

COVID-19 Scenario Modeling Hub Report

12 January, 2022

Scenario Modeling Hub Team¹

This is a revised version of a previously published report, which addresses a technical issue that affected ensemble projections. The qualitative conclusions of the initial report remain unchanged.

Executive Summary

This report presents the results of the eleventh round of projections from the COVID-19 Scenario Modeling Hub. A consortium of eight modeling groups convened to generate week ahead projections of COVID-19 cases, deaths, and hospitalizations for a period of three months (weeks ending 2021-12-25 to 2022-03-12), given four scenarios of severity, immune escape, and transmissibility of the Omicron variant. A full list of contributors is included at the end of the report. See the table on the next page for an overview of the scenarios included in this round. Detailed scenario descriptions and setting assumptions are provided [here](#).

Key Takeaways from the Eleventh Round

- Based on epidemiological data that has been published since scenario specification, our pessimistic severity scenarios (C and D) are now considered unlikely, hence all key takeaways are based on optimistic severity scenarios (A and B).
- The Omicron wave is projected to be sharp and fast by most models in all scenarios, with most models projecting that both cases and hospitalizations peak before the end of January 2022 in every state, and all models projecting peaks before March 1, 2022.
- While cases, hospitalizations and deaths will have receded substantially from the peak by the end of the projection period (March 12, 2022), all are projected to remain elevated compared to June 2021 levels.
- In the scenario with high immune escape and low transmissibility, we expect incident hospitalizations to peak at 124,000 per week (95% PI 38,000-263,000, or 40-300% of the Delta peak). In the scenario with low immune escape and high transmissibility we expect hospitalizations to peak at 171,000 per week (95% PI 50,000-327,000, or 60-370% the Delta peak).
- Overall, during the projection period December 19, 2021 to March 12, 2022, we expect to see 832,000 (95% PI 409,000-1,710,000) cumulative hospitalizations and 111,000 (95% PI 54,000-251,000) cumulative deaths resulting from the Omicron wave in the high immune escape and low transmissibility scenario. We expect 1,547,000 (95% PI 562,000-2,384,000) cumulative hospitalizations and 191,000 (95% PI 58,000-305,000) cumulative deaths in the low immune escape and high transmissibility scenario.
- This is a rapid round of projections based on early data, hence there is a large number of caveats to these projections:
 - The intrinsic severity of Omicron and the protection afforded by full vaccine schedules and boosters remain debated. While Scenarios A and B are broadly consistent with current data, scenario specifications and resulting projections will need to be refined as we learn more about Omicron.
 - Most models assume the same serial interval for the Omicron and Delta variants. Some recent data has suggested a shorter serial interval for Omicron, which would result in a lower transmissibility advantage over Delta; hence a smaller Omicron wave.
 - Case projections should be considered with caution due to potential changes in the definition and identification of a case in the Omicron era. Issues include higher rates of asymptomatic infections in a wave driven by breakthrough infections and reinfections, unreported positive home tests, and saturation in testing due to the sheer volume of Omicron infections.
- More details on the results of each model are provided in the Appendix.

¹Compiled by Justin Lessler, Rebecca Borcherding, Emily Howerton, and Claire Smith.

Round 11 Scenario Specifications

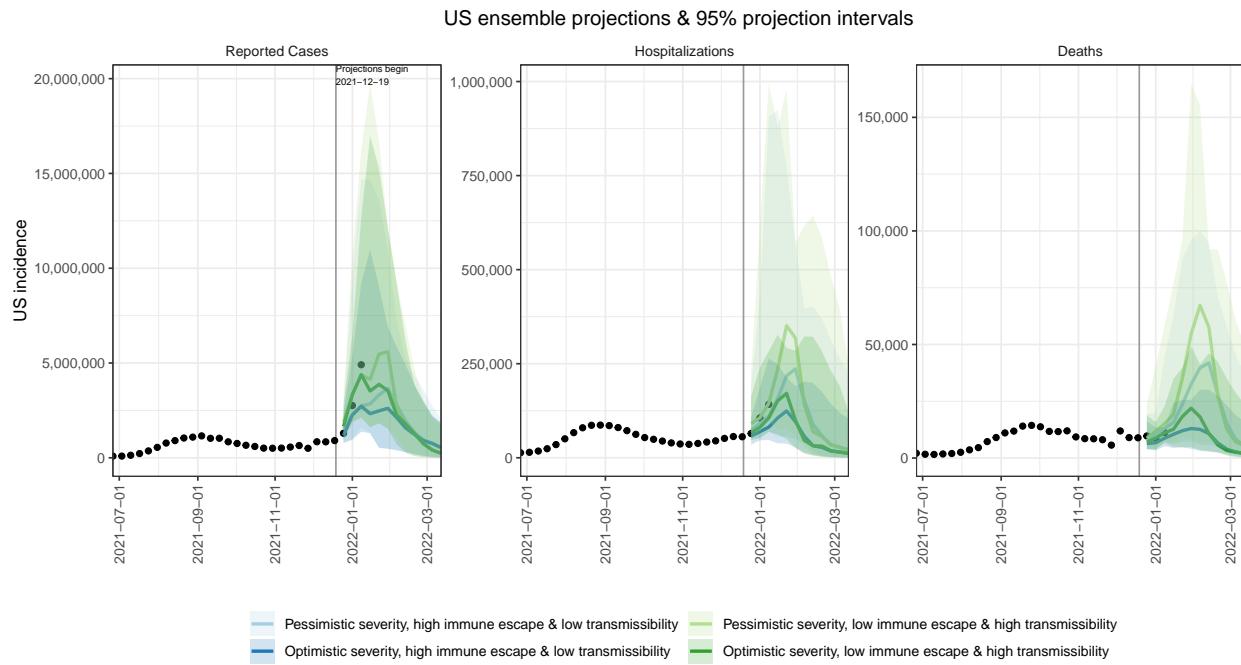
See detailed notes on each scenario below	Higher immune escape / Lower transmissibility increase <ul style="list-style-type: none"> Advantage Omicron over Delta in South Africa, Rt ratio: 2.8 Intrinsic transmissibility Omicron: 1x seasonally-adjusted R0 of Delta Immune escape: 80% of previously immune are susceptible to infection 	Lower immune escape / Higher transmissibility increase <ul style="list-style-type: none"> Advantage Omicron over Delta in South Africa, Rt ratio: 2.8 Intrinsic transmissibility Omicron: 1.66x seasonally-adjusted R0 of Delta* Immune escape: 50% of previously immune are susceptible to infection
Lower severity:	<p>Scenario A</p> <ul style="list-style-type: none"> Among naive individuals, 50% reduction in severity of Omicron infection, relative to Delta (all-age risk of hospitalization and death divided by two; age-specific risks at teams discretion). Among previously infected or vaccinated, residual protection for Omicron cases: <ul style="list-style-type: none"> Hospitalization: 85% [i.e., $\text{Pr}(\text{hosp} \text{any immunity}) = 0.15 * \text{Pr}(\text{hosp} \text{naive})$] Death: 95% [i.e., $\text{Pr}(\text{death} \text{any immunity}) = 0.05 * \text{Pr}(\text{death} \text{naive})$] 	Scenario B
Status quo severity:	<p>Scenario C</p> <ul style="list-style-type: none"> Among naive individuals, no change in severity of Omicron infection, relative to Delta Among previously infected or vaccinated, residual protection for Omicron cases: <ul style="list-style-type: none"> Hospitalization: 70% Death: 85% 	Scenario D

* Assuming Delta R0 = 6, Omicron R0 = 6 or R0 = 10

Figure 1: Round 11 Scenario Specifications

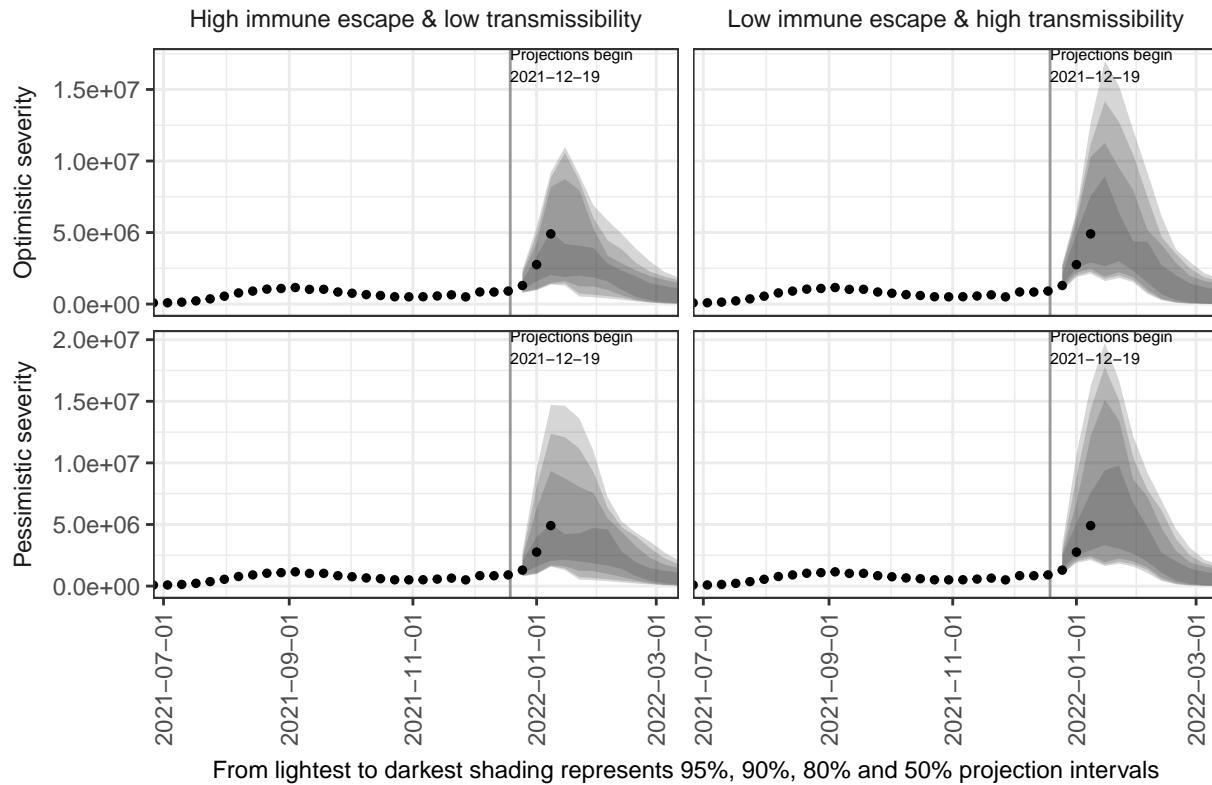
National ensemble projections

Ensemble projections for national cases, hospitalizations and deaths separated by scenario.

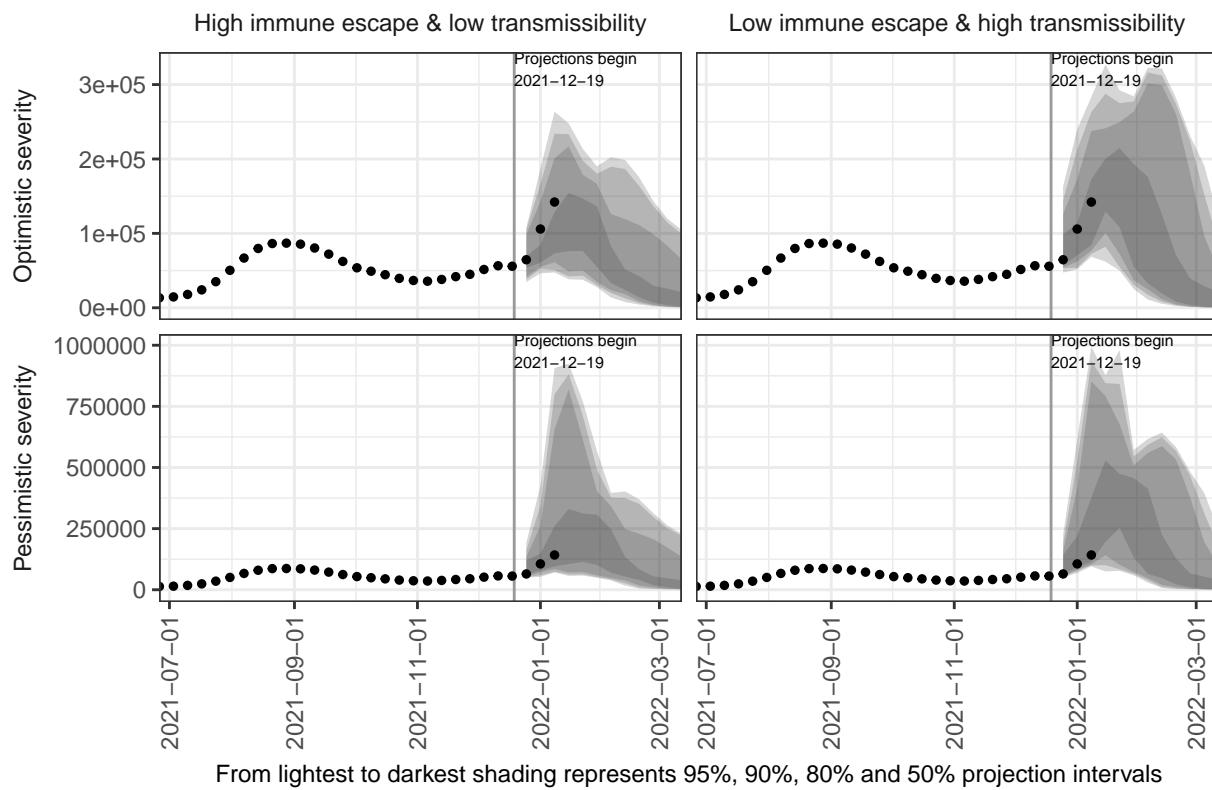


Ensemble projection intervals

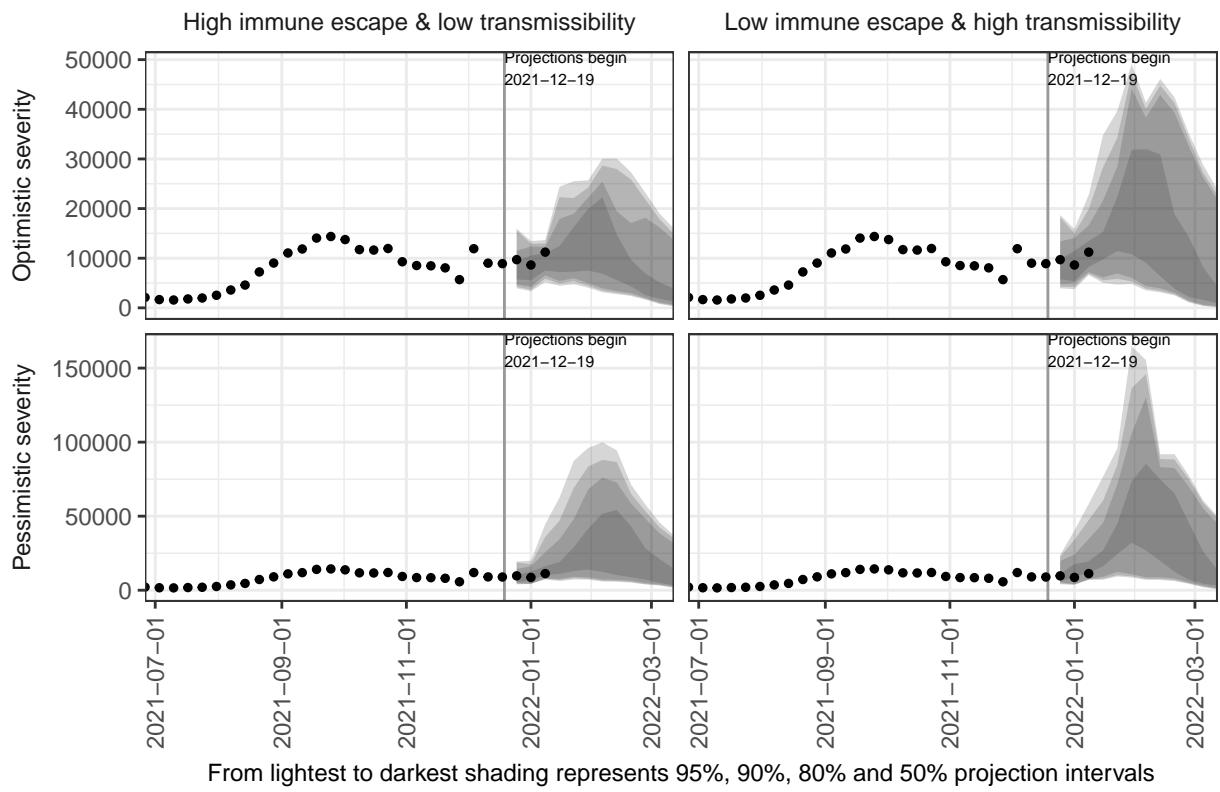
National ensemble projection intervals – Reported Cases



National ensemble projection intervals – Hospitalizations

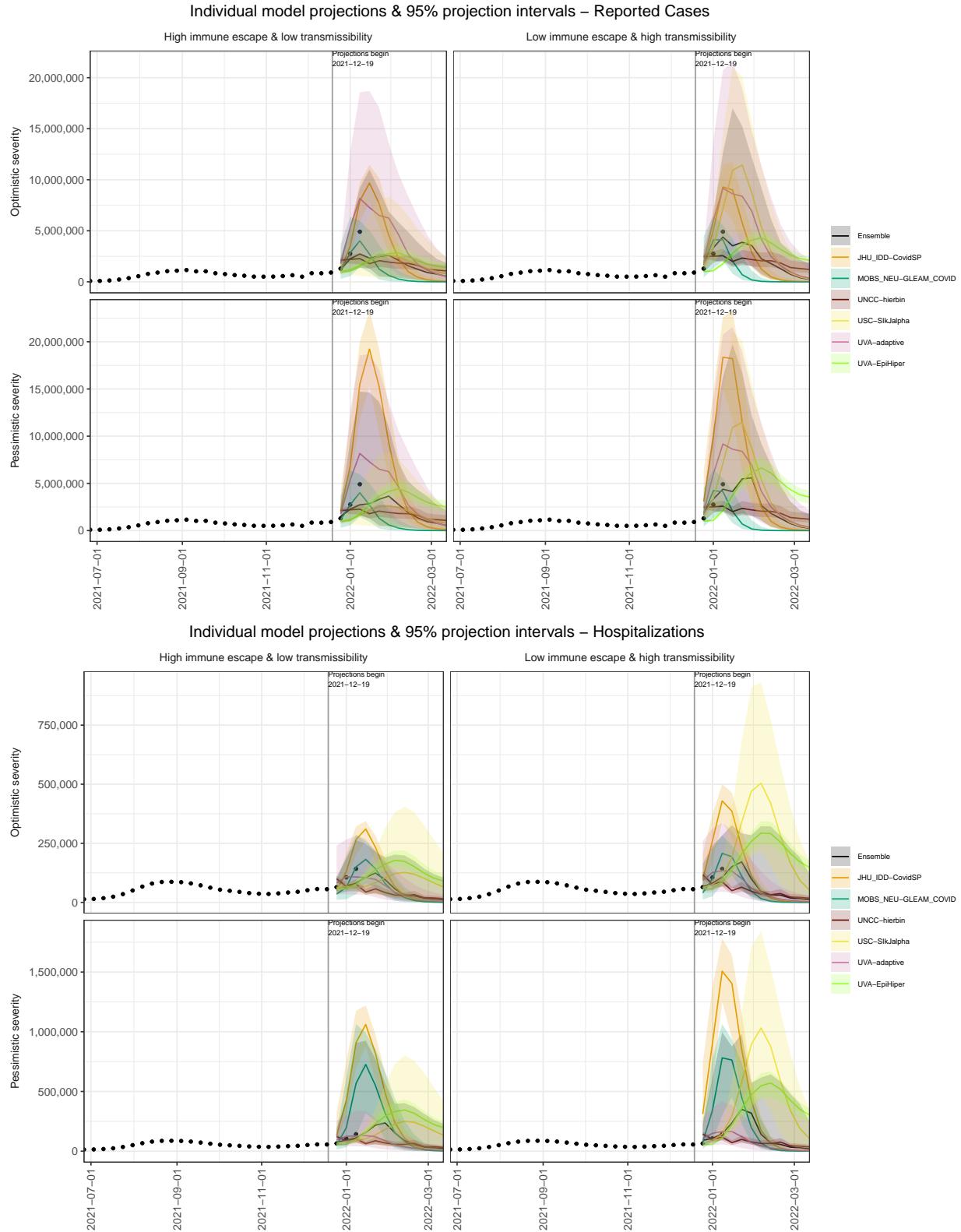


National ensemble projection intervals – Deaths

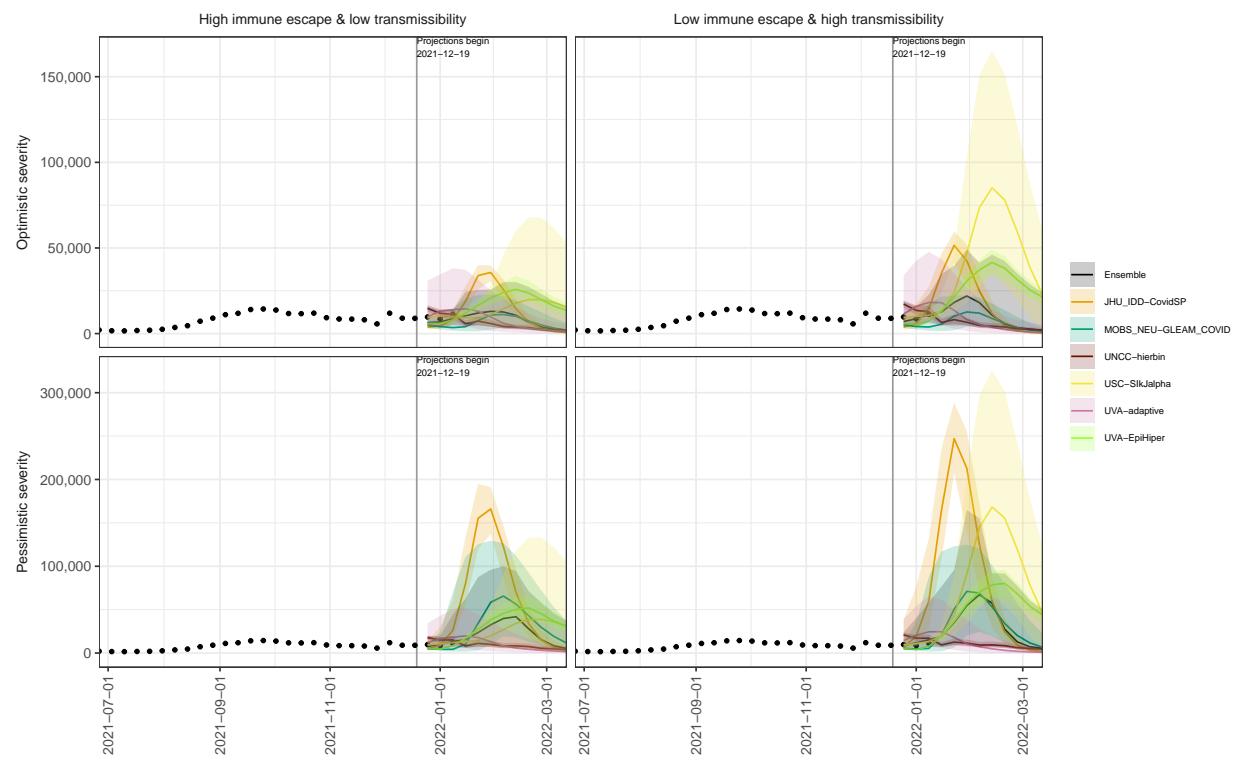


National individual model projections

Individual model projections and ensemble by scenario for national cases, hospitalizations, and deaths.

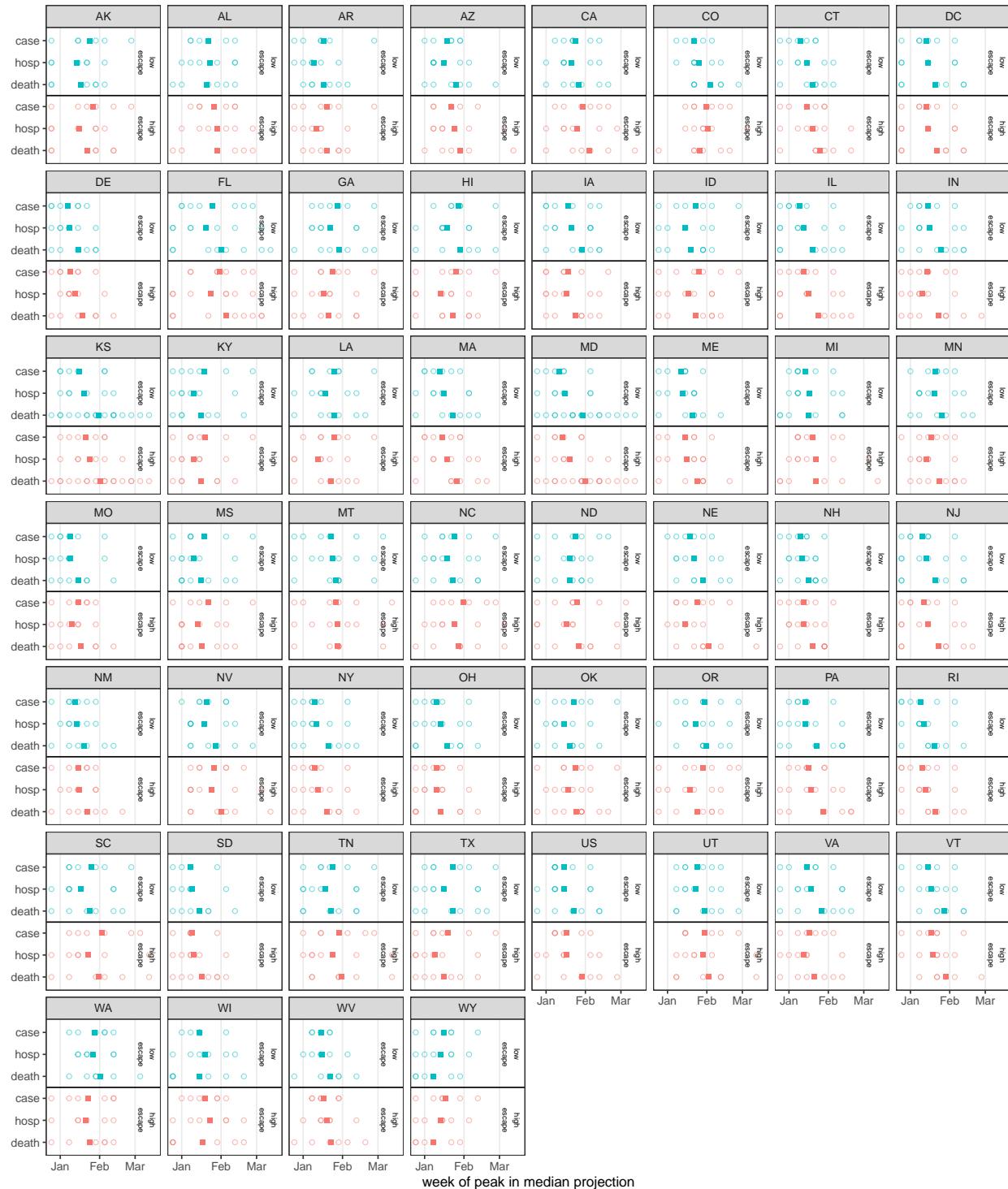


Individual model projections & 95% projection intervals – Deaths



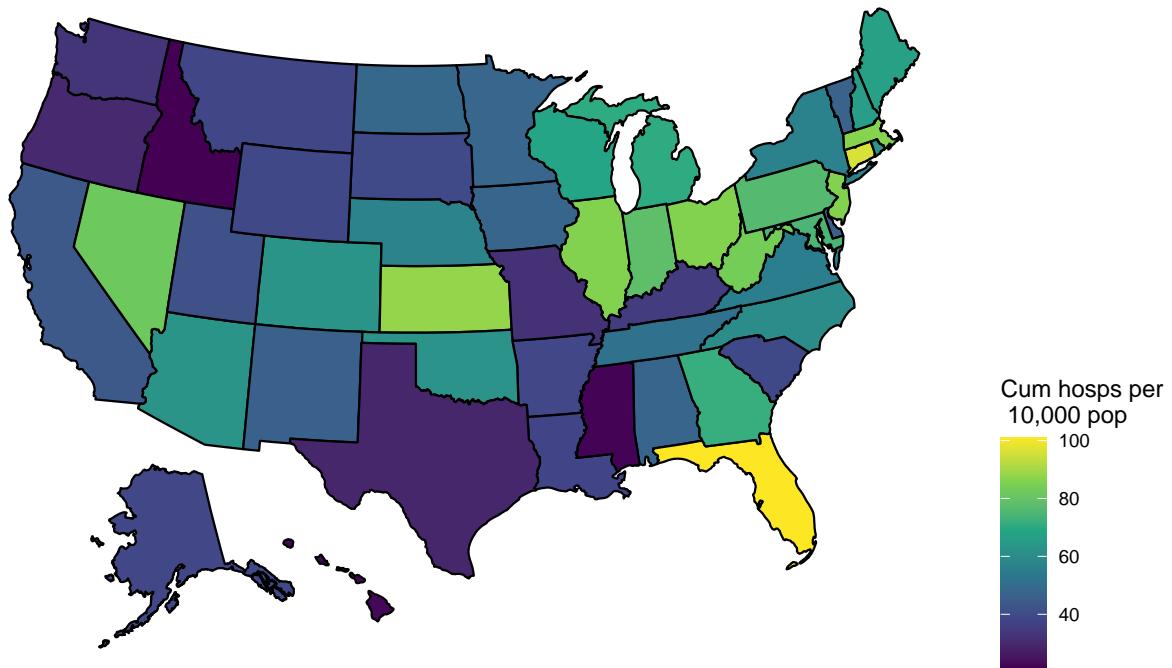
Peak timing

Circles are the dates at which each individual model's median projection peaks. The squares are the average of the peak dates across models. Data shown here is only for the optimistic severity scenarios, as severity is not expected to impact timing.

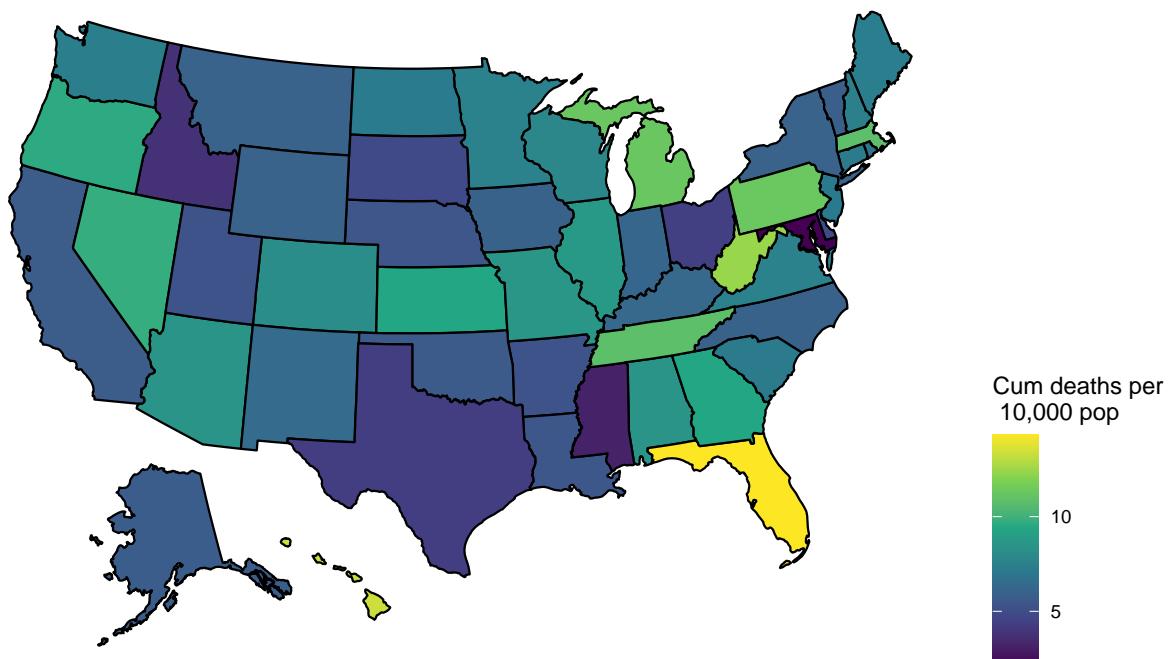


Risk maps

Cumulative reported hospitalizations per 10,000 population in scenario with pessimistic severity, and high immune escape & low transmissibility: December 19, 2021 to March 12, 2022

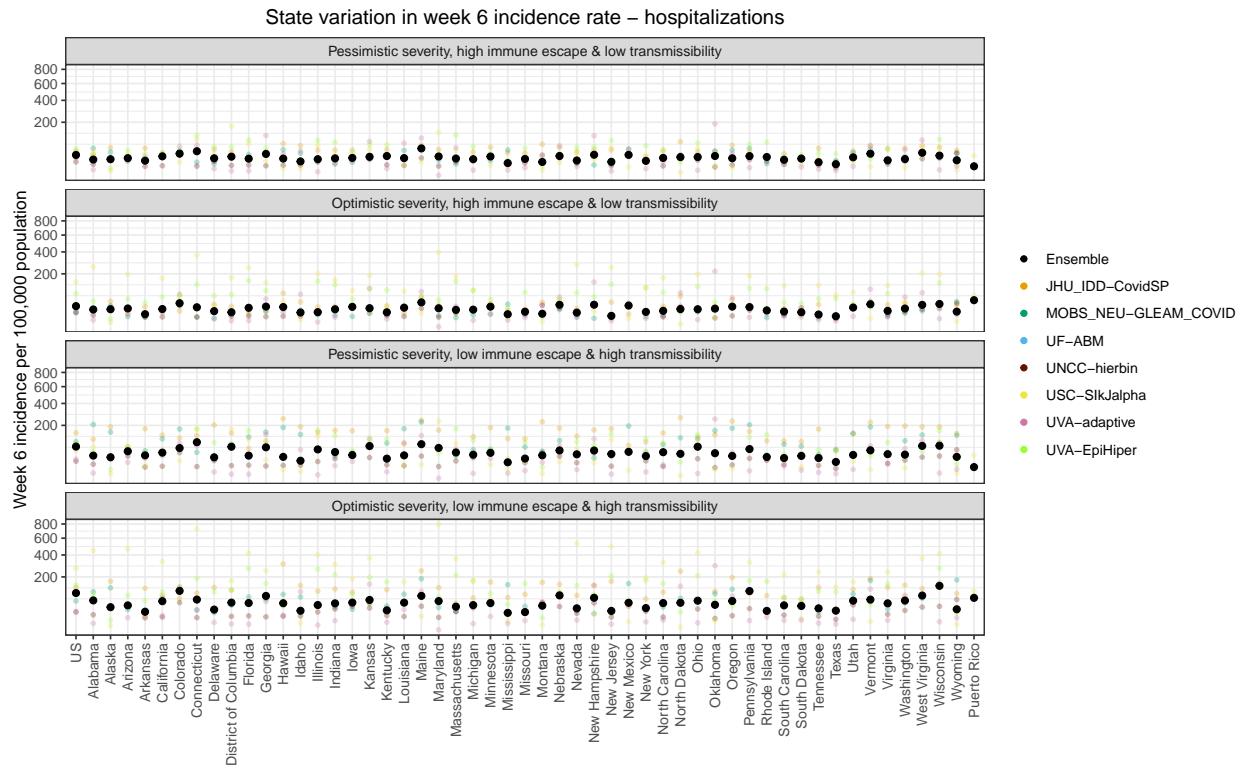


Cumulative deaths per 10,000 population in scenario with pessimistic severity, and high immune escape & low transmissibility: December 19, 2021 to March 12, 2022

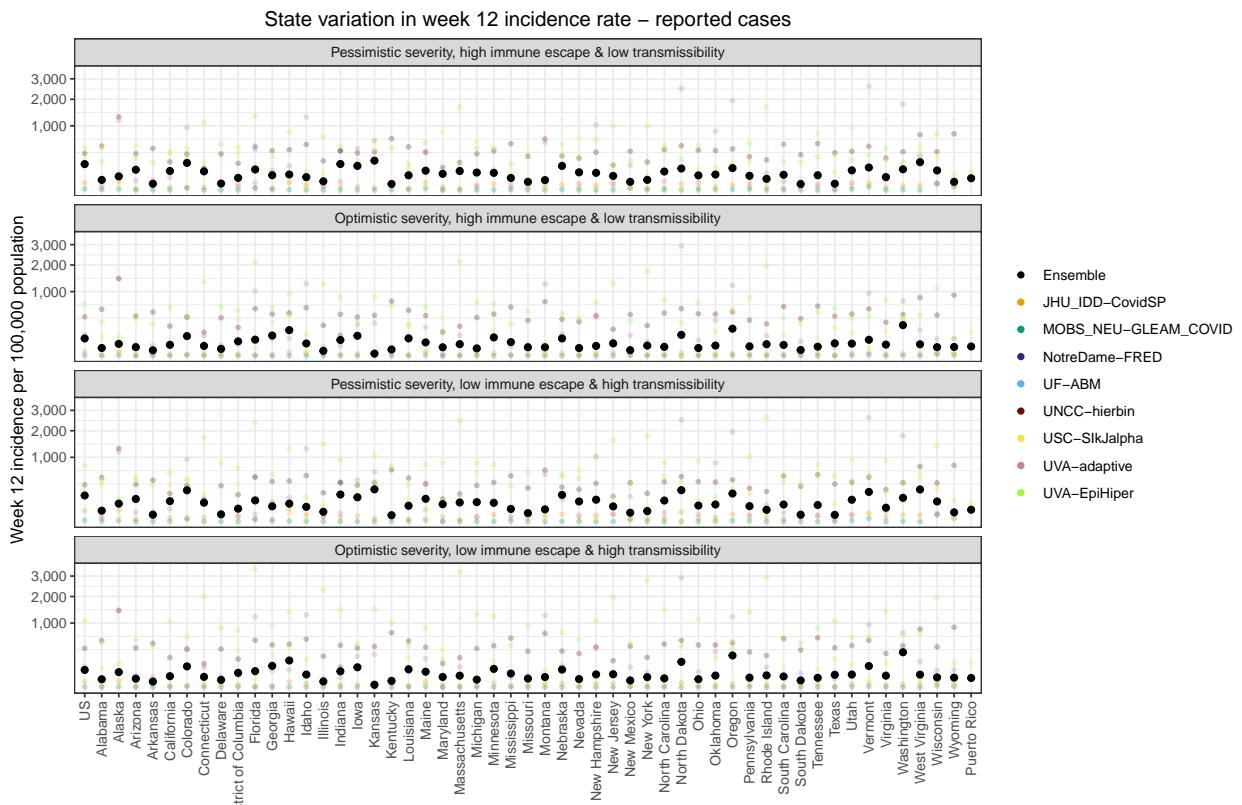


State-level deviation from national

Individual model and ensembles projections for state-level hospitalization incidence per 100,000 population at week 6.



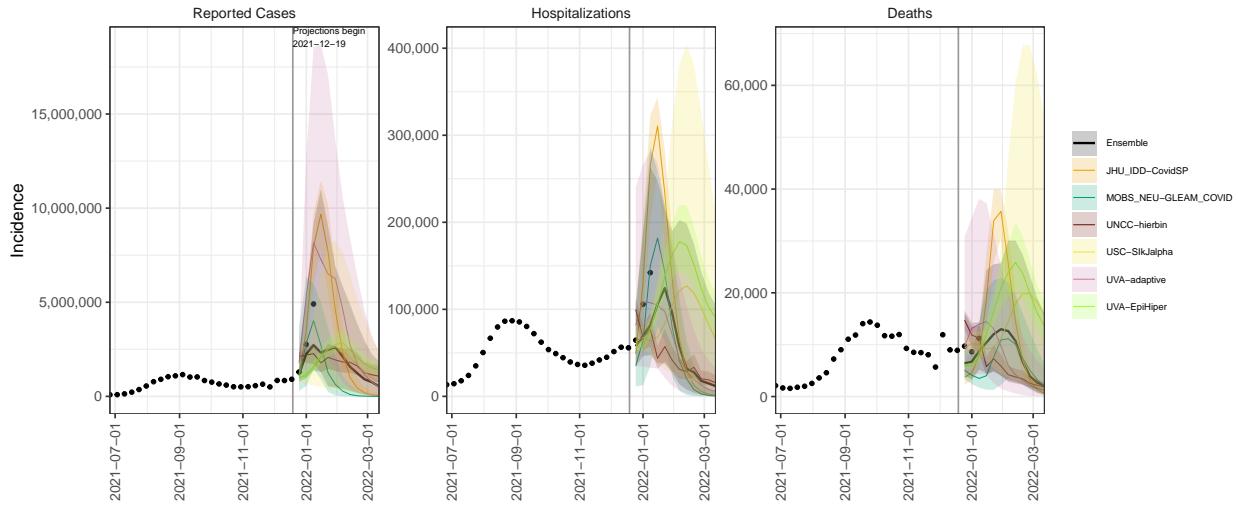
Individual model and ensembles projections for state-level incidence per 100,000 population at week 12.



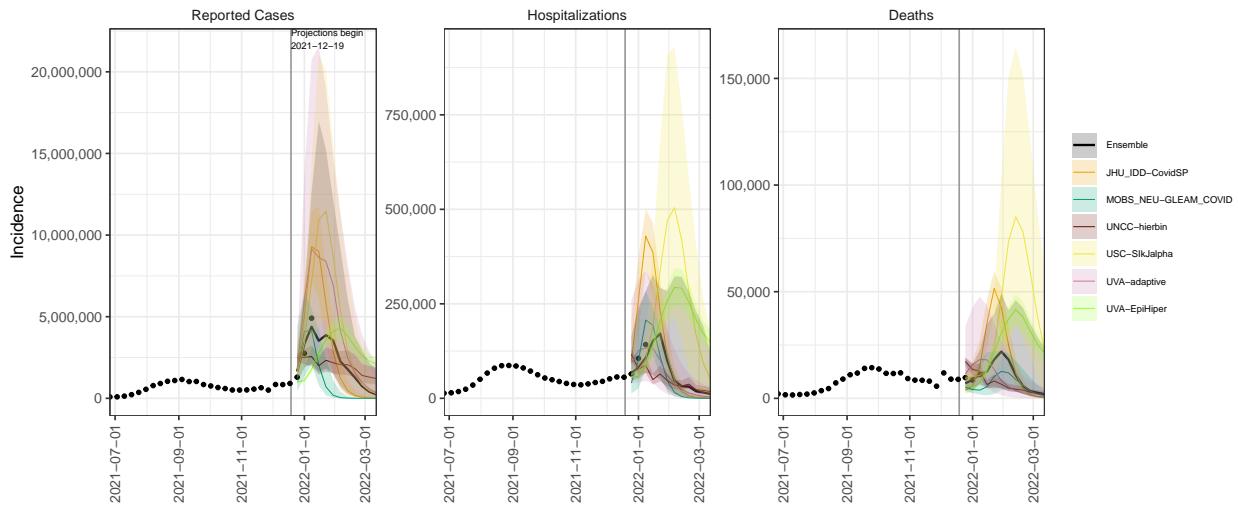
National model variation

Individual model projections for national incident cases, hospitalizations and deaths.

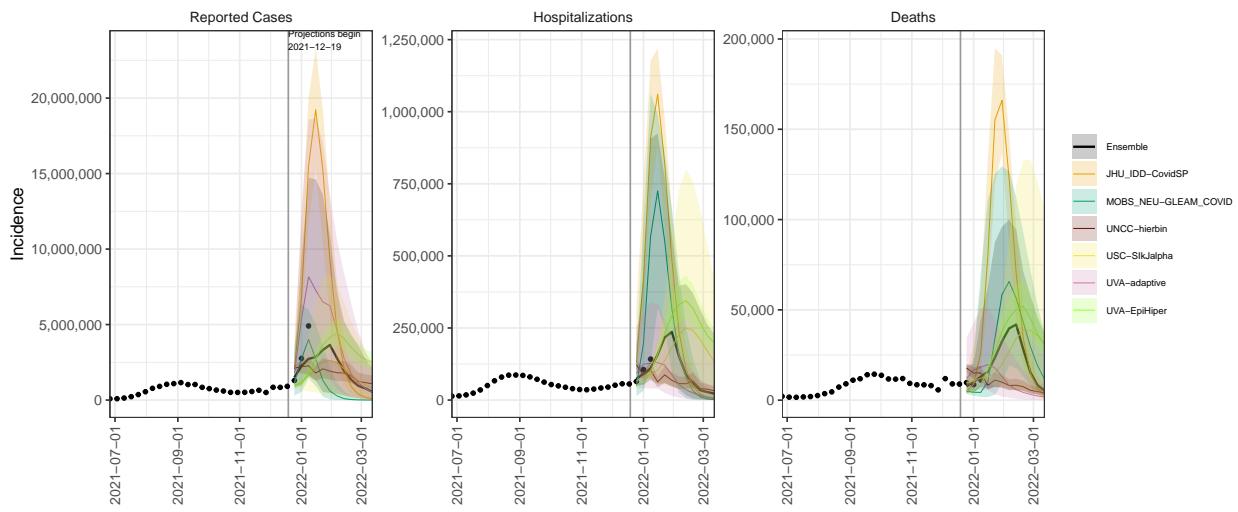
Individual model projections & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



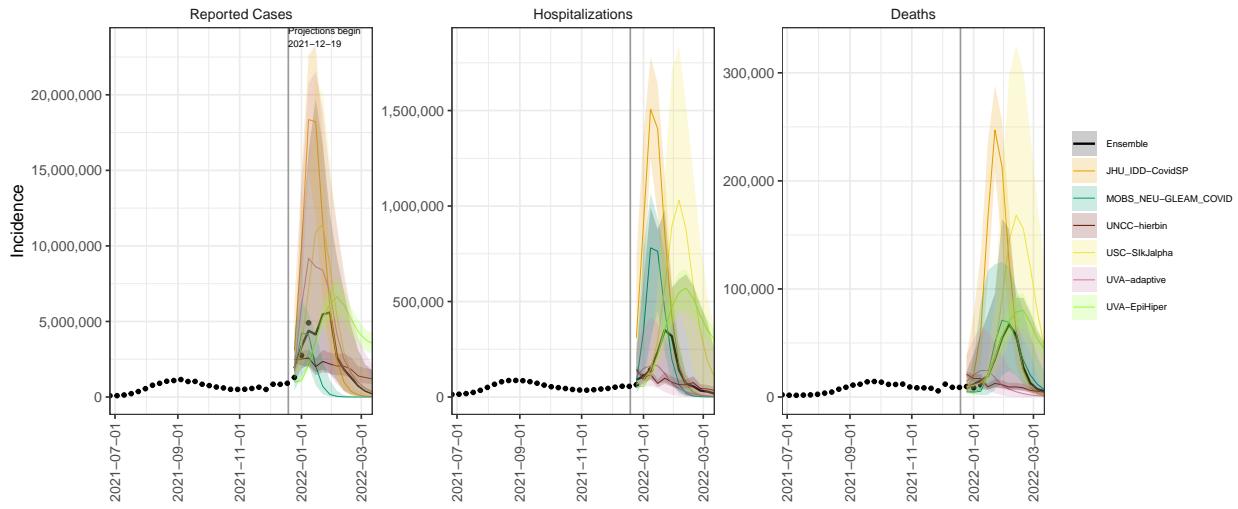
Individual model projections & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



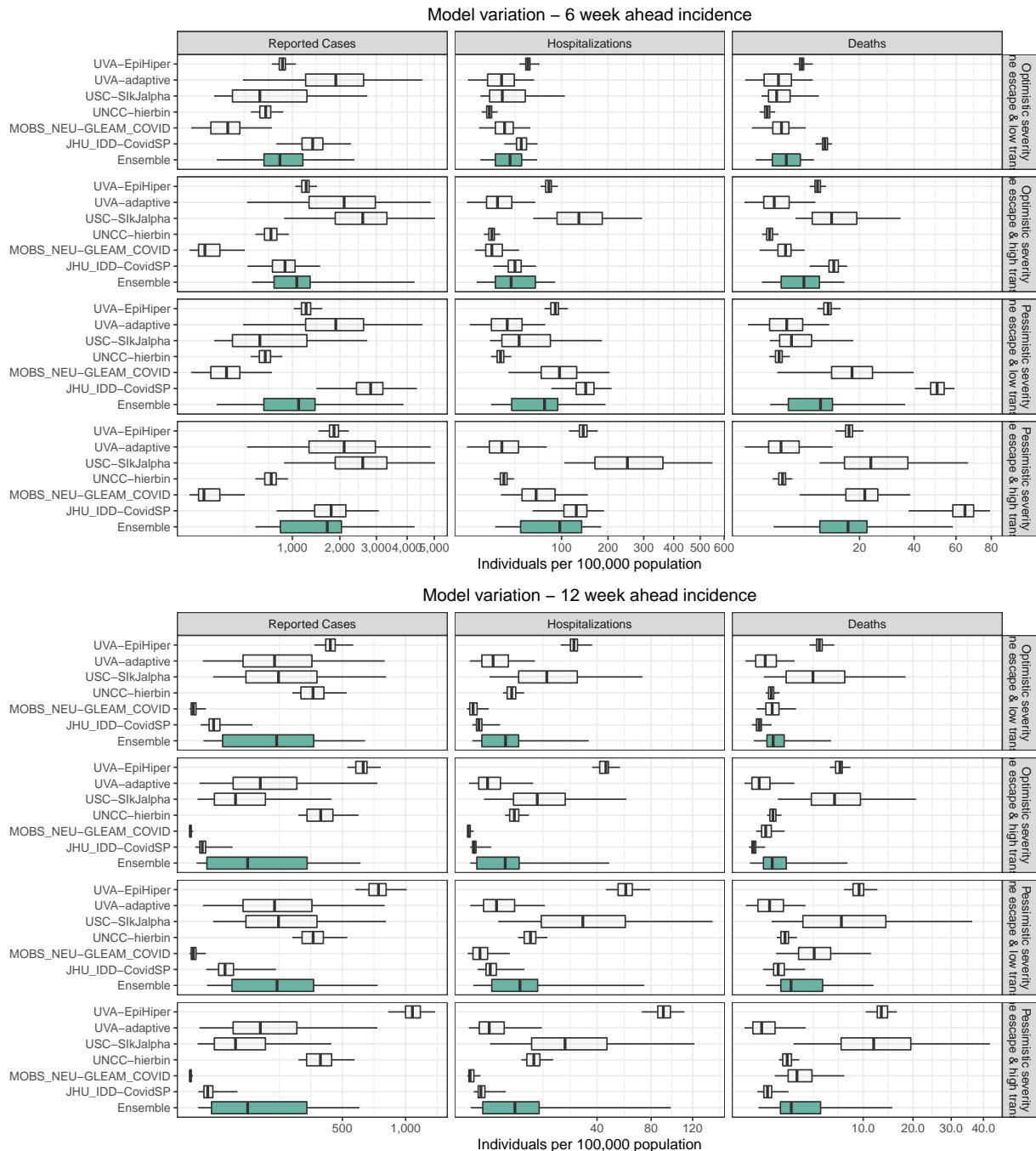
Individual model projections & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



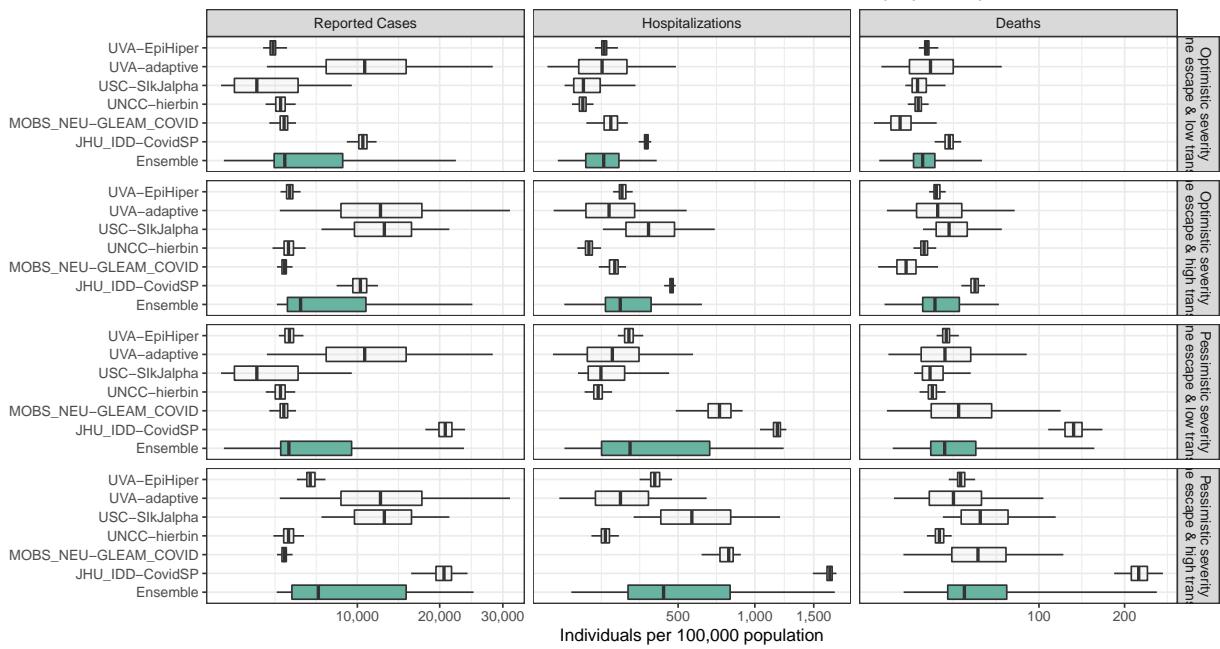
Individual model projections & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



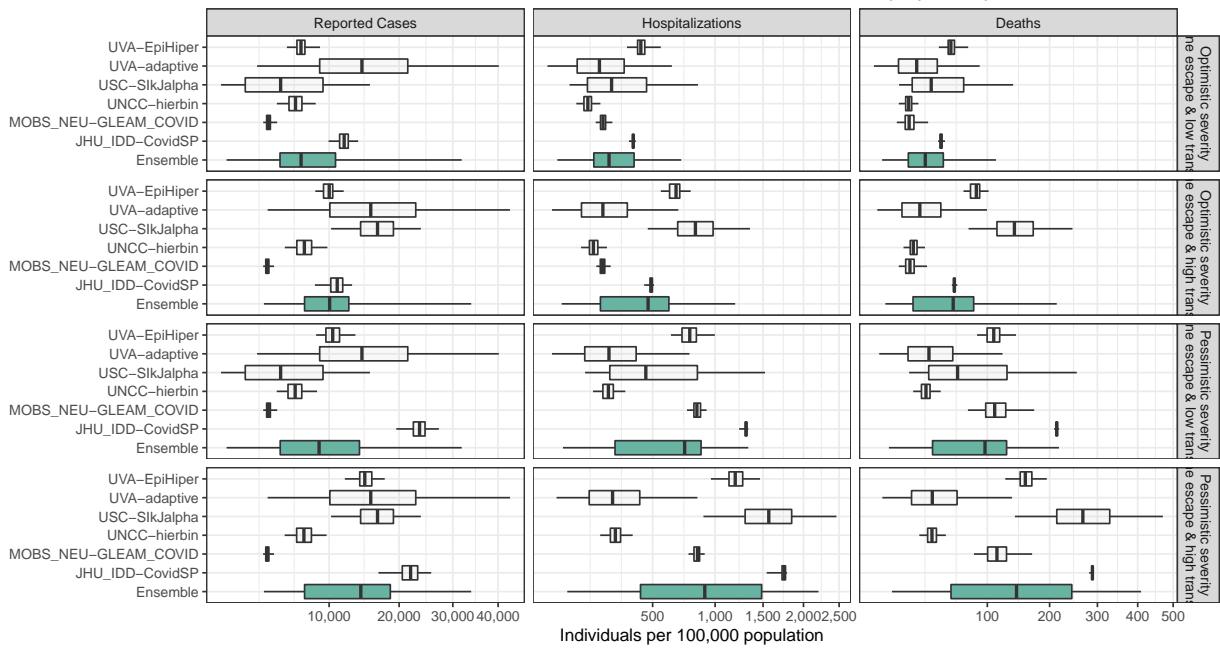
Projection distributions



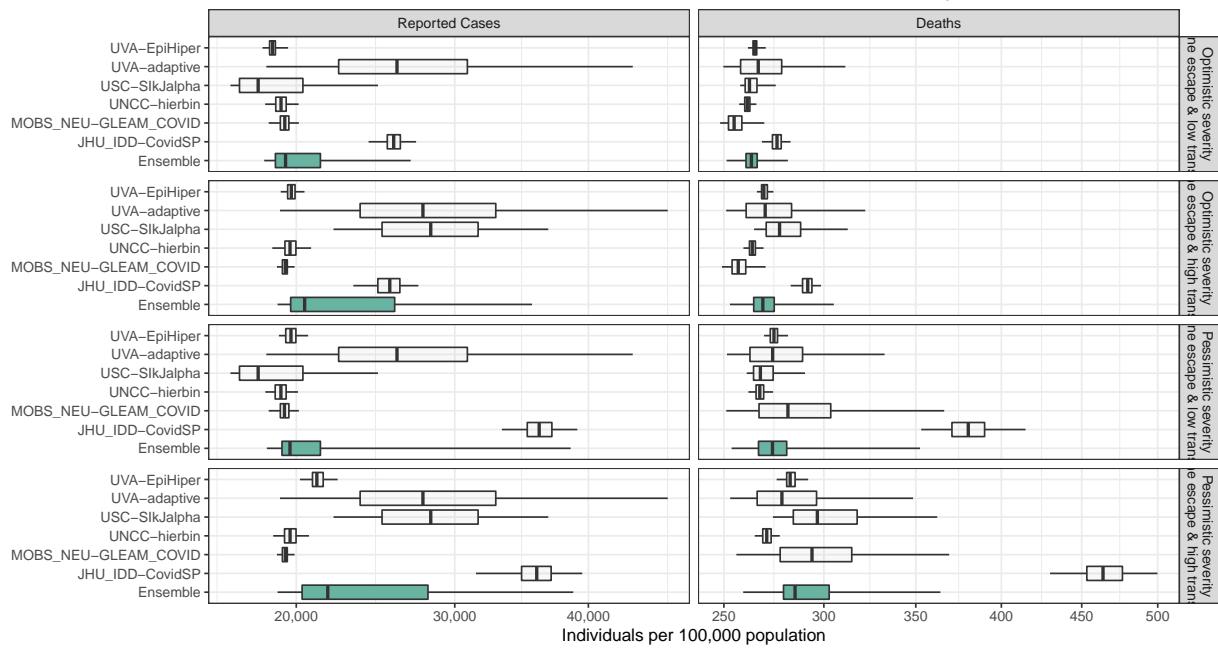
Model variation – 6 week ahead cumulative incidence over projection period



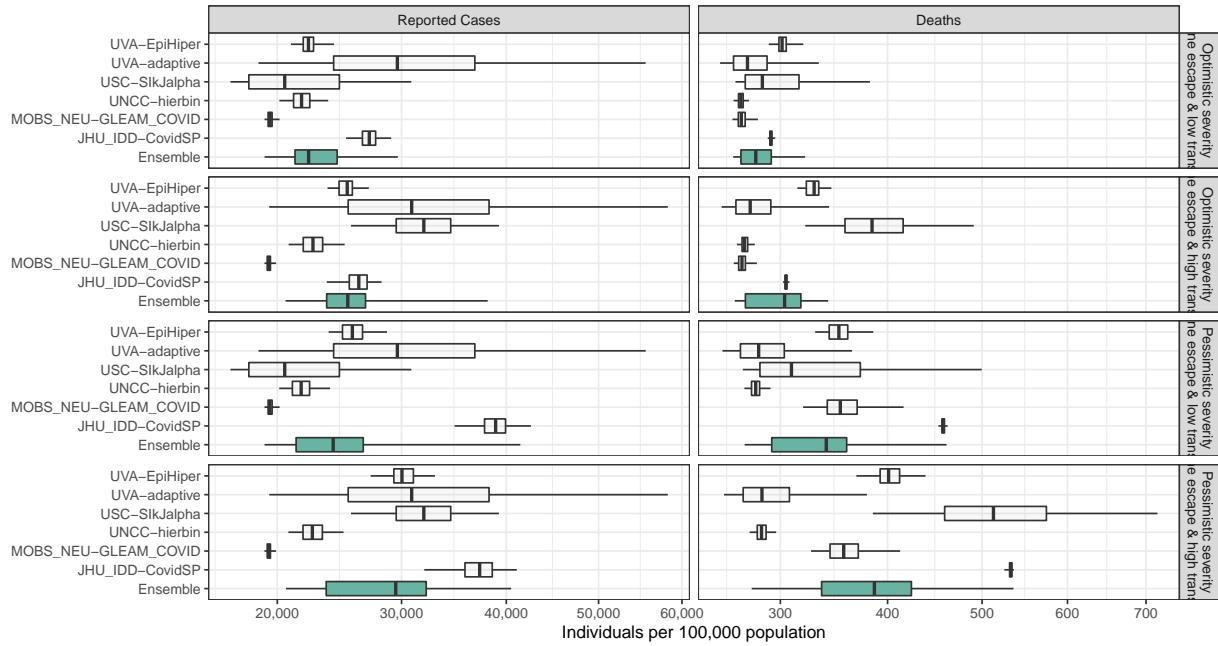
Model variation – 12 week ahead cumulative incidence over projection period



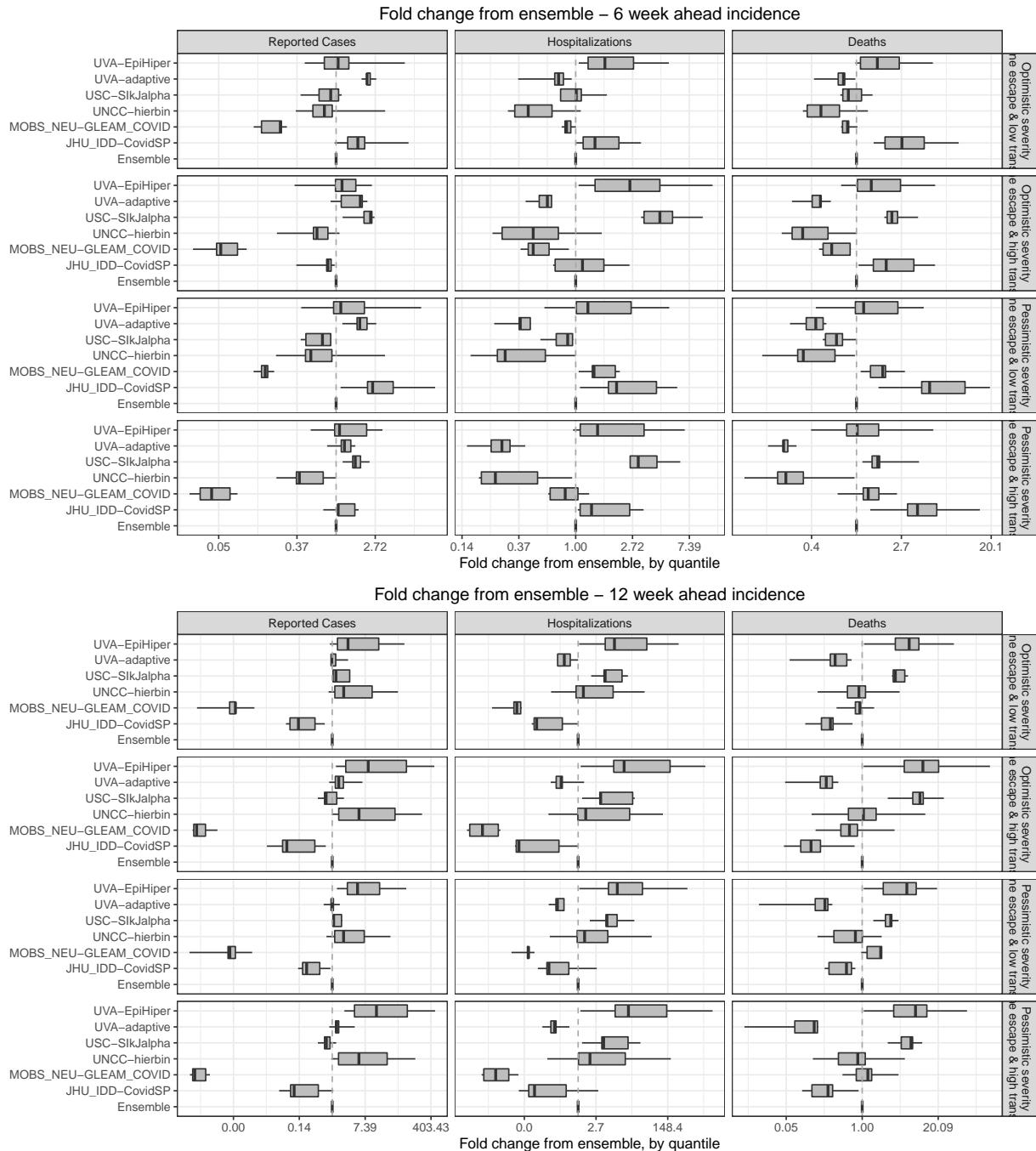
Model variation – 6 week ahead cumulative incidence over entire pandemic



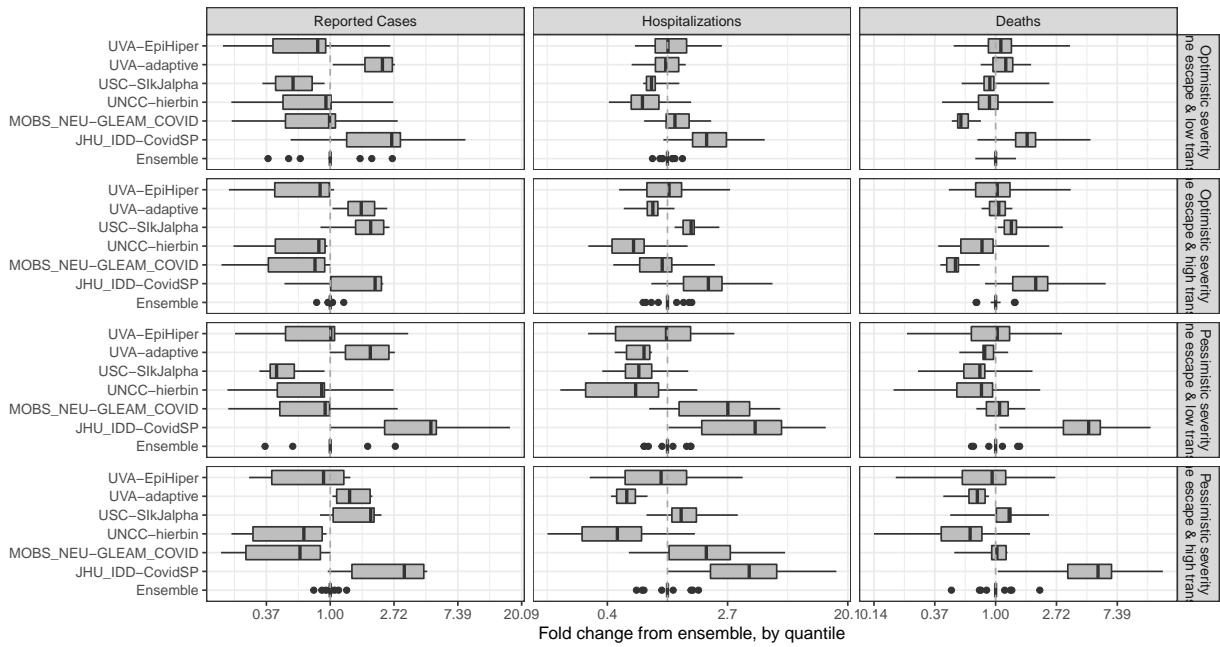
Model variation – 12 week ahead cumulative incidence over entire pandemic



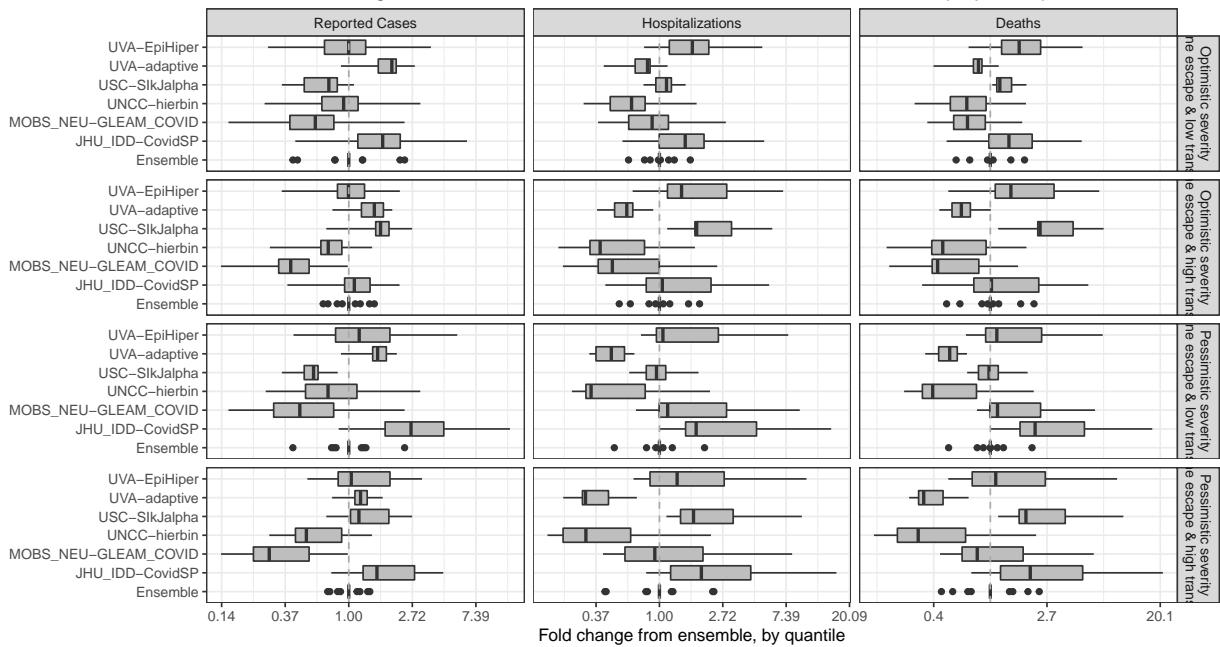
Difference between model and ensemble distributions



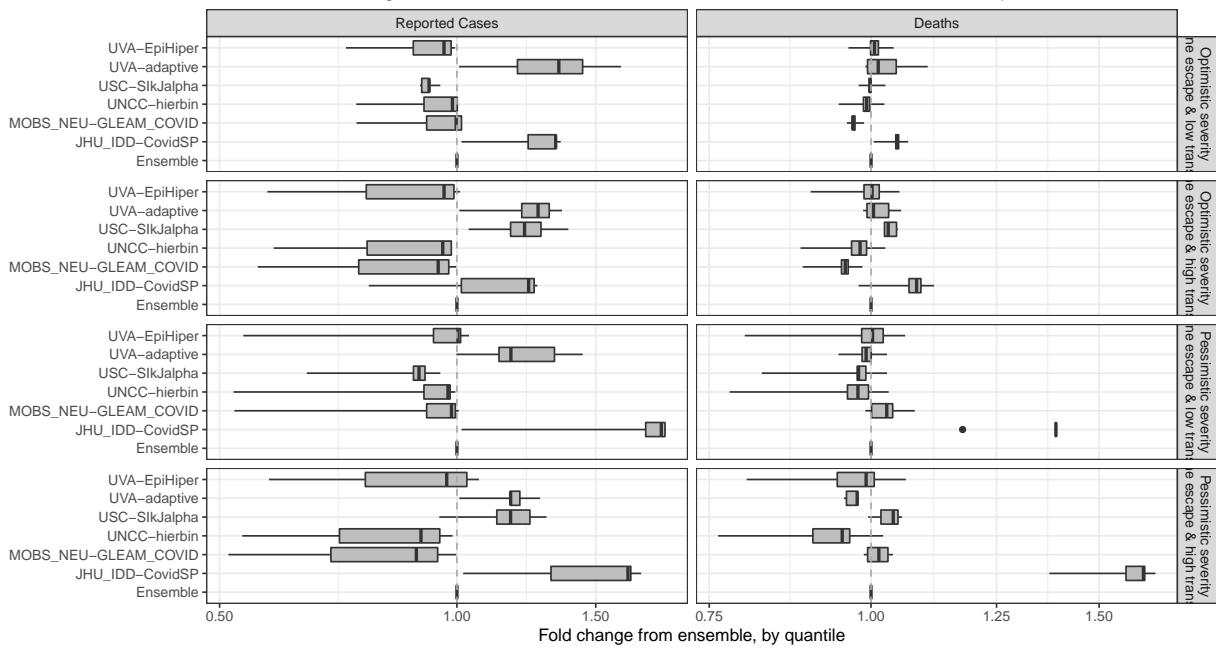
Fold change from ensemble – 6 week ahead cumulative incidence over projection period



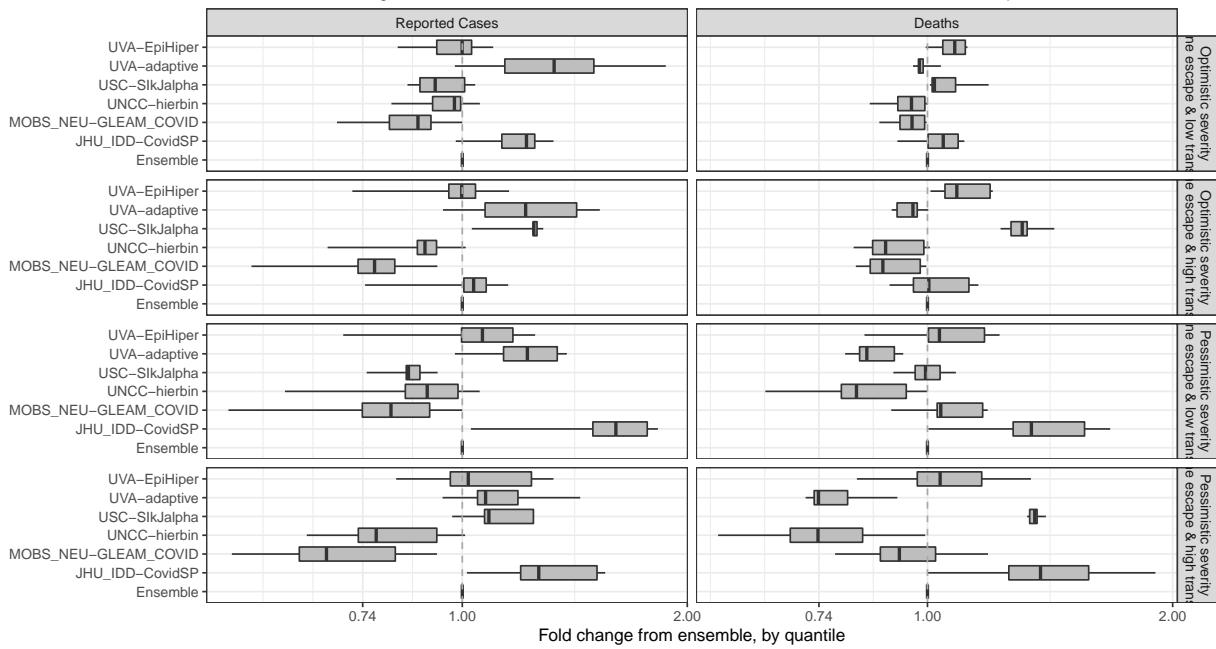
Fold change from ensemble – 12 week ahead cumulative incidence over projection period



Fold change from ensemble – 6 week ahead cumulative incidence over entire pandemic



Fold change from ensemble – 12 week ahead cumulative incidence over entire pandemic



Model Abstracts

Johns Hopkins ID Dynamics COVID-19 Working Group — COVID Scenario Pipeline

Introduction: As part of the eleventh round of scenario projections from the COVID-19 Scenario Modeling Hub in the United States, the Johns Hopkins Infectious Disease Dynamics (JHU-IDD) team produced six-month projections according to a set of four scenarios definitions. Under these scenarios, designed to capture the uncertainty in both the transmissibility/immune escape tradeoff and severity of the newly emerged Omicron variant, the JHU-IDD team estimates there will be a substantial wave of COVID-19 cases, hospitalizations, and deaths in all scenarios.

Methods: The JHU-IDD model refits the entire pandemic in every state across the US for each round of scenarios, fitting to overall deaths and variant-specific case data, estimated by multiplying the state-specific proportion of circulating wild-type, Alpha, and Delta variant by the reported number of cases by state. The model is a meta-population compartmental model fit through a Markov process, whereby 300 “slots” (similar to a Markov chain) simulate the pandemic over 100-300 iterations, sampling across a set of model parameter, accepting and rejecting the set of parameter values according to a Poisson distribution for both cases and deaths. This model is multi-strain and age-stratified (0-17, 18-64, 65+ years).

Intrinsic transmissibility is defined through a global R₀, specific to each major variant, including wild type (R₀=2.3), Alpha (R₀=3.45), Delta (5.52), and Omicron (R₀=5.52 or 9.16). This gets adjusted up or down by state depending on the fitted local variance parameter. Seasonal terms for each month in each state are also fit and shared across years. Non-pharmaceutical interventions and behavior (NPIs) impact is also estimated within the model as changes in transmissibility during periods of time defined by changes in official or otherwise specific changes in control and behavior (including school year start and holiday periods). NPIs were assumed to be at the same level of effectiveness following New Years as they were estimated to be prior to the Thanksgiving holiday.

Vaccination is incorporated into the model using state-specific, reported vaccination rate by age group. Vaccination is assumed to saturation at either a level estimated by surveys from the US Census Bureau, adjusted for sampling bias, or at asymptotic fits to current data curves, whichever is lower. Booster uptake was assumed to saturate at 70% of the saturation coverage limits of dose 2 for each age group. Immunity from both vaccination and infection is assumed to wane by six months on average, waning to VEs of 0.55, 0.60, 0.87, and 0.90 against infection, symptoms, hospitalization, and death. Reductions in immunity assumed by scenarios regarding immune escape are applied on top of VE and waning. No changes in health care capacities or quality, or reactive interventions were included in these scenarios.

Results: In all scenarios we observe a rapid rise of cases, hospitalizations, and deaths following the rapid introduction and takeover of the Omicron variant. Cases are projected to peak during the first two weeks of January 2022, along with hospitalizations; deaths peak are in the latter half of January. Similar to the rapid rise, we observe a rapid peaking and then declining of cases. Cases peak near 9 million weekly for scenarios A and B and 18 million weekly for C and D. No major heterogeneity is observed per population by state. However relative to previous case levels, substantial variation is observed, with states with the lowest previous burden experiencing the highest relative impacts.

Discussion: With the emergence of the Omicron variant and rapid spread globally, much uncertainty has remained regarding its immune escape, transmissibility, and severity. To bound this uncertainty in order to estimate the potential impact in the US, the COVID-19 Scenario Modeling Hub has bounded these parameters in four scenarios. The projection from our model under the assumptions of these scenarios demonstrate substantial and rapid impact from the emergence of the Omicron variant in the US. In all scenarios and in all states, cases are expected to exceed all previous waves, resulting from the high transmissibility coupled with high levels of immune escape in all scenarios. Hospitalizations and deaths are expected to be substantially higher than previous waves overall, though varying by state, resembling hospitalizations and deaths during the winter 2020 wave in states with high previous burdens of disease. Scenarios with high severity are expected to now be unlikely given recent findings.

Conclusion: The Omicron variant is likely to produce substantial transmission, resulting in a major wave

of cases, hospitalizations, and deaths across the US. While these scenarios may not be correct, they present a picture of how this situation is likely to unfold. While control measures, behavior change, and likely higher residual protection than was assumed in these scenarios are all likely to decrease or at least delay what these scenarios project, the impact of Omicron is expected to be substantial.

Northeastern University MOBS Lab — GLEAM COVID

Summary: In all scenarios we project a very quick growth of cases, overshadowing any growth we have seen in past waves. The projected number of infections is likely to overwhelm the testing systems. Projections for deaths are strongly dependent on the specific scenario, ranging from 60% of the delta wave to almost 4 times the January 2021 peak. Hospitalizations numbers ranges from number comparable to the January 2021 peak to a factor 4 to 5 larger in the most pessimistic scenarios. This points out to a likely increased pressure on Hospitals and the health care system. Latest data from the UK and other countries seems to rule out the most pessimistic scenarios and we suggest a cautious approach in reporting those.

Methods: We use a multi-scale epidemic model to project scenarios concerning the impact on deaths and hospital admission of the Omicron SARS-CoV-2 variant in the USA. The model considers a multi-strain structure that has been expanded to account for the ancestral virus and the beta, delta, and omicron variants. We calibrate the model on the full evolution of the pandemic. This will also provide estimates of previously infected people, vaccinated, etc. individuals at the county level in the US. We consider seasonal forcing and, waning immunity for vaccinated and infected individuals. We consider a status quo scenario for the NPIs level and booster uptake informed by the dynamic of the previous vaccination uptake (one and two doses). The severity, and overall protection offered by the vaccines for severe and fatal evolution of the disease to omicron are according to the SMH scenario directions. We do not assume any degradation in the quality of care.

Results: We observe a very fast rise of cases with the wave reaching its peak in all scenarios close to mid-January. The peak for hospitalization and deaths is shifted according to the disease natural history delay and the deaths reporting delay. Heterogeneity across states is observed although the general conclusions concerning the fast-growing number of cases and increased pressure on the health care systems are holding across all jurisdictions.

Discussion: The scenarios are meant to bound from above and below possible instances of the Omicron surge. Results are consistent on timing and number of cases, however the overall impact on hospitals and deaths is varying considerably according to the severity and vaccines protection to severe disease manifestations estimates. Data gathered recently indicates that scenarios D & C may be overly pessimistic because of the lack of any severity reduction. Scenarios A & B are more aligned with recent evidence but we think that a lower bound to the possible outcome of the Omicron's surge should consider more optimistic severity reduction and hospitalization protection from fully immunized individuals.

Conclusion: Models projects a very rapid surge of Omicron cases with a peak likely in the month of January. Refined scenarios are necessary to provide a more realistic envelope for the impact on the health care systems and the fatality that we will observe in future weeks.

University of Florida - ABM

Summary of results

- Using an agent-based model with demographics, vaccination coverage, and pandemic history for the state of Florida, we projected the cases, hospitalizations, and deaths caused by the SARS-CoV-2 omicron variant.
- Our model ranks the proposed scenarios, from most to least optimistic, in the following order: A, C, B, D. This ranking held for all outcomes (reported cases, hospitalizations, and deaths), as well as for infections (not reported).

- In terms of reported cases, Scenarios A and C (immune escape = 0.8, transmissibility = 1x delta) had roughly similar outcomes, with an omicron wave predicted to be milder than delta; and scenarios B and D (immune escape = 0.5, transmissibility = 1.66 x delta) had roughly similar outcomes, with an omicron wave predicted to be more severe than delta.
- Only Scenario D resulted in more deaths due to omicron than occurred due to delta.

Explanation of observed dynamics given model assumptions

- One important assumption in our model is that fully vaccinated individuals are less infectious compared to partially vaccinated and unvaccinated individuals. Given that approximately 60% of the population is fully vaccinated prior to the omicron wave, those with breakthrough omicron infections will experience less onward transmission. Thus, in scenarios A and C, given a higher immune escape assumption but lower overall transmission advantage, even though many breakthrough omicron infections may occur, these will result in fewer secondary infections than in infections in unvaccinated people, partially explaining the more optimistic projections for these scenarios.

How did you identify the initial distribution of susceptibility?

- Initial distribution of susceptibility is constant across all replicates up until December 1, 2021, when we assume omicron first started to be introduced to the state. We explicitly model all previous waves of the pandemic, and a vaccine-roll out based on what has occurred in Florida (i.e., health care workers first, followed age-eligibility changes as they occurred in the state).

How did you model waning immunity during the projection period and if so how?

- In past-work, we determined that assuming leaky immunity and changes in VOC transmissibility and immune escape ability were better at predicting apparent loss of vaccine protection than immunity that intrinsically wanes. Our model therefore does not assume intrinsic waning of immunity from prior infection or vaccination. Our assumptions result in estimated vaccine direct effectiveness against infection that is ~0.8 early in 2021, down to ~0.2 against delta and ~0.1 against omicron.

How did you specify seasonality?

- Seasonality is modeled using a sine model with a 6 month period, with transmission probability peaking in July and January.

How did you implement NPIs?

- Closure of non-essential businesses and schools occur in our model early in the pandemic, but not during the omicron wave.
- Individuals in the model have time-varying personal-protective behaviors, namely avoiding social contacts and high-risk businesses like bars and restaurants.

What were your baseline conditions for Delta prevalence?

- We assume that when omicron is first introduced in our model (December 1, 2021), infections are very low, but all are caused by delta. This is consistent with Florida data.

What were your assumptions of changing severity with variants?

- We interpret severity as the probability that a symptomatic infection will result in a severe (i.e., hospitalizable) infection. We assume alpha severity is similar to wildtype infections, whereas delta severity is 2.5x higher. Omicron severity was defined relative to delta, according to the specified scenarios.

University of North Carolina at Charlotte - UNCC-hierbin

Summary of results: We observed a sharp increase in reported cases, hospitalization, and death since week 1 of simulation, regardless of scenario. There are about 200k cases per day for almost a month before decreasing.

Methods: How much of the pandemic data was fit, and what this means for estimates of R₀. We used data from June 2021 when the Delta variant became dominant in the U.S. This would also help fit the asymptotic curve without interfering with the original variant. We did not estimate R₀. We used what was provided (1.66x higher transmissibility, assuming the same recovery rate).

Determining the distribution of susceptibility: We used what was provided in the scenario guideline (rates of breakthrough), and current prevalence to estimate potential susceptible population.

Waning immunity: Waning immunity was not modeled explicitly in this round. However, breakthrough infections were considered as a form of “waning” or “leaking”.

Implementation of seasonality: Seasonality was adjusted from 2020-2021 data as the baseline scenario.

Implementation of NPIs: Not modeled explicitly in this round.

Baseline conditions for Delta prevalence: 20-50% depending on state, but this probably needs to be re-calibrated.

Assumptions about vaccine/booster uptake during the projection period: Same as current vaccine/booster uptake rate, modeled implicitly.

Assumptions of changing severity and other differences between Omicron and prior variants: We used what was provided in the scenario guideline (same severity or 50% reduction in severity).

Assumptions about any decline in quality of care offered as public health systems reach capacity: Not modeled explicitly in this round.

Results: Observed timing and magnitude of peak cases, hospitalizations, deaths at national level, >1.4M cases per week for almost 4 weeks since the beginning of simulation. Case number drops down slightly before rebouncing again in mid-February. Similar patterns were observed for hospitalization and death, though more heterogeneity than cases.

Notable points of state-level heterogeneity: Most states follow similar patterns as national level, but quite a few states may have later surges in cases.

Discussion: Explanation of results in light of model assumptions. See below. Also the model used a mixture (weighted average) of short-term prediction (using 30d data) and long-term prediction (using >150d data).

If a peak was not observed, which components of model explain this result?: The peak was more like a plateau in our model projection. The reason was the interaction between decline of originally projected cases and increased transmissibility of Omicron.

Conclusion: Omicron definitely increased cases similar to or even larger than Delta last year. Under optimistic conditions (reduced severity), Omicron seemed to have lesser impact on the healthcare system. However, precautions need to be taken because severity could change given the large number of mutations of Omicron.

University of Virginia — adaptive

Summary: Across all projected scenarios, we see a rapid rise in cases in the near term, that far exceed previous waves, and remain at these very elevated rates through the end of January. Due to large number of cases among those with some level of immunity, and the diminished severity of these infections, the spikes in hospitalizations and deaths are projected to be slightly lower to 30% higher across the scenarios. Our method tracks the levels of vaccination and infections across all previous variants and omicron at the state

level, thus enabling the temporal effects of waning of immunity specific to drive transmission dynamics. These projections are based on our best assessment of the current knowledge of a wide array of parameters with significant uncertainties; regardless of the specific numbers currently used, these projections signal a wave of unprecedented infections that will likely require a change to how we approach the management of the pandemic.

Methods:

Approach: At its core we use a metapopulation model framework with multiple tiers of immunity and multiple strains of infections. These can be represented as a matrix with the columns representing: no infection, infections from previous strains, infections from omicron; the rows representing the number of vaccinations from none to 3 doses. The populations of each state modeled, fall into these cells which affords this segment of the population different levels of protection against infection (and other outcomes). We fit the entire history of the pandemic (since Jan 23, 2020) for each state, using seroprevalence to estimate the case to infection ratios over time. Based on findings from previous rounds, we model waning immunity as constant rate from those who are recovered to freshly susceptible with an expected dwell time of 6 months. Projected transmission rates are assumed to remain constant based on the most recent fitted week's transmission rate.

External Effects: Seasonality is not internally modeled but rather is captured in the implementation of scenarios, however, given the emergence of the new variant and the already strong effects from holiday travel, we did not include seasonality in the projected scenarios for this round. Similarly, based on previous experience with the unpredictability of the implementation of and adherence to non-pharmaceutical interventions (NPIs) we don't explicitly model these changes and assume that the core transmissibility that has generated cases in the recent past remains constant into the future. While we know these rates will change in the future, however, the degree and timing of these changes are impossible to predict and thus are not captured in these projected scenarios. We've modelled the emergence of Omicron in these scenarios to be very rapid (0.32 growth rate), with prevalence of infection moving from 1% on Dec 12 to 99% on Jan 4th, reaching 50% on Dec 21st. Due to limited data on heterogeneities across states, this is assumed across all states. We model the uptake of vaccinations similarly to previous rounds, with the anticipated overall acceptance (~83%) being reached by the end of February. We assume booster coverage will achieve 40% of this anticipated total coverage over that time as well.

Outcomes: Severity of disease is estimated based on the pre-Omicron stage of the outbreak, thus using the previous month of case to hospitalization ratios as a baseline to then apply the specified outcome impact from omicron. This model does not capture the impact on healthcare delivery when capacities are reached nor any degradation in care that may arise from shortages of health care staff, equipment, or supplies.

Results: Our projected cases rise very rapidly from the Dec 18th, projection point reaching peak intensity in early January, but remaining at near peak levels through the month of January before receding. Hospitalizations are similar but lag by roughly a week as do deaths. We anticipate that case detection may diminish significantly as infections surge and testing capacities may get reached and test seeking behavior may alter as severity of symptoms may decrease, however, this effect is not captured in these models, thus the projected cases are likely in excess of what will be observed. Our state level results show a pattern where states in the northeast with high levels of vaccine coverage (2 doses) but with limited surges from Delta experience more extreme waves of infection. Due to the heterogeneity in transmission rates (related to severity of the previous wave of Delta and the delayed emergence of omicron) several states show very limited impact from this wave (eg Montana, Oregon, Louisiana), which is a result this is more related limitations on the projection assumptions used

Discussion: The emergence of Omicron and the likely huge surge of infections it will usher in, signifies another milestone in this pandemic, and will likely require a change to how we manage this pandemic. The significant number of infections among those with prior immunity (either from vaccine or natural infection) should not generate the same number of hospitalizations and deaths and thus signifies a shift in what a "confirmed" case means both for health and infection risks. A limitation in our model's projections is the sensitivity of the projection to recent levels of transmission which is assumed to remain constant into the future. In mid-December there are several states that are experiencing declines and thus very low levels of transmission, which may lead to a mis-estimated level of transmission from omicron. Despite these

limitations, the overall picture is of a rapid rise in transmission which may remain sustained for several weeks.

Conclusion: There is uncertainty in many of the parameters used in these projections as well as several assumptions that will impact the eventual accuracy of these projections, however, the key takeaway is that a rapid rise in infections due to Omicron is imminent. Even with diminished severity, this surge may have a significant impact on hospitalizations and deaths as the vulnerable segments of society that had avoided infection to date are finally infected by Omicron.

University of Virginia - EpiHiper

Summary of results: Significant difference between the best scenario (A) and the worst (D) with cases/hospitalizations/deaths doubled or even more.

Methods:

- How much of the pandemic data was fit, and what this means for estimates of R₀. We use data up to 2021-12-11 to initialize disease state of each individual. We use data up to 2021-12-18 to estimate R_effective right before the projection period. We do not explicitly estimate R₀.
- Determining the distribution of susceptibility. We initialize each individual of the population to one of (i) naively susceptible, (ii) vaccinated, (iii) recovered, (iv) partially susceptible, and (v) infected states, based on county level confirmed cases data. We use vaccine administration data to determine people vaccinated with different vaccines and divide them between (ii) and (iv). We estimate prior infections from cumulative cases and divide them between (iii) and (iv) based on waning. We estimate (v) (infected but not yet recovered) from recent confirmed cases. The rest of the population are set to (i).
- Whether or not waning immunity was modeled explicitly over the projection period and if so, what assumptions were made? We explicitly model waning immunity. The immune waning has an exponential distribution with mean of 0.5 year for the time to transition to a partially susceptible state; the age-specific protection on nodes in the partially susceptible state is as specified in the scenario description. The protection against infection is 60% (<65yo) or 40% (>=65yo); the protection against severe disease is 90% (<65yo) or 80% (>=65yo).
- Implementation of seasonality. N/A.
- Implementation of NPIs. We have modeled the following NPIs: (i) A fraction (15%) of the population chooses to reduce non-essential activities. (ii) All K-12 schools are closed during winter break; and face masks are used in school while schools are open. (iii) A fraction (75%) of symptomatic people choose to self-isolate themselves at home.
- Baseline conditions for Delta prevalence. We have about 65% infections being Delta at the beginning of the projection period.
- Assumptions about vaccine/booster uptake during the projection period. For each state, we determine an upper bound on vaccine uptake based on state level vaccine acceptable data; prior vaccinations based on vaccine administration data; and a vaccination schedule (age stratified) subject to the upper bound. Child vaccination (5-11yo) follows the specifications. Booster coverage is 50% of fully vaccinated.
- Assumptions of changing severity and other differences between Omicron and prior variants. We follow the scenario specifications.
- Assumptions about any decline in quality of care offered as public health systems reach capacity. We do not explicitly model PH system capacity.

Results: - Observed timing and magnitude of peak cases, hospitalizations, deaths. At national level, cases peak in early Feb. 2022 with about 3M (scenario A) to 6.5M (scenario D) cases weekly; hospitalizations peak in early-mid Feb. with about 170K (scenario A) to 560K (scenario D) hospitalizations weekly; deaths peak in mid-late Feb. with about 25K (scenario A) to over 75K (scenario D) deaths weekly. - Notable points of state-level heterogeneity. Cases peak in Feb. 2022 in most states, except for a few that peak as early as in mid-Jan.

Discussion: - Explanation of results in light of model assumptions. With Omicron, the overall $R_{\text{effective}}$ becomes larger than 1 in most states for all scenarios. Most of the projected infections are Omicron. From Feb. remaining nodes susceptible to Omicron are not enough to keep $Rt > 1$. - If a peak was not observed, which components of model explain this result? N/A.

University of Southern California Data Science Lab — SI kJalpa

In Round 11, the updated model projects upcoming peaks in all outcomes in all scenarios, although, with large intervals. Scenario A with high immune escape and low severity is the most favorable.

Methods: Due to the high transmissibility and immune escape nature of Omicron, we made significant changes to the model to explicitly account for various paths to partial immunity and time at which it was acquired. These include (1) 1st time infections, (2) 2nd+ time infections, (3) infection after 2-doses, (4) infections after a booster, (5) 2-doses with no prior infection, (6) booster with no prior infection, (7) 2-doses with prior infection(s), and (8) booster with prior infection(s). Having these states over time, age-groups, and variants allows for precise computation of immunity in the population at a given time. As a result, we can track new infections among the observed data that have protection from a prior immunity (from vaccine/booster/infection), while accounting for waning immunity. We considered two circulating “variants”: (i) Omicron and (ii) Other. The reason for switching from multi-strain model was to avoid uncertainties that arise due to low-prevalence variants with noise data. A logistic regression model was fit to estimate the prevalence of the two variants over time which is then used to disaggregate the reported cases into time-series of each variant. Transmission rates are estimated using recent data with an exponential forgetting factor to favor more recently seen trends. However, it requires estimation of immunity, which is measured starting from the beginning of the pandemic. Due to combining of all non-Omicron variants as “Other”, the model assumes that they have identical waning and no immune-escape. To focus on the uncertainty around Omicron, we did not consider any changes in NPI, and no seasonality was introduced. The same vaccination adoption model was used for 2-dose vaccination and boosters. The adoption model assumes that the behavior is contagious, where the eligible population adopts the vaccine at a rate determined by the recent population who adopt it. Uncertainty in the future of boosters is employed by assuming that they will eventually saturate between 40% to 70% of the coverage of 2-dose vaccine.

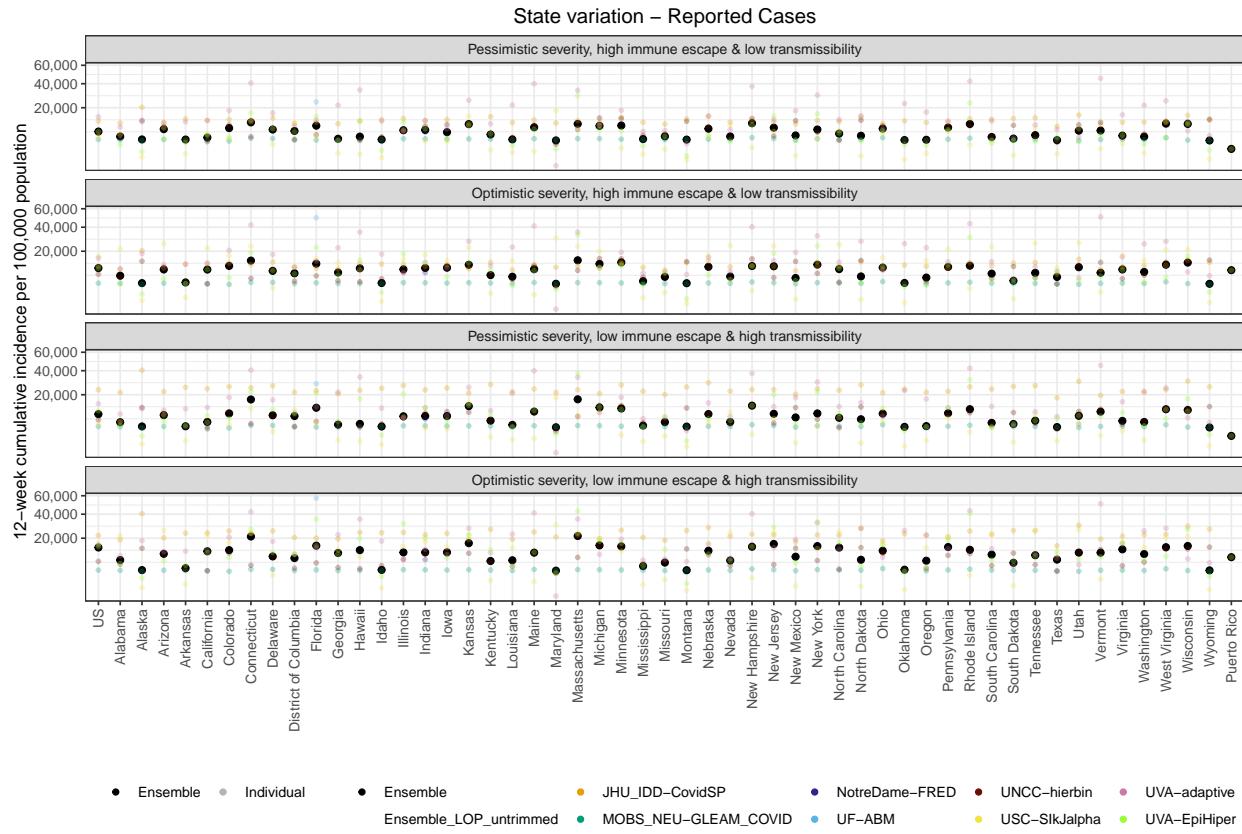
Results: Based on the projections, high immune escape results in significantly smaller peaks in cases than low immune escape scenarios. For hospitalizations and deaths, optimistic severity with high immune escape produced the most favorable outcomes with the peak point projections within 1.5x of prior largest peak for most states. At the national level, cases peak in mid (Scenarios B/D) to late January (Scenarios A/C), hospitalizations peak in late January to early February, while deaths peak in mid-February.

Discussion: The key modeling choice that affected the projections was the residual protection from infection due to waning. Counter-intuitively, higher protection leads to larger peaks. This is because if protection (and hence, immunity) is high, then Delta must have a very high R_0 to be able to produce cases at the rate seen recently. As a result, Omicron will have a high(er) R_0 with reduced immunity in the population. We also observe that majority of the new cases are first-time infections with no prior immunity. Therefore, despite having residual protection against severe outcomes from prior immunity, the large peaks in cases produce significant peaks in hospitalizations and deaths.

