likelihood to acquire infection is 50% less compared to a non-vaccinated individual of the same age. The level of protection against infection is presented in Table 1.
    - **Hospital admissions:** vaccinated individuals who acquire infection are at lower risk of a COVID-19 related hospital admission. The level of protection against severe disease, which we assume to be in line with hospital admissions, is presented in Table 1.
    - **Transmission:** vaccinated individuals who acquire infection have a lower risk of transmitting the disease. This assumption is based on a study in the UK on the effect of vaccination on household transmission of SARS-CoV-2 (Harris et al., 2021). The level of protection against transmission is presented in Table 1.

- **Severe non-hospitalized cases** are currently not separately modelled, hence the impact of vaccination on non-hospitalized severe cases, seen in primary care, is not separately shown.
- **Vaccine-induced immunity** against infection is implemented as a step function with a switch from e.g. 0% to 50% protection against infection 21 days after the first vaccine dose. Vaccine-induced protection against hospital admission is implemented incrementally on the protection against infection. Protection from the 2nd dose is assumed to be present 7 days after administration. We consider differences between mRNA and adenovirus-based vaccines in how they induce immunity and protection.
- The reported JnJ and Curevac vaccines are accounted for in the model as (being similar to) AstraZeneca. Their numbers of administered vaccine doses are too low to outweigh the increase in computational burden and complexity of the model when adding an additional subdivision in the model.
- **Waning of vaccine-induced immunity is included in the transmission model.** We assume that on average 50% of the vaccine-induced protection will be lost in 6 months. This corresponds with a transition rate of 1/180 days towards the waning immunity compartments.
- **Third doses (boosters) are included in the transmission model.** Boosters are by default administered 6 months after the full vaccination scheme, while starting from the reported age-specific uptake of "extra doses" by Sciensano. We assume that all booster doses are mRNA-type vaccines, and as such boosed individuals will be (re)located in the appropriate "mRNA 2nd dose" health compartment. Waning of vaccine-induced immunity also applies after booster doses.

11. **Vaccine uptake**

- The vaccine-type and age-specific uptake in the model of first, second and booster doses over time at the national level is based on the reported uptake by Sciensano, derived from Epistat on December 7th, 2021. The uptake by age group is presented in Figure S1.
- We do not account explicitly for risk-group vaccination, since the model structure does not allow to model a sub-population with a differential risk and potentially a more severe COVID-19 disease episode once infected (i.e., a higher probability of hospitalization and/or a higher probability of death, if hospitalized).
- By default, we include vaccine uptake in the population from 12 years of age upwards. For 12-19-year-olds, this is implemented in our 10-year age grouped model structure by applying a proportionate fraction to the 10-19 year age group, i.e. having 80% of the 10-19-year-old population potentially take up vaccines.
- **Scenario A and E:** The current (limited risk group) vaccine uptake for 5-11-year-old children reported by Sciensano on December the 7th, 2021, is used for the projections.
- **Scenario B with universal vaccination in children 5-11 years of age in December 2021 and January 2022:** The uptake reported by Sciensano concerning 0-11-year-old children is considered until December 7th. Afterwards, we assume a 1st dose vaccine uptake rate in the 5-11-year-old age group of 640 000 mRNA doses over 2.5 months. We assume a linear increase in vaccine uptake until 80% coverage is reached in the 10-19-year-old group and 40% in the 0-9-year-old group (which corresponds to 80% in the 5-9-year-old group). The time between 2 mRNA doses is assumed to be 3 weeks and the vaccine uptake is presented in Figure 1b.
- **Scenario C with at least 90% vaccination coverage in each adult age cohort in January 2022:** We assume to reach at least 90% vaccination coverage in each age cohort of the Belgian population over the age of 18 years. In adult age groups that already achieved at least 90% coverage, uptake is not further increased. In all other adult age groups uptake is increased from currently observed uptake to 90%. This corresponds with the administration of 255 000 first doses in January 2020, leading to an overall average vaccination uptake of 91% in adults over 18 years in the simulations shown under this scenario. The time between 2 mRNA doses is assumed to be 3 weeks and the vaccine uptake is presented in Figure S2. All scheduled booster doses are administered after 6 months after the primary schedule.

Table 1: Vaccine efficacy for adeno-based and mRNA-based vaccines against the Alpha and Delta variant by clinical outcome derived from Bernal et al. (2021) and Stowe et al. (2021). We assume waning of vaccine-induced immunity of on average 50% after 6 months.

Clinical outcome	Vaccine type	Alpha variant	Delta variant
Infection (Bernal, 2021)	Adeno: 1st dose	49%	30%
Infection (Bernal, 2021)	Adeno: 2nd dose	74%	67%
Infection (Bernal, 2021)	mRNA: 1st dose	48%	36%
Infection (Bernal, 2021)	mRNA: 2nd dose (and boosters)	94%	88%
Severe disease (Stowe, 2021)	Adeno: 1st dose	80%	71%
Severe disease (Stowe, 2021)	Adeno: 2nd dose	89%	92%
Severe disease (Stowe, 2021)	mRNA: 1st dose	80%	94%
Severe disease (Stowe, 2021)	mRNA: 2nd dose (and boosters)	95%	96%
Transmission (Harris, 2021)	mRNA and Adeno (and boosters)	45%	45%

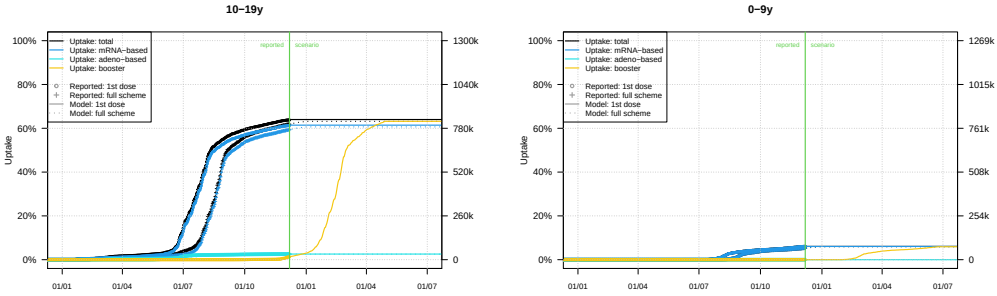
- **Scenario D with 95% adult vaccination coverage in January 2022:** We assume to reach 95% vaccination coverage in the Belgian population over the age of 18 years. This corresponds with the administration of 570 000 first doses in January 2020. The time between 2 mRNA doses is assumed to be 3 weeks and the vaccine uptake is presented in Figure S3. All booster doses are administered after/within 6 months after the primary schedule.
- **Scenario F with additional vaccine uptake in July and August 2021:** The vaccine uptake for 5y-9y and 10y-11y old children is adjusted in line with the reported uptake for 12y-15y and 16y-17y old children, respectively. As such, for each reported mRNA vaccine in the 16-17-year-old group in July and August 2021, we include one vaccine dose for the 10-11-year-old group. For the 5-9-year-old children, we apply the same approach based on the reported uptake for the 12-15-year-old children, while accounting for the number of age cohorts in both groups (5 cohorts vs 4 cohorts). The final uptake is approximately 80% in the 10-19-year-old group, and 40% in the 0-9-year-old group (which corresponds to 80% in the 5-9-year-old group). The time between 2 mRNA doses is assumed to be 3 weeks and the vaccine uptake is presented in Figure 1c.

Major limitations

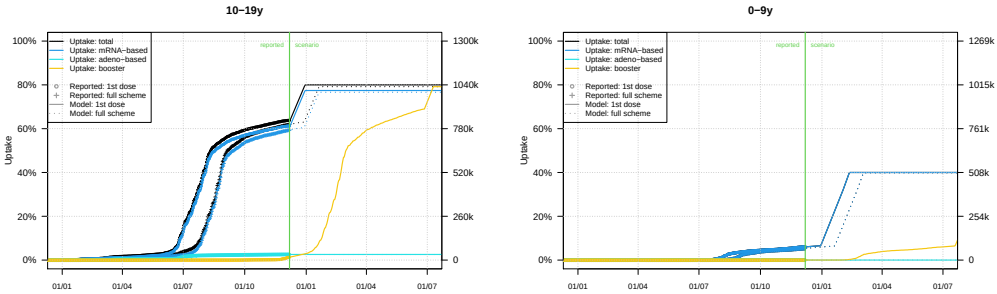
- **This transmission model is suited for scenario analyses to investigate possible future or counterfactual retrospective paths, it is not a prediction model.**
- The model is calibrated on hospitalizations and informed by the Belgian CoMiX social contact data survey. These empirical social contact data inform mainly the frequency and age structure of person-to-person social interactions, but are less informative with regards to the adherence to restrictions. The fact that the model is primarily calibrated on hospitalizations, and given the time lag between incurring infection and being admitted to hospital, makes this model less sensitive for rapidly changing dynamics. Another issue is that empirical data on social contact patterns to inform the model is also lagging.
- The daily age distribution of hospitalized patients is derived from the individual hospital survey **up to November 30th, 2021**, in which patients are only included at hospital discharge. This implies a considerable delay in the availability of up to date information concerning the age distribution of hospitalizations. In a transition phase in which the age distribution changes drastically, e.g. due to the depletion of susceptible persons in older age groups as a result of vaccination, this delay could have a considerable impact on future trajectories.
- Pending on data on for the Omicron VOC, we are making the implicit assumption that the Delta VOC will remain the dominant strain throughout the simulations. Nonetheless, other VOCs may have different transmission probabilities and probabilities to cause disease, hospitalization, death, and different vaccine effectiveness characteristics against each of these manifestations.
- While we have introduced waning of vaccine-induced immunity (including after booster doses), we have not yet introduced waning of immunity after infection in the model structure. Since especially children

have not been vaccinated, and have often been infected , this leads to an overestimation of sustained immunity acquired in children, and an underestimation of the potential impact of childhood vaccination.