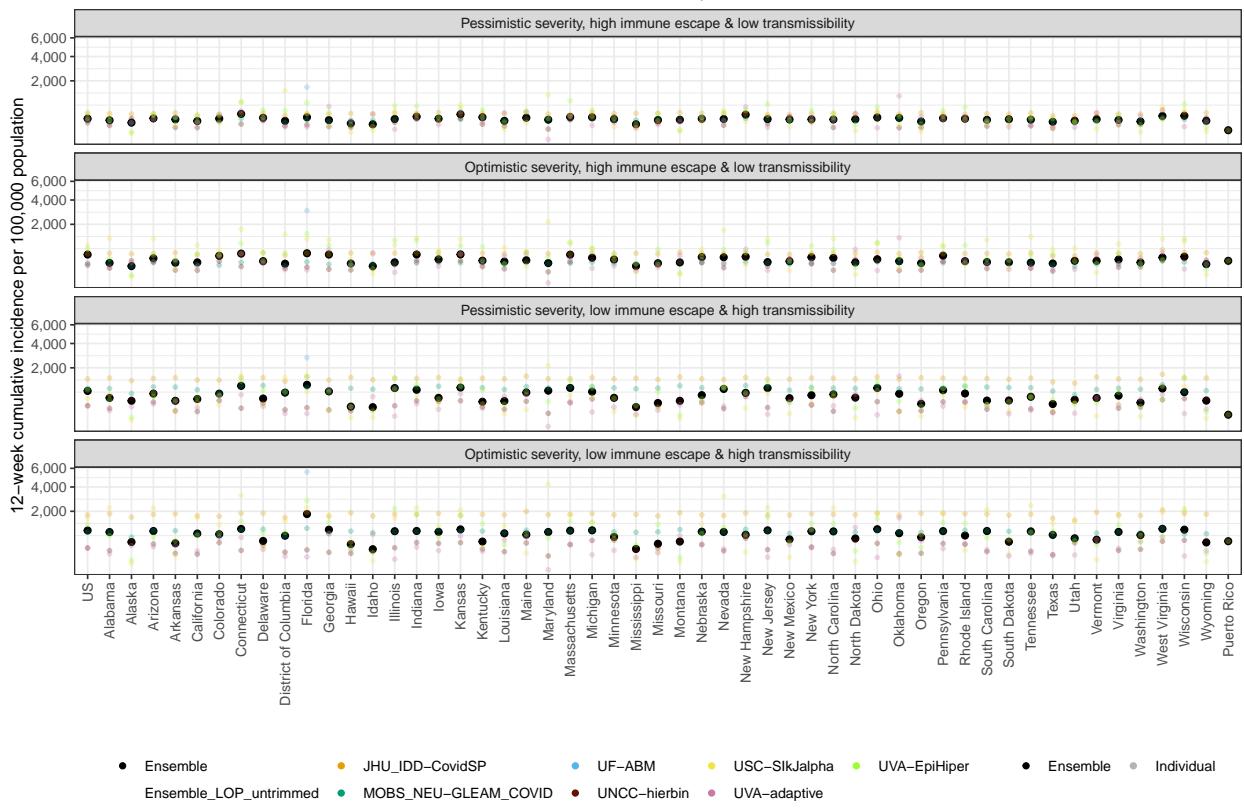
Conclusion: While peaks higher than the prior ones are projected for all scenarios, significant uncertainties remain attributed to modeling choices, as presented by the large intervals. Particularly, waning of immunity needs to be accurately estimated for better projections.

Supplemental Plots

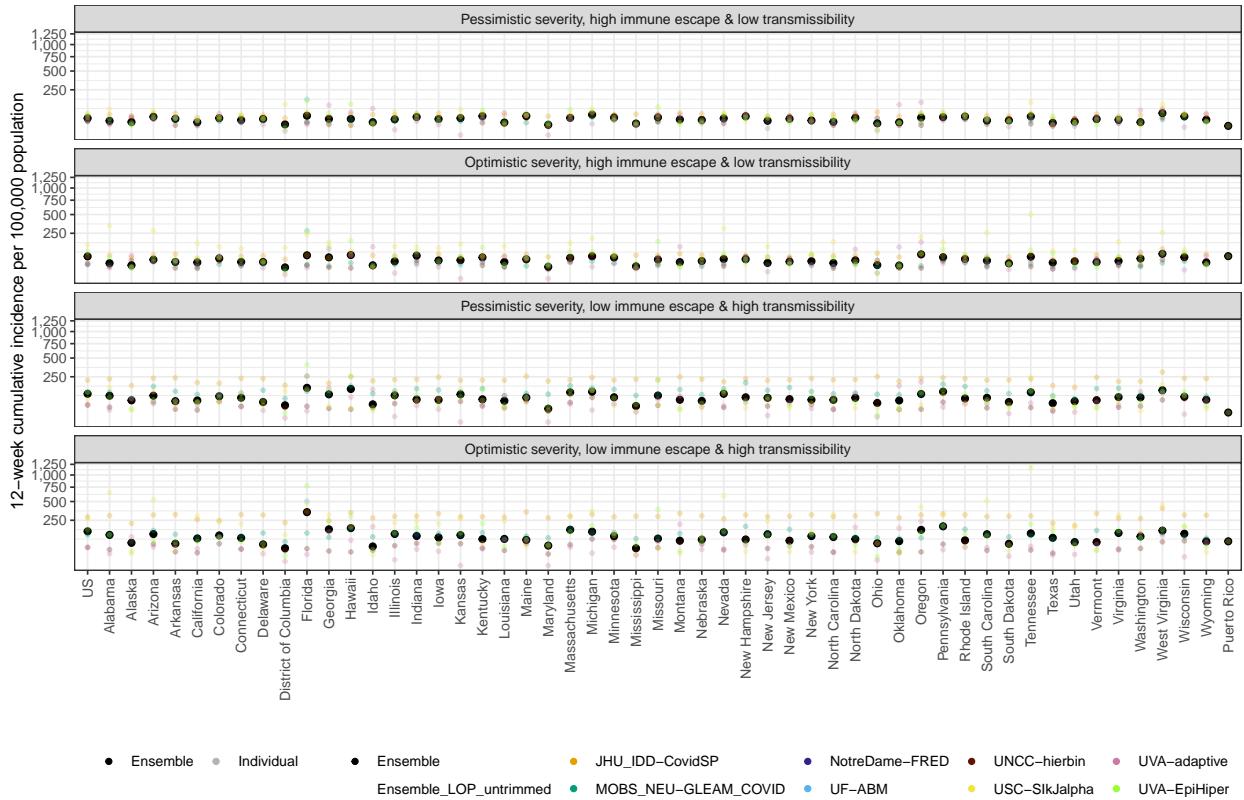
Individual model and ensembles projections for state-level cumulative incidence per 100,000 population over 12-week projection period.



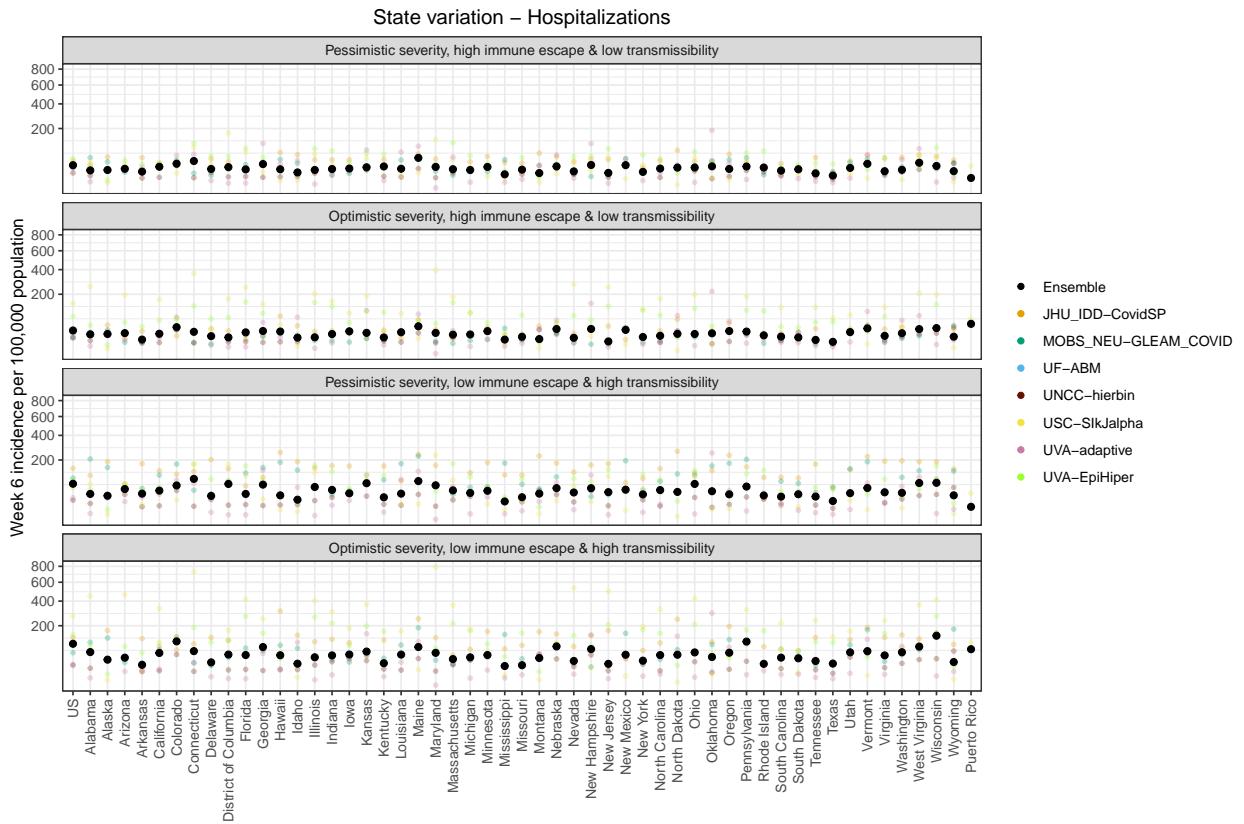
State variation – Hospitalizations

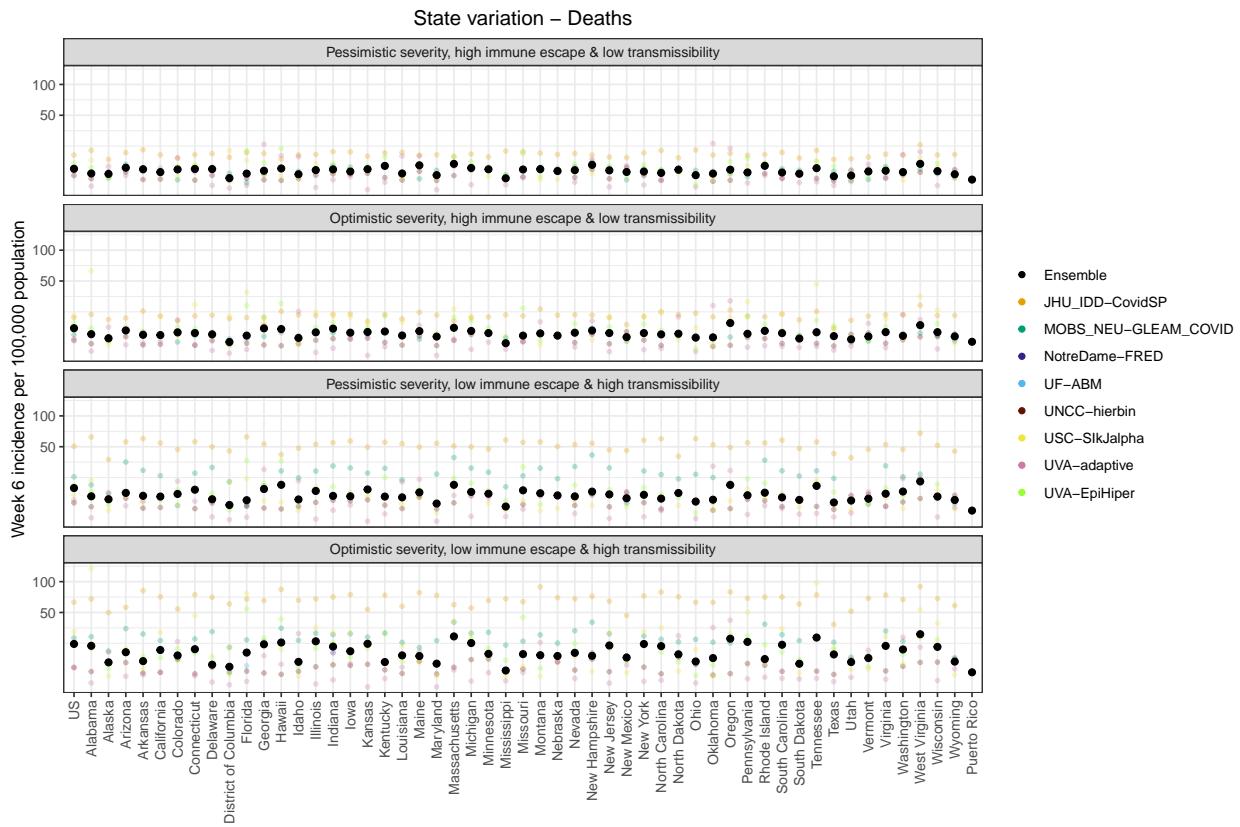


State variation – Deaths

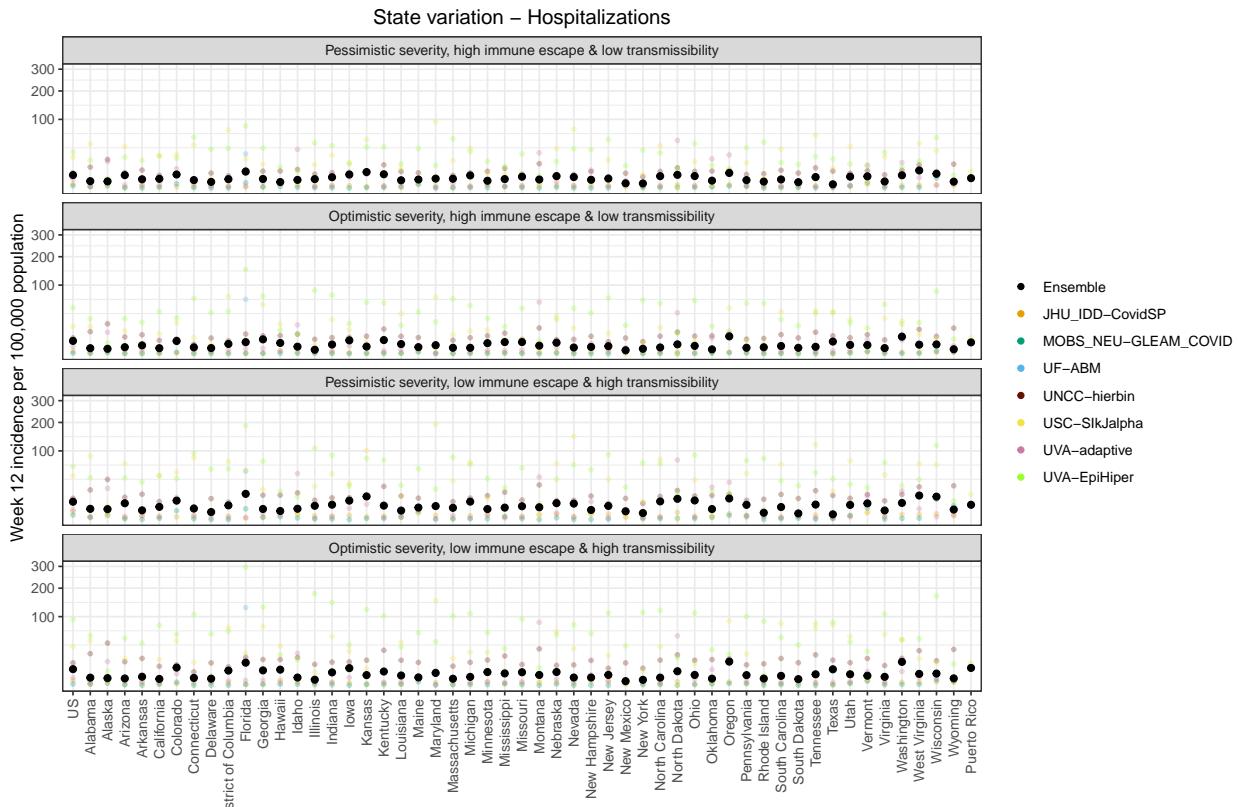


Individual model and ensembles projections for state-level death and hospitalization incidence per 100,000 population at week 6.

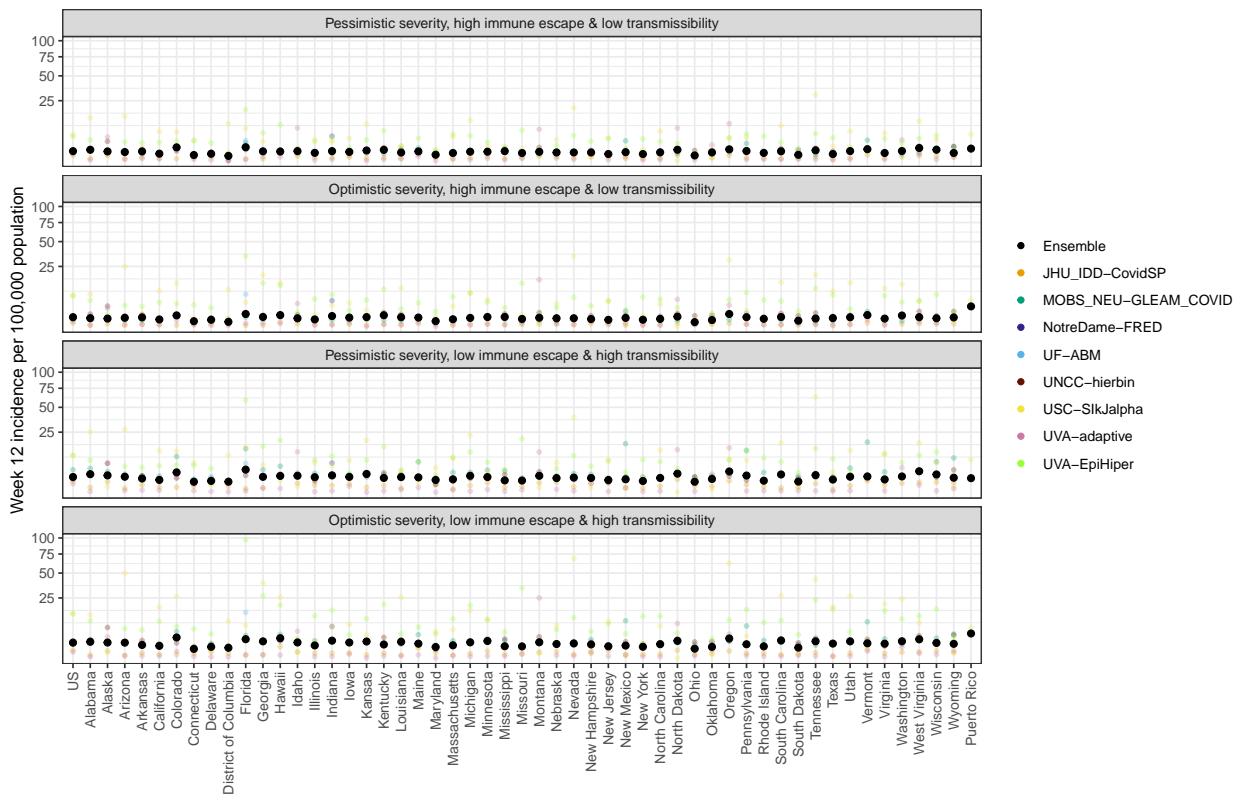




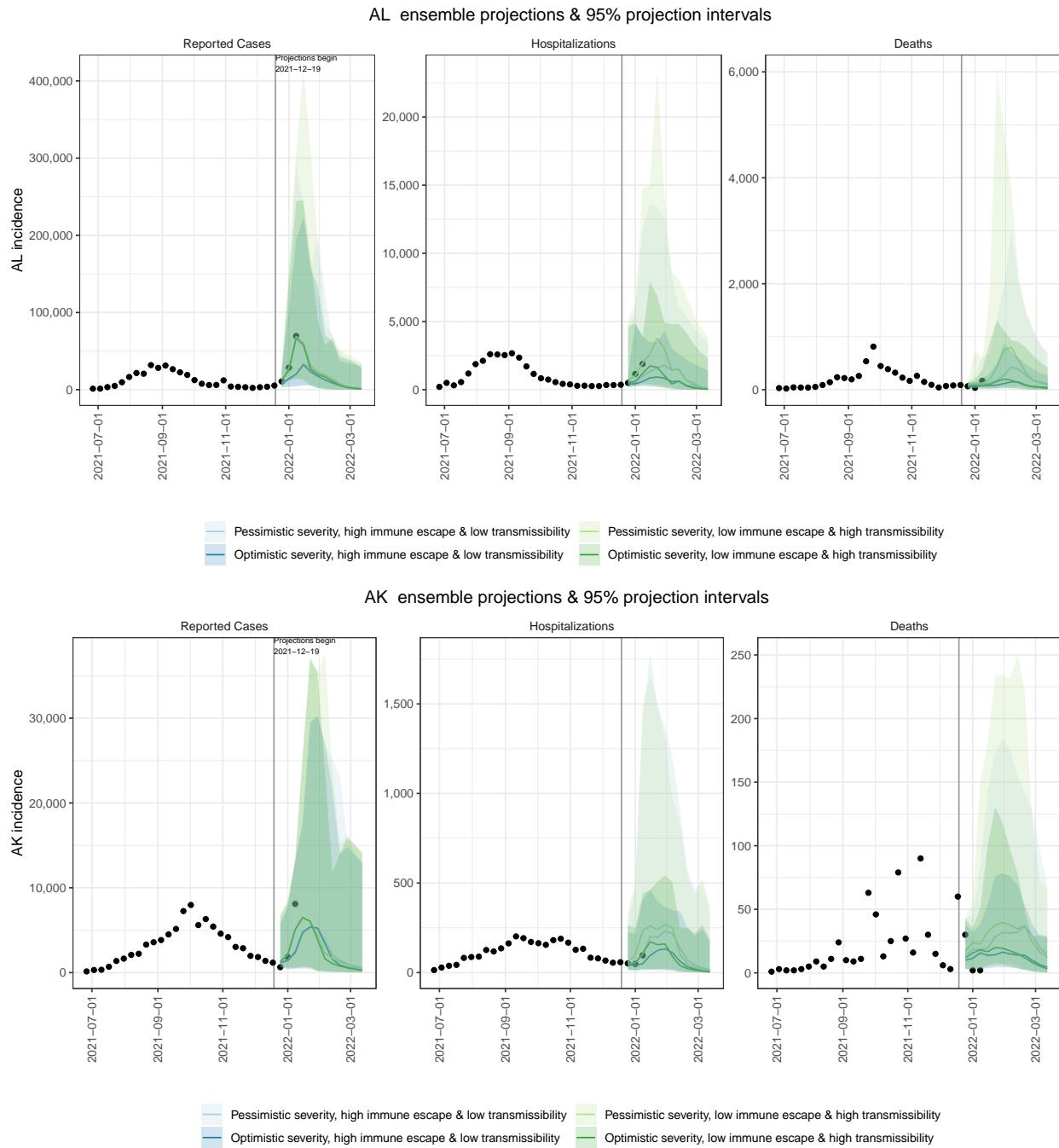
Individual model and ensembles projections for state-level incidence per 100,000 population at week 12.



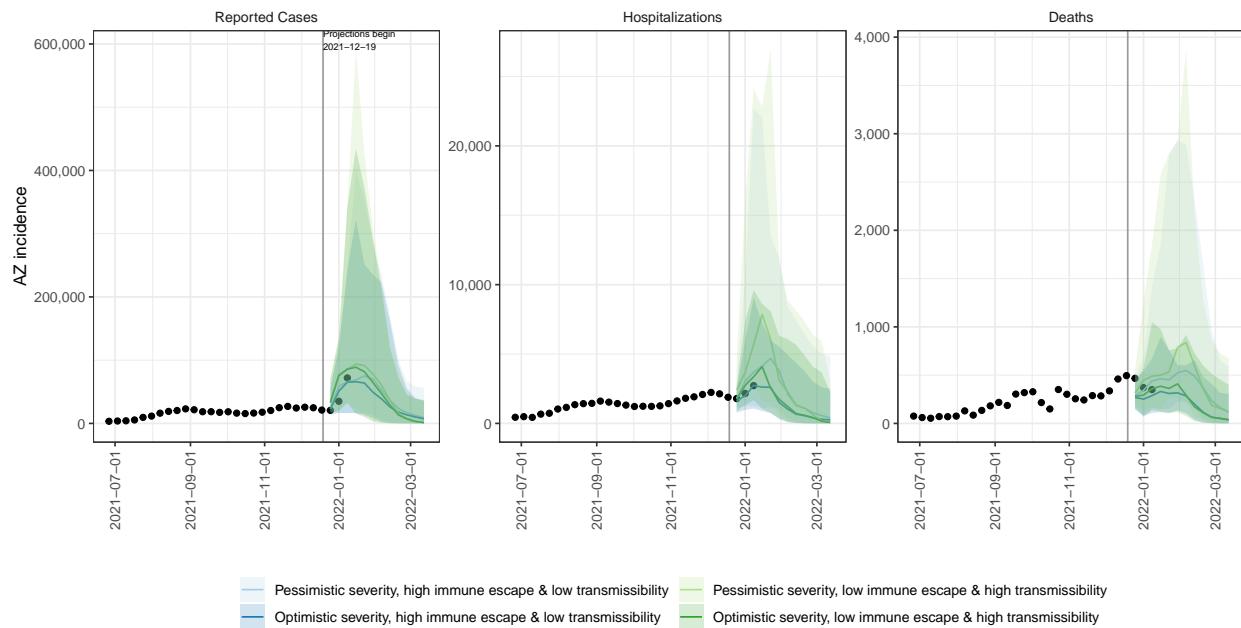
State variation – Deaths



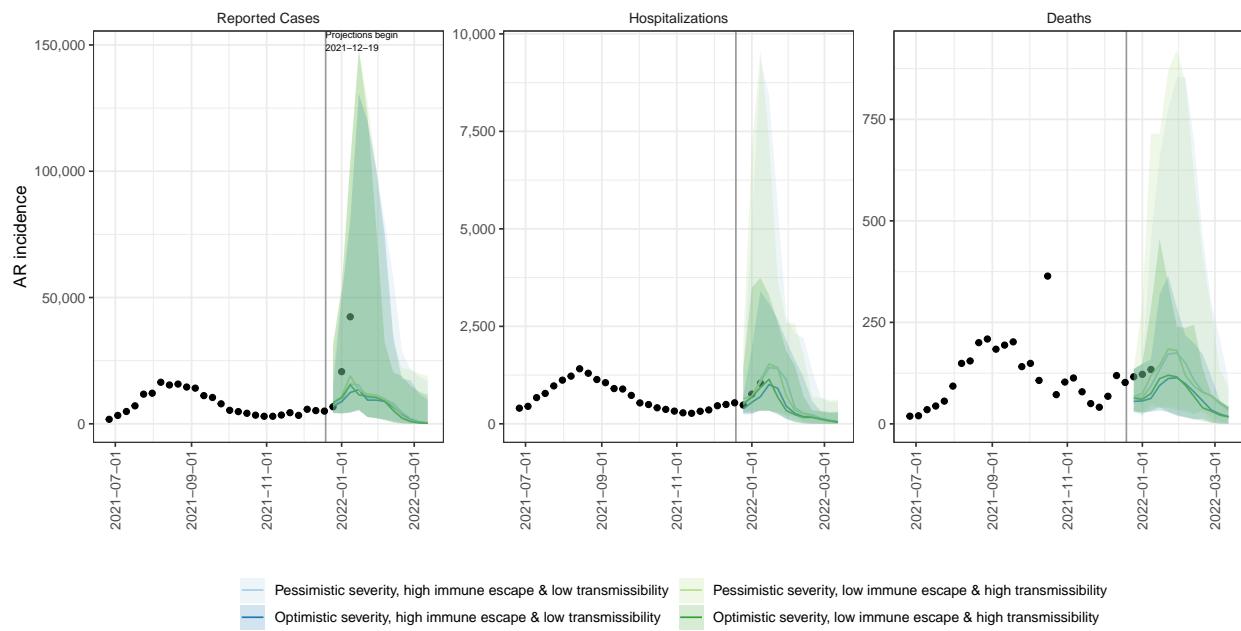
State-level ensemble plots



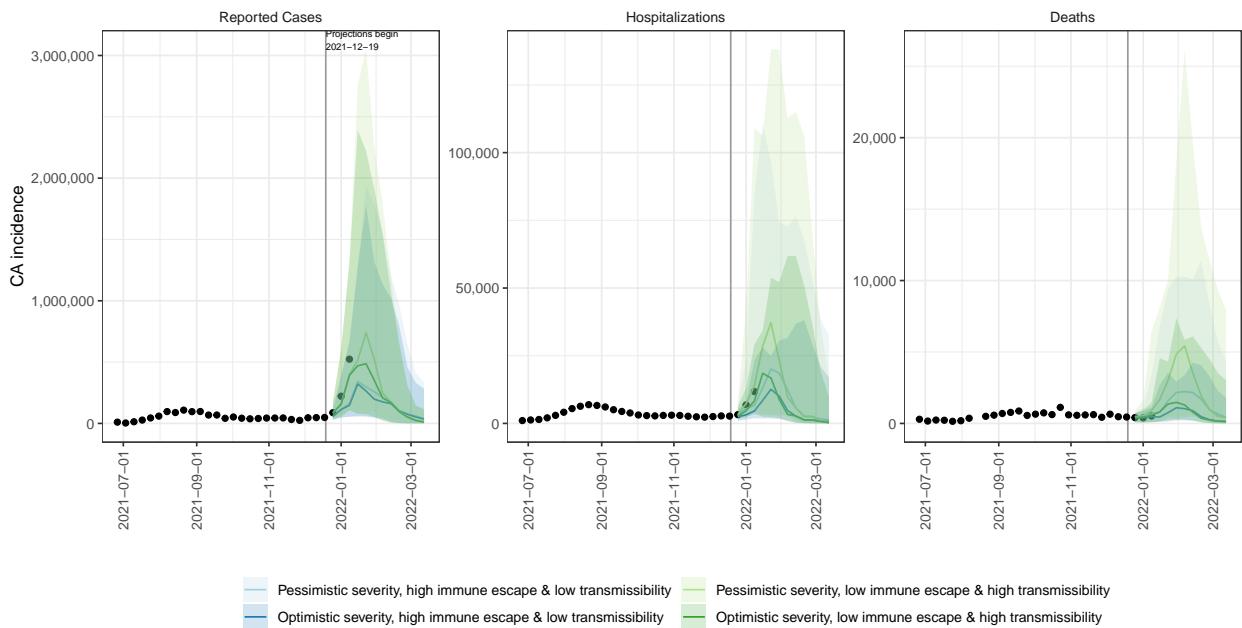
AZ ensemble projections & 95% projection intervals



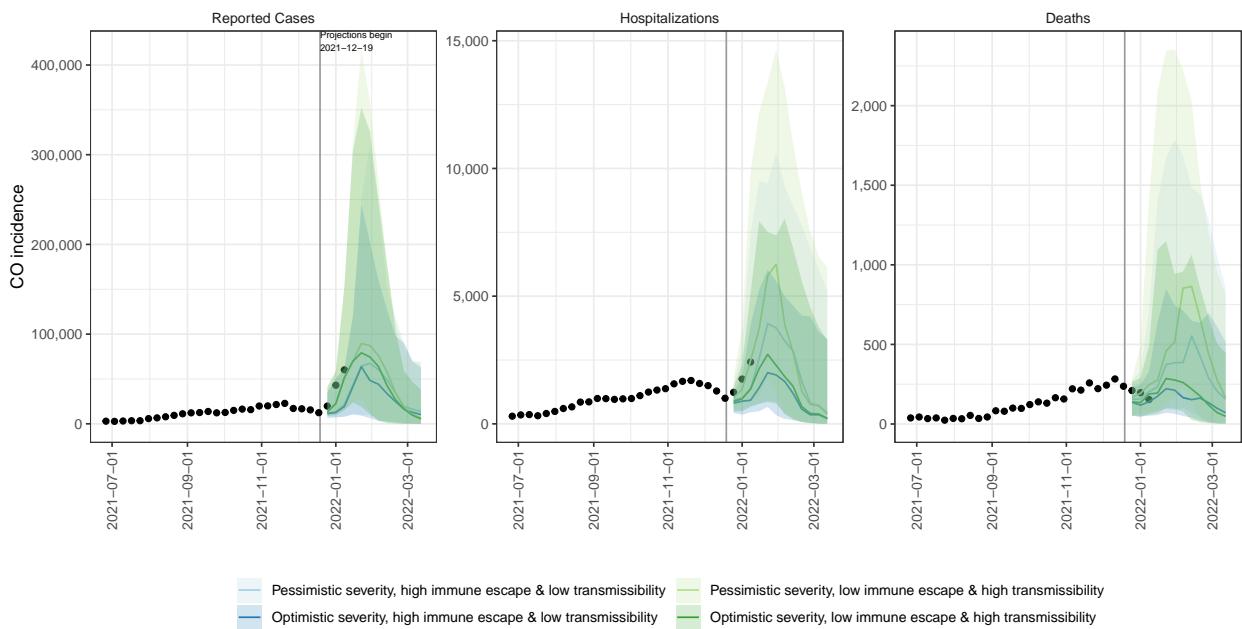
AR ensemble projections & 95% projection intervals



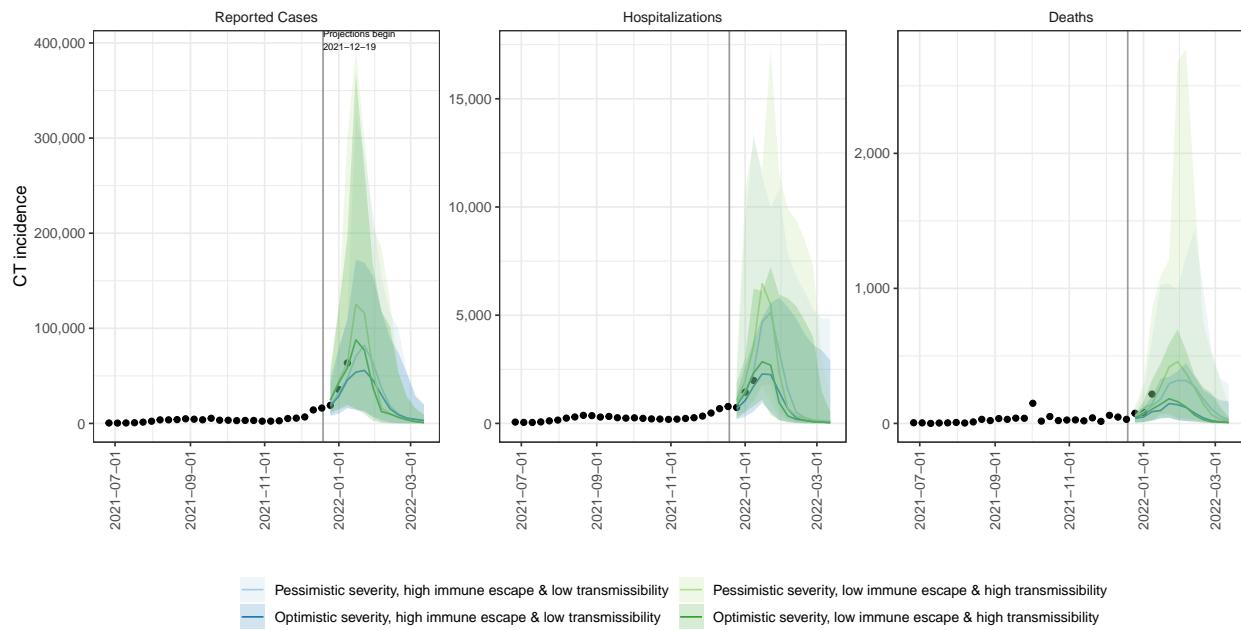
CA ensemble projections & 95% projection intervals



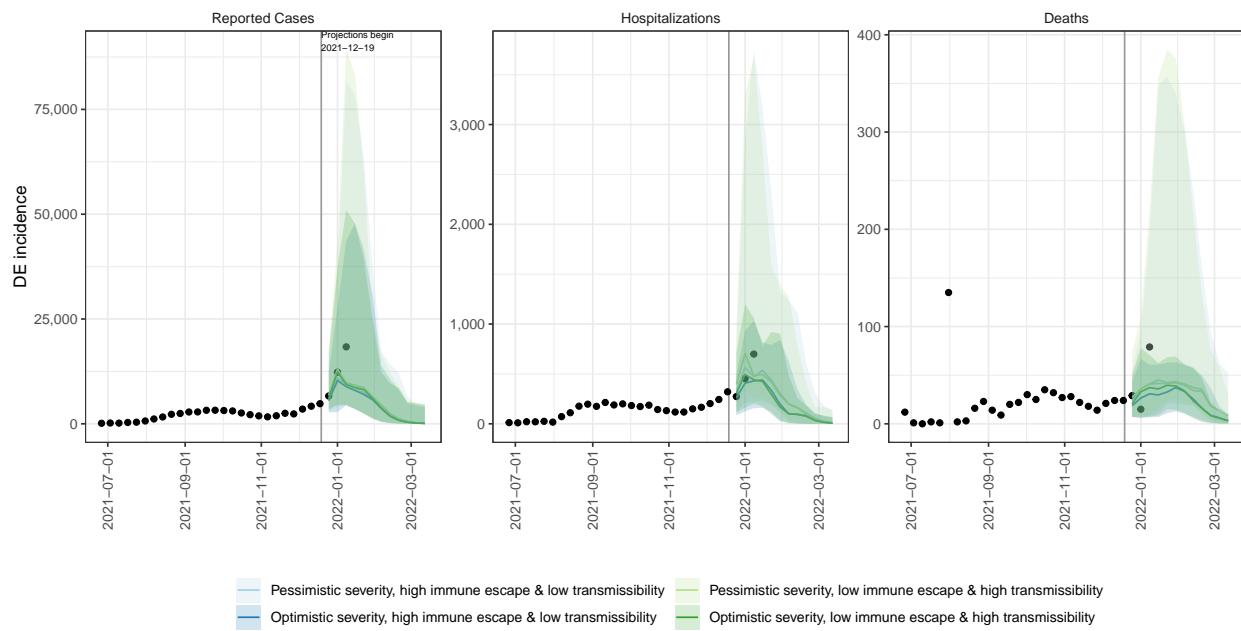
CO ensemble projections & 95% projection intervals



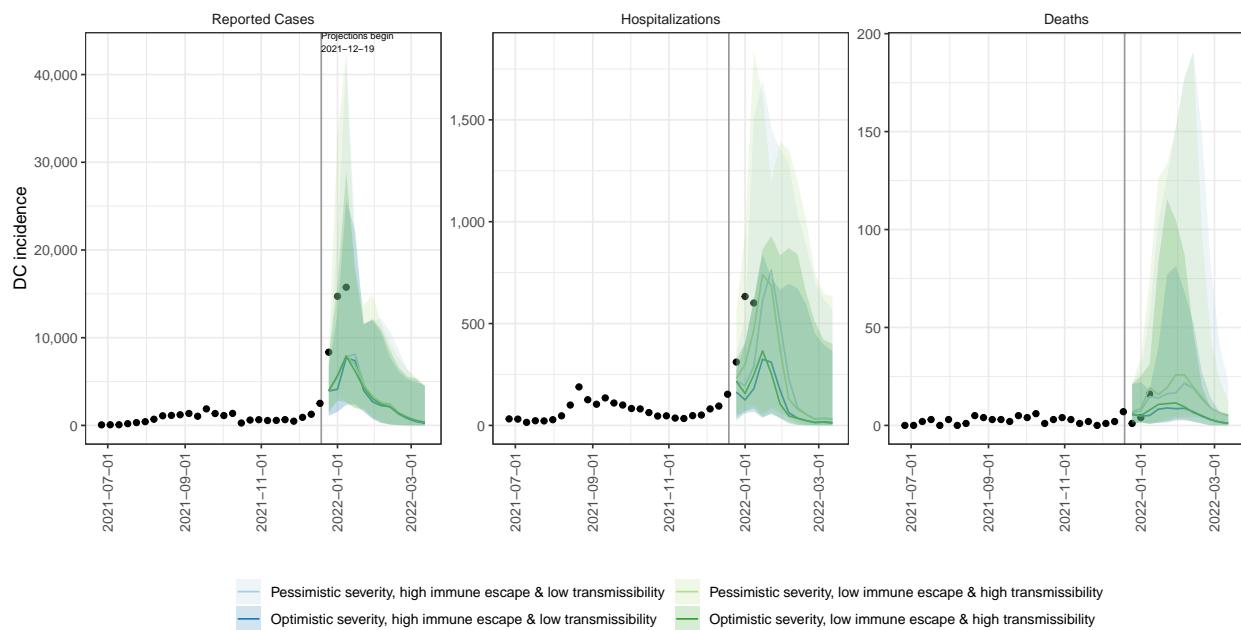
CT ensemble projections & 95% projection intervals



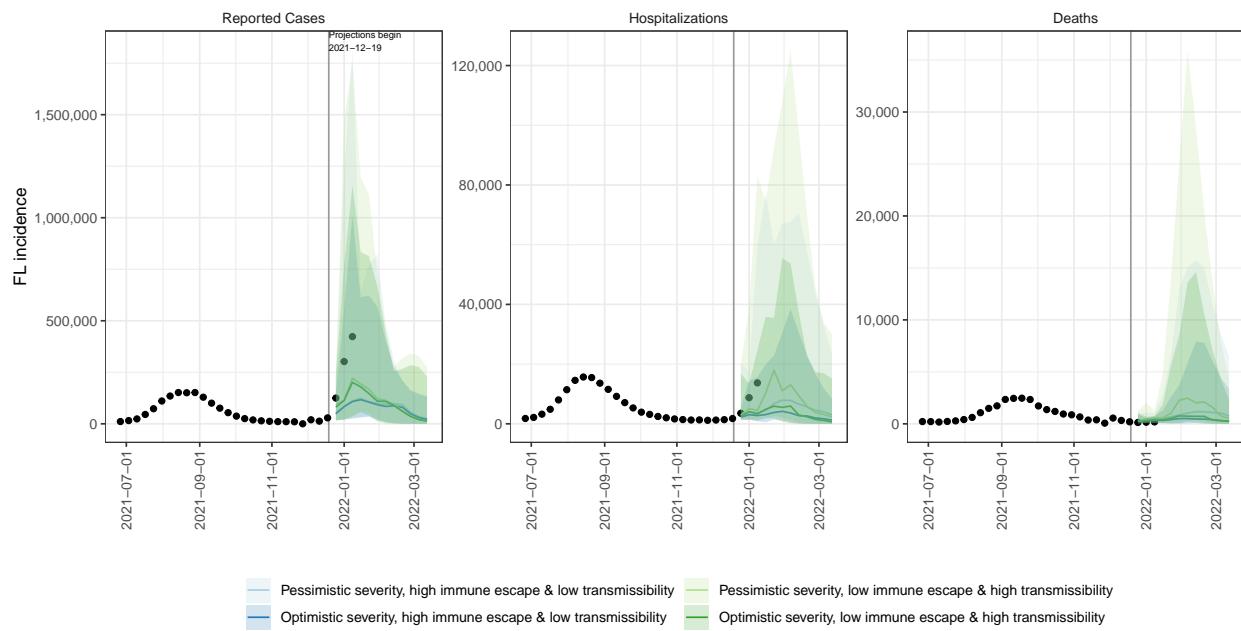
DE ensemble projections & 95% projection intervals



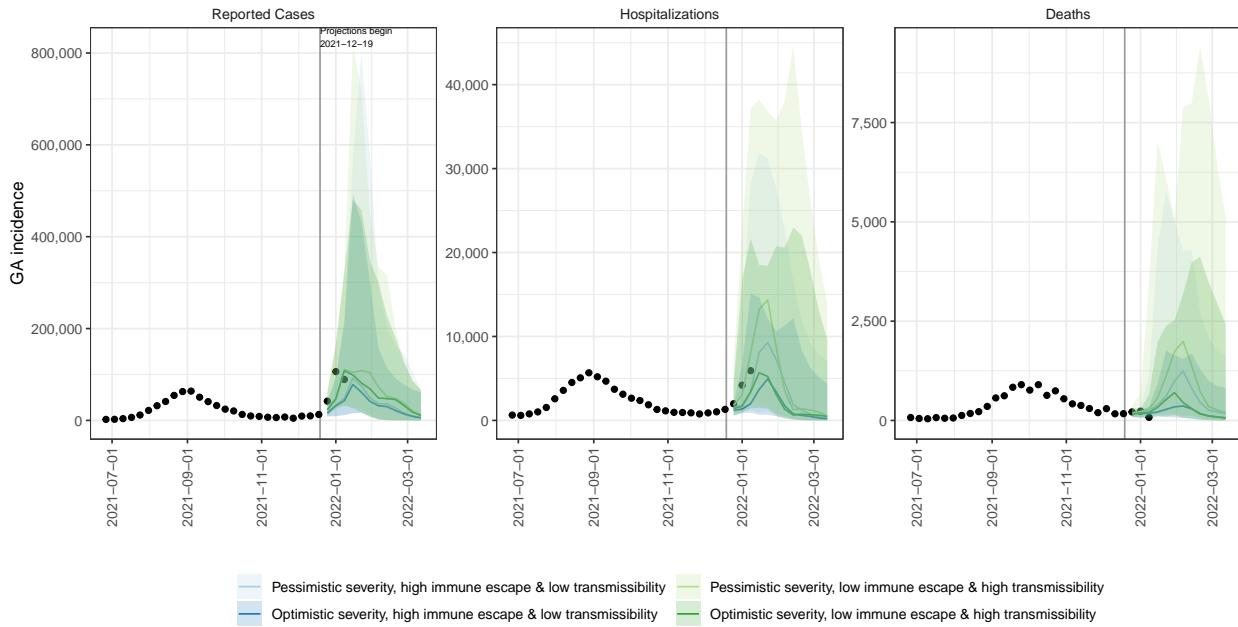
DC ensemble projections & 95% projection intervals



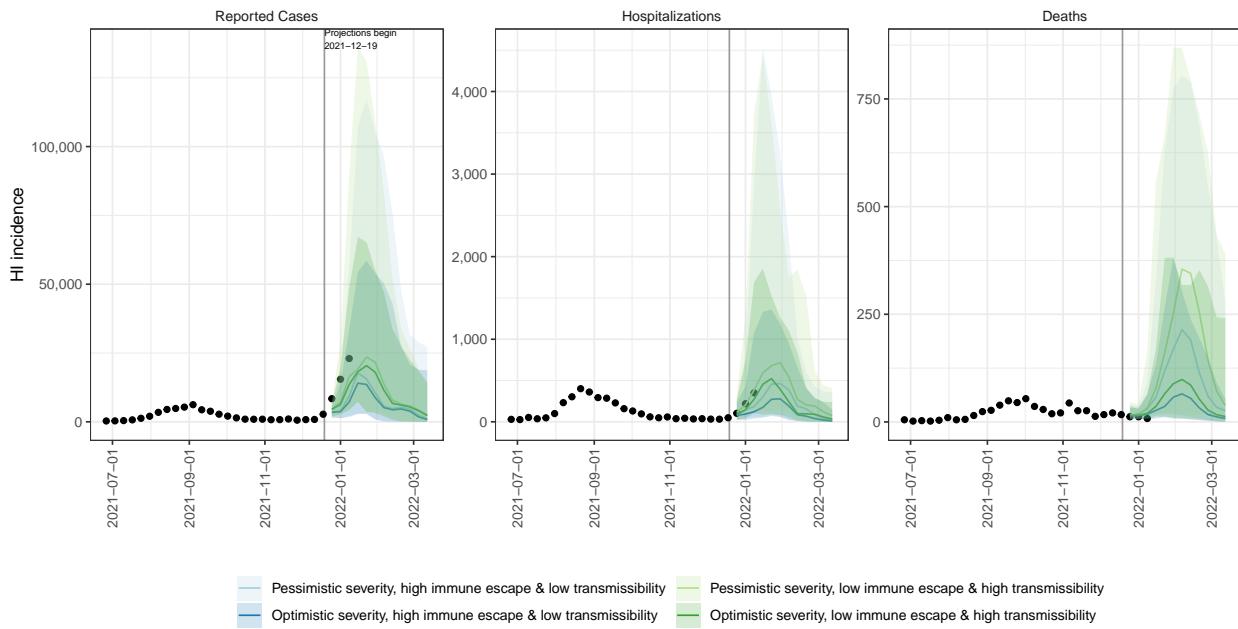
FL ensemble projections & 95% projection intervals



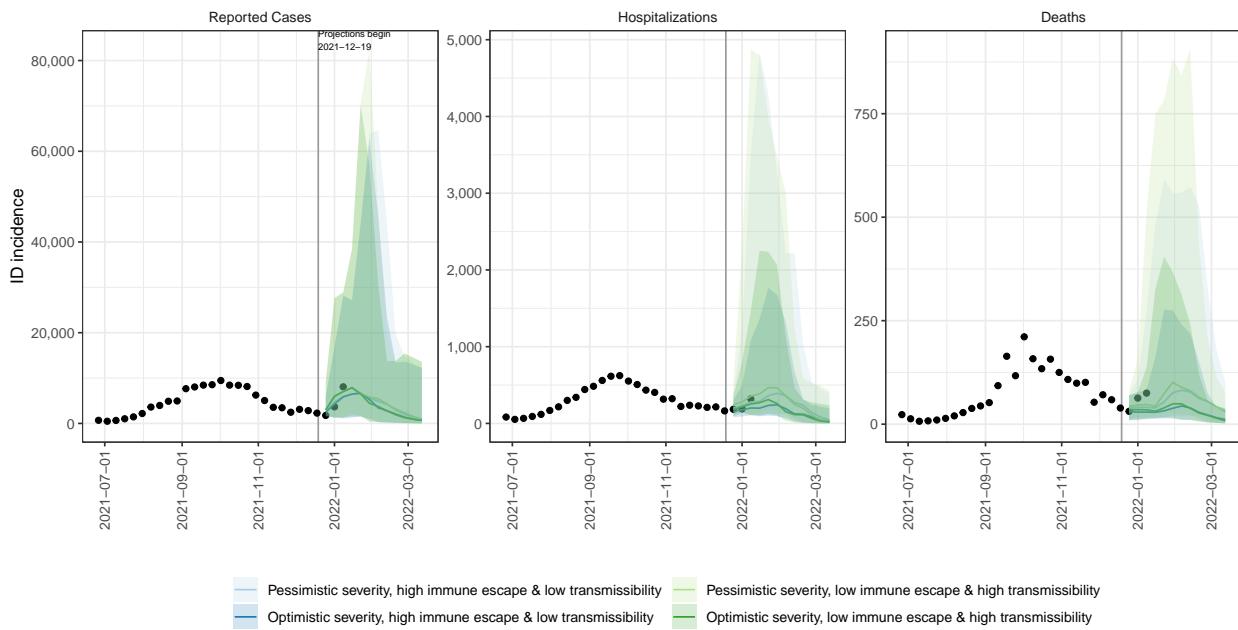
GA ensemble projections & 95% projection intervals



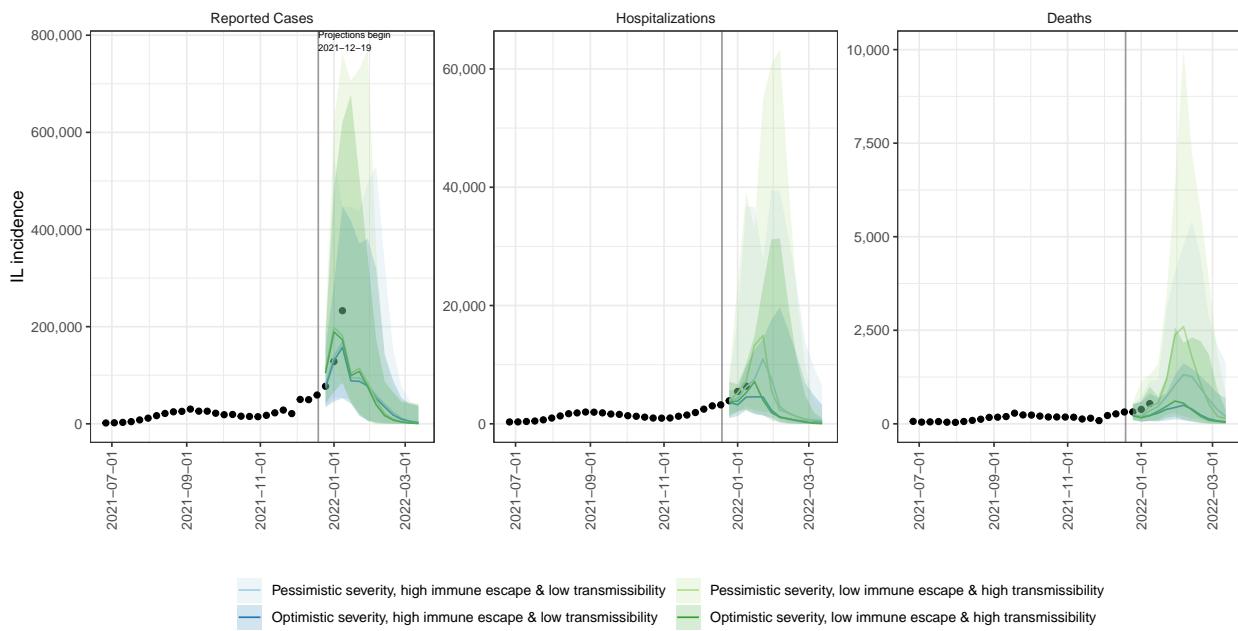
HI ensemble projections & 95% projection intervals



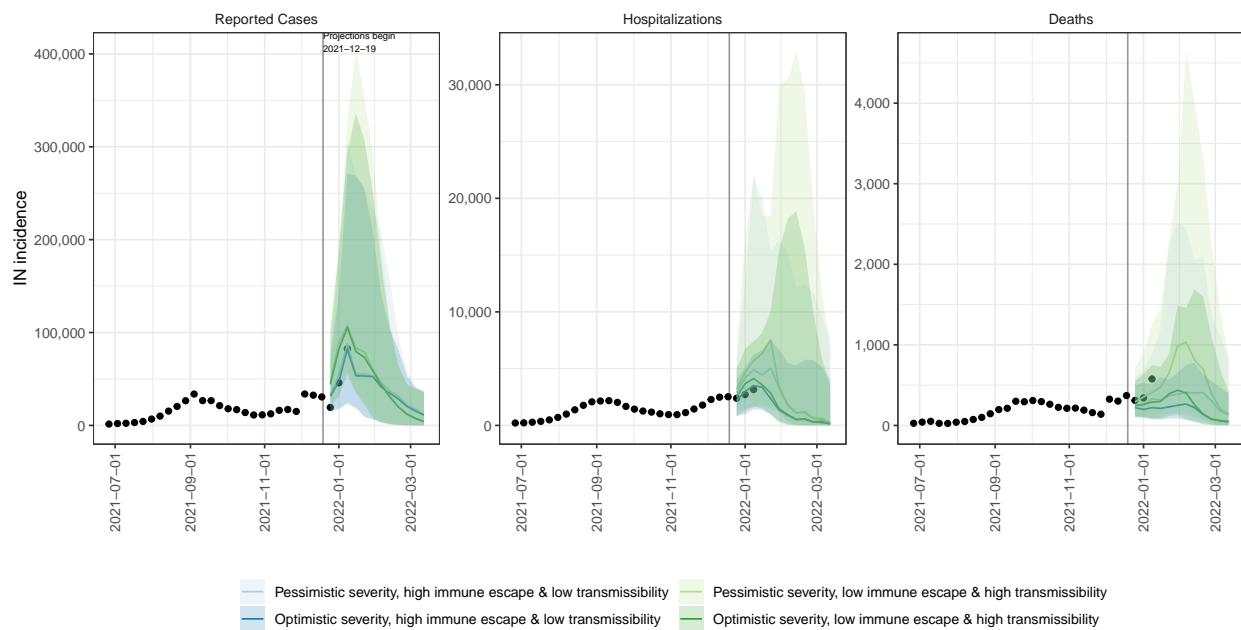
ID ensemble projections & 95% projection intervals



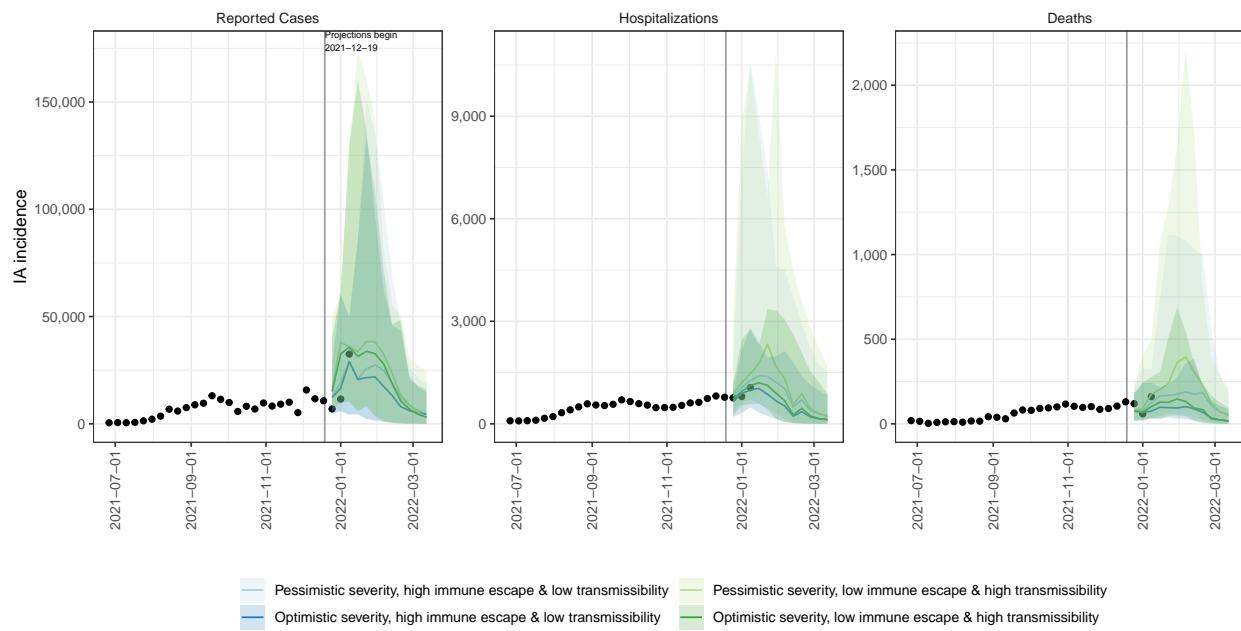
IL ensemble projections & 95% projection intervals



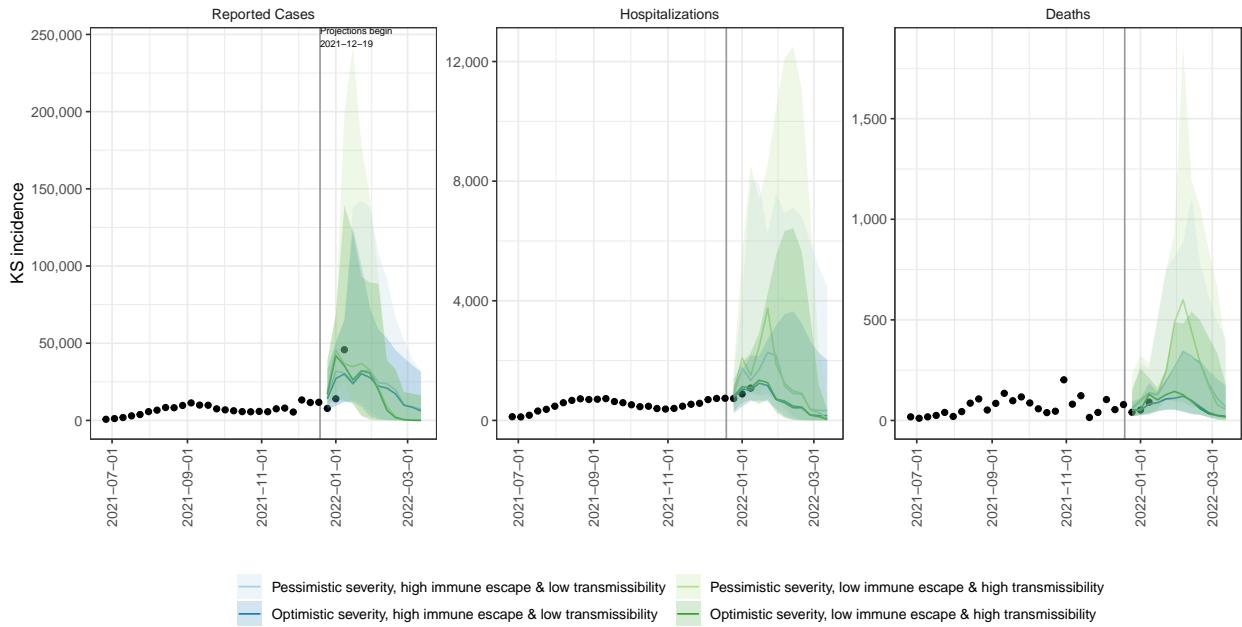
IN ensemble projections & 95% projection intervals



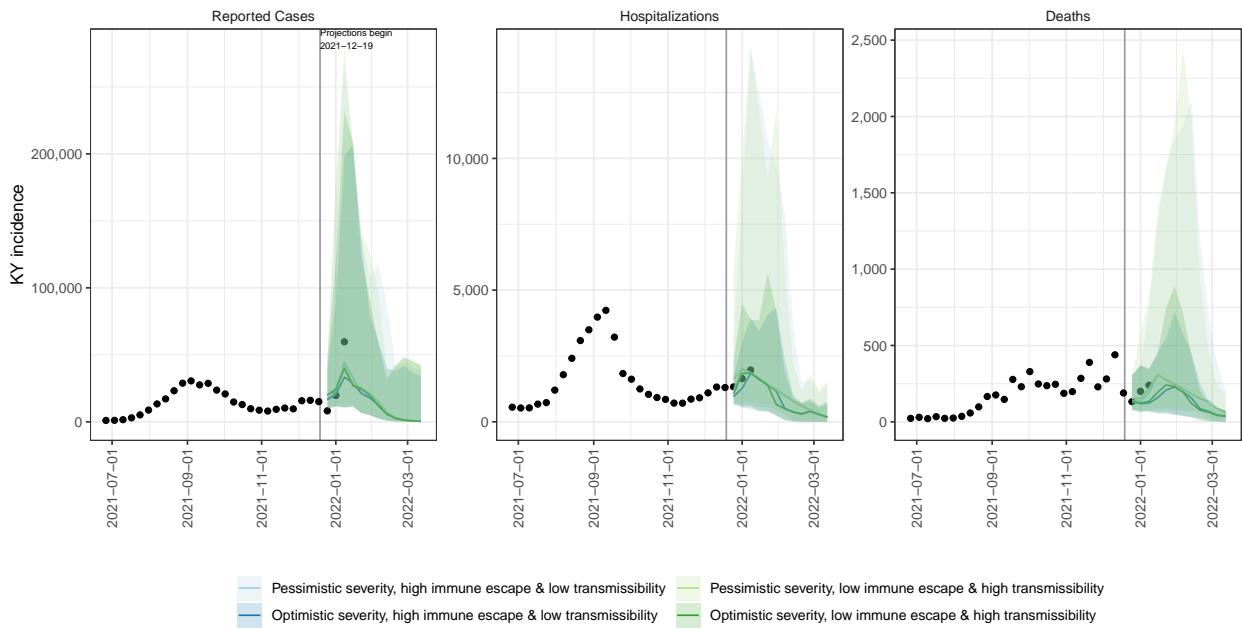
IA ensemble projections & 95% projection intervals



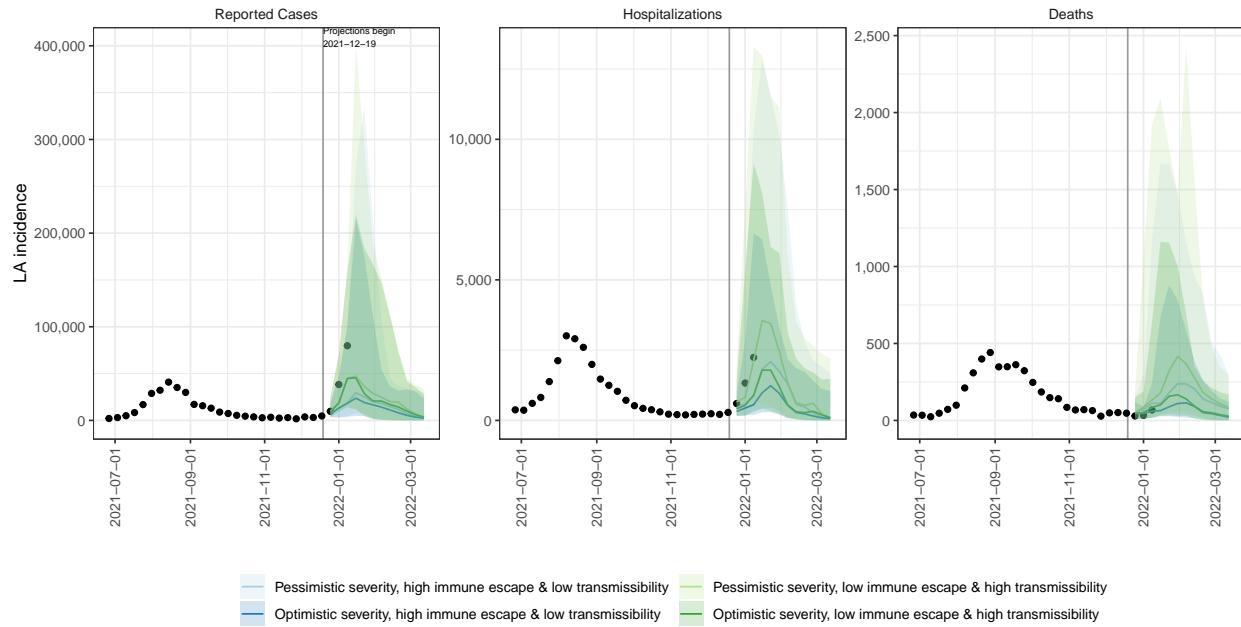
KS ensemble projections & 95% projection intervals



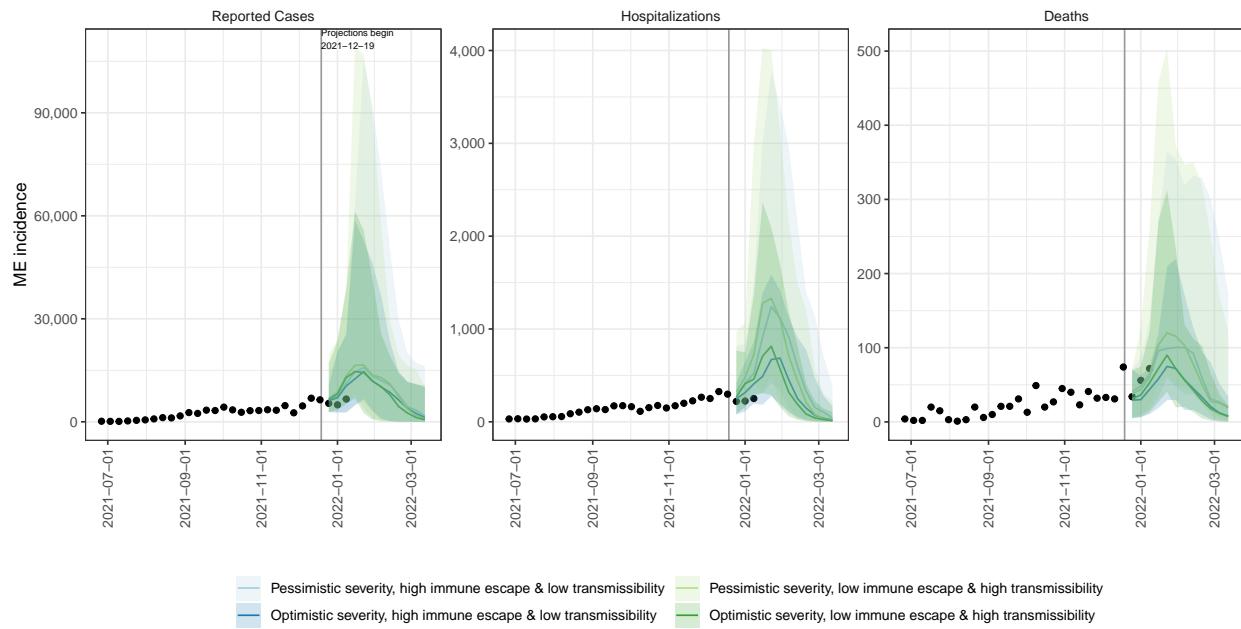
KY ensemble projections & 95% projection intervals



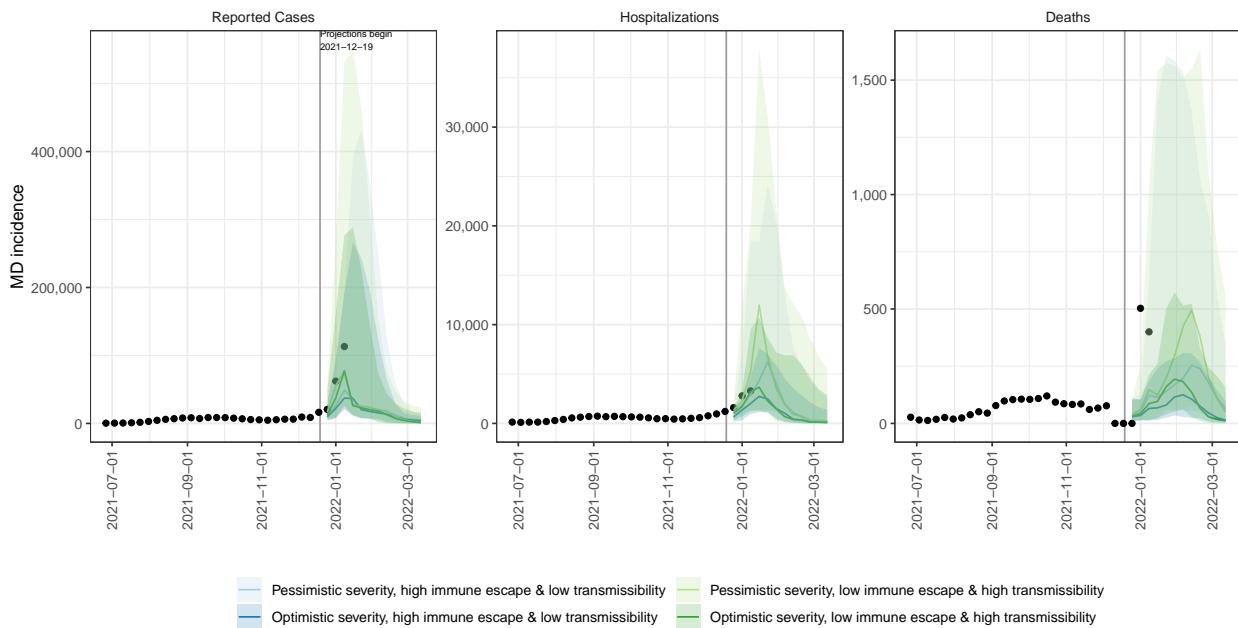
LA ensemble projections & 95% projection intervals



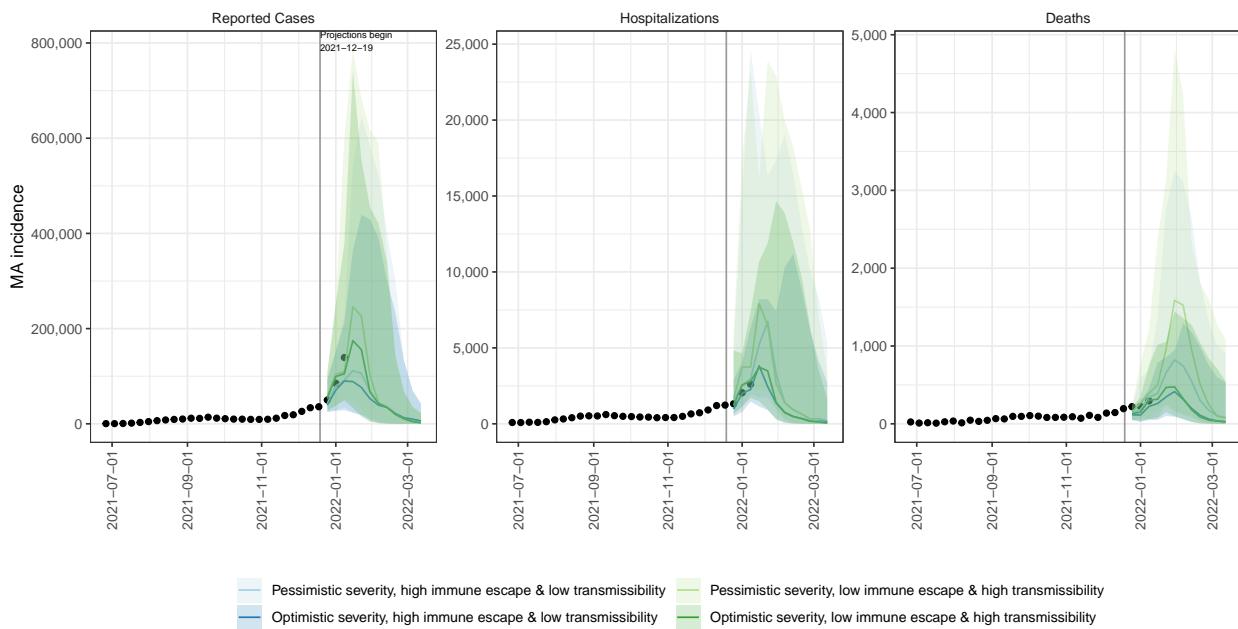
ME ensemble projections & 95% projection intervals



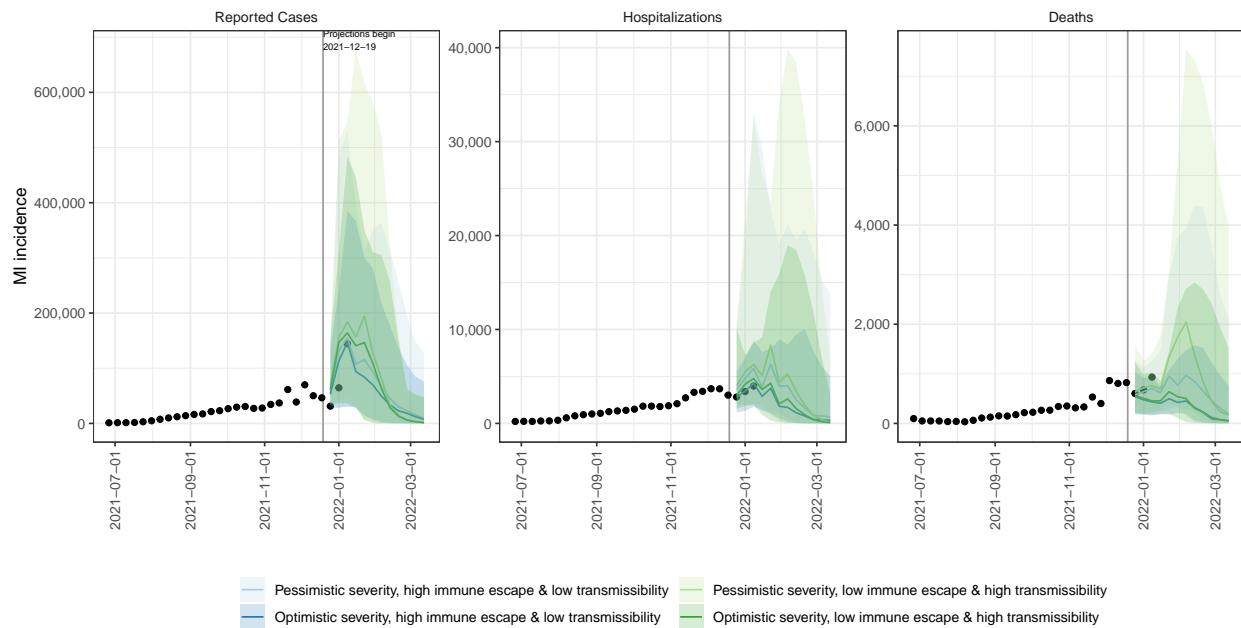
MD ensemble projections & 95% projection intervals



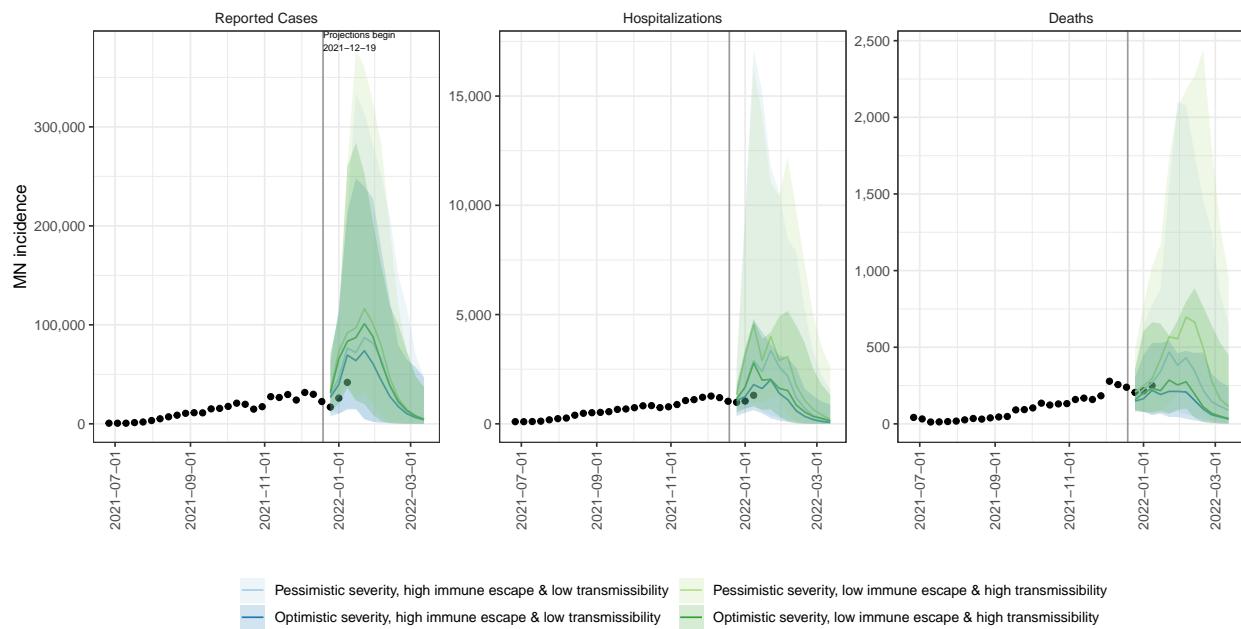
MA ensemble projections & 95% projection intervals



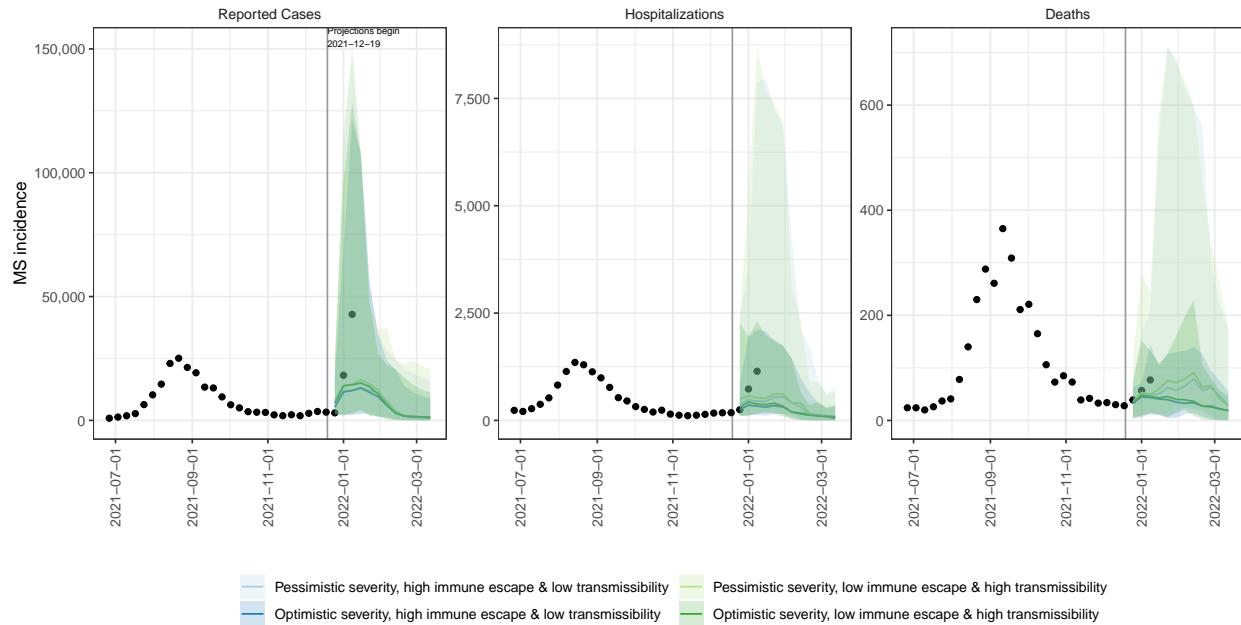
MI ensemble projections & 95% projection intervals



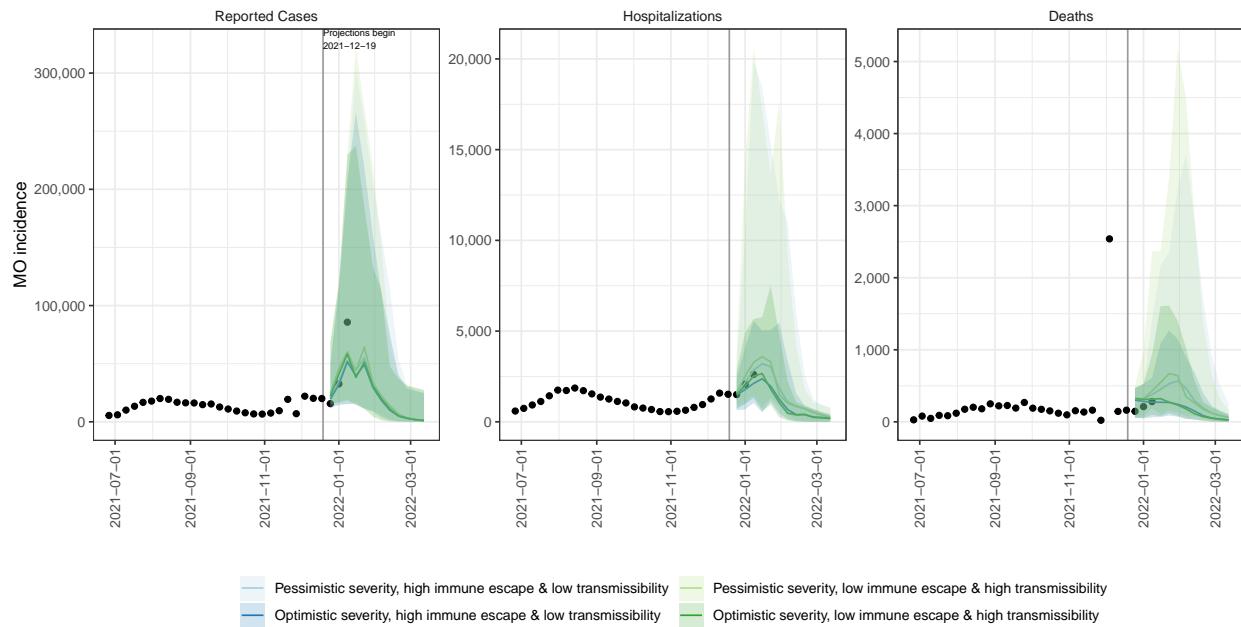
MN ensemble projections & 95% projection intervals



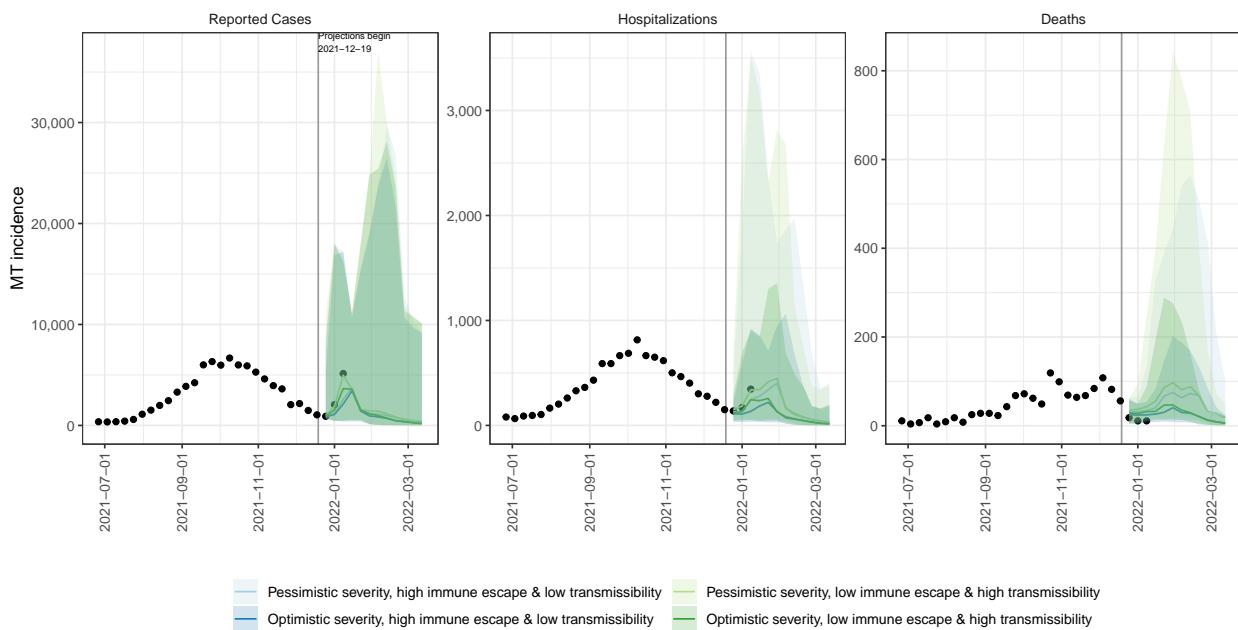
MS ensemble projections & 95% projection intervals



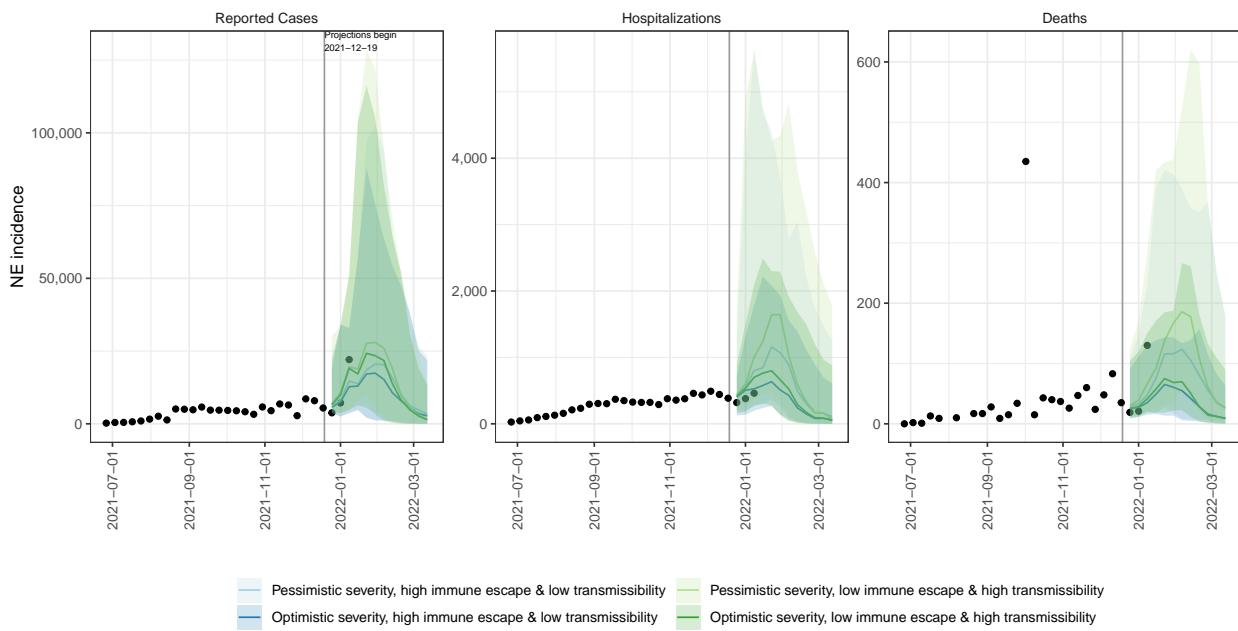
MO ensemble projections & 95% projection intervals



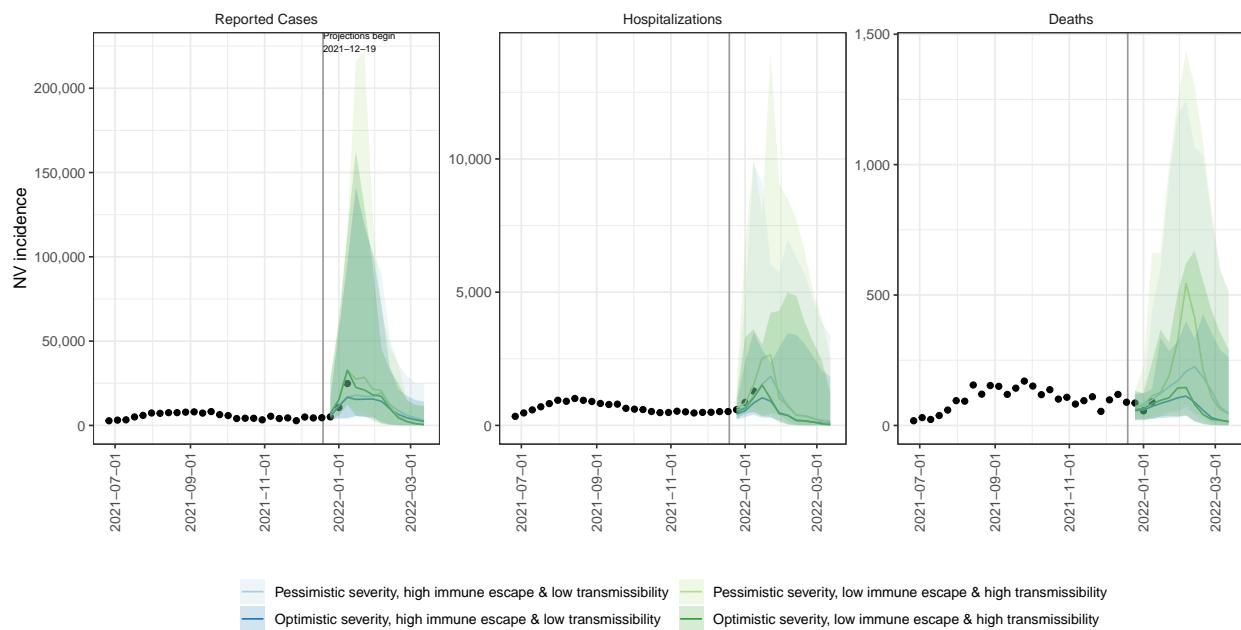
MT ensemble projections & 95% projection intervals



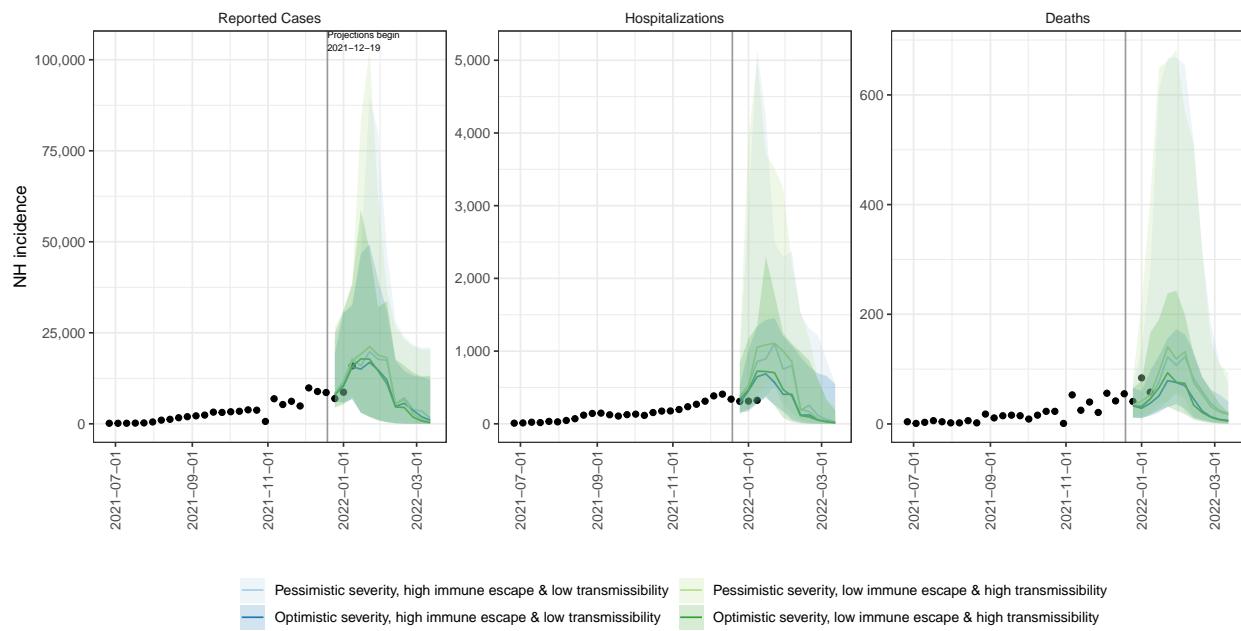
NE ensemble projections & 95% projection intervals



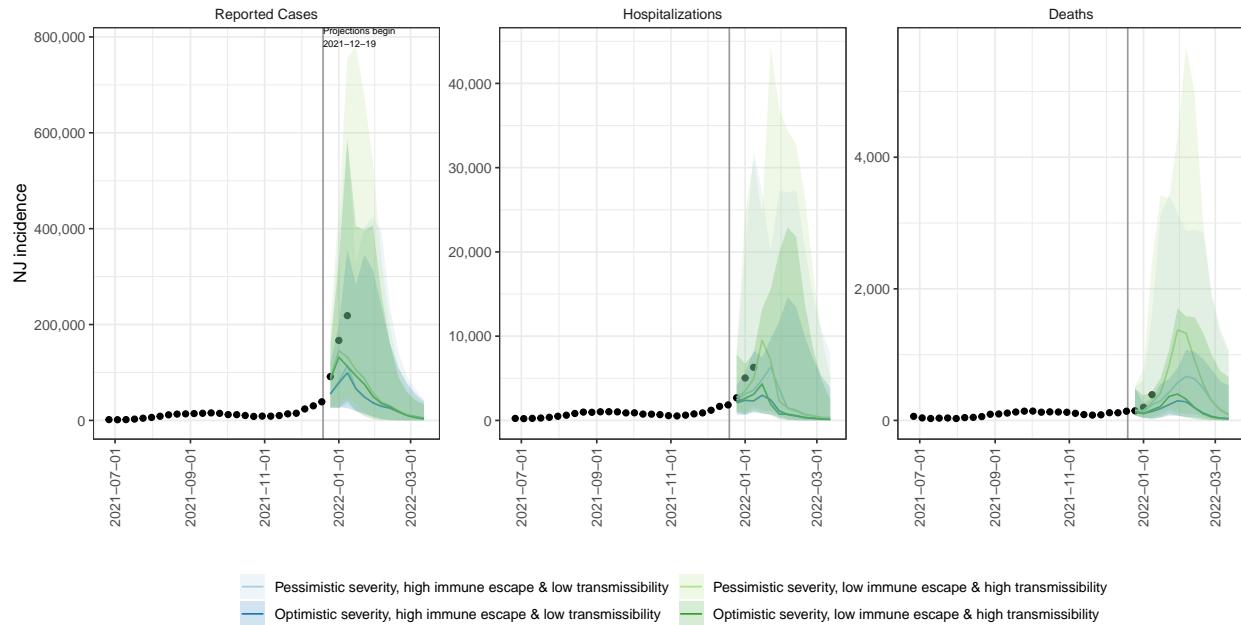
NV ensemble projections & 95% projection intervals



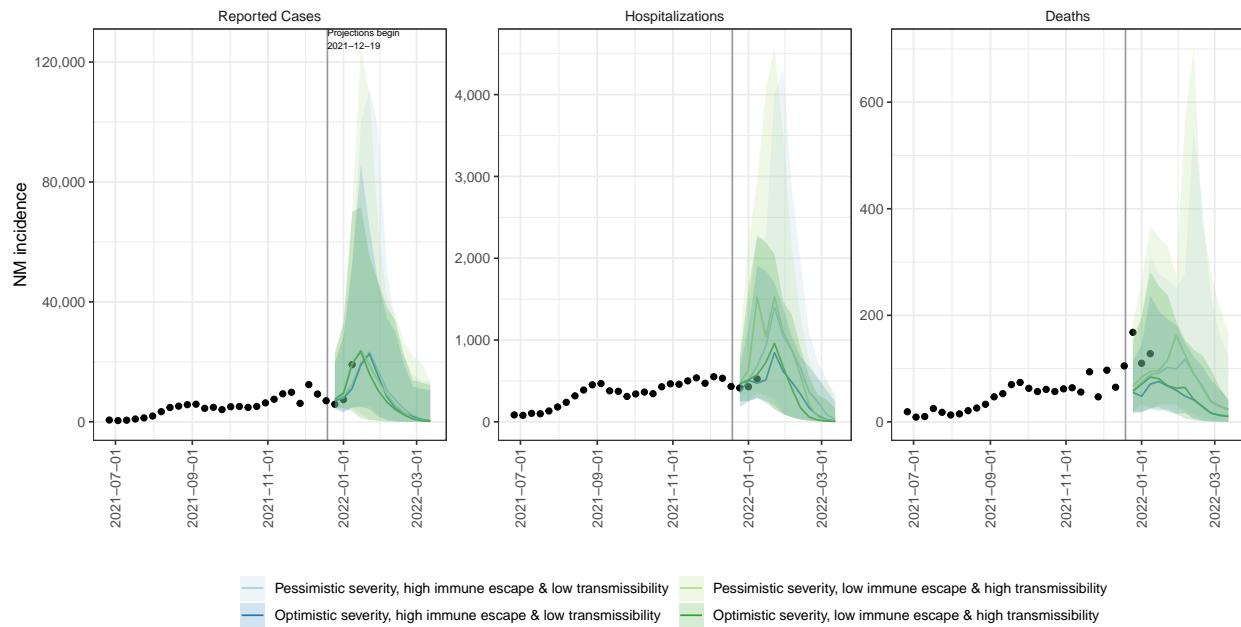
NH ensemble projections & 95% projection intervals



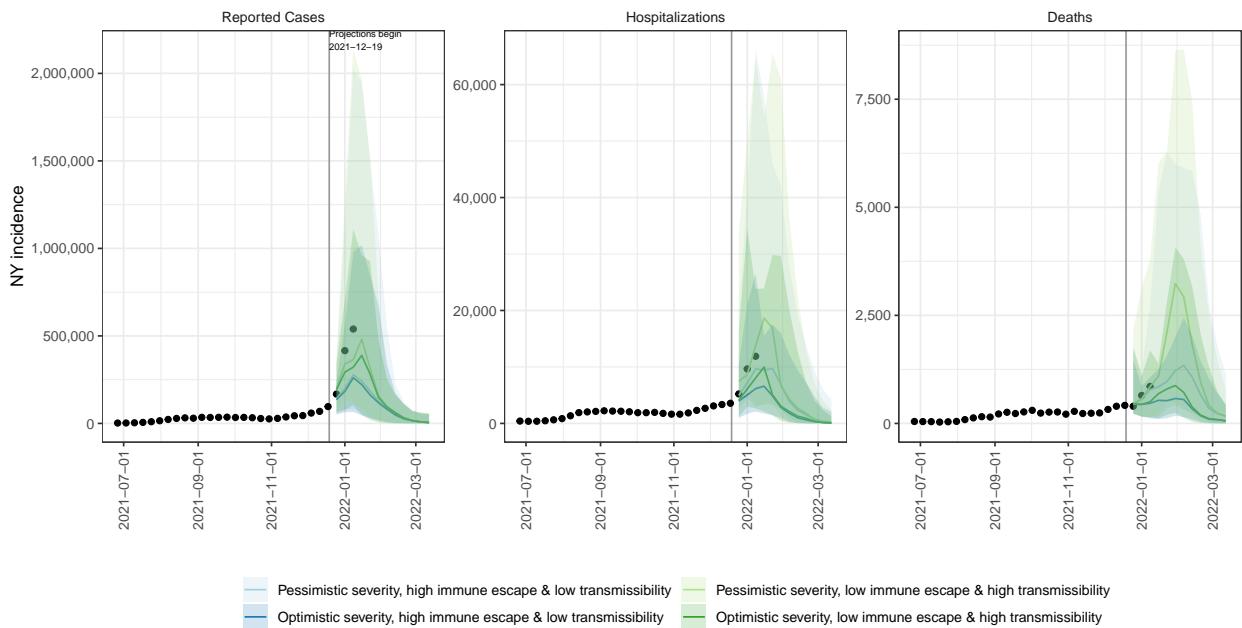
NJ ensemble projections & 95% projection intervals



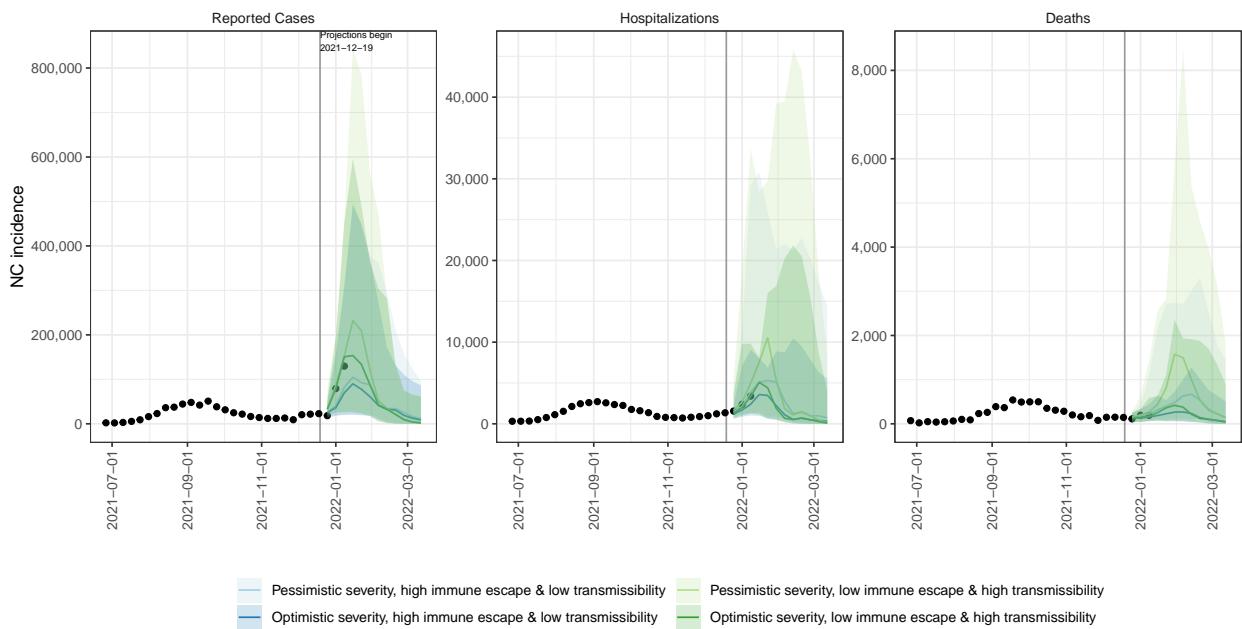
NM ensemble projections & 95% projection intervals



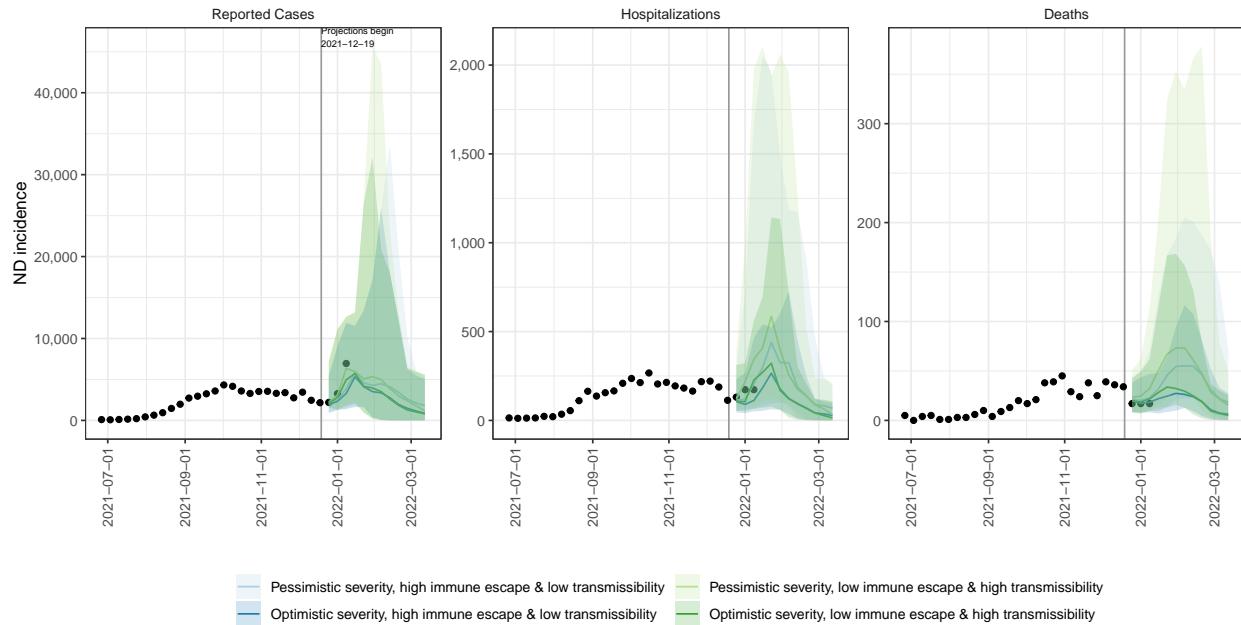
NY ensemble projections & 95% projection intervals



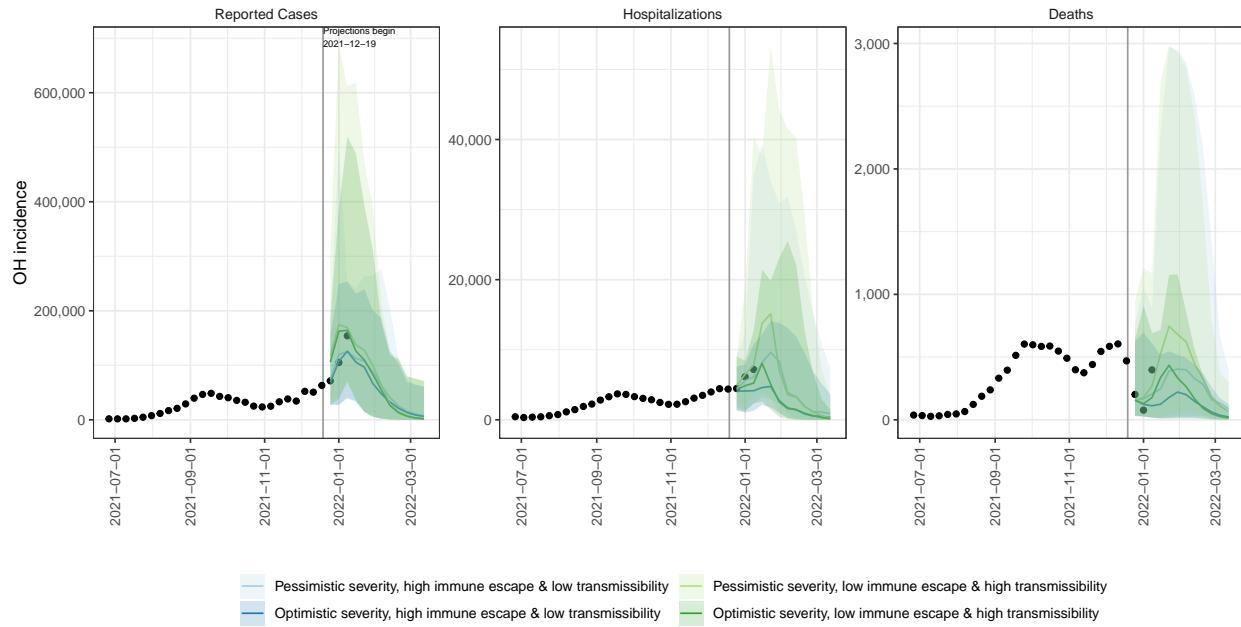
NC ensemble projections & 95% projection intervals



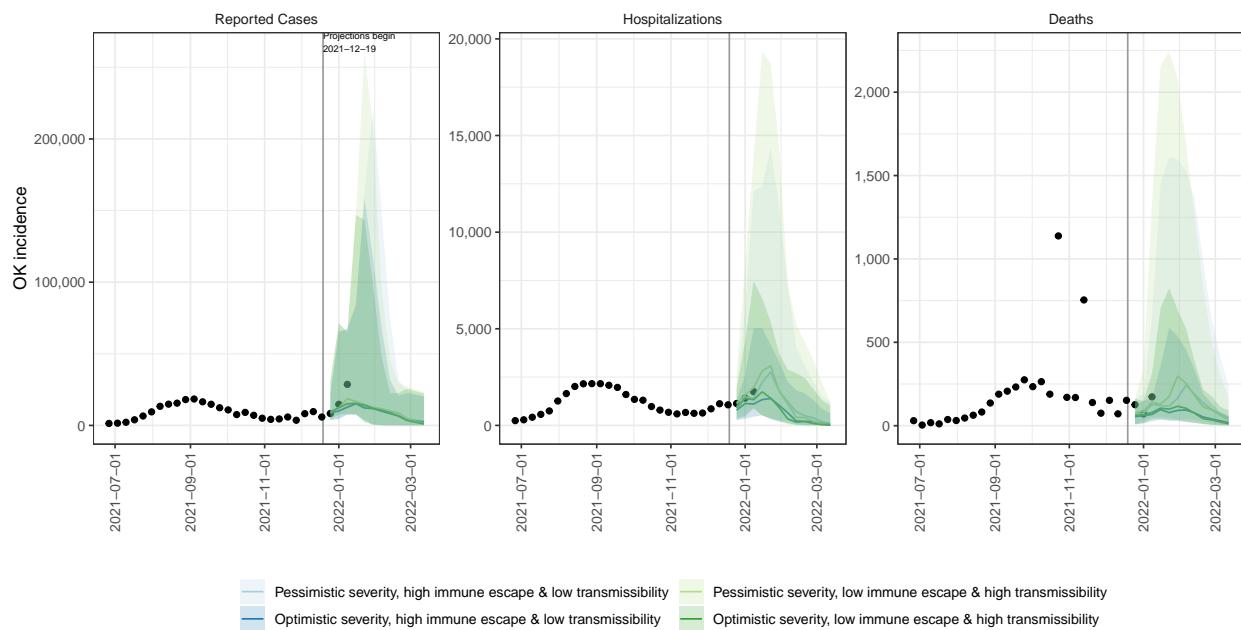
ND ensemble projections & 95% projection intervals



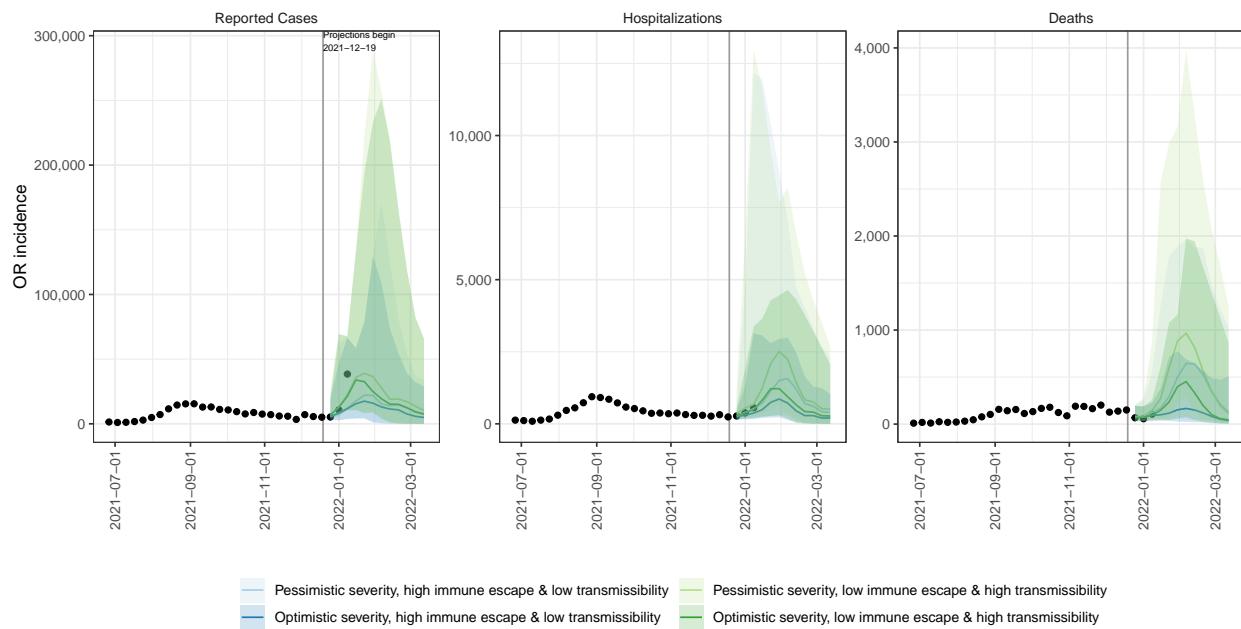
OH ensemble projections & 95% projection intervals



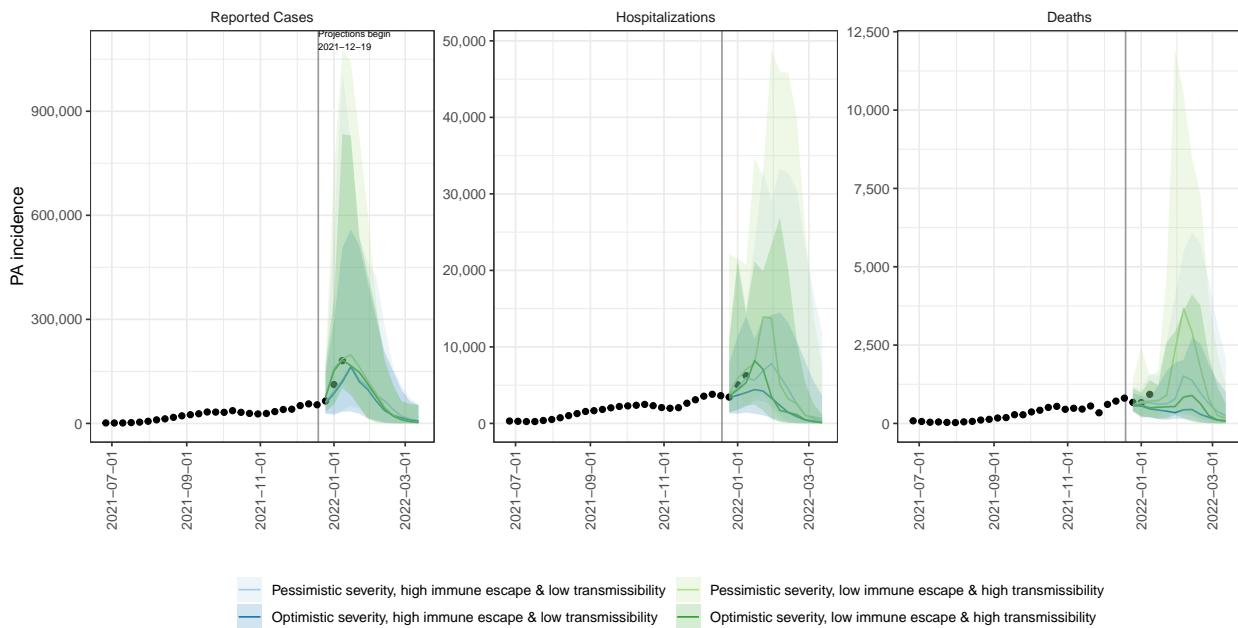
OK ensemble projections & 95% projection intervals



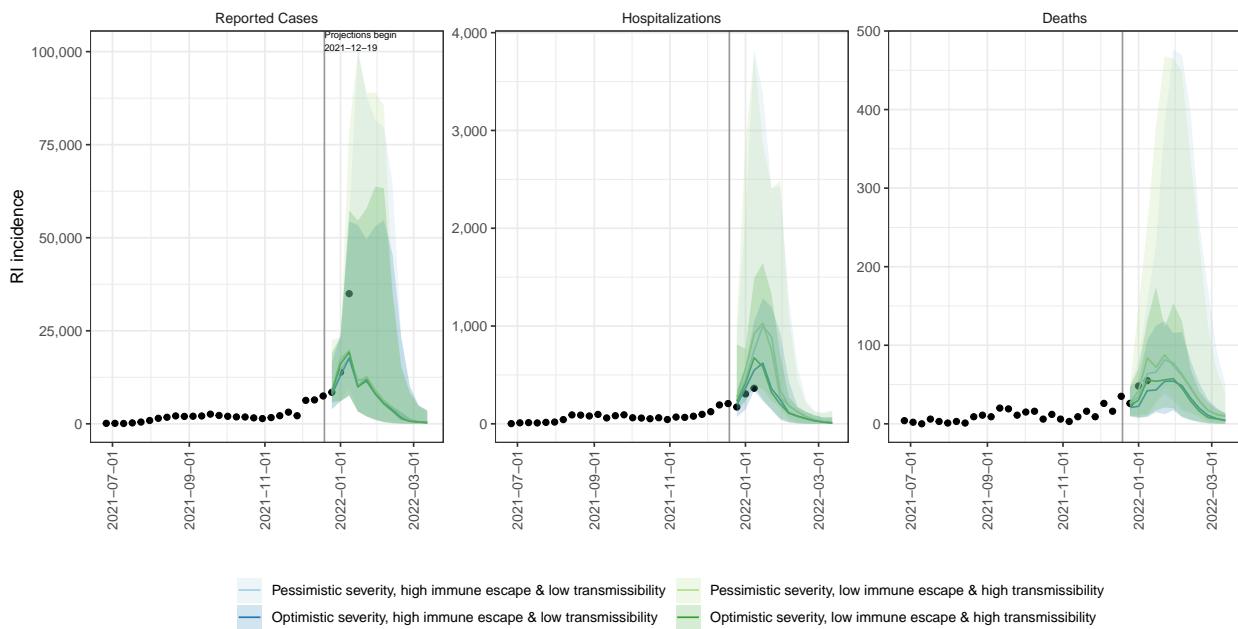
OR ensemble projections & 95% projection intervals



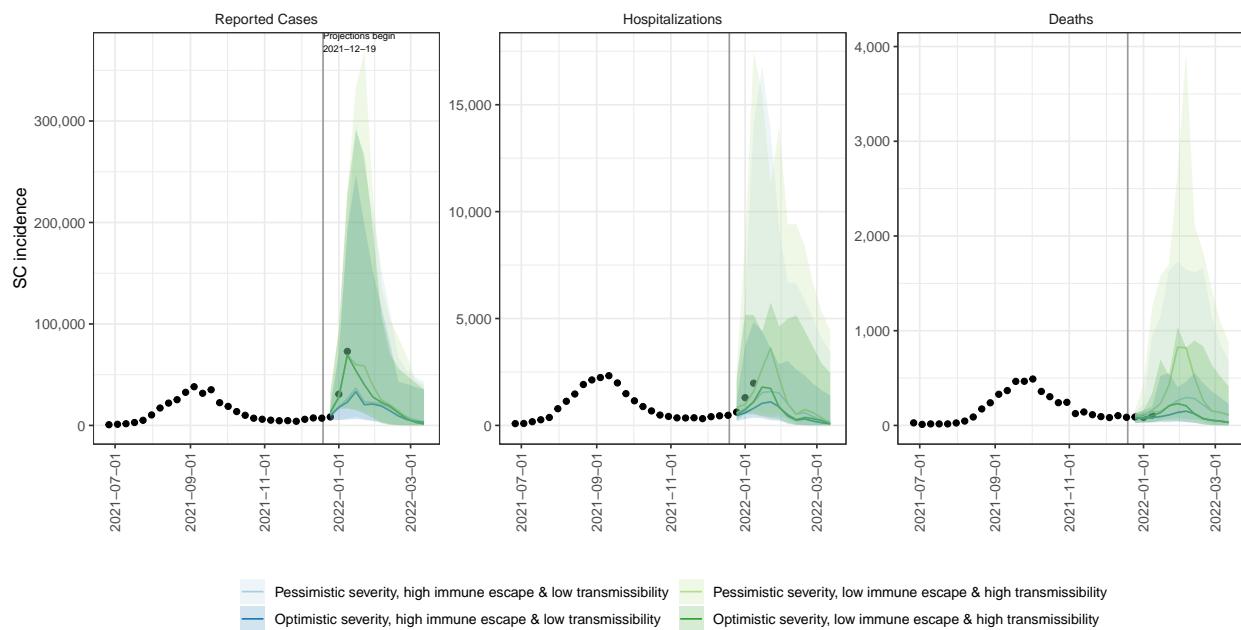
PA ensemble projections & 95% projection intervals



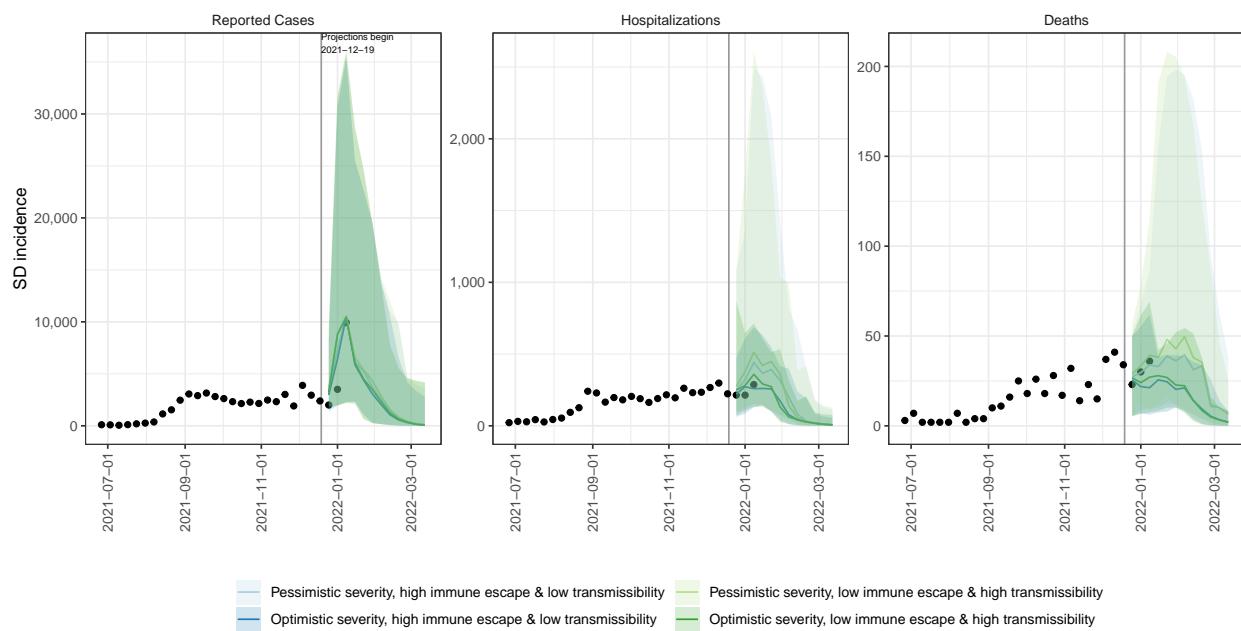
RI ensemble projections & 95% projection intervals



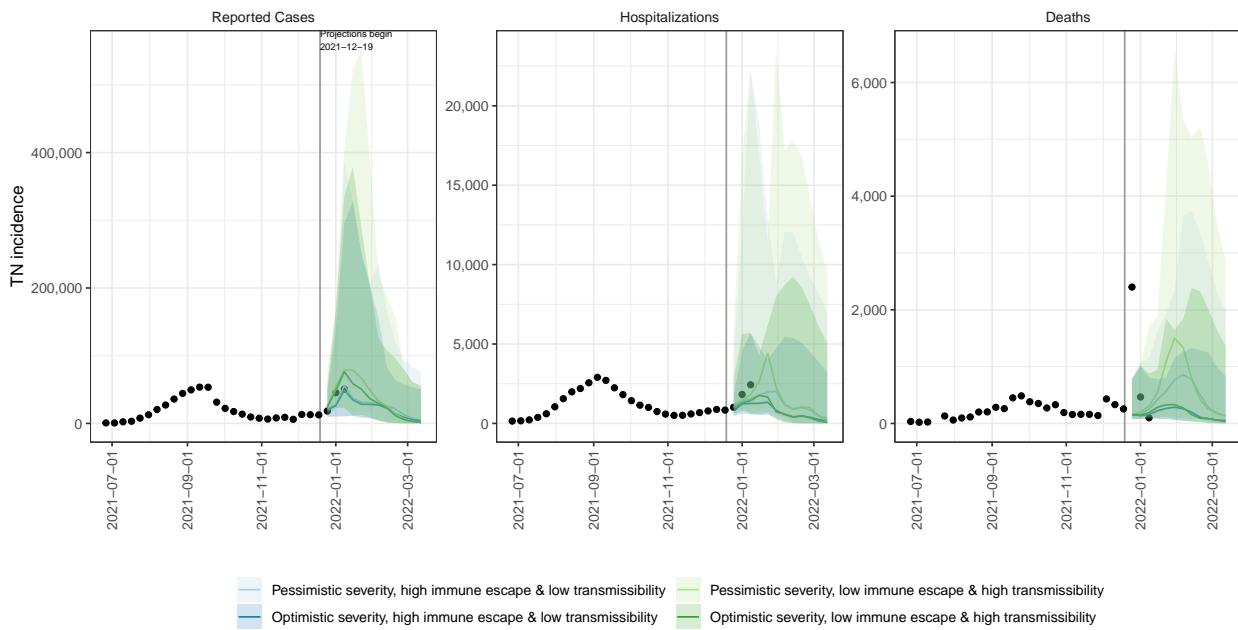
SC ensemble projections & 95% projection intervals



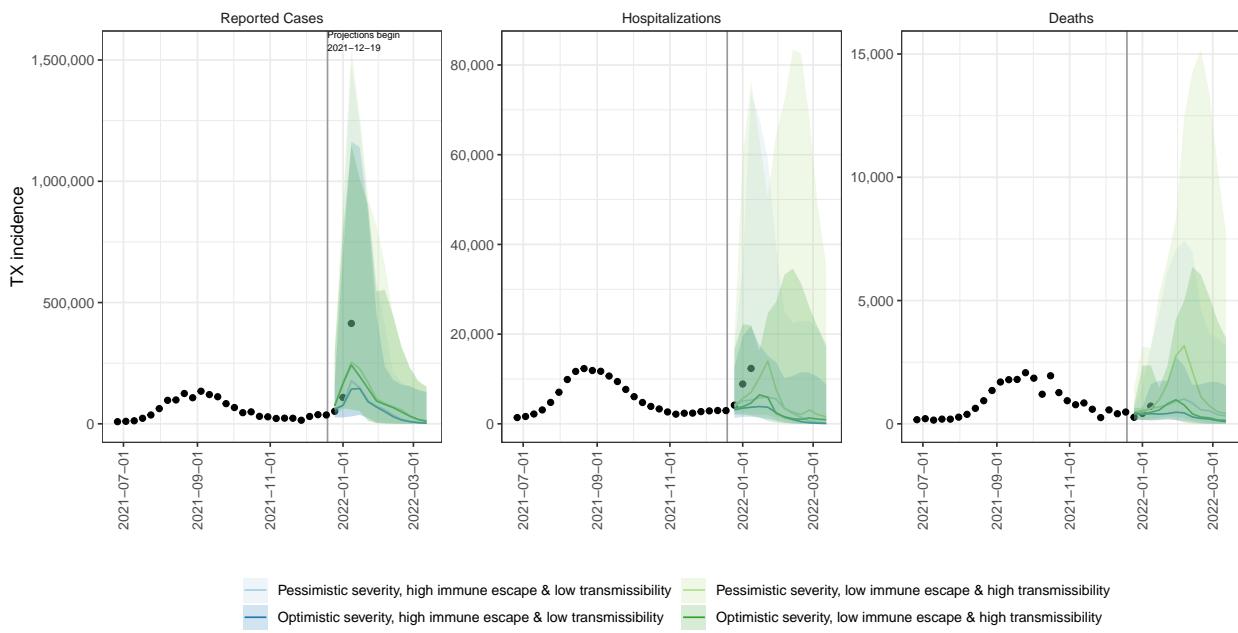
SD ensemble projections & 95% projection intervals



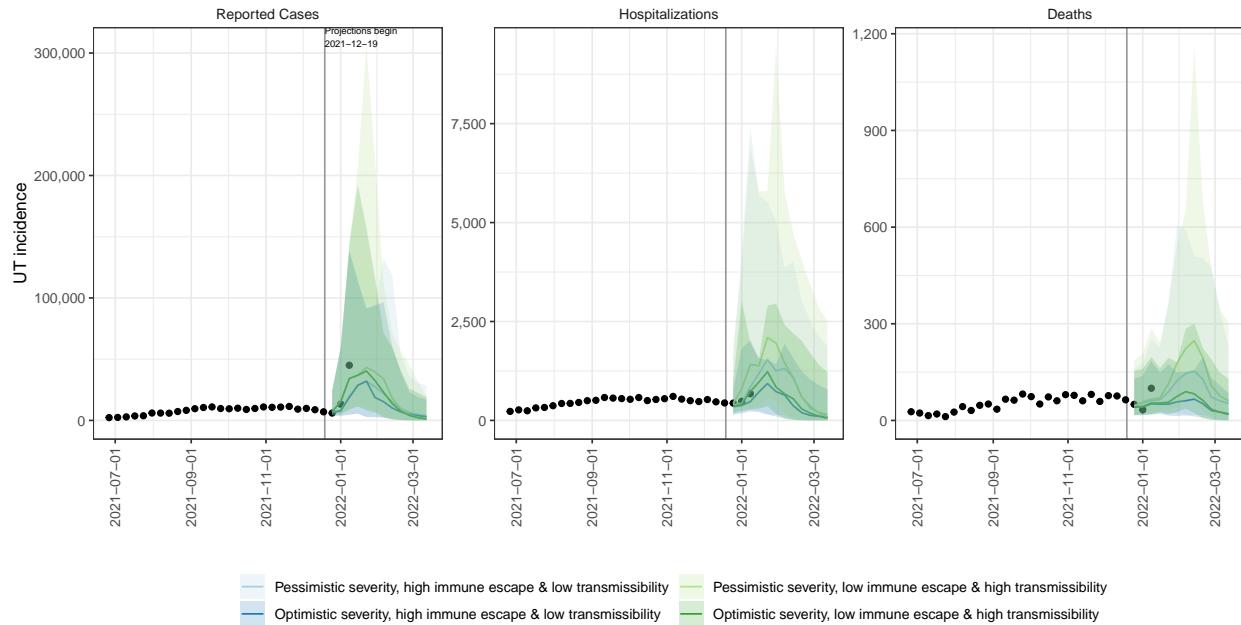
TN ensemble projections & 95% projection intervals



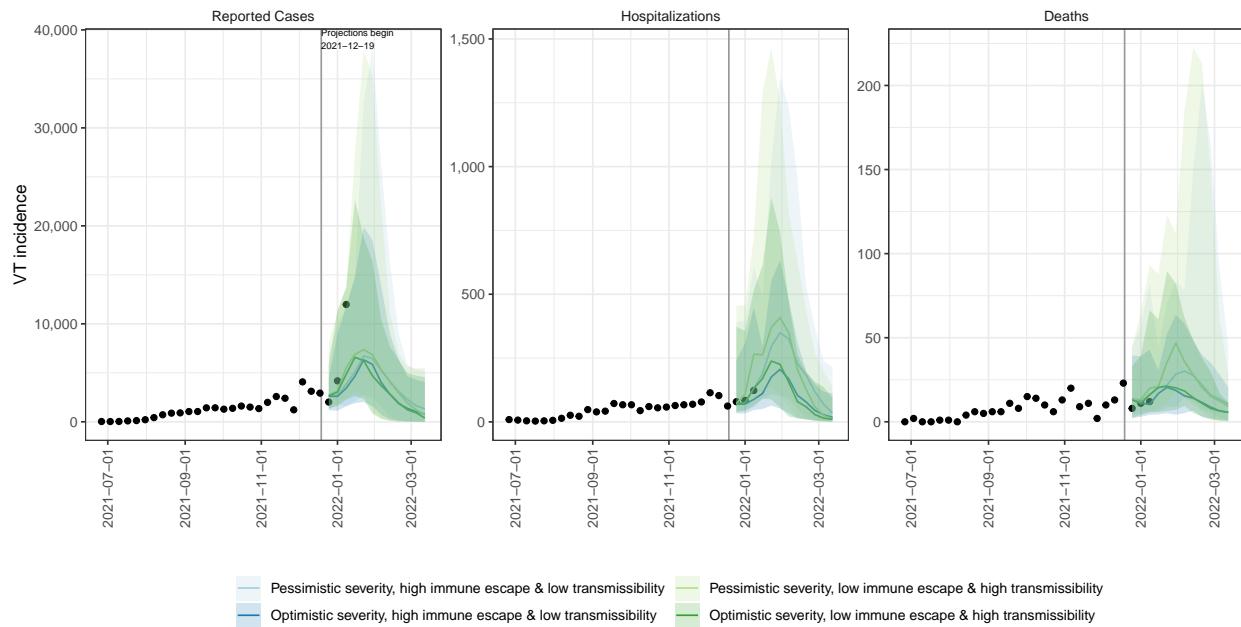
TX ensemble projections & 95% projection intervals



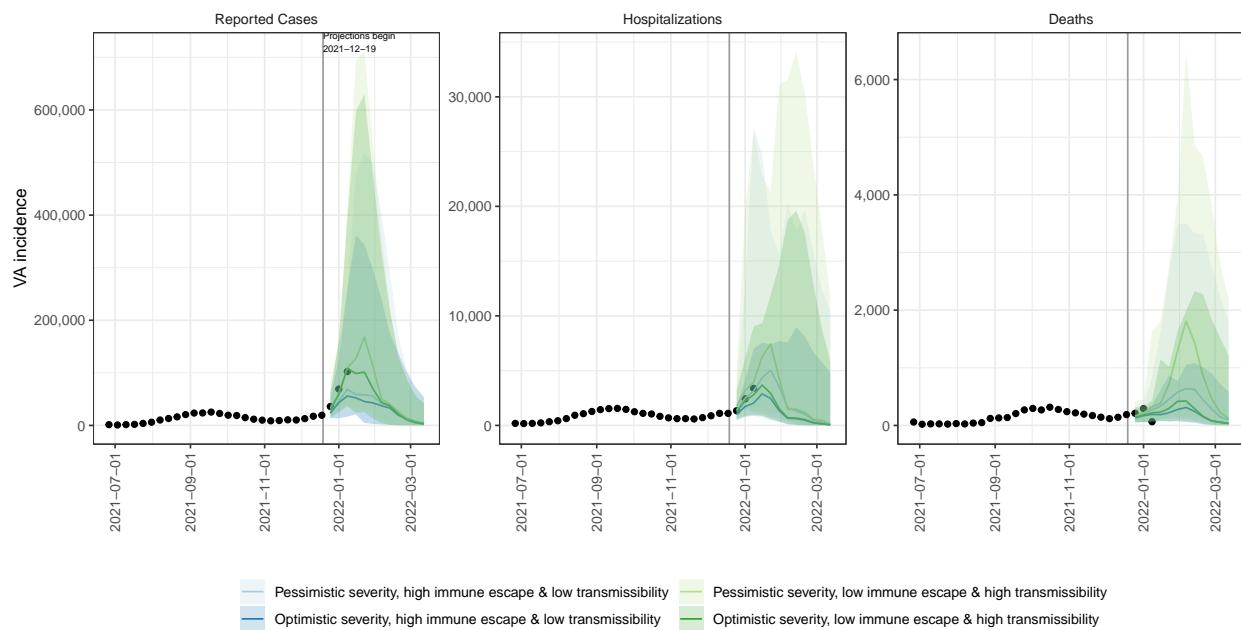
UT ensemble projections & 95% projection intervals



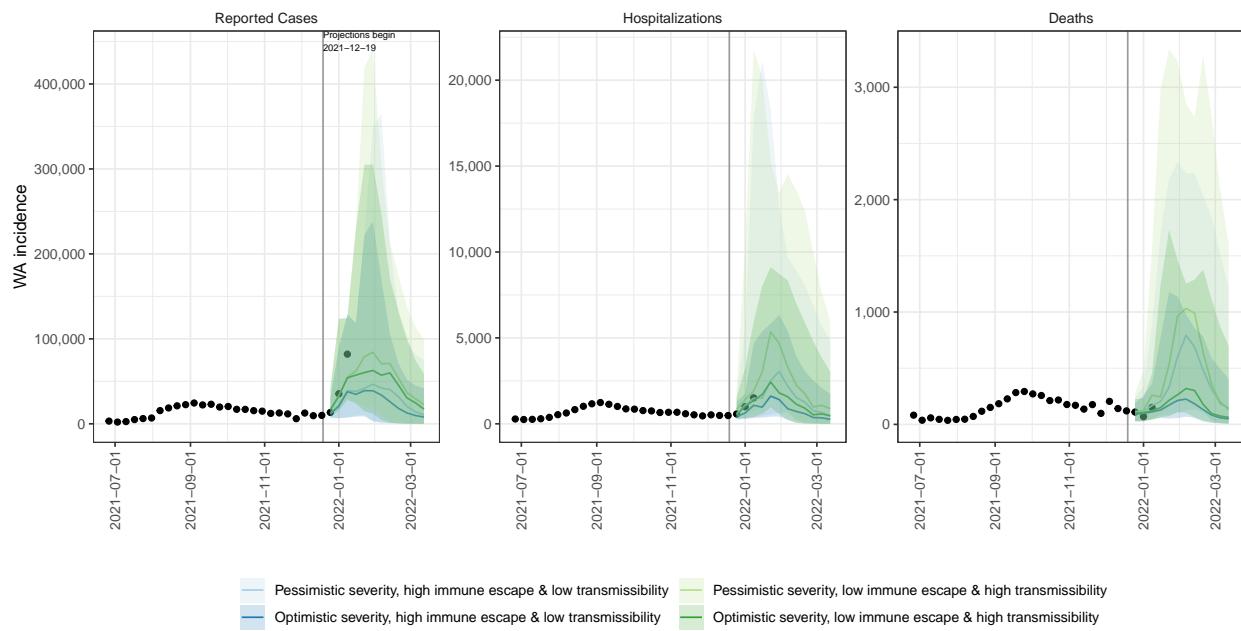
VT ensemble projections & 95% projection intervals



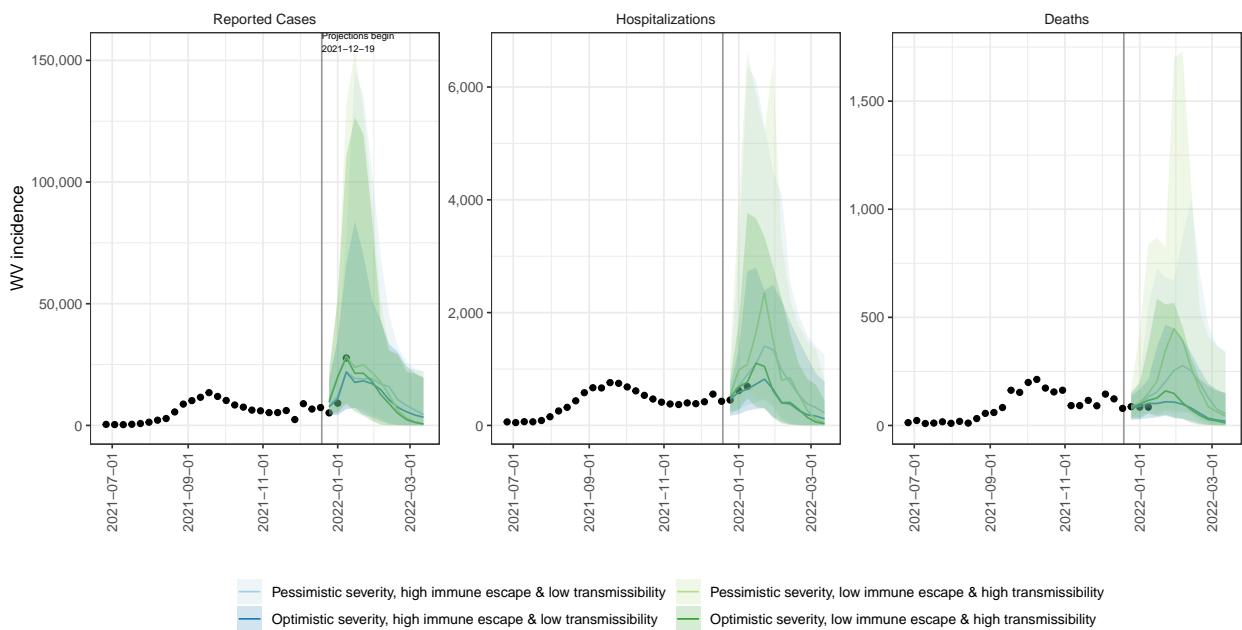
VA ensemble projections & 95% projection intervals



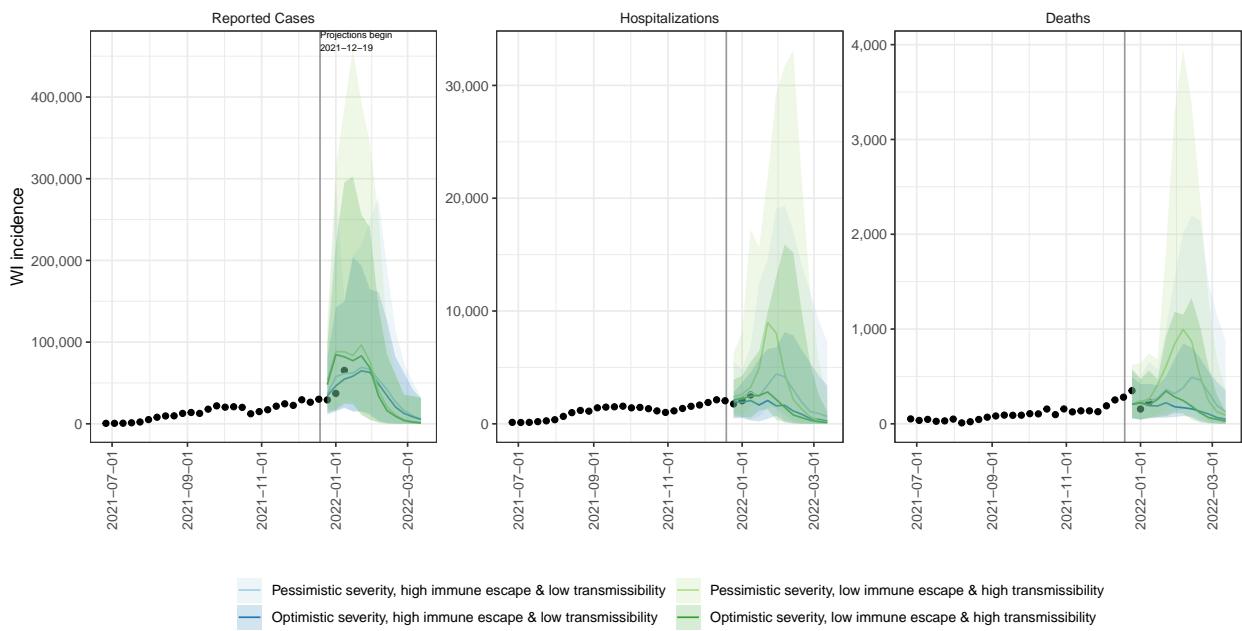
WA ensemble projections & 95% projection intervals



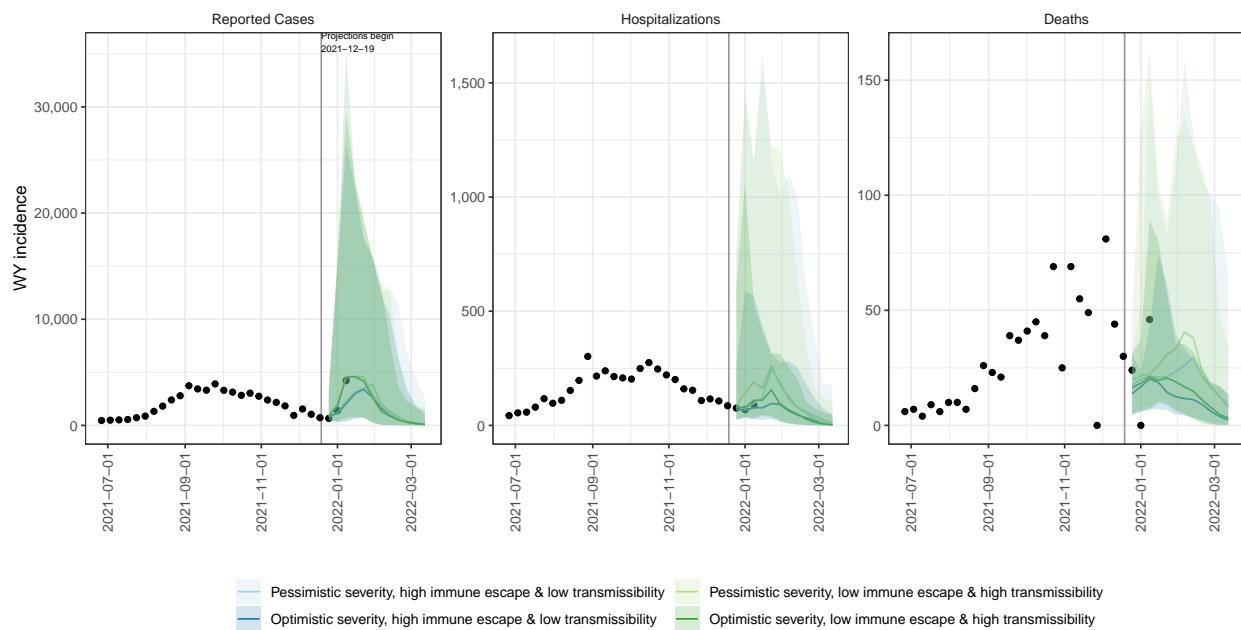
WV ensemble projections & 95% projection intervals



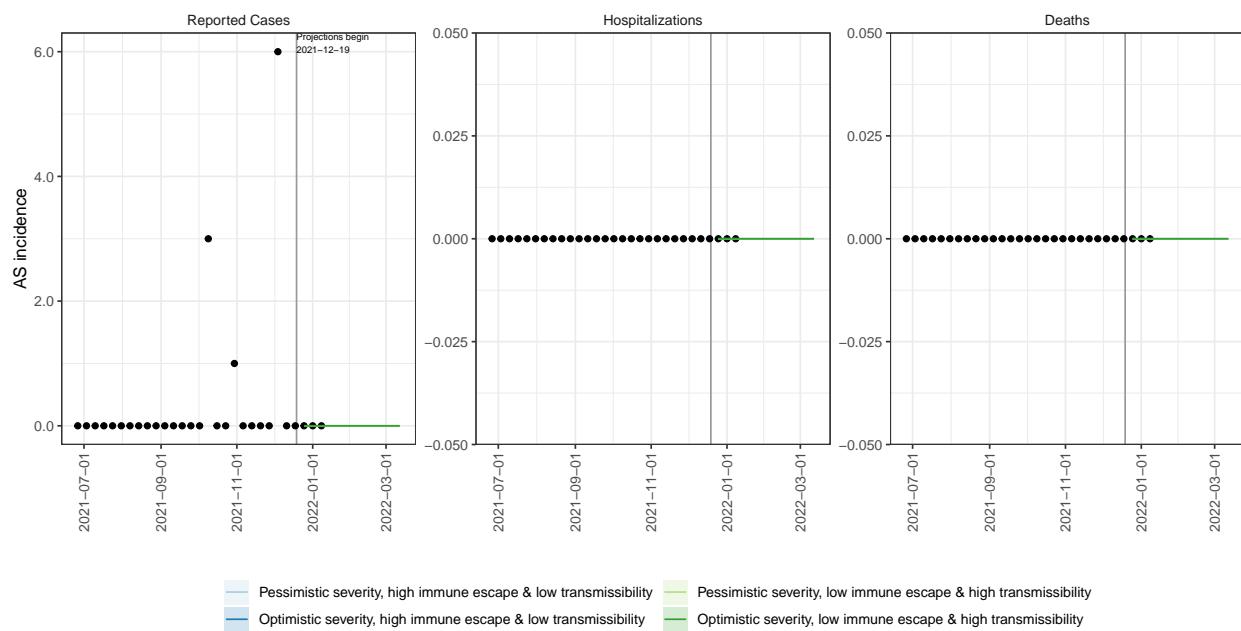
WI ensemble projections & 95% projection intervals



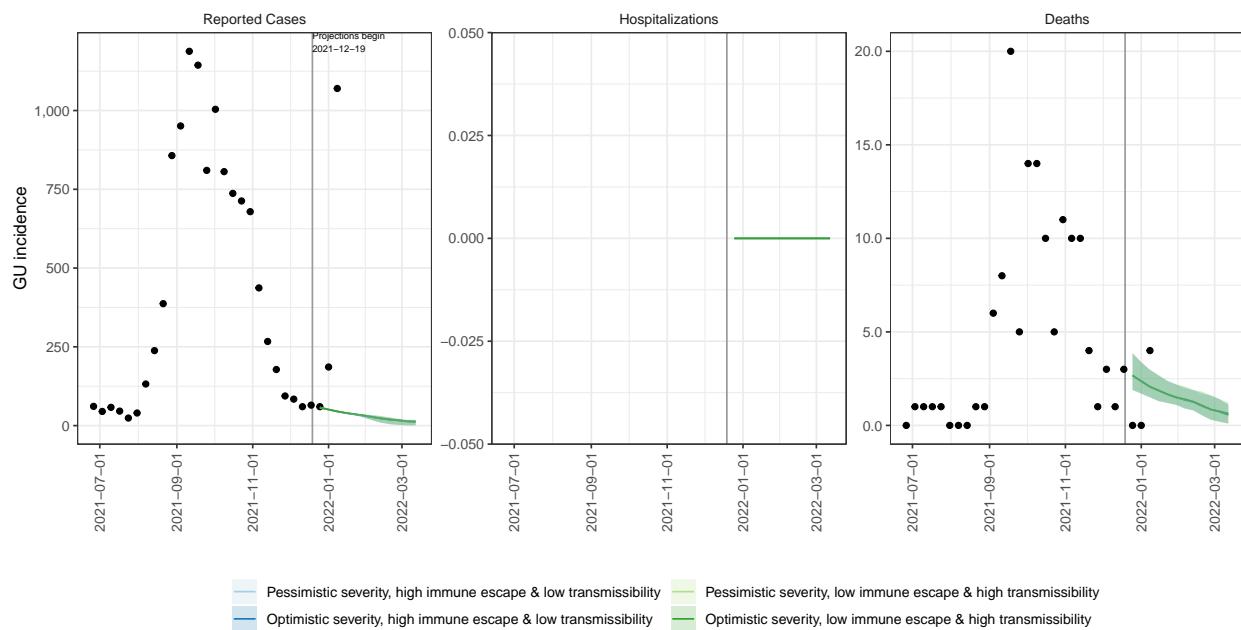
WY ensemble projections & 95% projection intervals



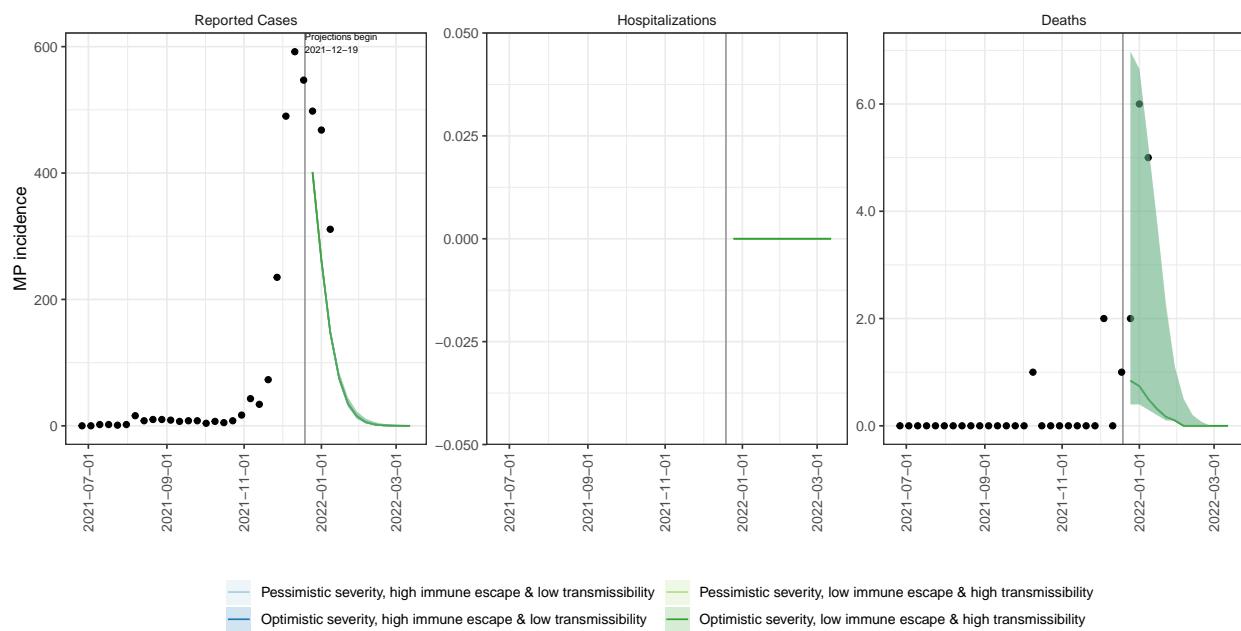
AS ensemble projections & 95% projection intervals

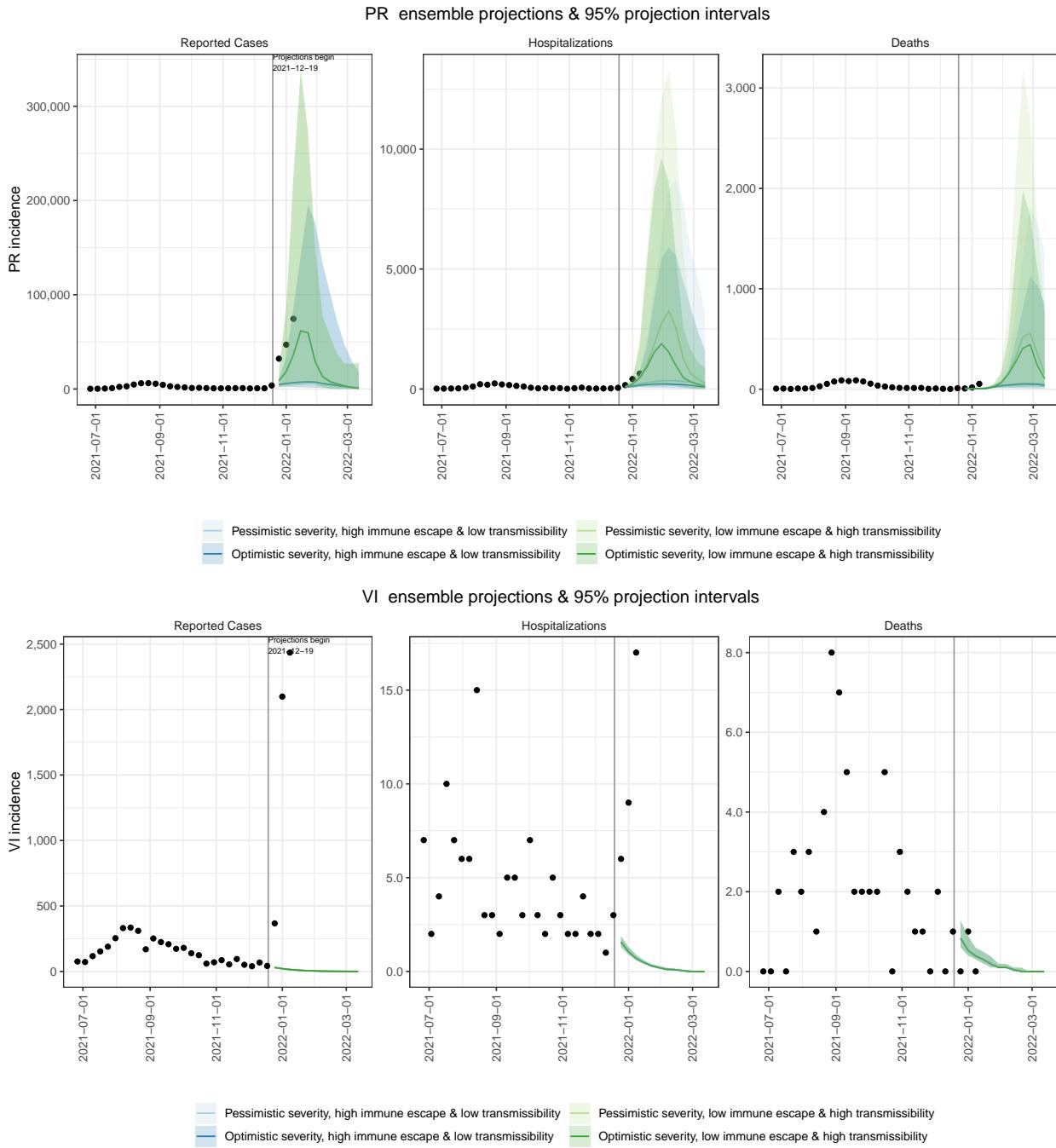


GU ensemble projections & 95% projection intervals



MP ensemble projections & 95% projection intervals

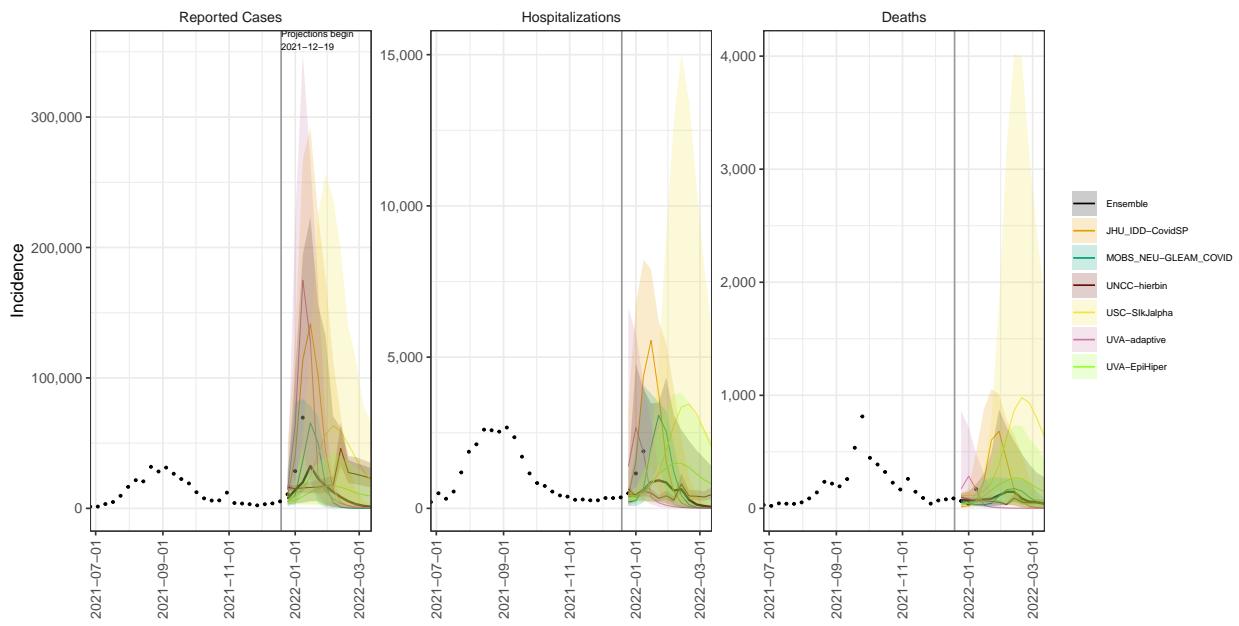




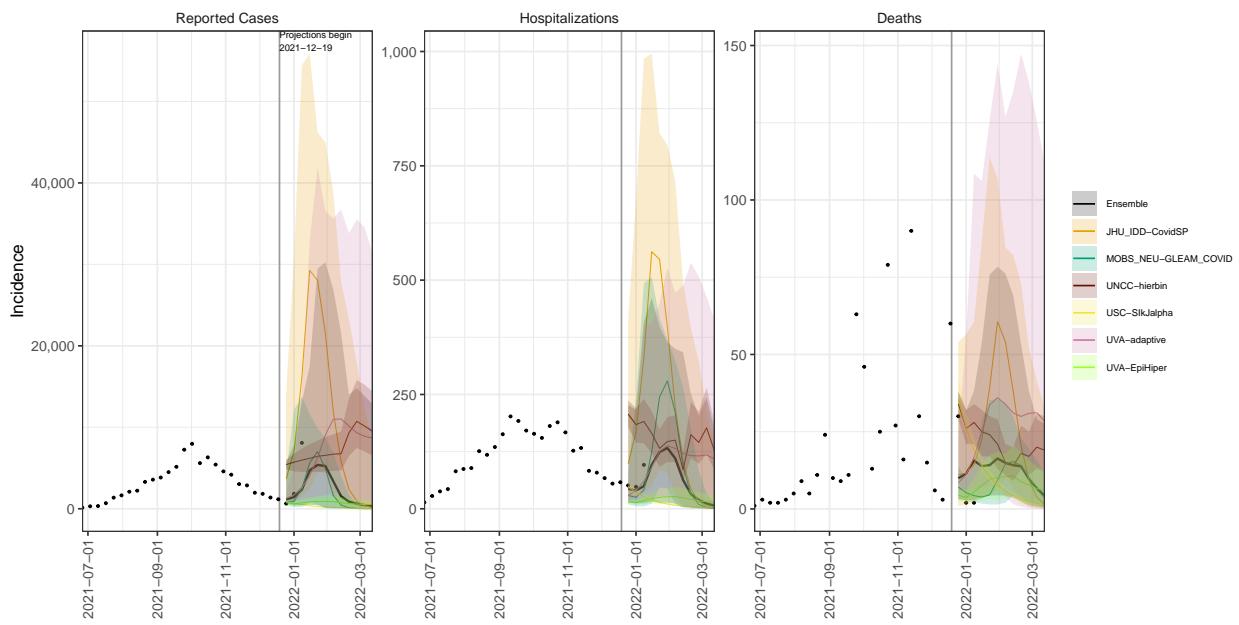
State-level model variation

National model variation for optimistic severity, high immune escape & low transmissibility scenario.

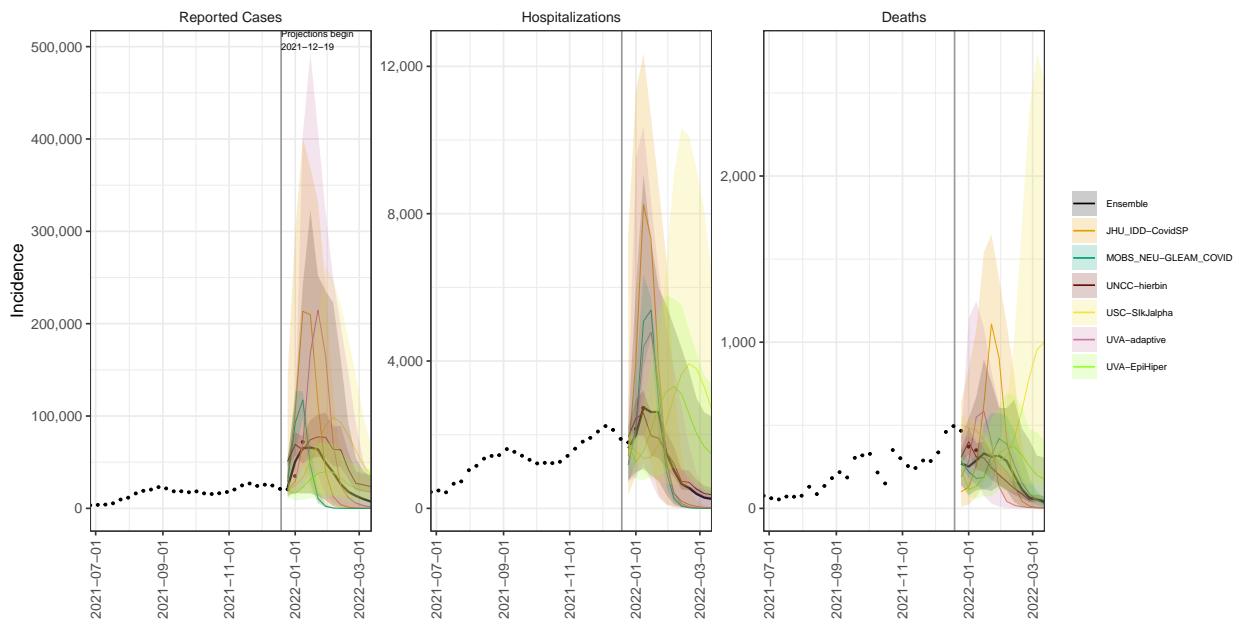
AL model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



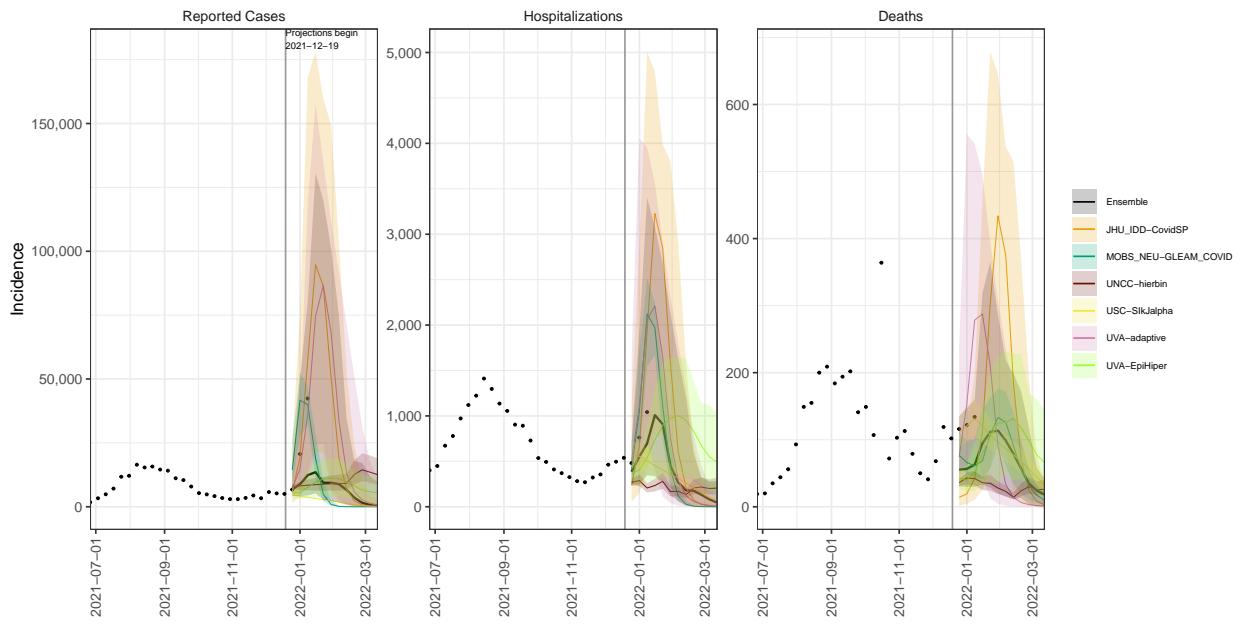
AK model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



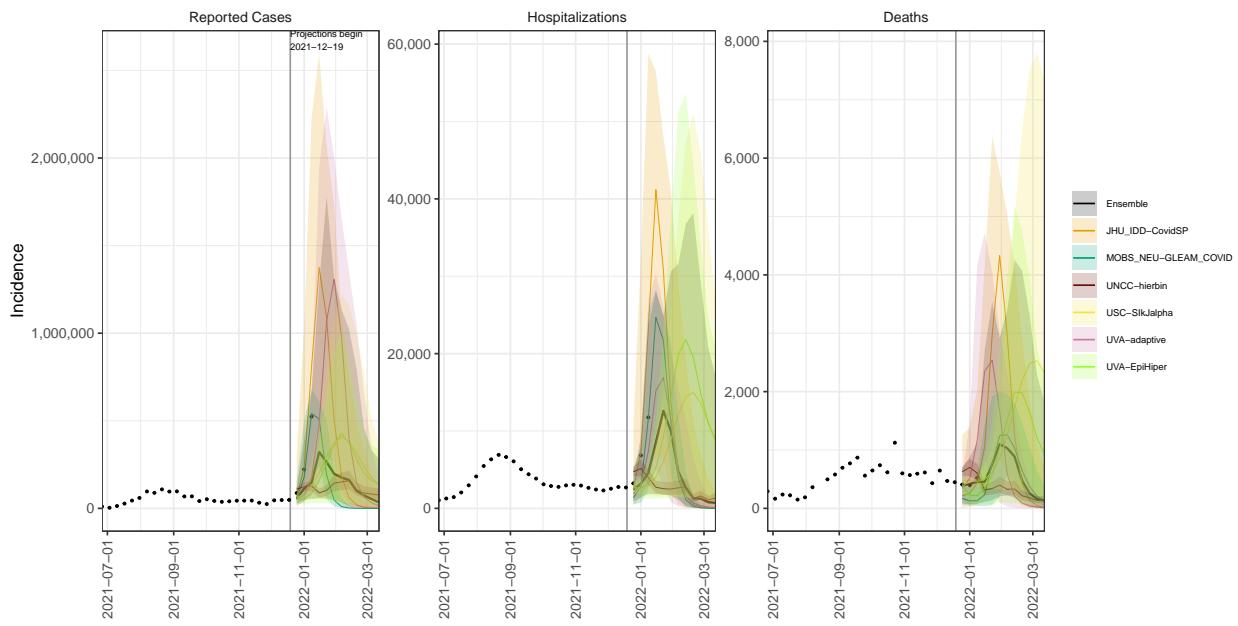
AZ model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



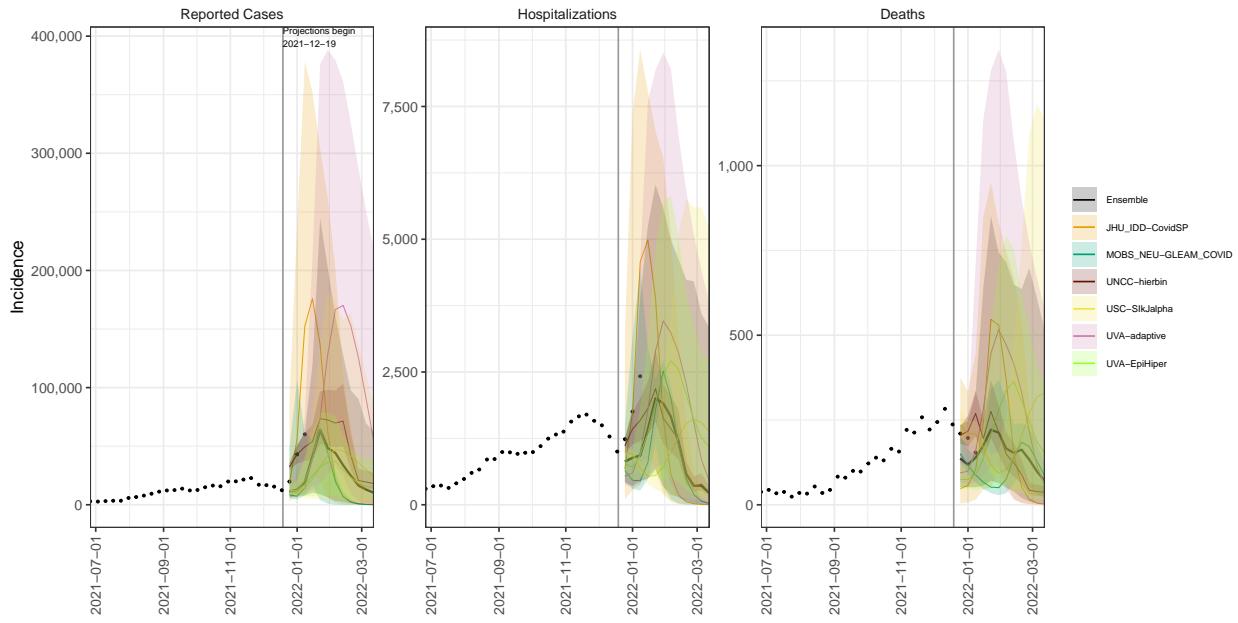
AR model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



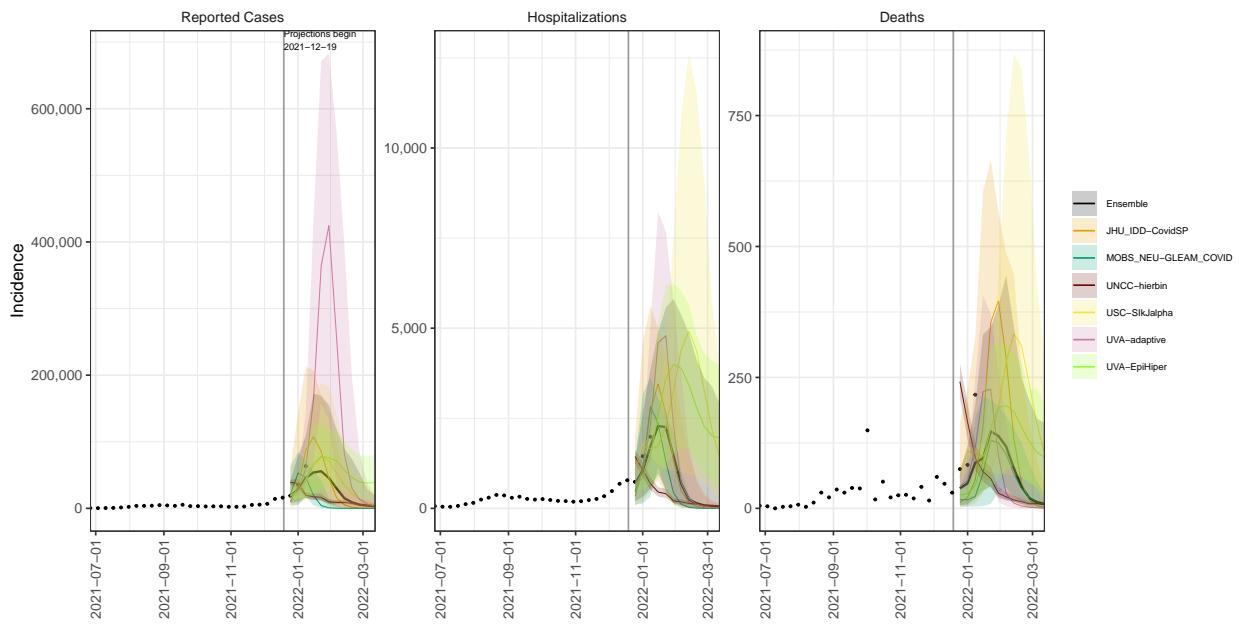
CA model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



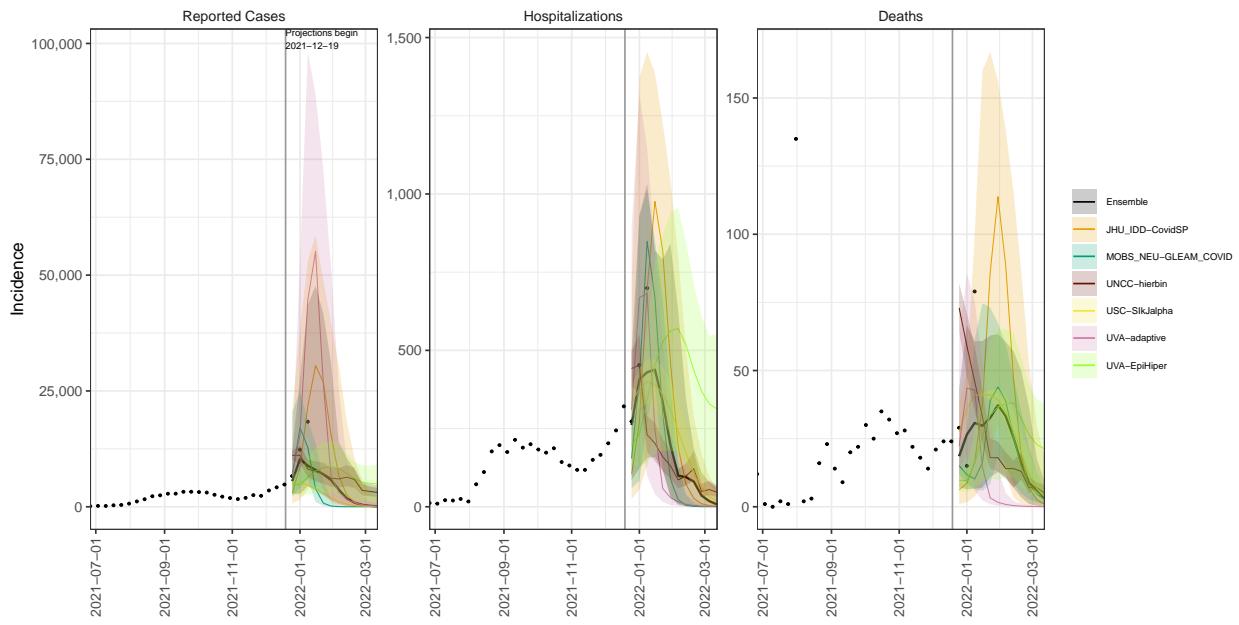
CO model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



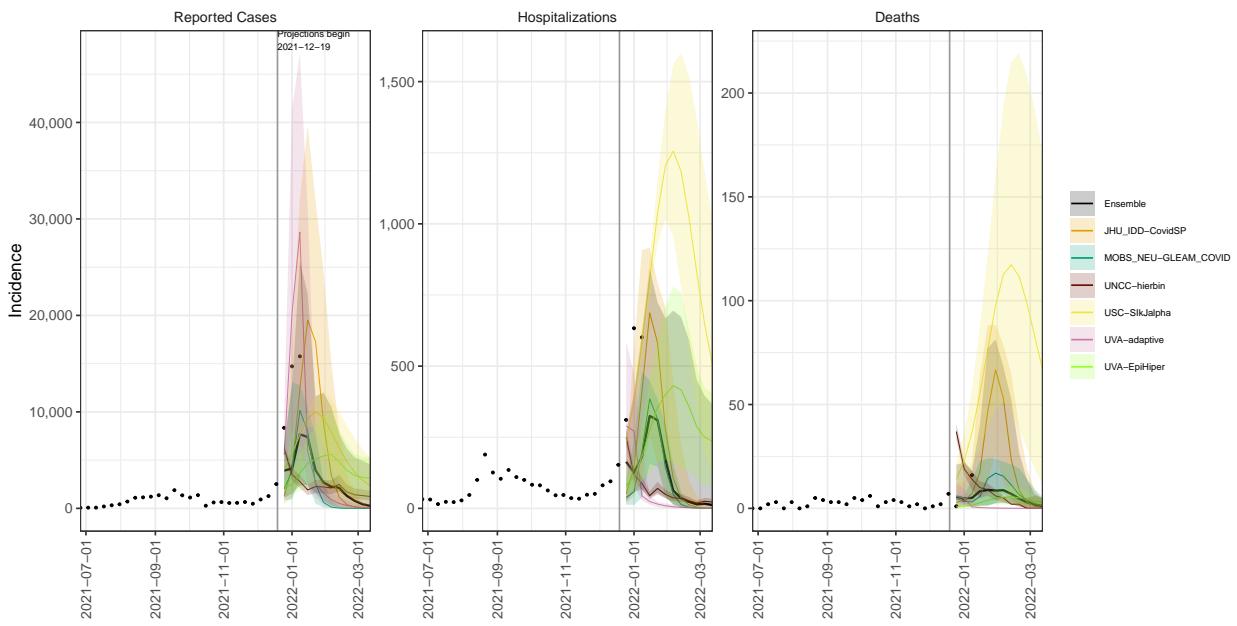
CT model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



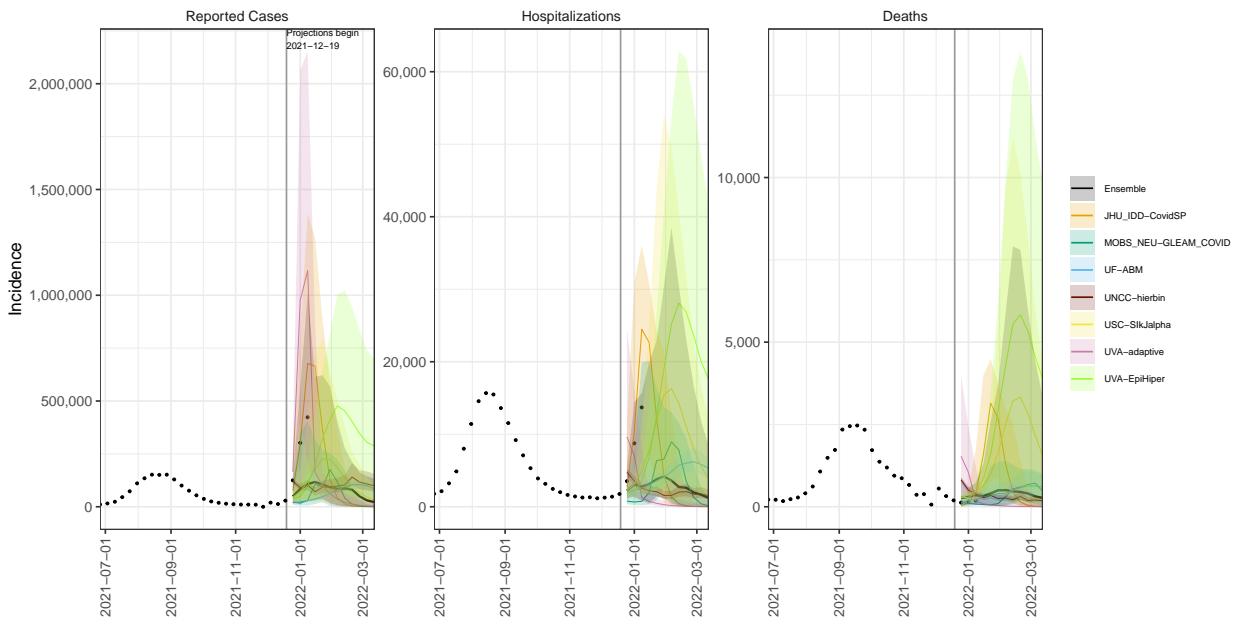
DE model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



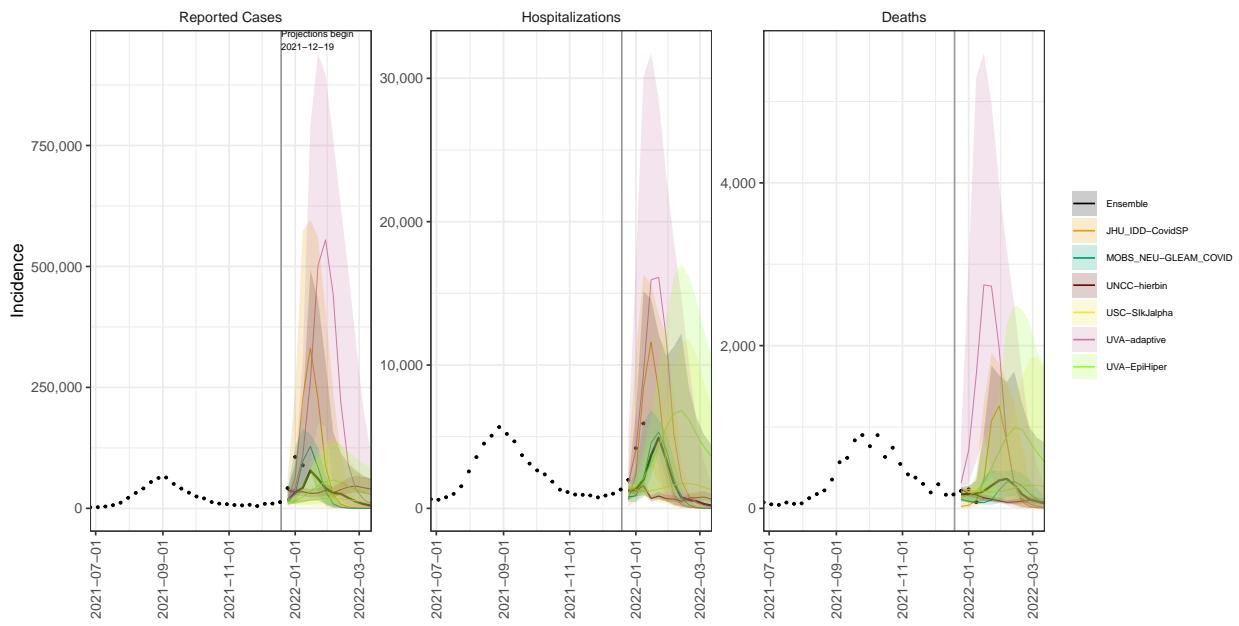
DC model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



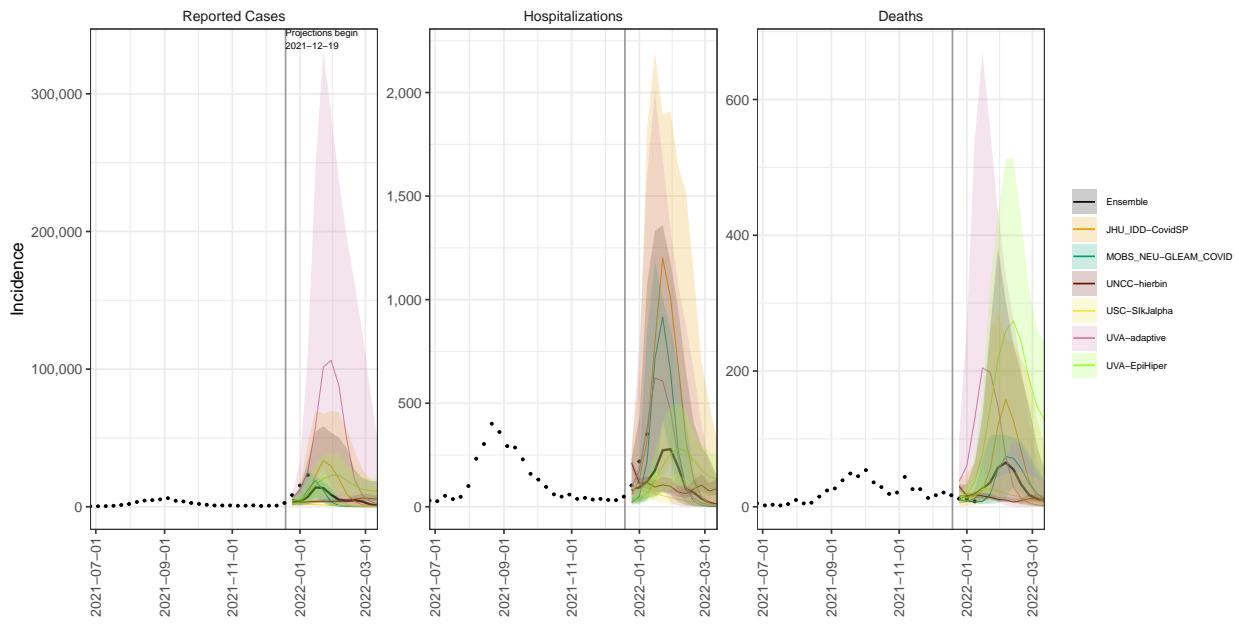
FL model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



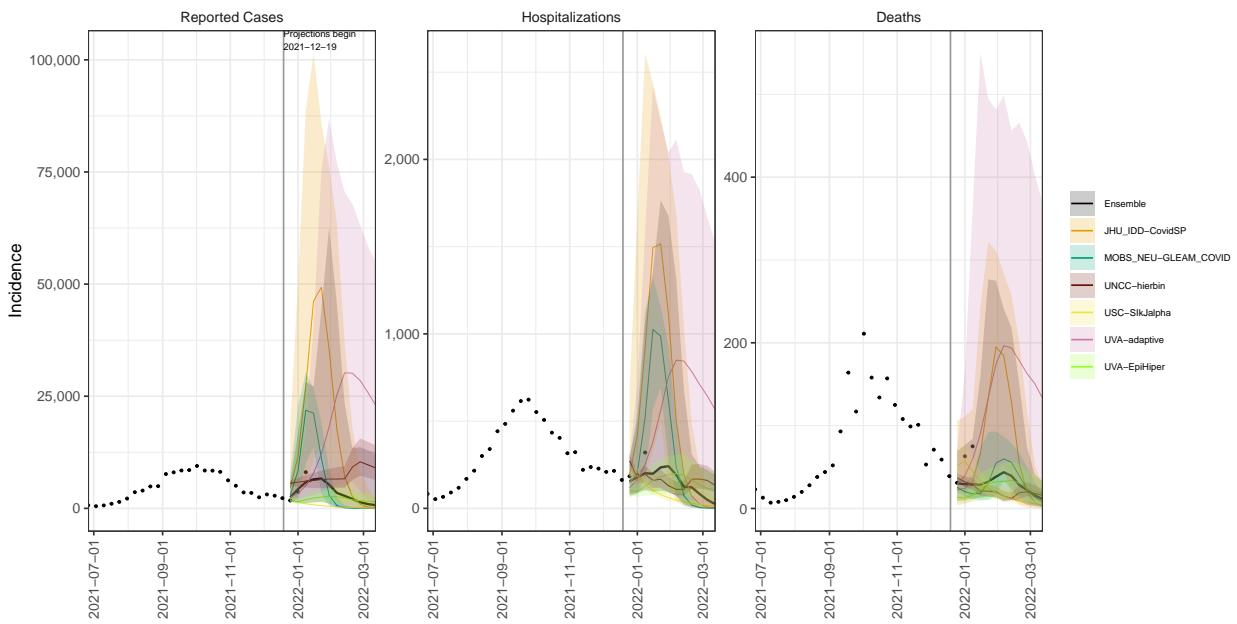
GA model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



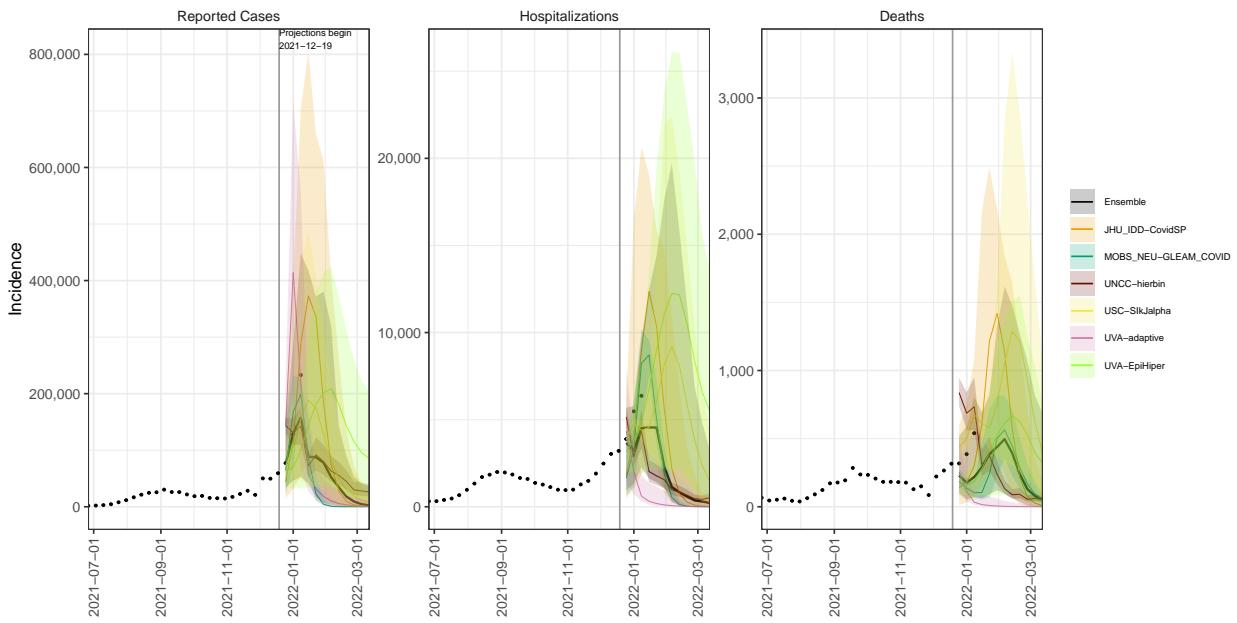
HI model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



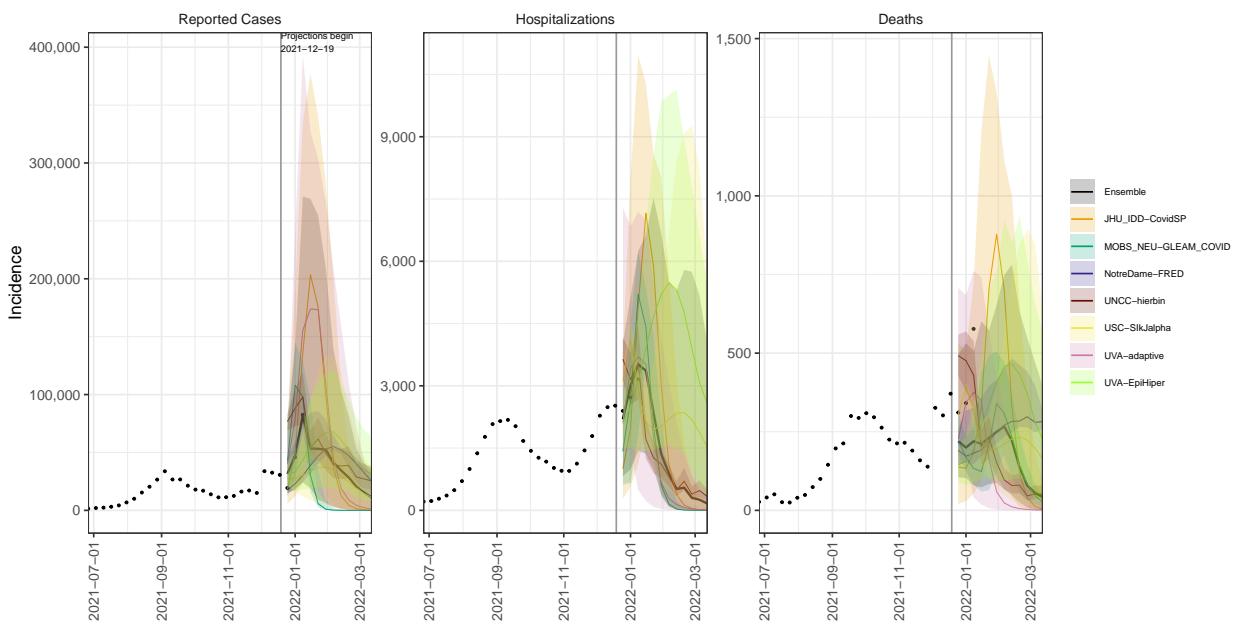
ID model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



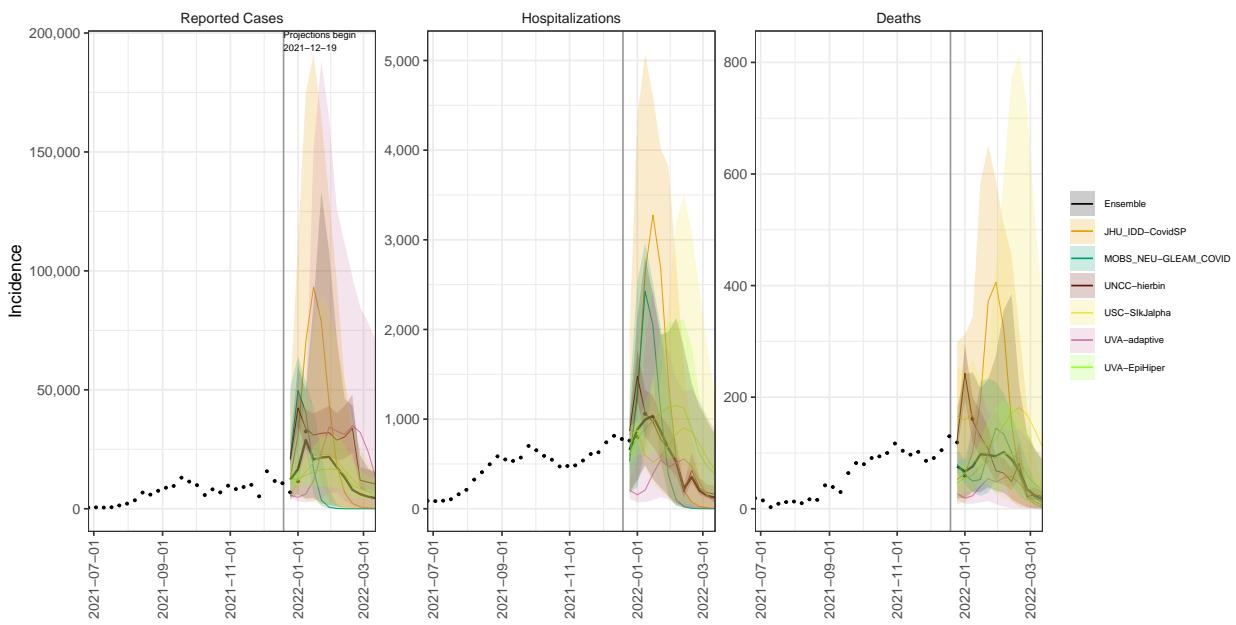
IL model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



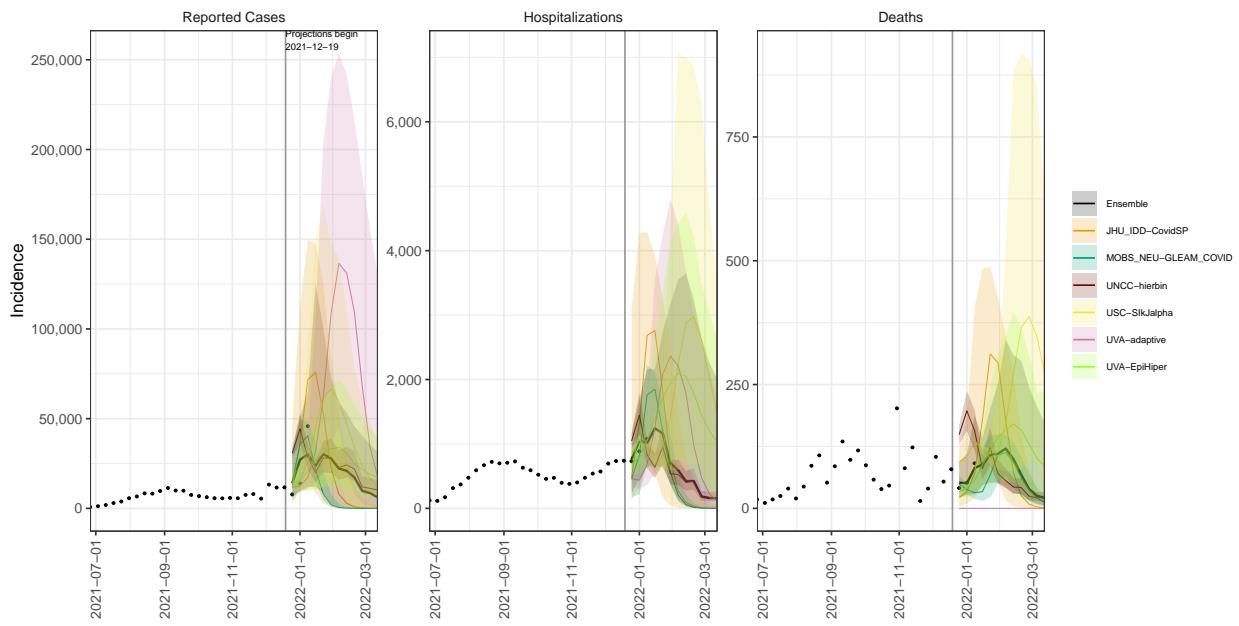
IN model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