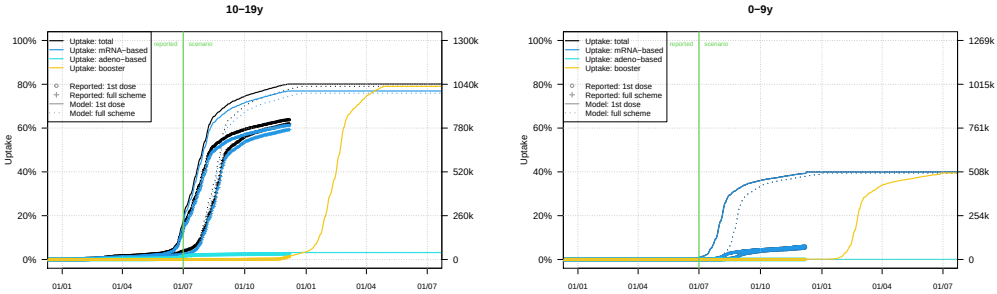
- The transmission model does not evaluate the prevented (severe) outpatient cases, which affect pressure exerted on primary care. The model does not include parameter uncertainty on vaccine uptake and effectiveness yet.
- The incremental transmissibility by the Alpha and Delta VOCs, which we include in the model, is not age-specific.
- We attribute the growth advantage of the VOCs completely to transmissibility, and as such, ignore the potential effect of immune escape on the speed of penetration.
- Vaccine-induced immunity is implemented by a step function. As such, it is assumed that build-up of immunity in vaccinated persons is not a gradual, but a step-wise process.



(a) Reported vaccine uptake for Belgium.



(b) Children 5-11-year-old are vaccinated in January 2022 up to a 80% coverage.



(c) Children 5-11-year-old are vaccinated in July-August 2021.

Figure 1: Model-based vaccine uptake for age groups 0y-9y and 10y-19y based on the reported uptake for Belgium and 2 additional scenarios regarding vaccine uptake for 5-11-year-old children.

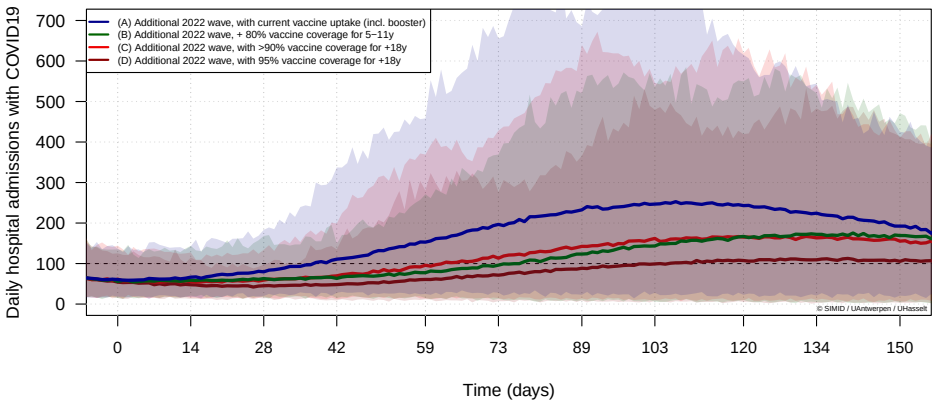
- We compare the reproduction number over time (Rt) in the simulation model with the Rt based on the confirmed cases by Sciensano using the R package "EpiEstim". Within the model environment, we dispose of perfect information and this allows us to calculate Rt based on all new symptomatic cases over time. The reported Sciensano data on the other hand is affected by changing testing strategies and adherence over time.
- This model does not explicitly account for importation by returning travelers which could have impact on the evolution of the epidemic. Importantly, an implicit attribution of such cases to local transmission is used instead.
- We present our modelling results by the mean and pointwise 95% credible interval based on 40 model realizations, which capture stochastic effects and parametric uncertainty. The interplay between these two sources of uncertainty is subject of future research.

Model results and discussion

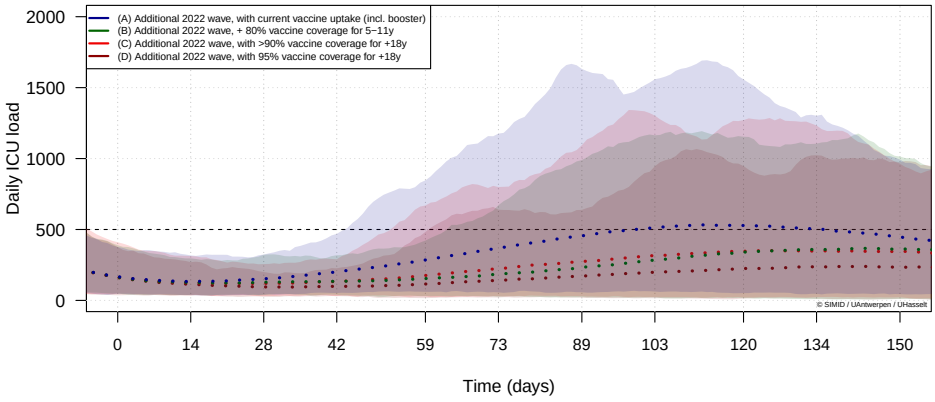
The following figures depict the results of our scenario analyses with respect to social mixing and vaccine uptake. All projections show a large 95% credible interval and should therefore be interpreted with great caution. The main conclusions are listed at the start of this document.

- Social mixing behaviour is assumed to be constant in the forward projections into the future. Without increased risk behaviour, the incidence of new infections decreases by definition with a decreasing number of susceptible individuals. Behavioural changes might counter this decreasing force of infection, though this is not studied here thoroughly.
- The model projections are based on the hospital admissions with COVID-19, hence one can interpret them to represent the upper limit for hospital admissions due to COVID-19.
- The national model does not account for local differences in immunity. As such, herd immunity effects in sub-populations with immunity levels above the national level are underestimated.
- We included extra results in supplement on the impact of vaccine uptake with an additional COVID-19 wave in 2022 assuming risk behaviour from January 2022 in line with 120% of the behaviour we estimated for early October 2021. The simulated burden of disease in the "no additional uptake" scenario (A) is higher and the differences between the uptake scenarios are more visible.

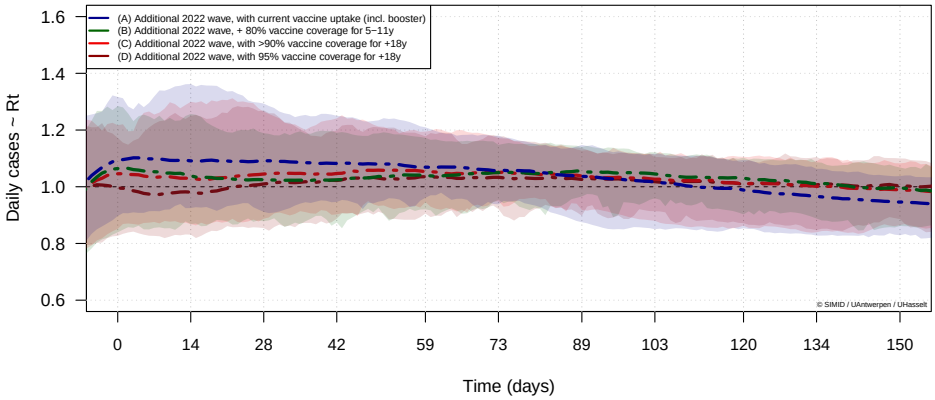
Scenario analysis of different future vaccine uptake options, given an additional wave in 2022 (reproducing estimated risk behaviour in October 2021).



(a) Daily hospital admissions with COVID-19



(b) ICU occupancy



(c) Reproduction number over time (Rt)

Figure 2: Model projections for Belgium on daily hospital admissions, ICU occupancy and reproduction number for different assumptions on vaccine uptake with a hypothetical increase in social contact behaviour in 2022. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.

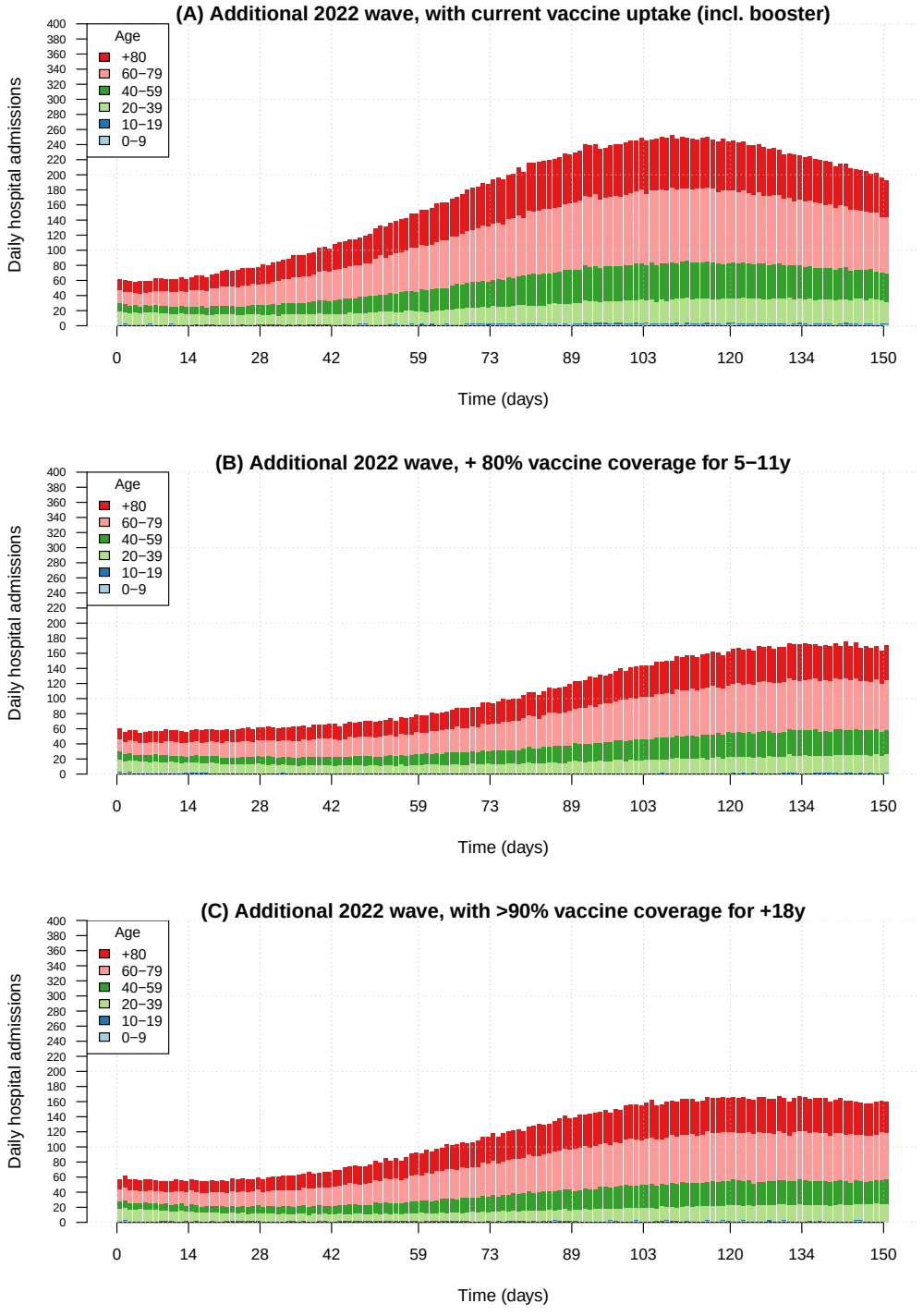


Figure 3: Model projections for Belgium on average daily hospital admissions with different assumptions on vaccine uptake.