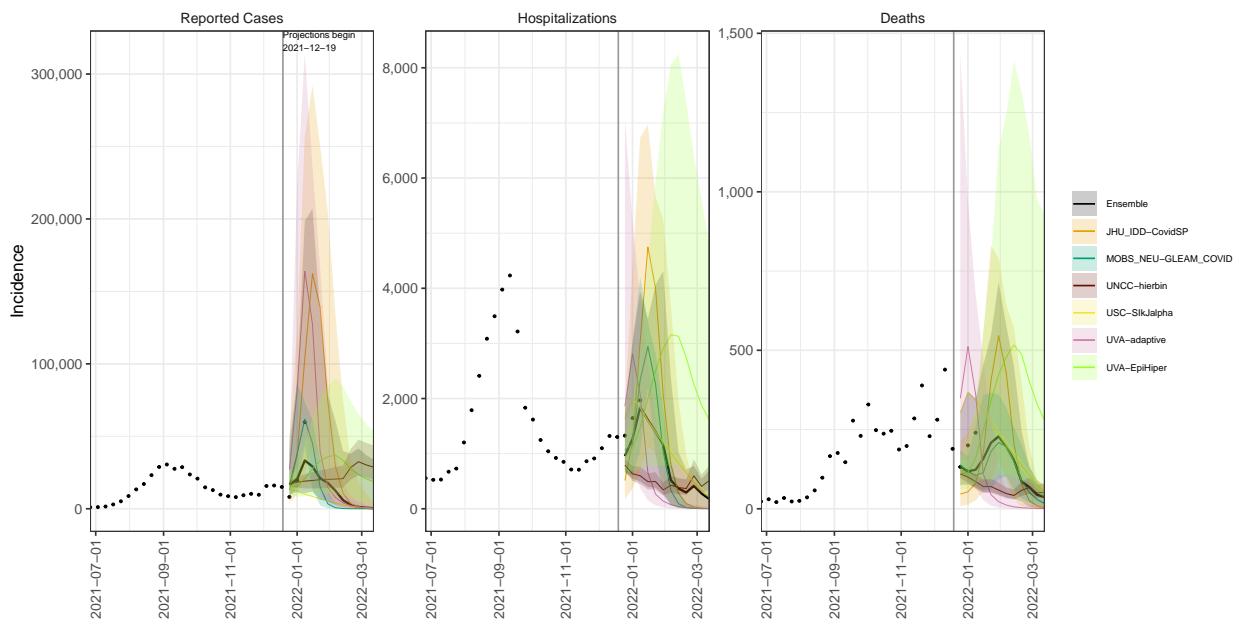
IA model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



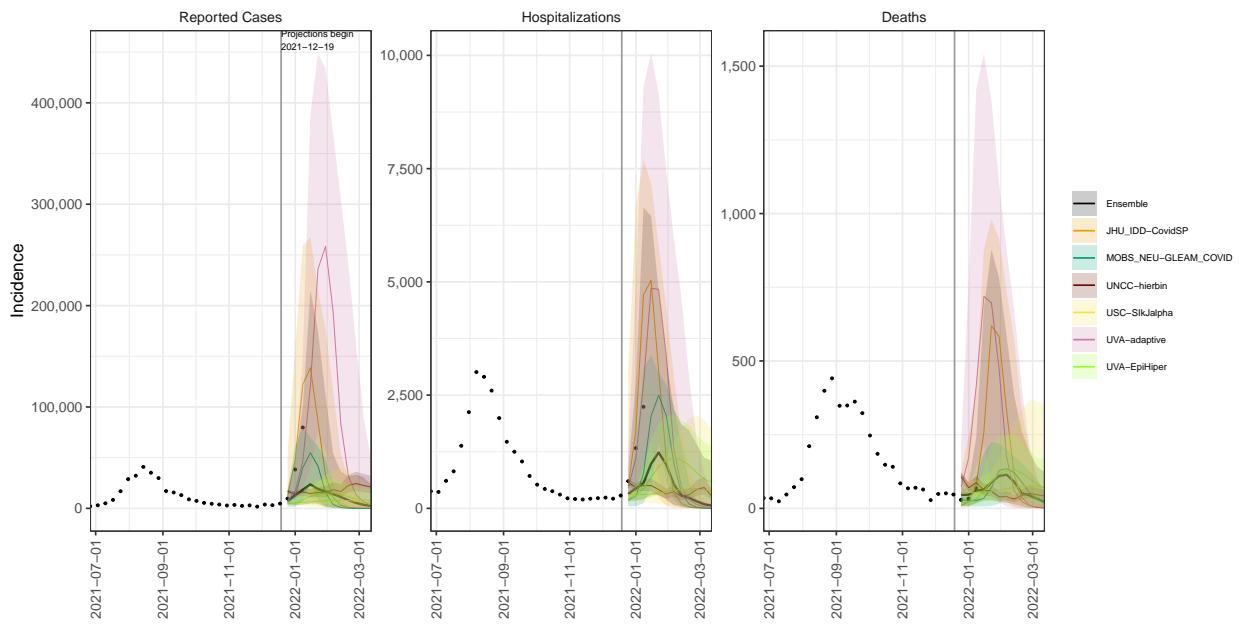
KS model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



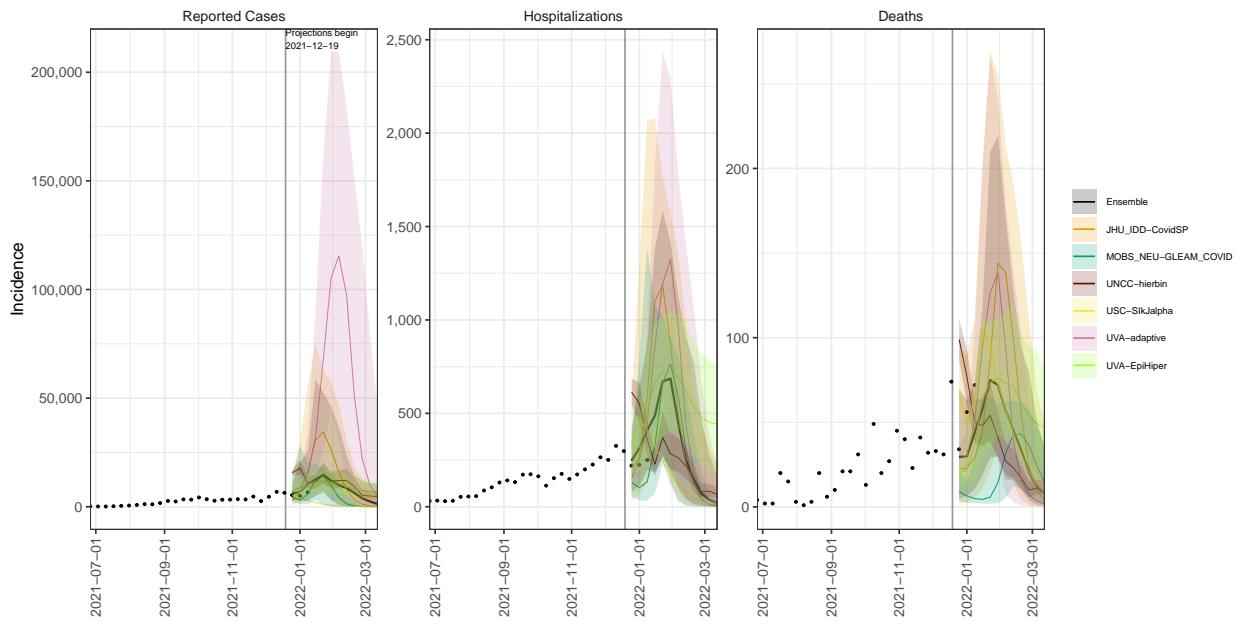
KY model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



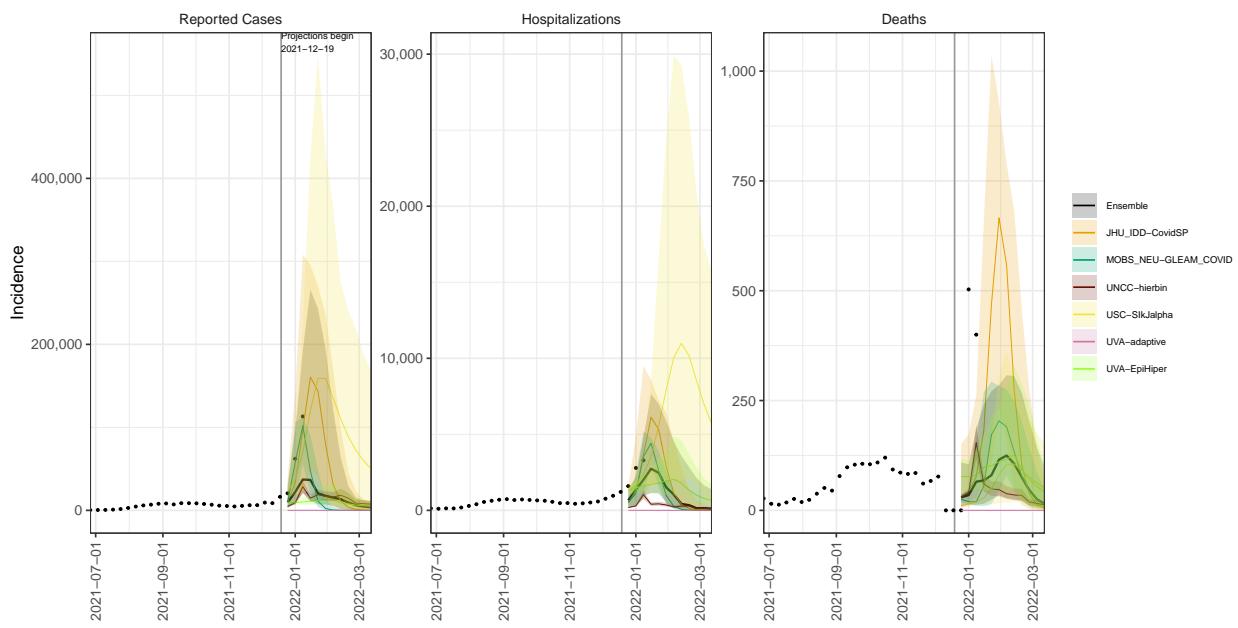
LA model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



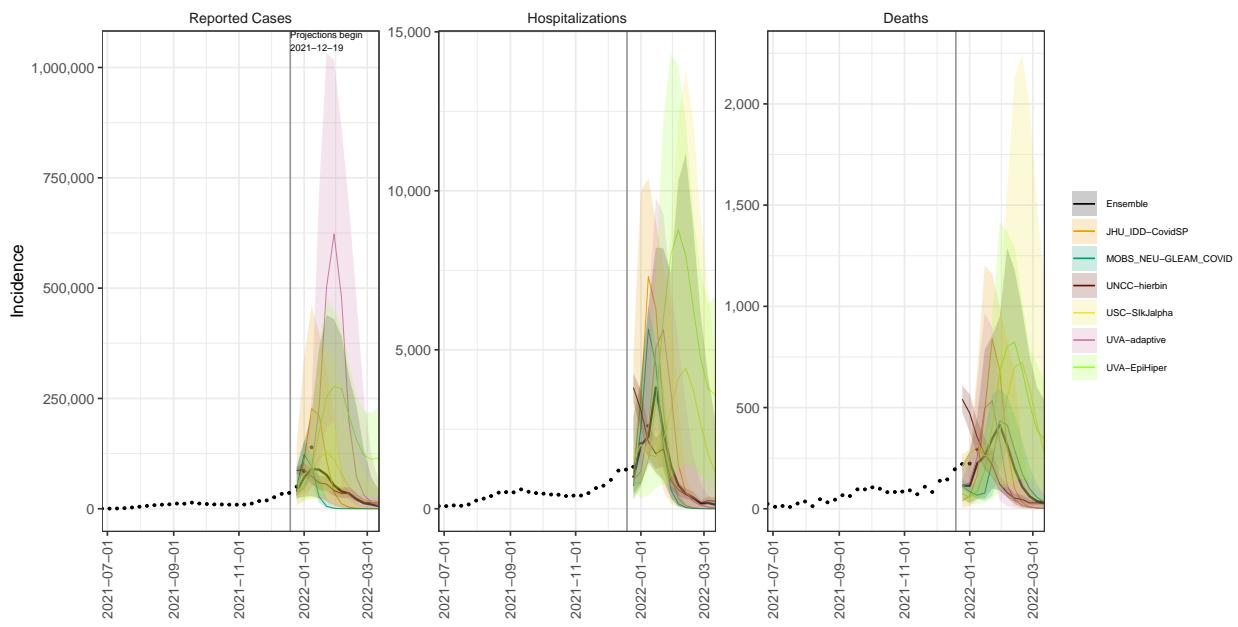
ME model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



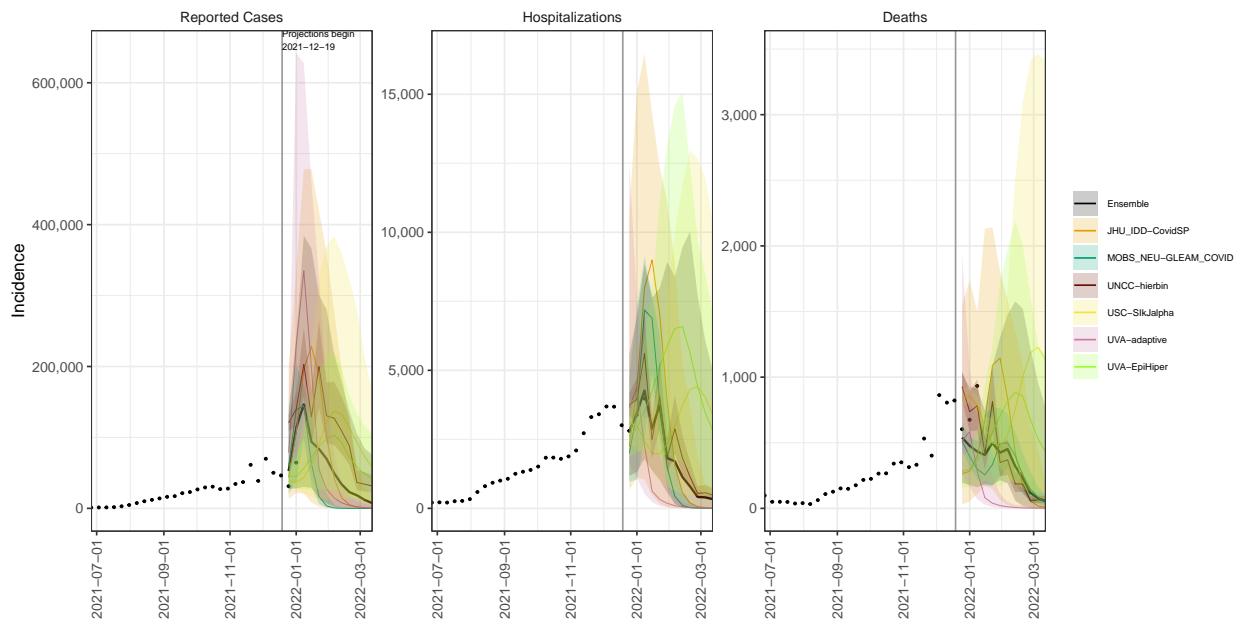
MD model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



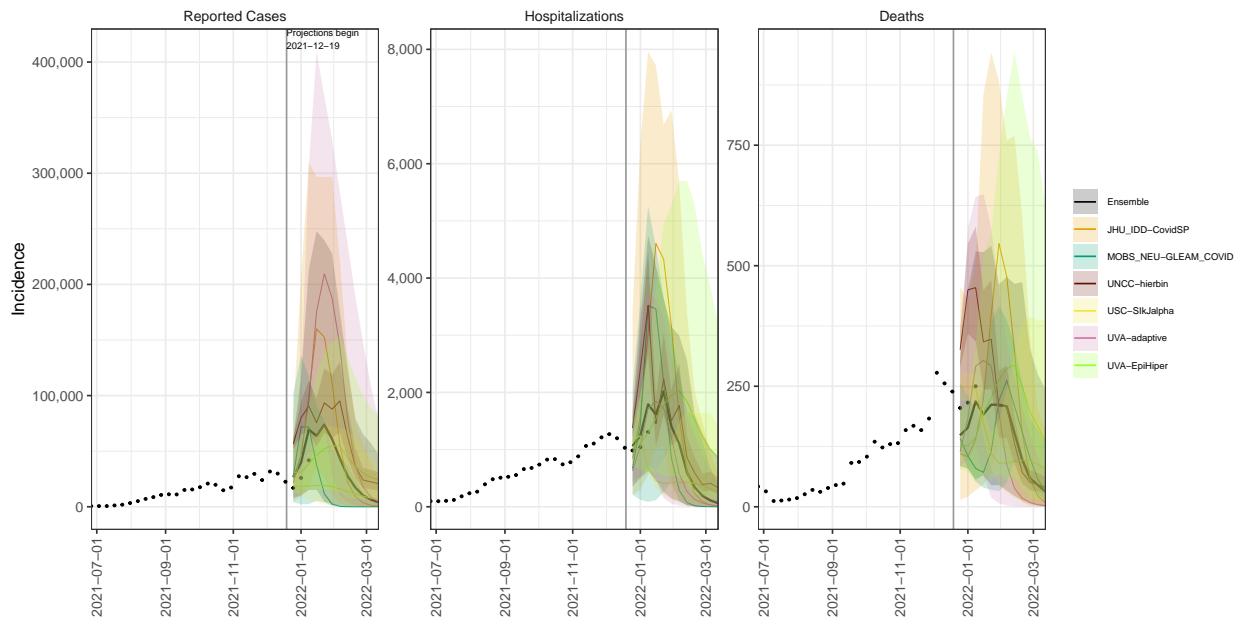
MA model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



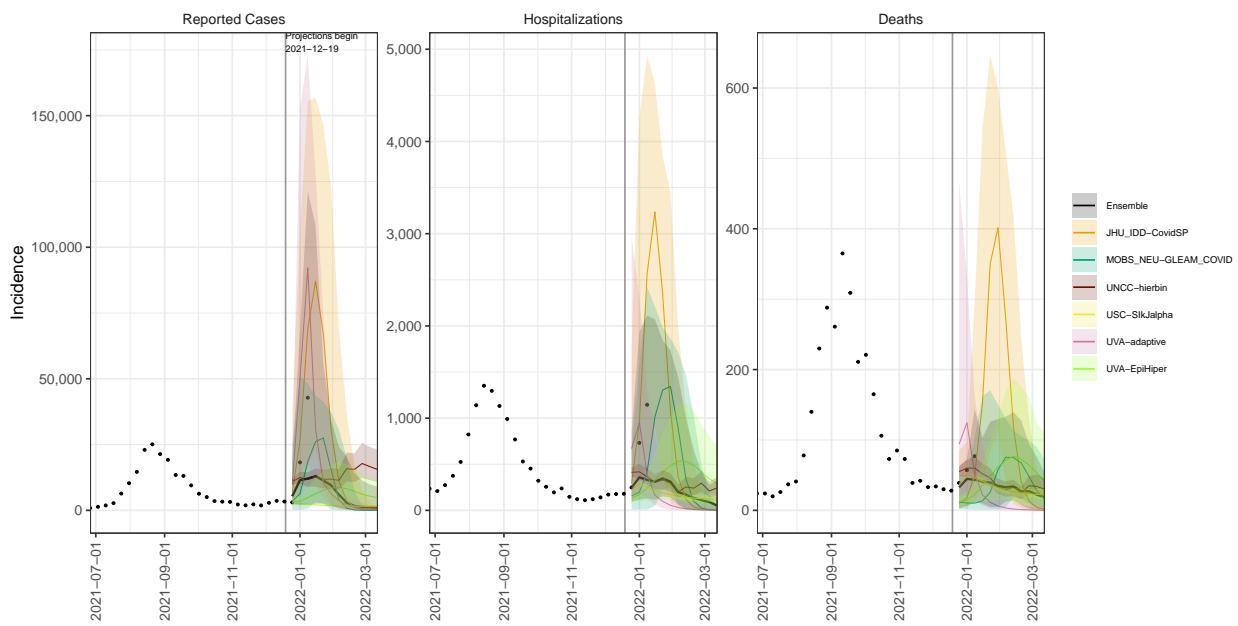
MI model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



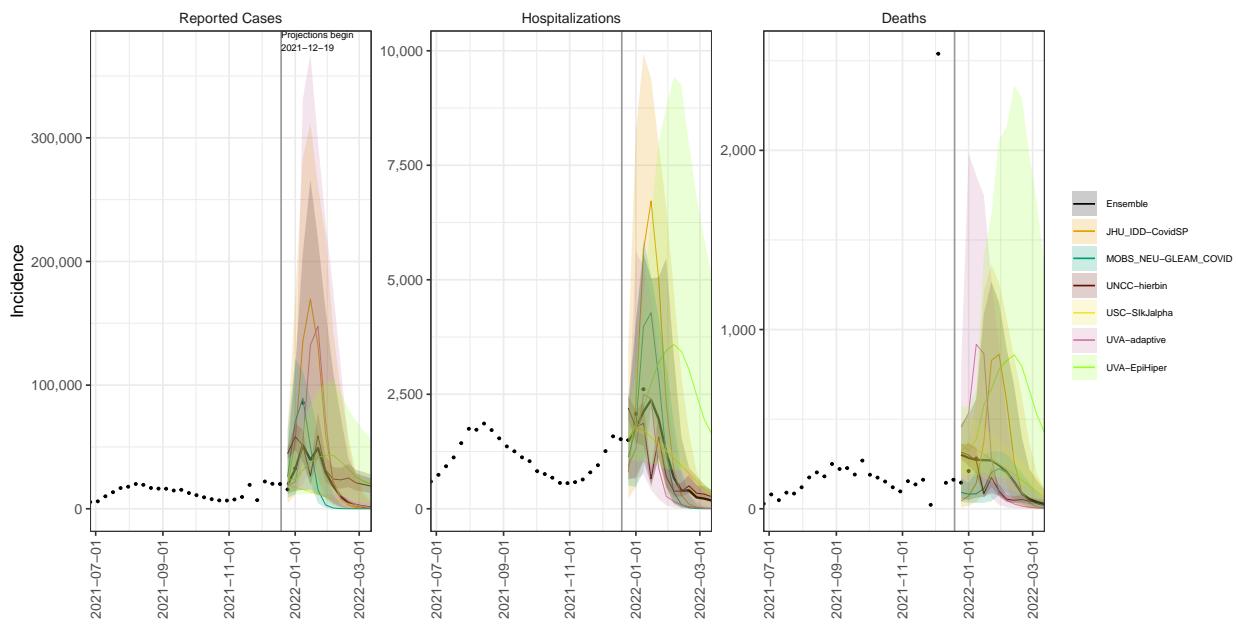
MN model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



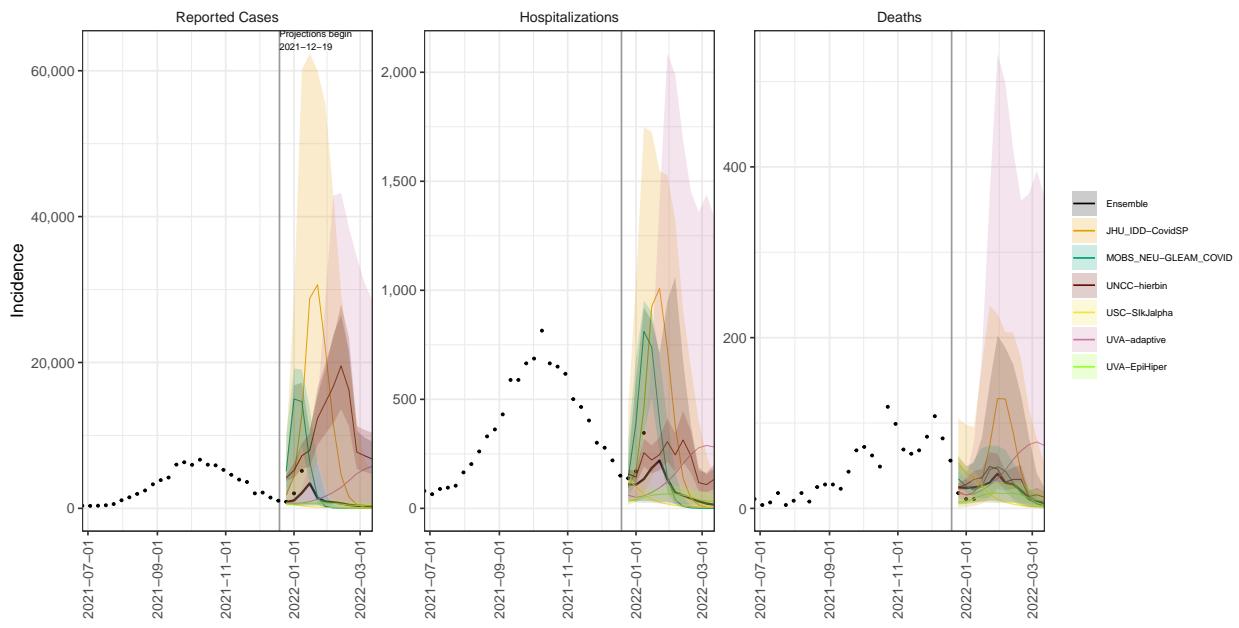
MS model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



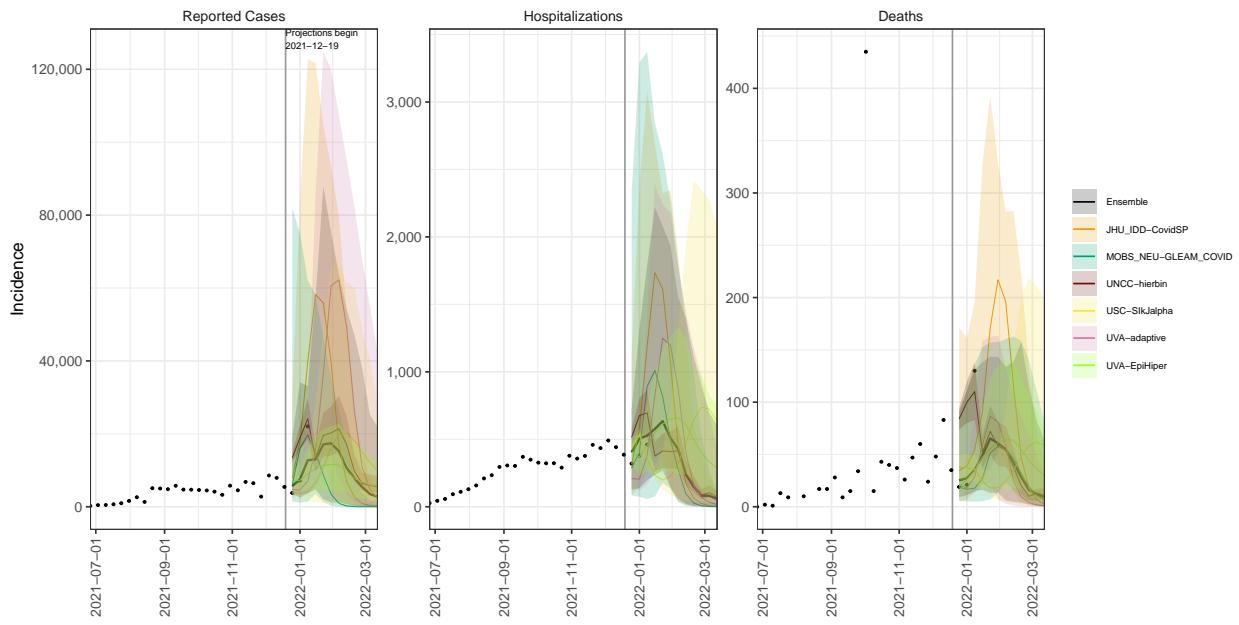
MO model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



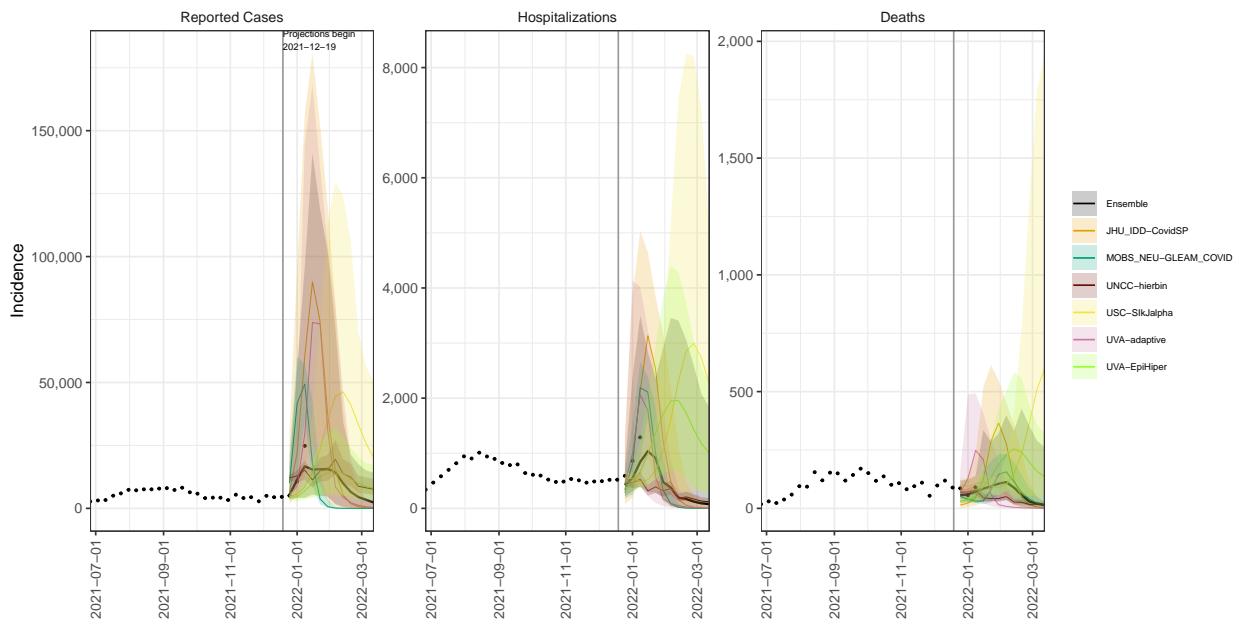
MT model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



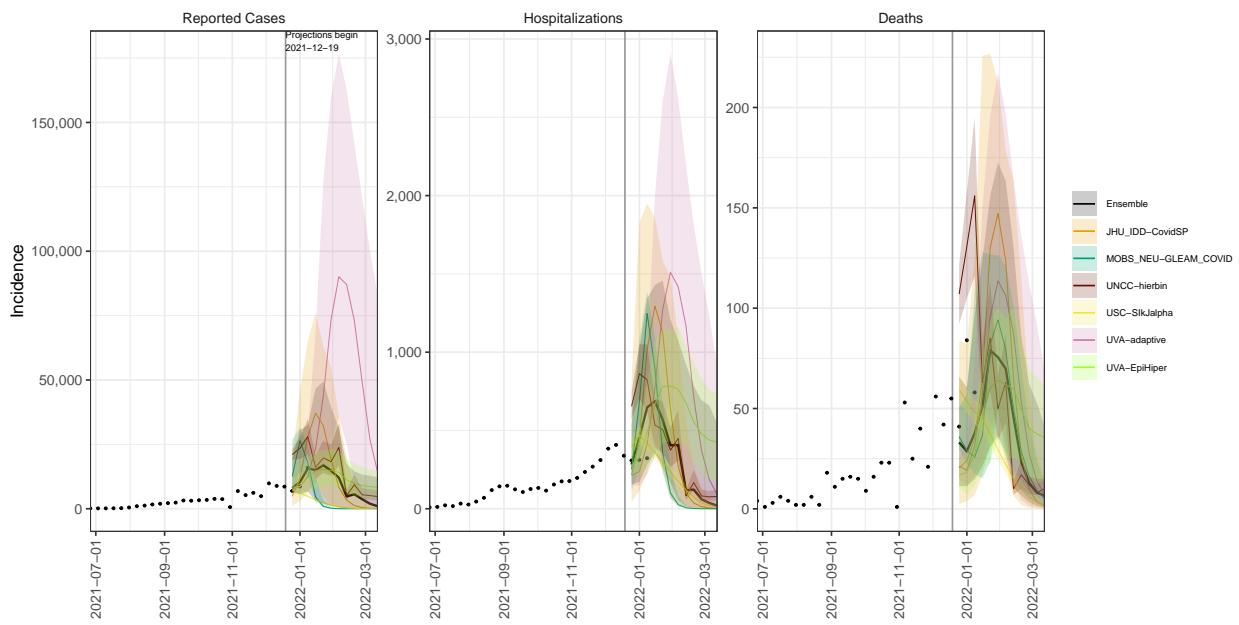
NE model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



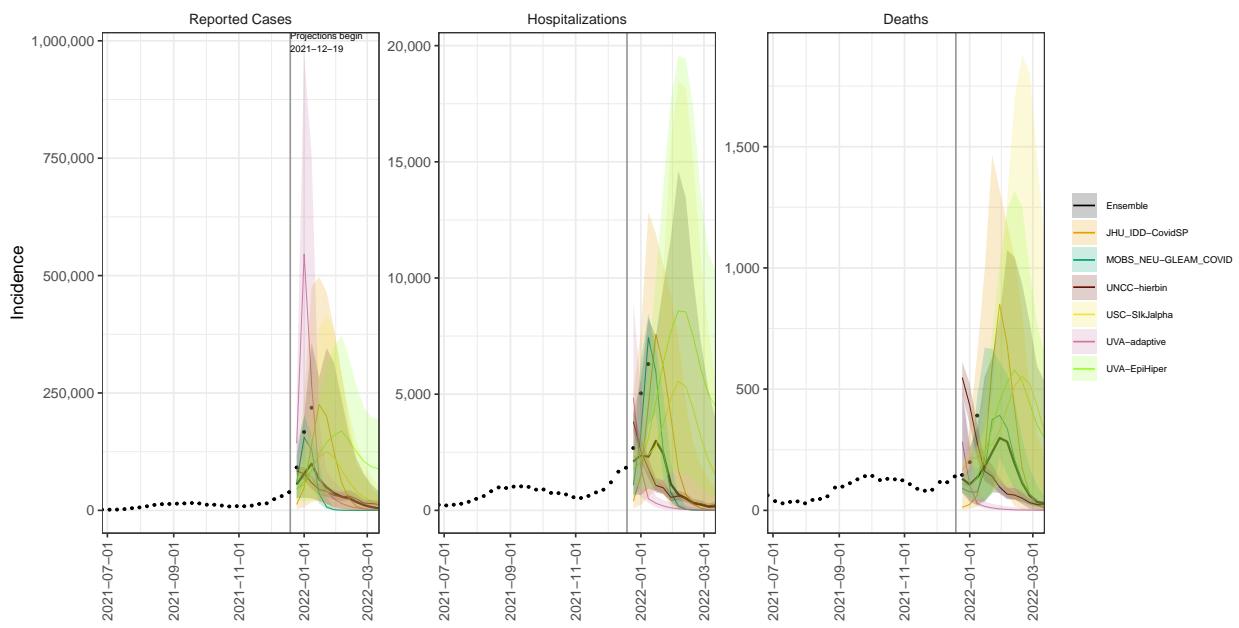
NV model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



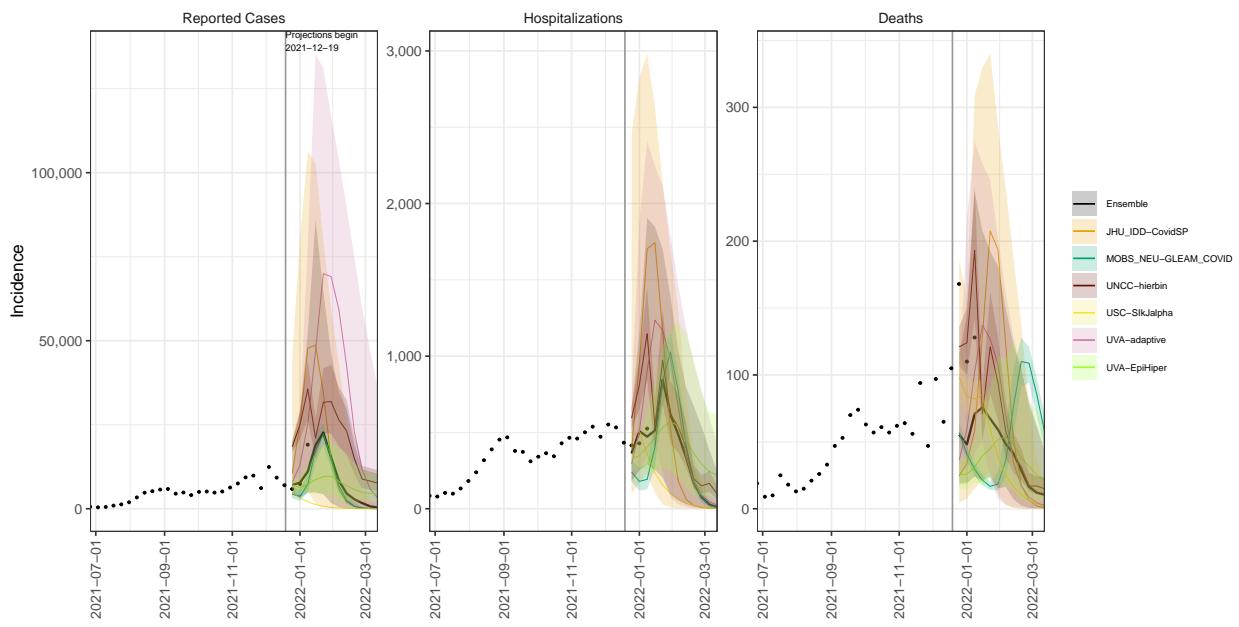
NH model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



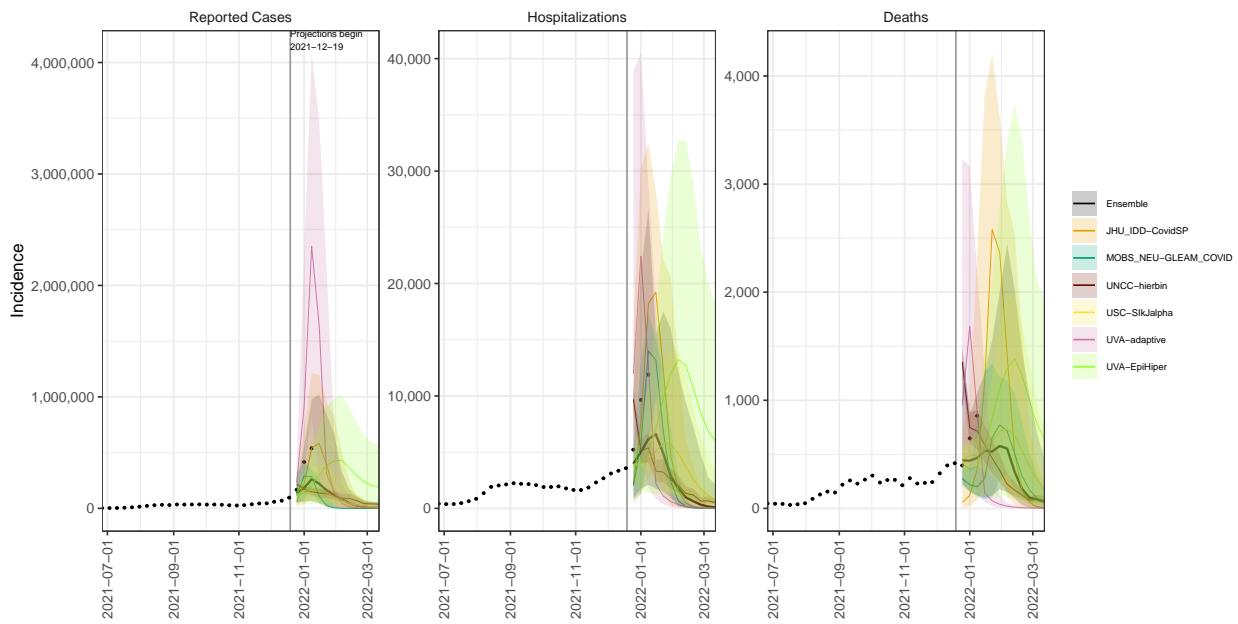
NJ model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



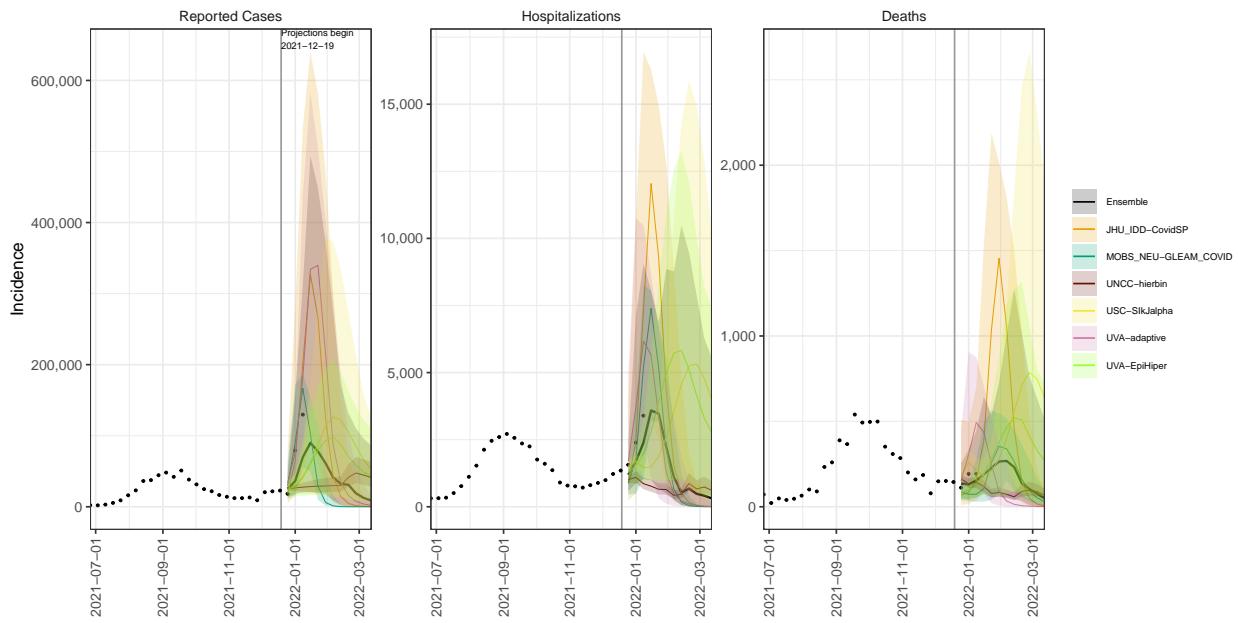
NM model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



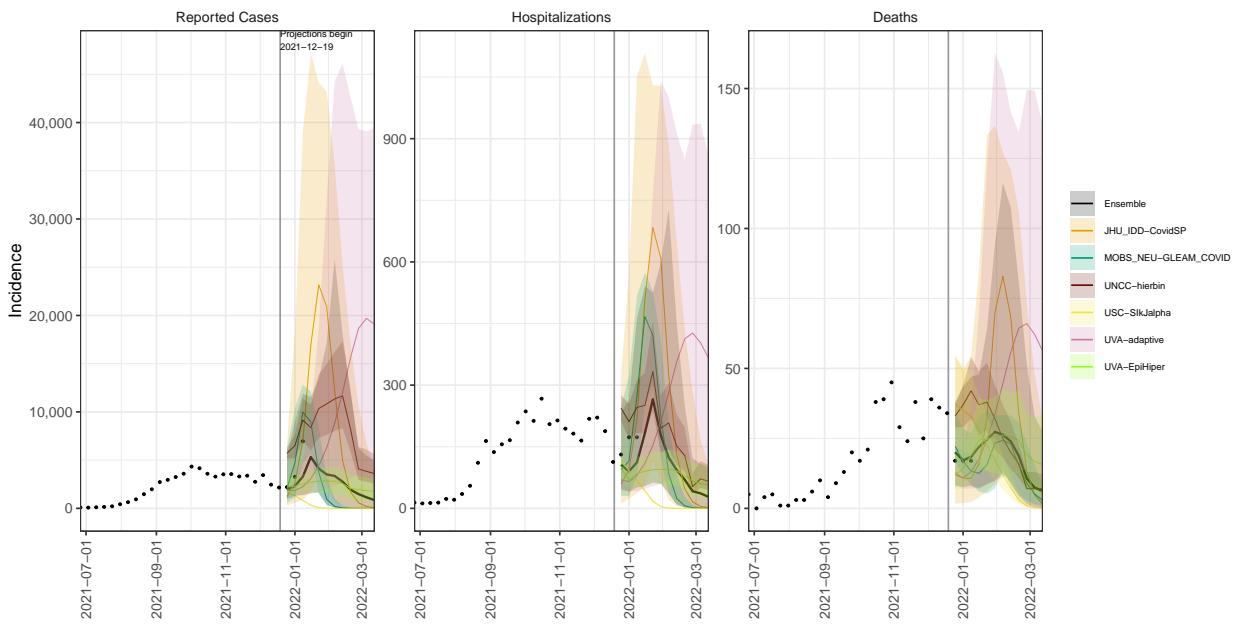
NY model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



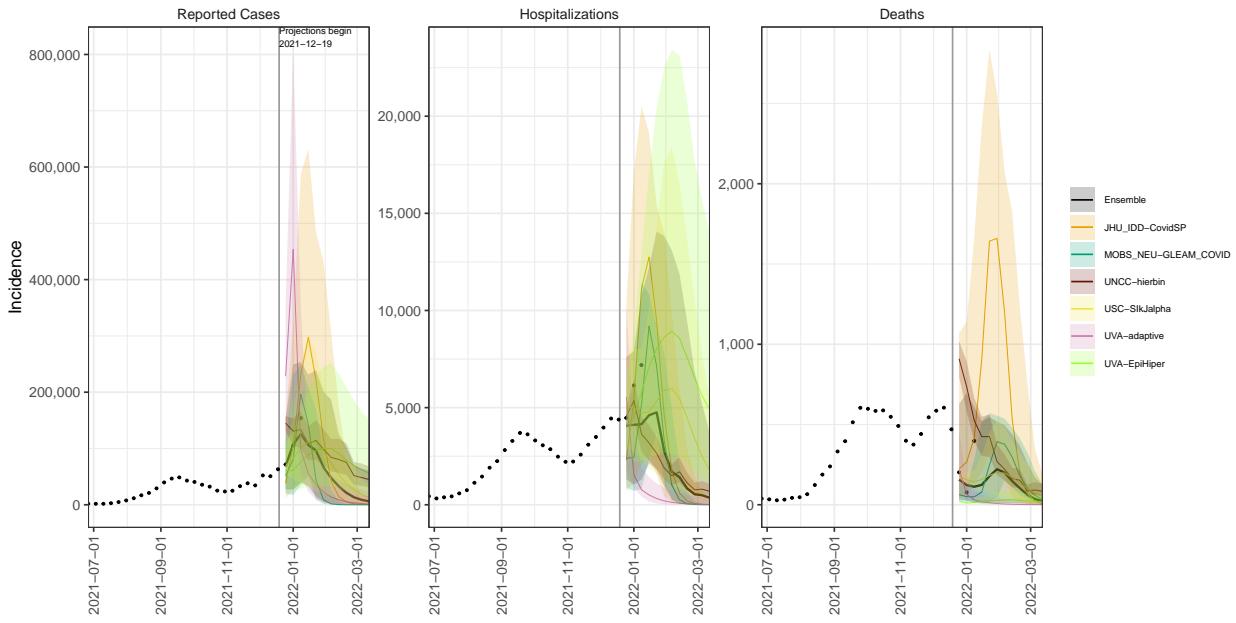
NC model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



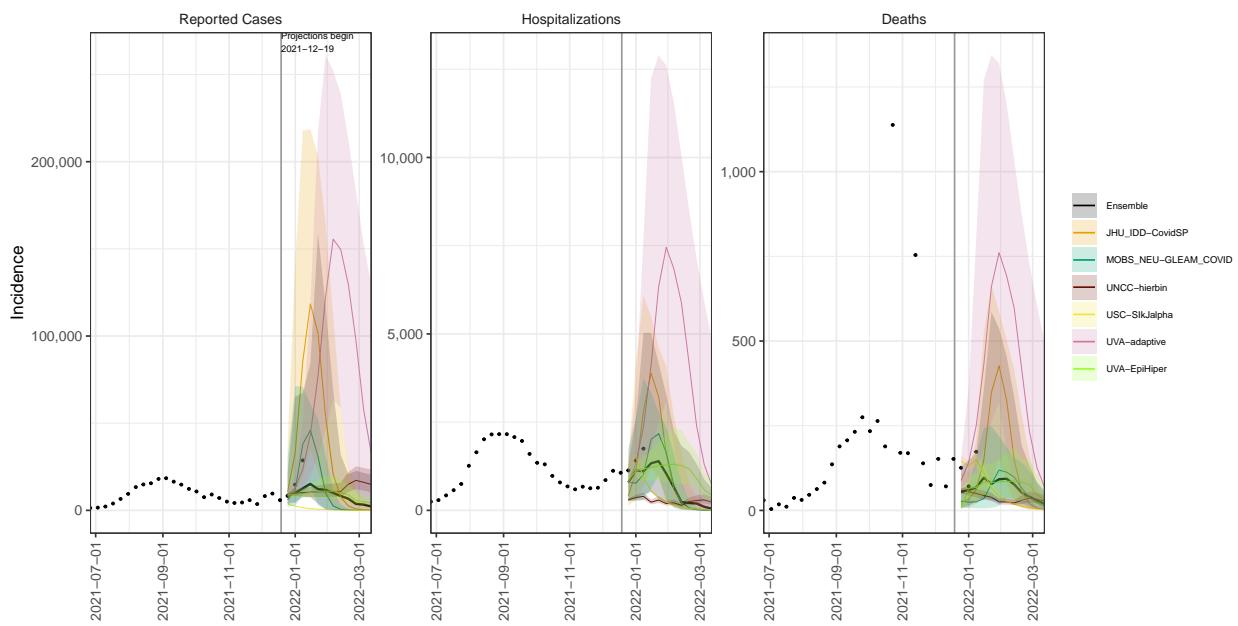
ND model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



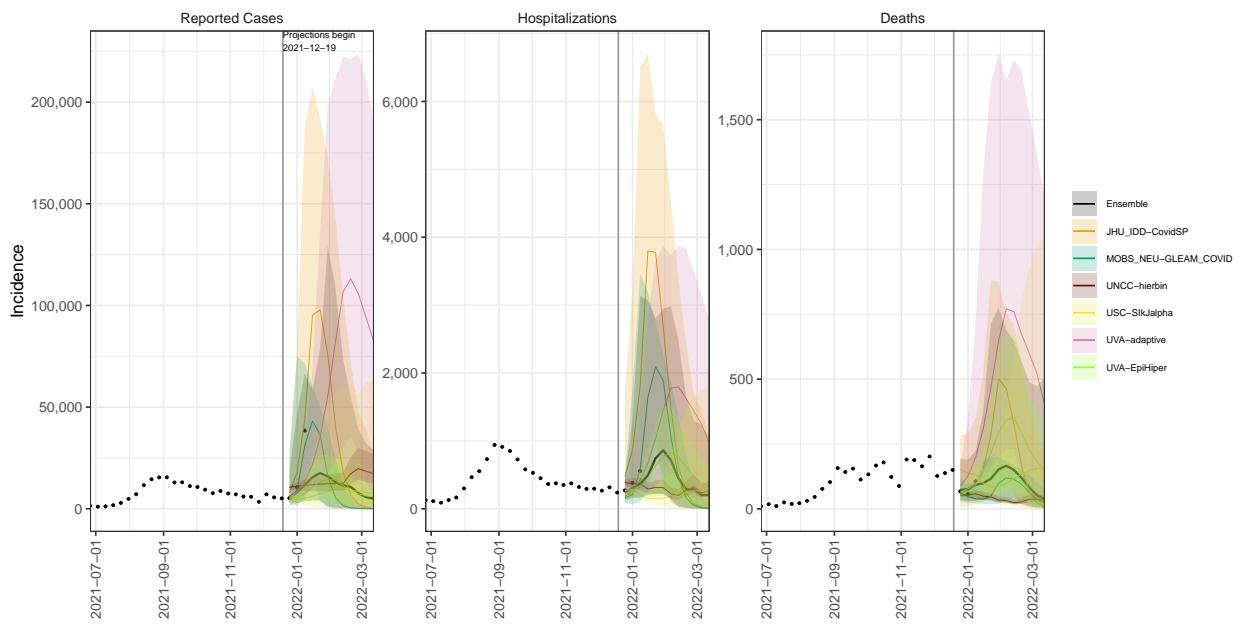
OH model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



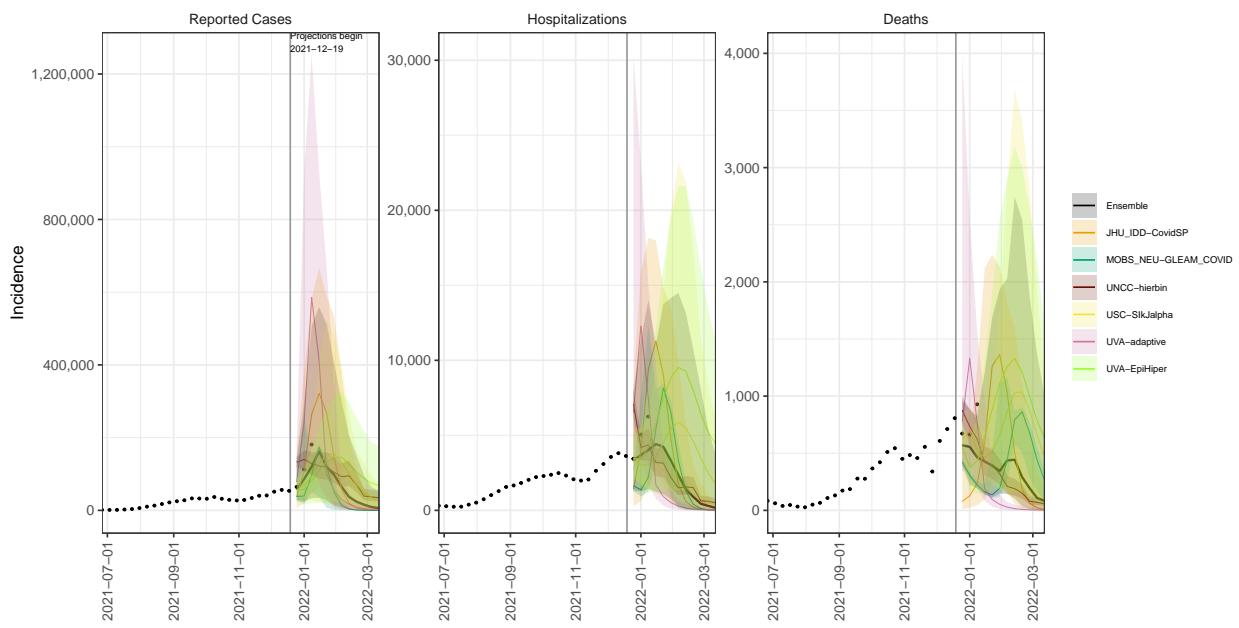
OK model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



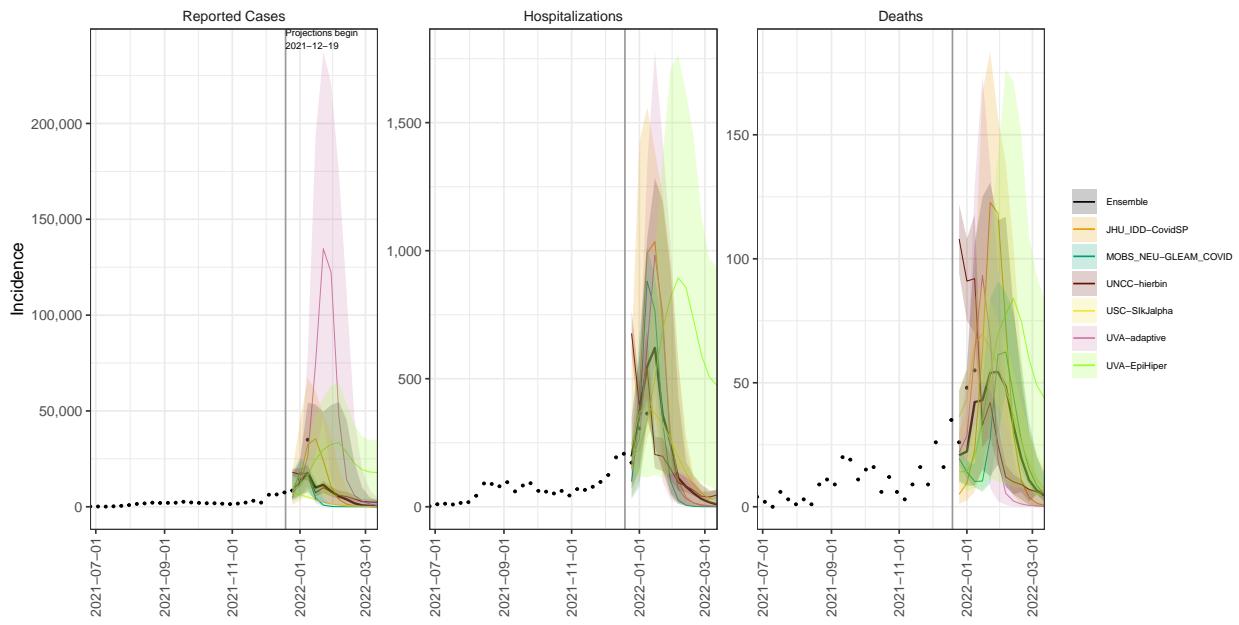
OR model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



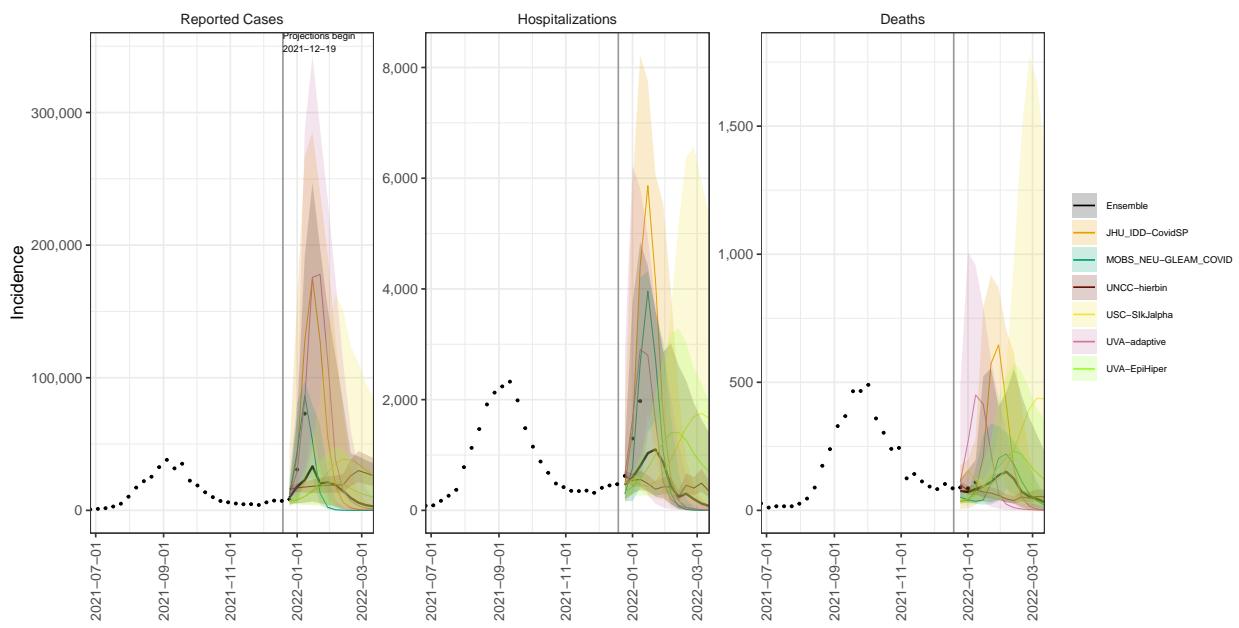
PA model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



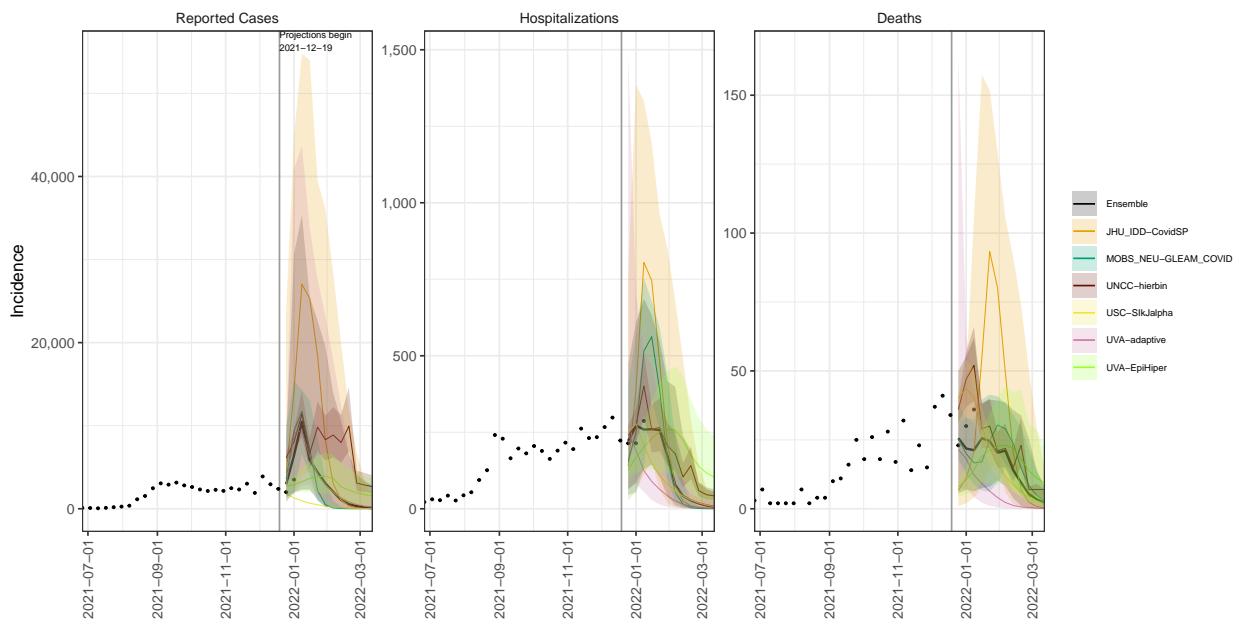
RI model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



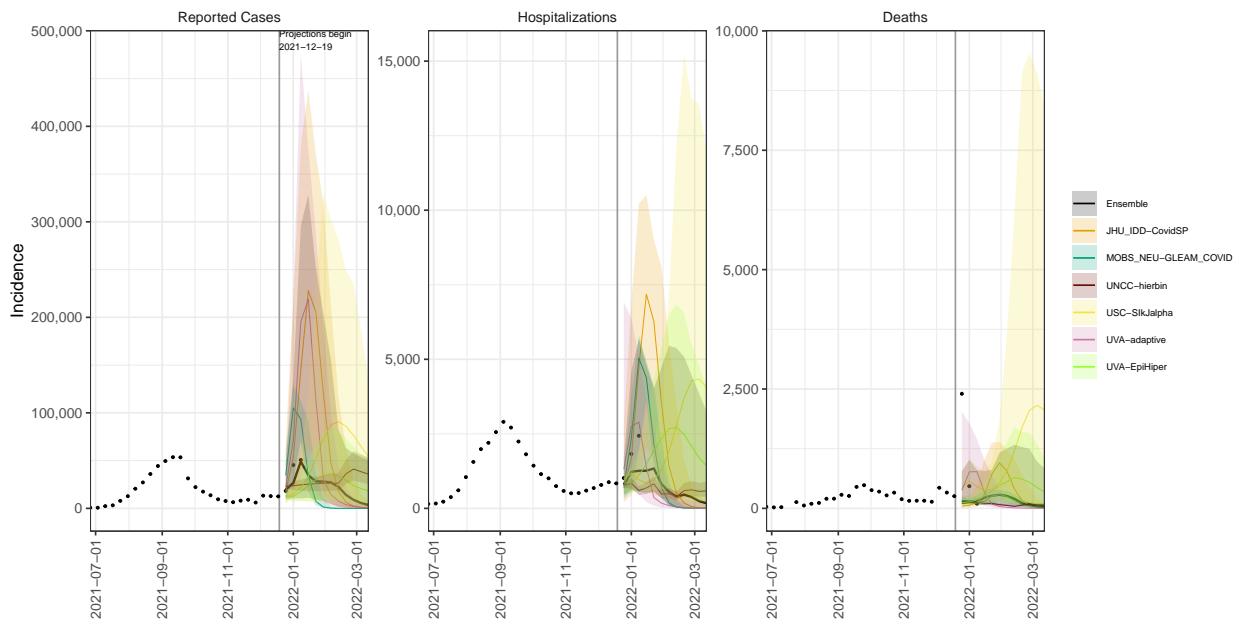
SC model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



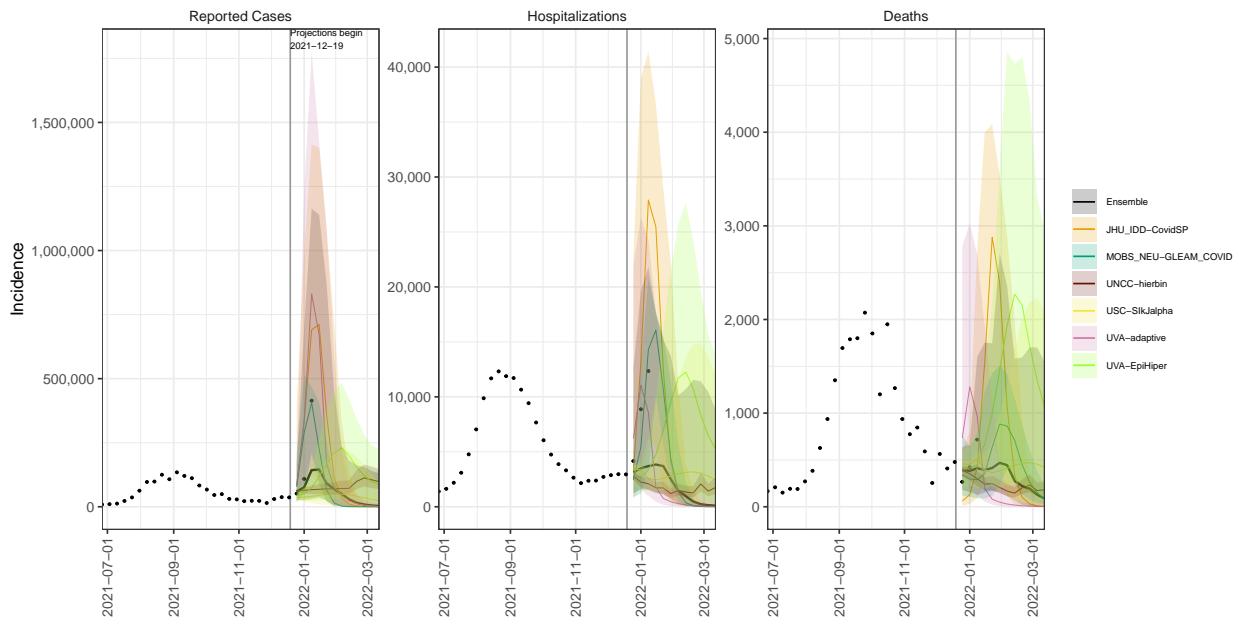
SD model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



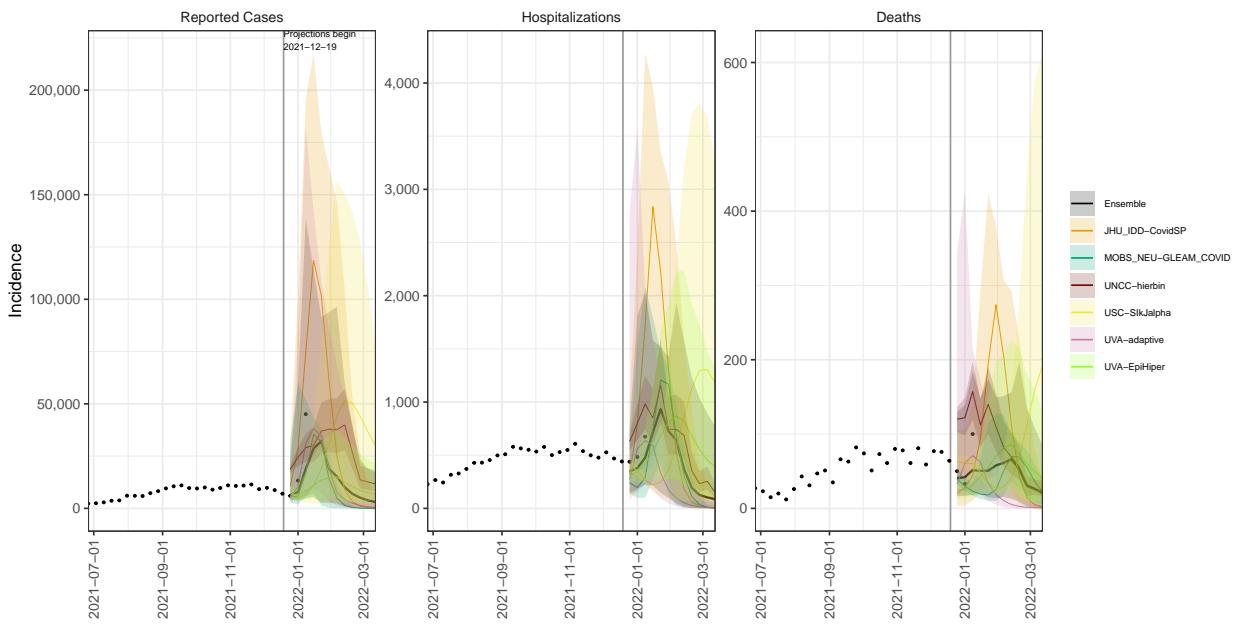
TN model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



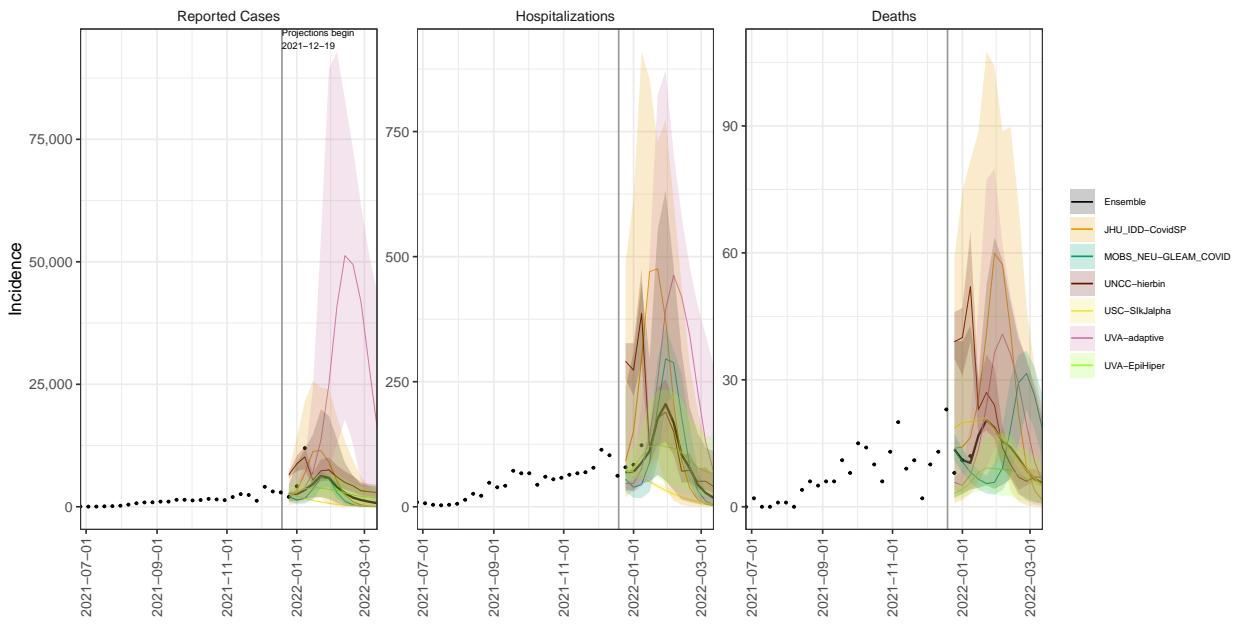
TX model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



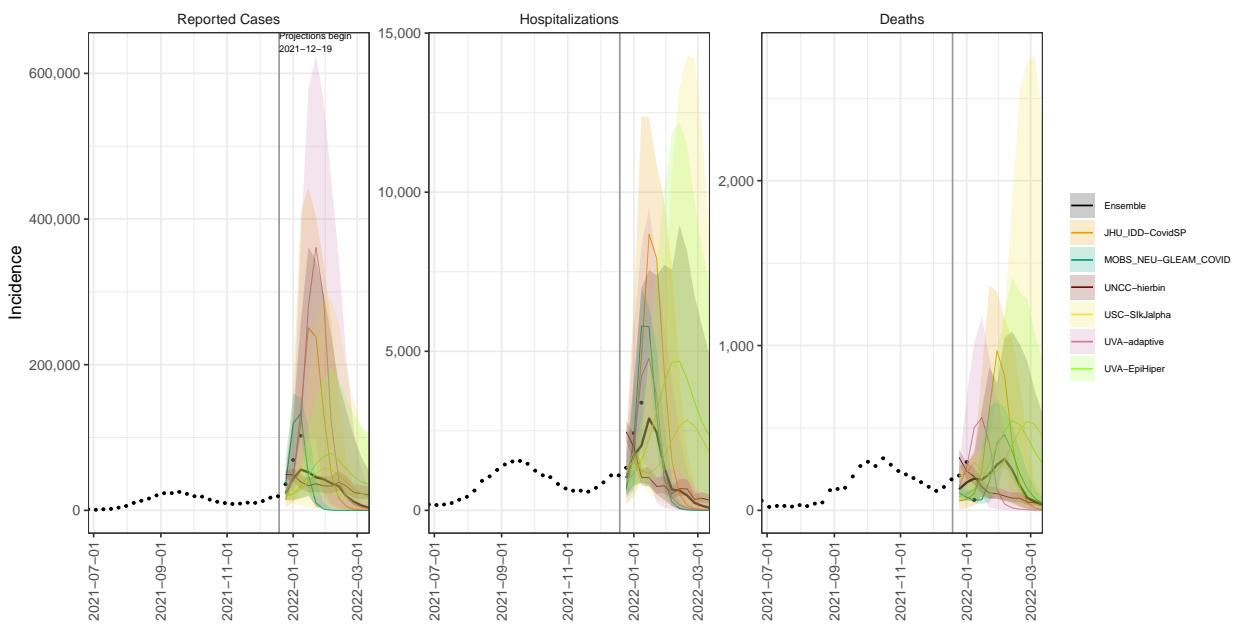
UT model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



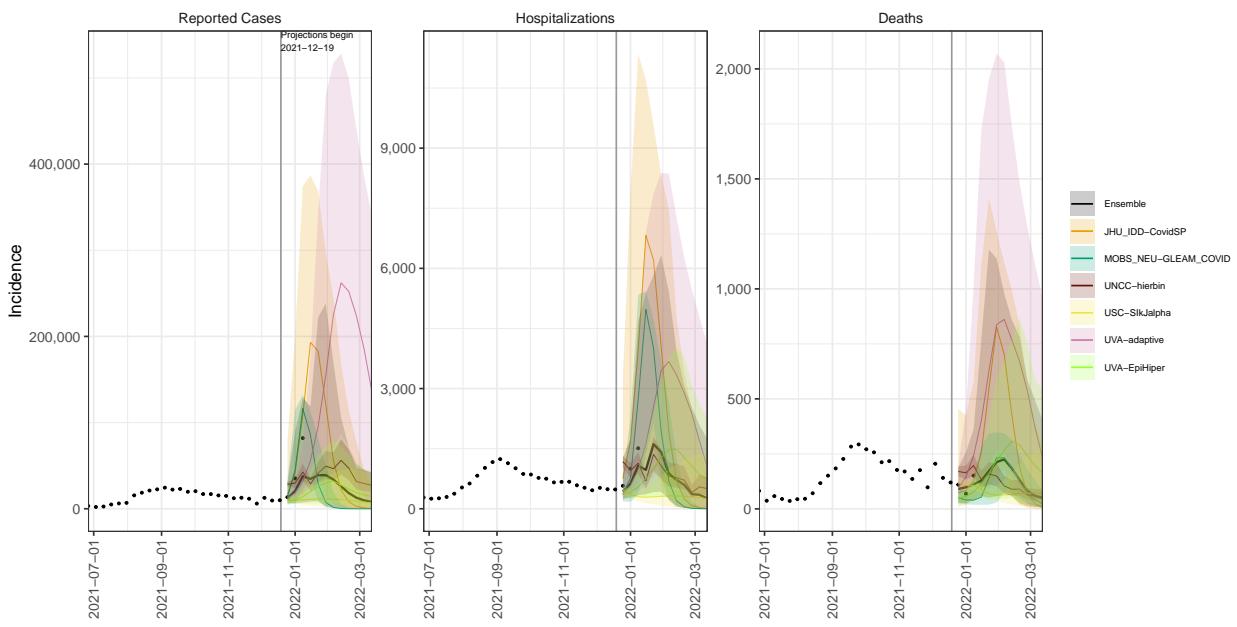
VT model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



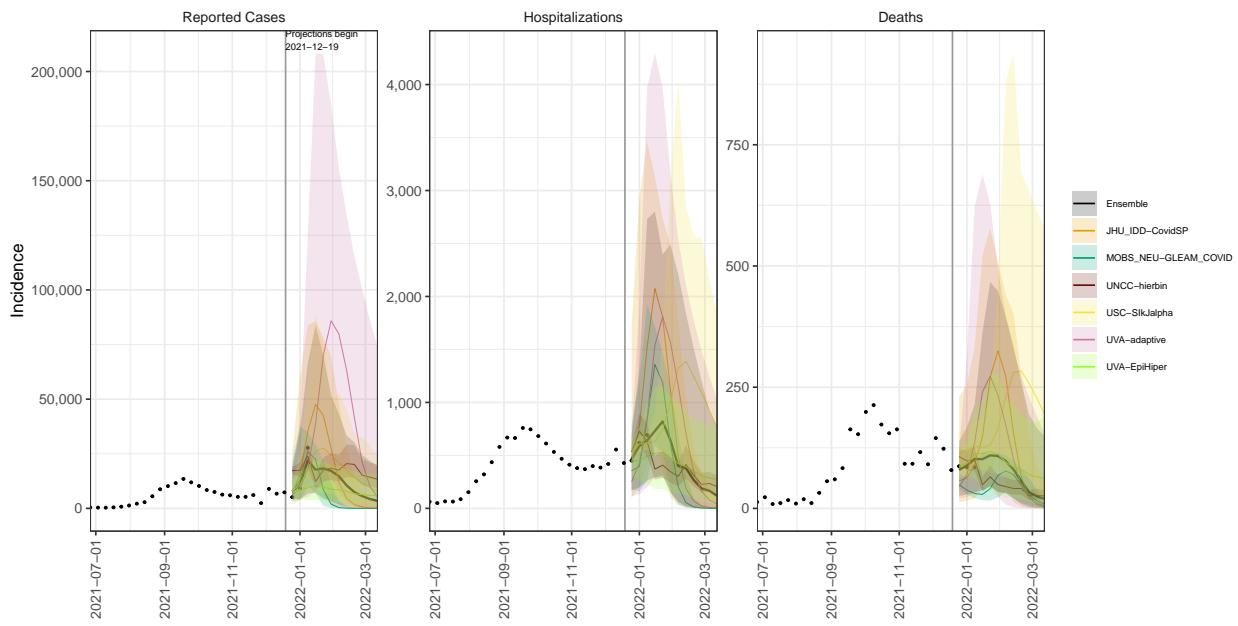
VA model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



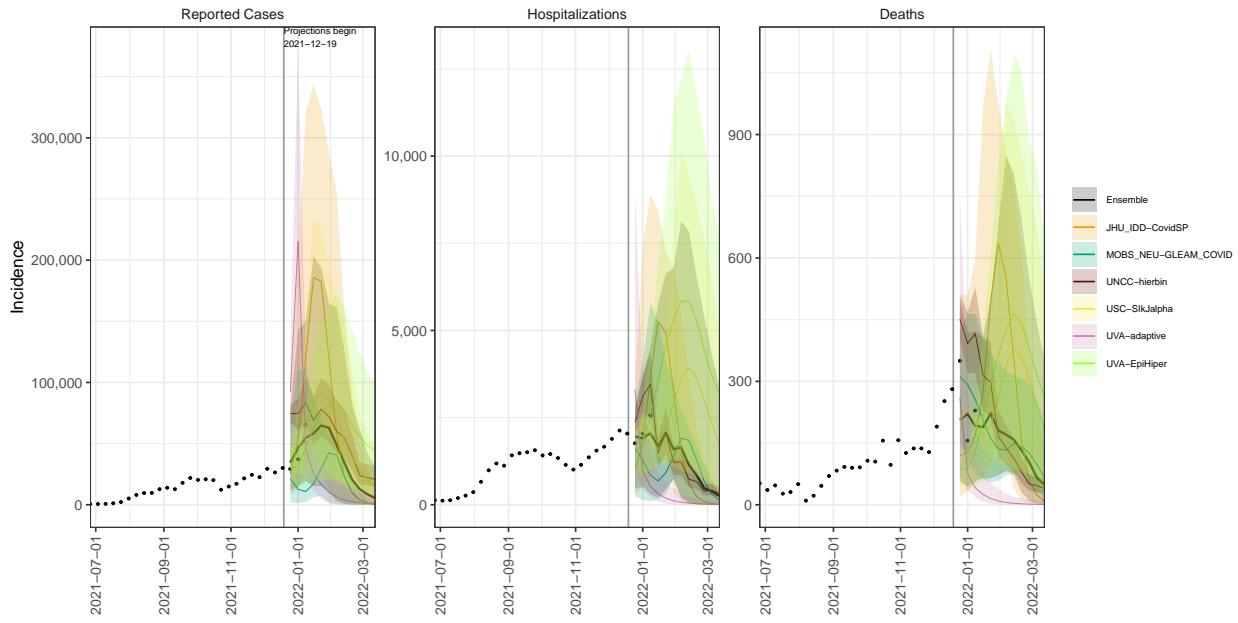
WA model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



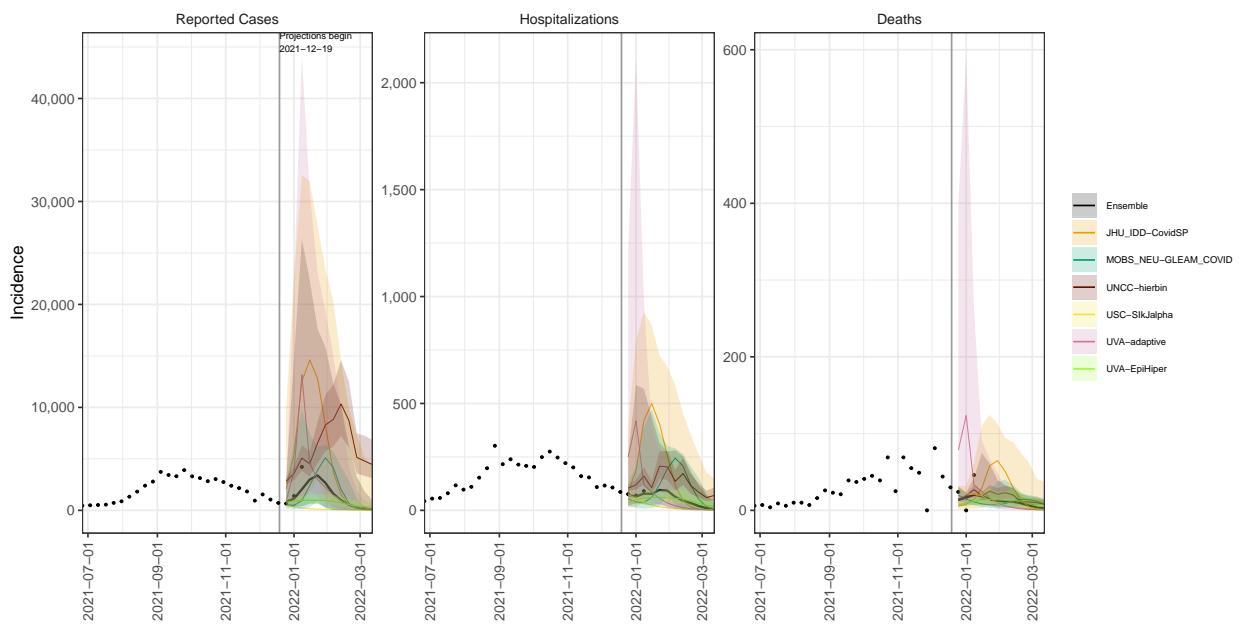
WV model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



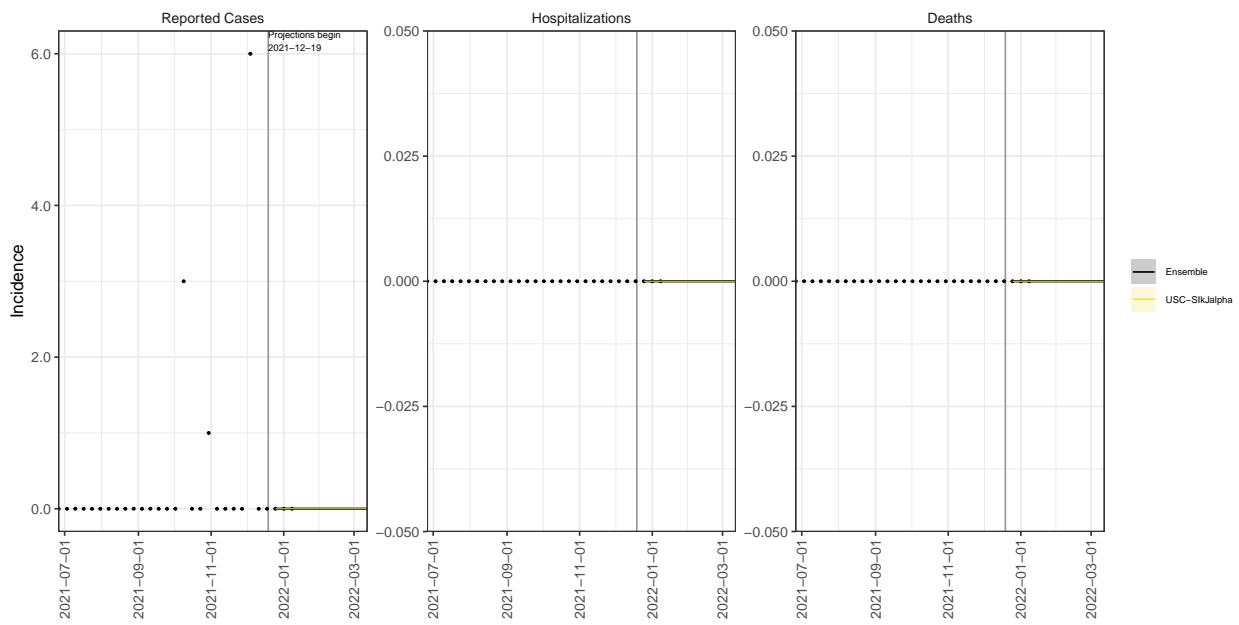
WI model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



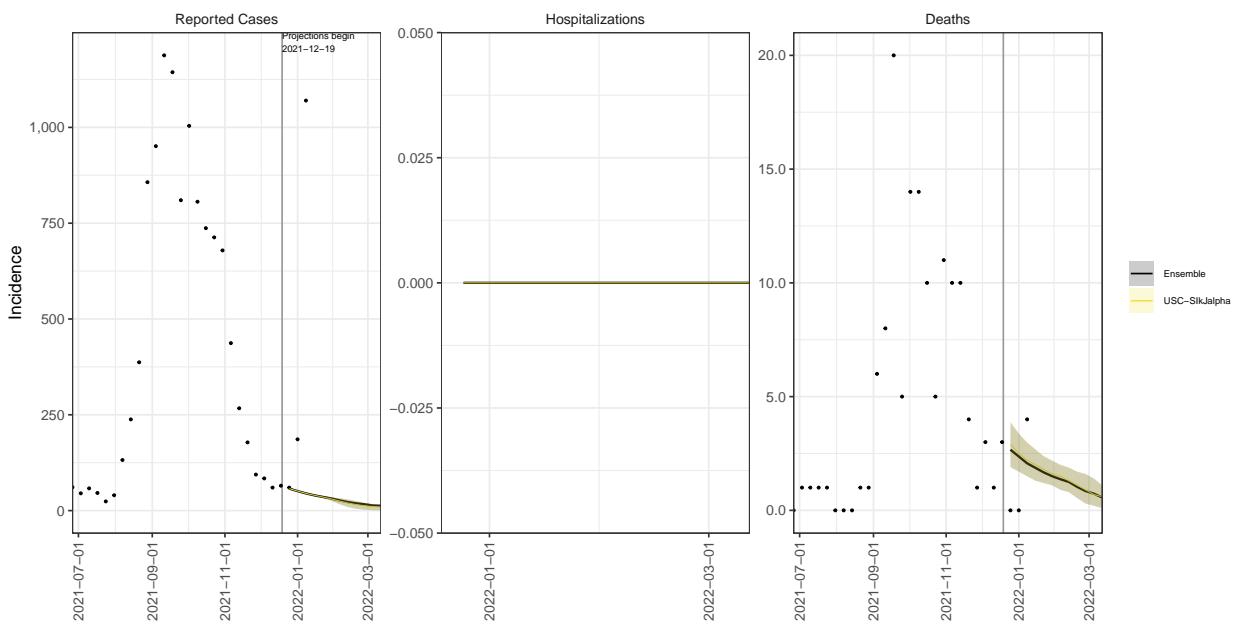
WY model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



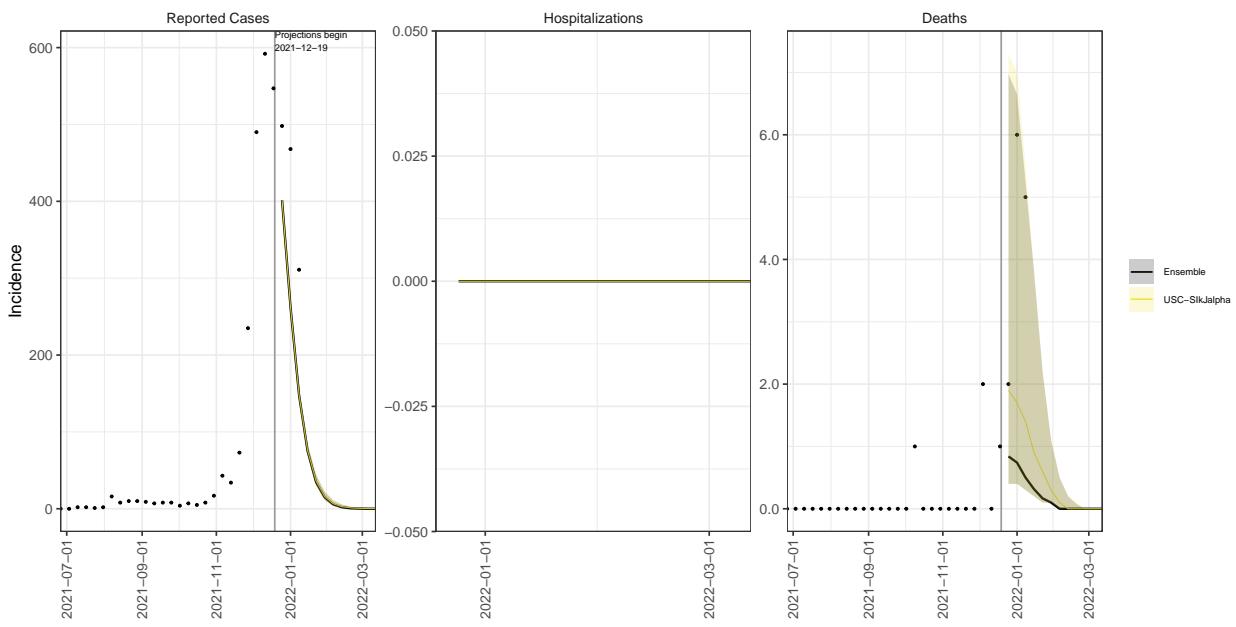
AS model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



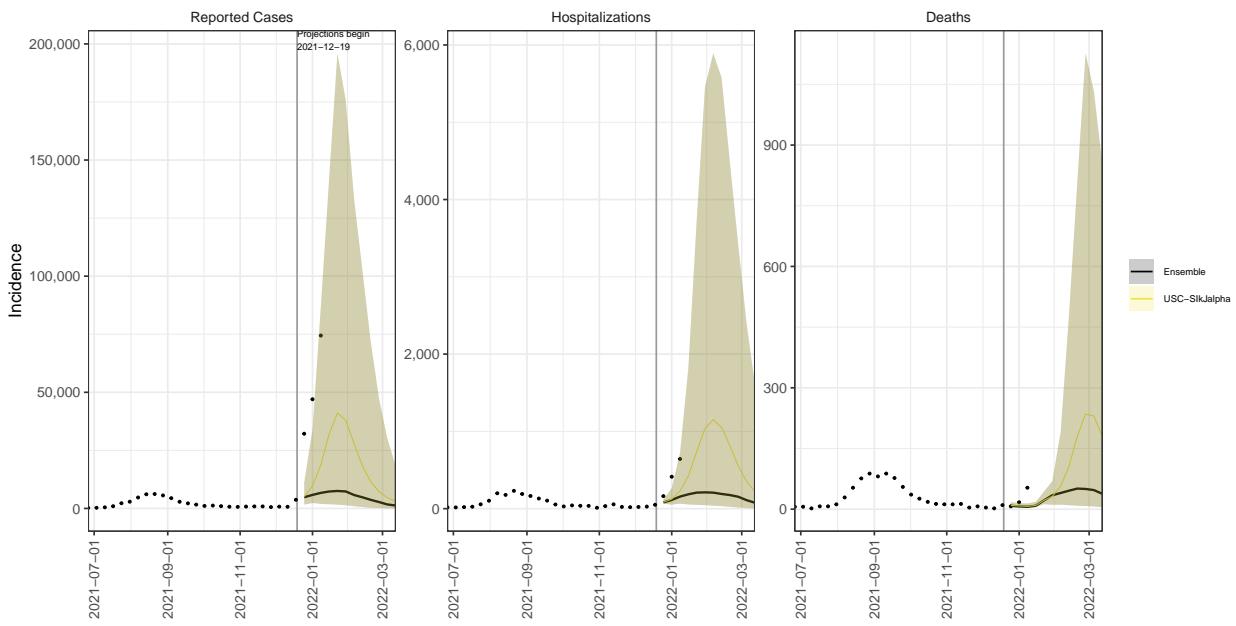
GU model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



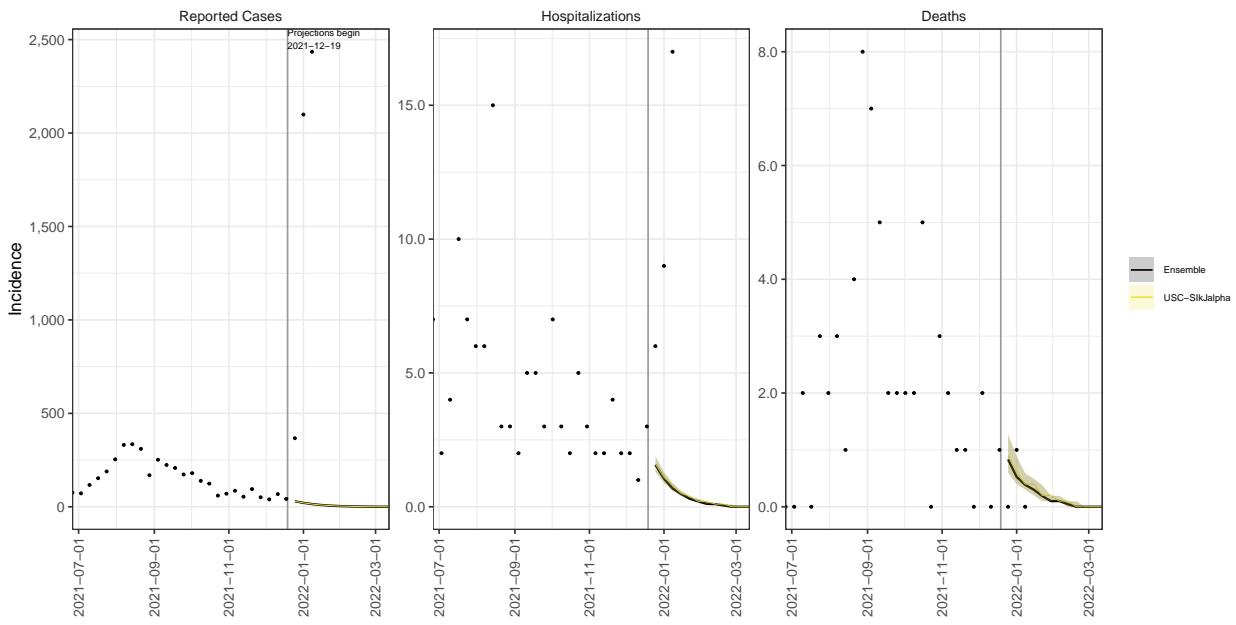
MP model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility



PR model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility

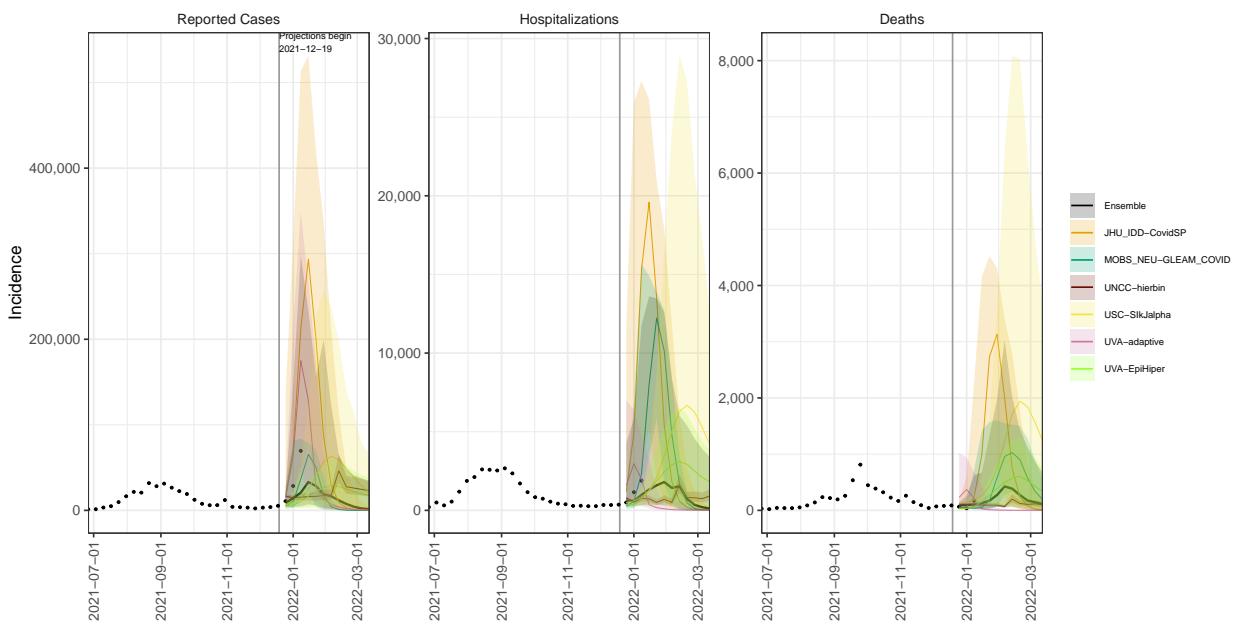


VI model variance & 95% projection intervals – Pessimistic severity, high immune escape & low transmissibility

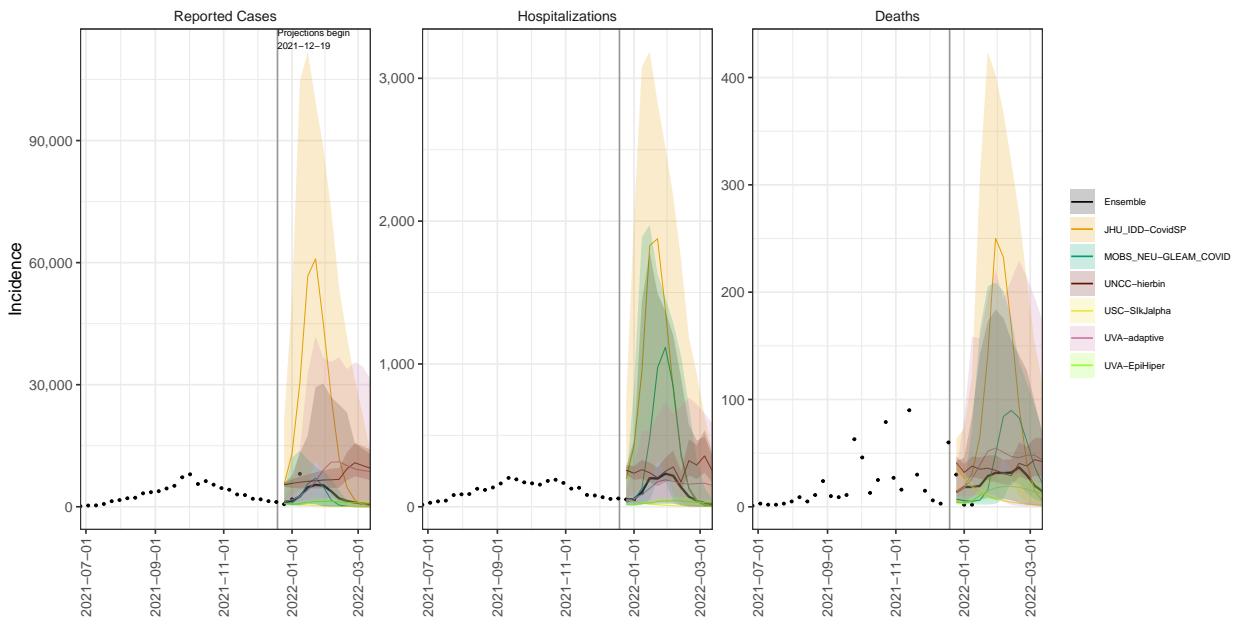


National model variation for pessimistic severity, high immune escape & low transmissibility scenario.