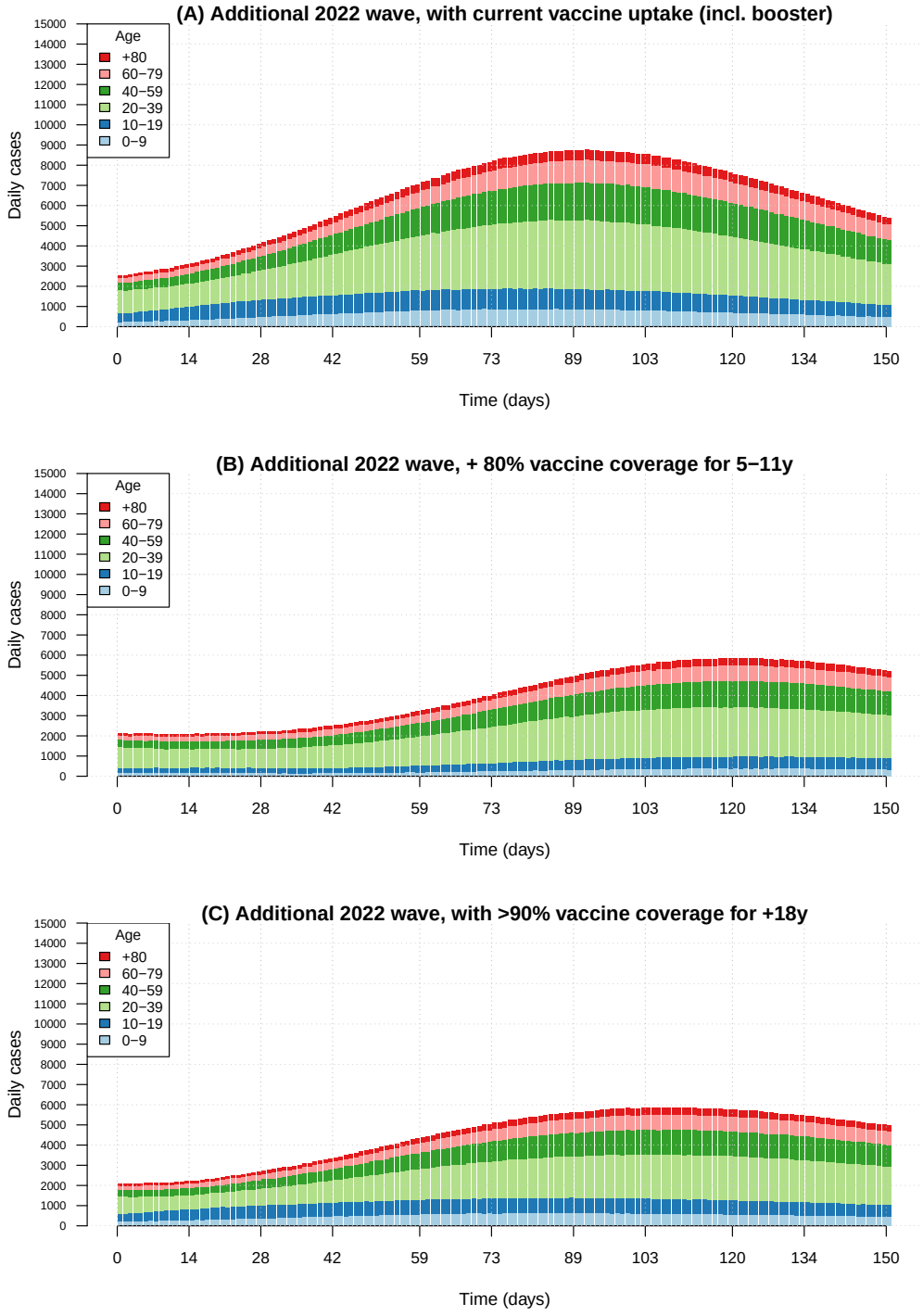
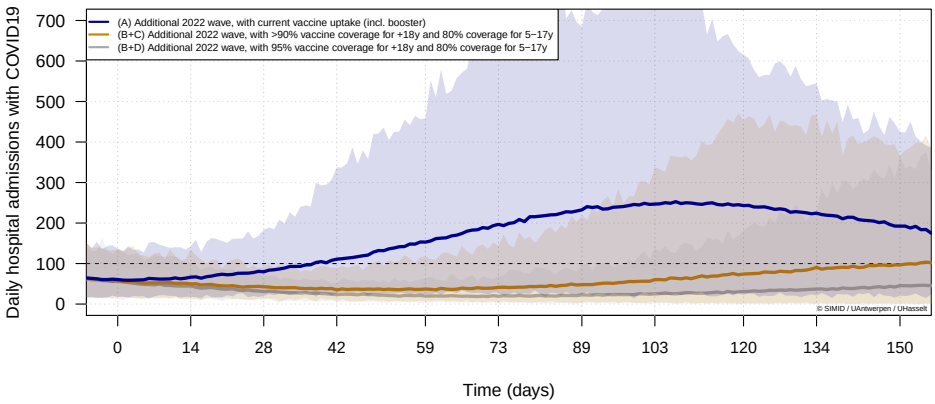
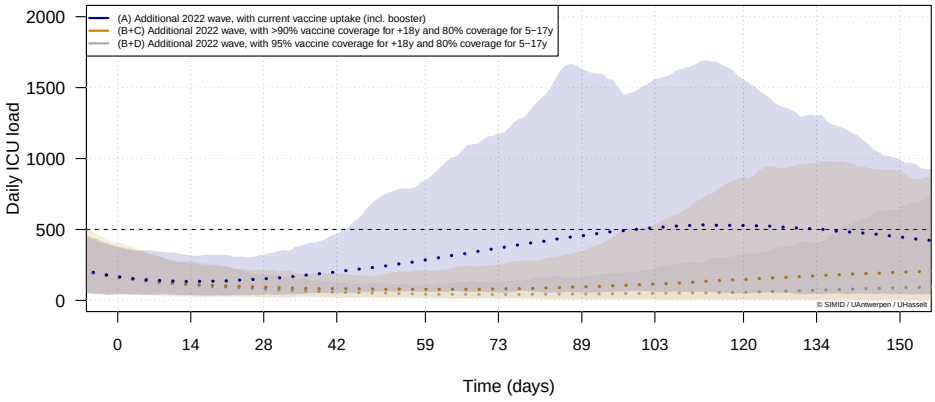


Figure 4: Model projections for Belgium on average daily infections with different assumptions on vaccine uptake.

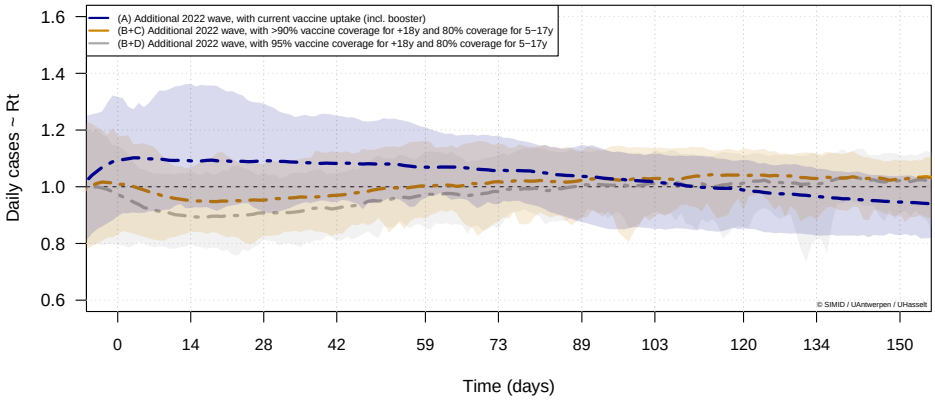
Combined uptake scenarios on future vaccine uptake with an additional wave in 2022 (reproducing estimated risk behaviour in October 2021).



(a) Daily hospital admissions with COVID-19



(b) ICU occupancy



(c) Reproduction number over time (Rt)

Figure 5: Model projections for Belgium of daily hospital admissions, ICU occupancy and reproduction number for a combination of vaccine uptake scenarios with a hypothetical increase in social contact behaviour in 2022. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.