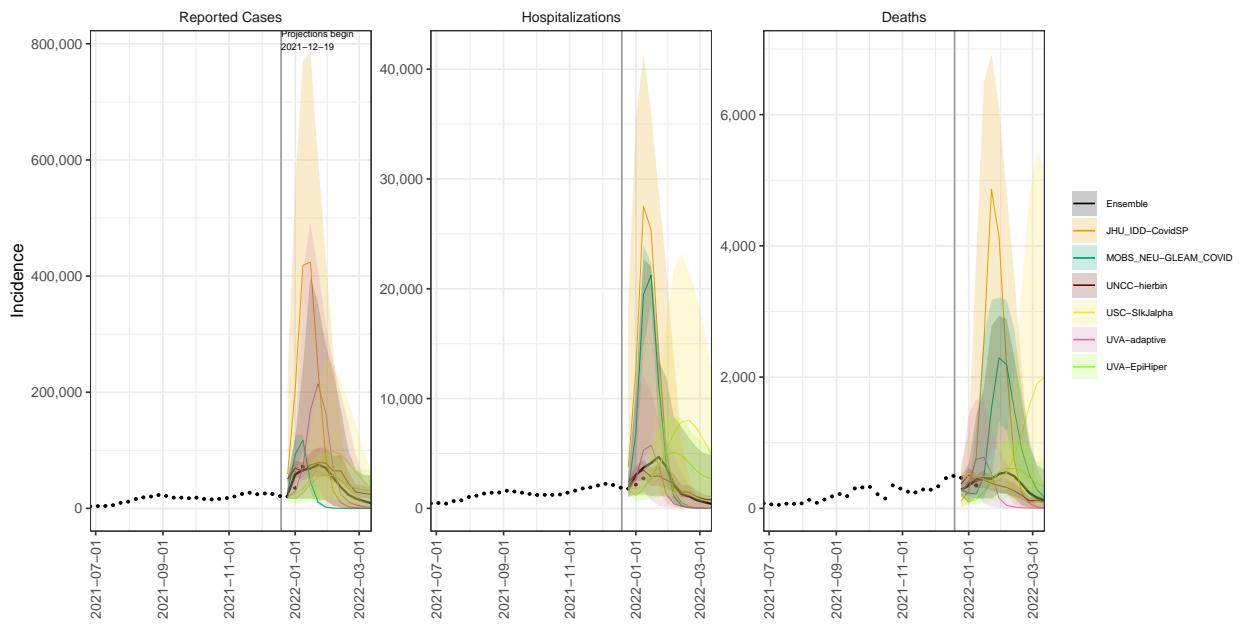
AL model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



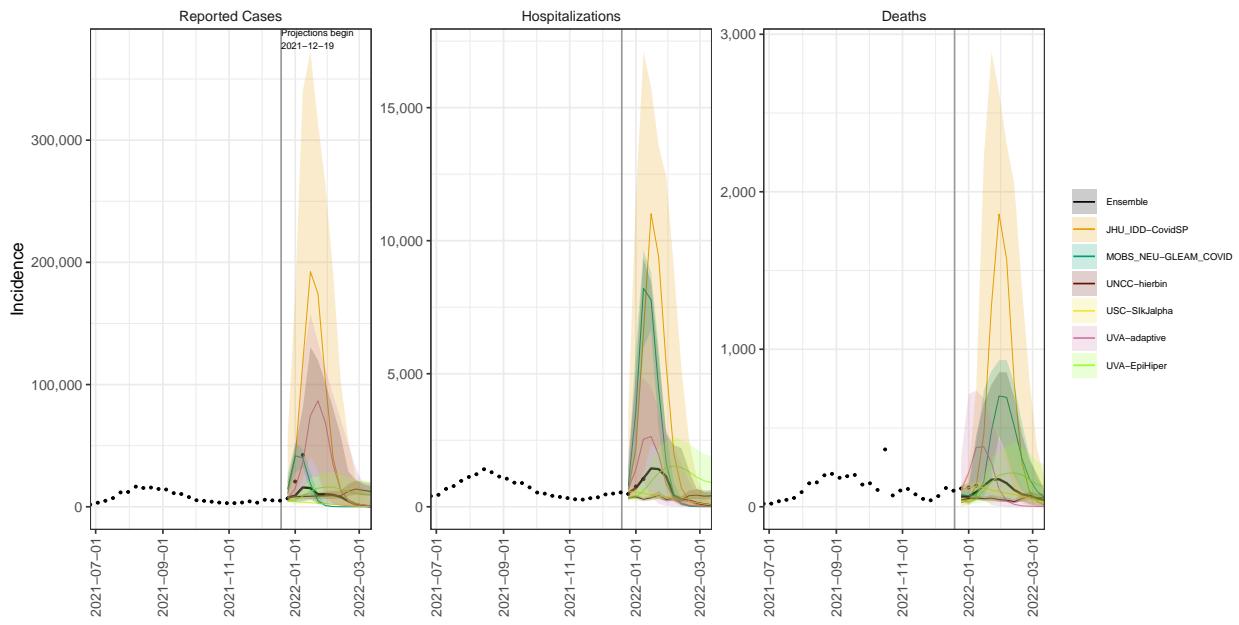
AK model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



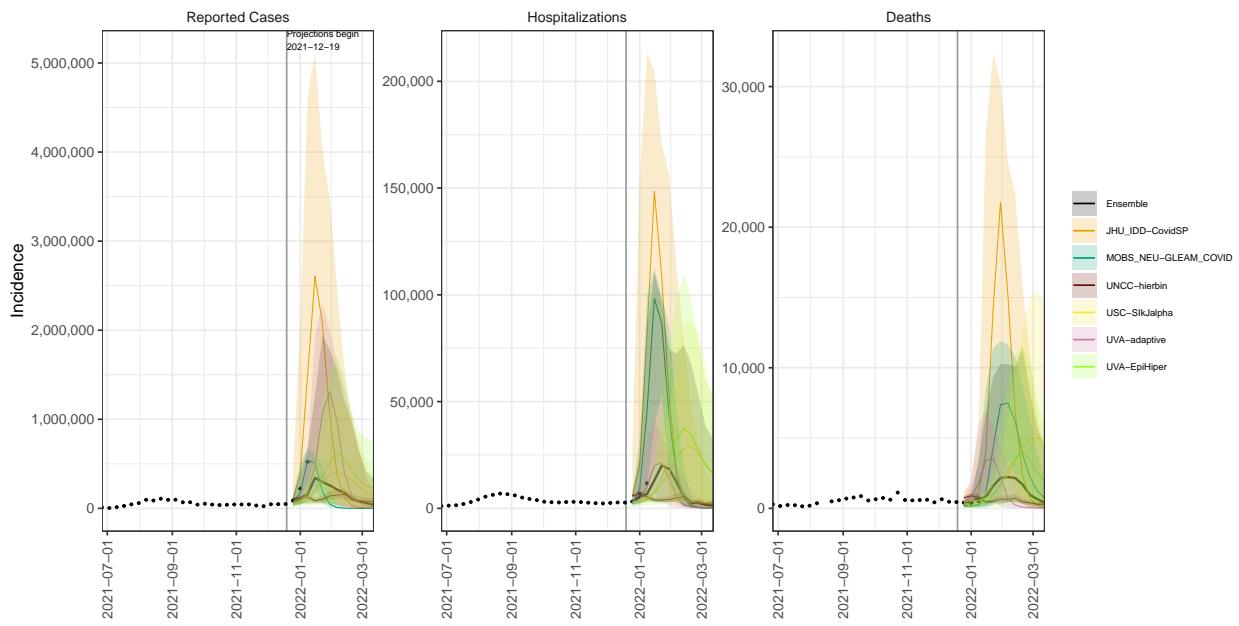
AZ model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



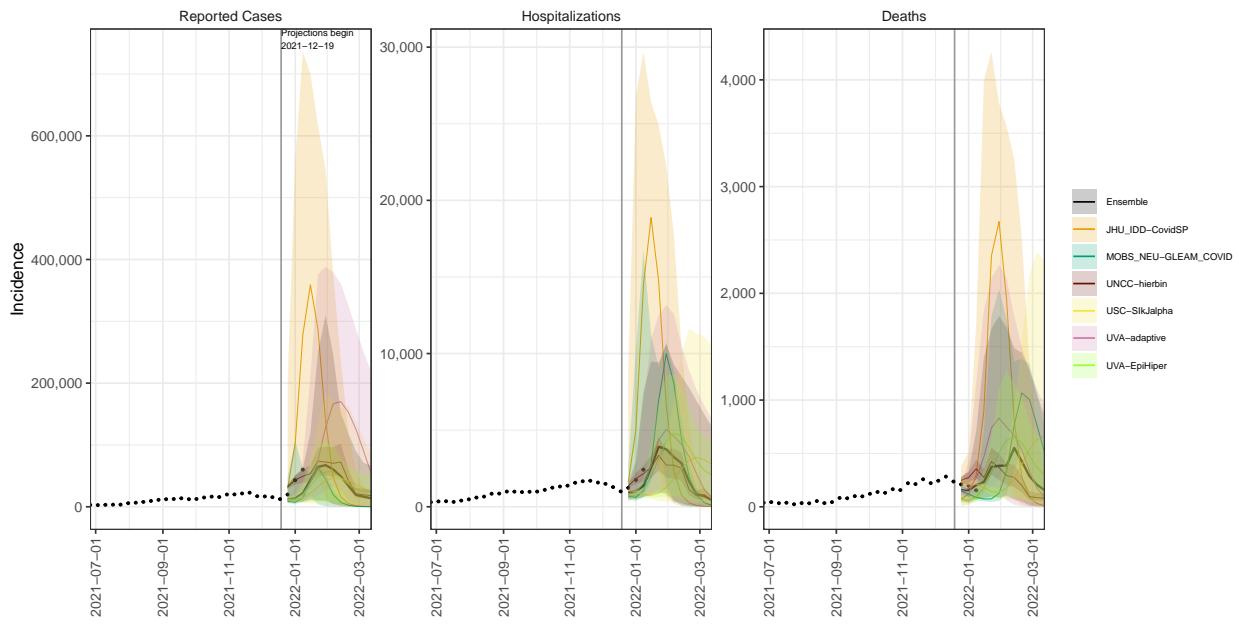
AR model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



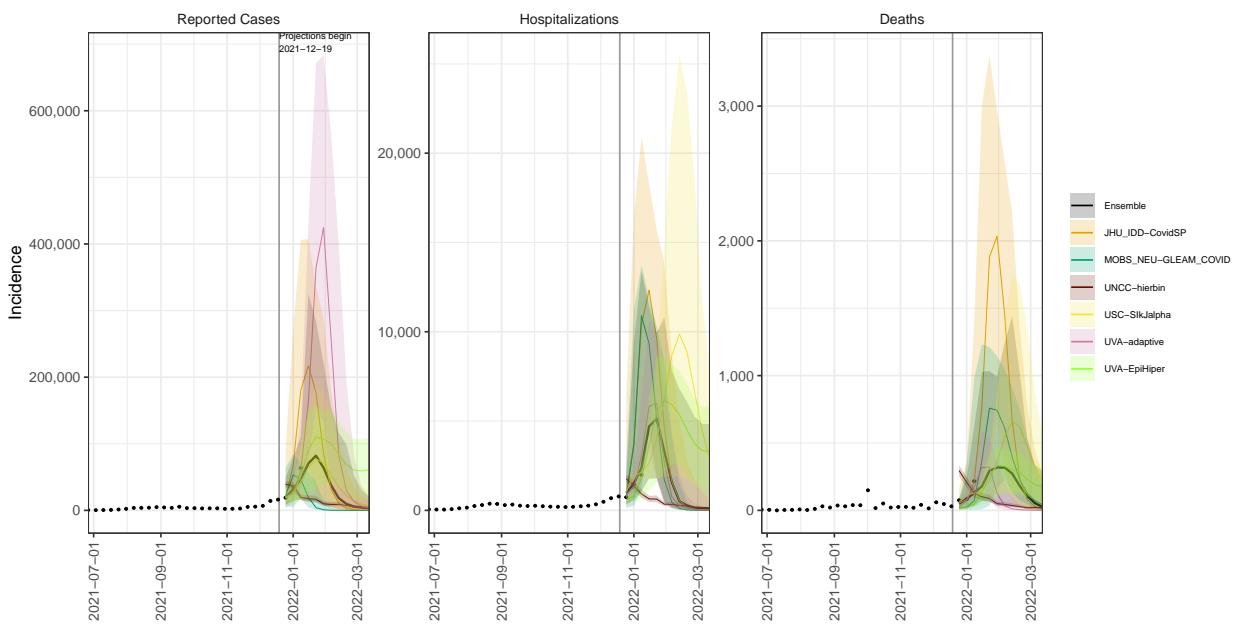
CA model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



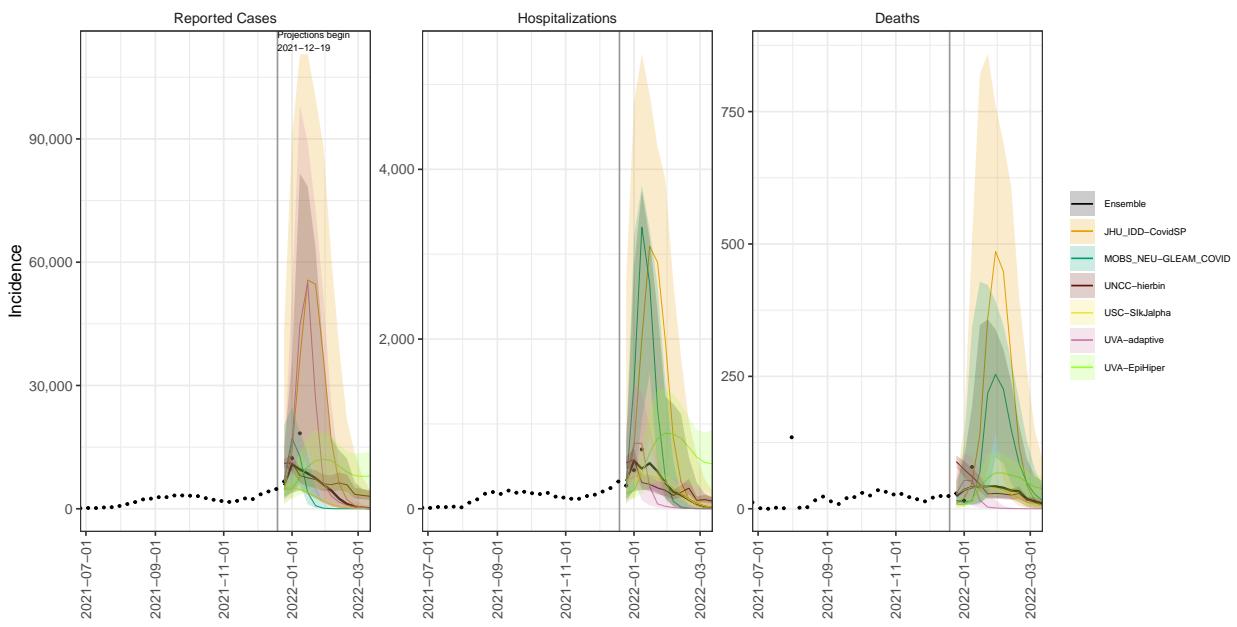
CO model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



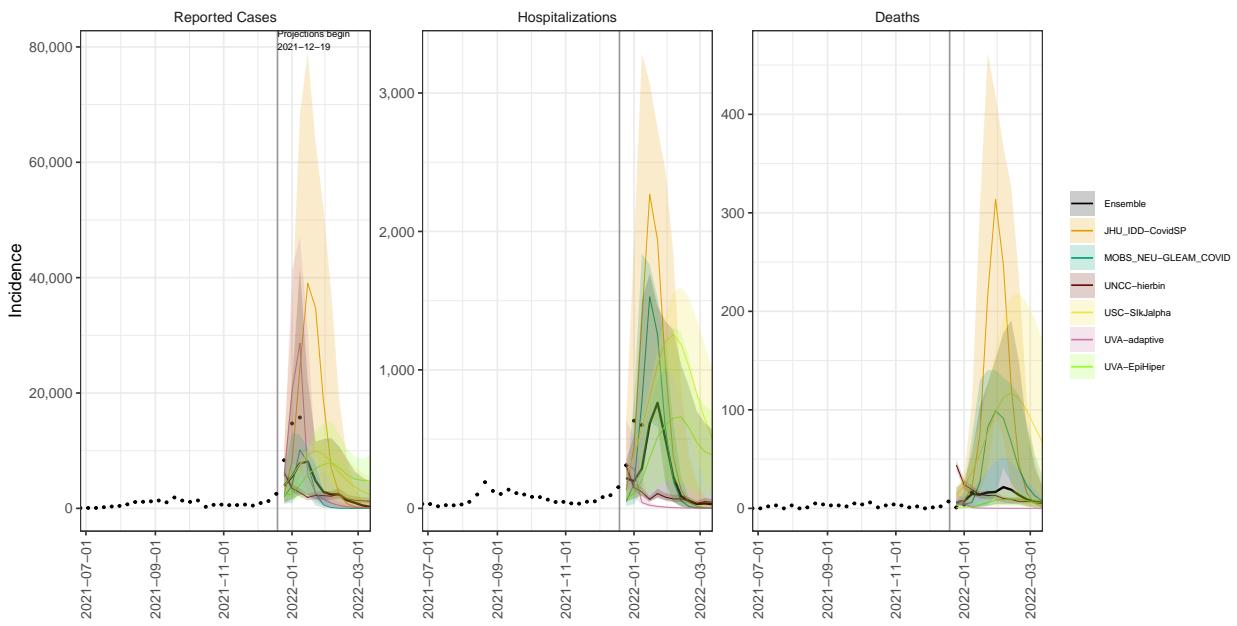
CT model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



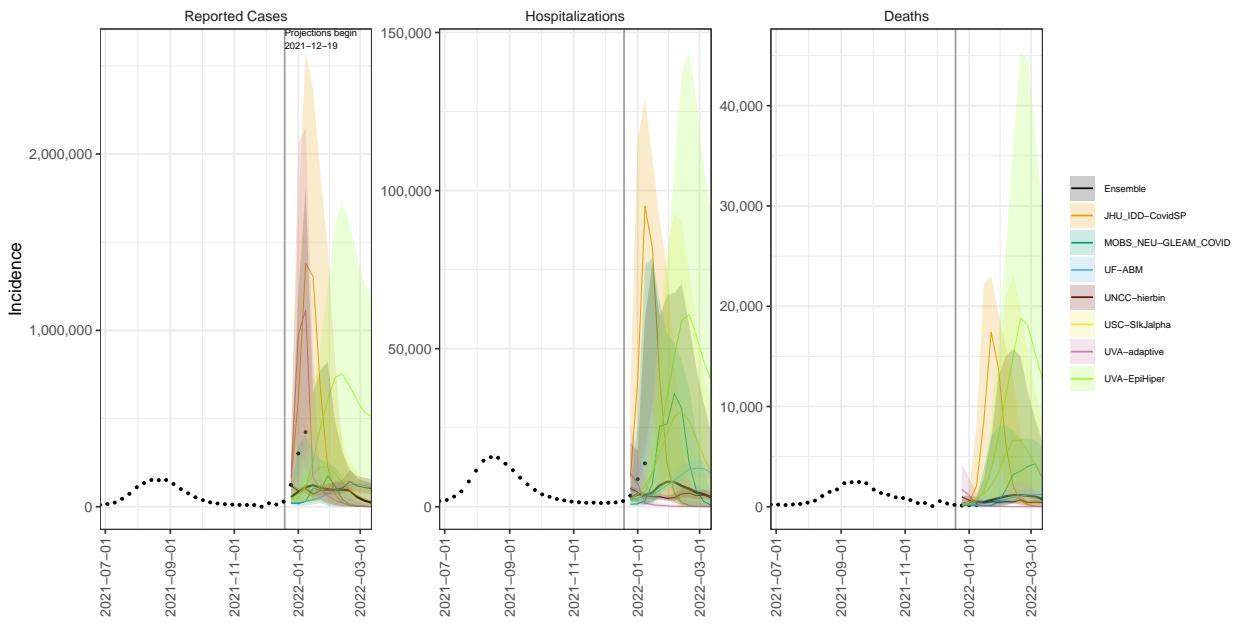
DE model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



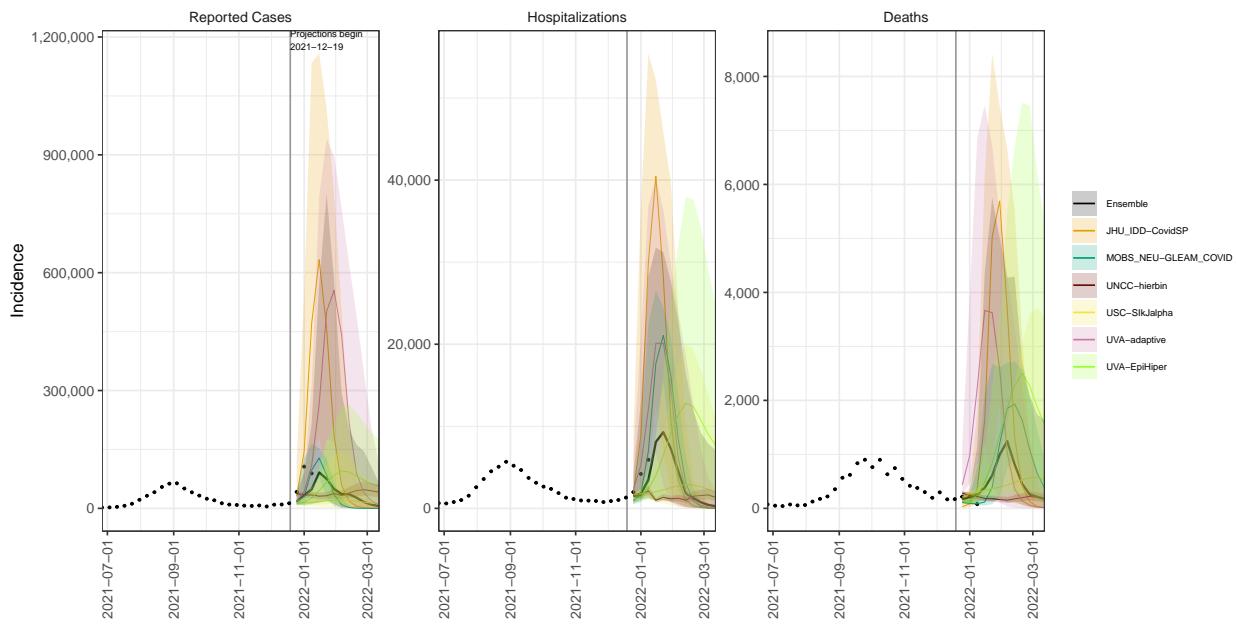
DC model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



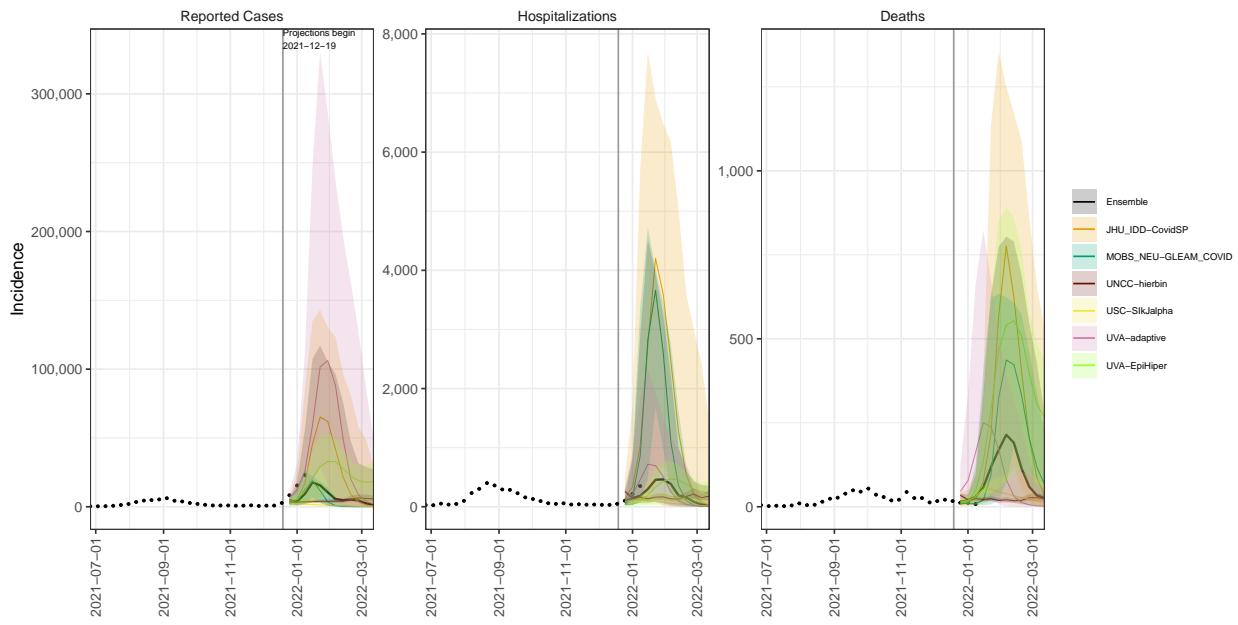
FL model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



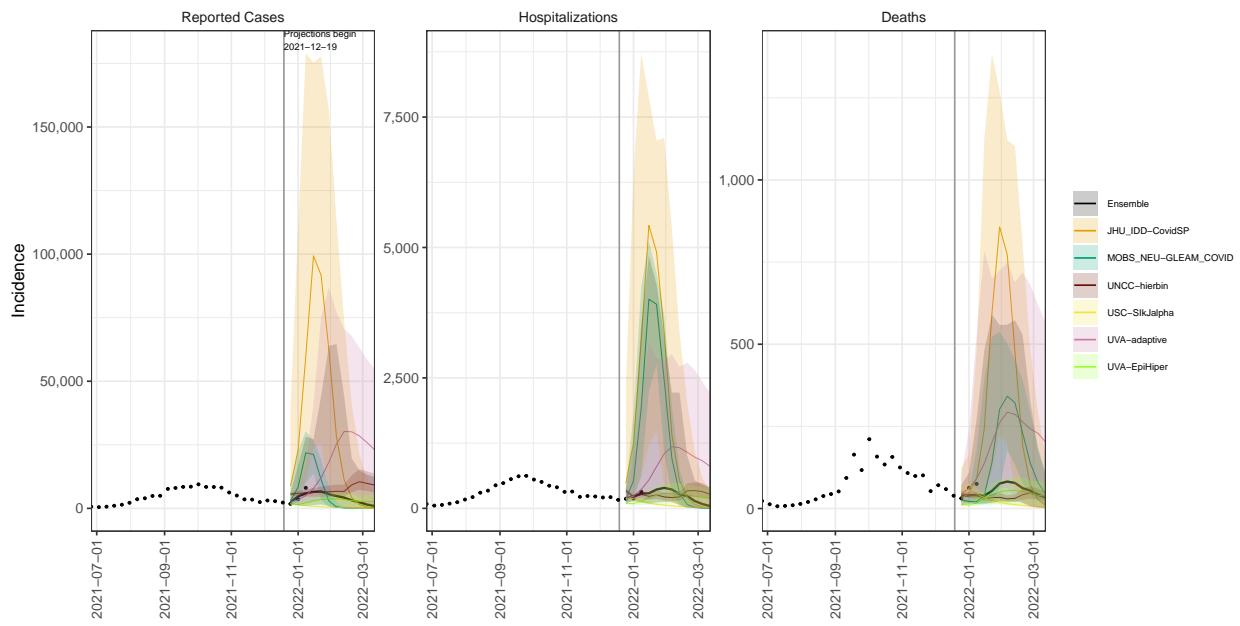
GA model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



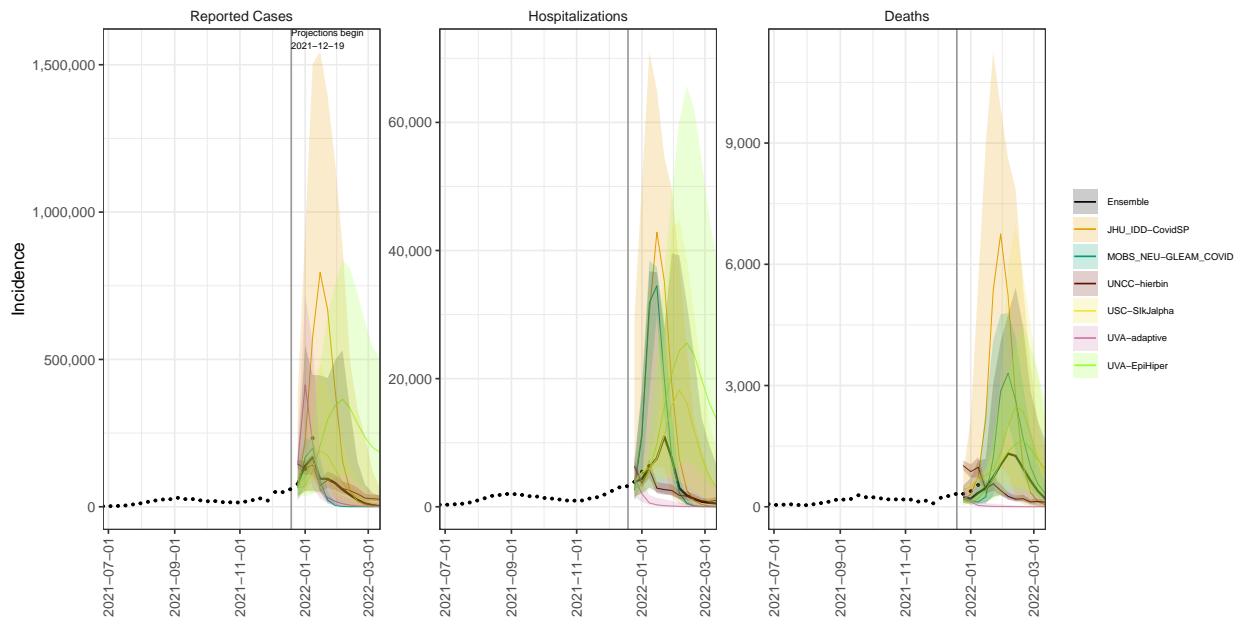
HI model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



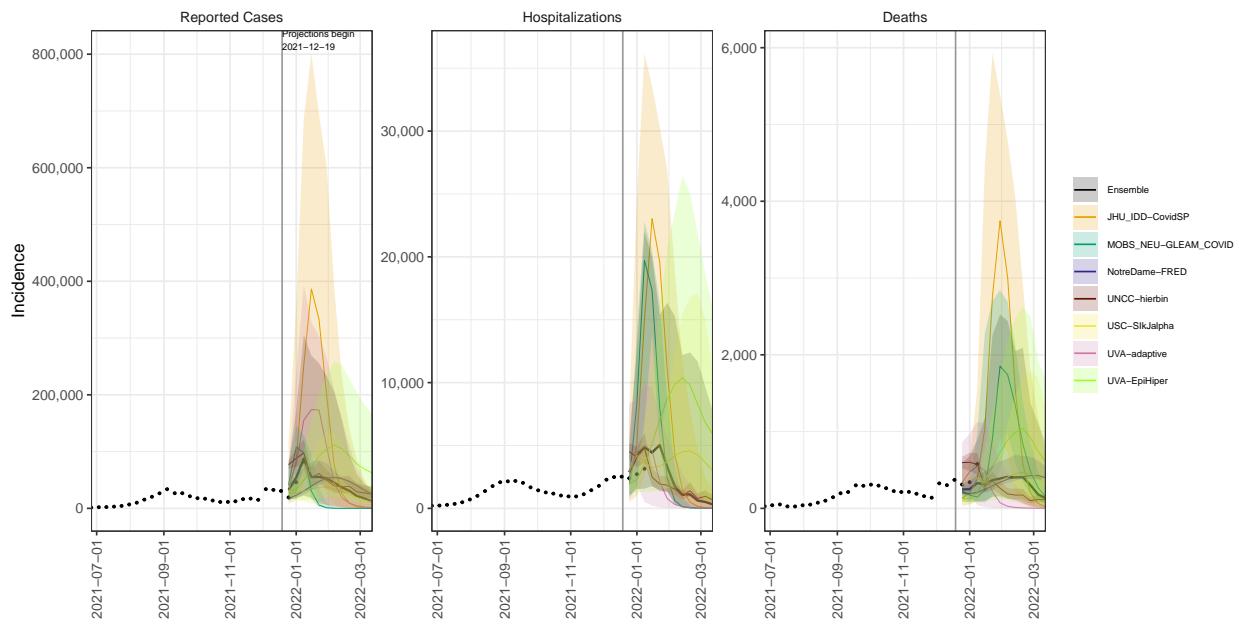
ID model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



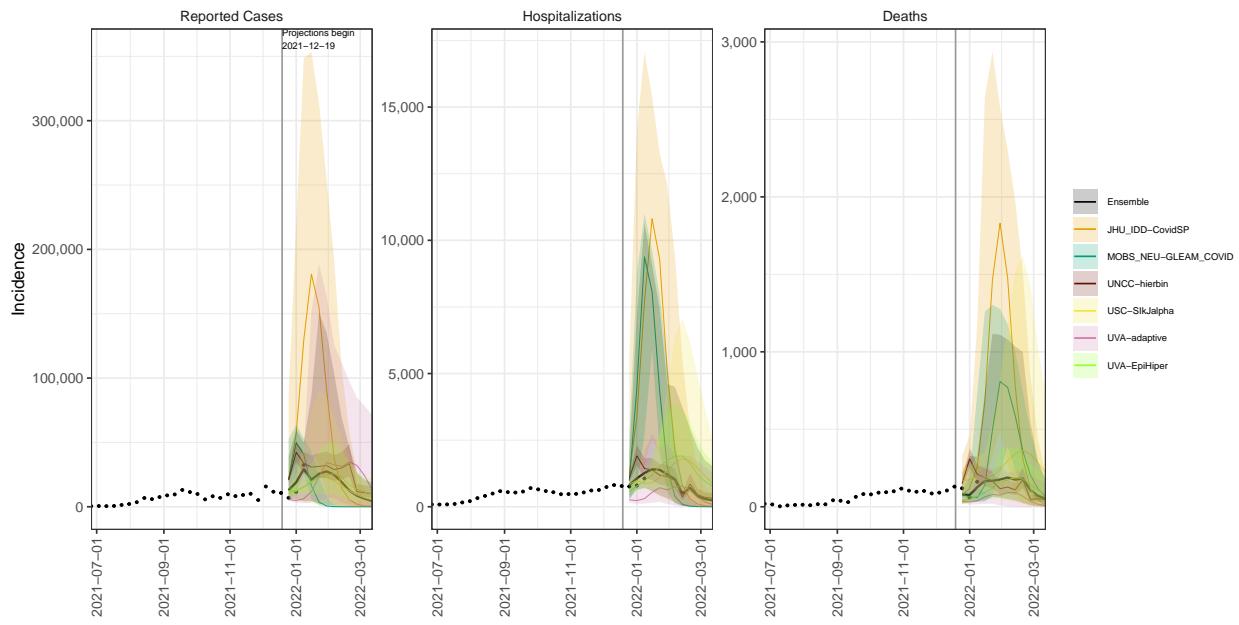
IL model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



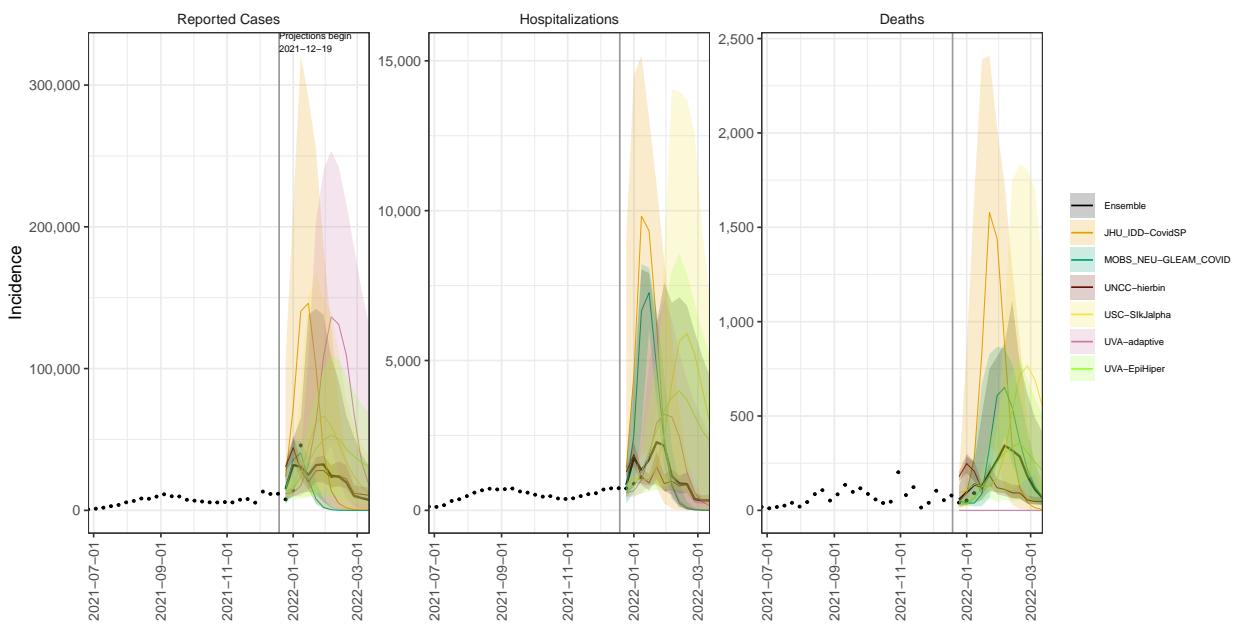
IN model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



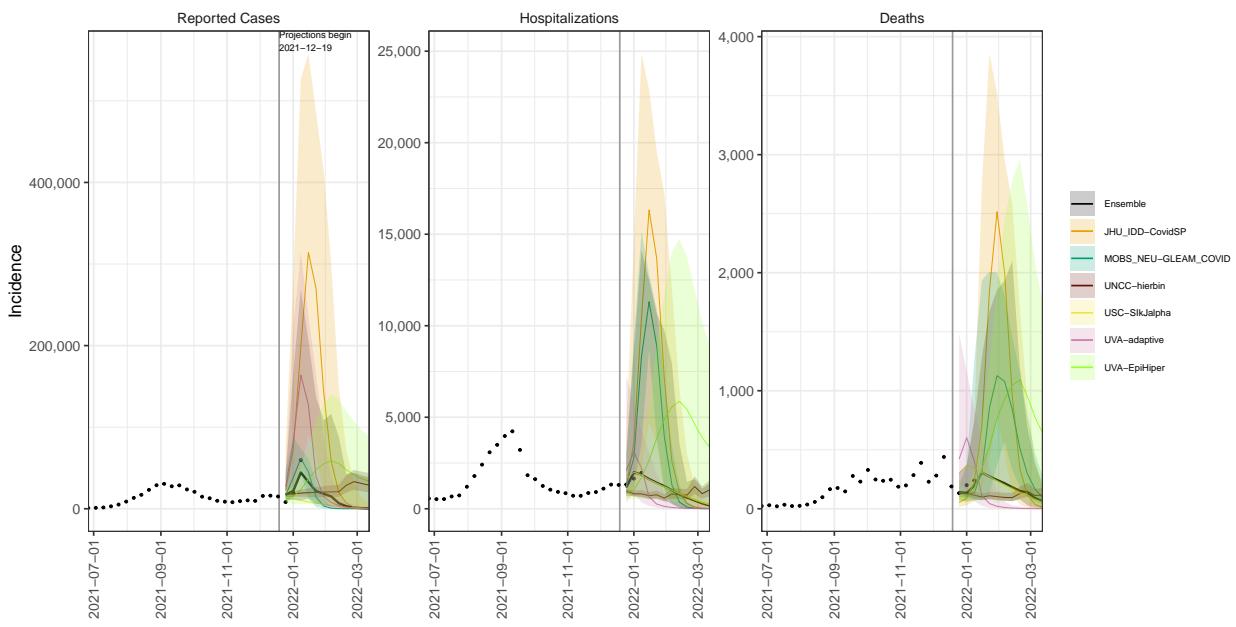
IA model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



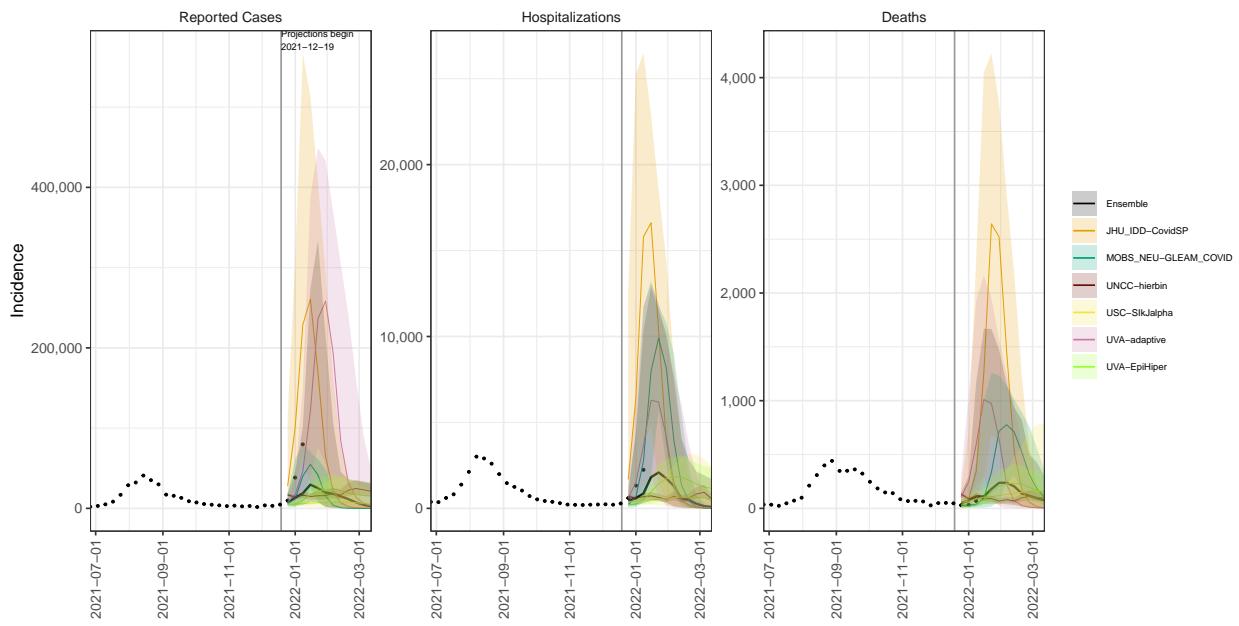
KS model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



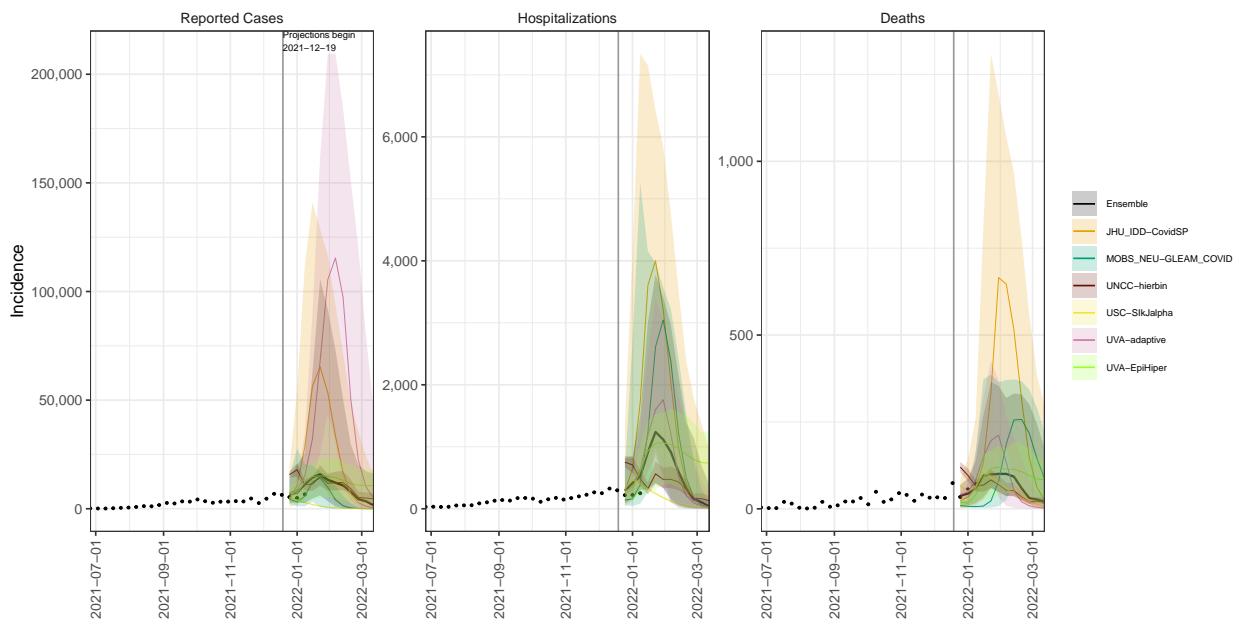
KY model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



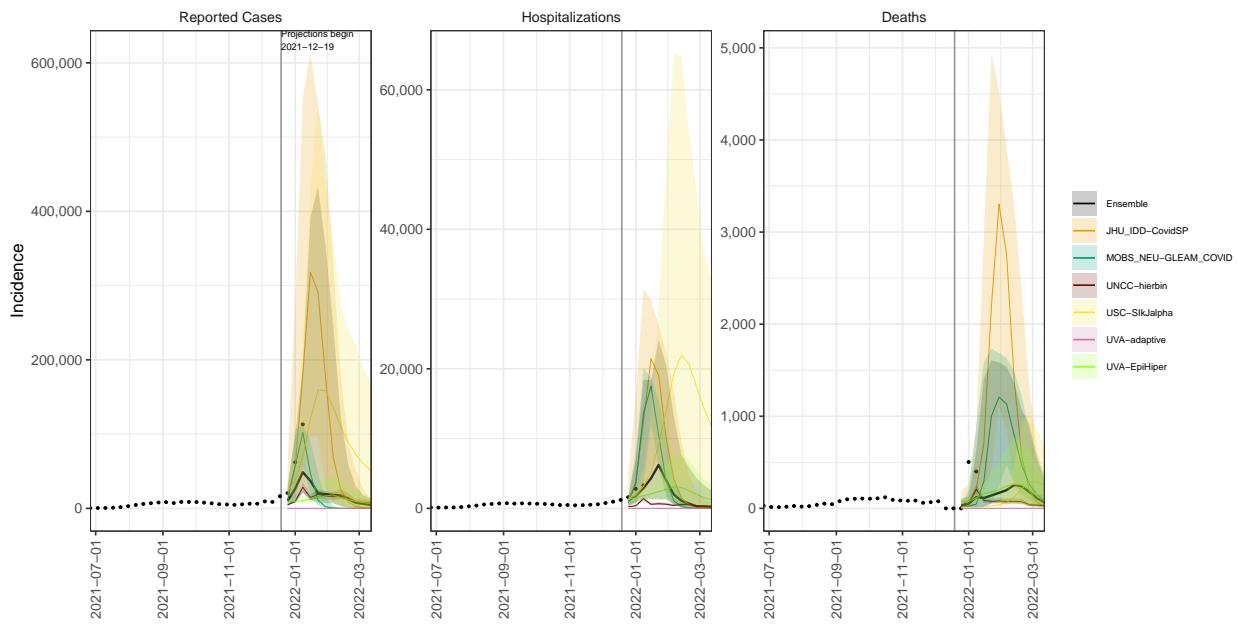
LA model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



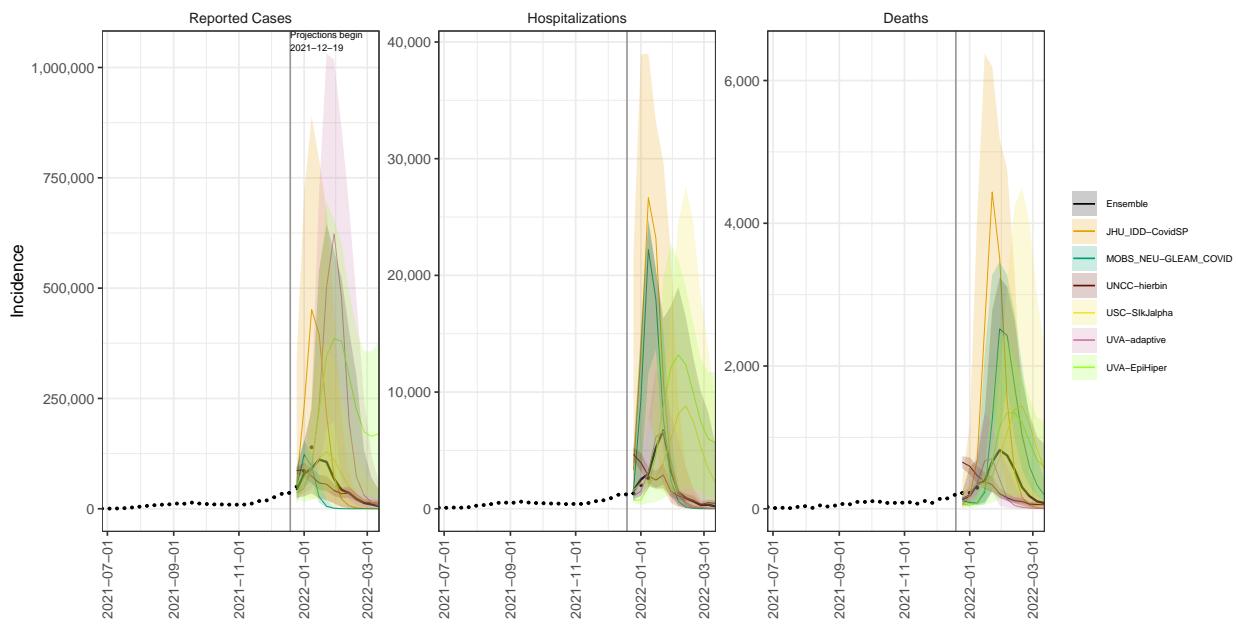
ME model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



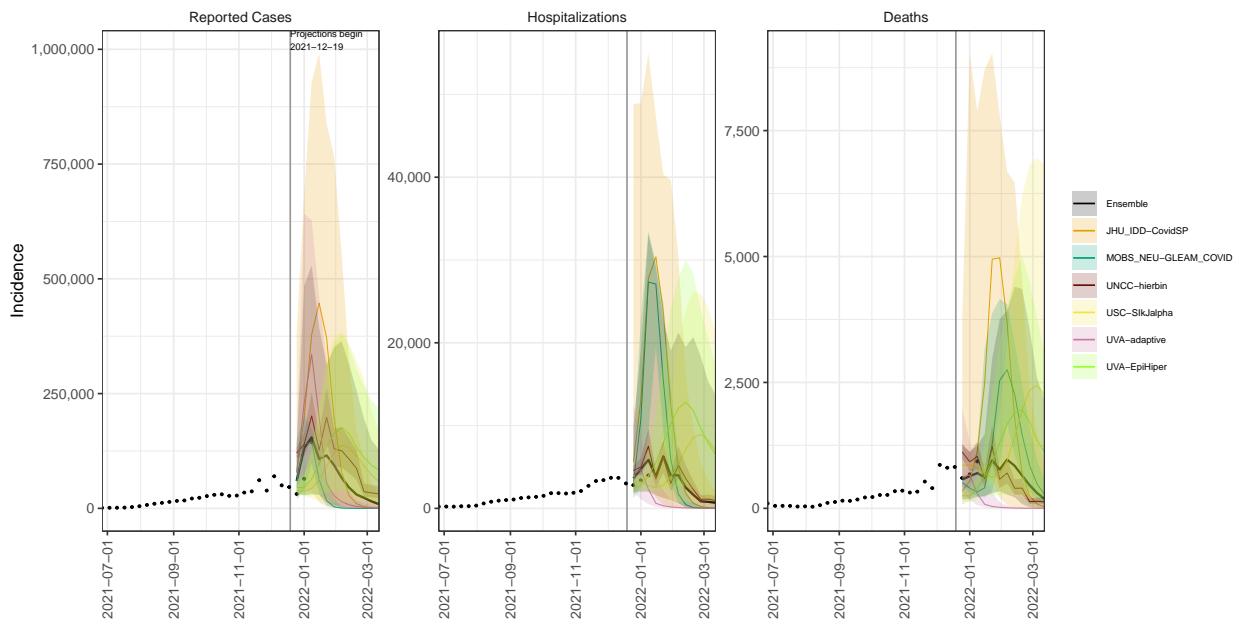
MD model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



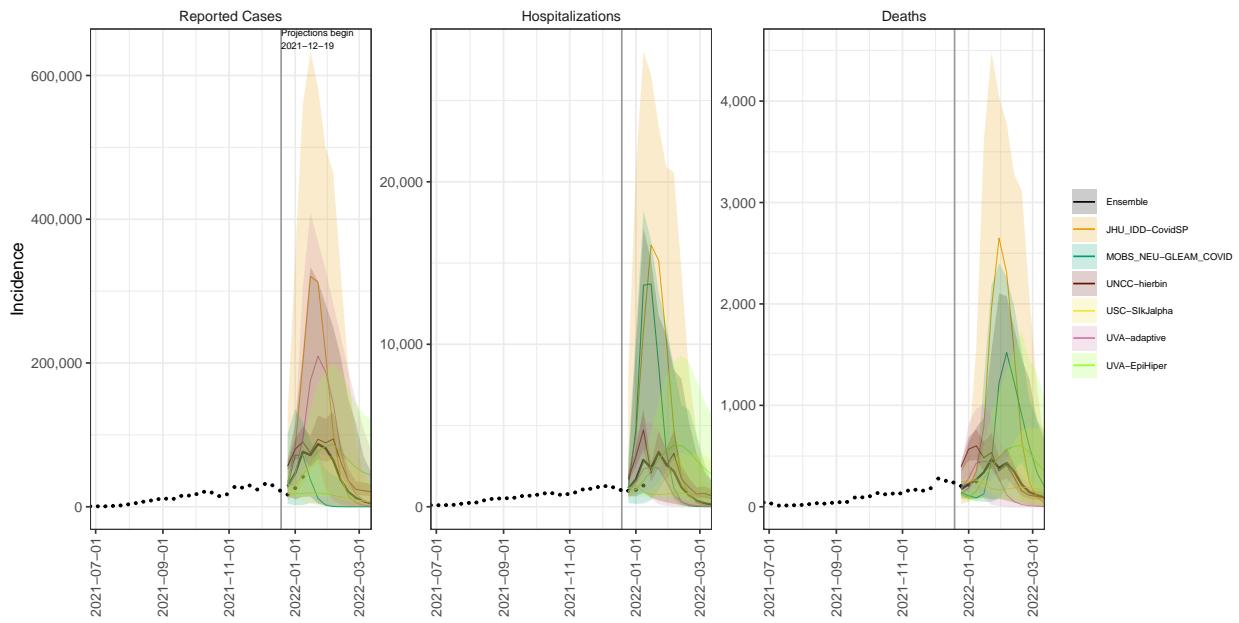
MA model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



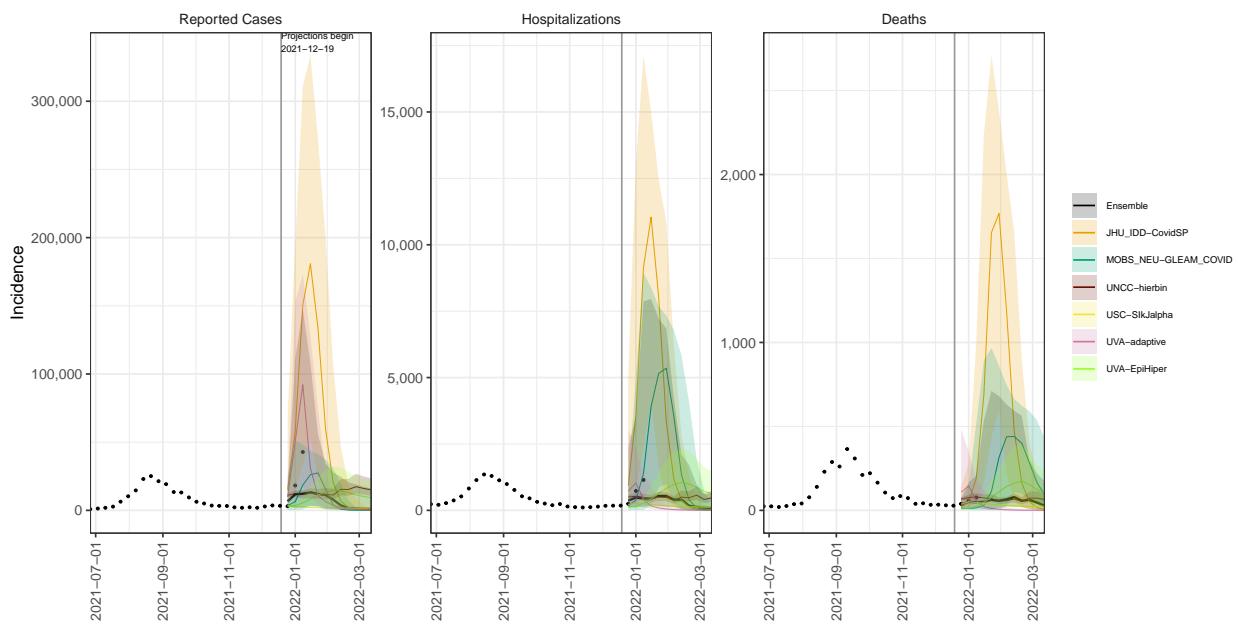
MI model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



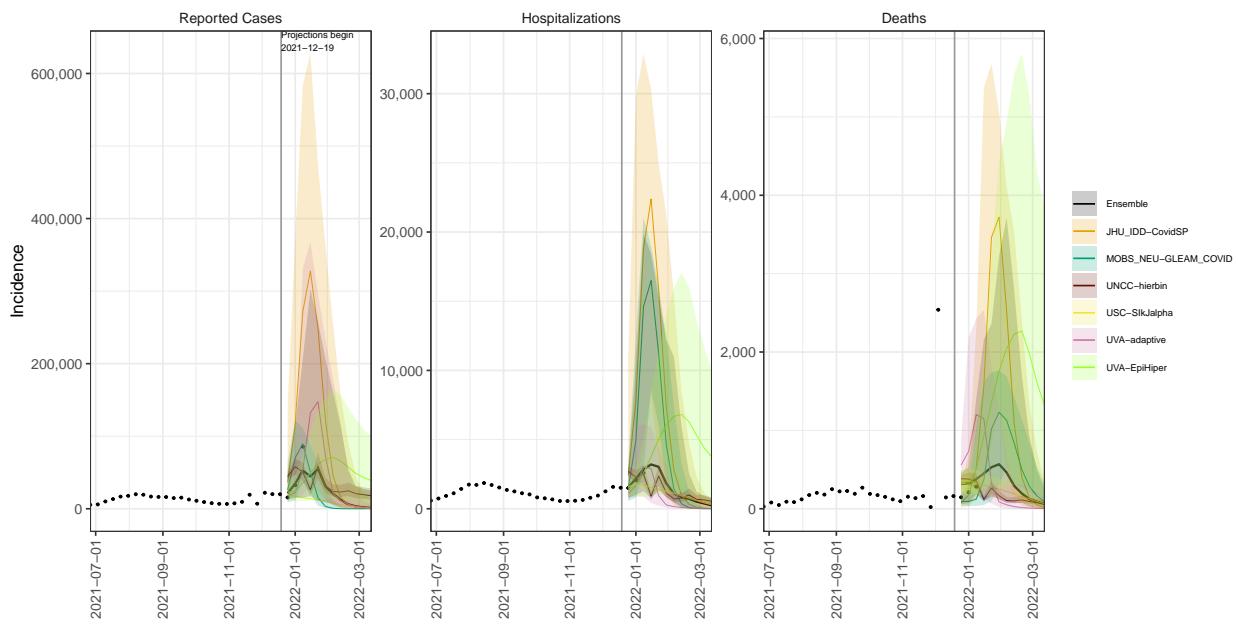
MN model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



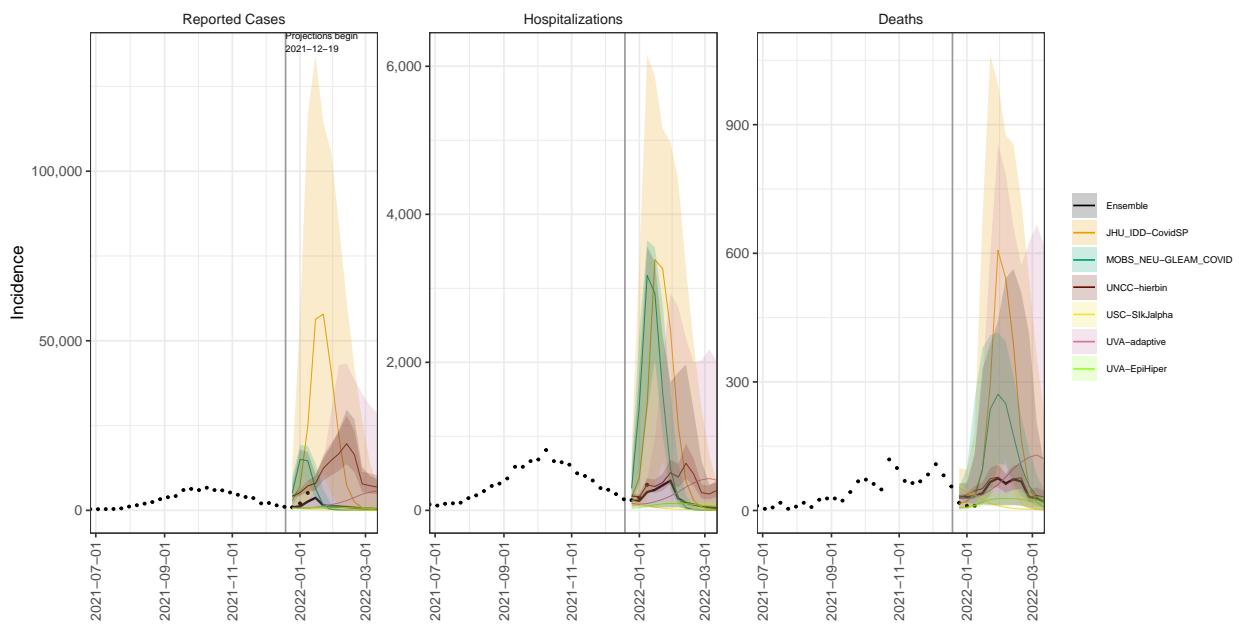
MS model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



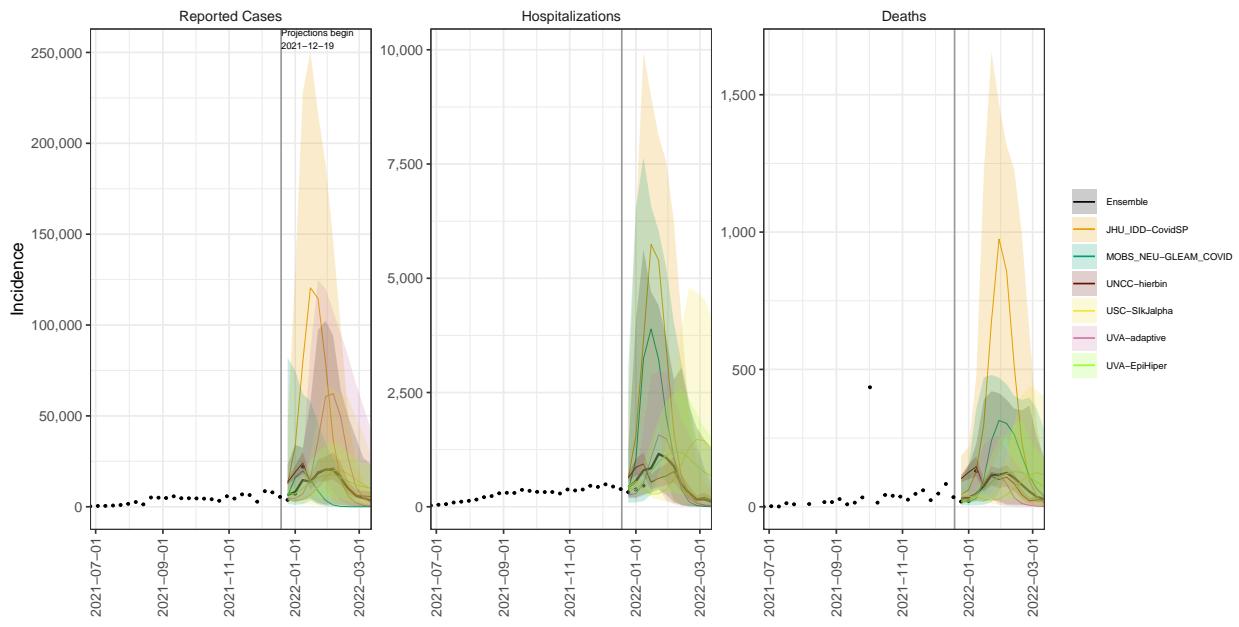
MO model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



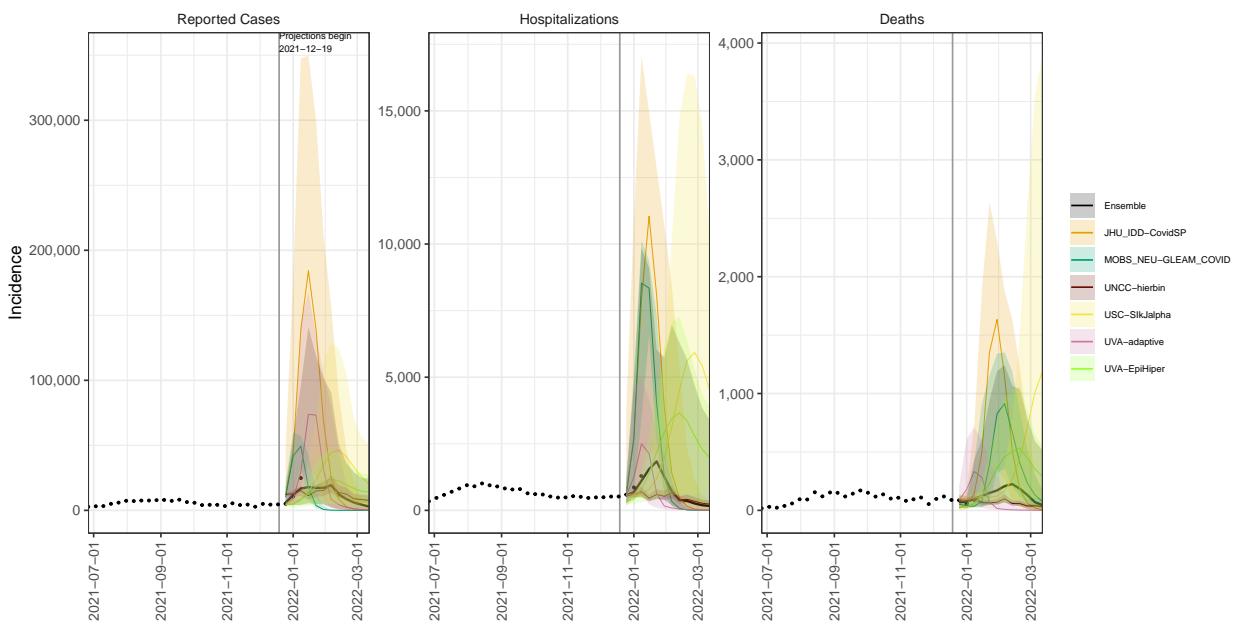
MT model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



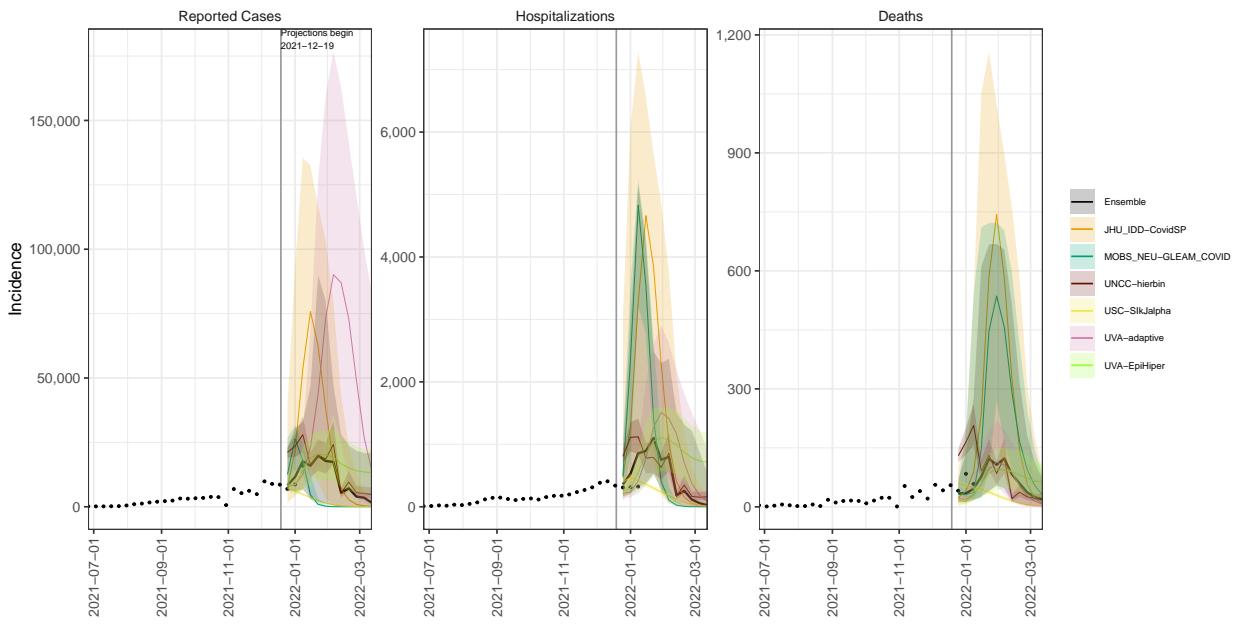
NE model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



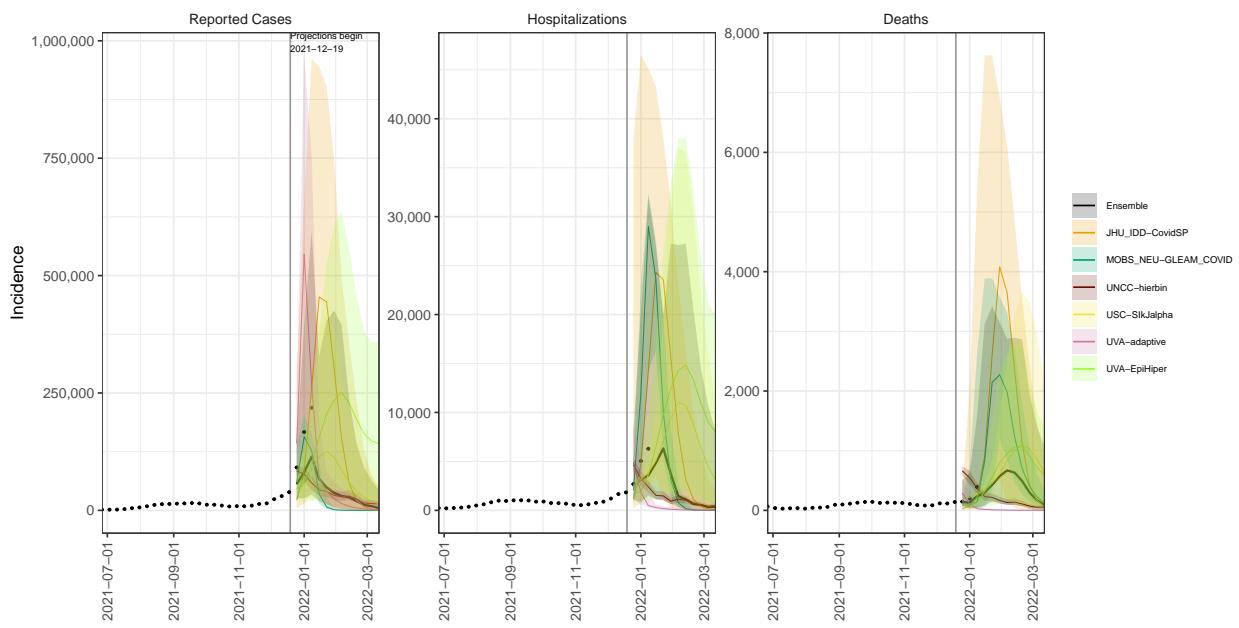
NV model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



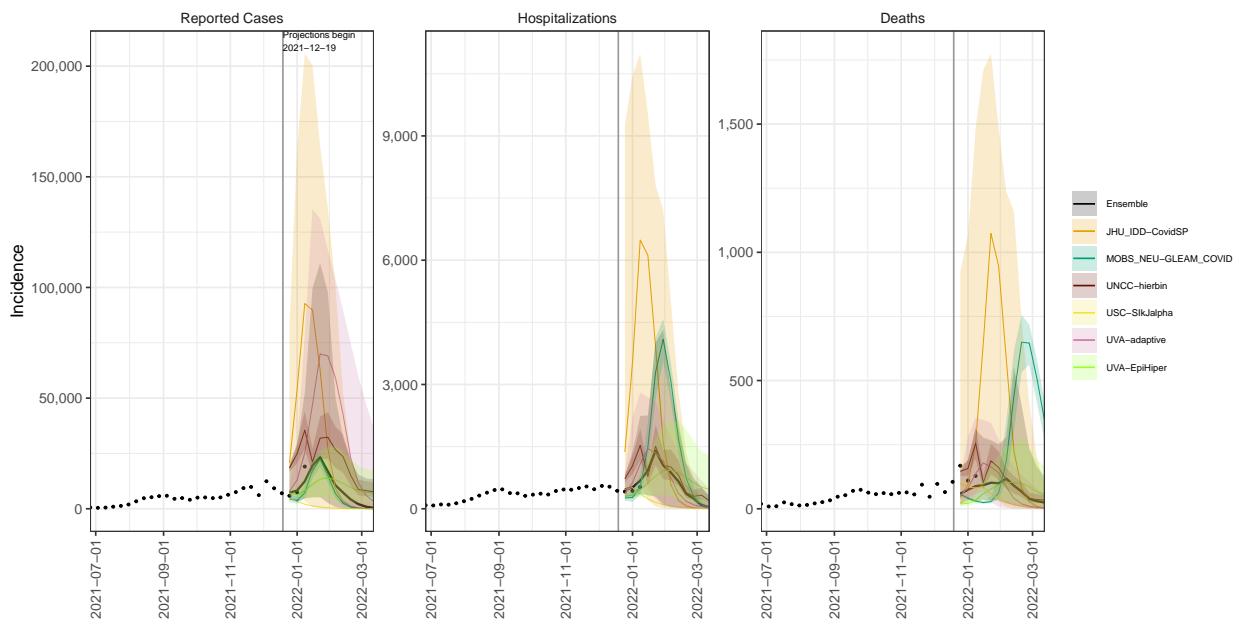
NH model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



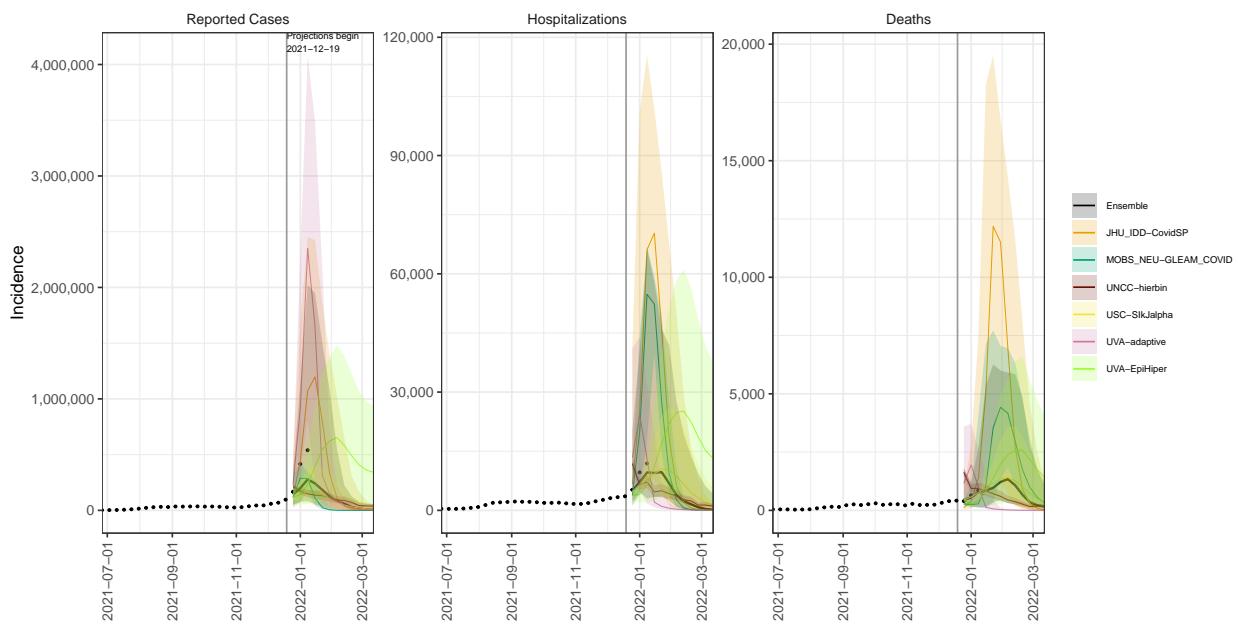
NJ model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



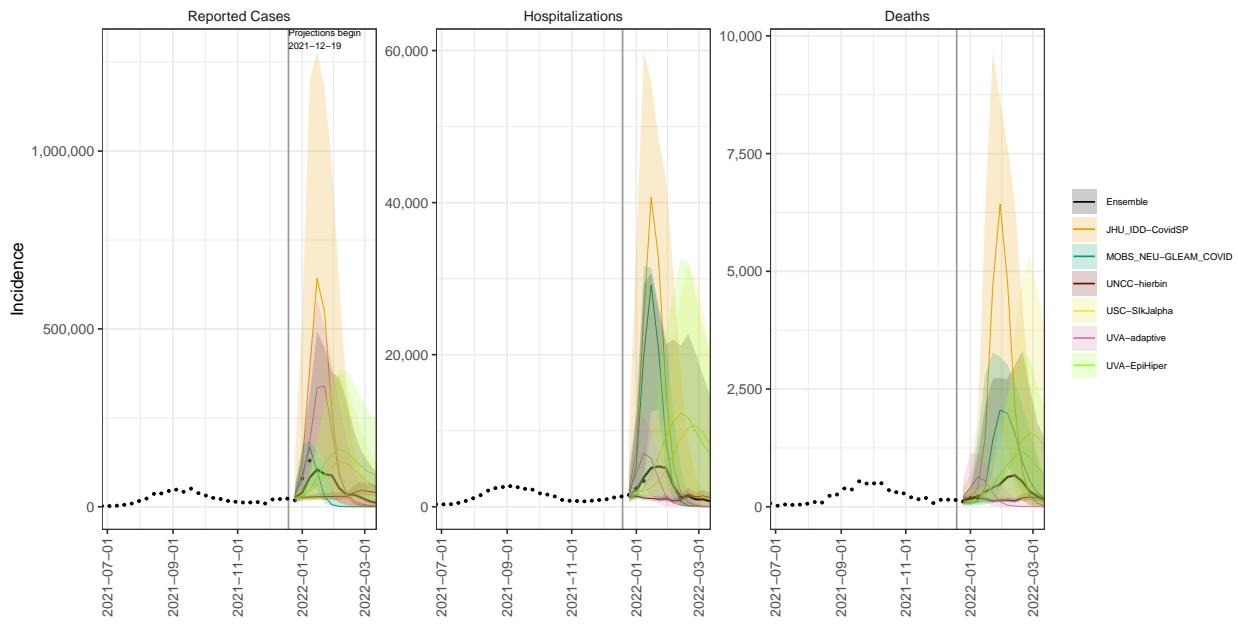
NM model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



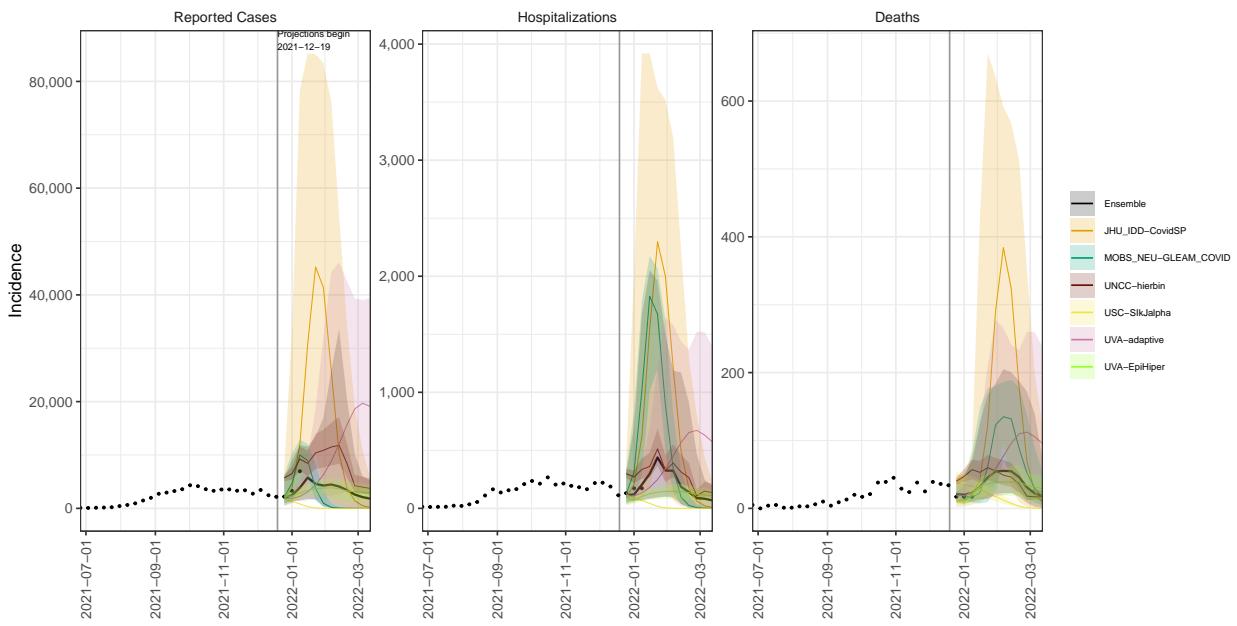
NY model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



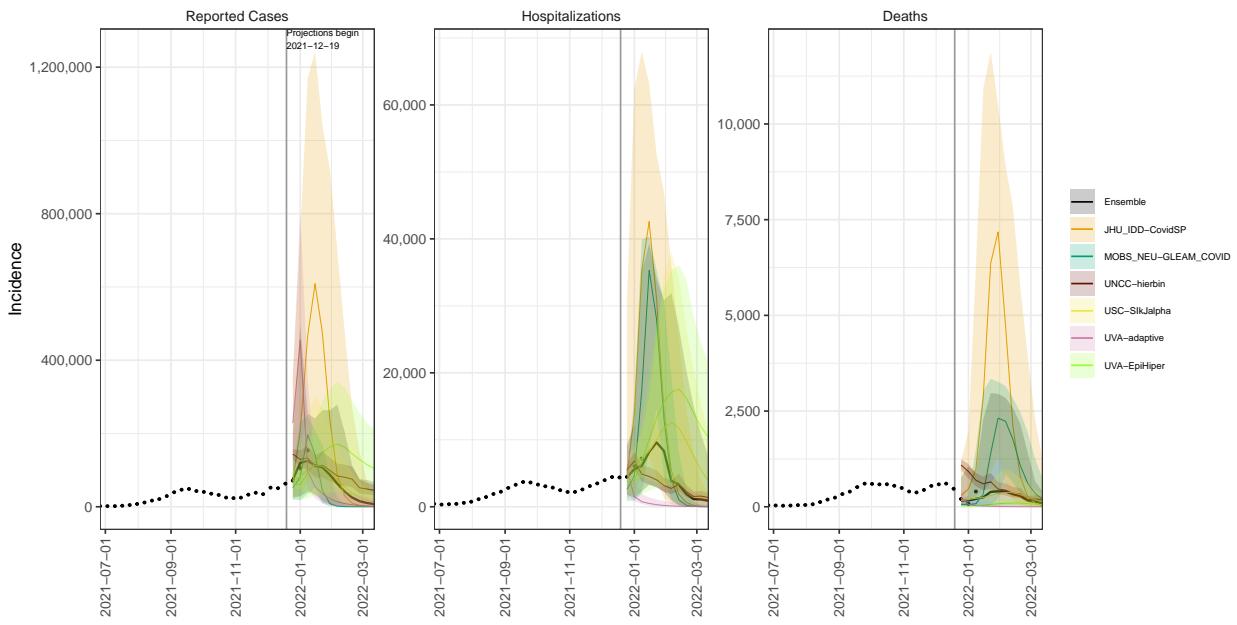
NC model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



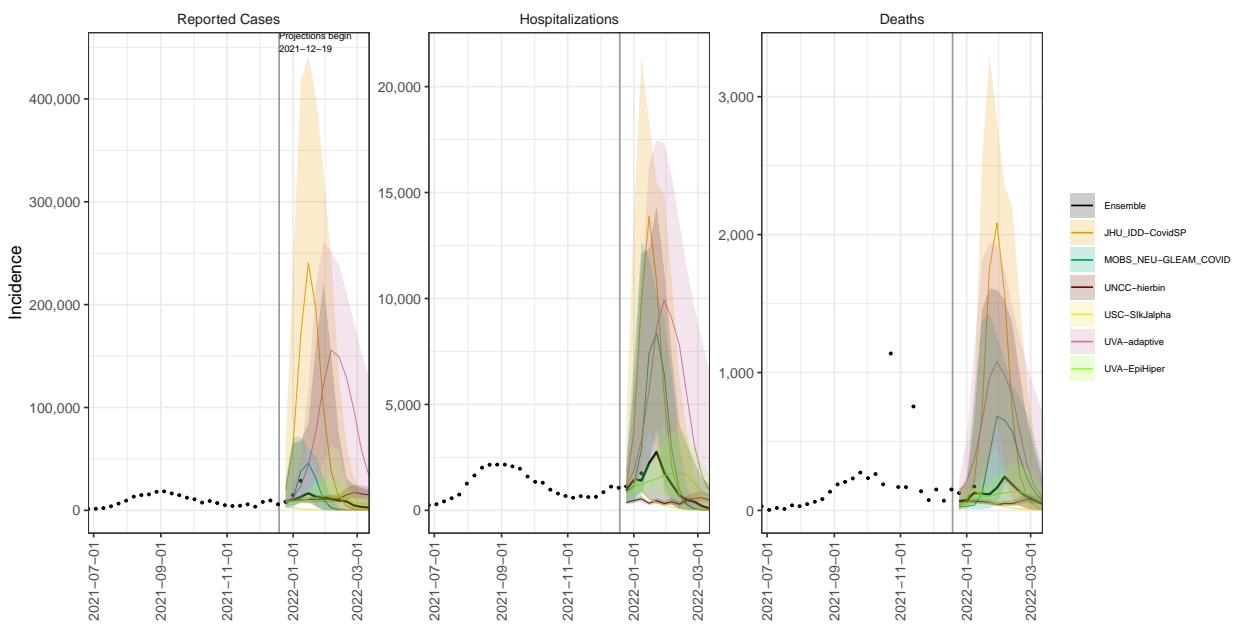
ND model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



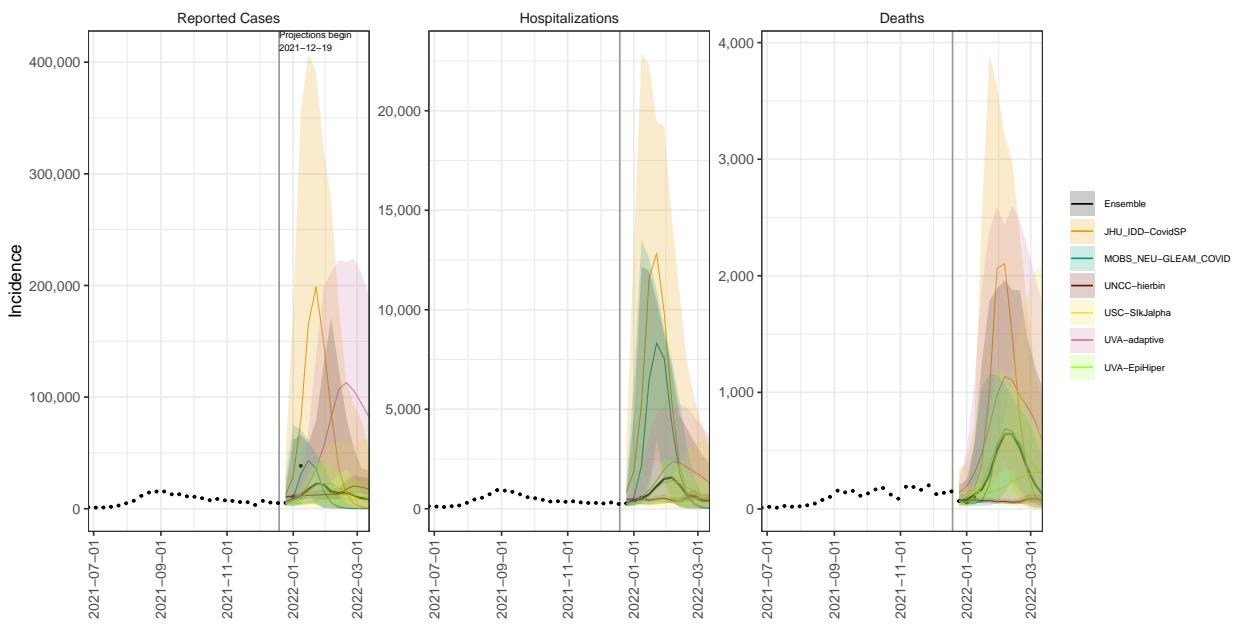
OH model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



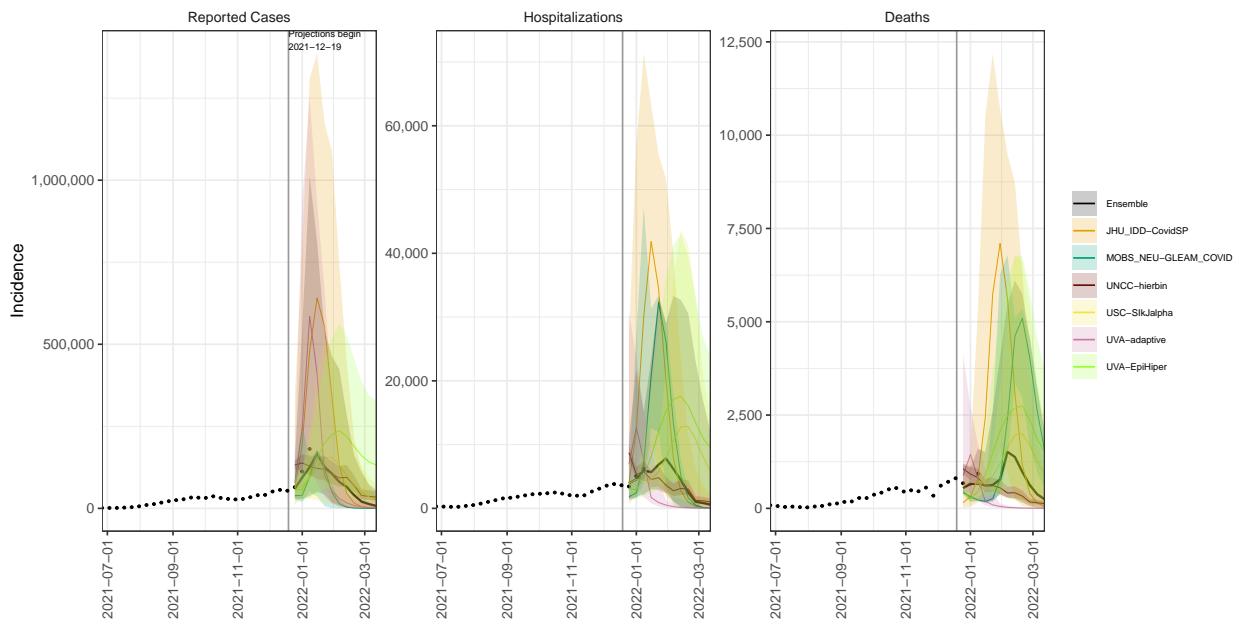
OK model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



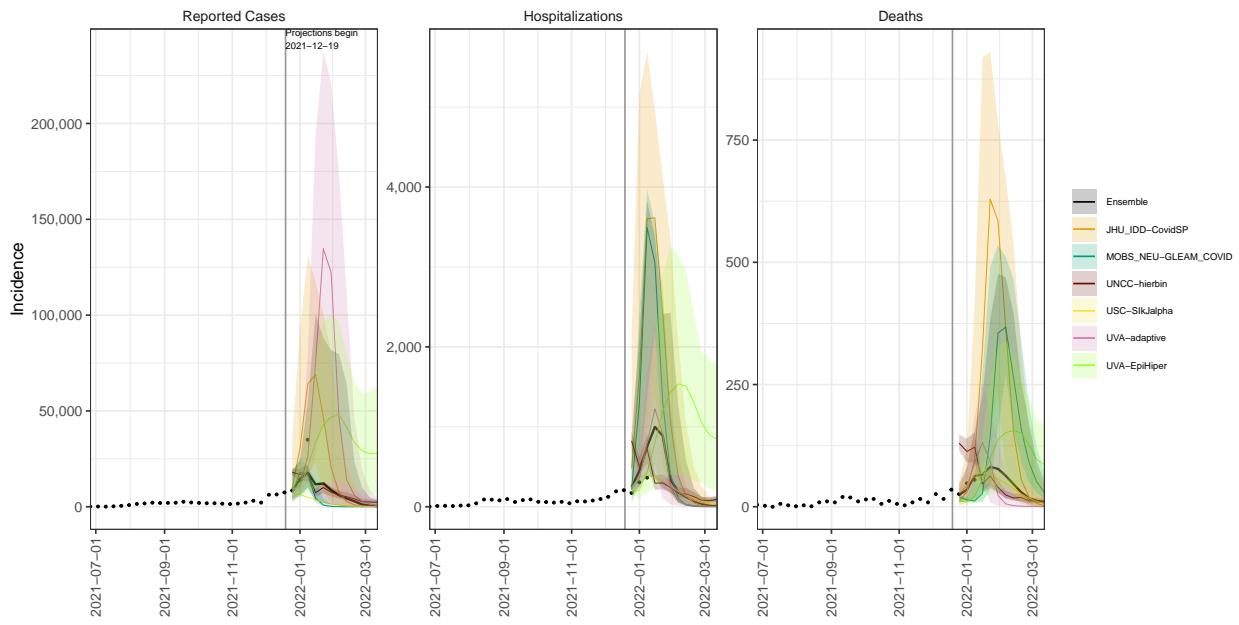
OR model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



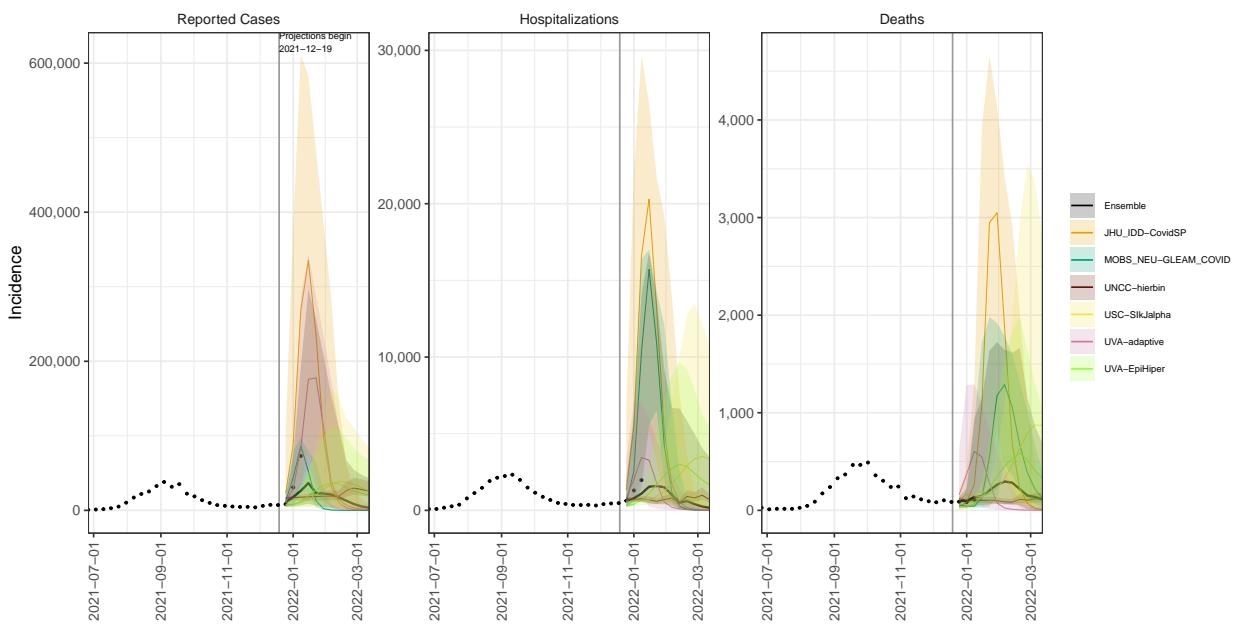
PA model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



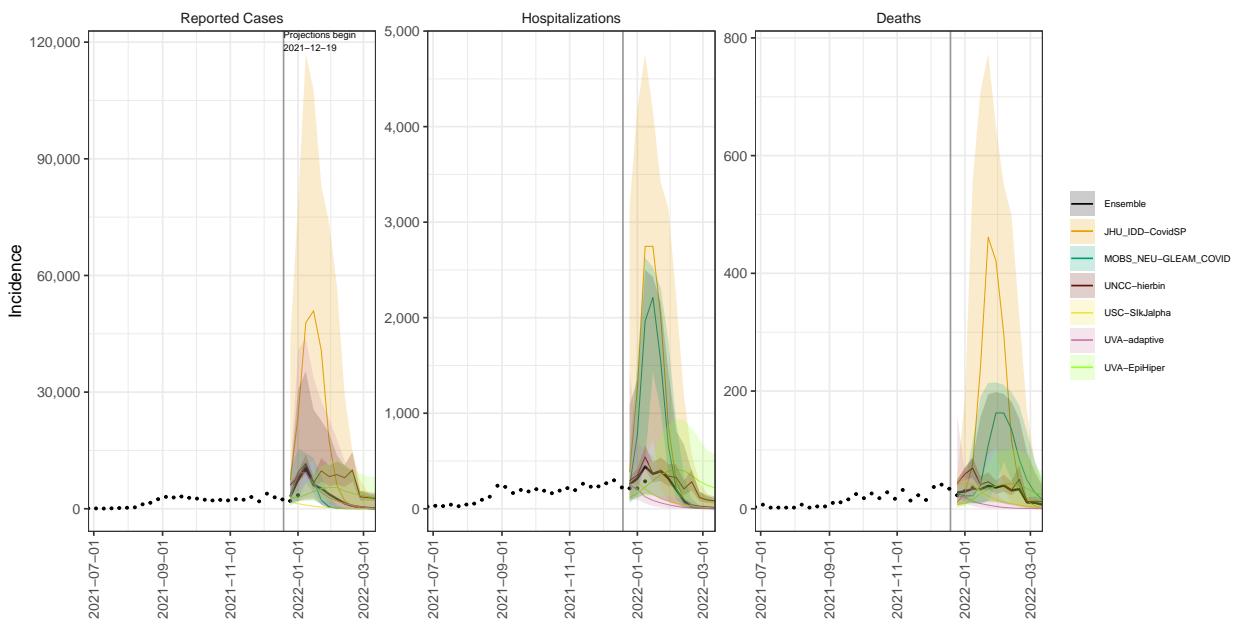
RI model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