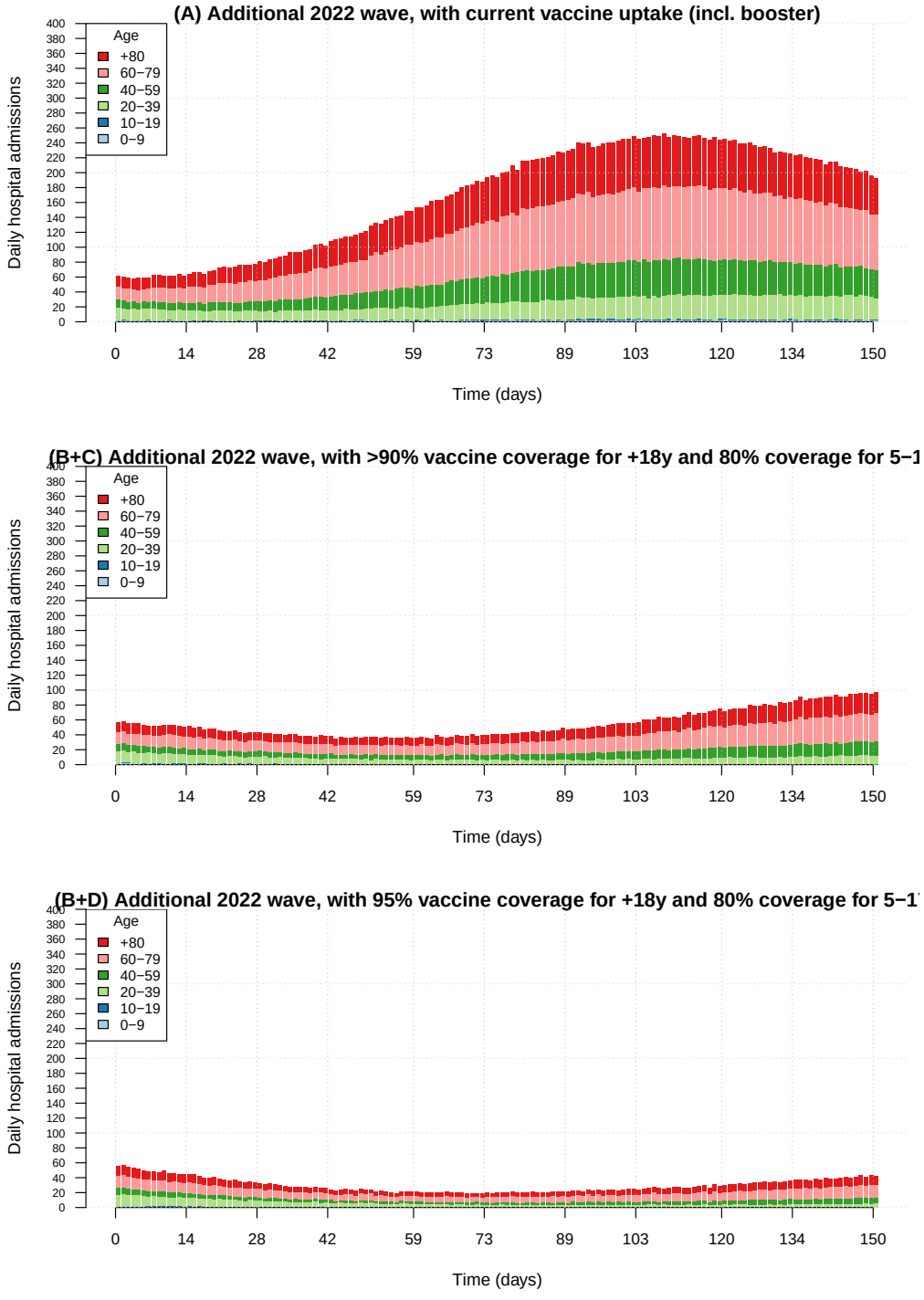


Figure 6: Model projections for Belgium on average daily hospital admissions with different assumptions on vaccine uptake.

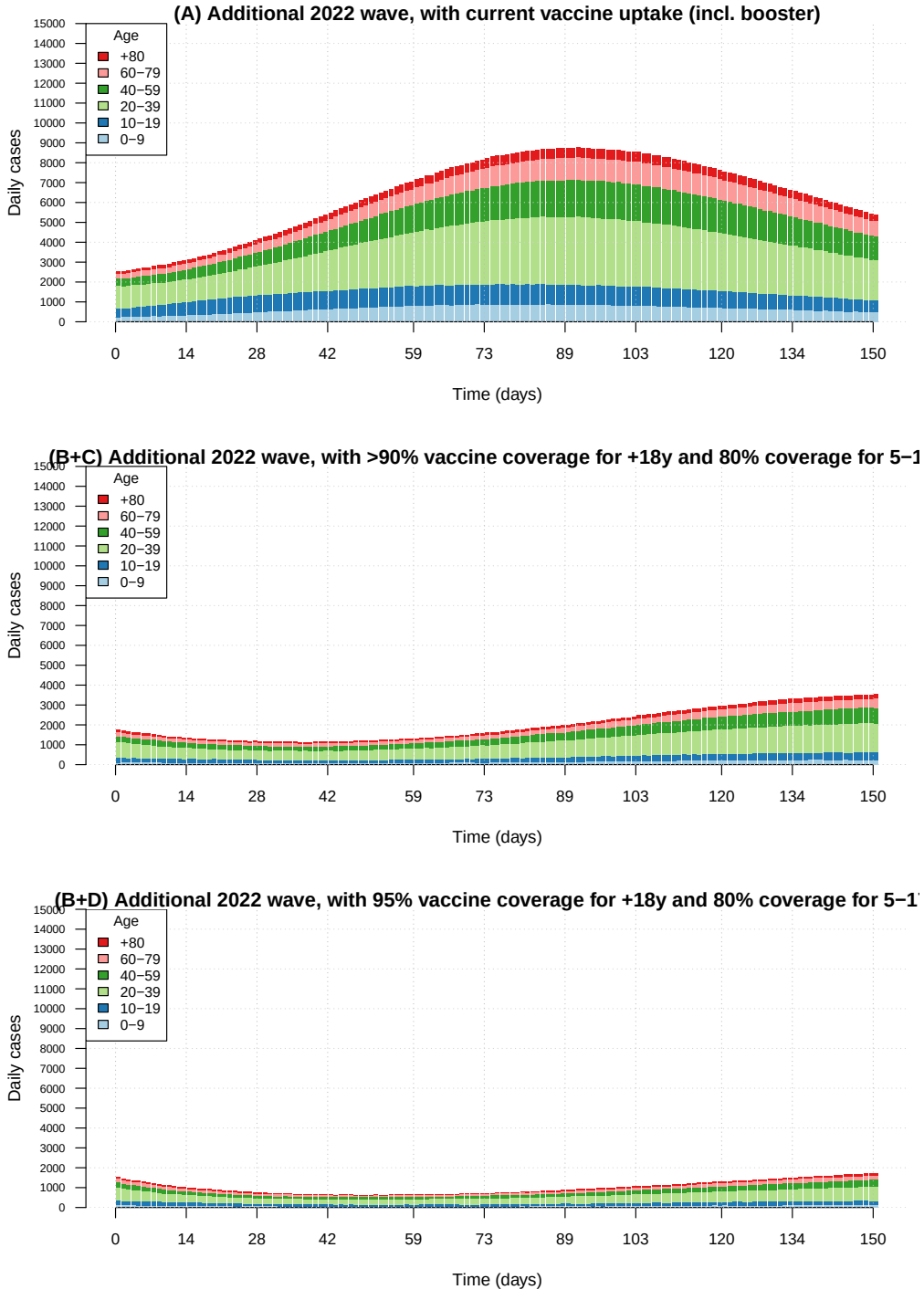
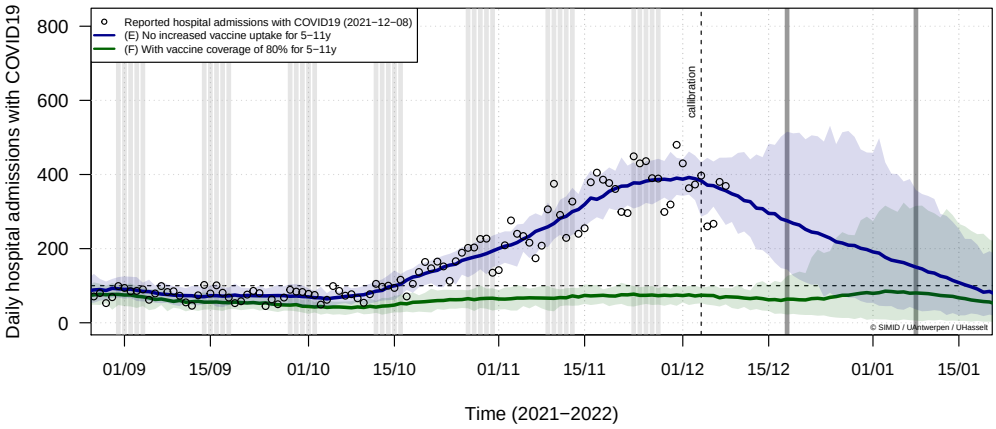
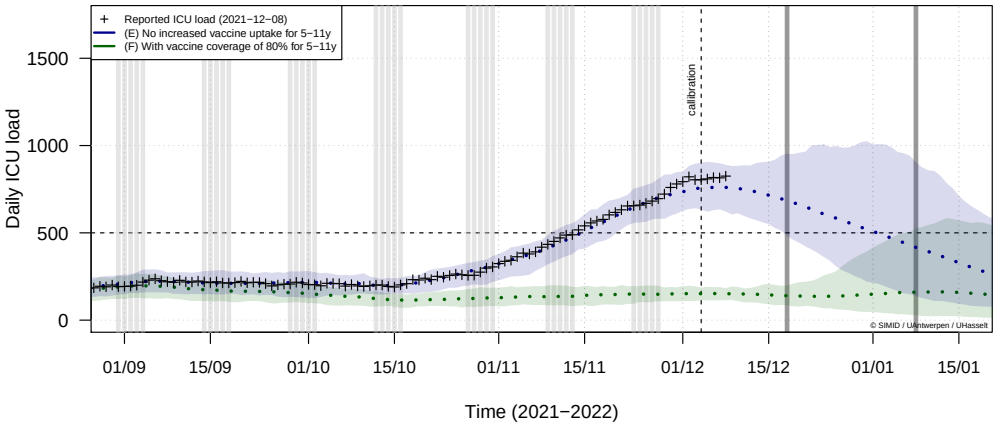


Figure 7: Model projections for Belgium on average daily infections with different assumptions on vaccine uptake.