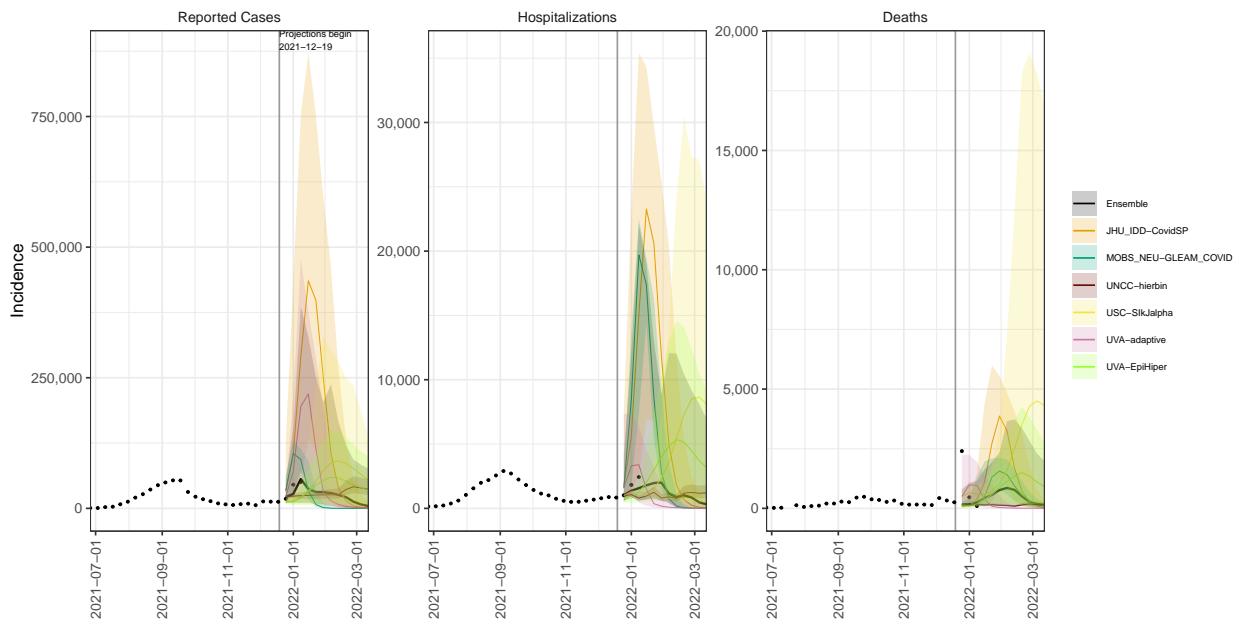
SC model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



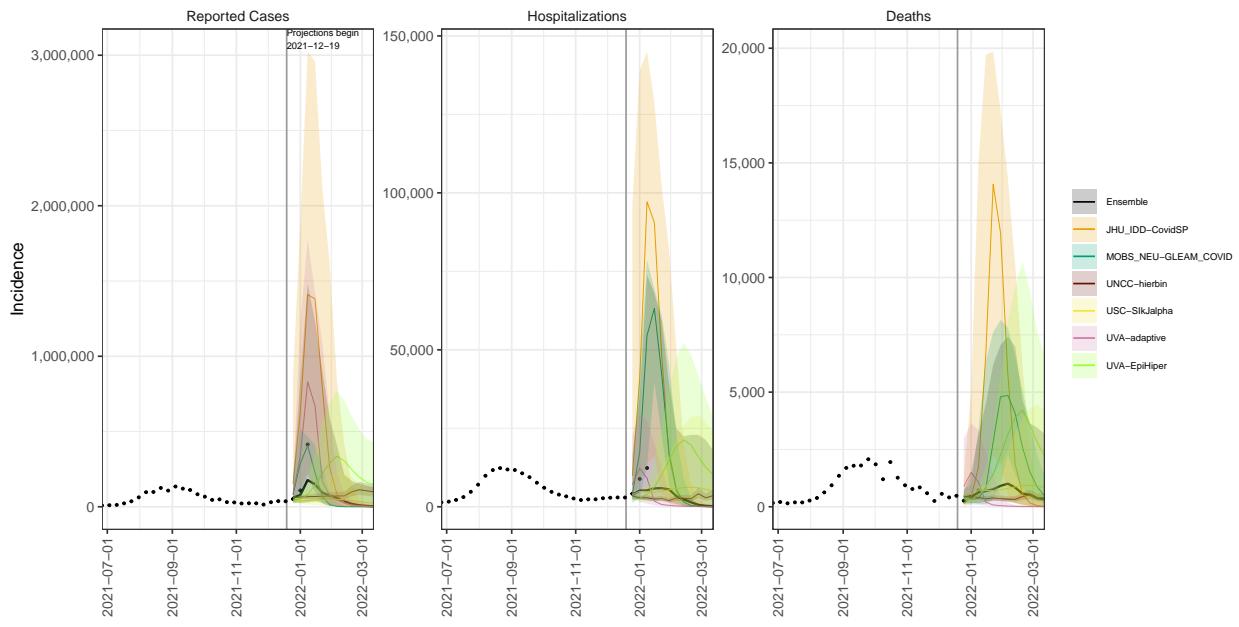
SD model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



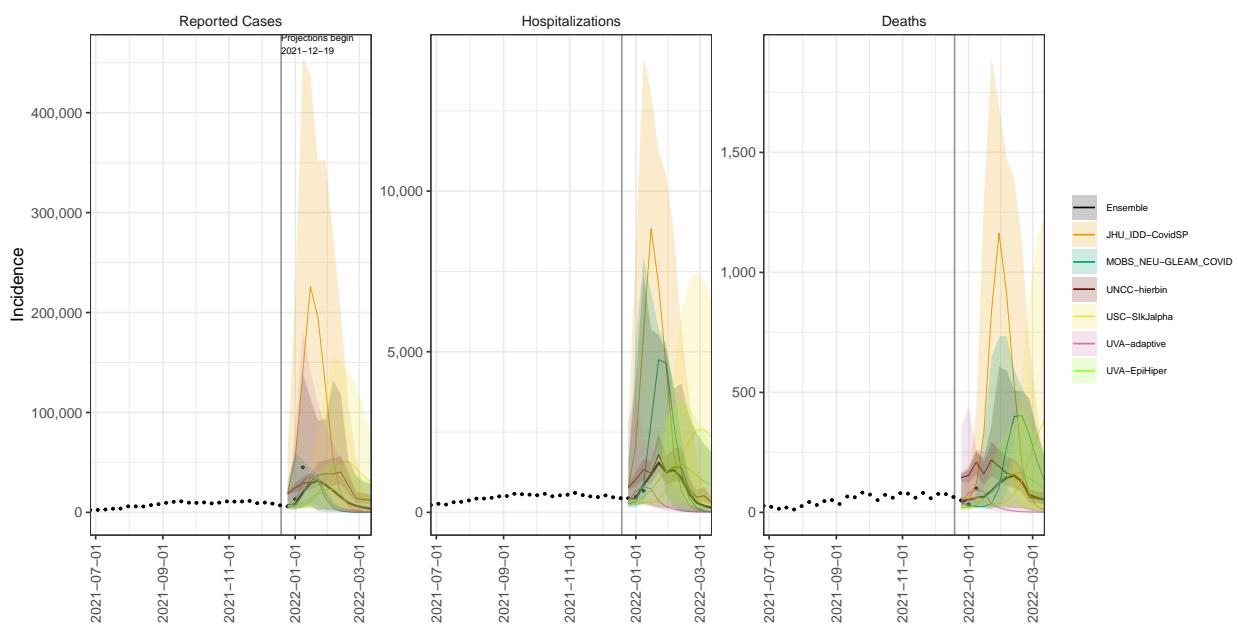
TN model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



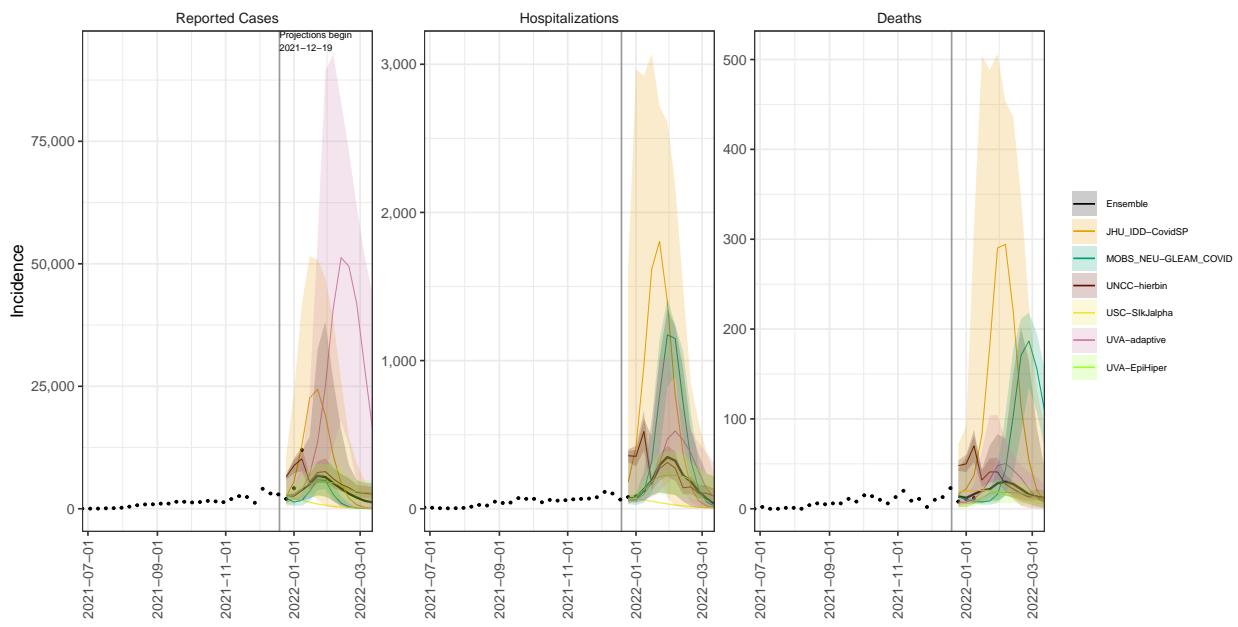
TX model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



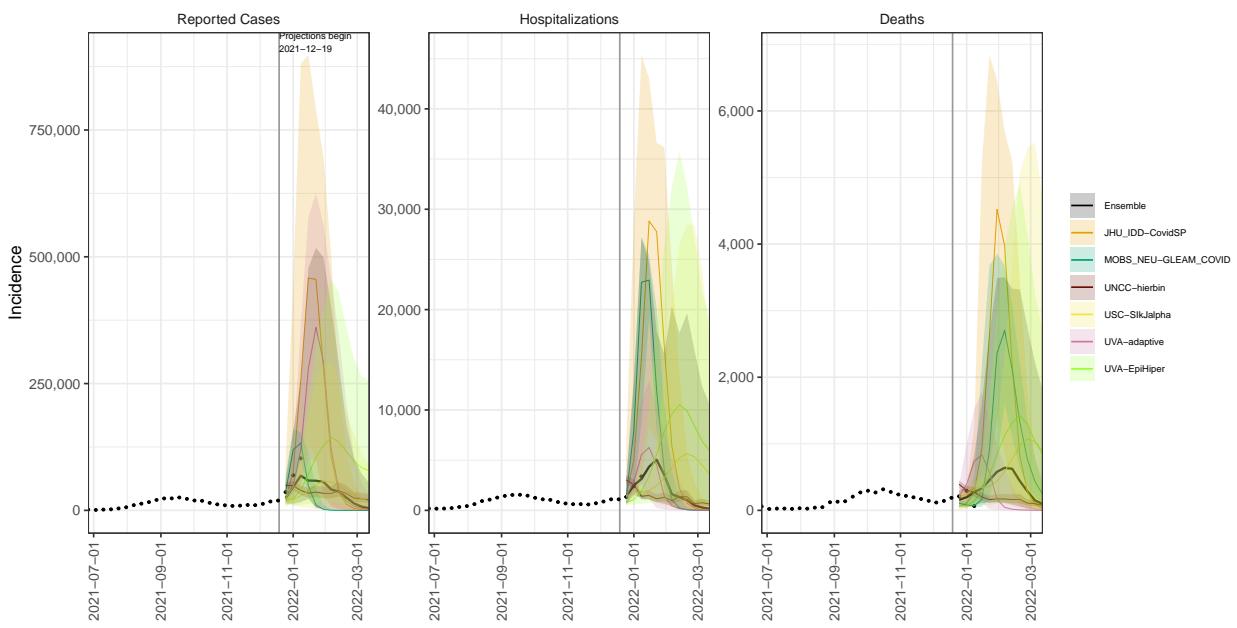
UT model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



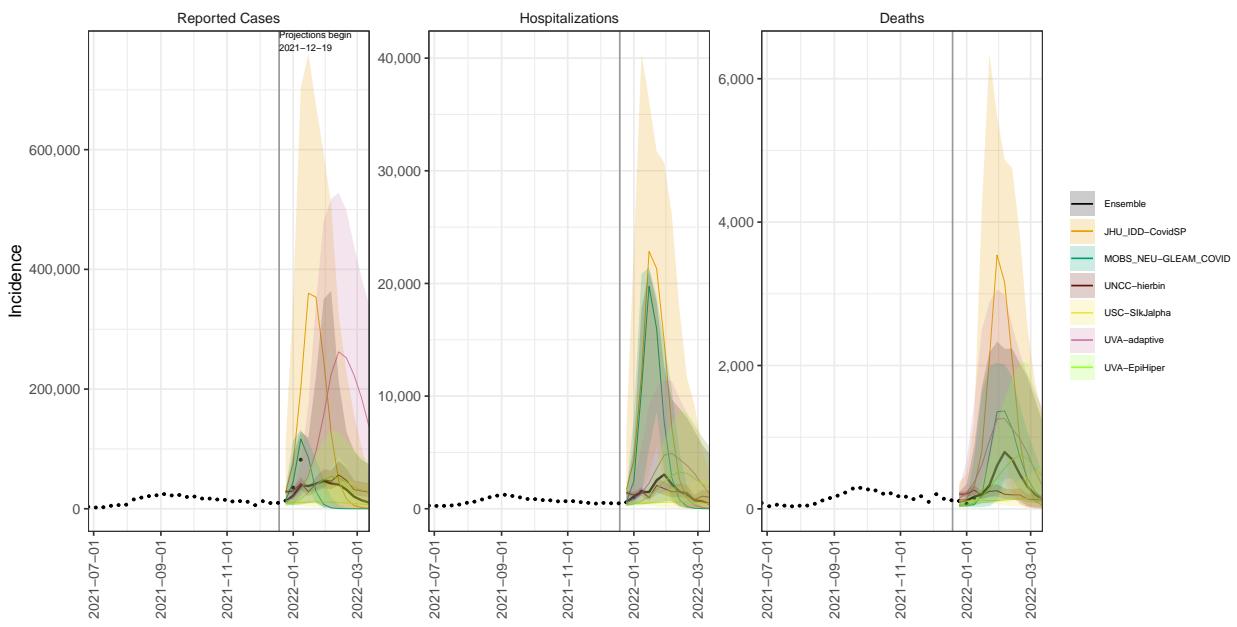
VT model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



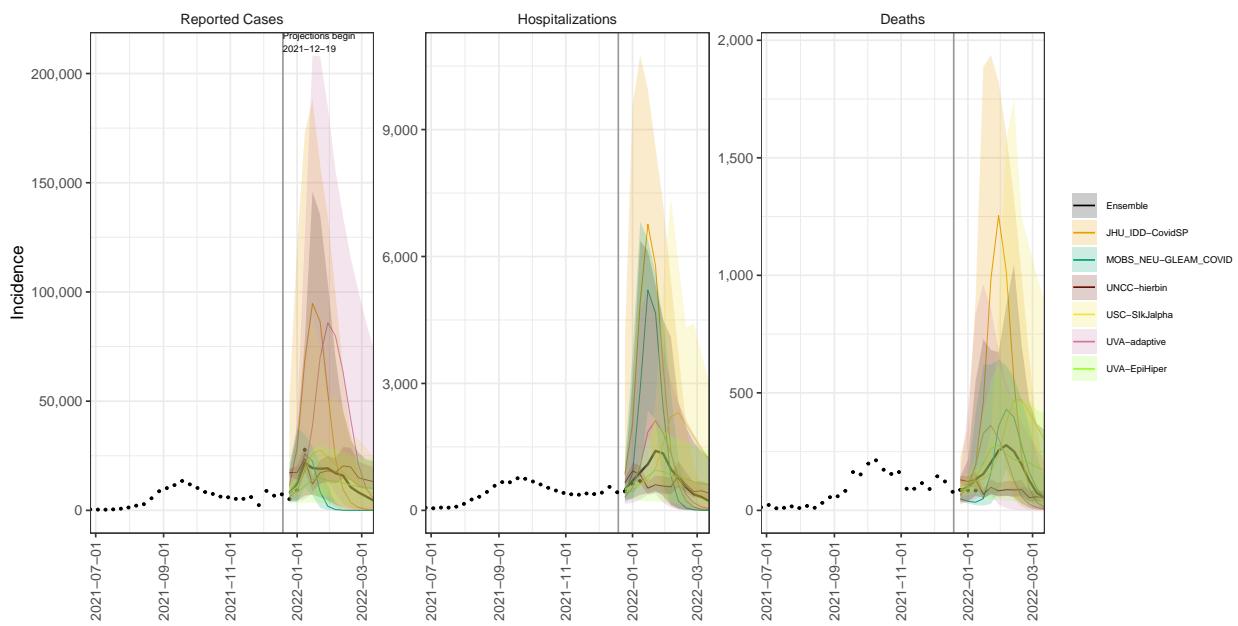
VA model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



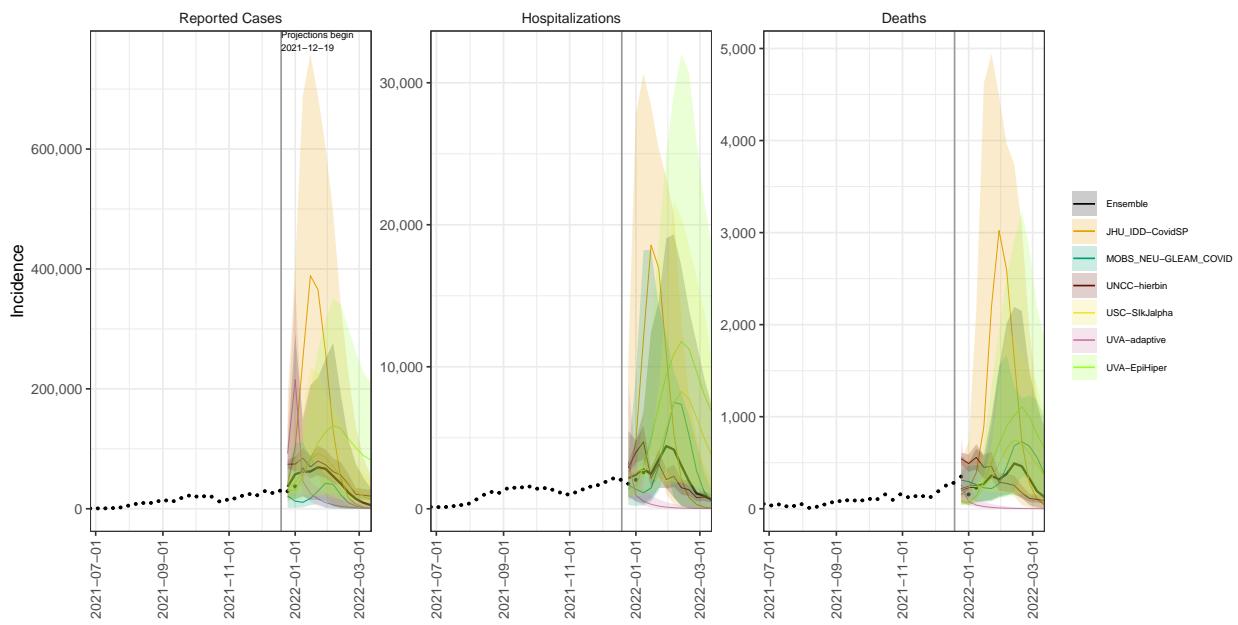
WA model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



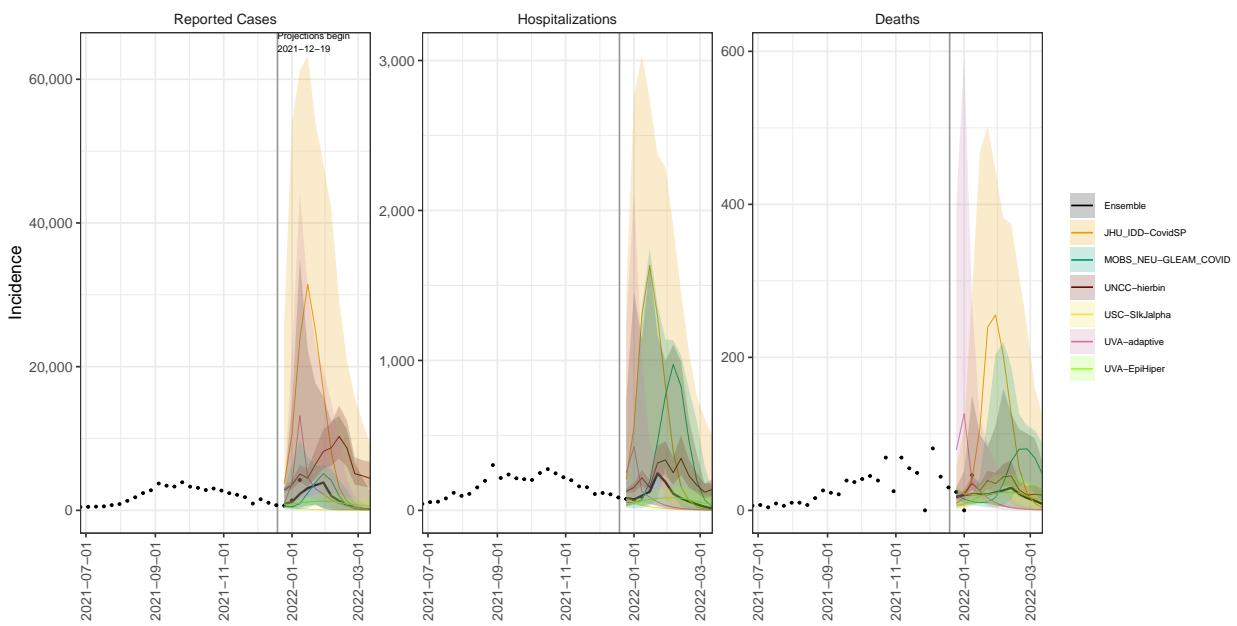
WV model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



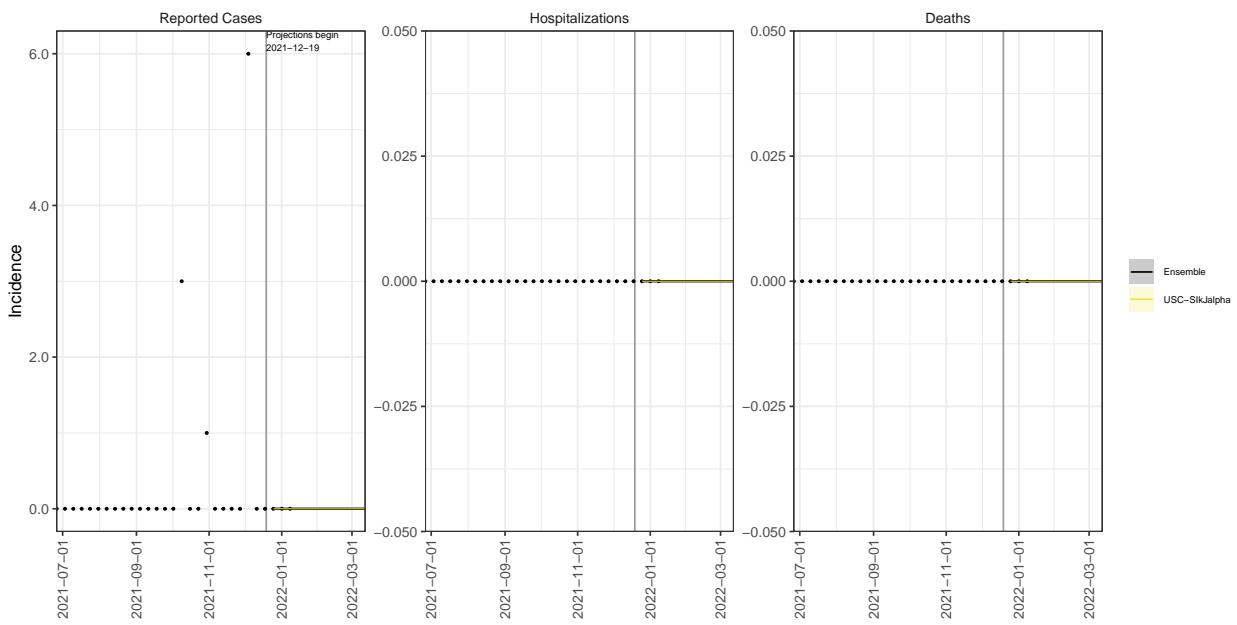
WI model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



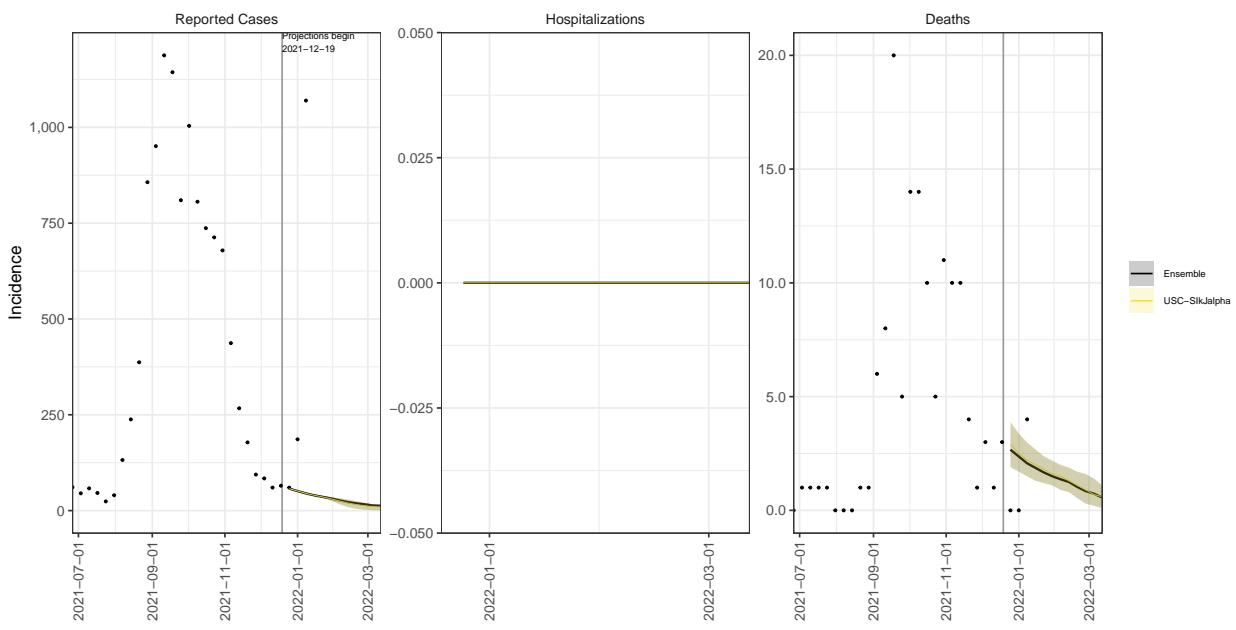
WY model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



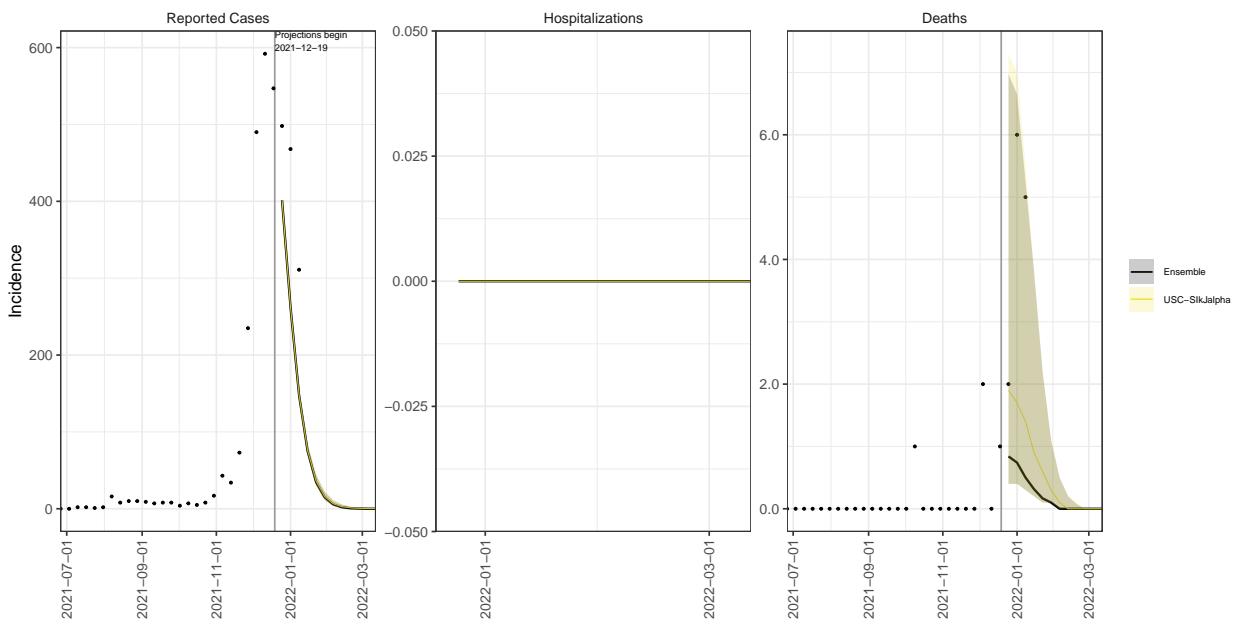
AS model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



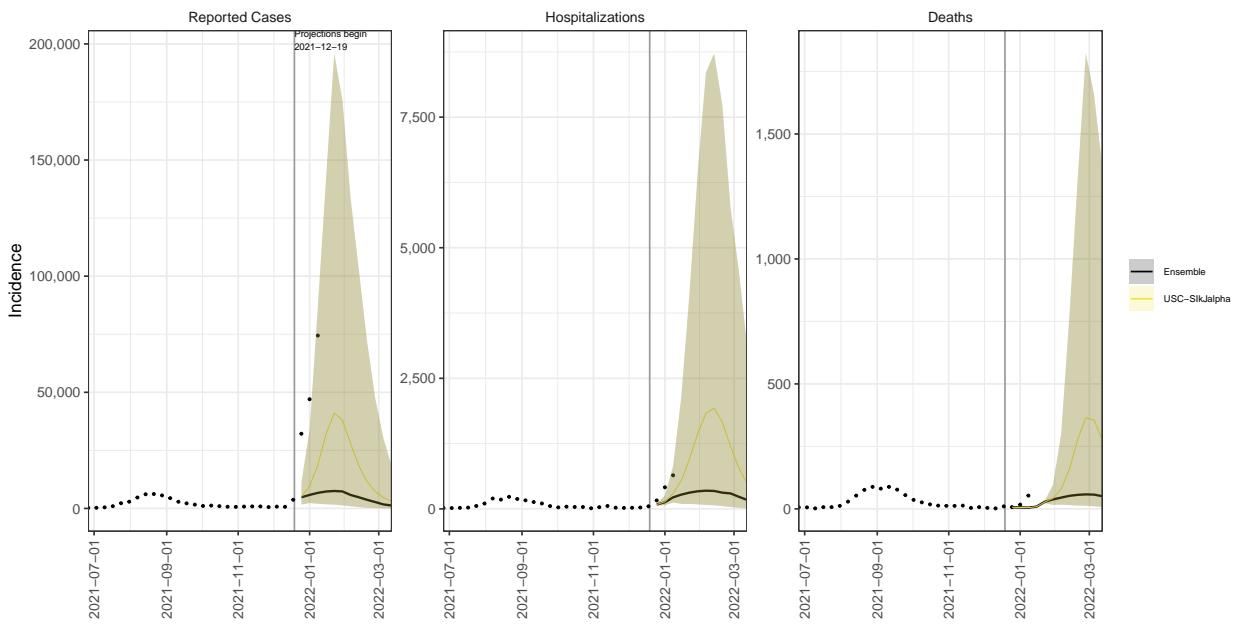
GU model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



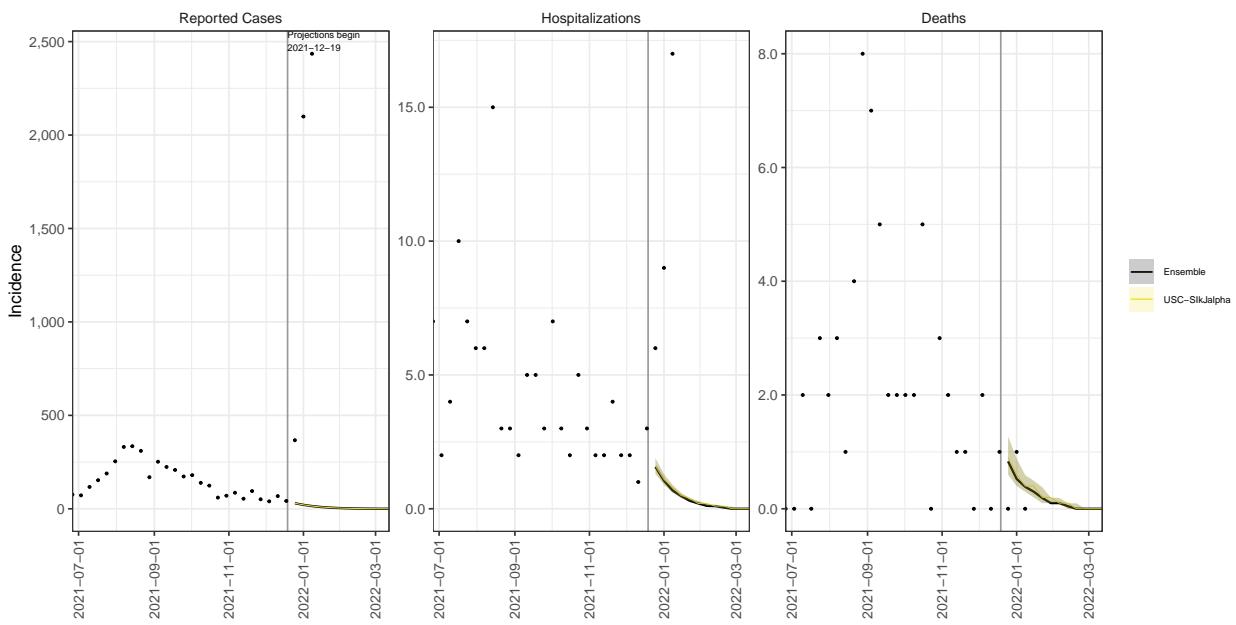
MP model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility



PR model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility

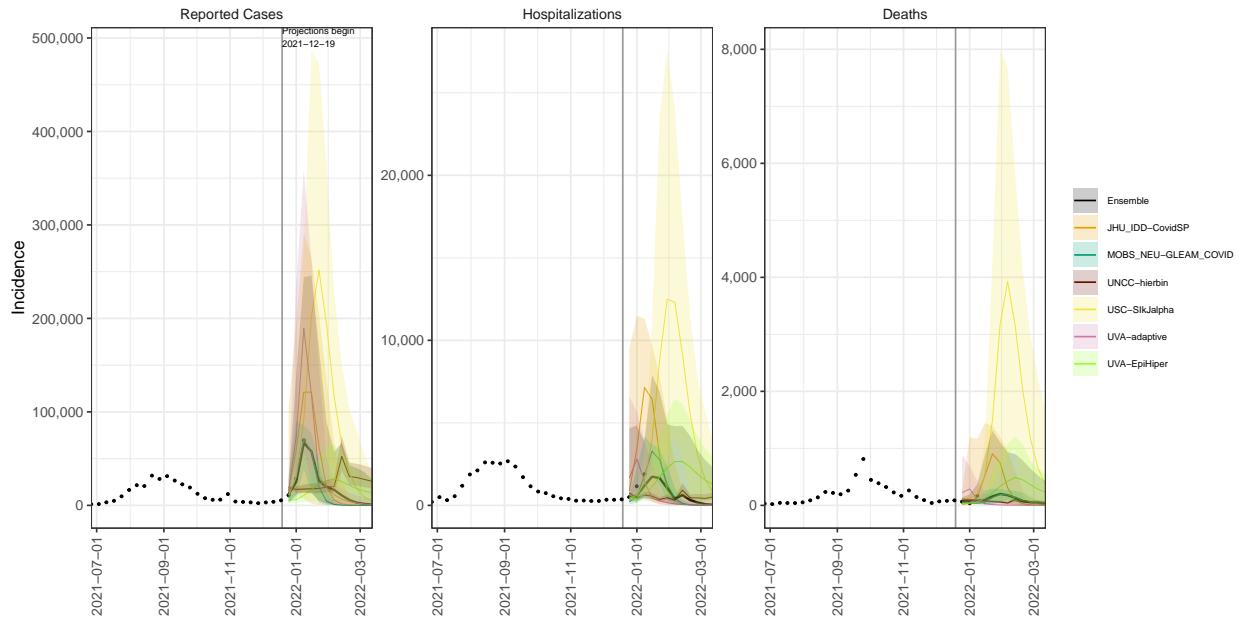


VI model variance & 95% projection intervals – Pessimistic severity, low immune escape & high transmissibility

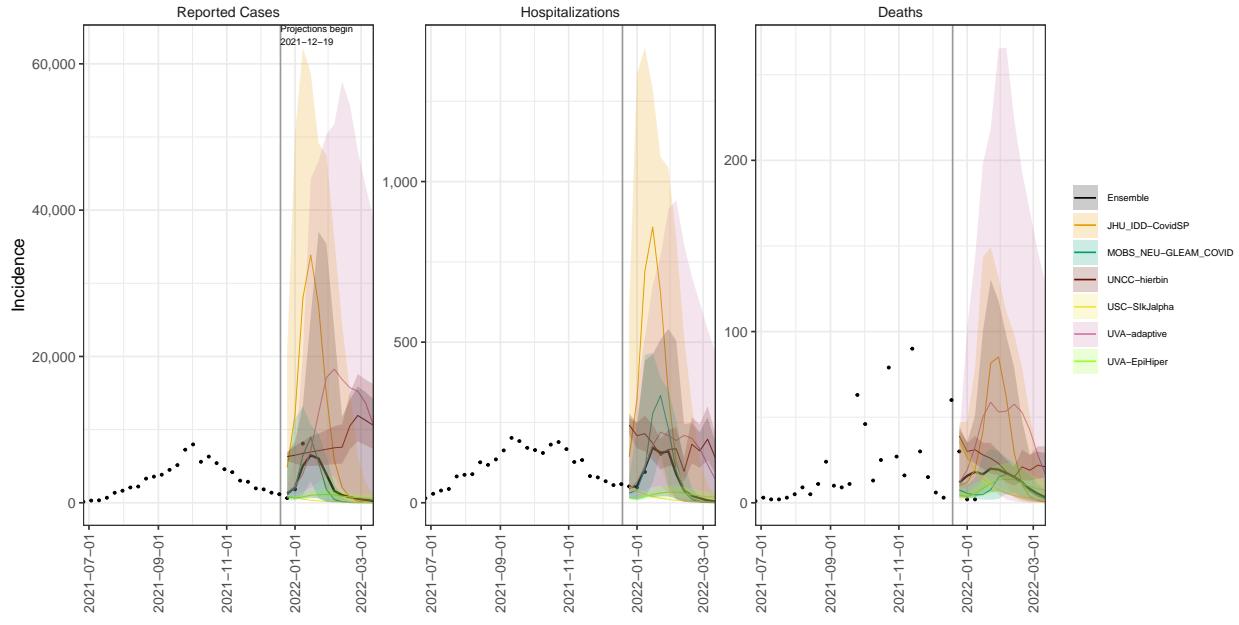


National model variation for the optimistic severity, low immune escape & high transmissibility scenario

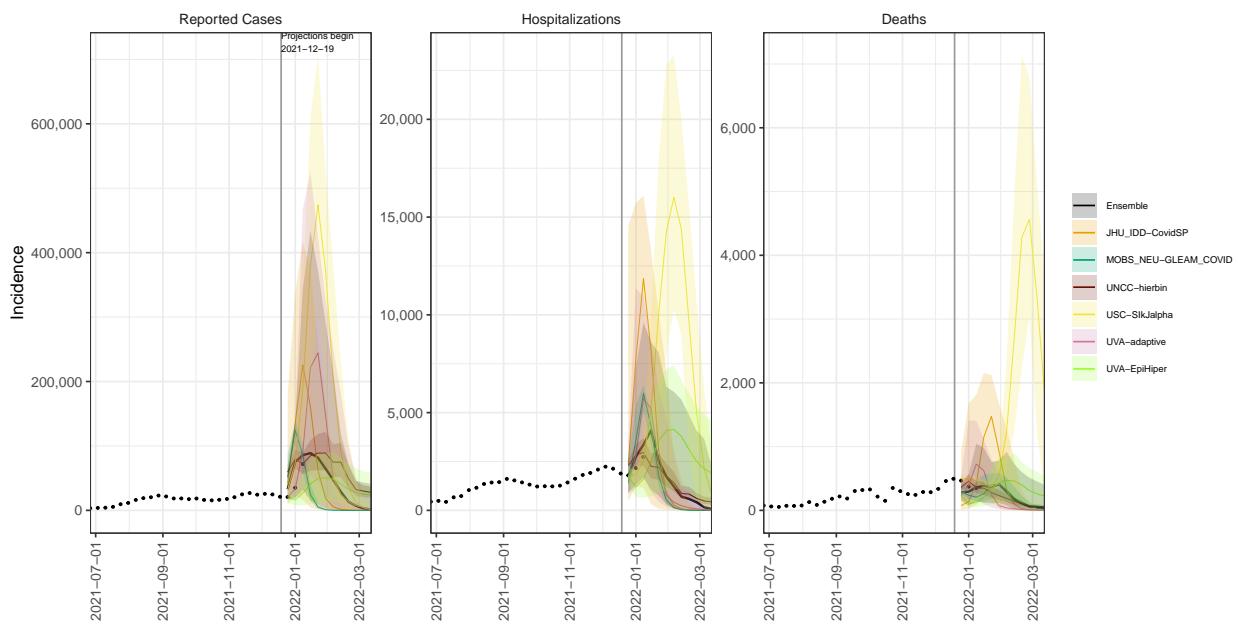
AL model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



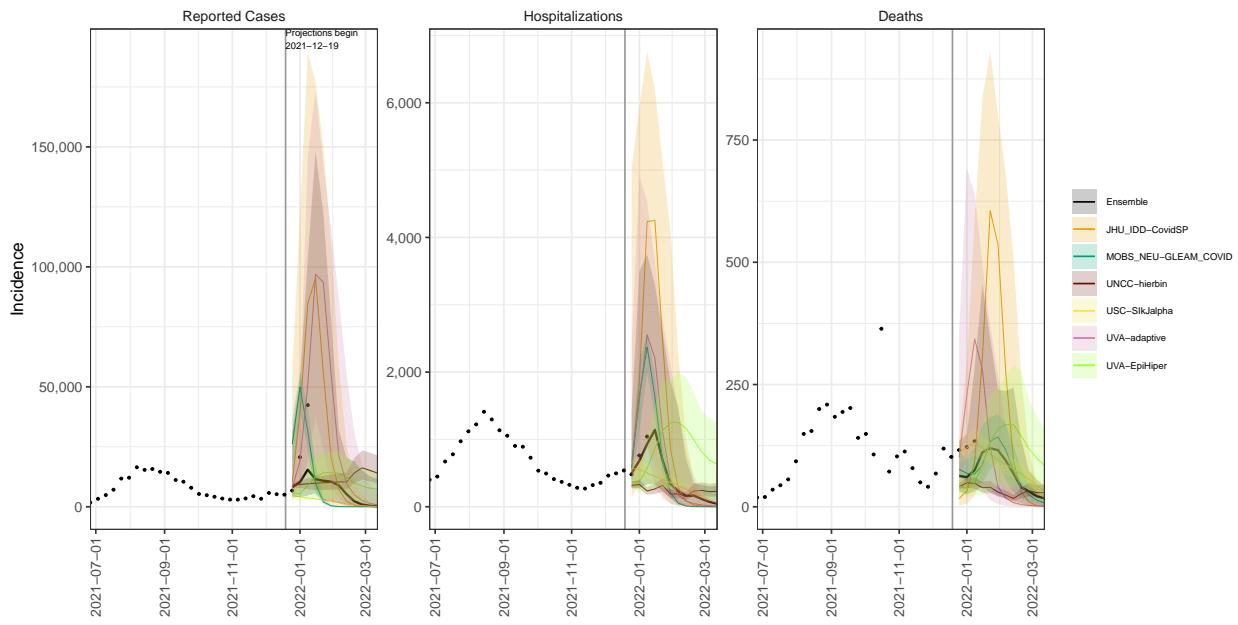
AK model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



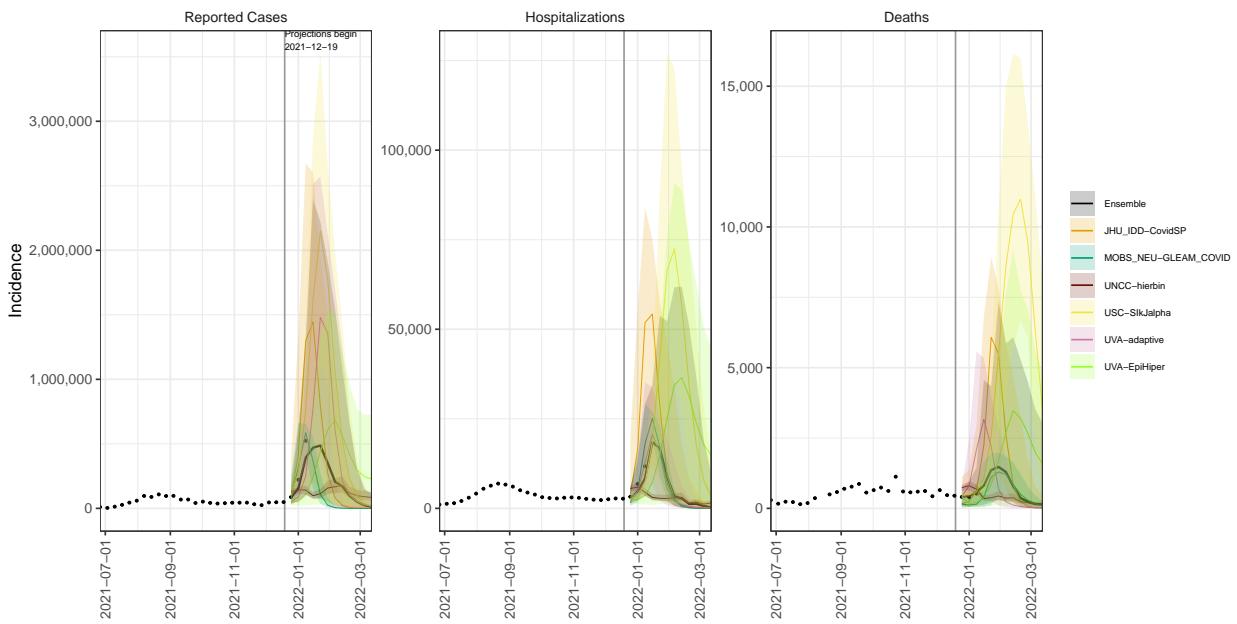
AZ model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



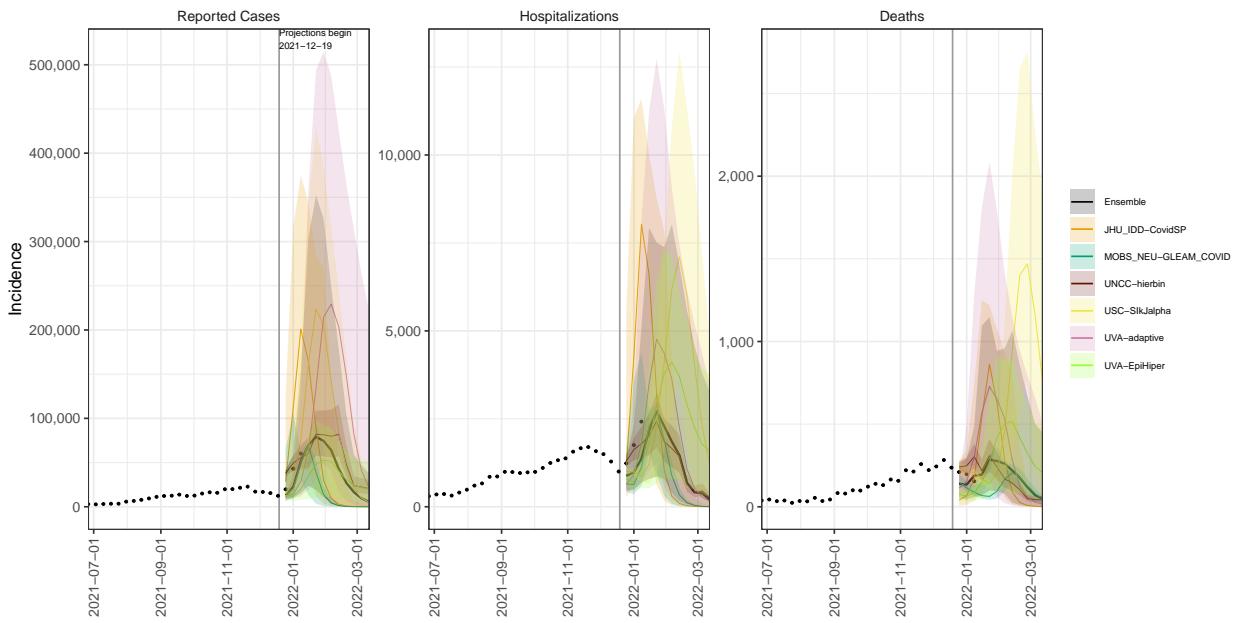
AR model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



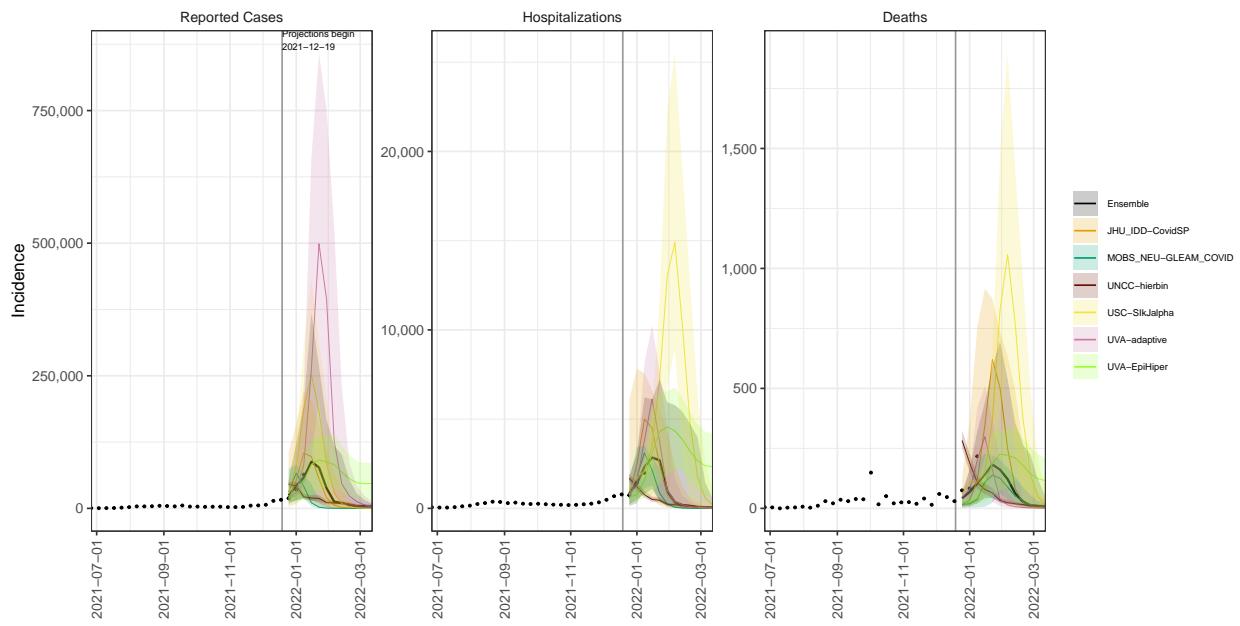
CA model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



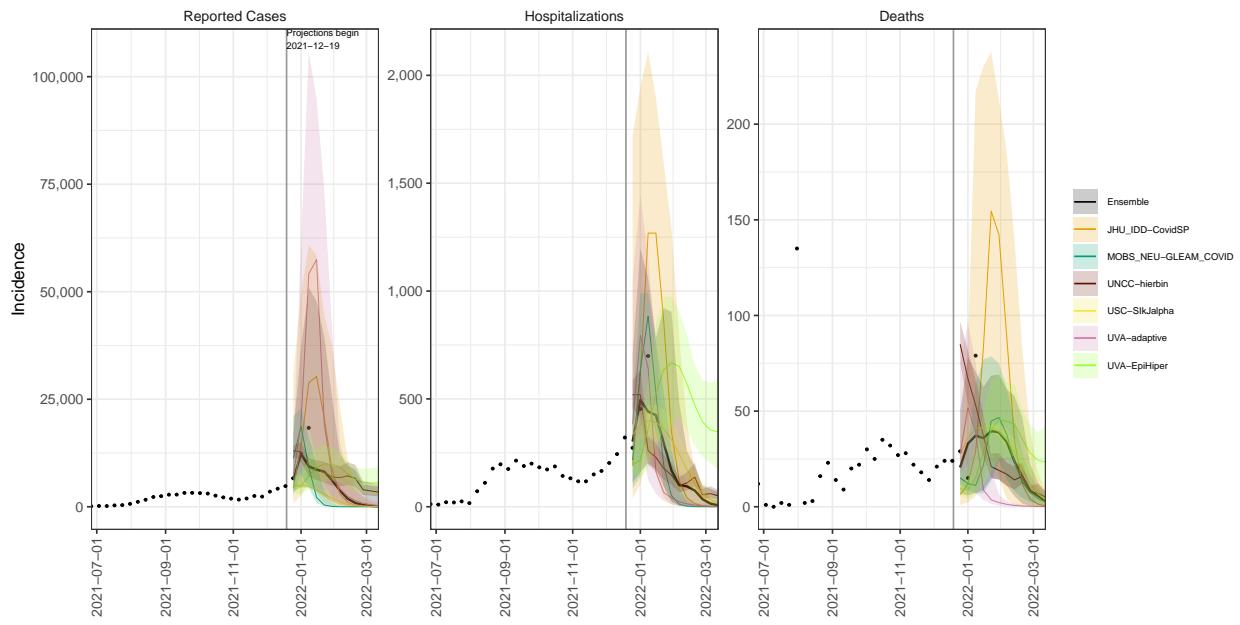
CO model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



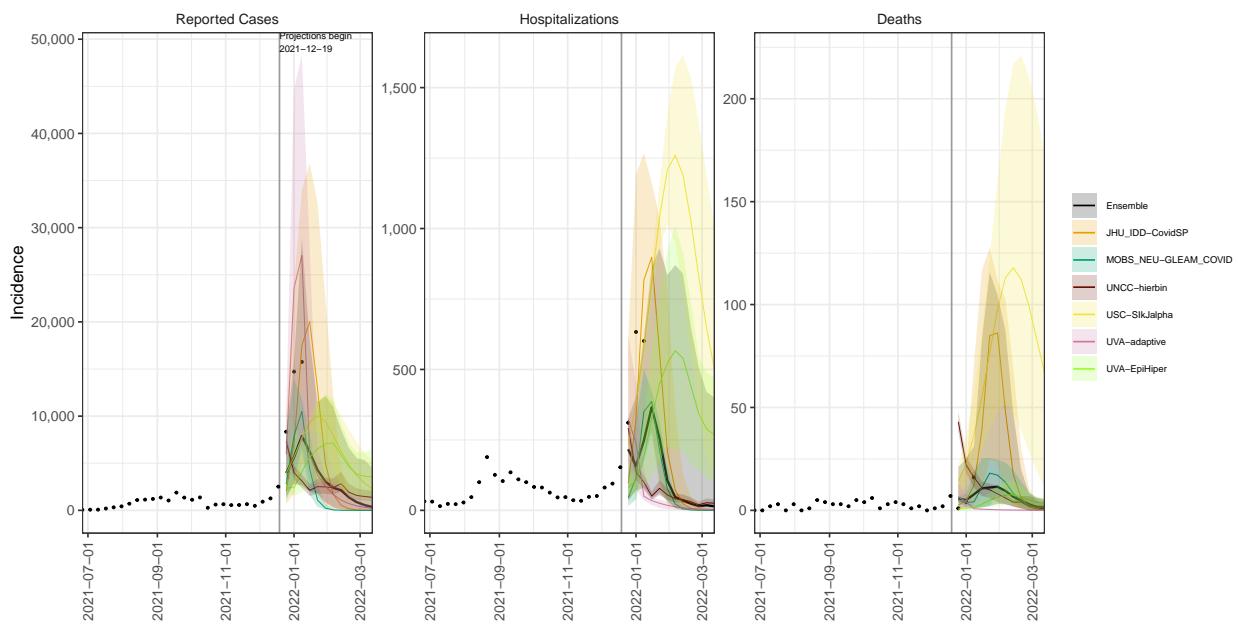
CT model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



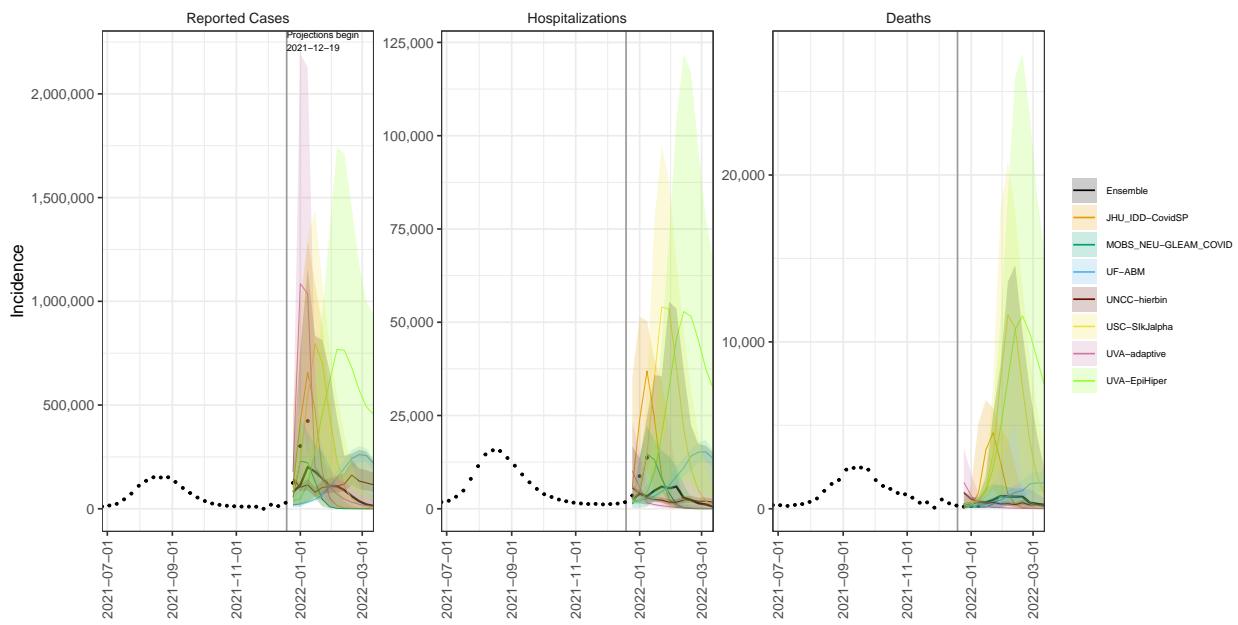
DE model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



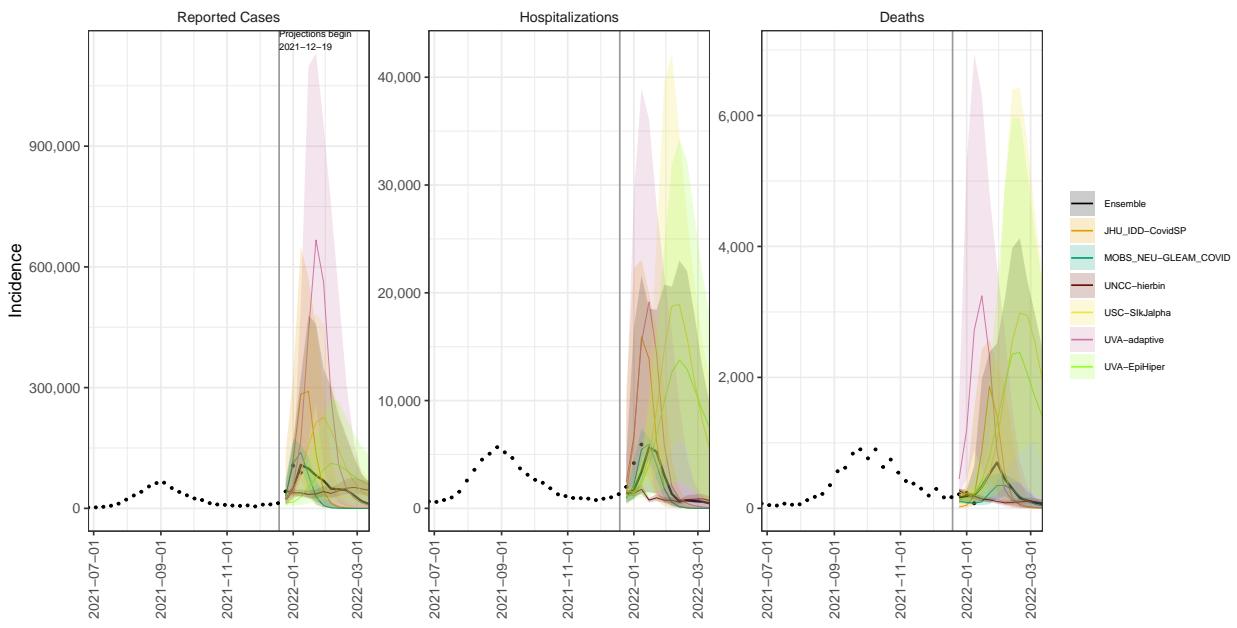
DC model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



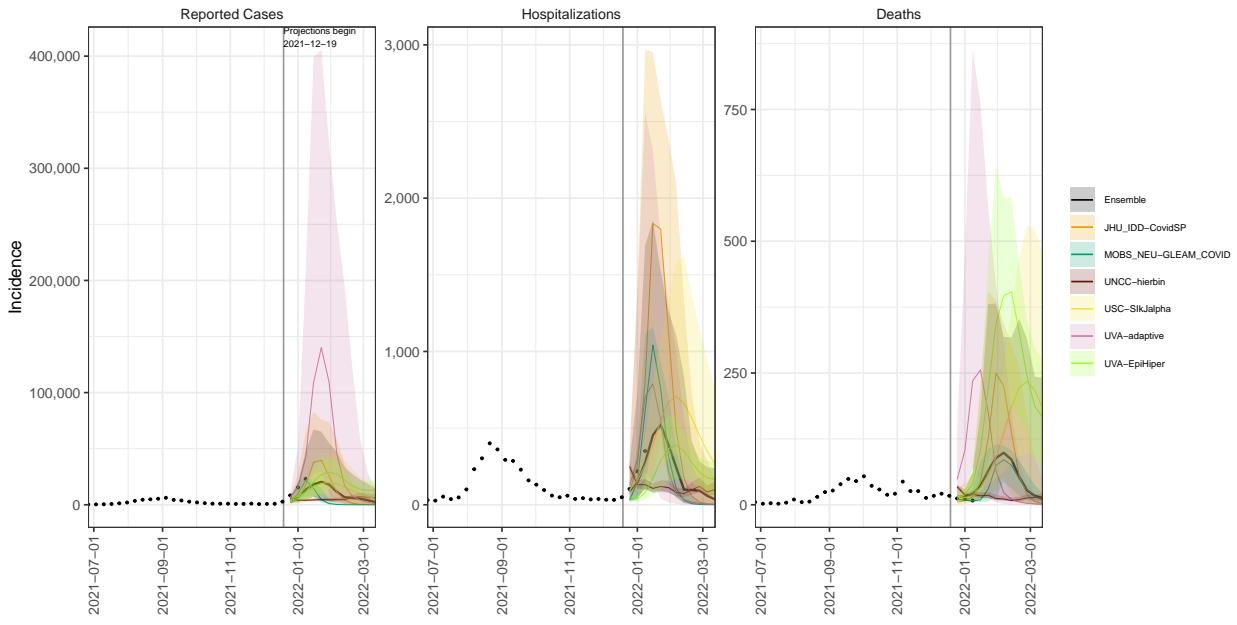
FL model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



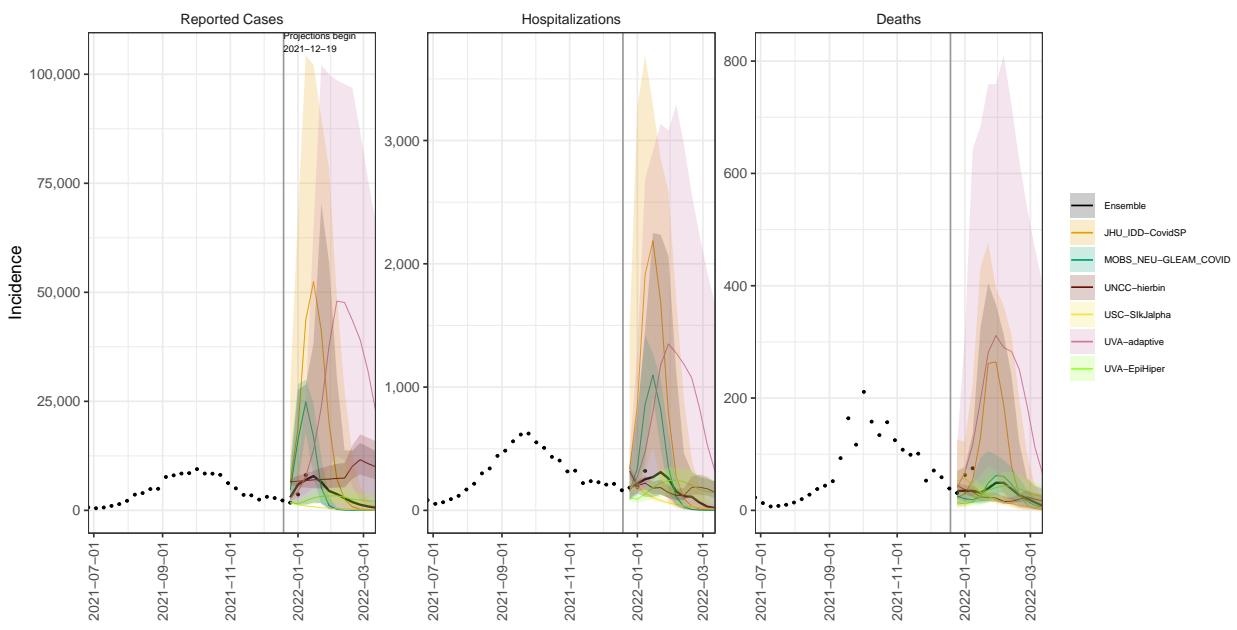
GA model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



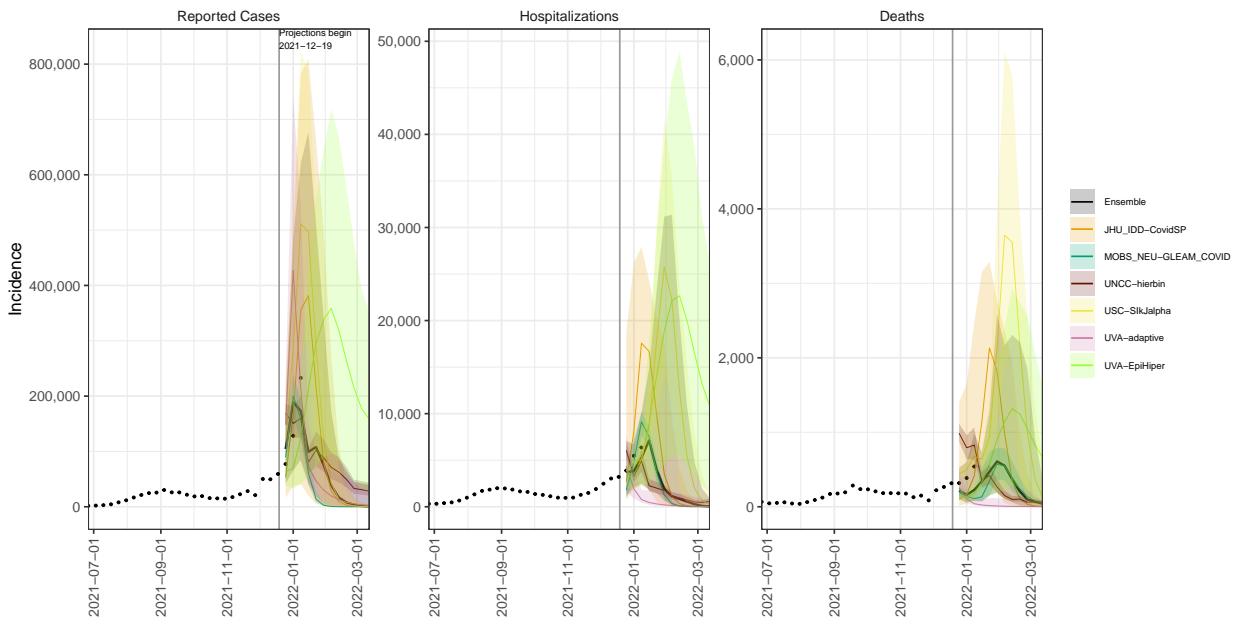
HI model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



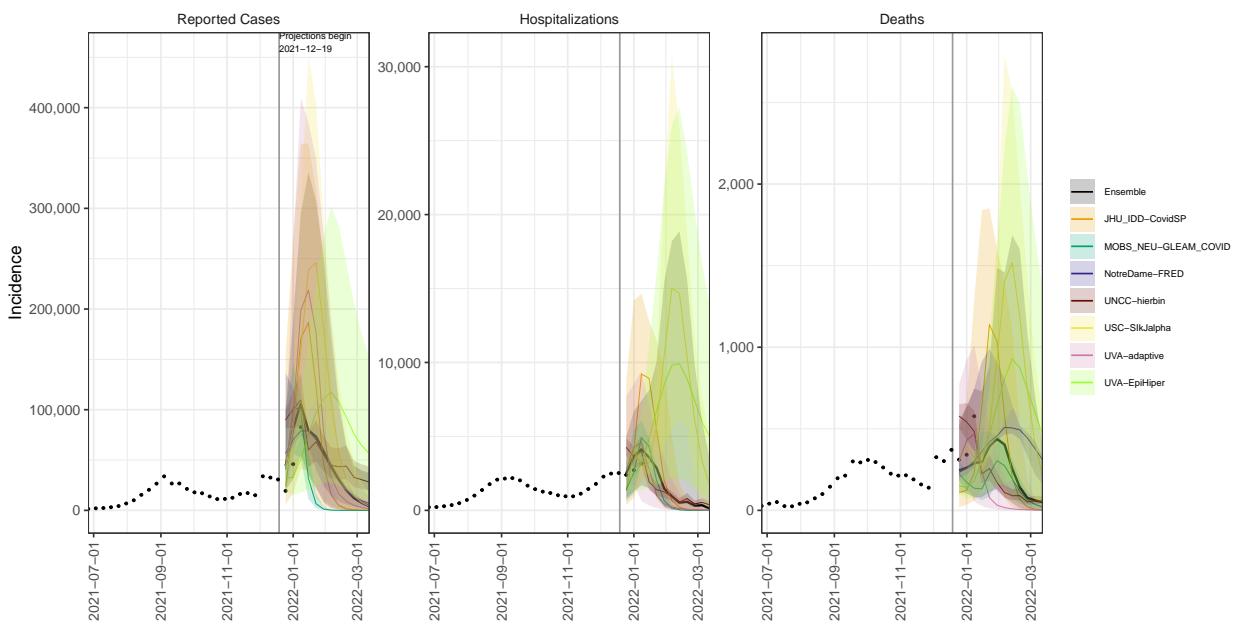
ID model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



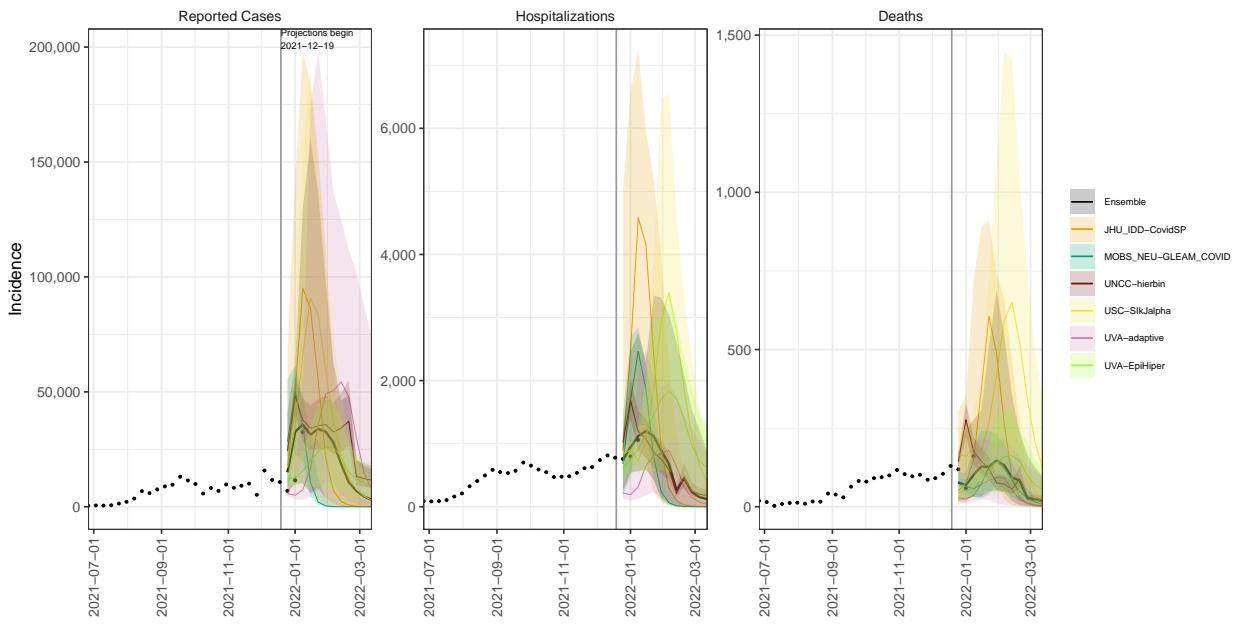
IL model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



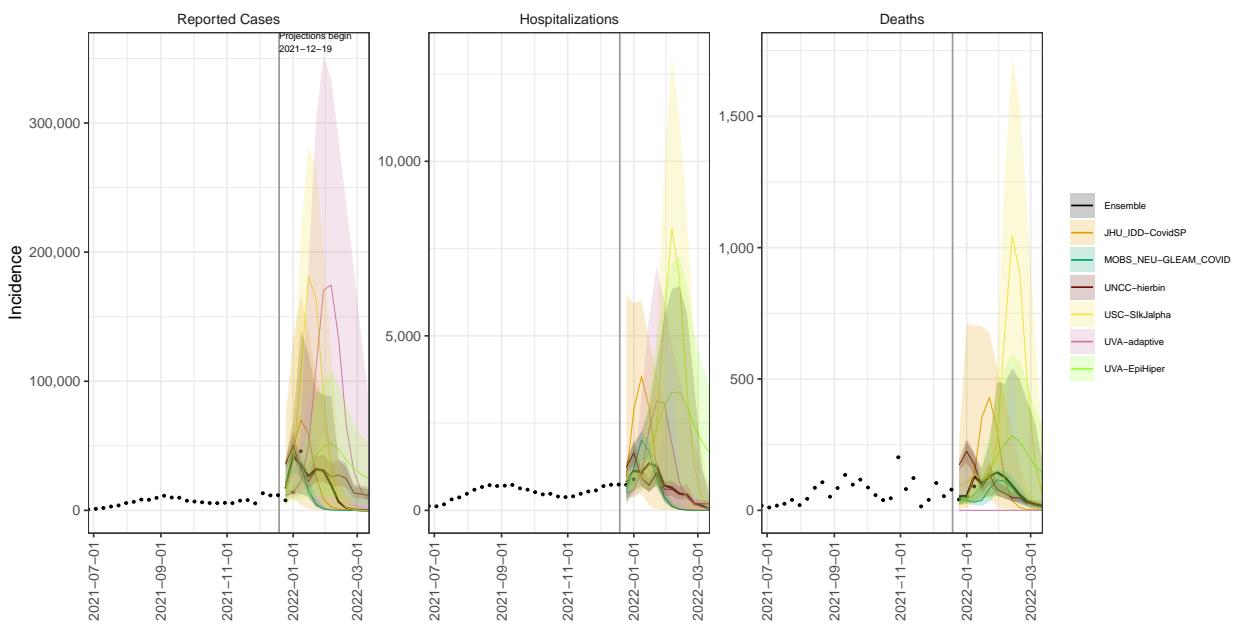
IN model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



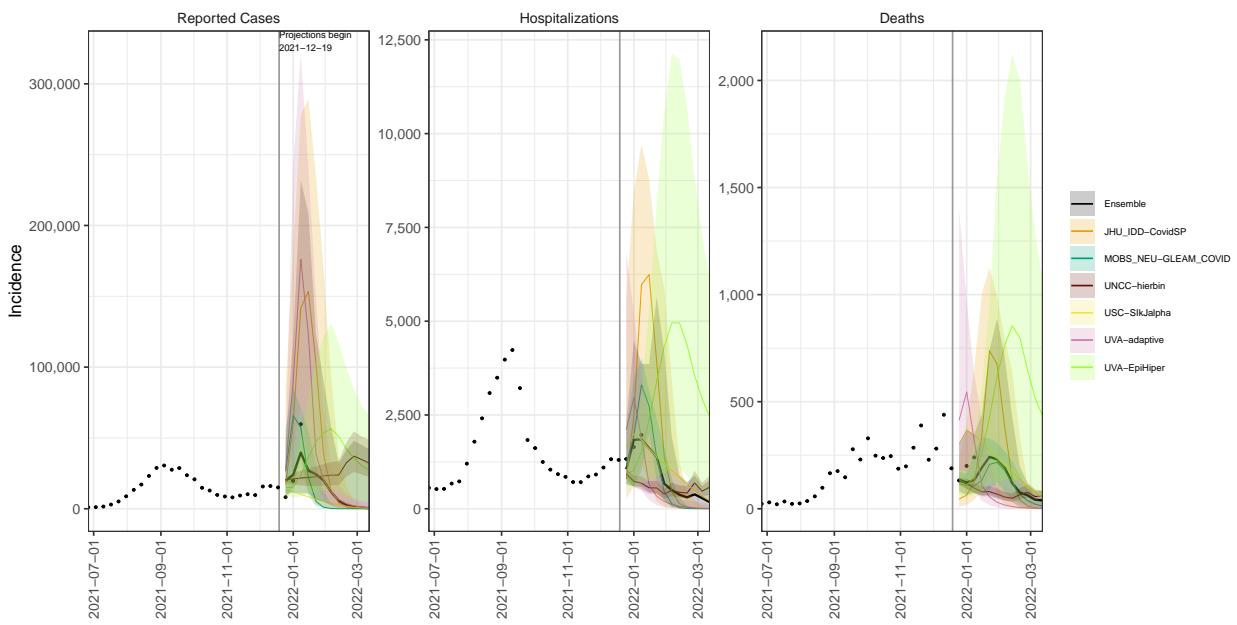
IA model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



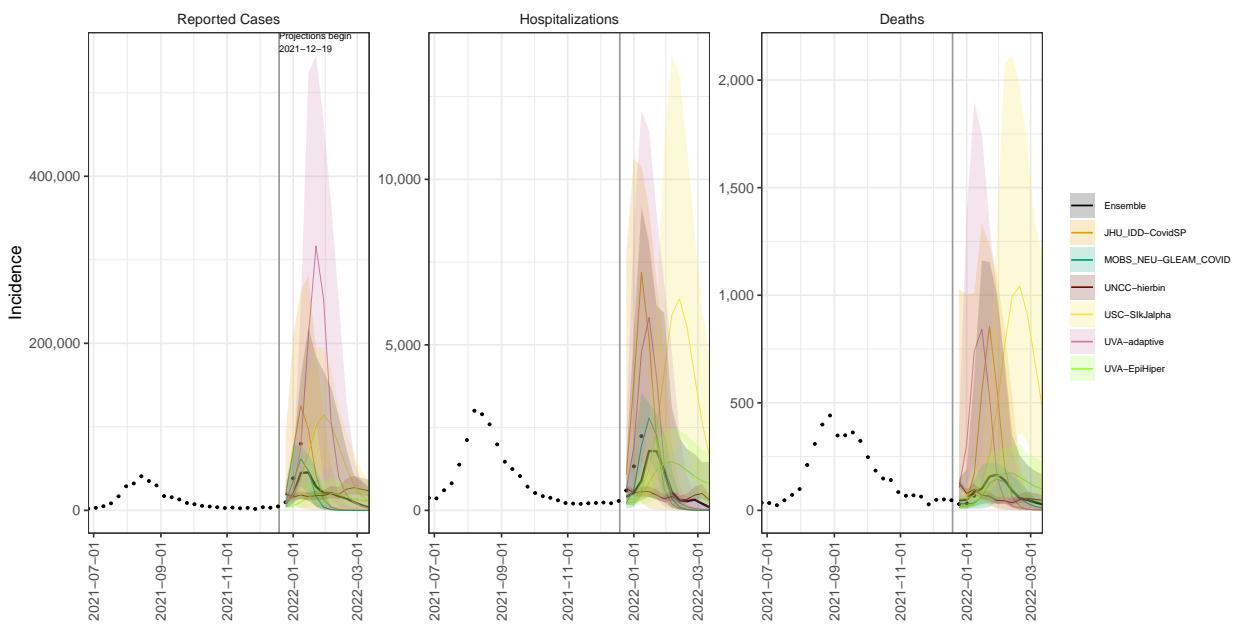
KS model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



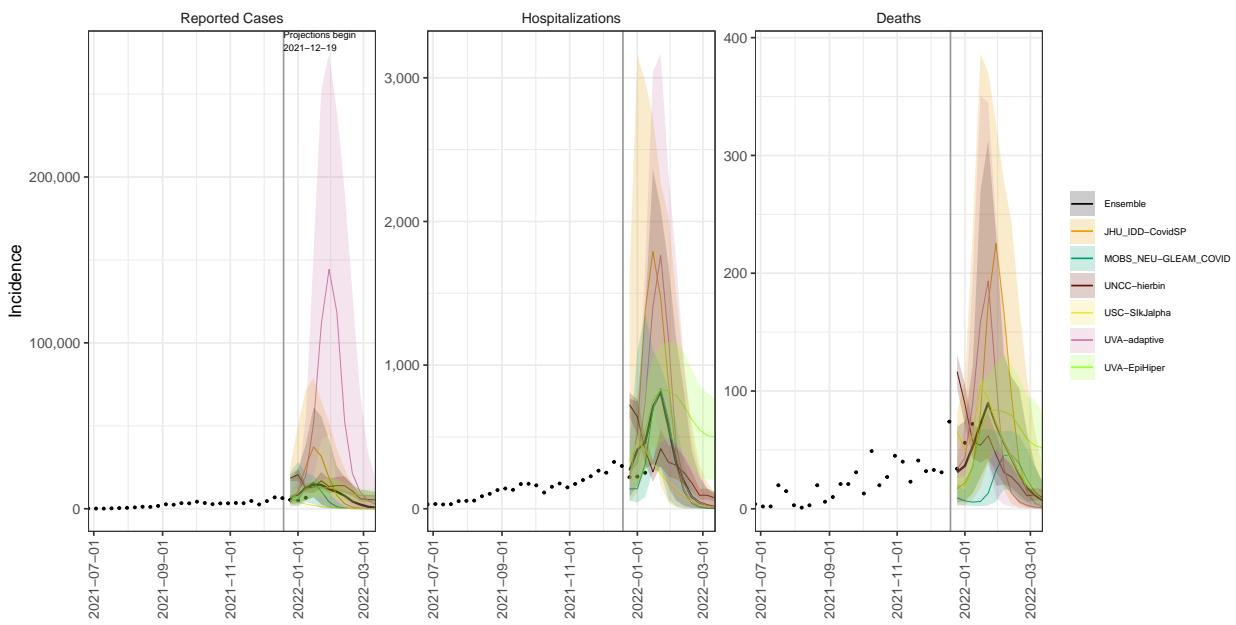
KY model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



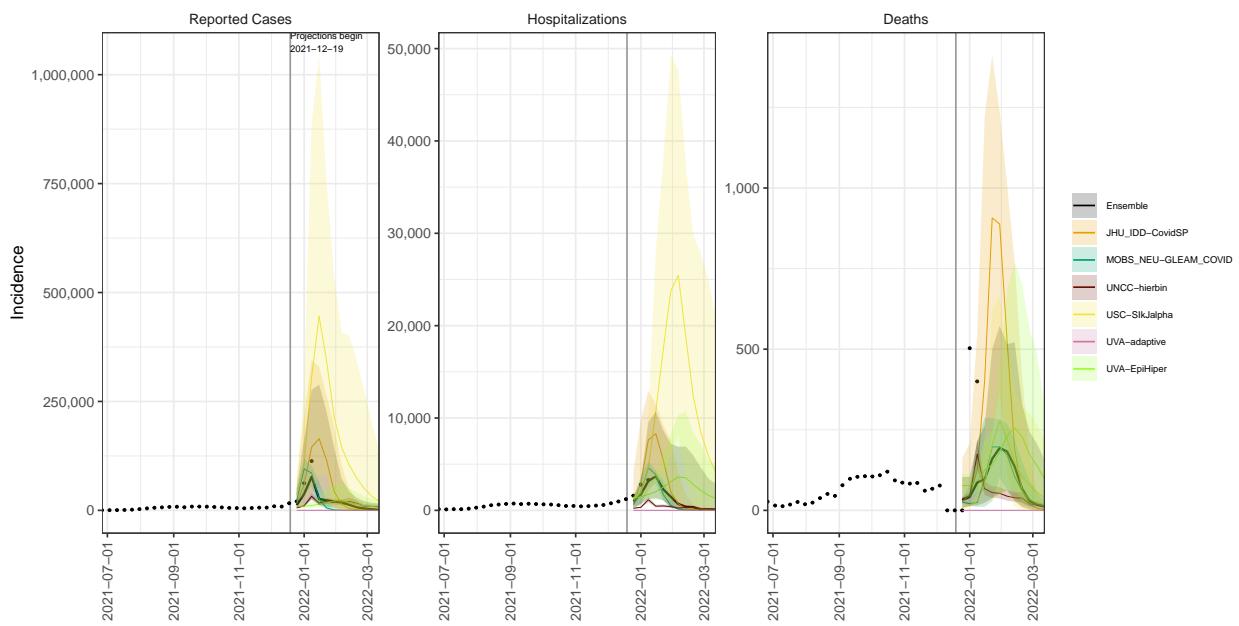
LA model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



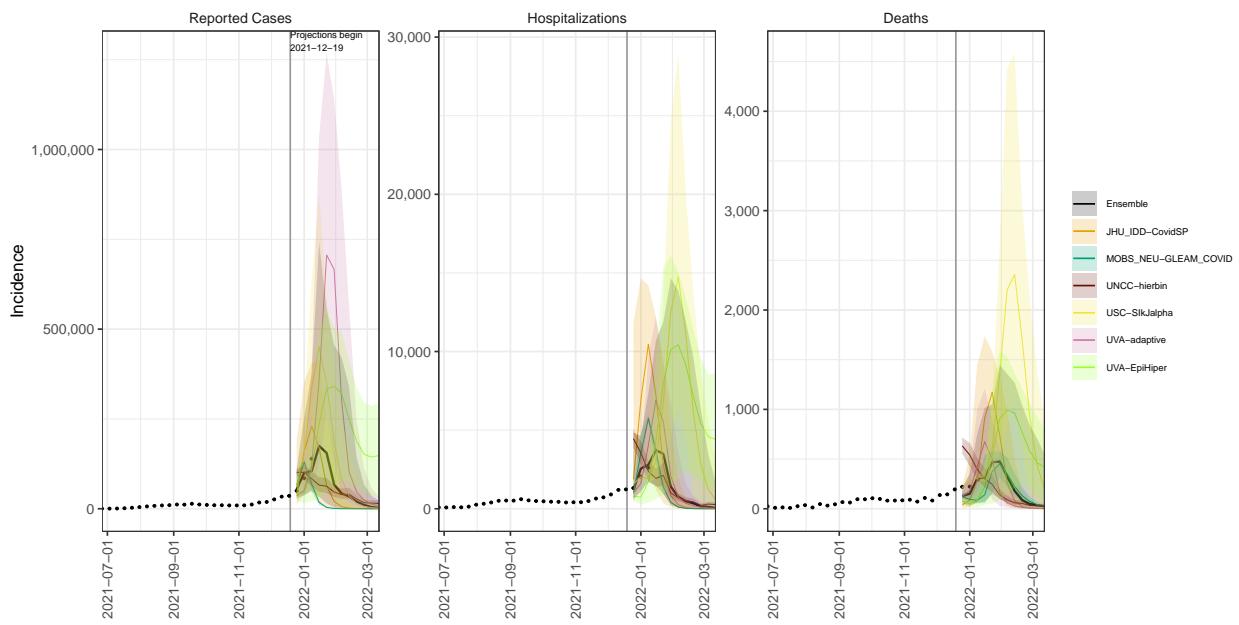
ME model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



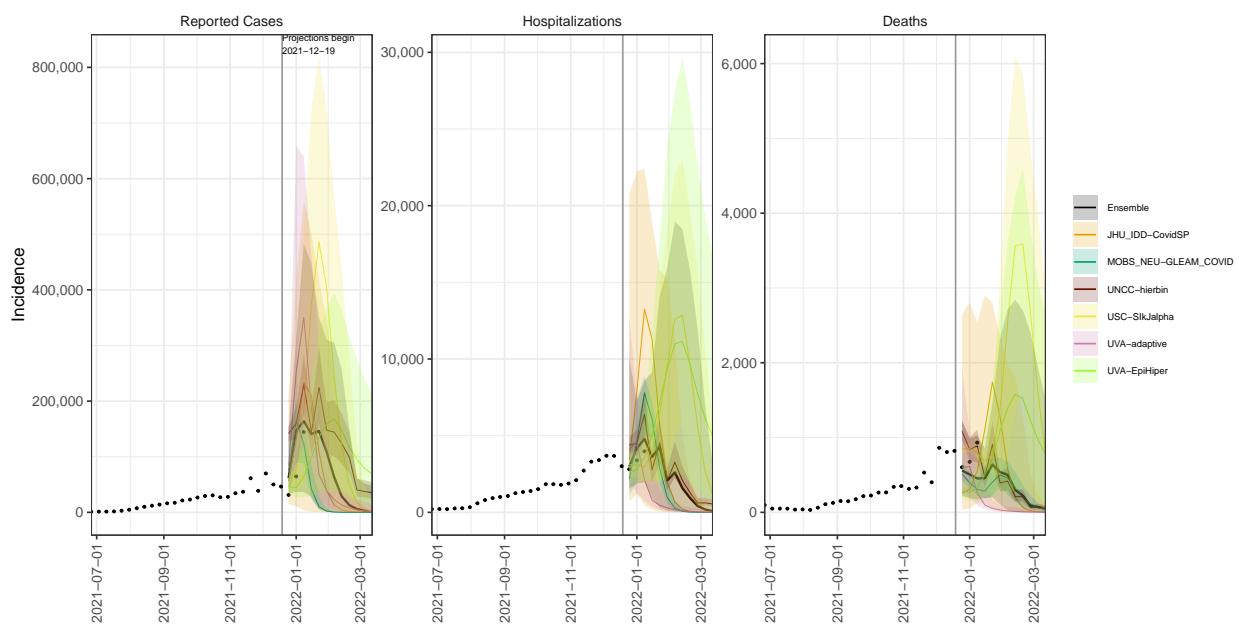
MD model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



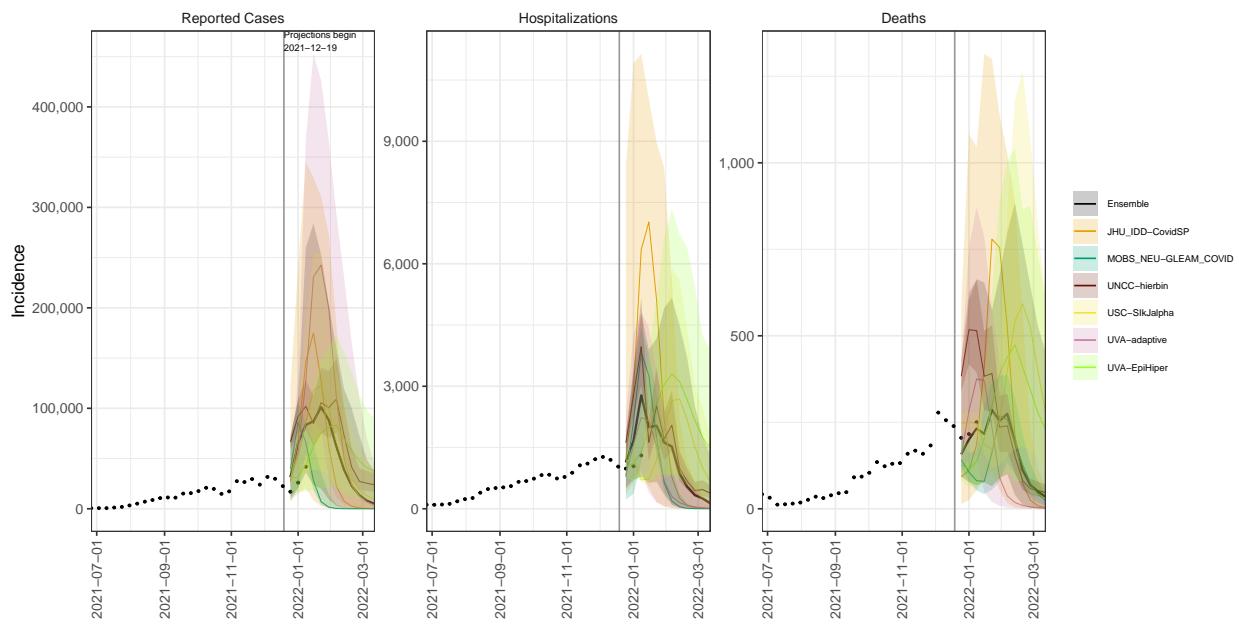
MA model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



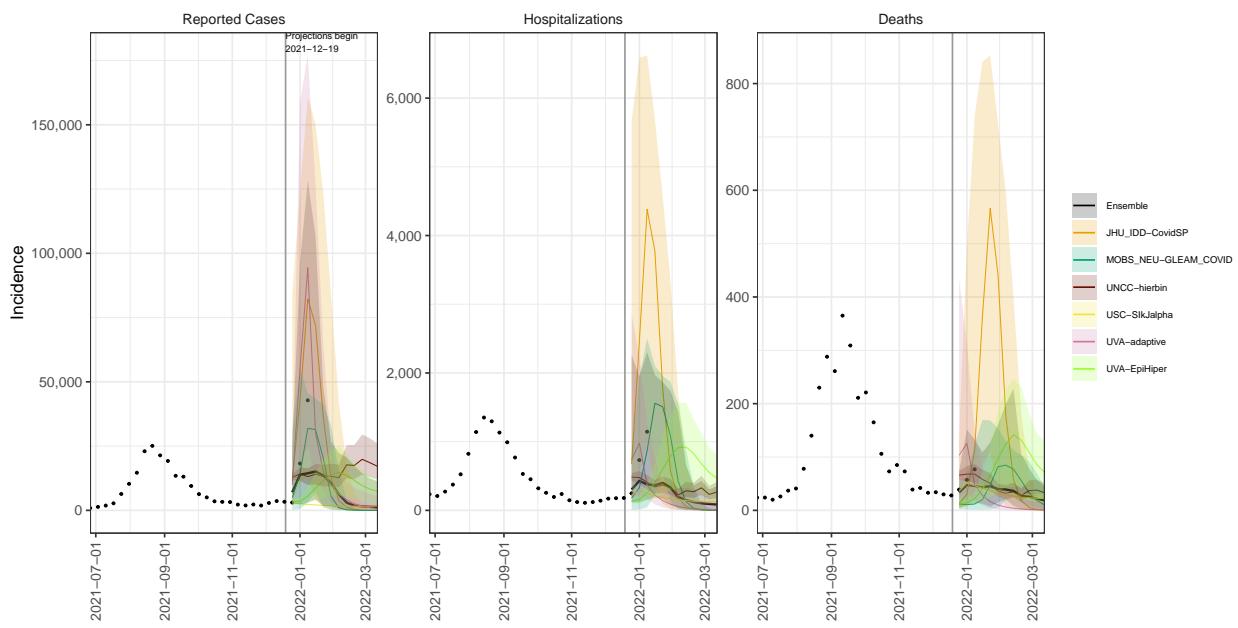
MI model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



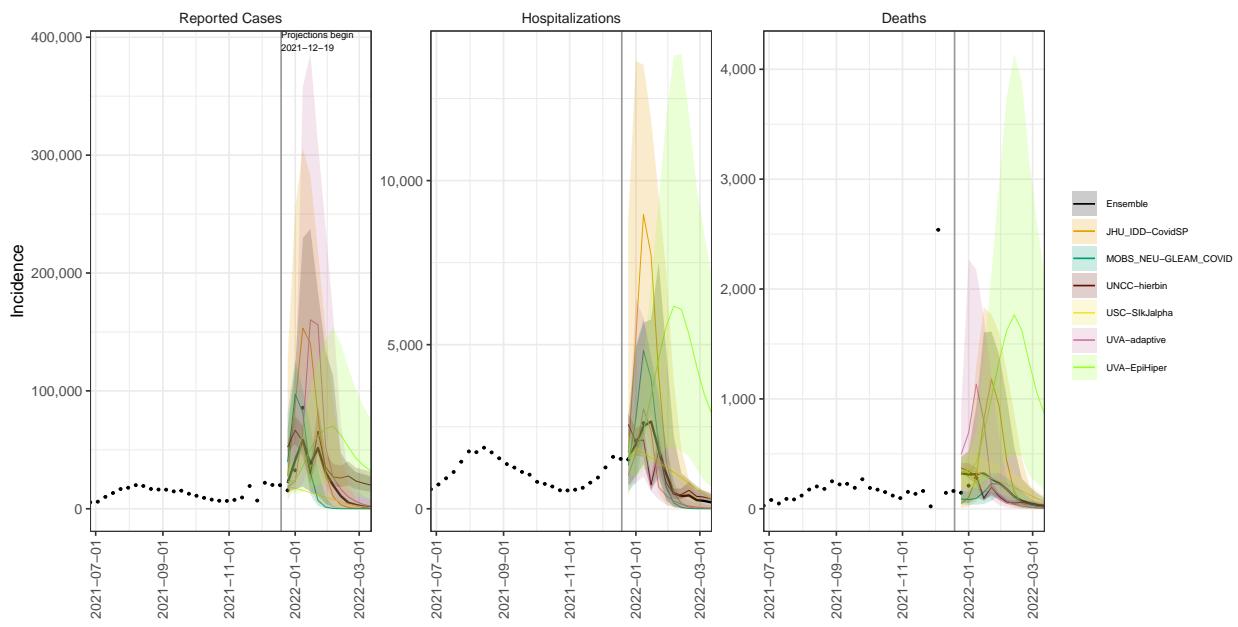
MN model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