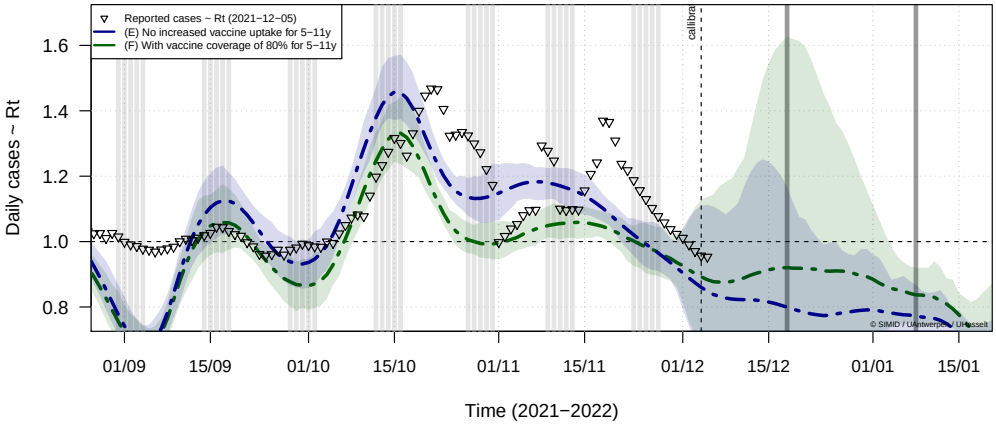
Retrospective vaccine uptake analysis for the fourth COVID-19 wave in Belgium.



(a) Daily hospital admissions with COVID-19



(b) ICU occupancy



(c) Reproduction number over time (Rt)

Figure 8: Model projections for Belgium of daily hospital admissions, ICU occupancy and reproduction number for different assumptions on vaccine uptake. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.

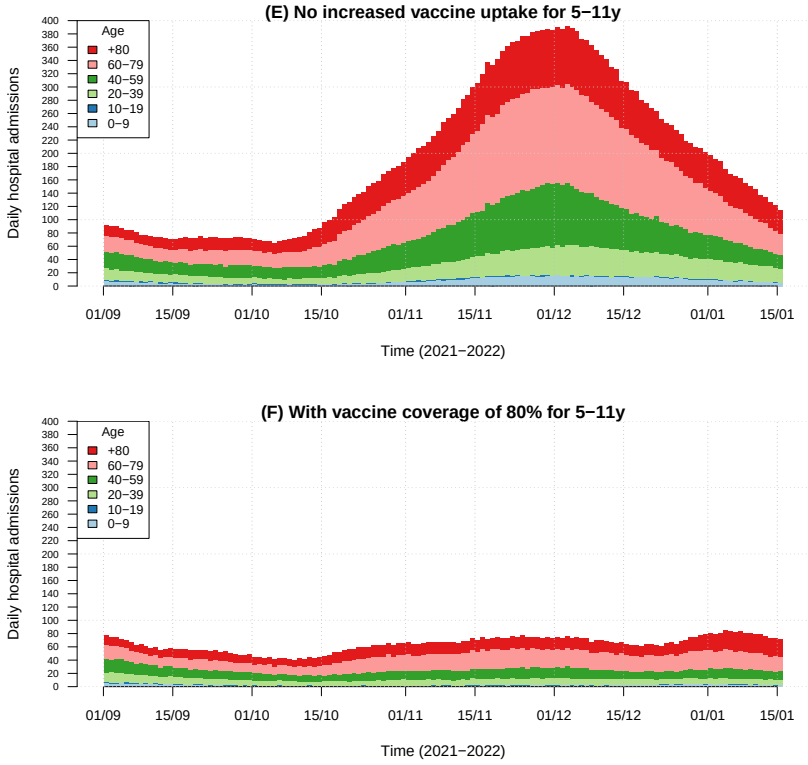


Figure 9: Model projections for Belgium on average daily hospital admissions with different assumptions on vaccine uptake.

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- Niel Hens (Universiteit Hasselt en Universiteit Antwerpen)
- Philippe Beutels (Universiteit Antwerpen)
- Steven Abrams (Universiteit Antwerpen en Universiteit Hasselt)

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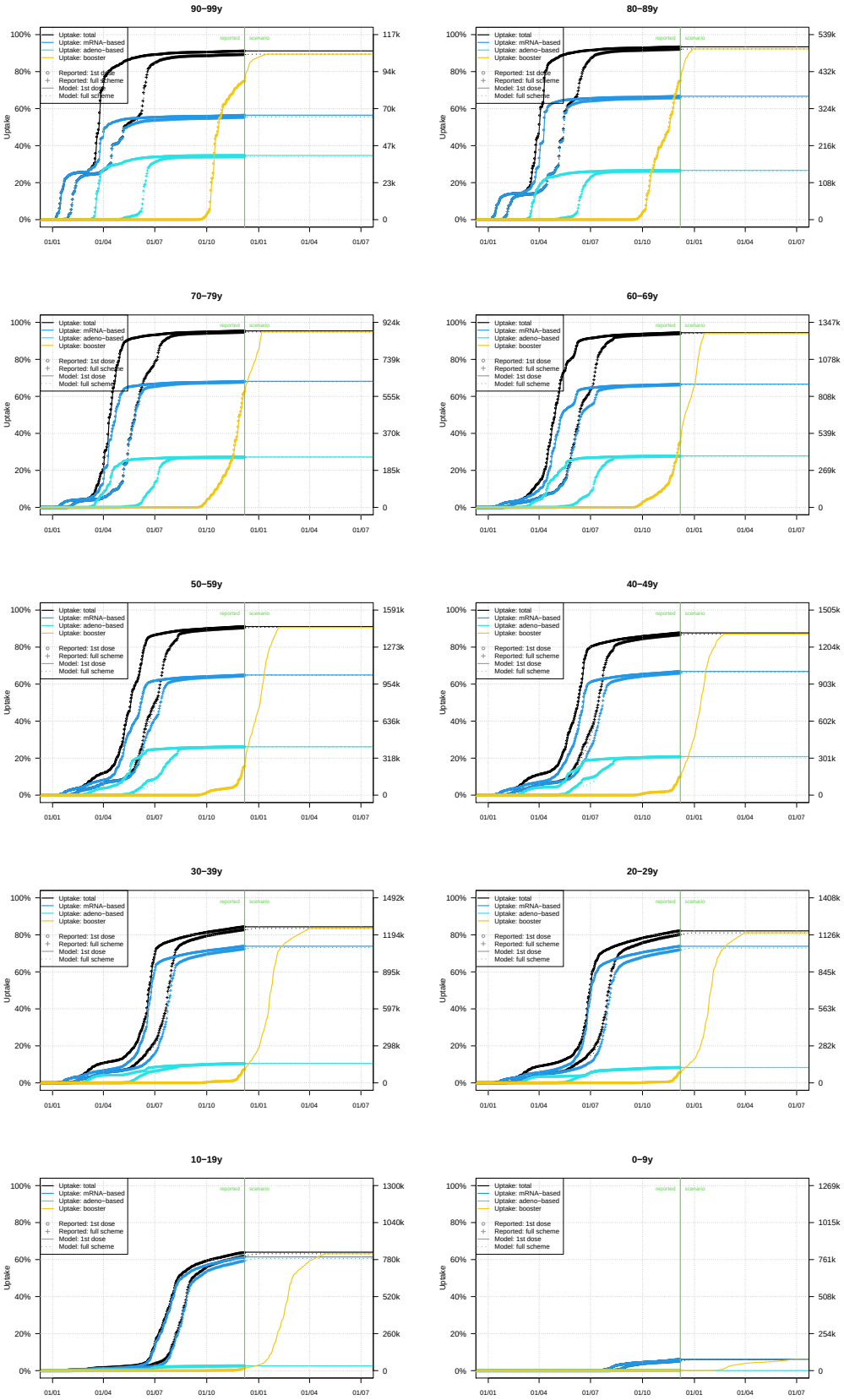


Figure S1: Included vaccine uptake by age based on the reported uptake for Belgium.

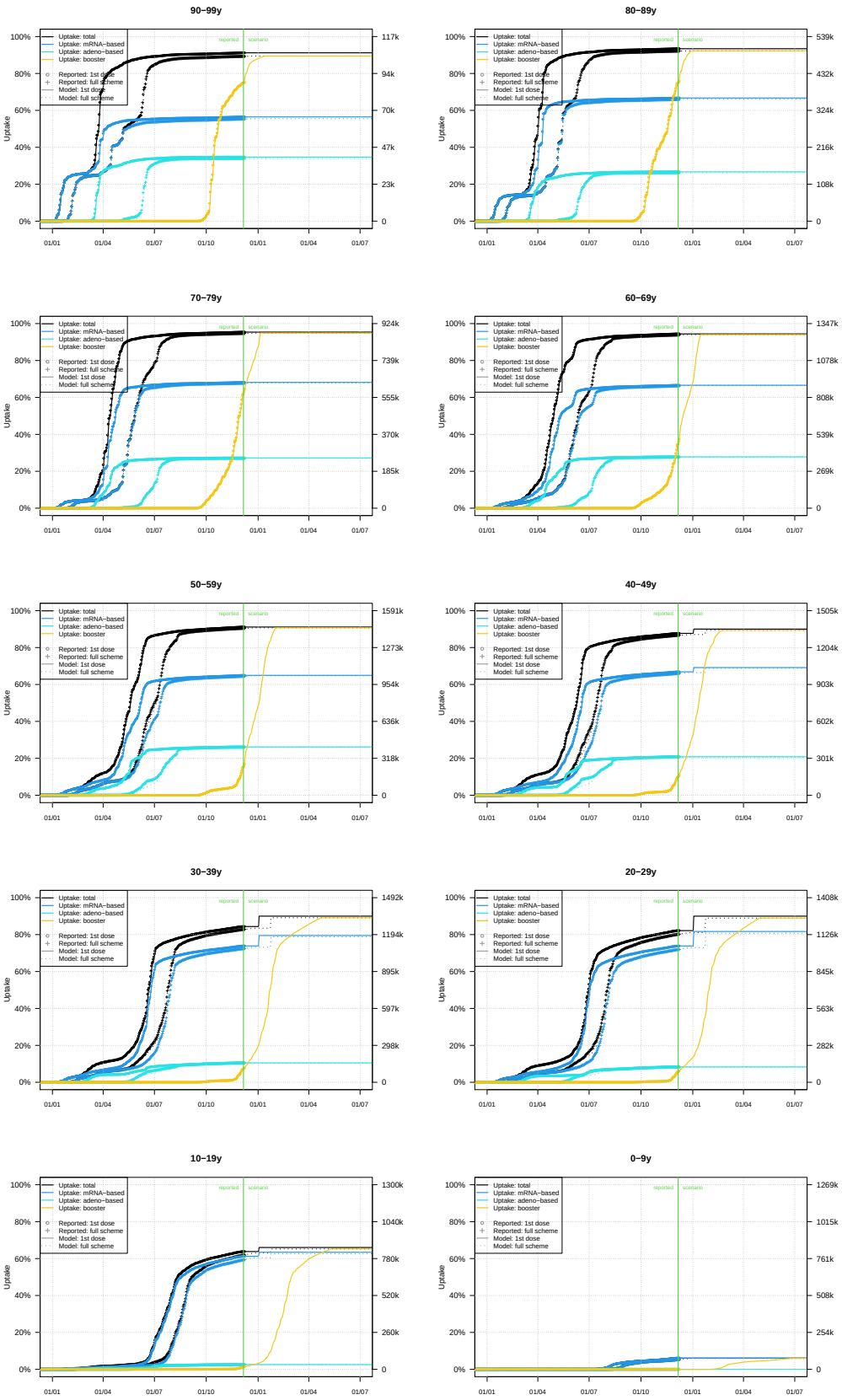


Figure S2: Included vaccine uptake by age based on the reported uptake for Belgium with 90% vaccine coverage from the age of 18y and reported uptake up to 17y.