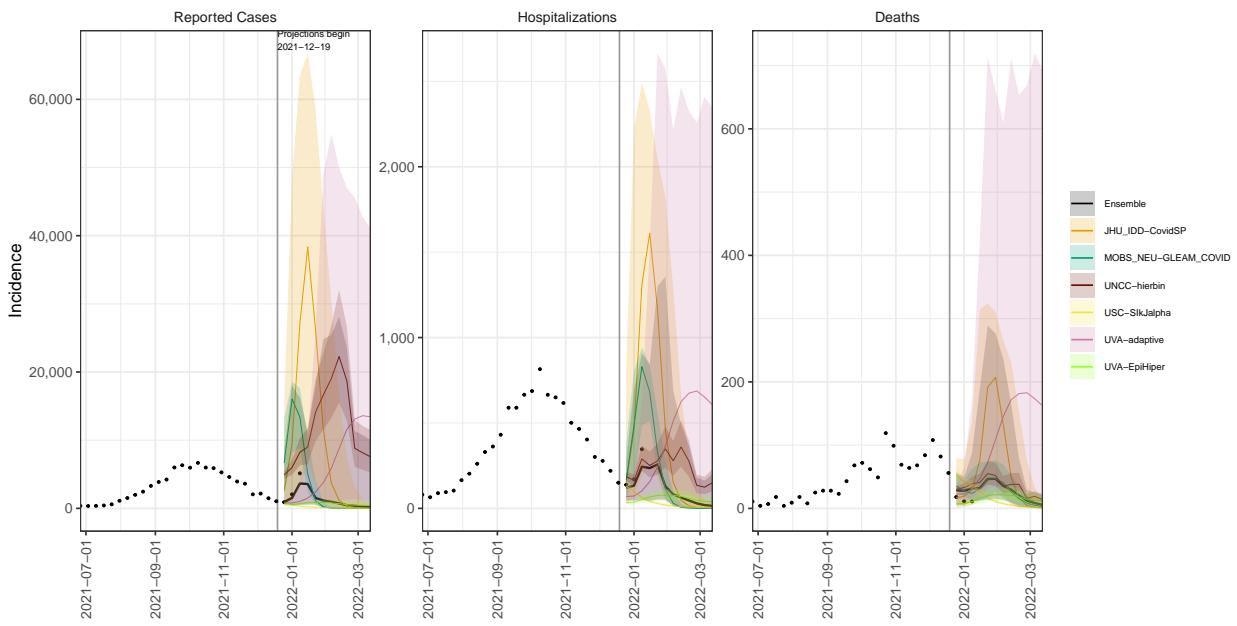
MS model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



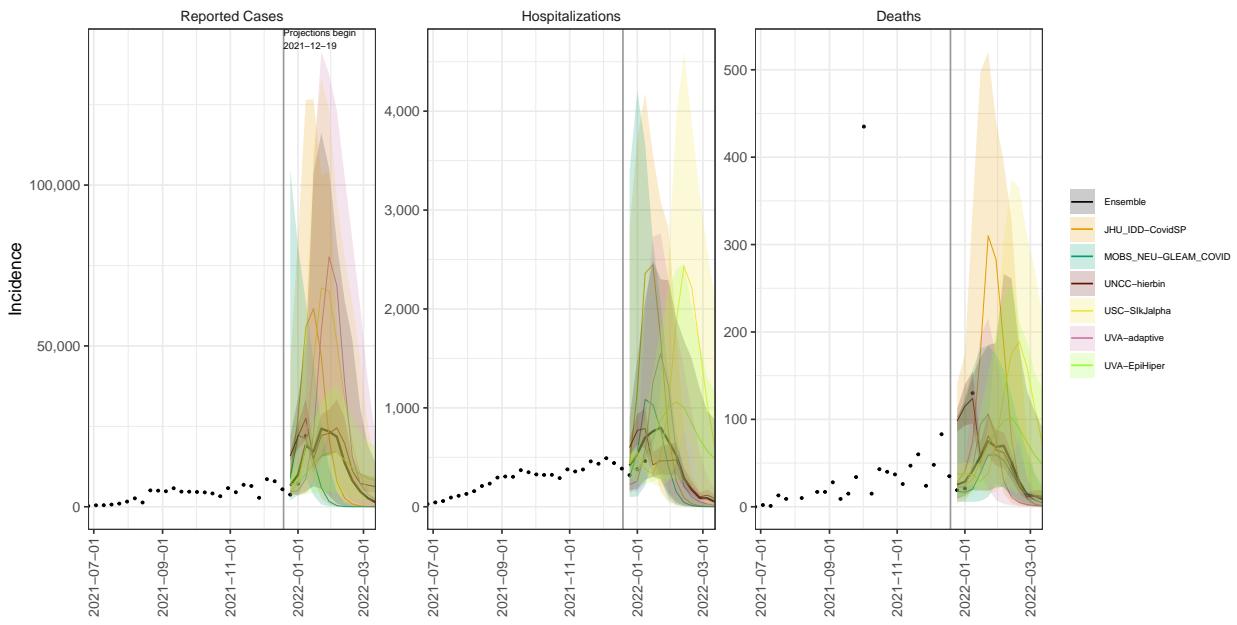
MO model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



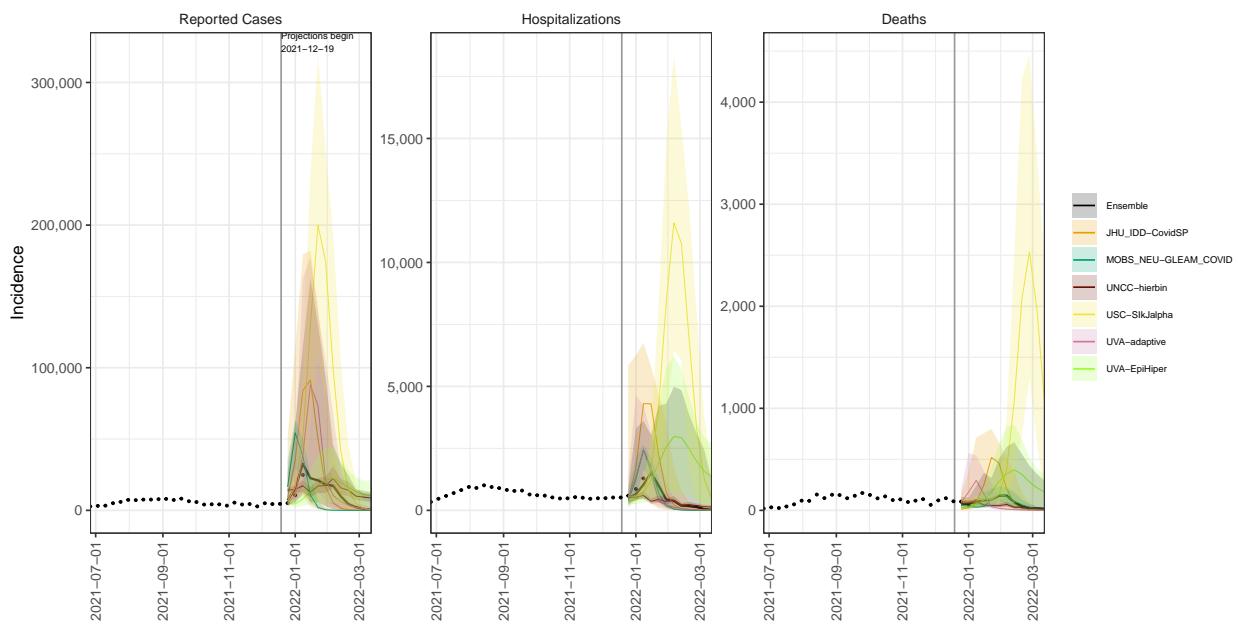
MT model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



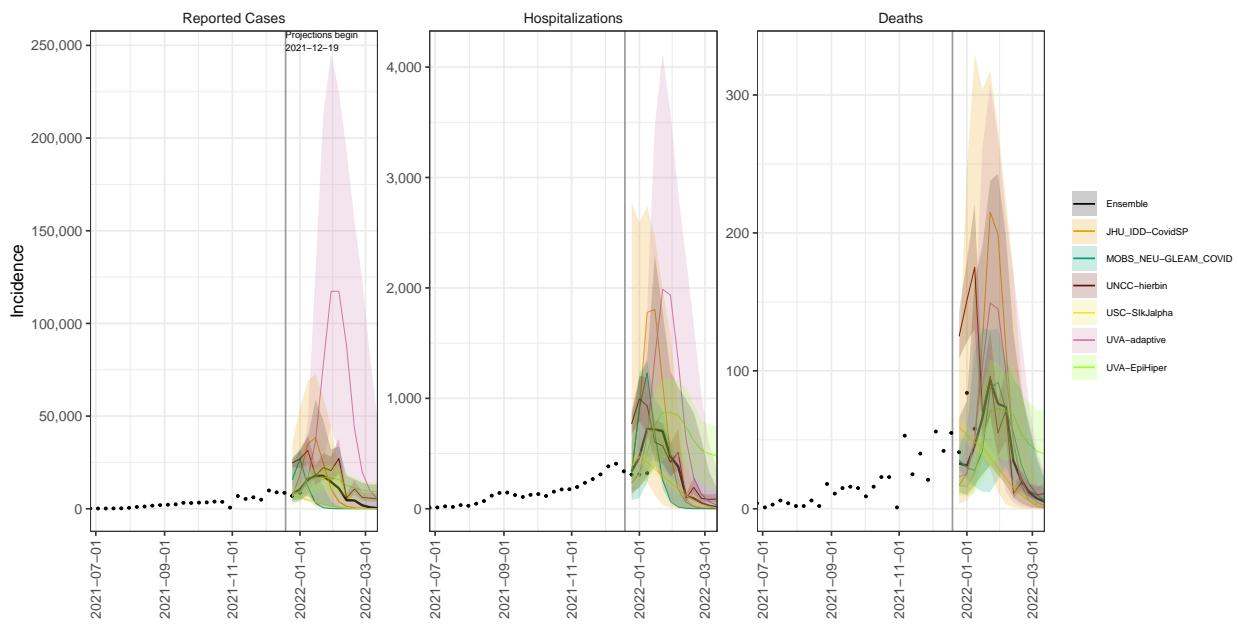
NE model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



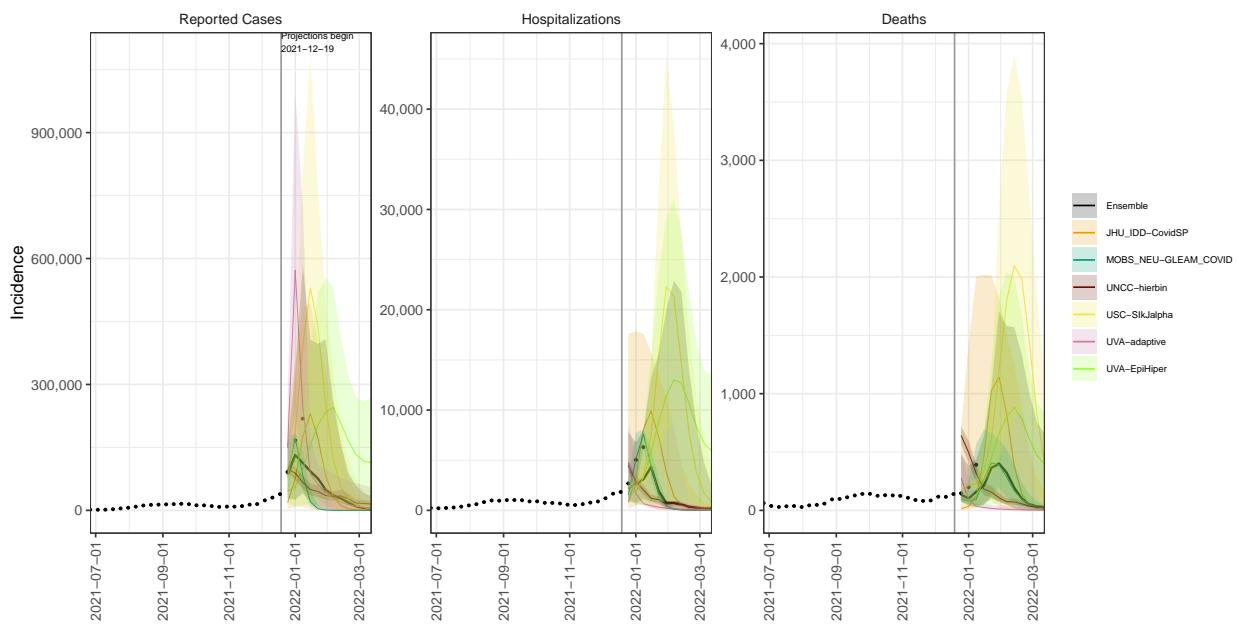
NV model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



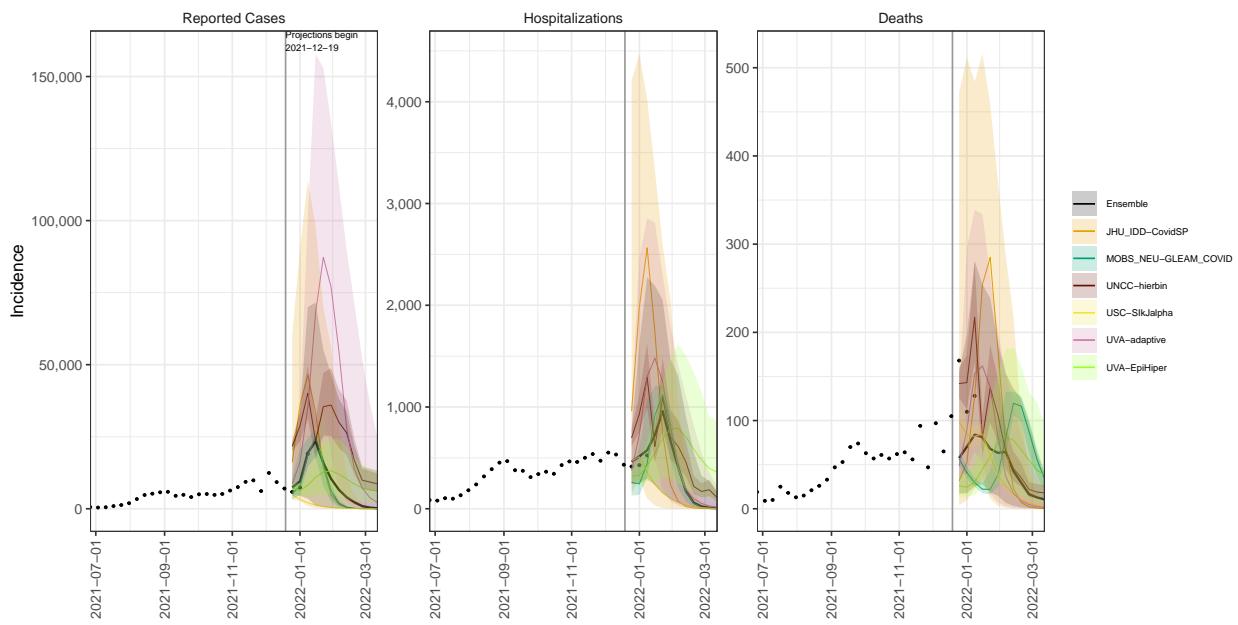
NH model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



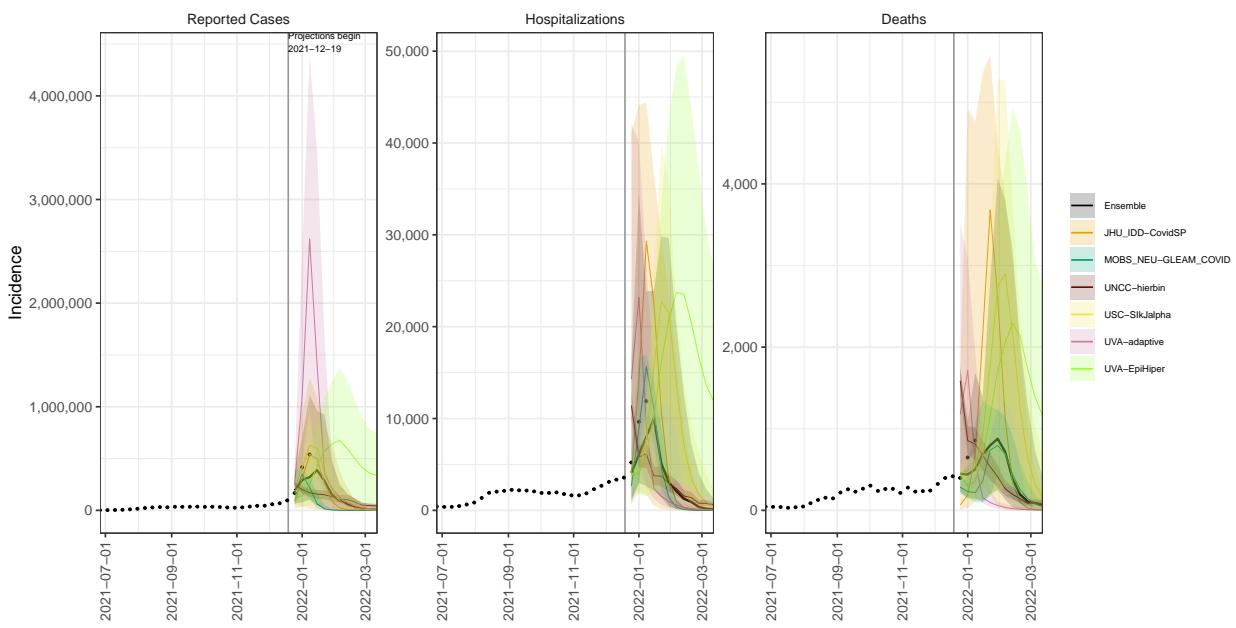
NJ model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



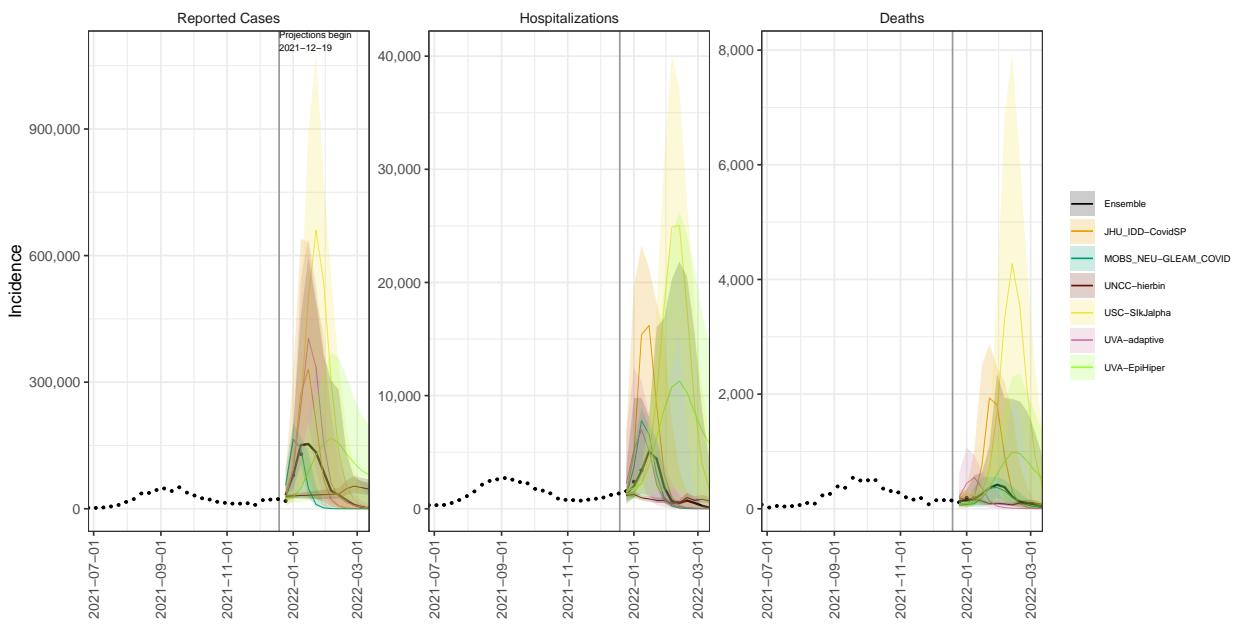
NM model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



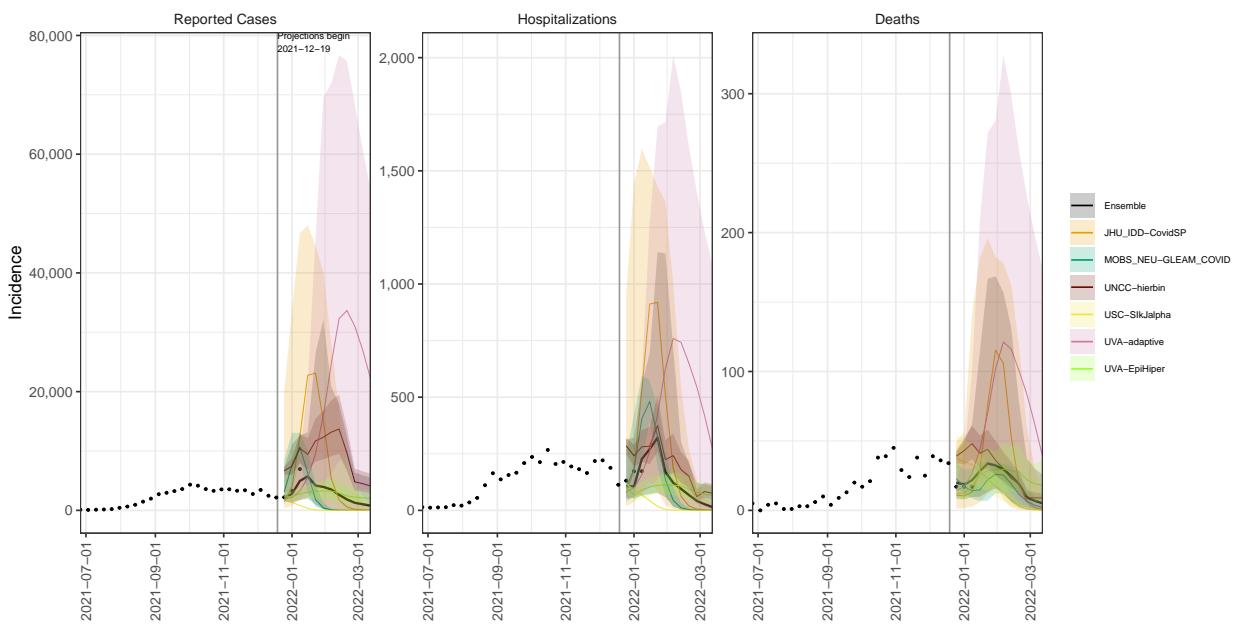
NY model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



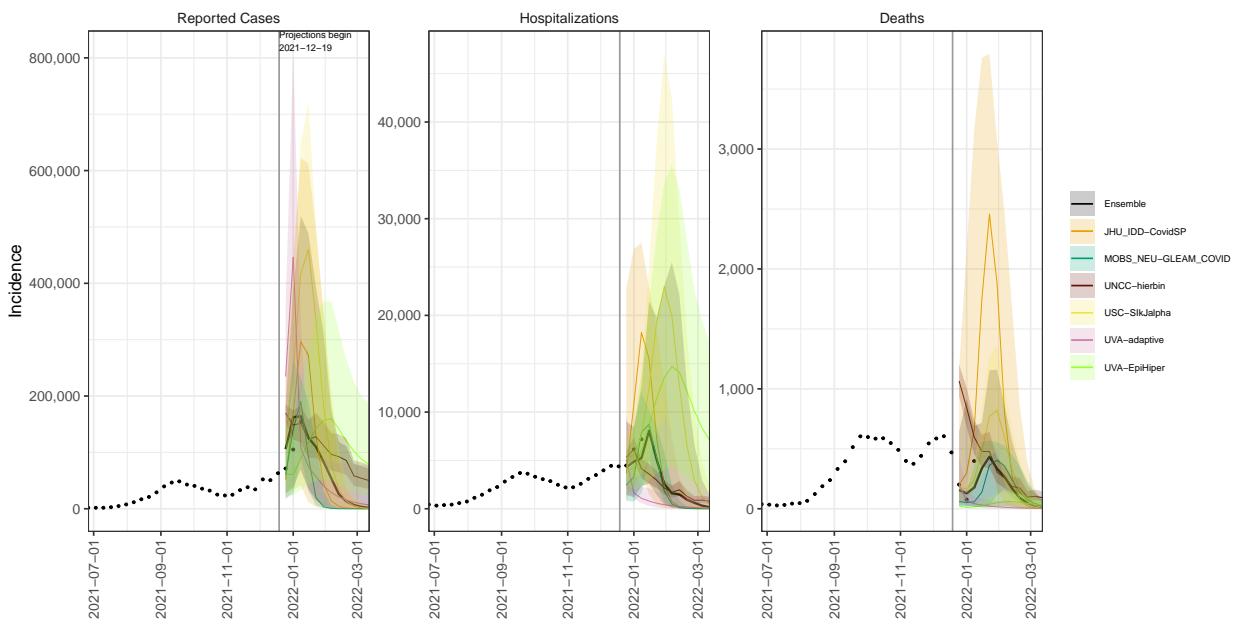
NC model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



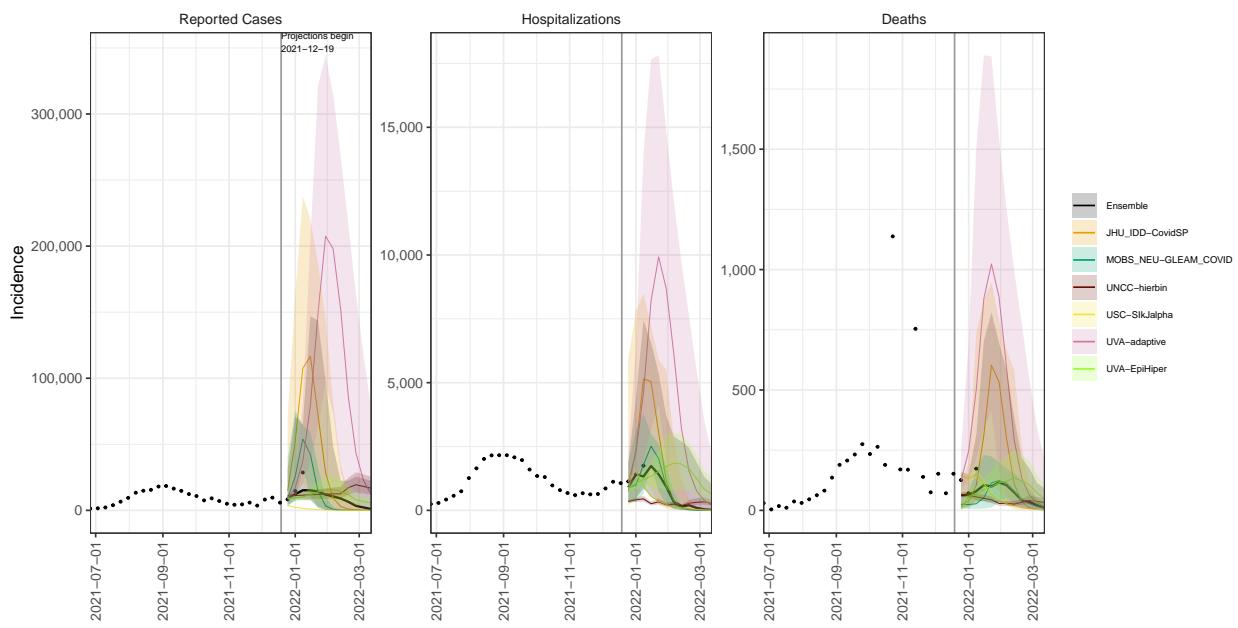
ND model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



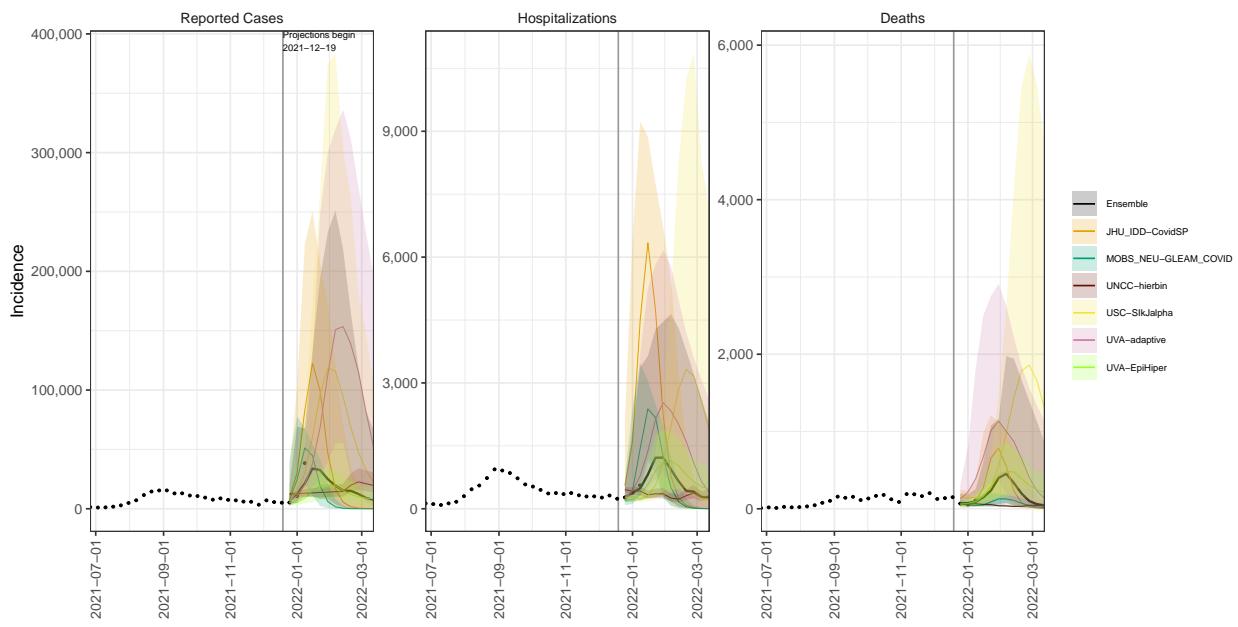
OH model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



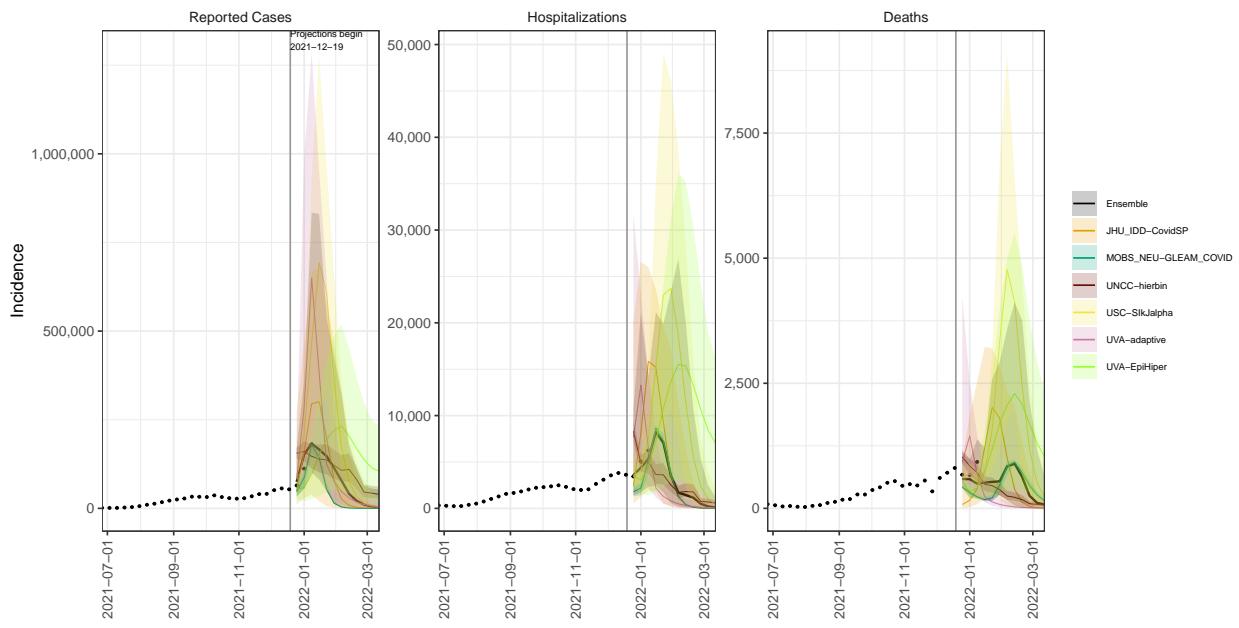
OK model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



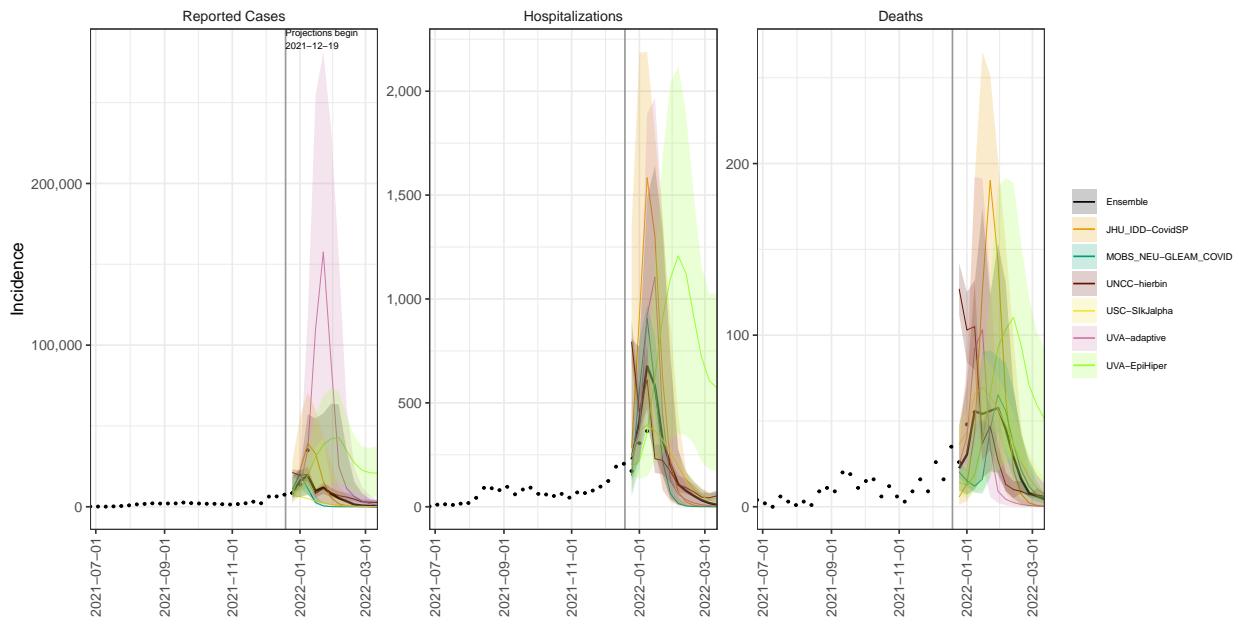
OR model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



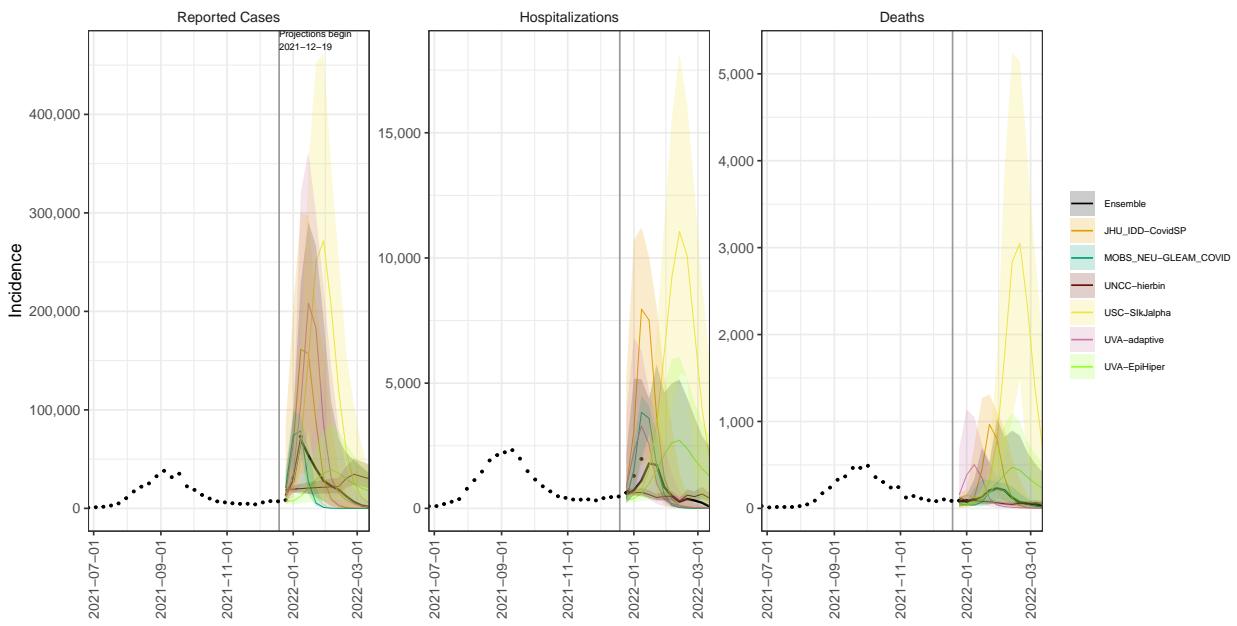
PA model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



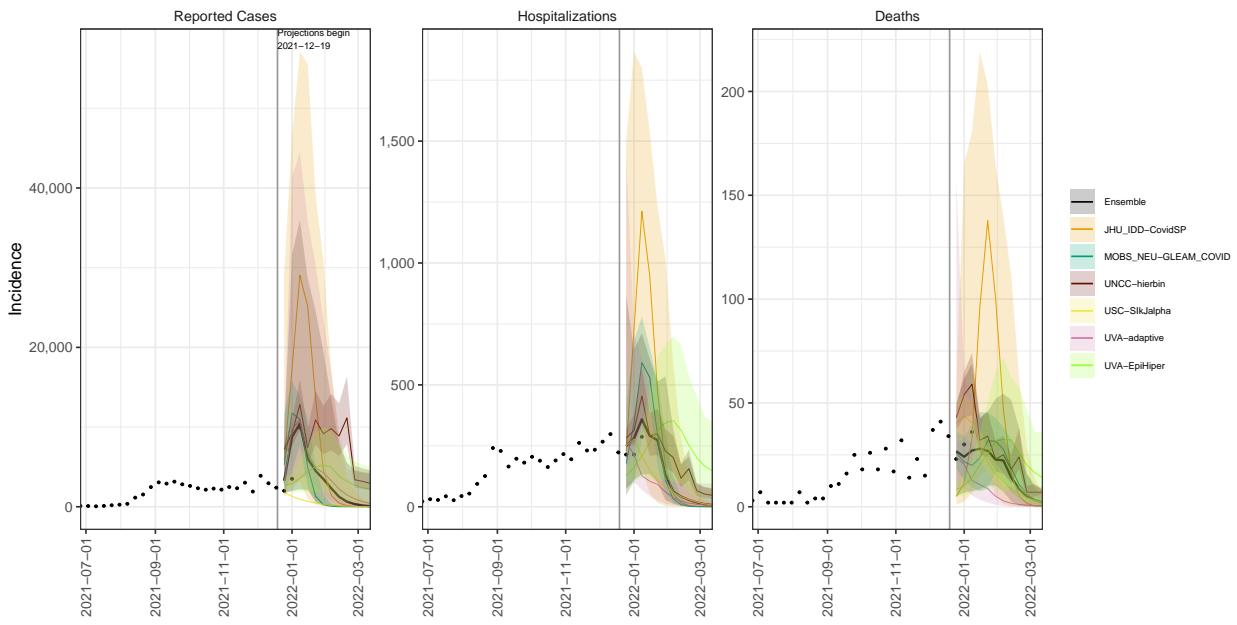
RI model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



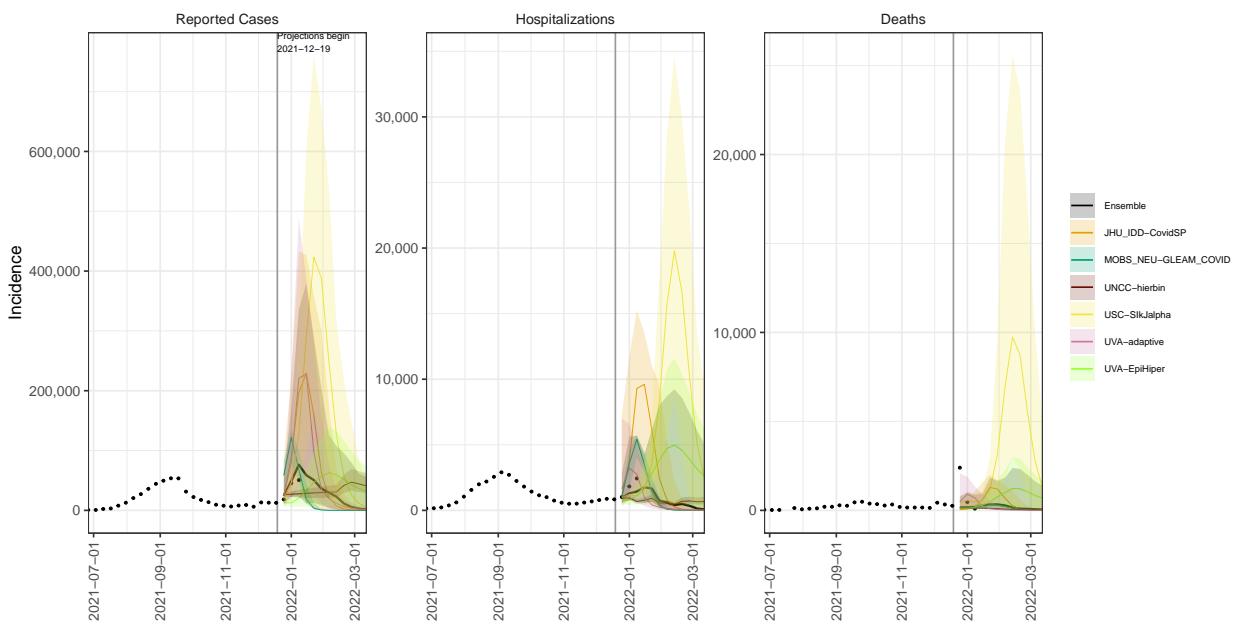
SC model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



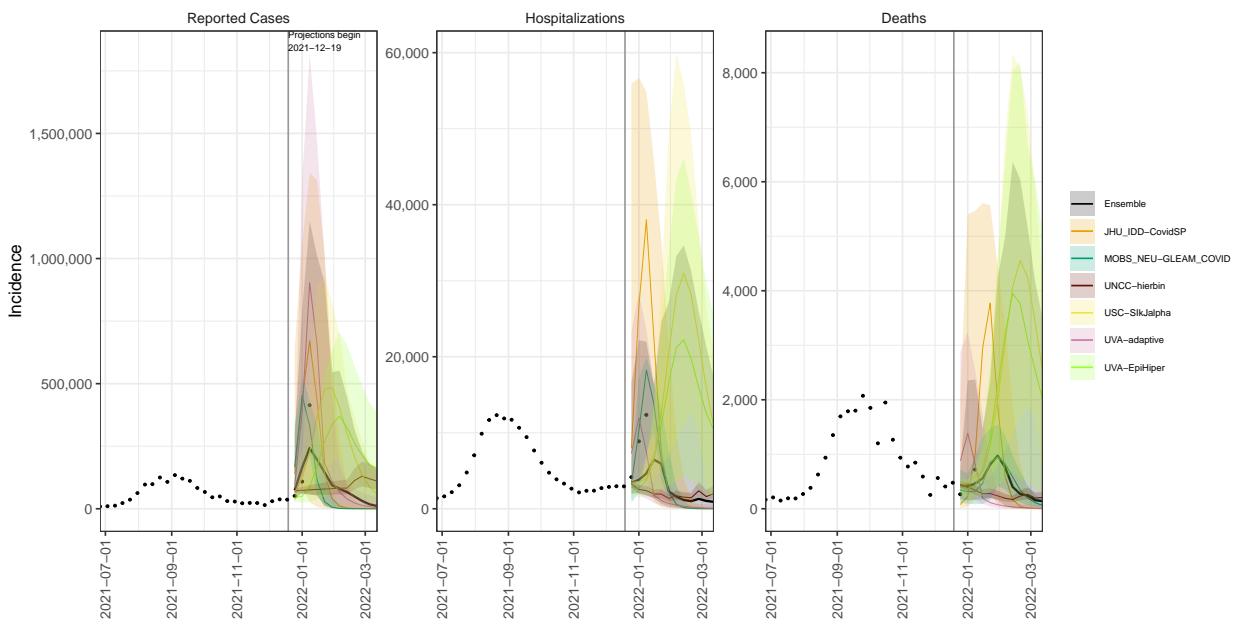
SD model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



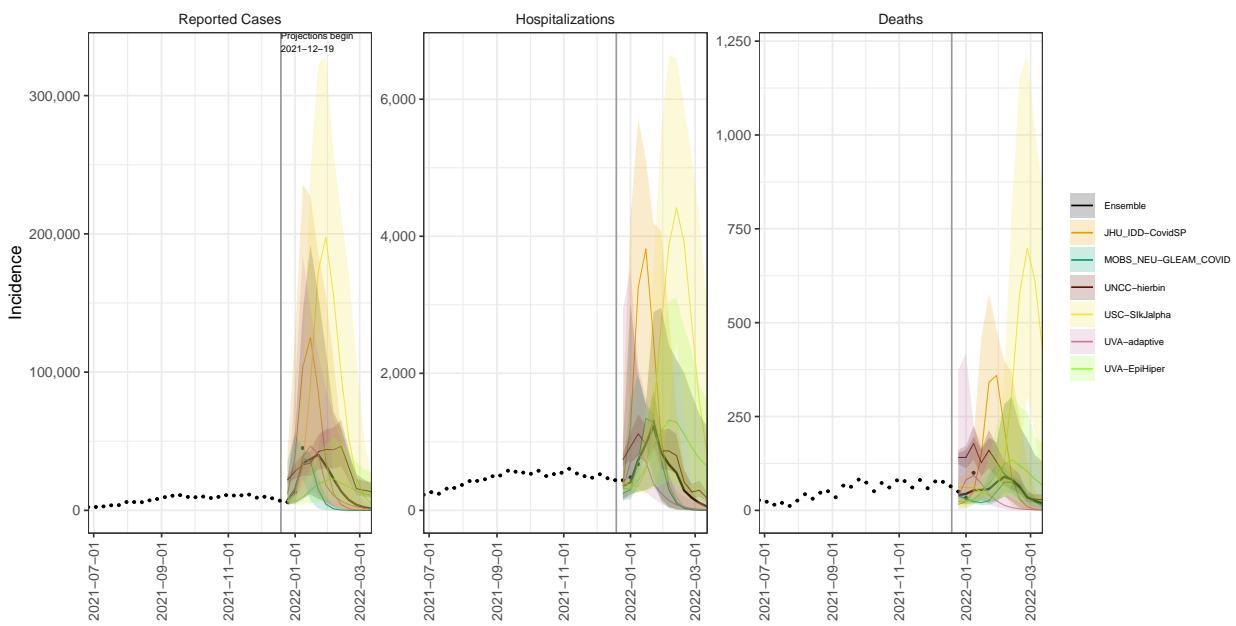
TN model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



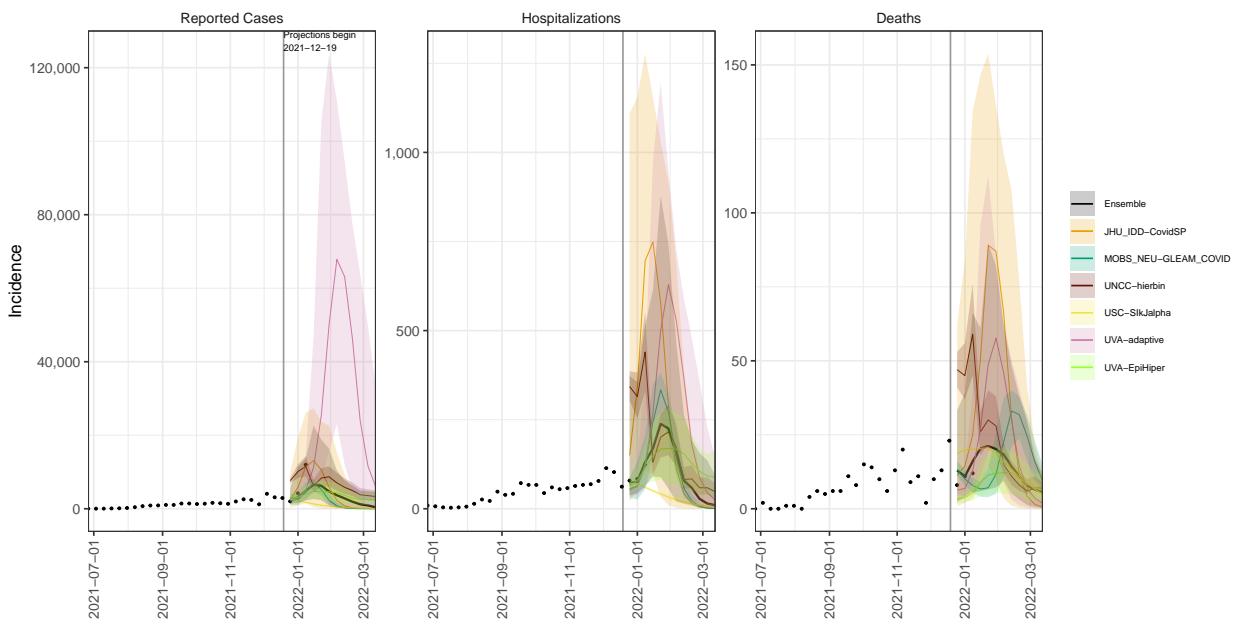
TX model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



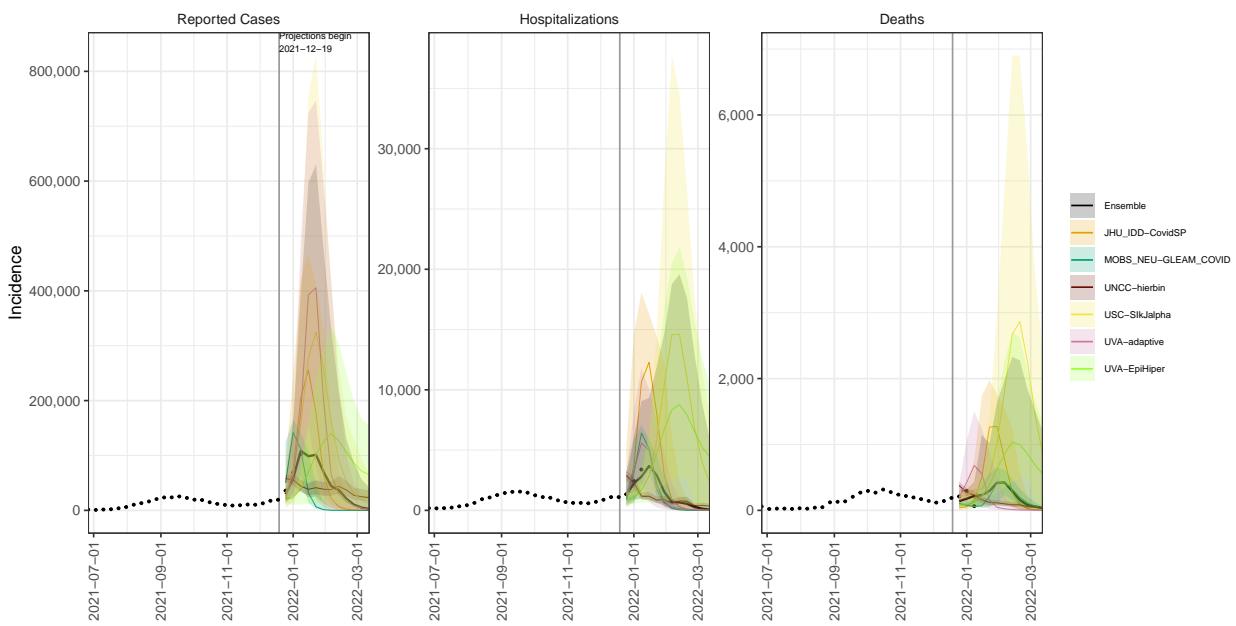
UT model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



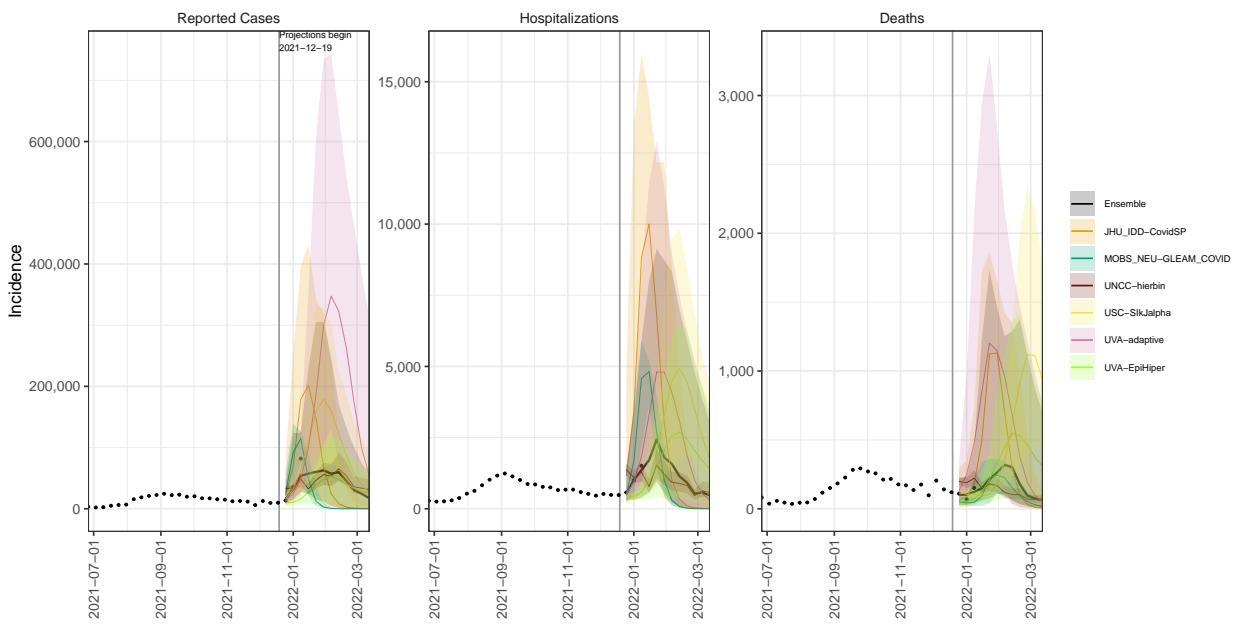
VT model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



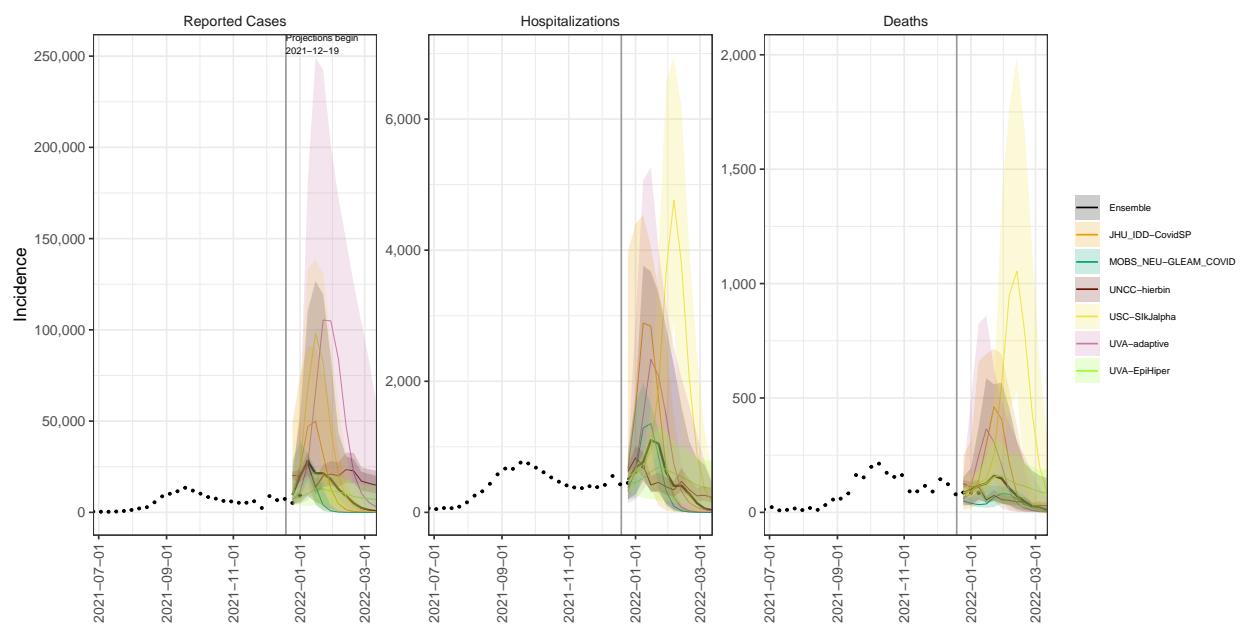
VA model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



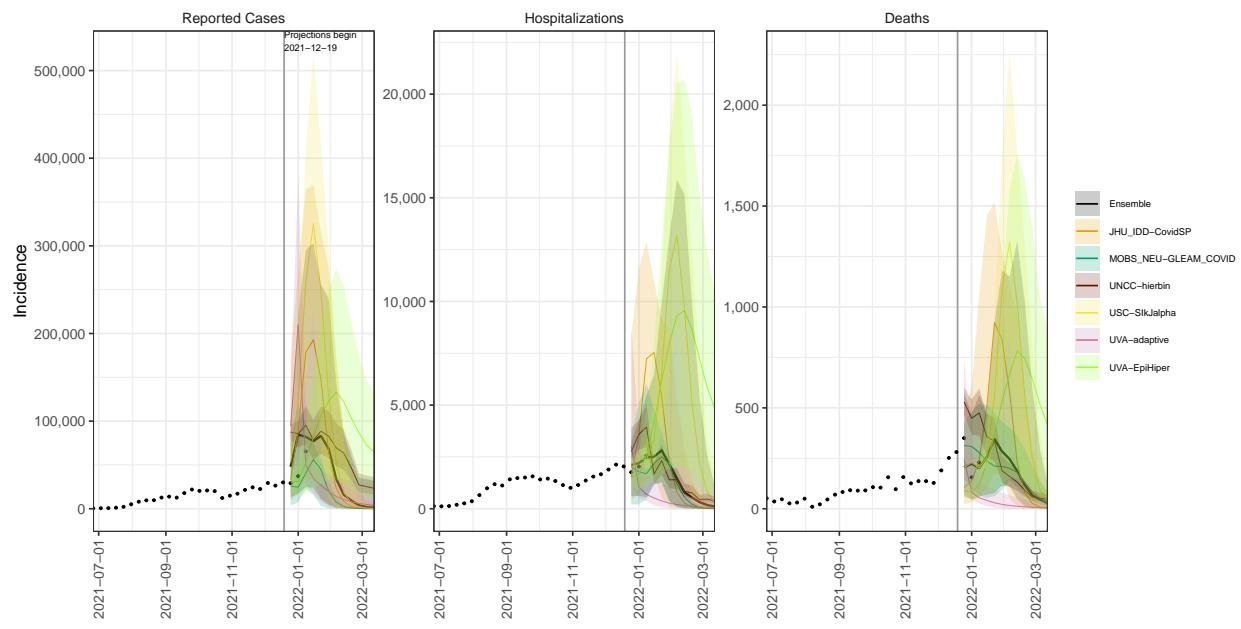
WA model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



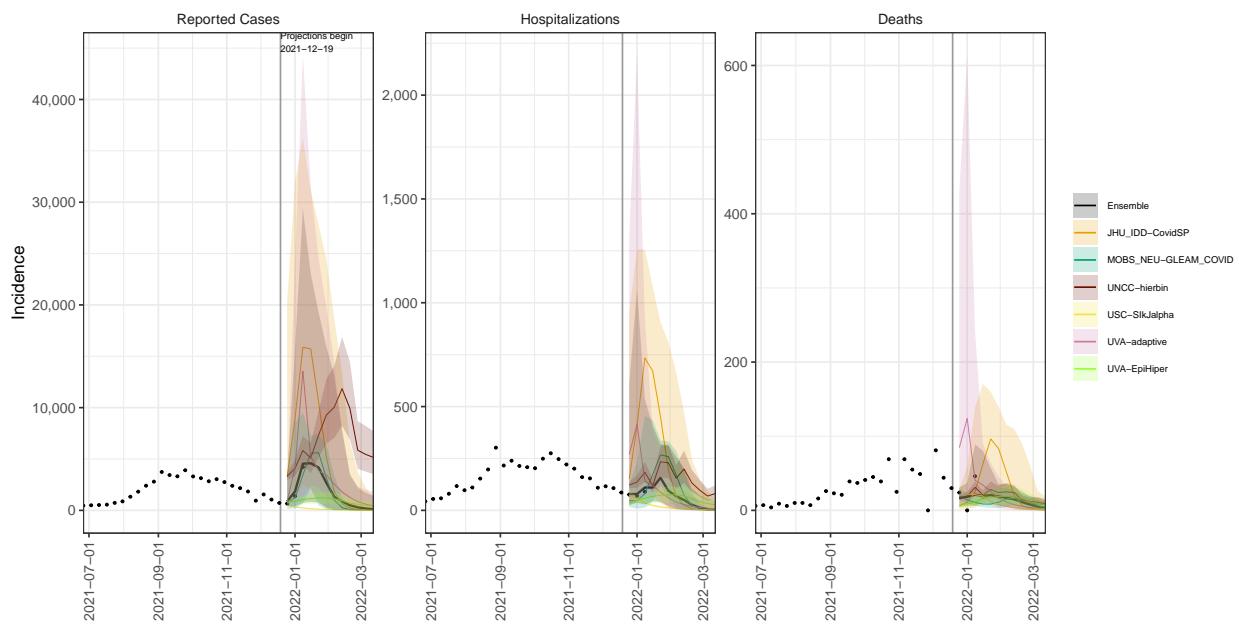
WV model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



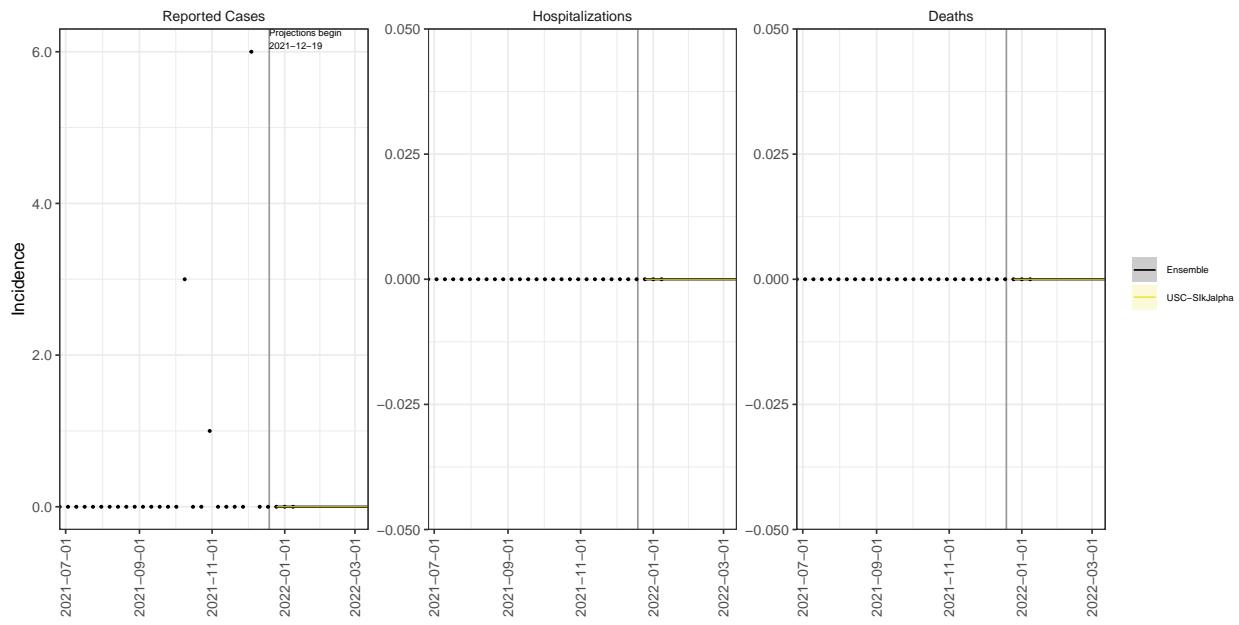
WI model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



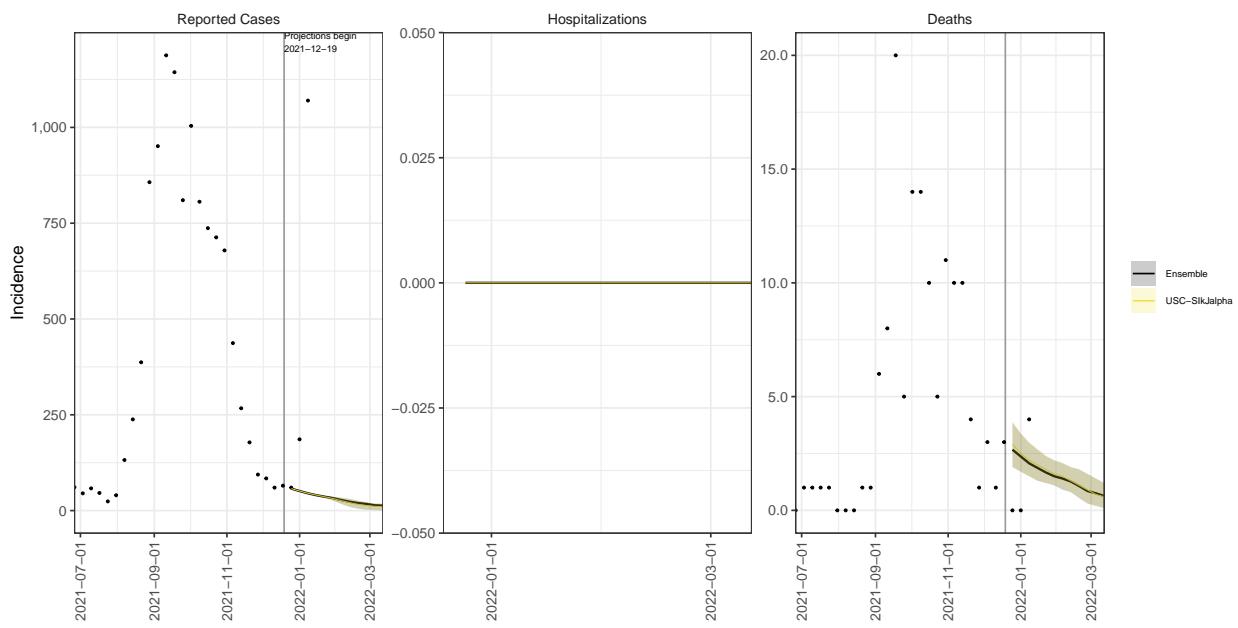
WY model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



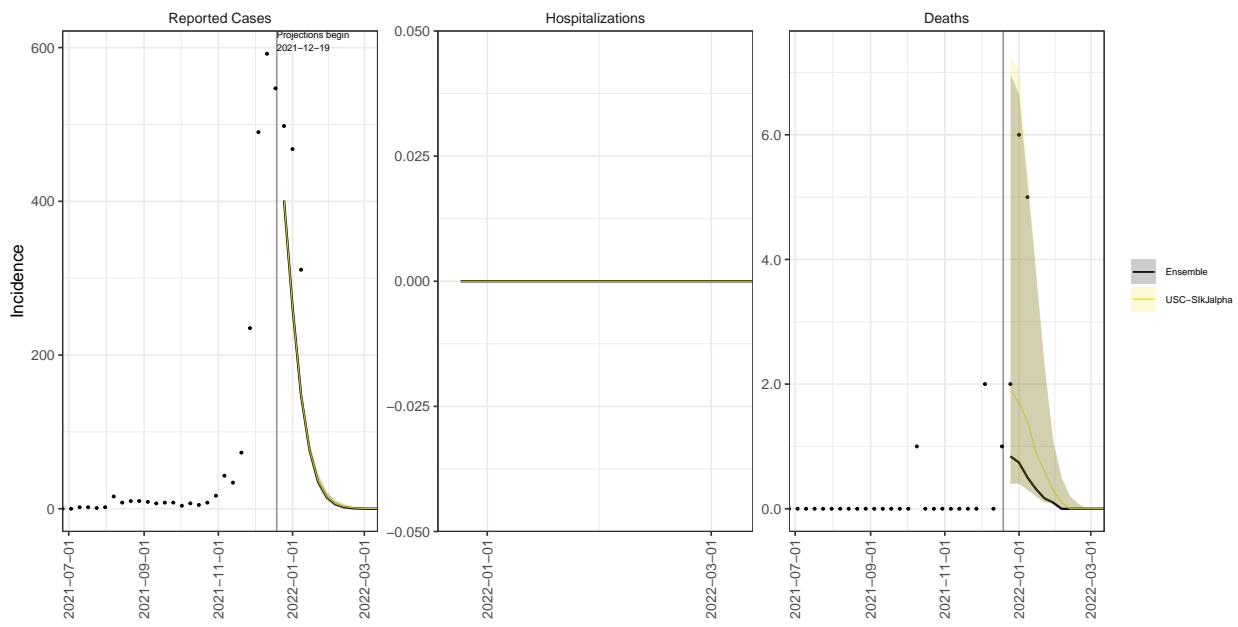
AS model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



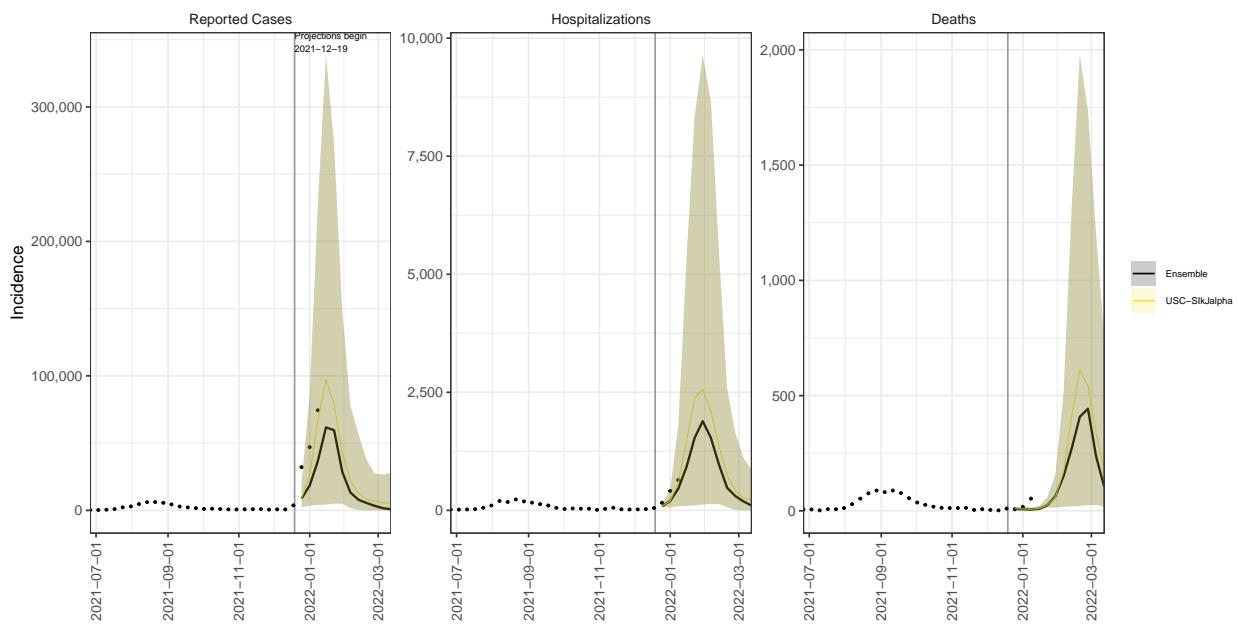
GU model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



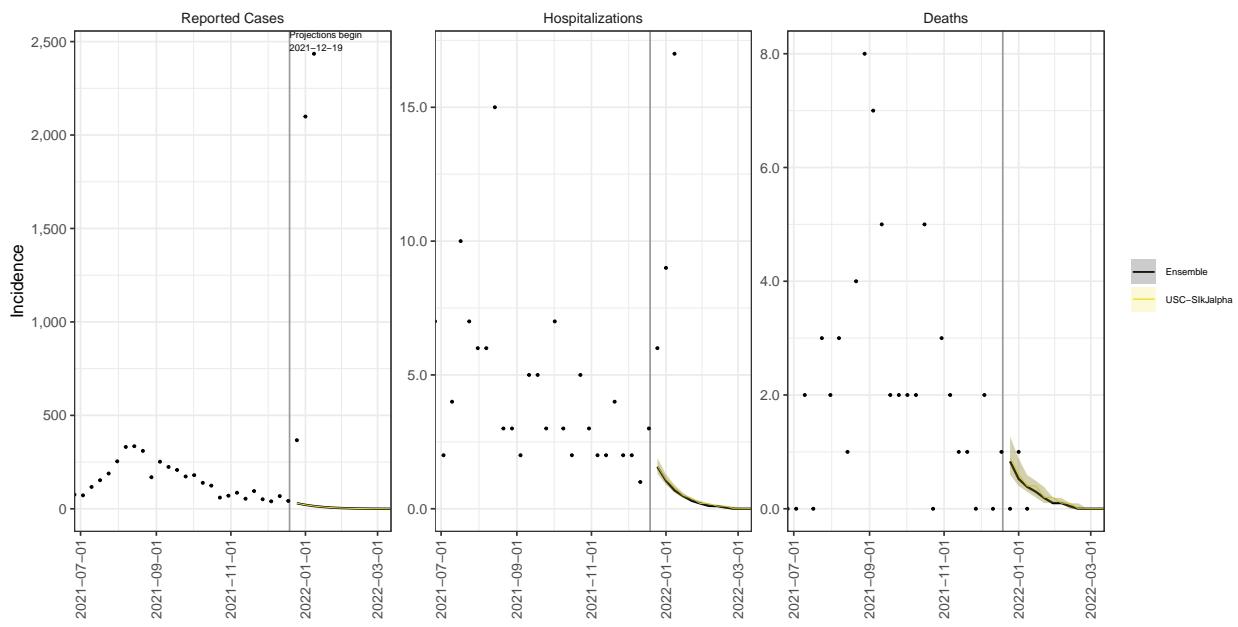
MP model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility



PR model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility

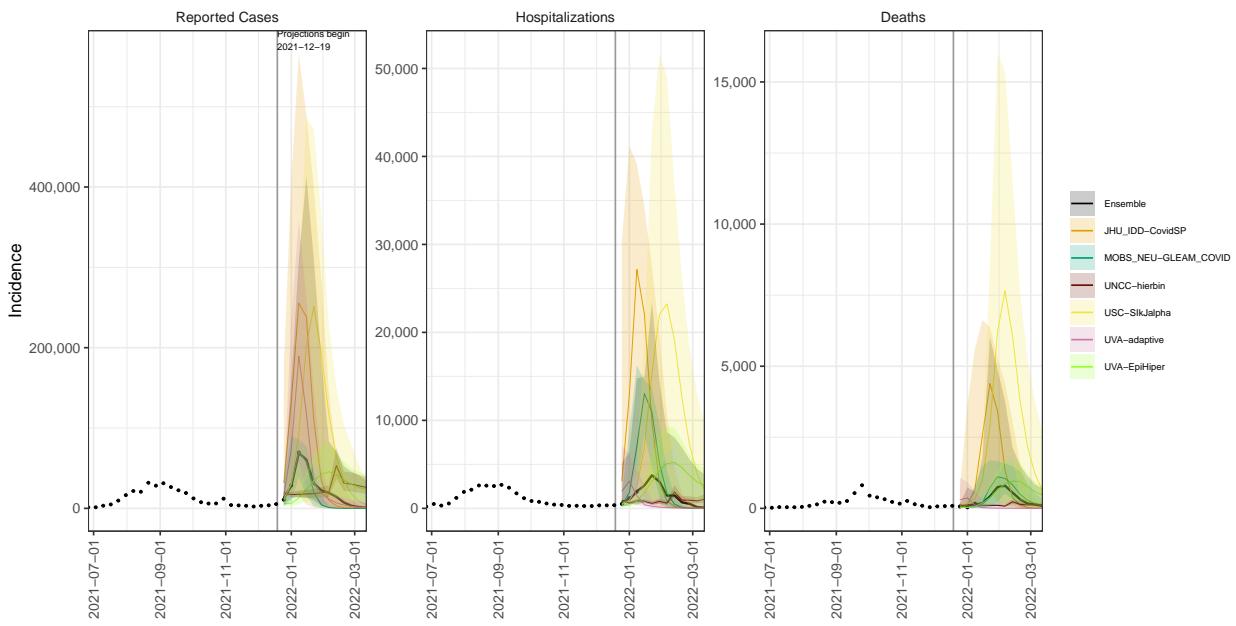


VI model variance & 95% projection intervals – Optimistic severity, high immune escape & low transmissibility

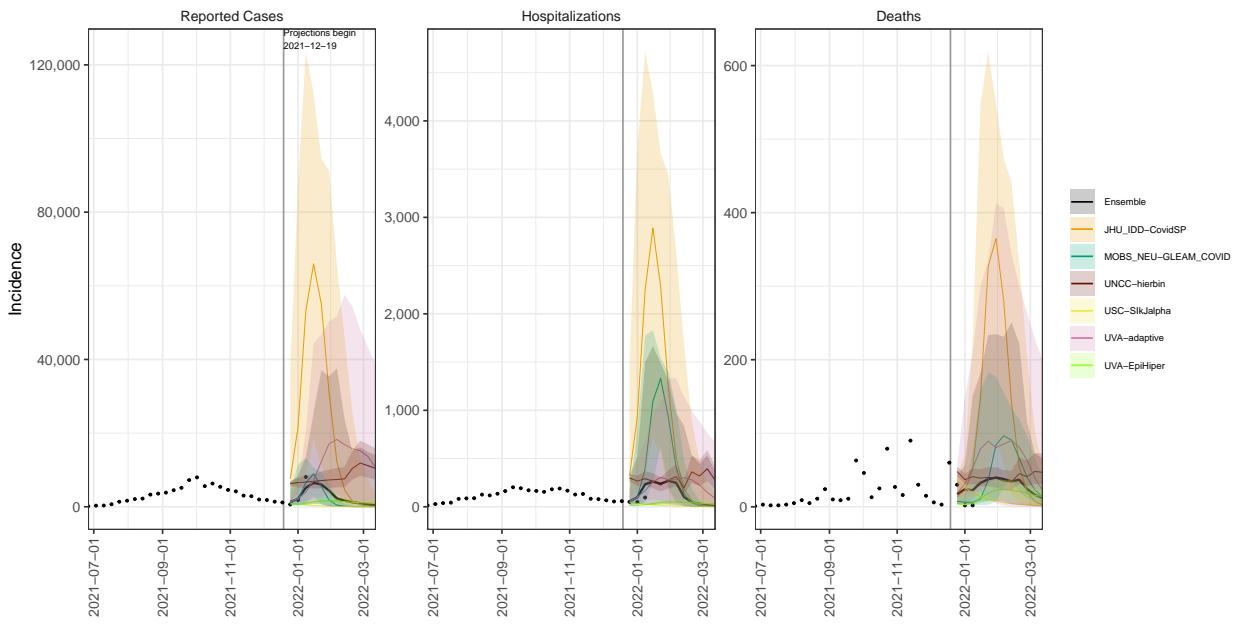


National model variation for the pessimistic severity, low immune escape & high transmissibility scenario.

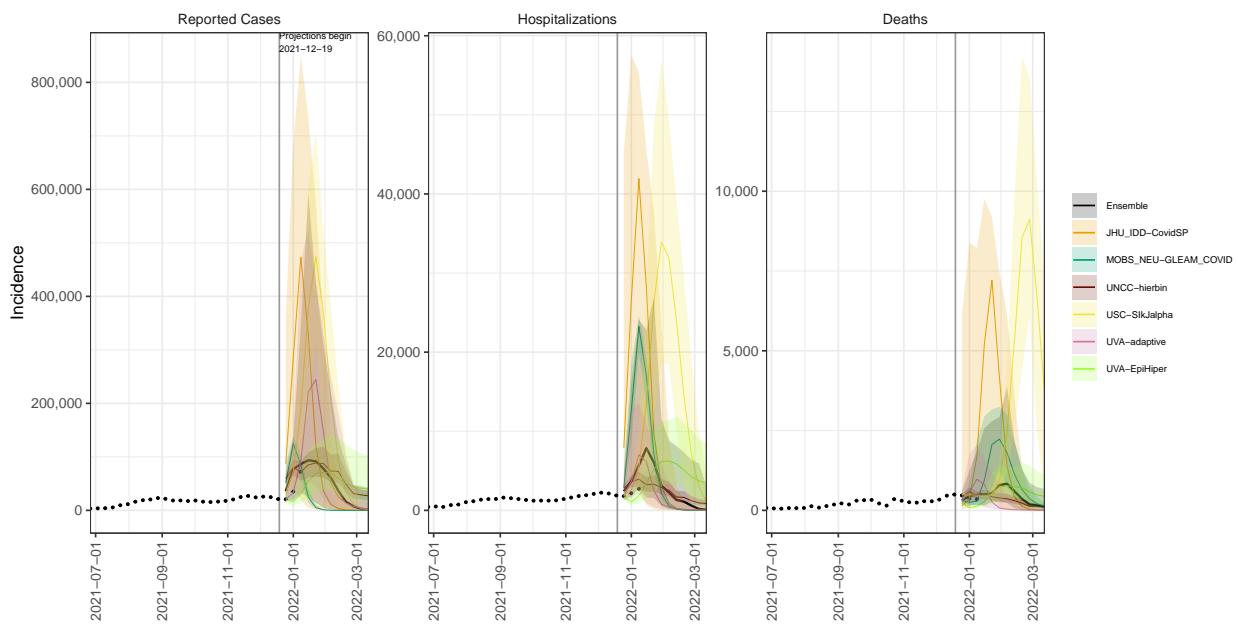
AL model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



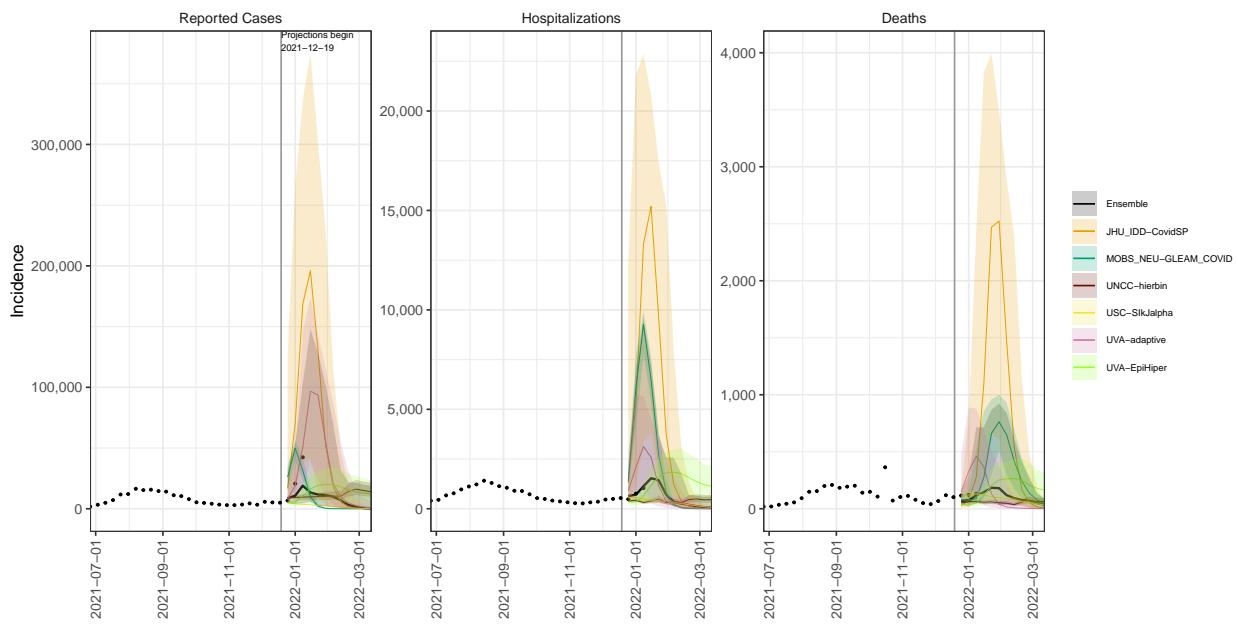
AK model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



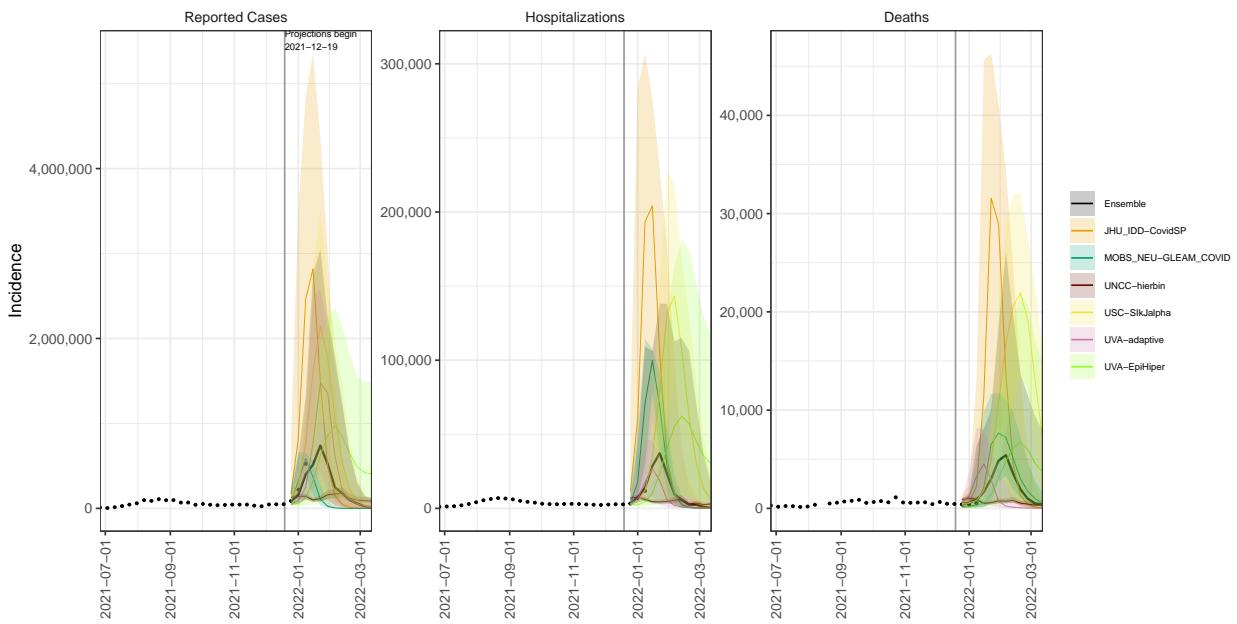
AZ model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



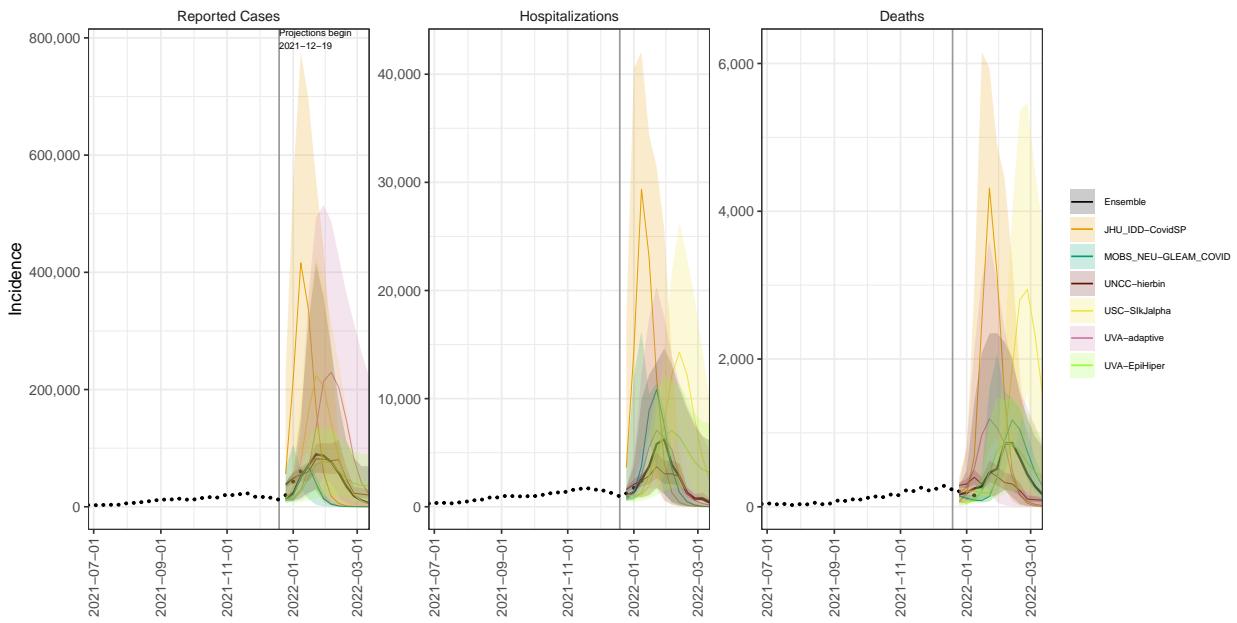
AR model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



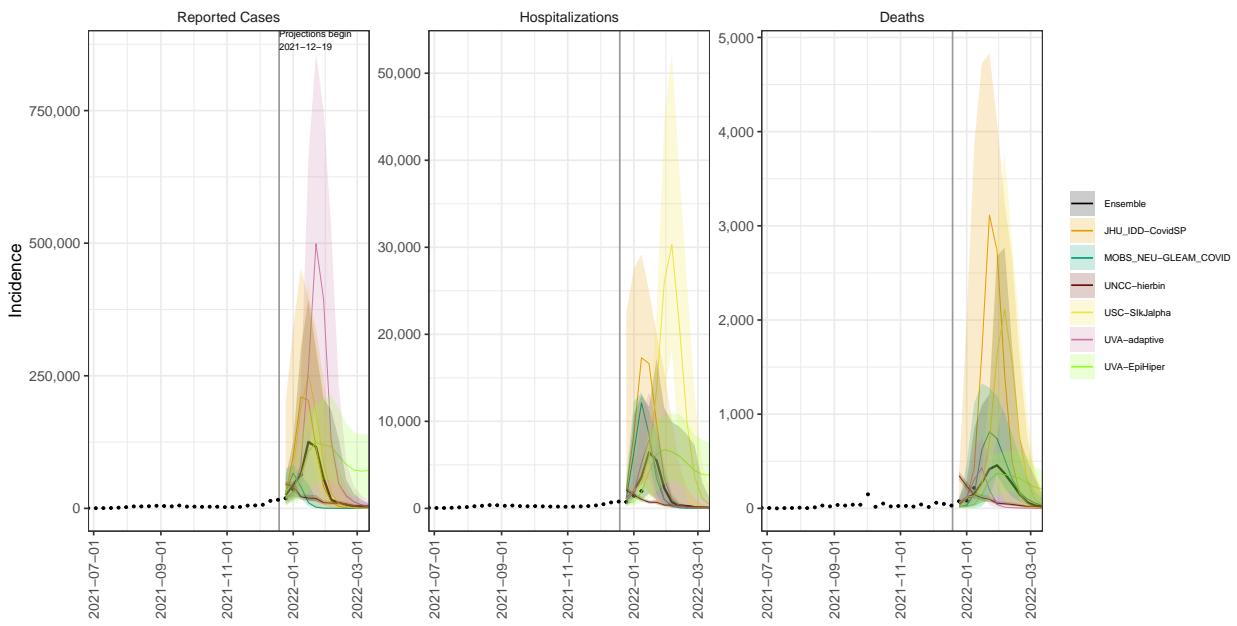
CA model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



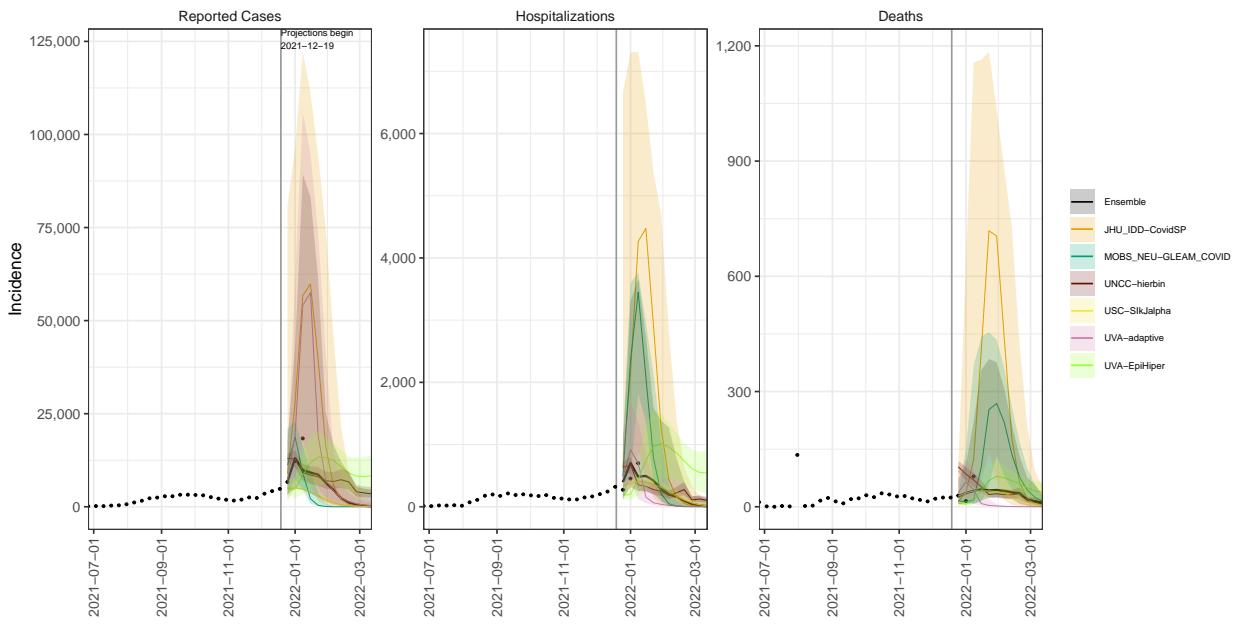
CO model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



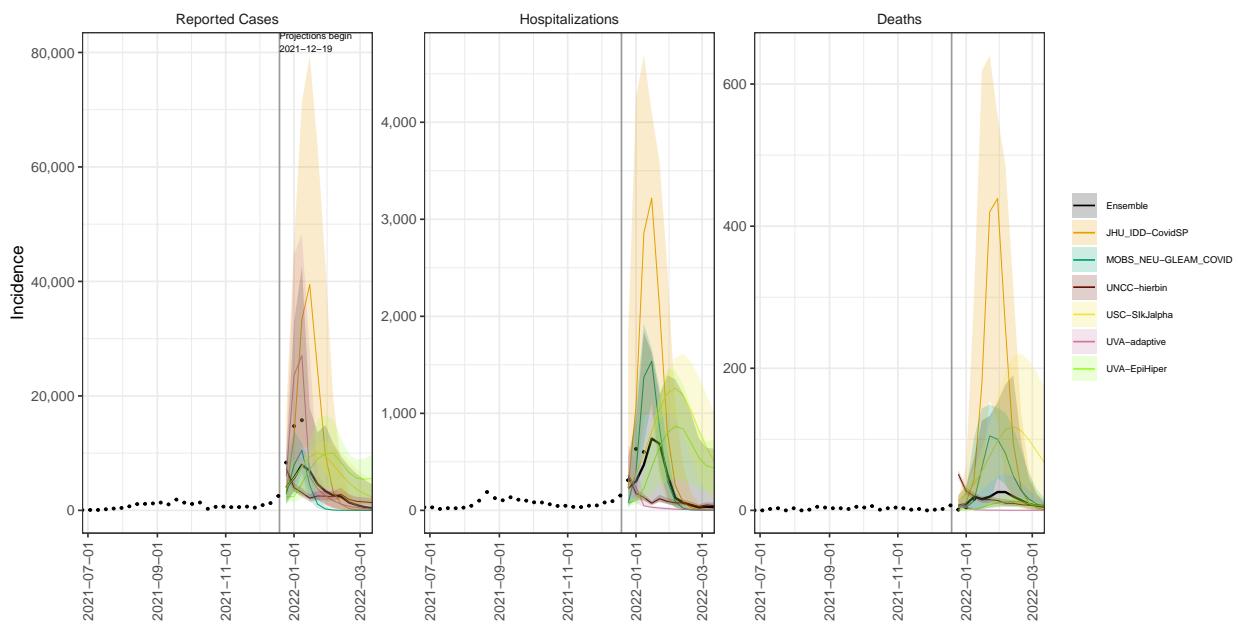
CT model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



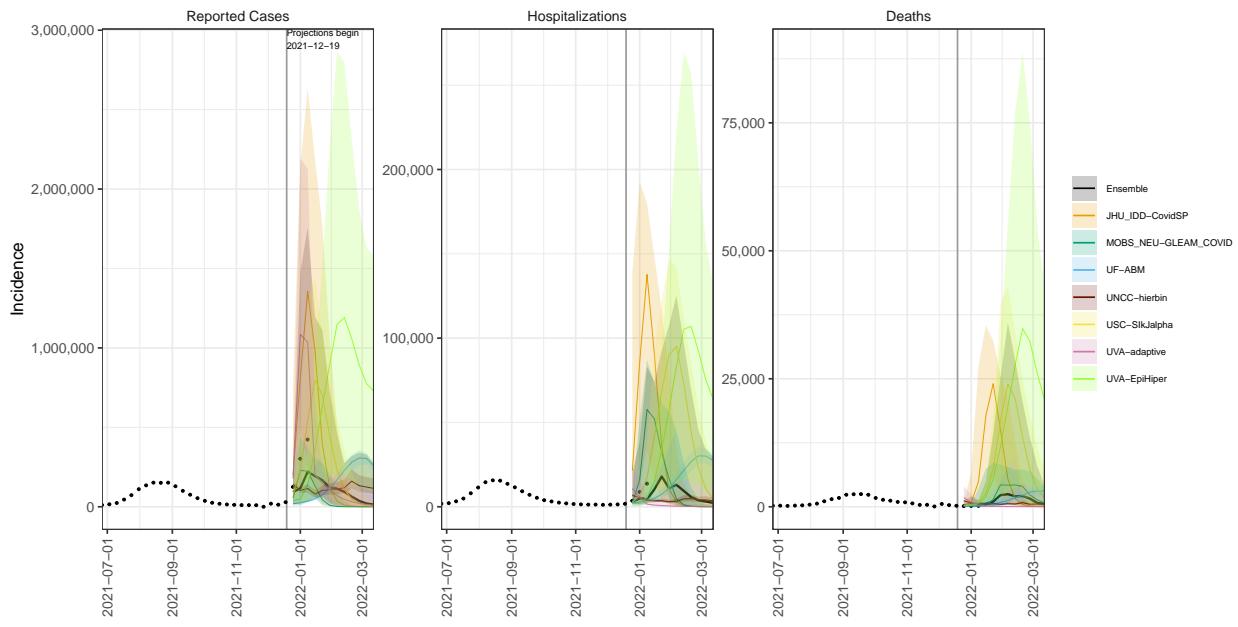
DE model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



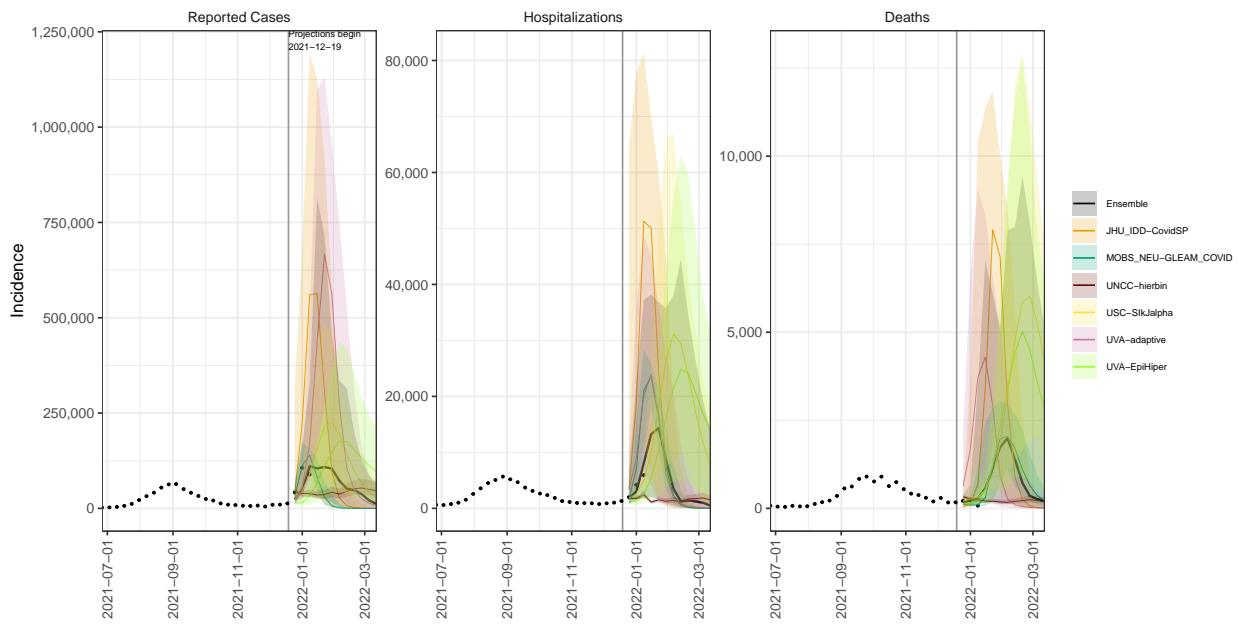
DC model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