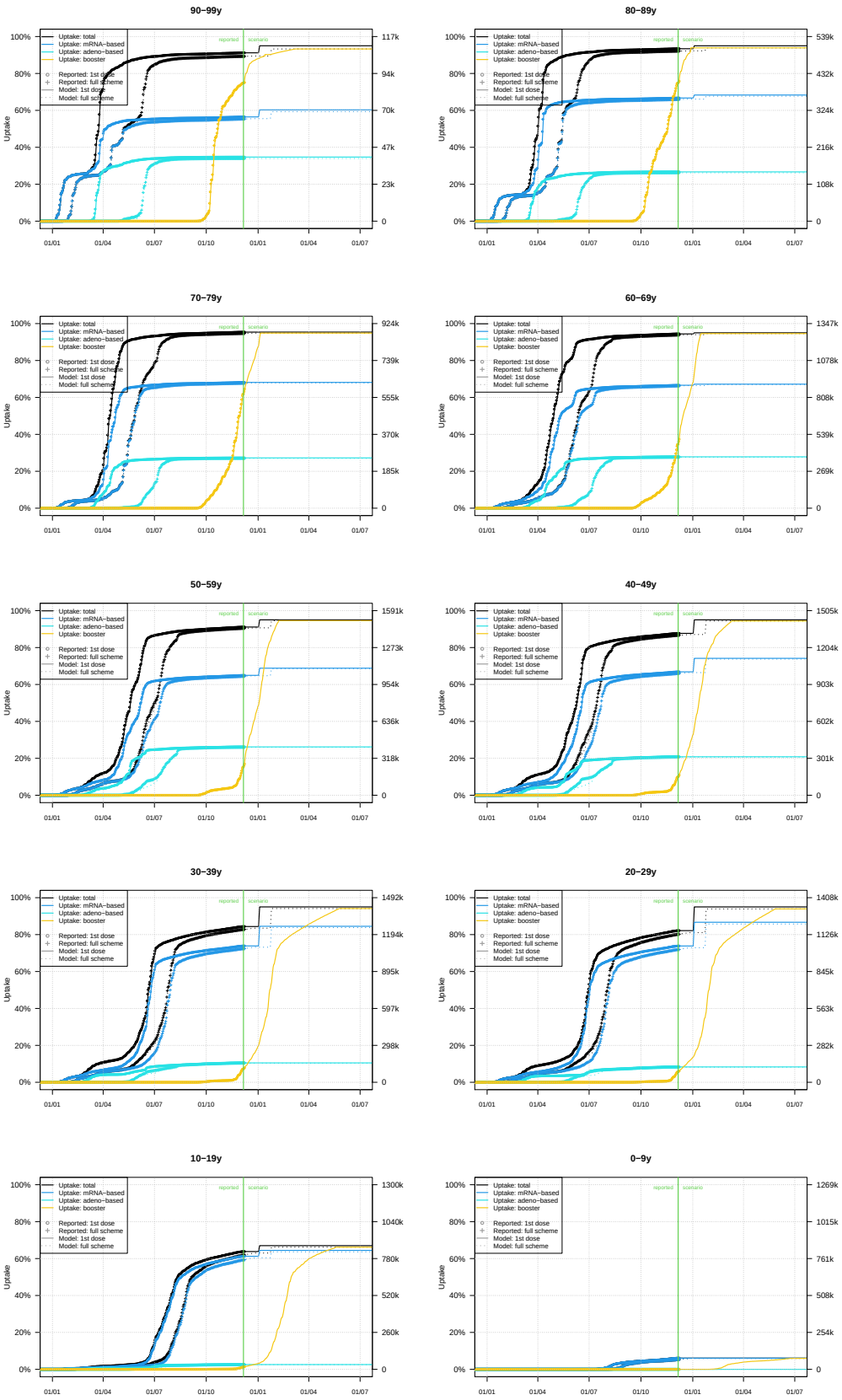
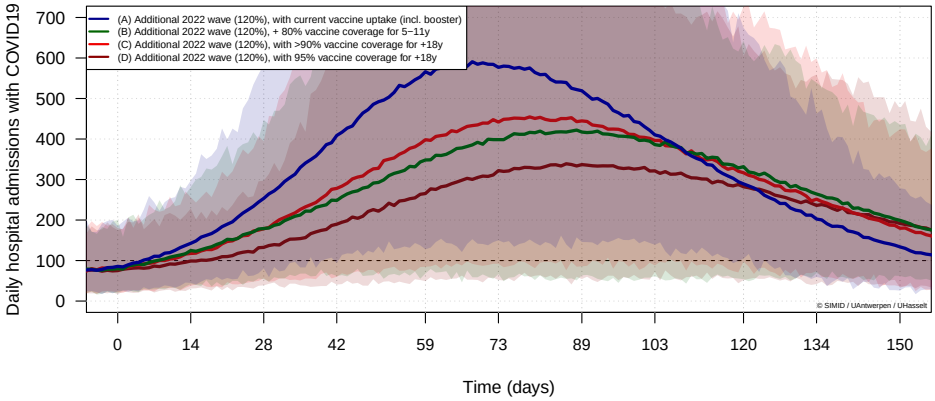
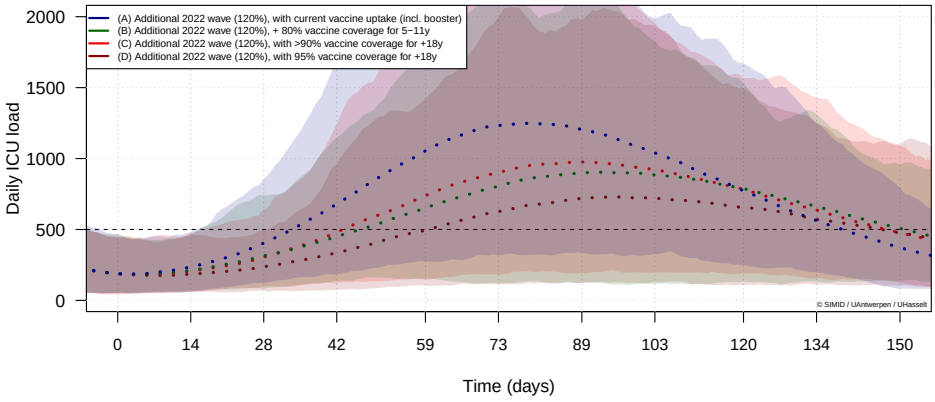


Figure S3: Included vaccine uptake by age based on the reported uptake for Belgium with 95% vaccine coverage from the age of 18y and reported uptake up to 17y.

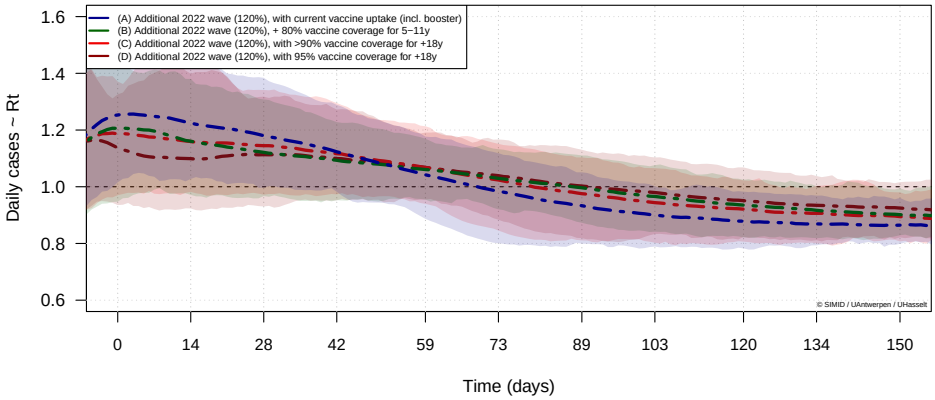
Extra scenario analysis of future vaccine uptake options, given an additional larger wave in 2022 (reproducing 120% of the estimated risk behaviour in October 2021).



(a) Daily hospital admissions with COVID-19

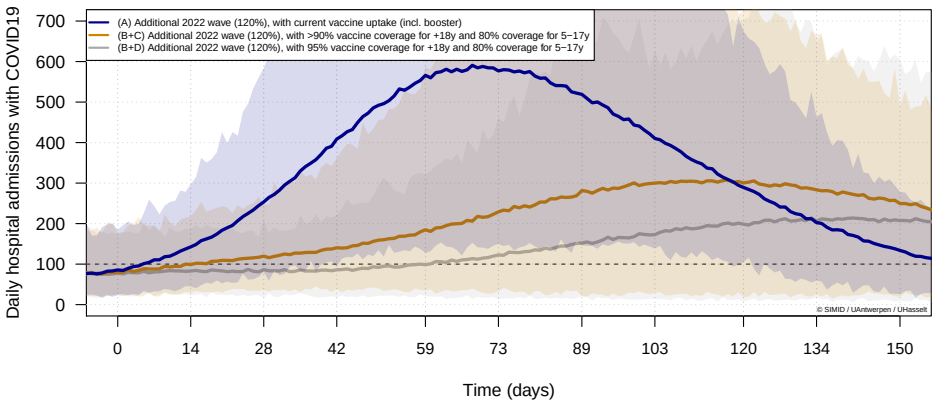


(b) ICU occupancy

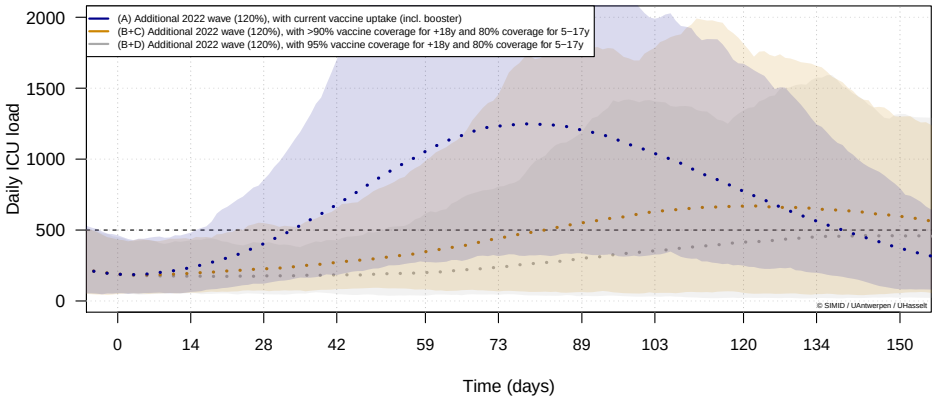


(c) Reproduction number over time (Rt)

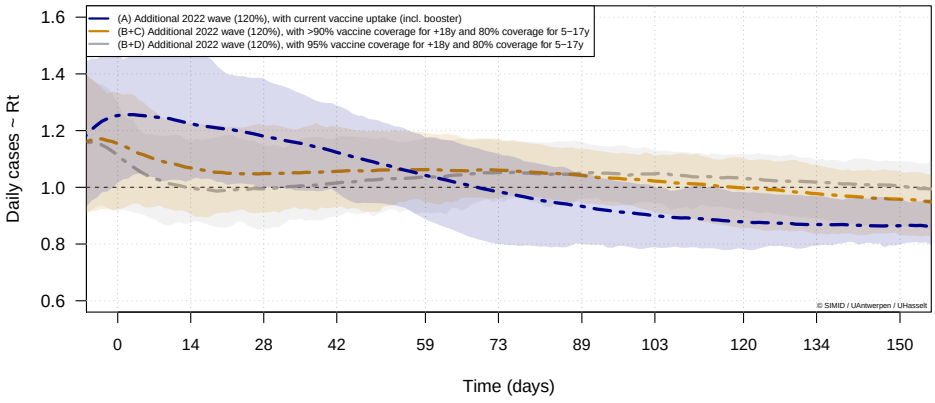
Figure S4: Model projections for Belgium of daily hospital admissions, ICU occupancy and reproduction number for different assumptions on vaccine uptake with a hypothetical increase in social contact behaviour in 2022 in line with 120% of the risk behaviour we estimated for early October 2021. This behaviour remains constant until the end of the simulation. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.



(a) Daily hospital admissions with COVID-19



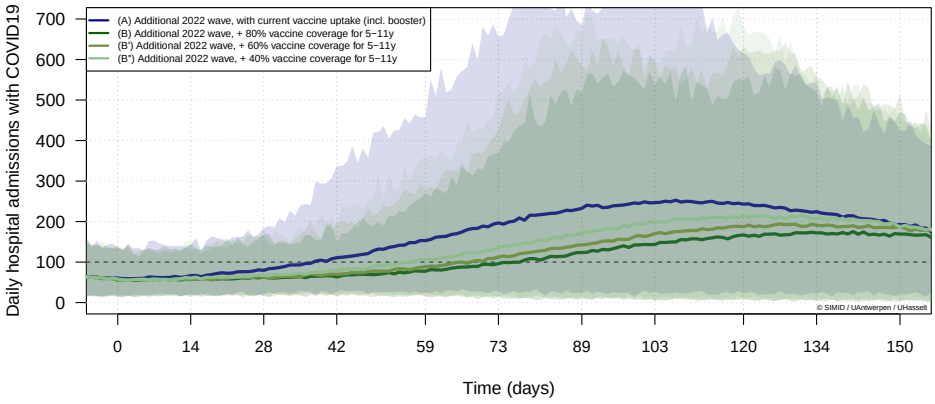
(b) ICU occupancy



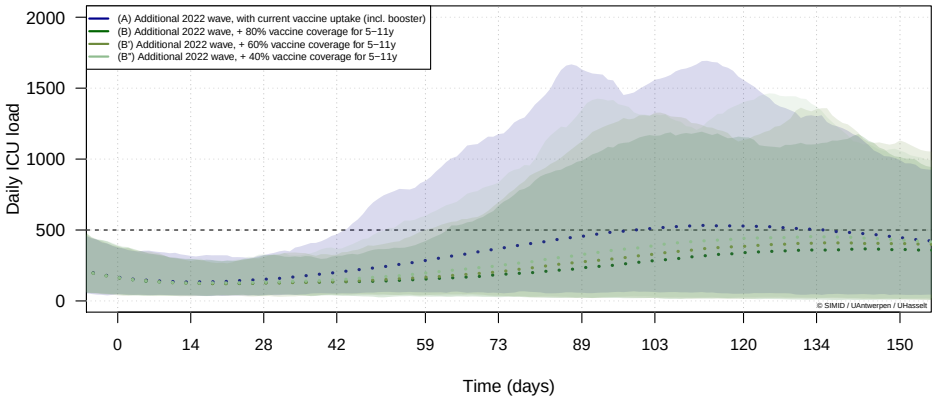
(c) Reproduction number over time (Rt)

Figure S5: Model projections for Belgium on daily hospital admissions, ICU occupancy and reproduction number for combinations of vaccine uptake scenario B, C and D with a hypothetical increase in social contact behaviour in 2022 in line with 120% of the risk behaviour we estimated for early October 2021. This behaviour remains constant until the end of the simulation. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.

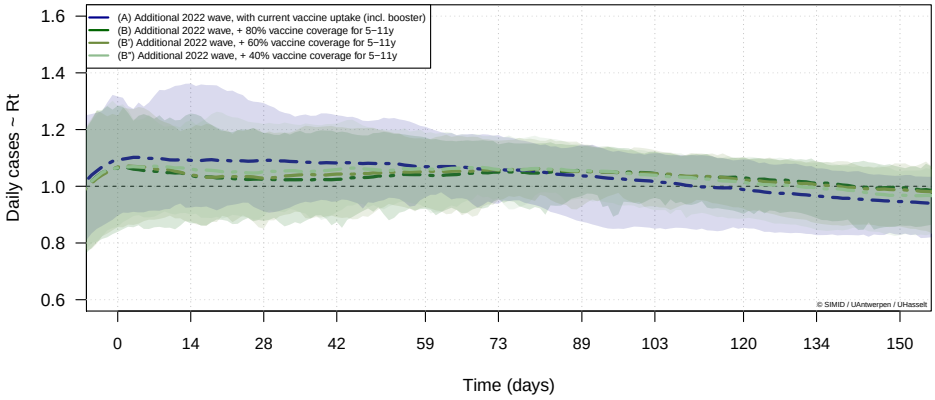
Extra scenario analysis: Sensitivity under different uptakes concerning vaccination coverage of 5-11-year-old children, with 40%, 60% and 80% coverage.



(a) Daily hospital admissions with COVID-19

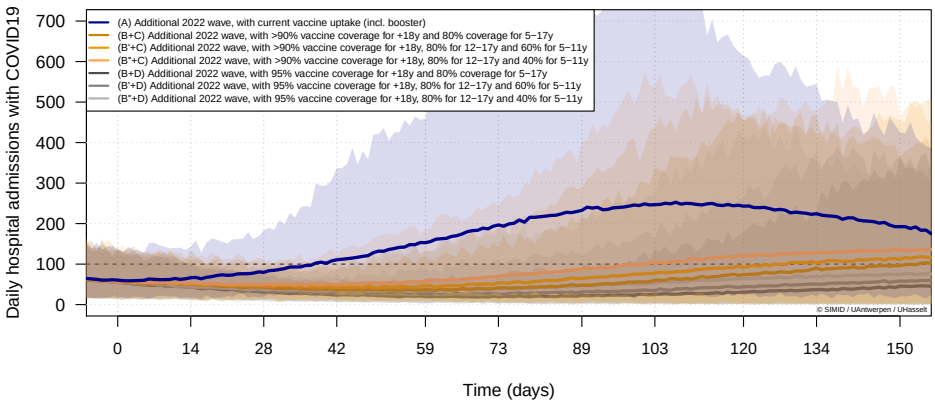


(b) ICU occupancy

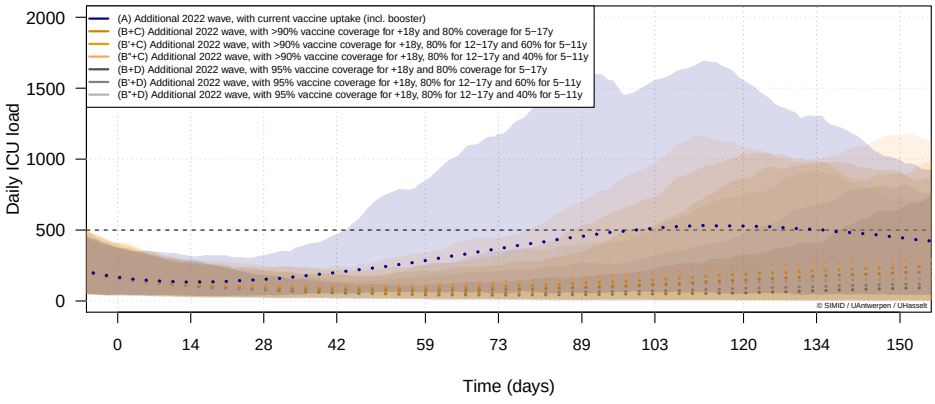


(c) Reproduction number over time (Rt)

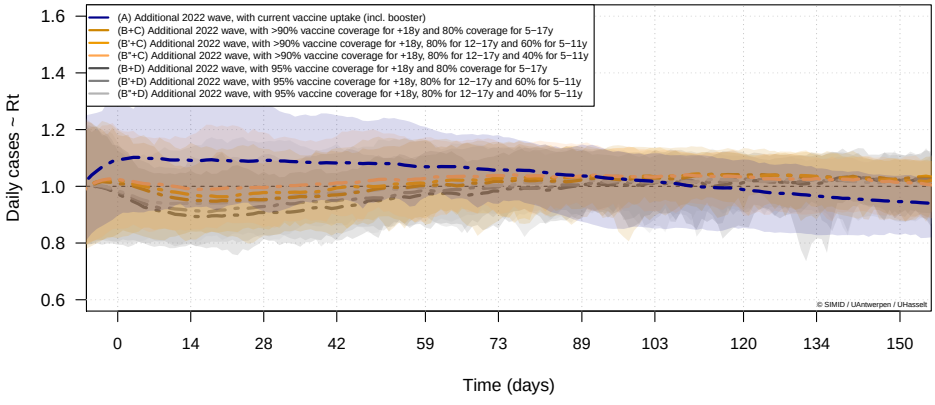
Figure S6: Sensitivity on daily hospital admissions, ICU occupancy and reproduction number for different assumptions on vaccine uptake concerning 5-11-year-old children with a hypothetical increase in social contact behaviour in 2022. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.



(a) Daily hospital admissions with COVID-19



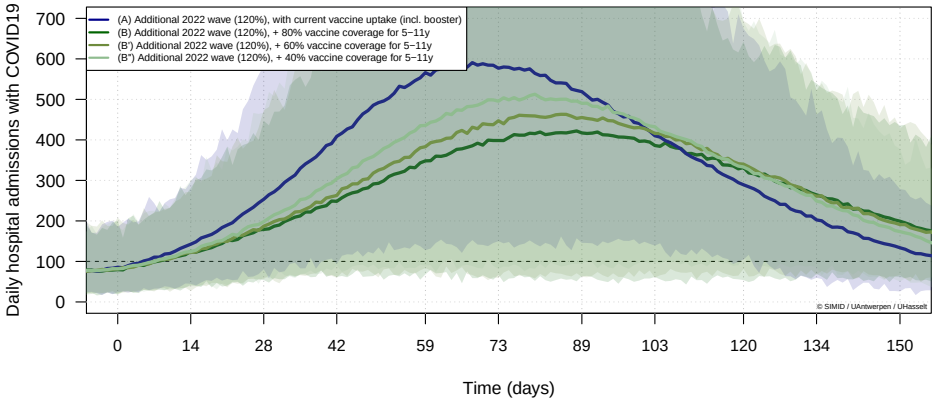
(b) ICU occupancy



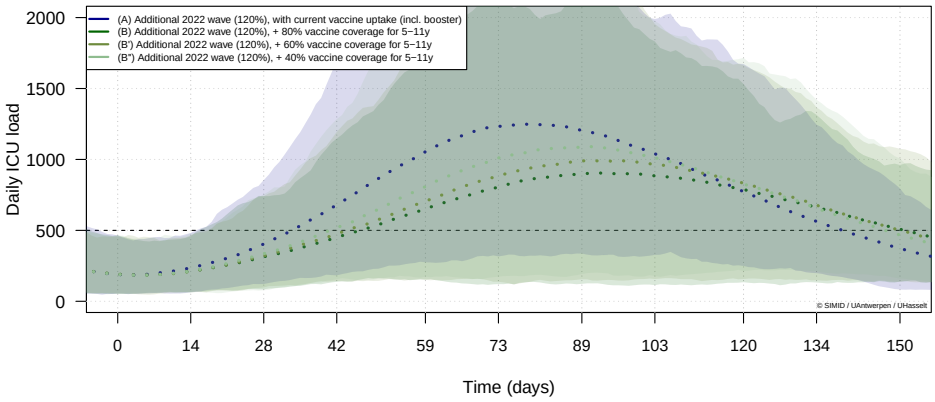
(c) Reproduction number over time (Rt)

Figure S7: Sensitivity on daily hospital admissions, ICU occupancy and reproduction number for combinations of vaccine uptake scenario B, C and D and for different assumptions on vaccine uptake concerning 5-11-year-old children with a hypothetical increase in social contact behaviour in 2022. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.

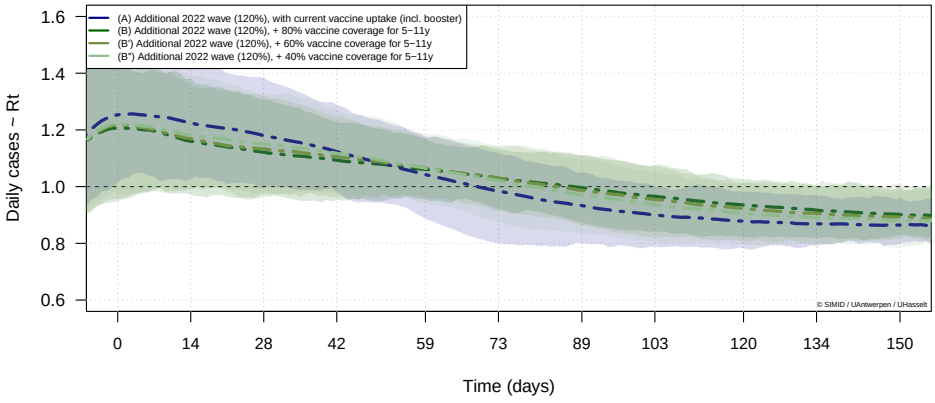
Extra scenario analysis: Sensitivity under different uptakes concerning vaccination coverage of 5-11-year-old children, with 40%, 60% and 80% coverage (on an additional larger wave in 2022 reproducing 120% of the estimated risk behaviour in October 2021).



(a) Daily hospital admissions with COVID-19

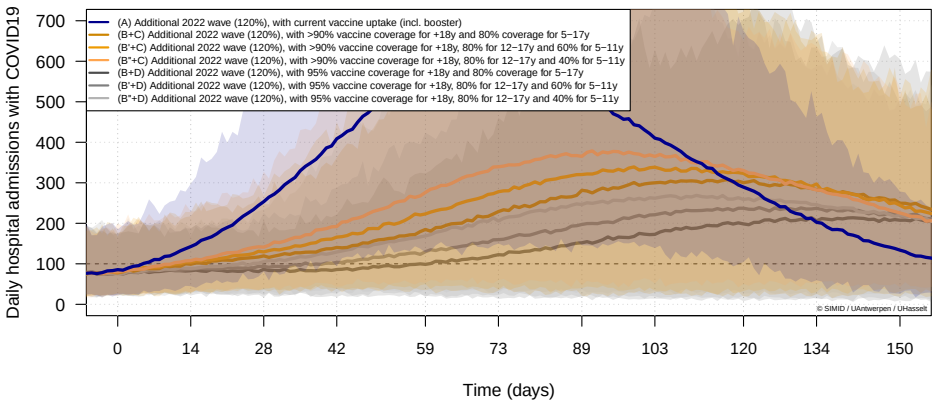


(b) ICU occupancy

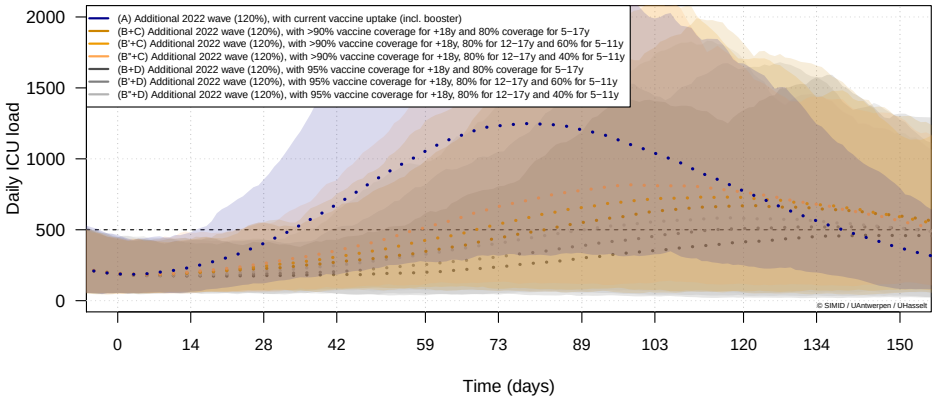


(c) Reproduction number over time (Rt)

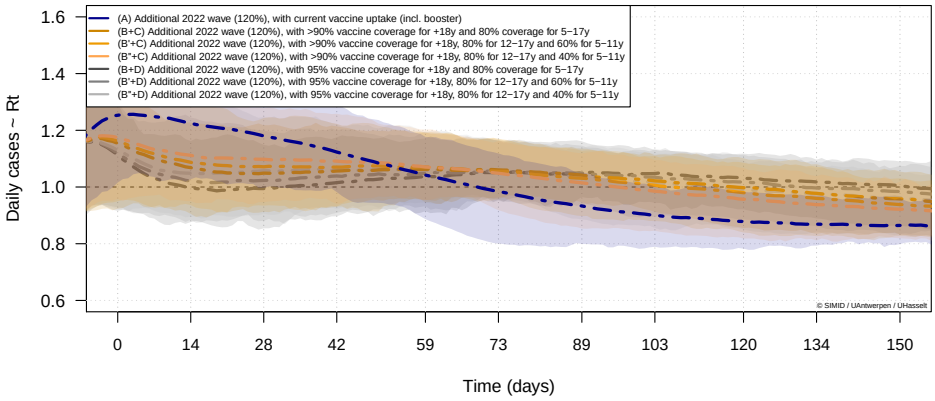
Figure S8: Sensitivity on daily hospital admissions, ICU occupancy and reproduction number for different assumptions on vaccine uptake concerning 5-11-year-old children with a hypothetical increase in social contact behaviour in 2022 in line with 120% of the risk behaviour we estimated for early October 2021. This behaviour remains constant until the end of the simulation. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.



(a) Daily hospital admissions with COVID-19



(b) ICU occupancy



(c) Reproduction number over time (Rt)

Figure S9: Sensitivity on daily hospital admissions, ICU occupancy and reproduction number for combinations of vaccine uptake scenario B, C and D and for different assumptions on vaccine uptake concerning 5-11-year-old children with a hypothetical increase in social contact behaviour in 2022 in line with 120% of the risk behaviour we estimated for early October 2021. This behaviour remains constant until the end of the simulation. The results are summarized by the mean (line) and 95% point-wise credible intervals (shaded area) of 40 model runs.