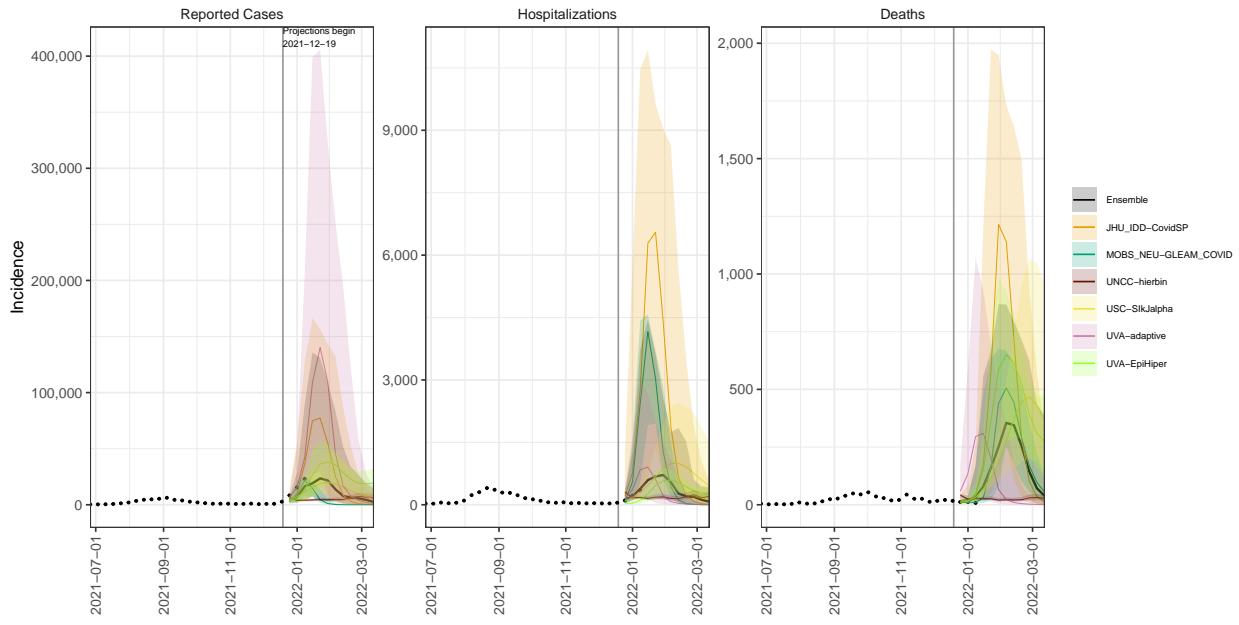
FL model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



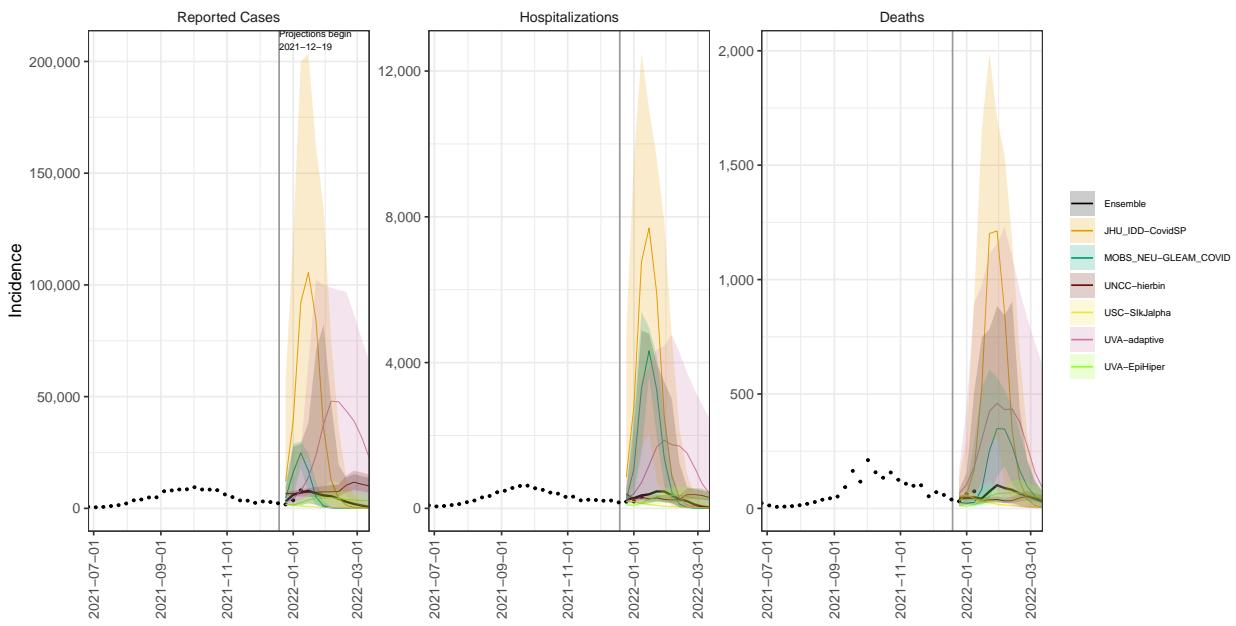
GA model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



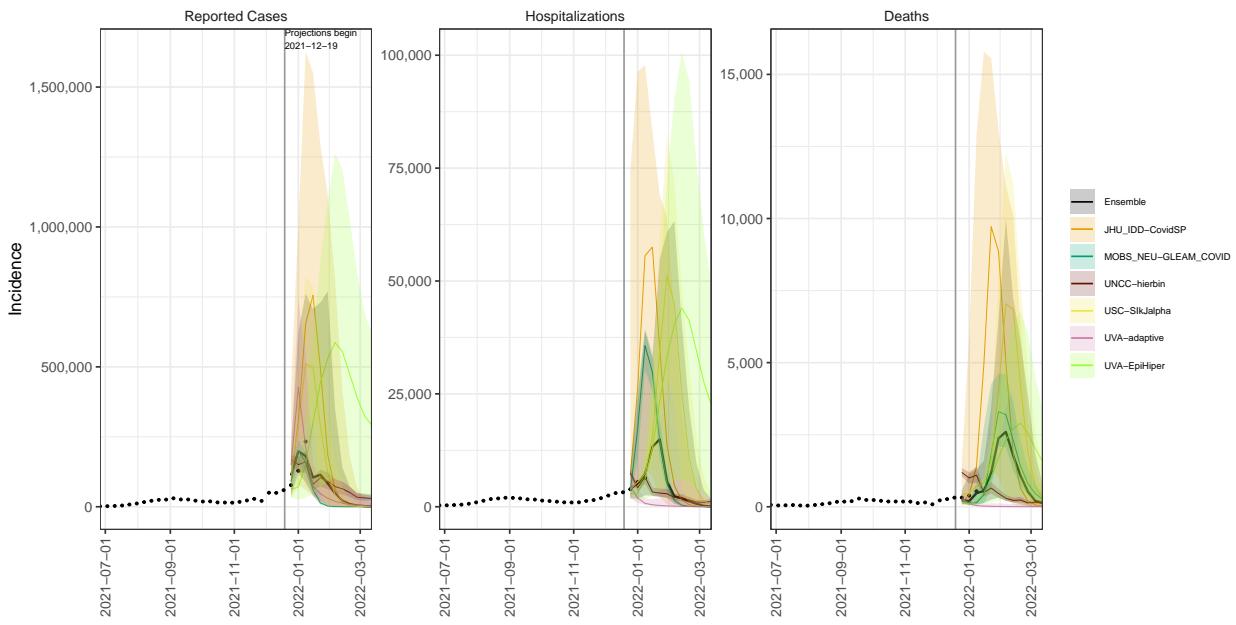
HI model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



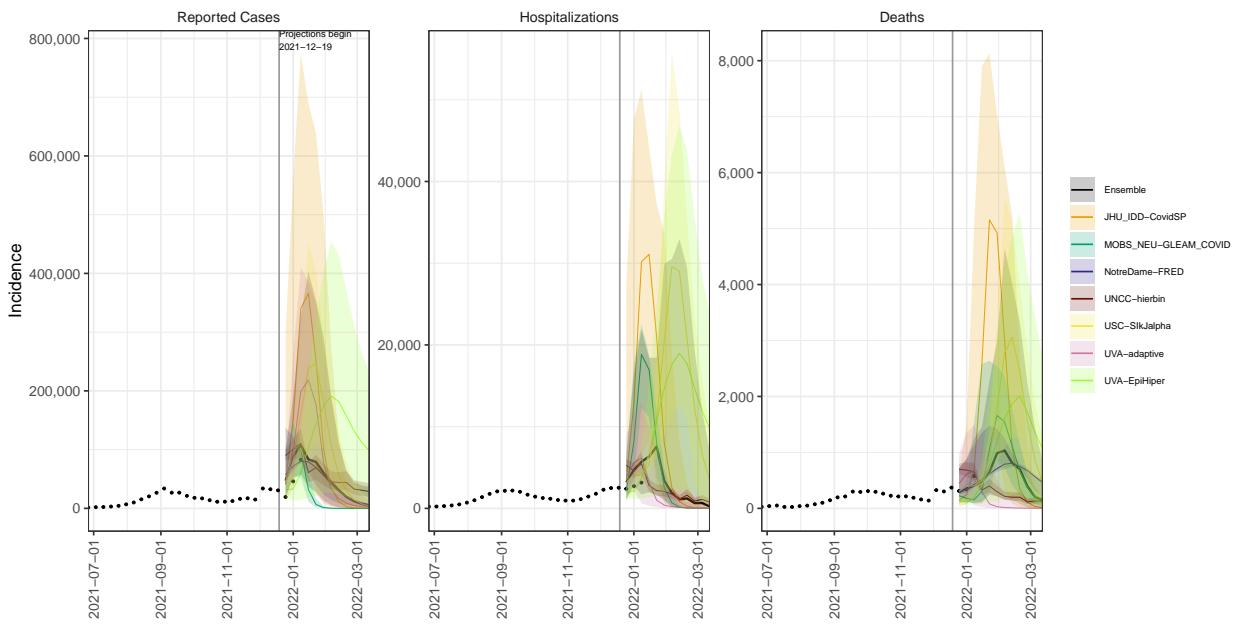
ID model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



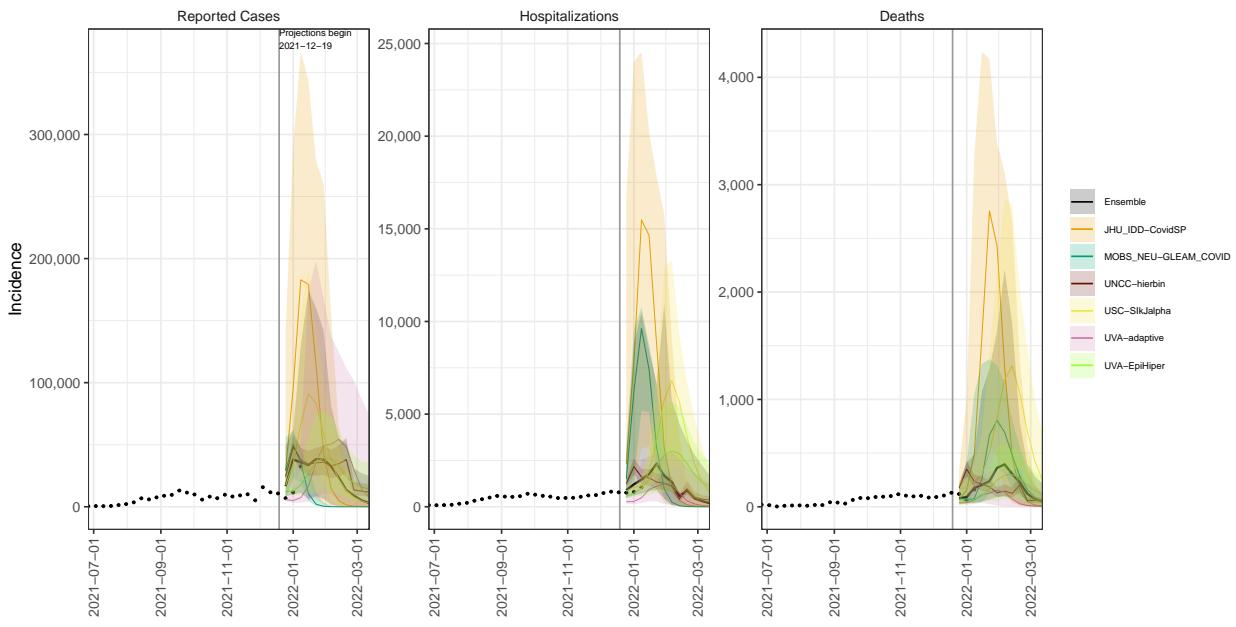
IL model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



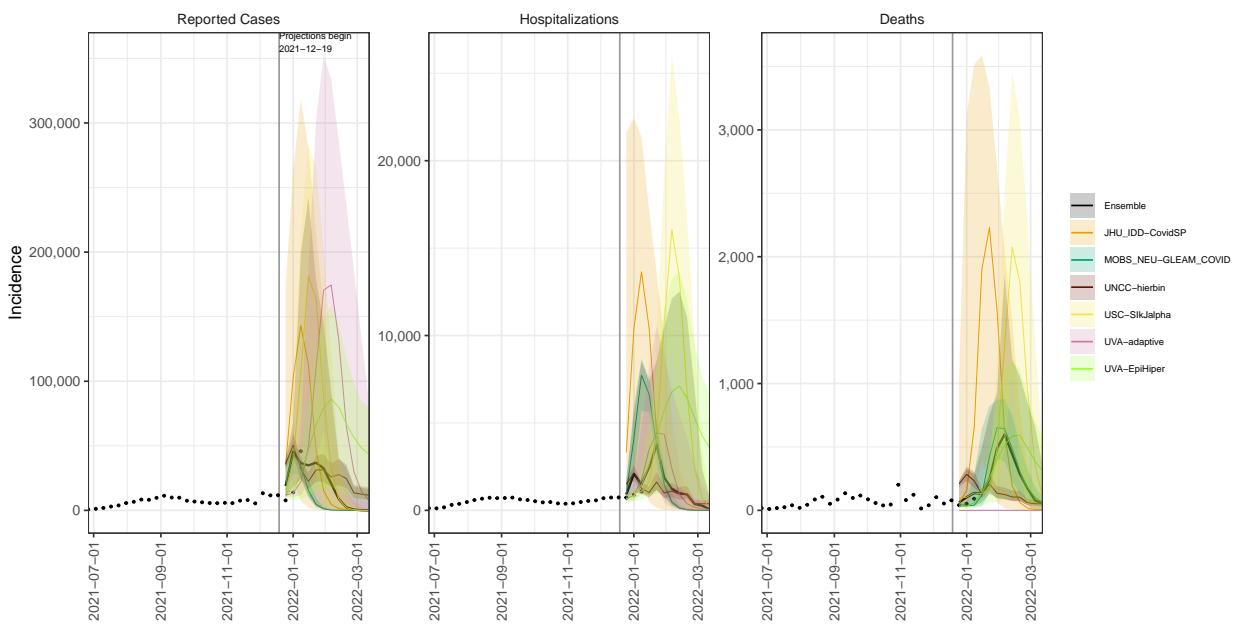
IN model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



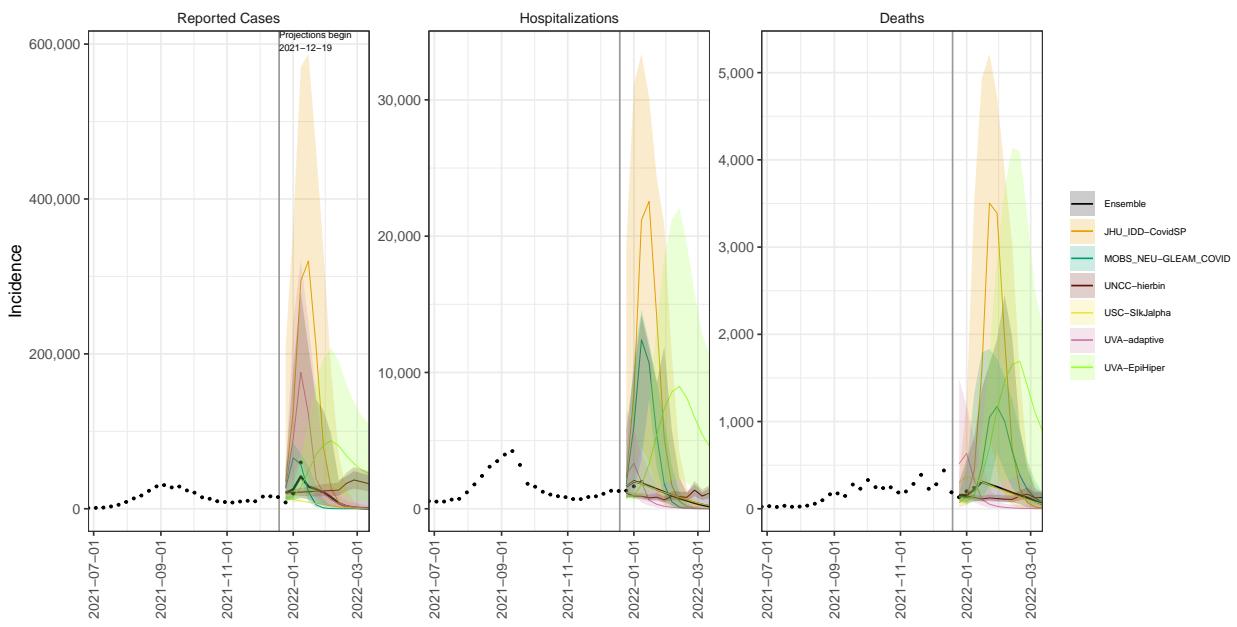
IA model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



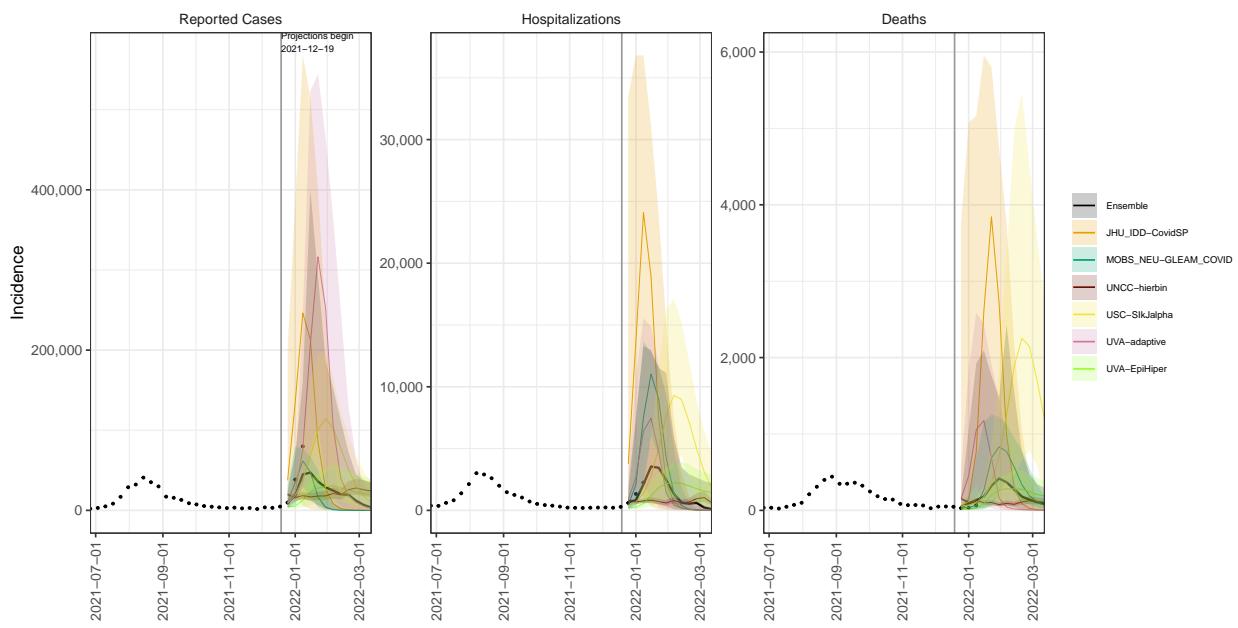
KS model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



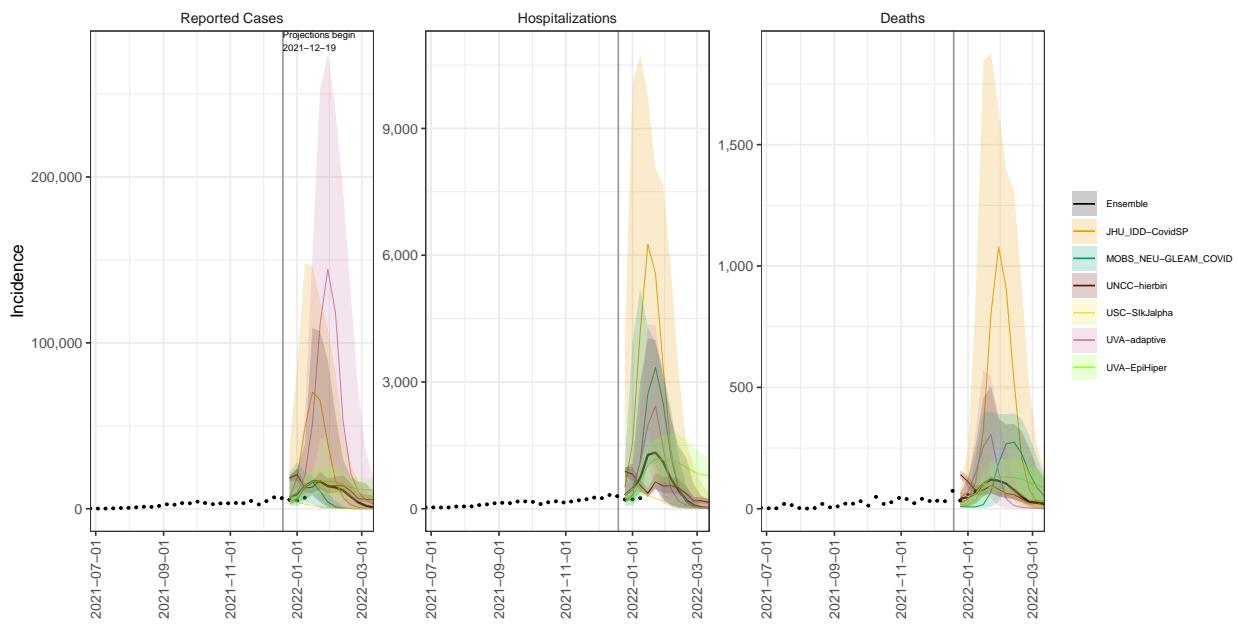
KY model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



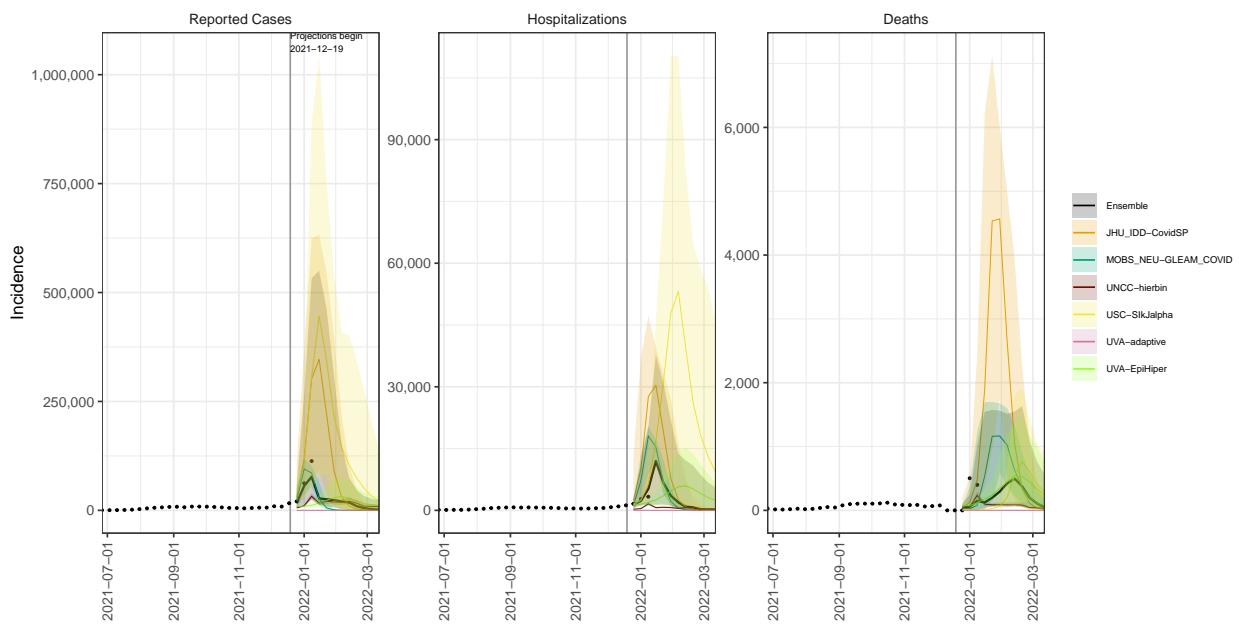
LA model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



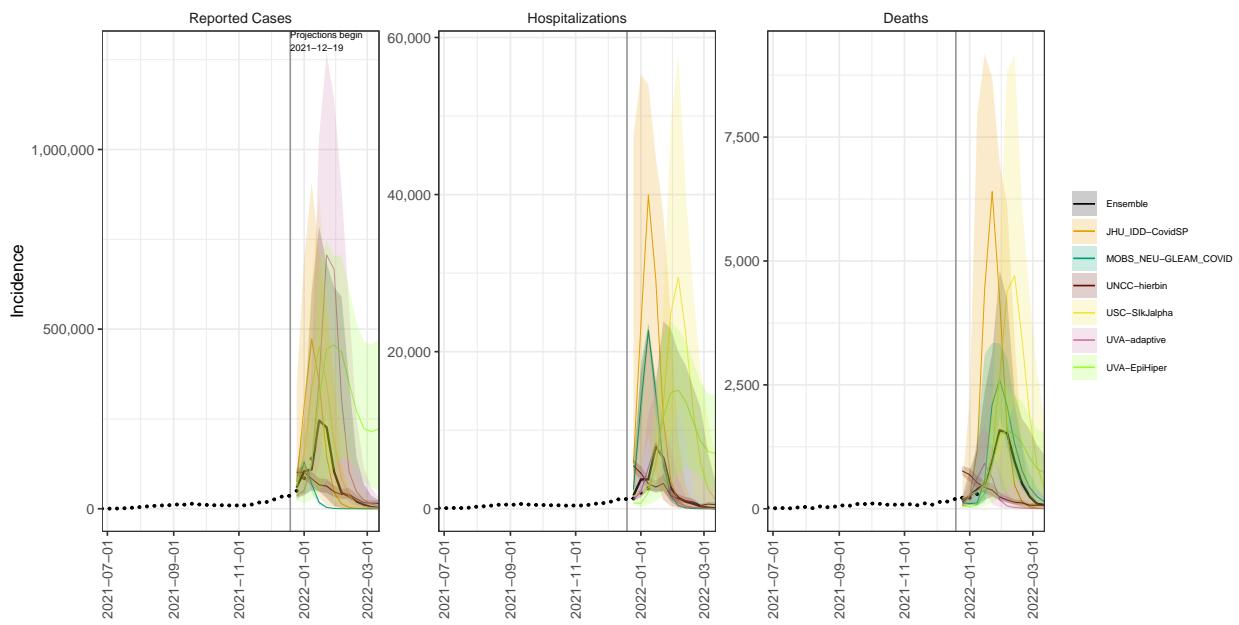
ME model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



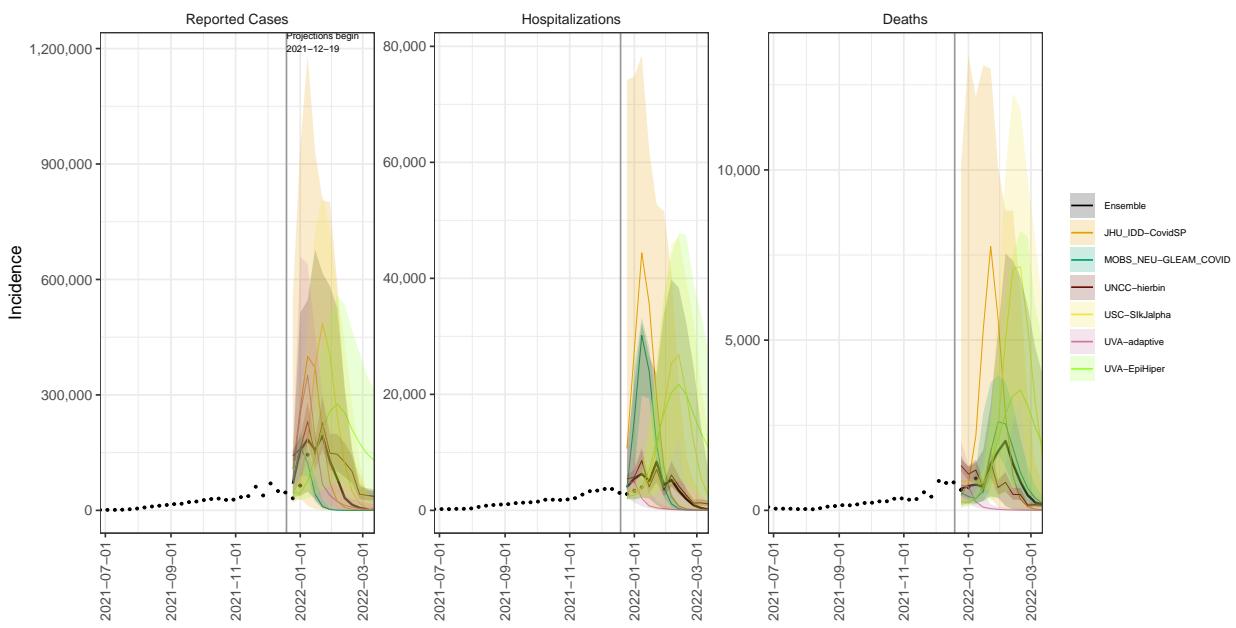
MD model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



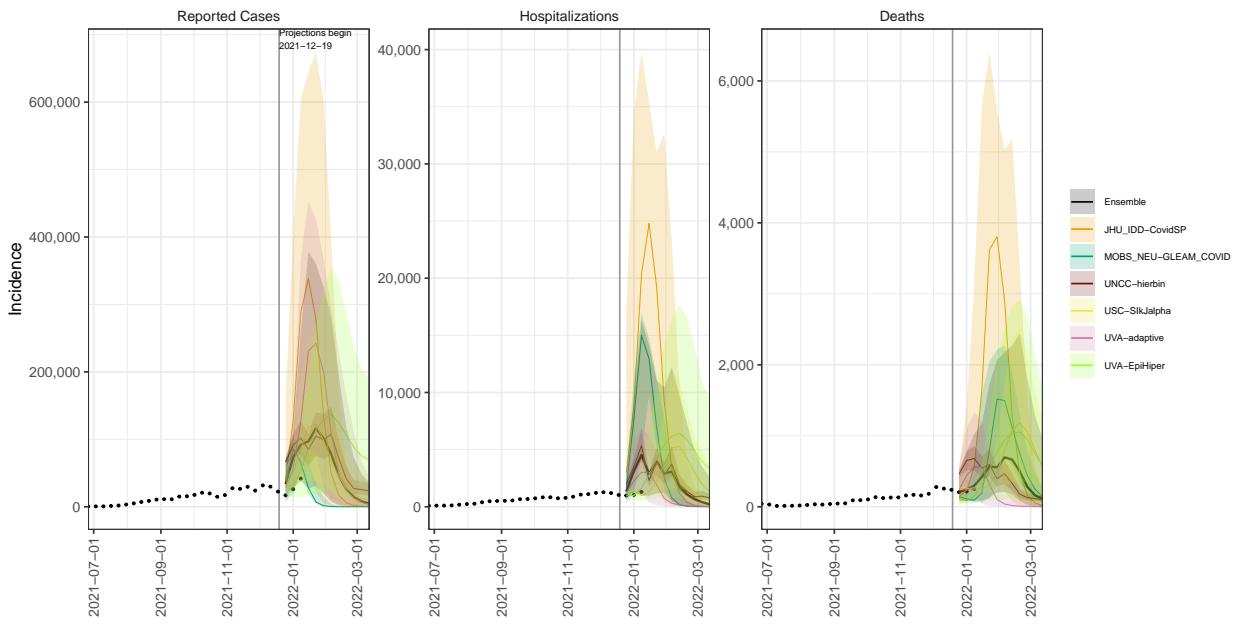
MA model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



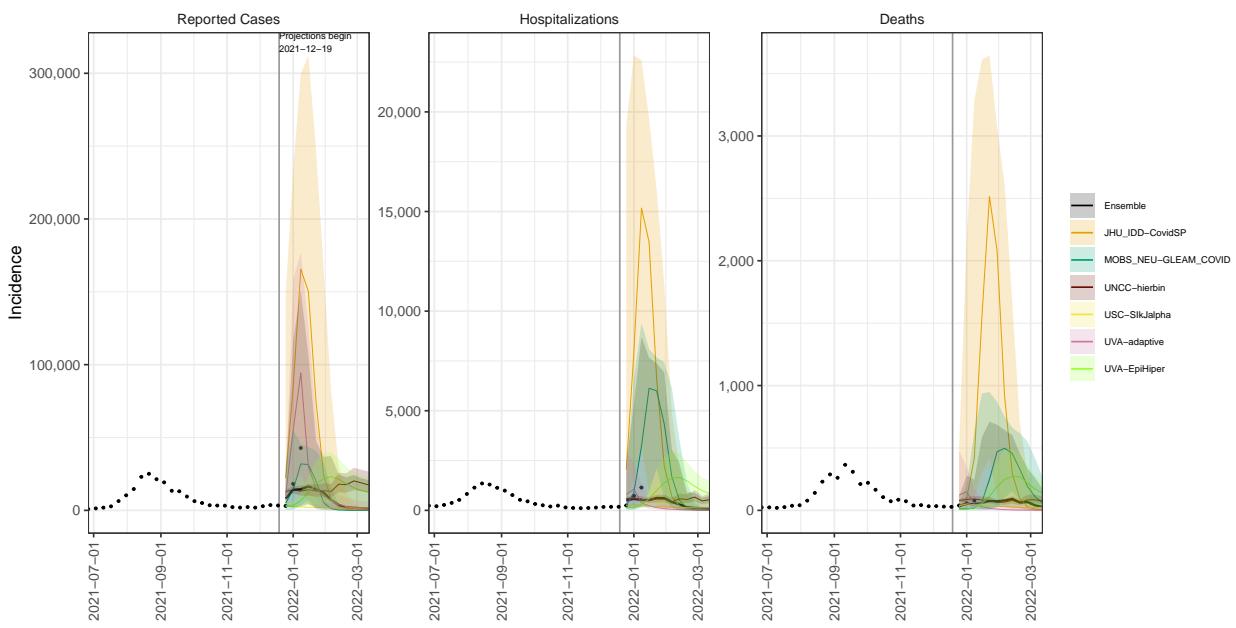
MI model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



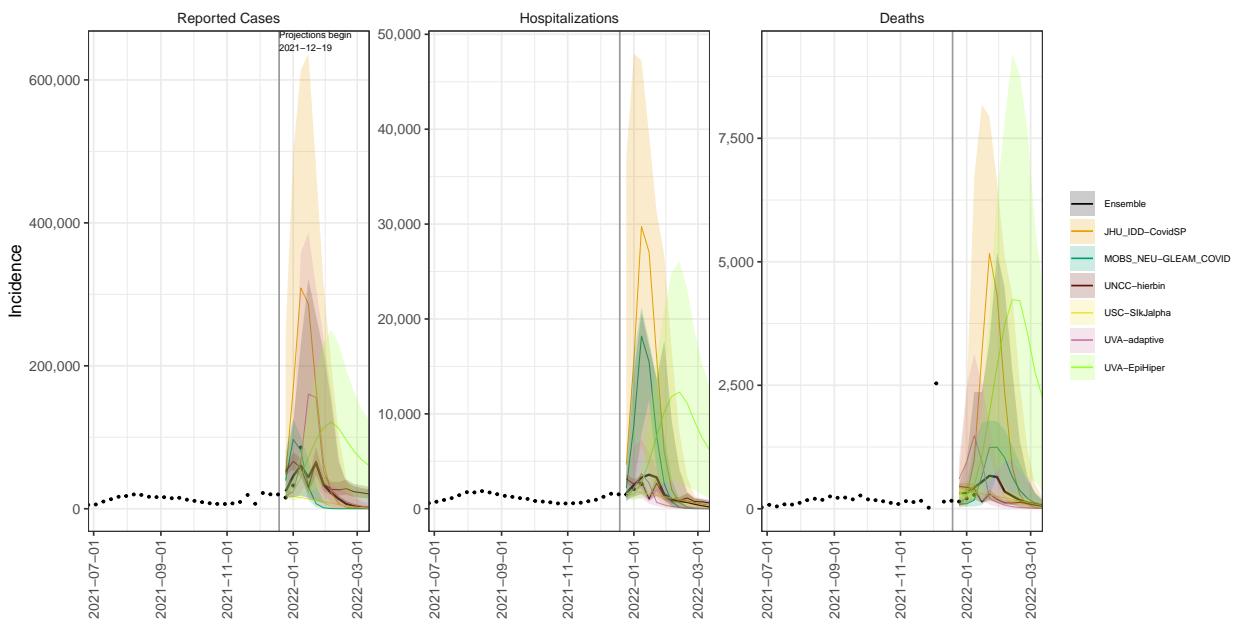
MN model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



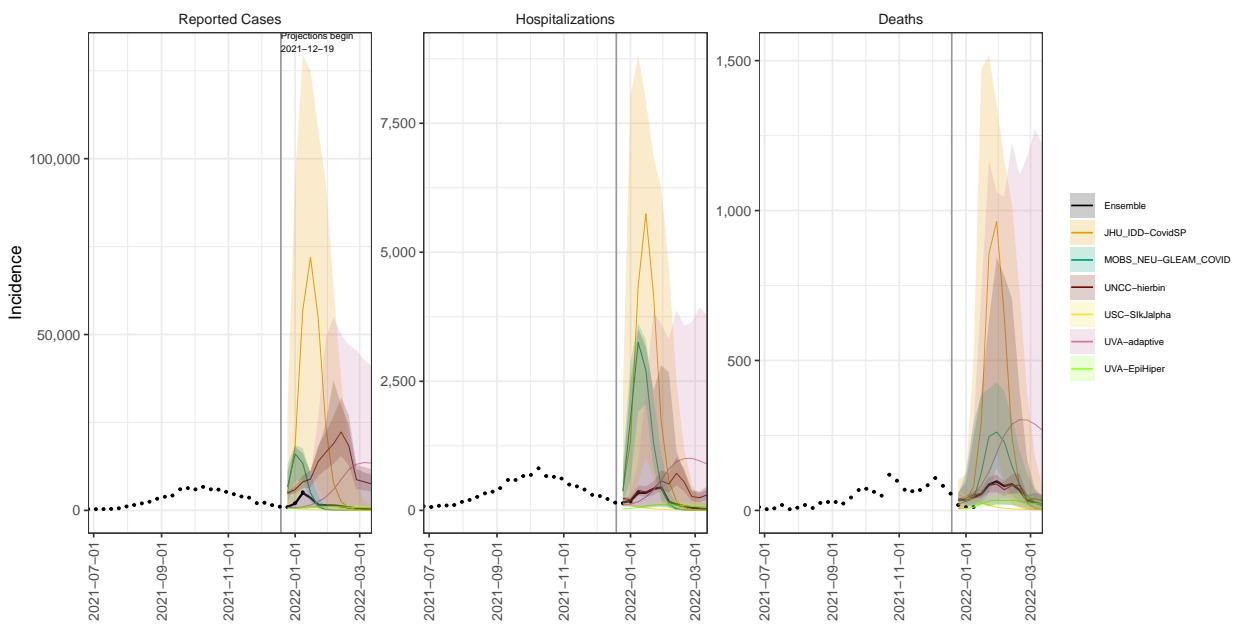
MS model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



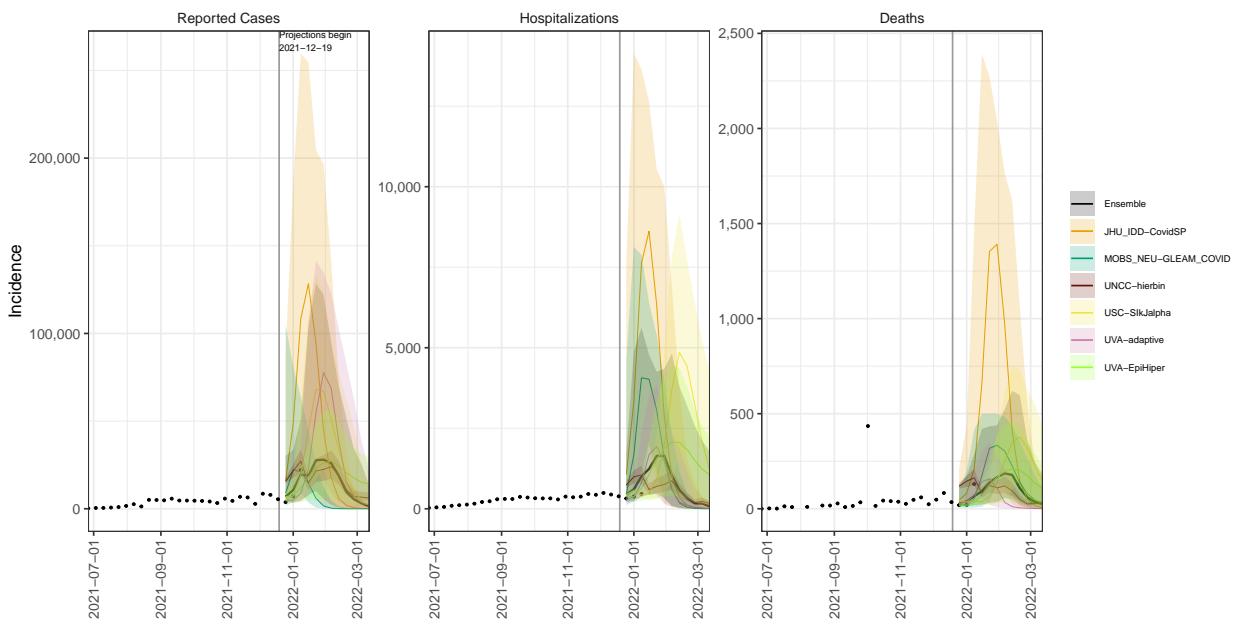
MO model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



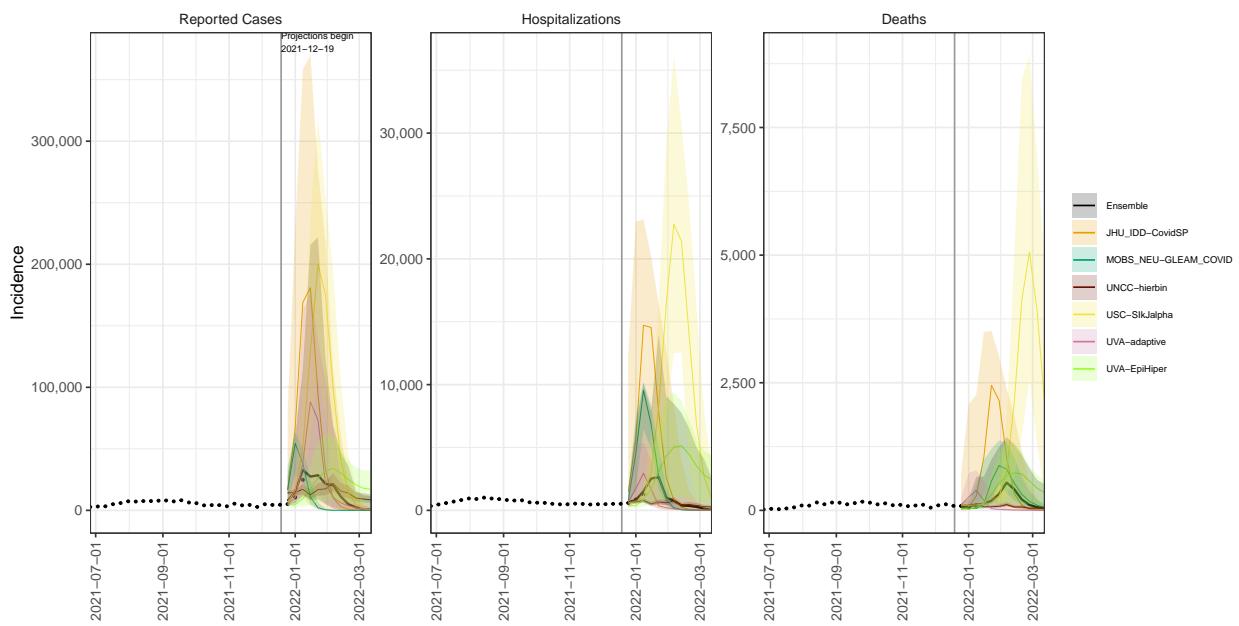
MT model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



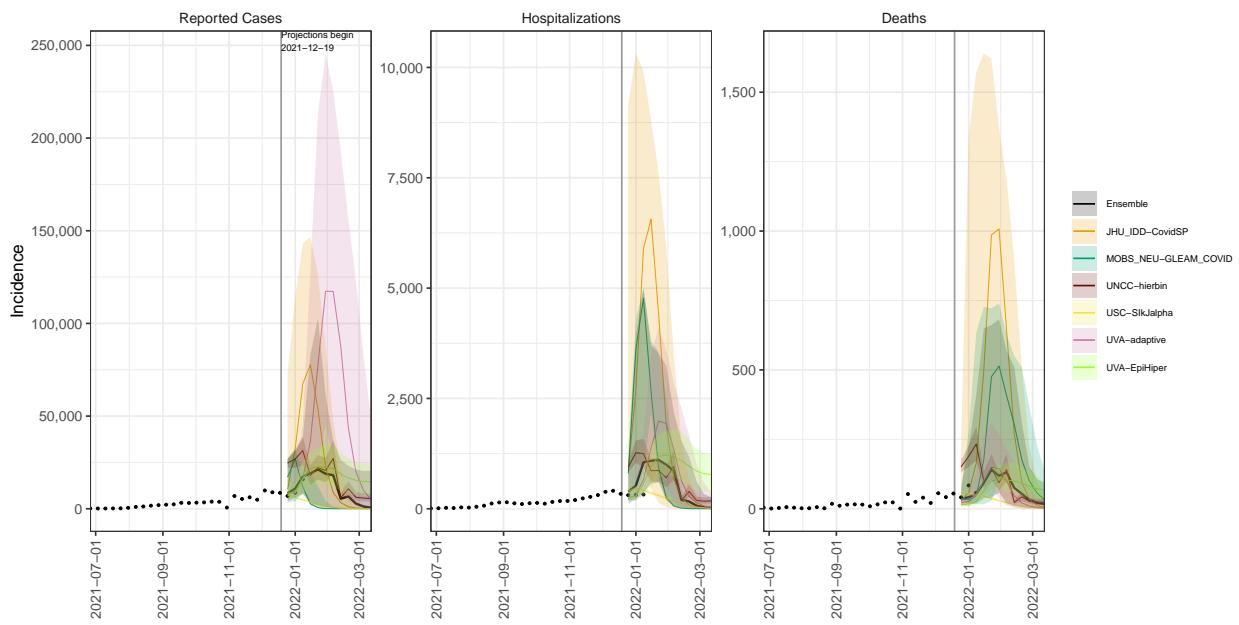
NE model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



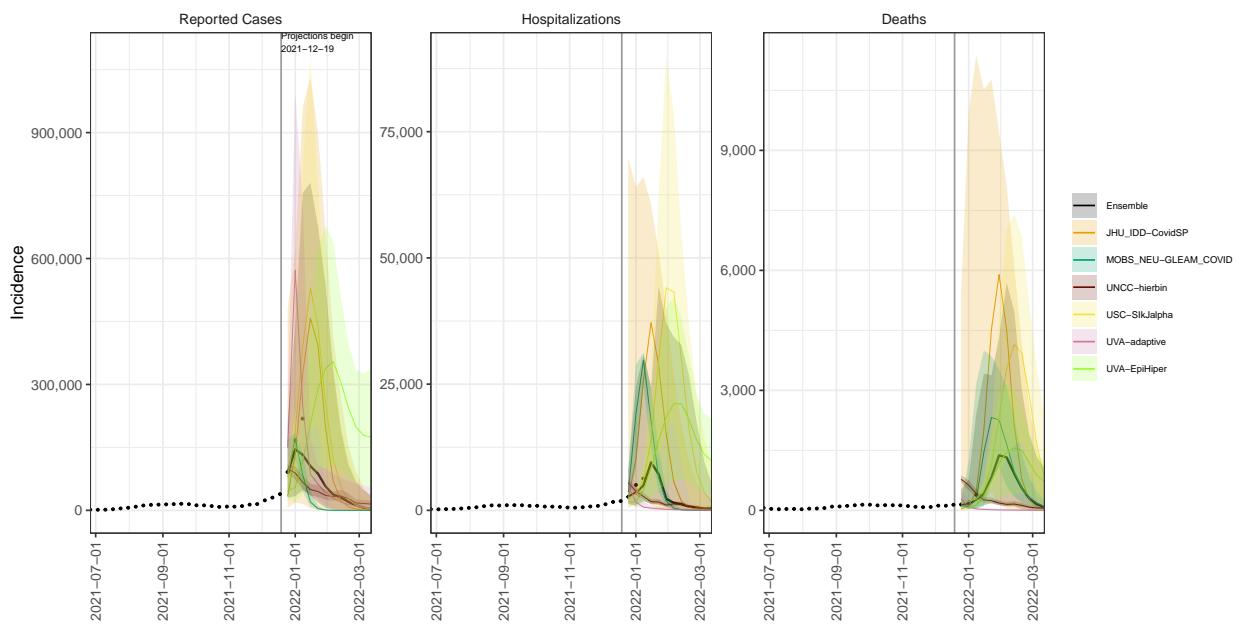
NV model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



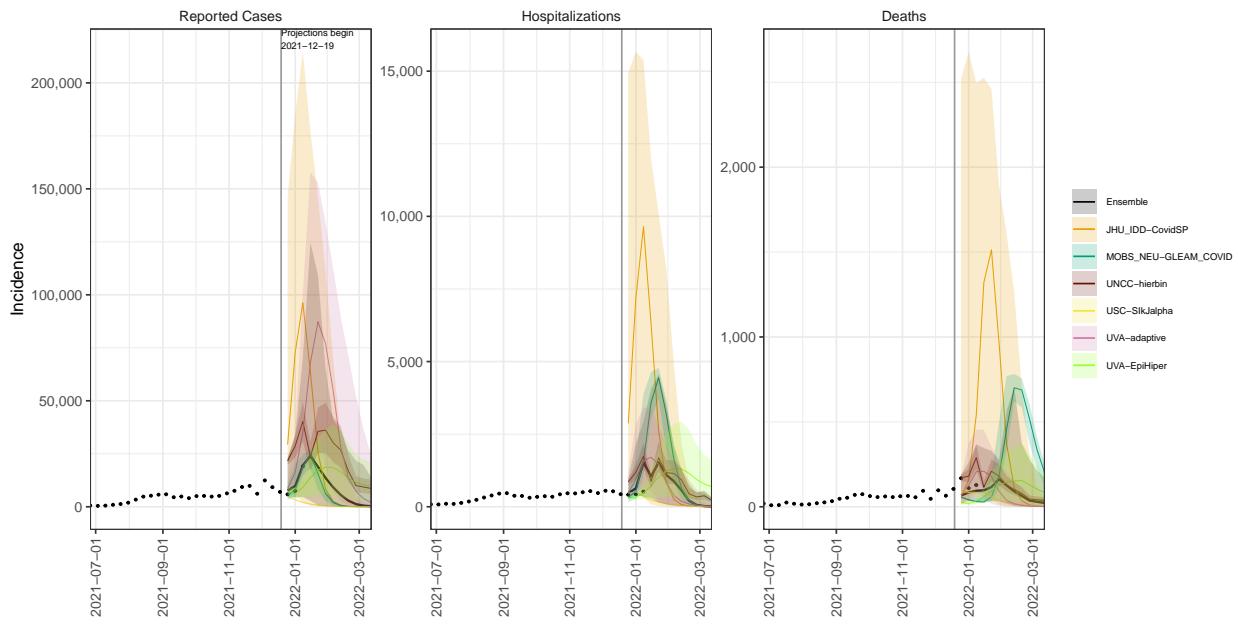
NH model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



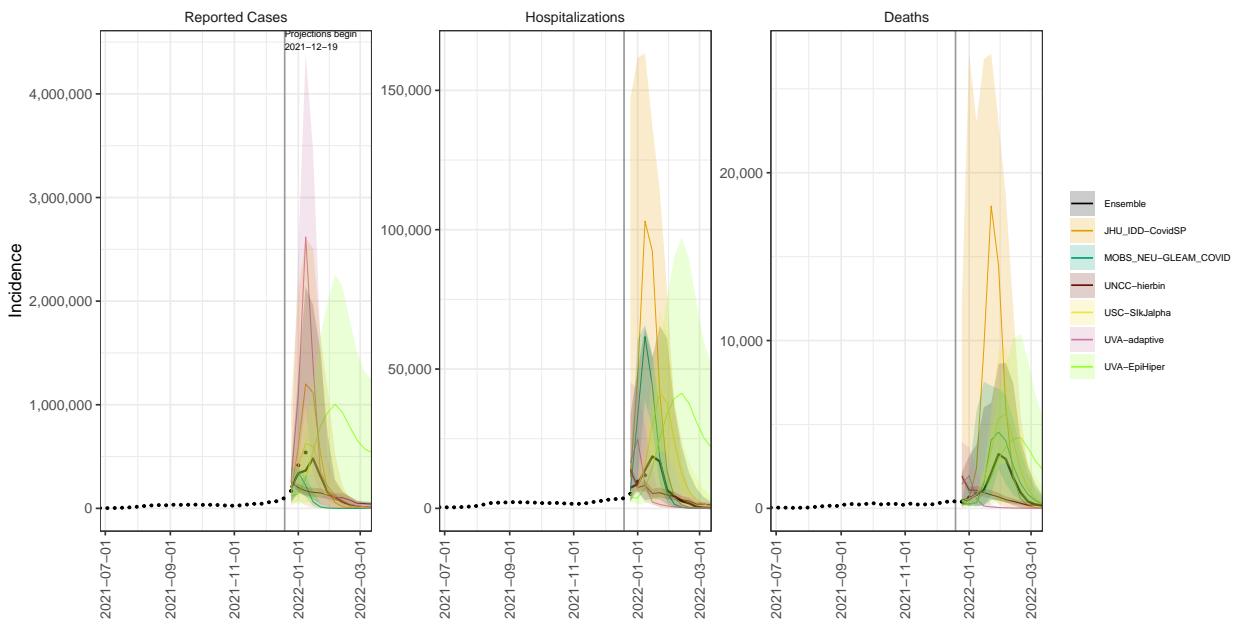
NJ model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



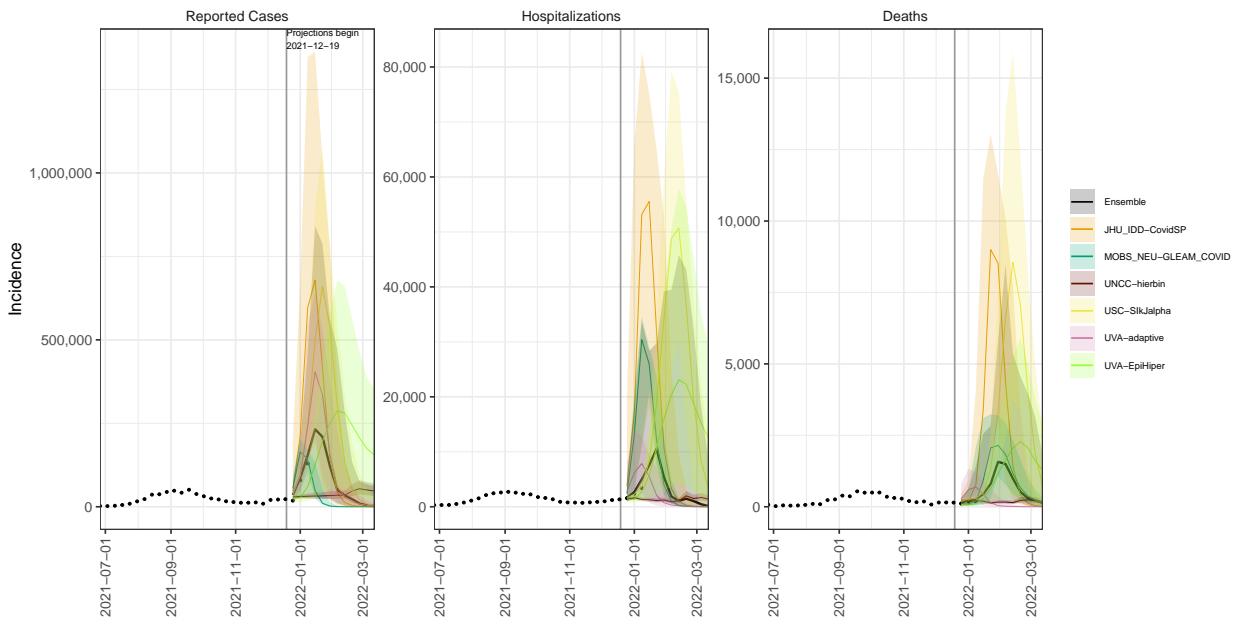
NM model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



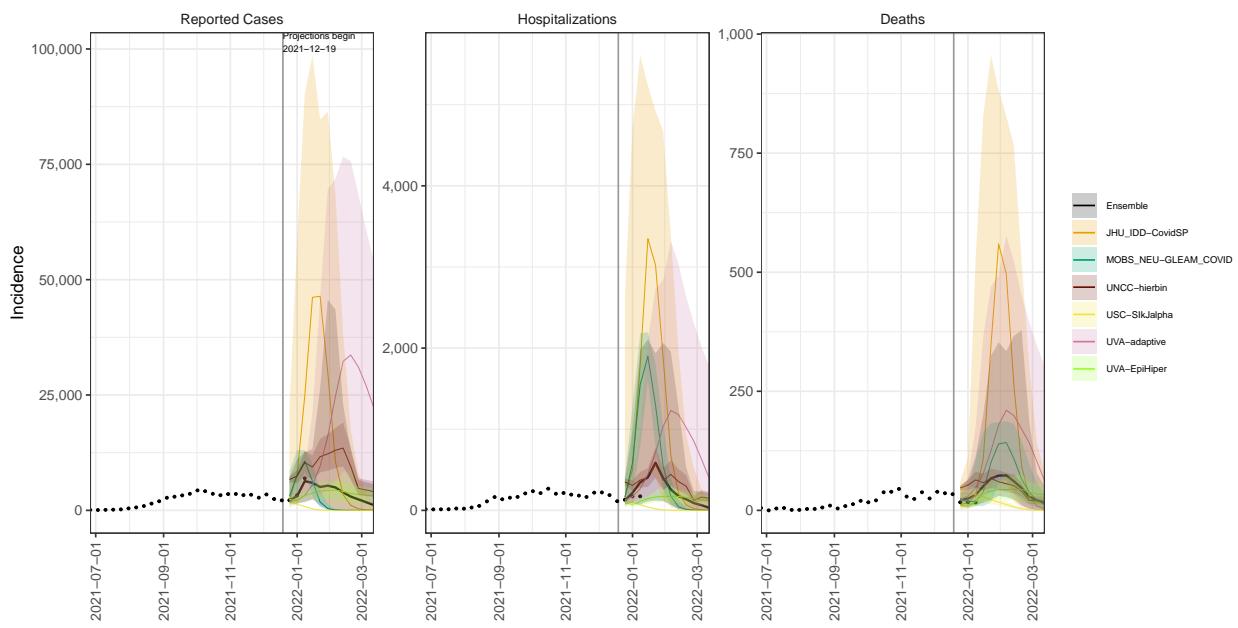
NY model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



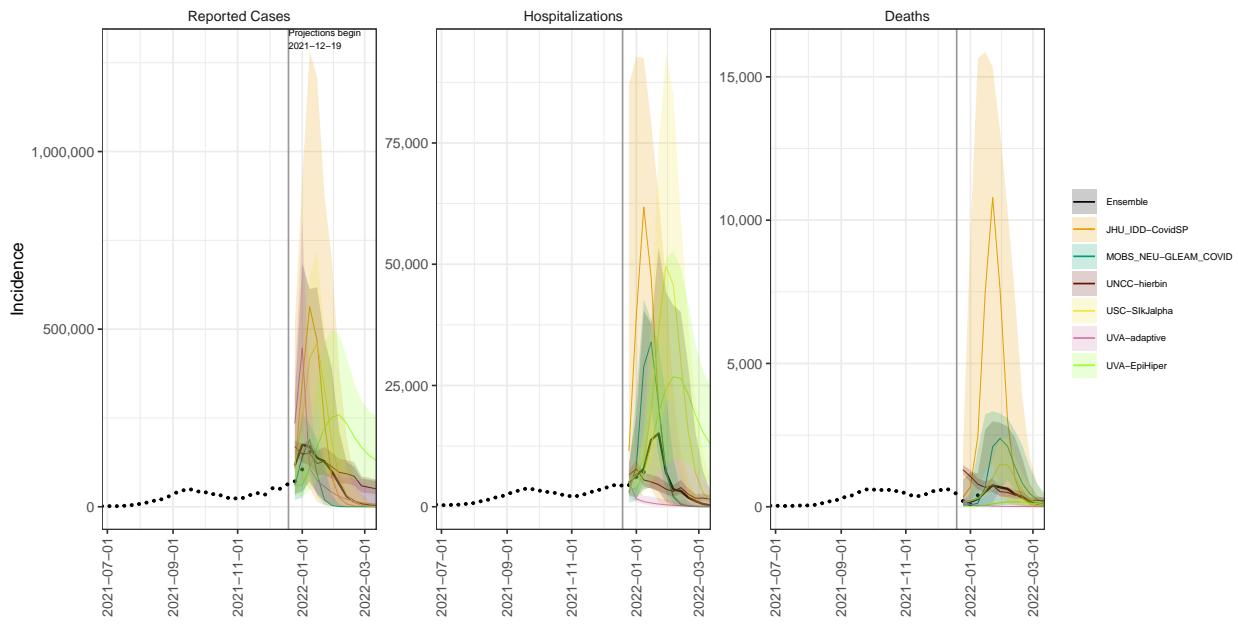
NC model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



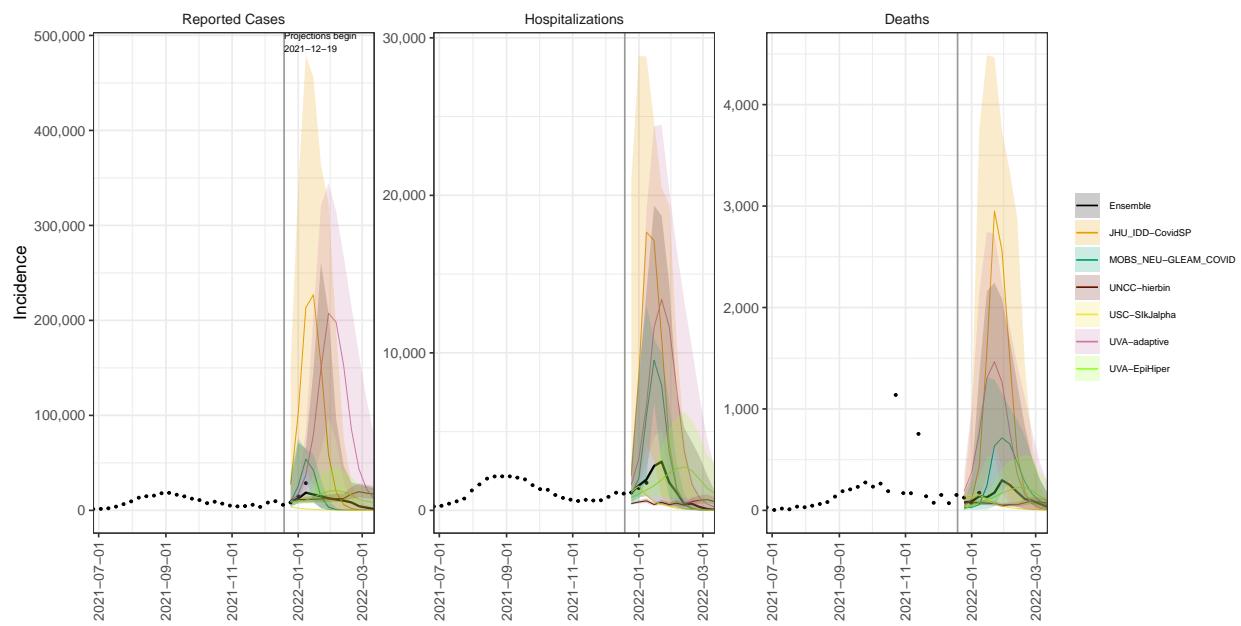
ND model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



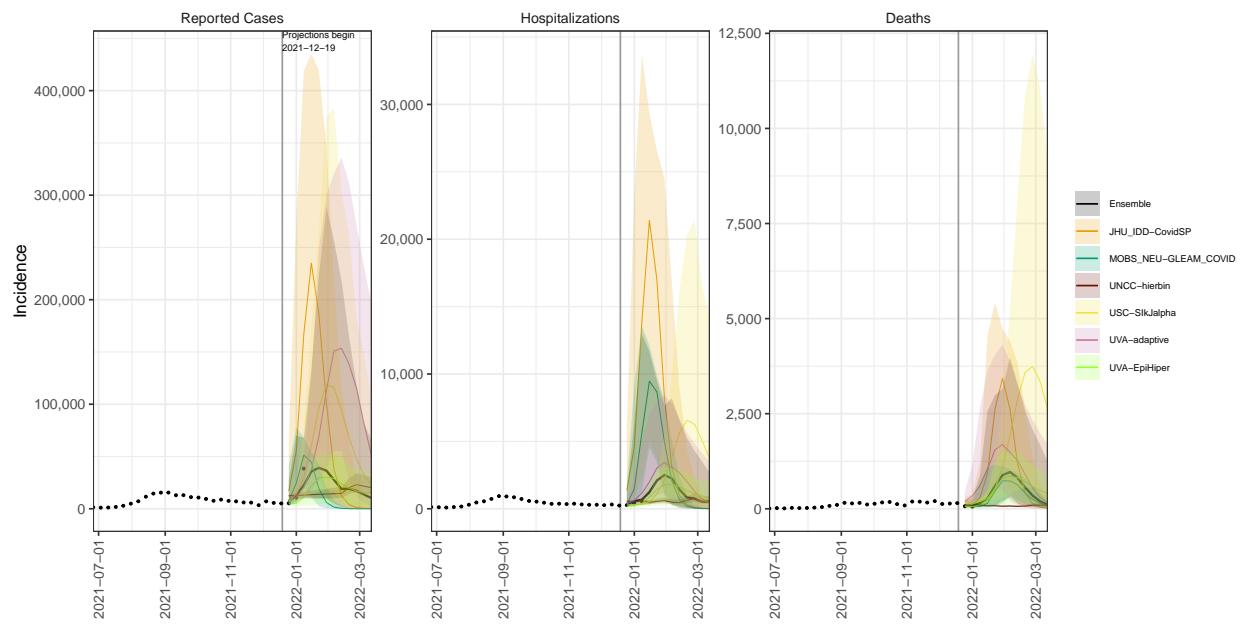
OH model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



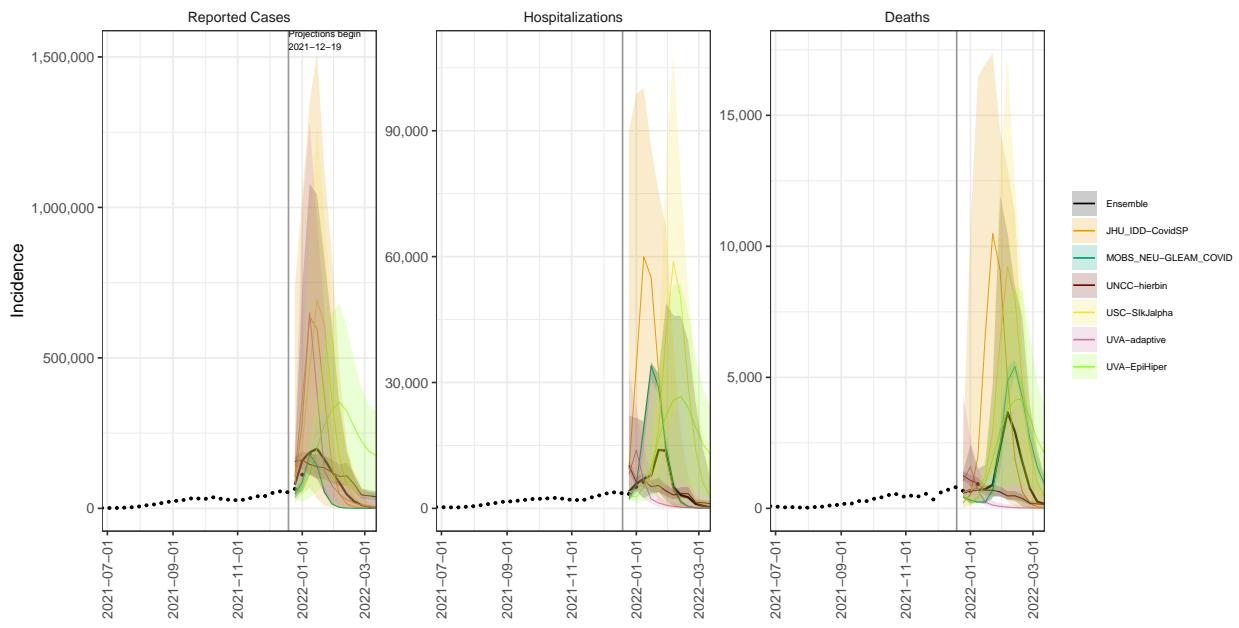
OK model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



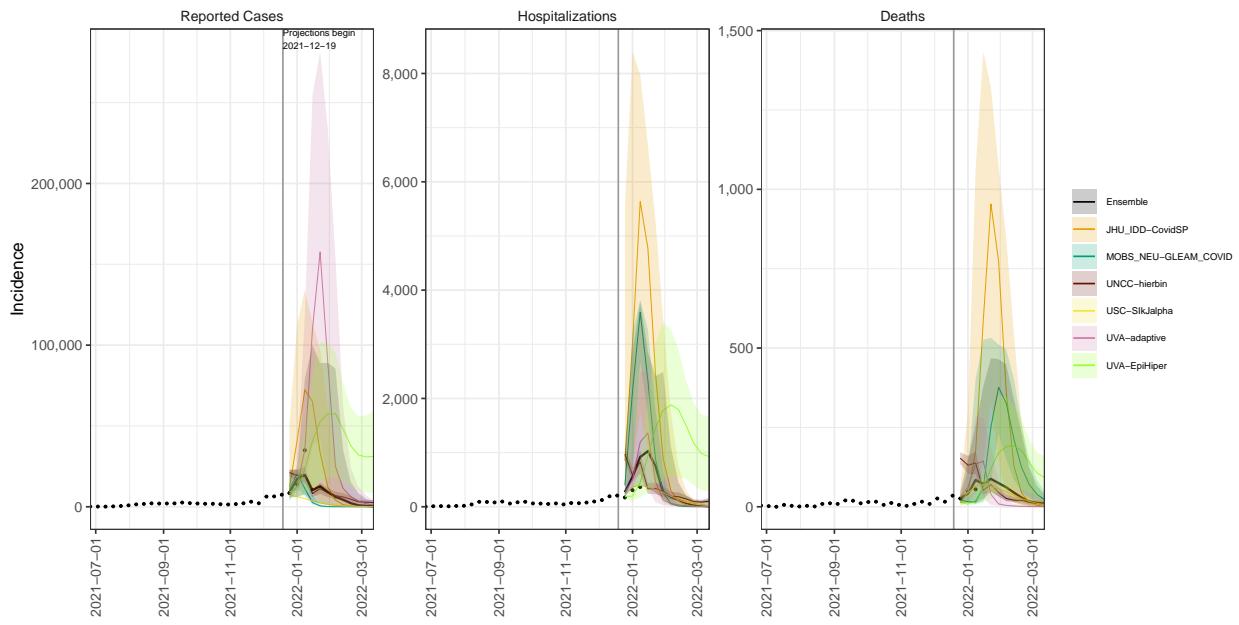
OR model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



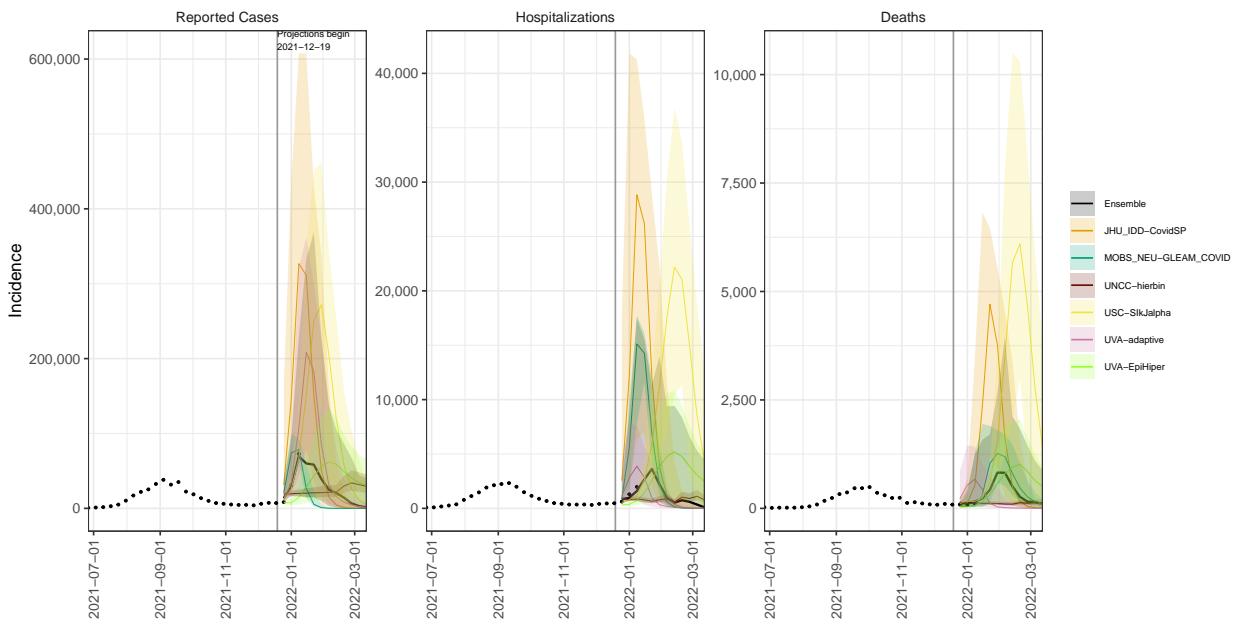
PA model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



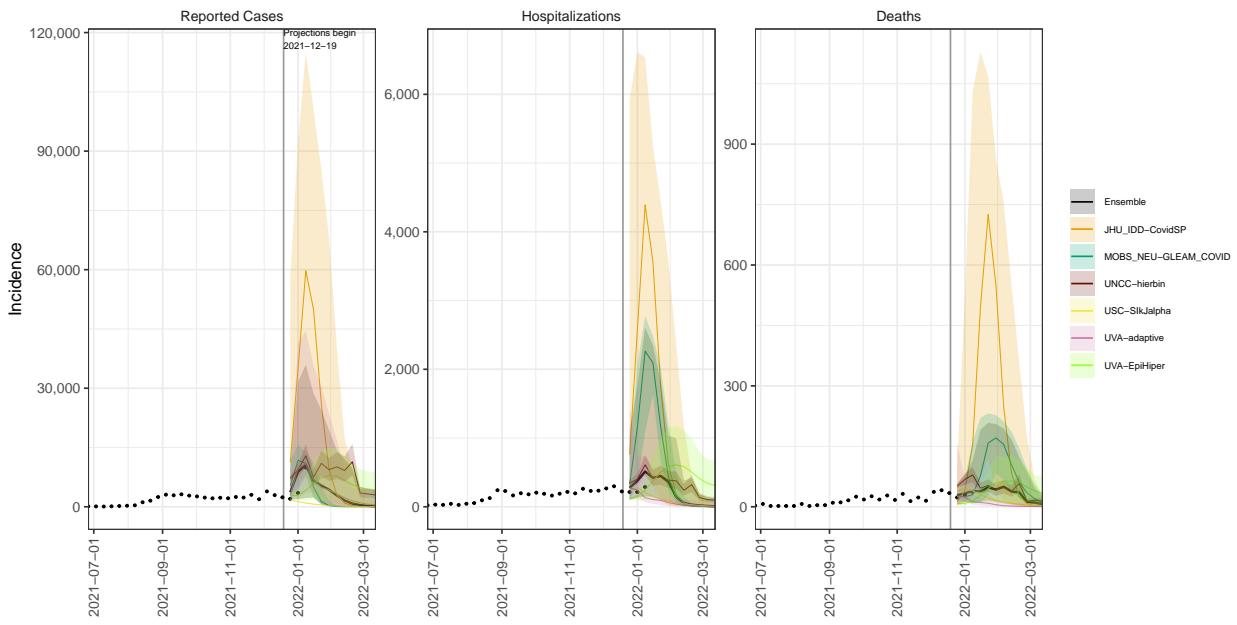
RI model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



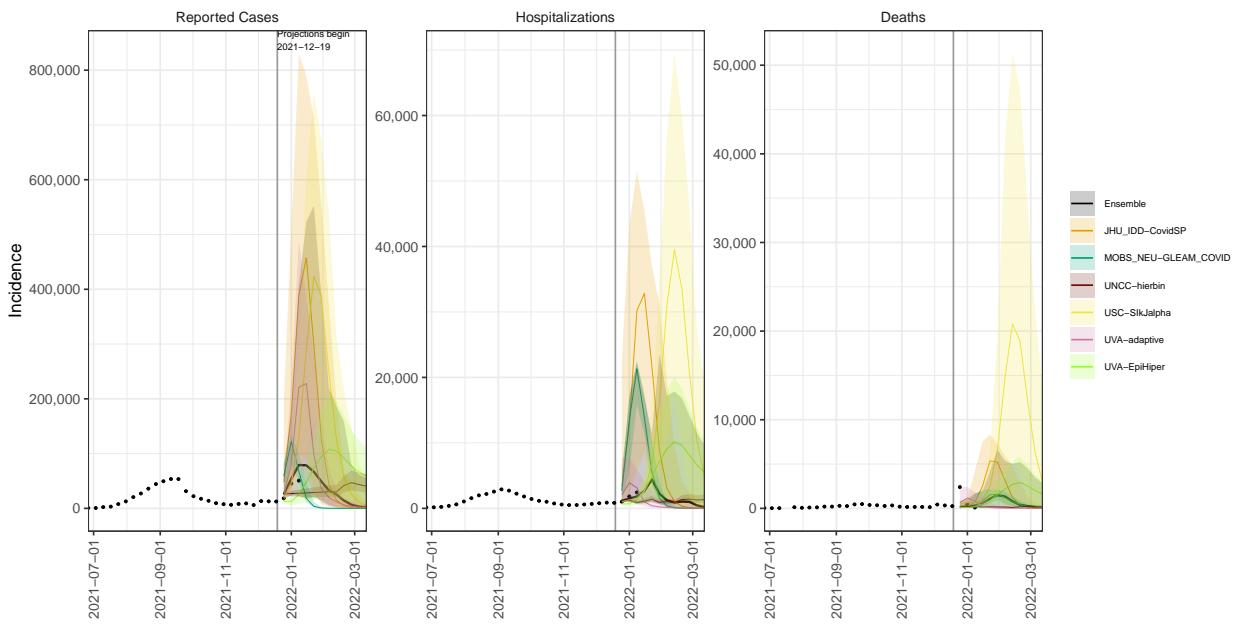
SC model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



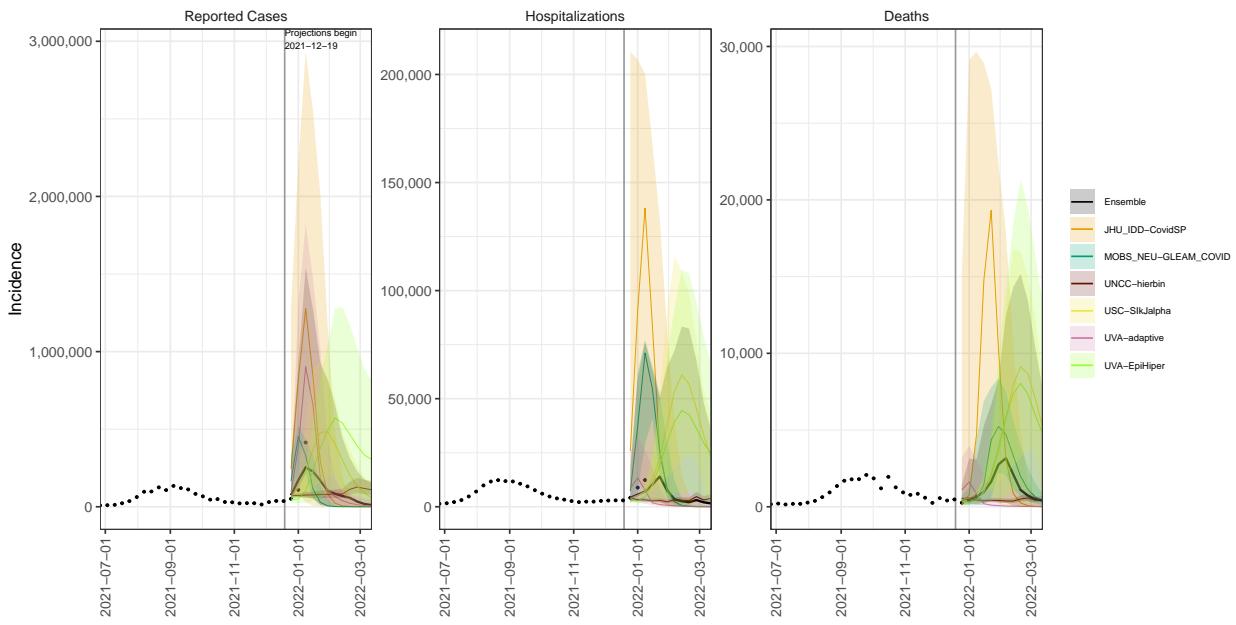
SD model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



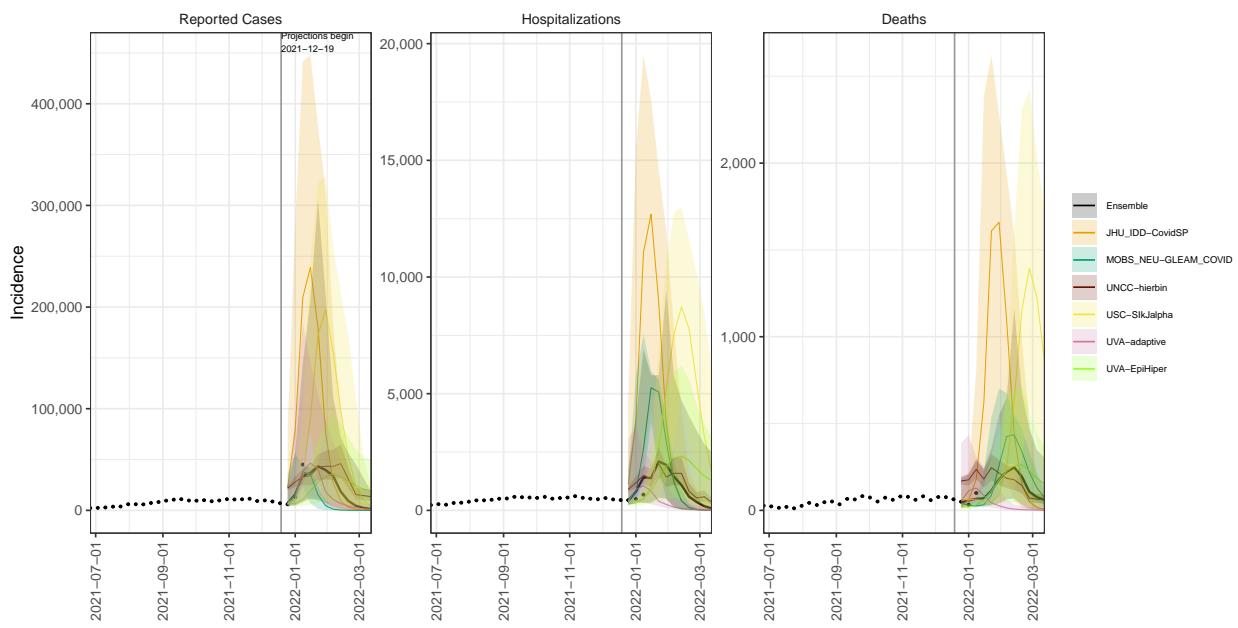
TN model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



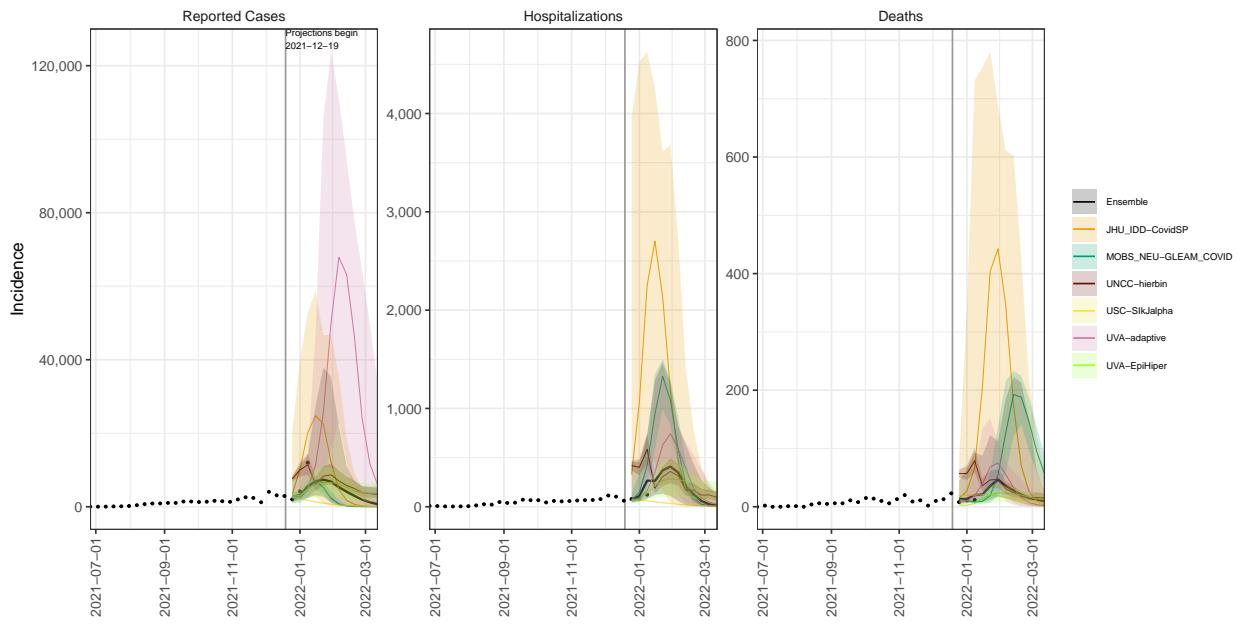
TX model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



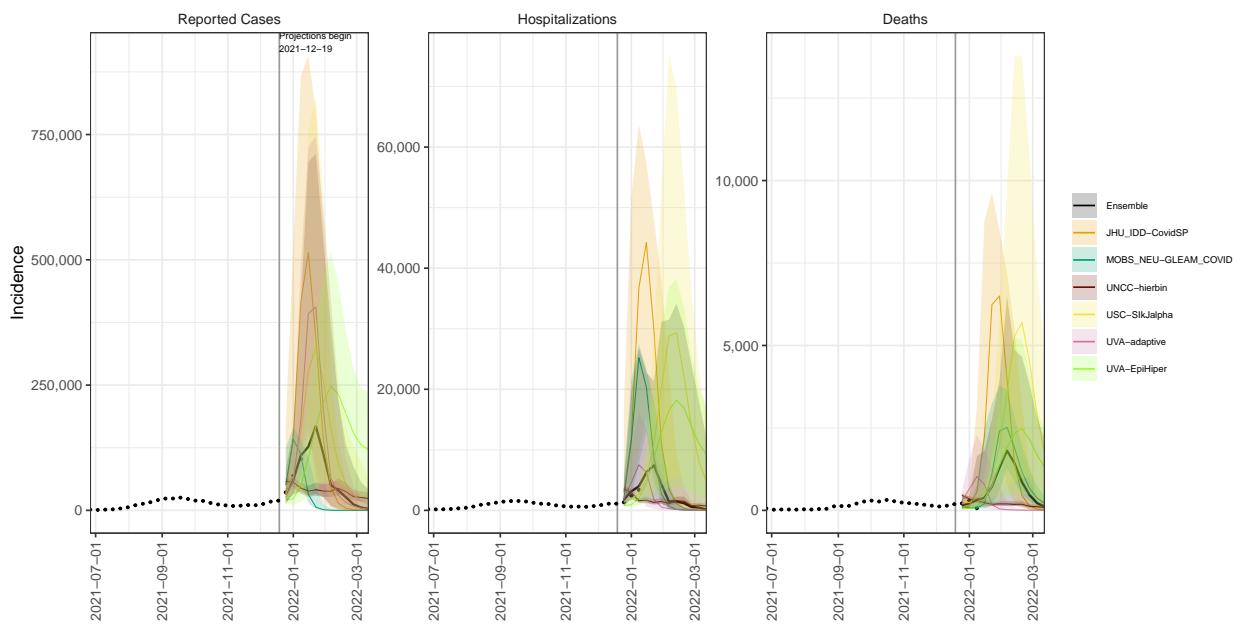
UT model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



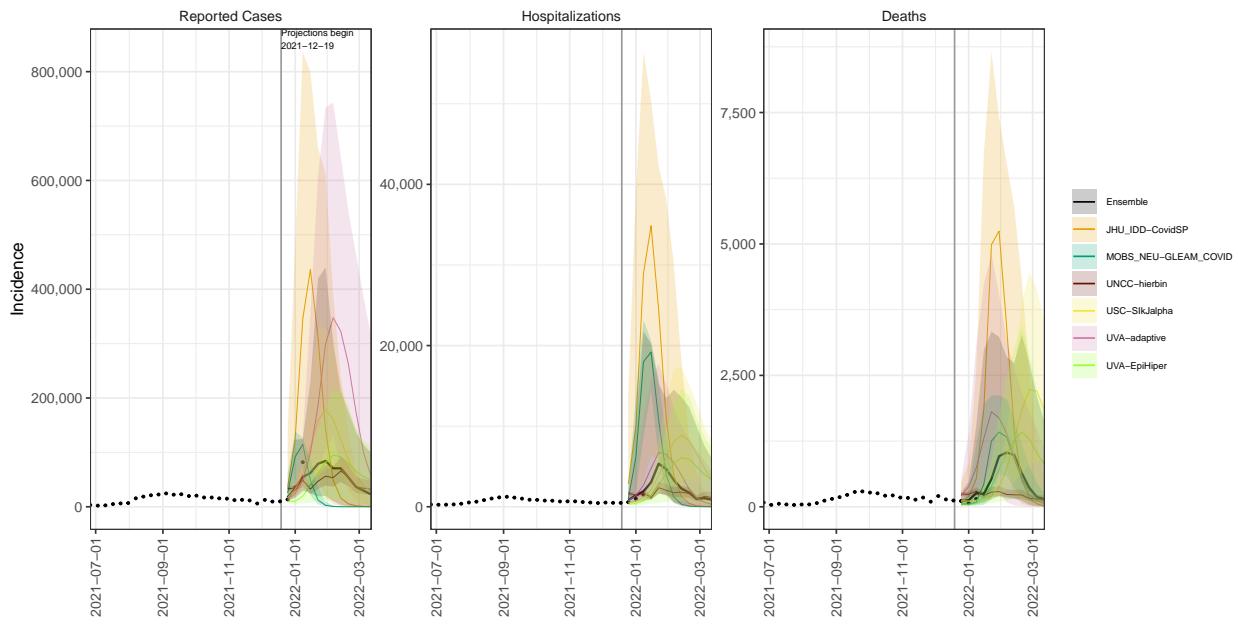
VT model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



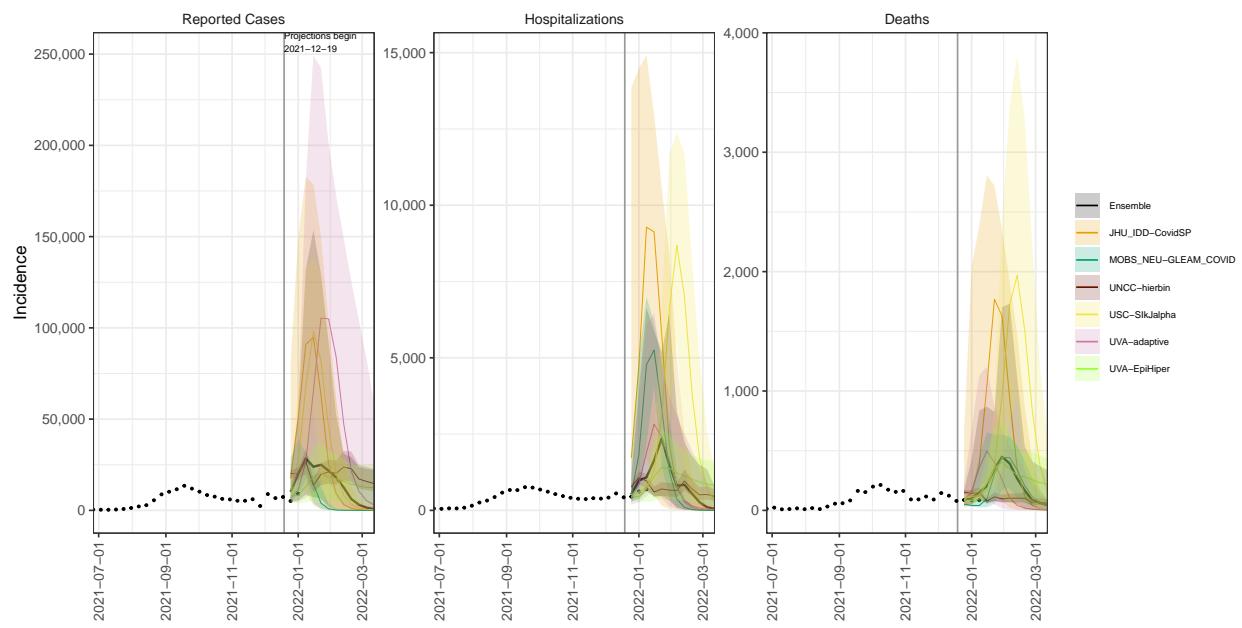
VA model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



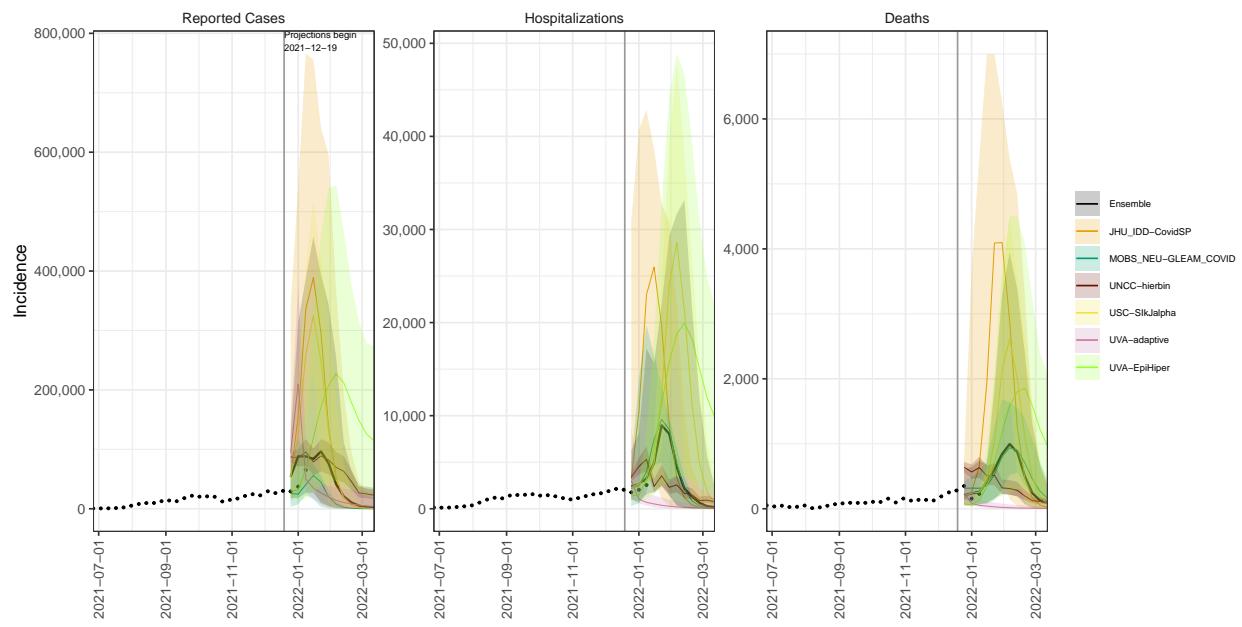
WA model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



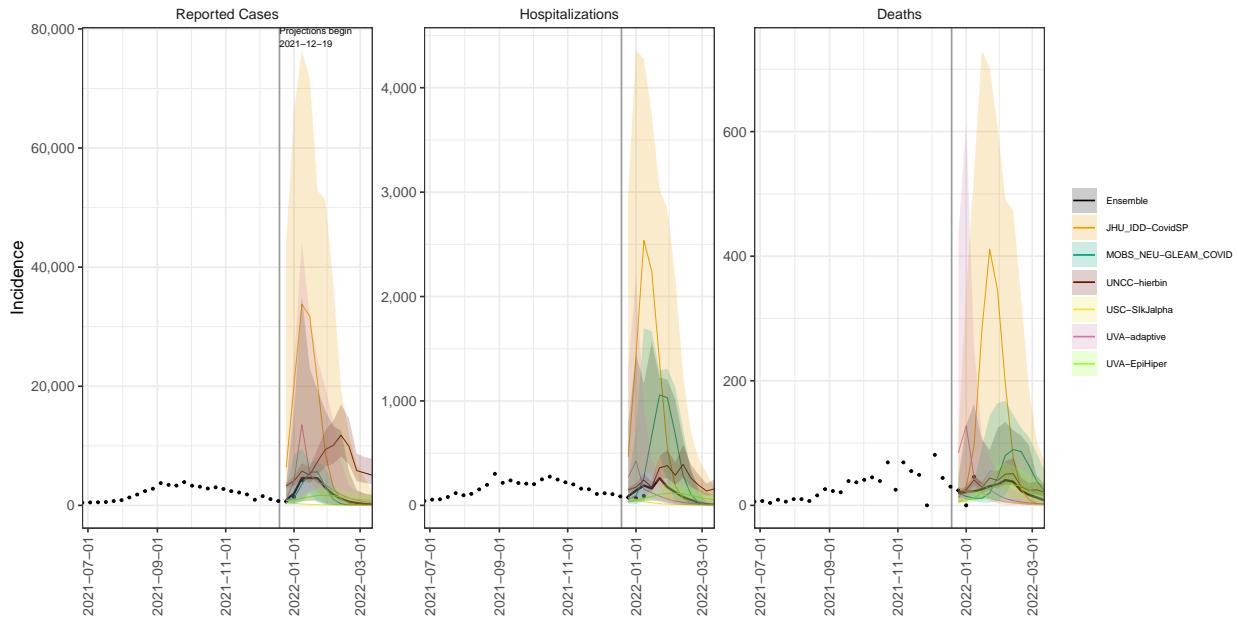
WV model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



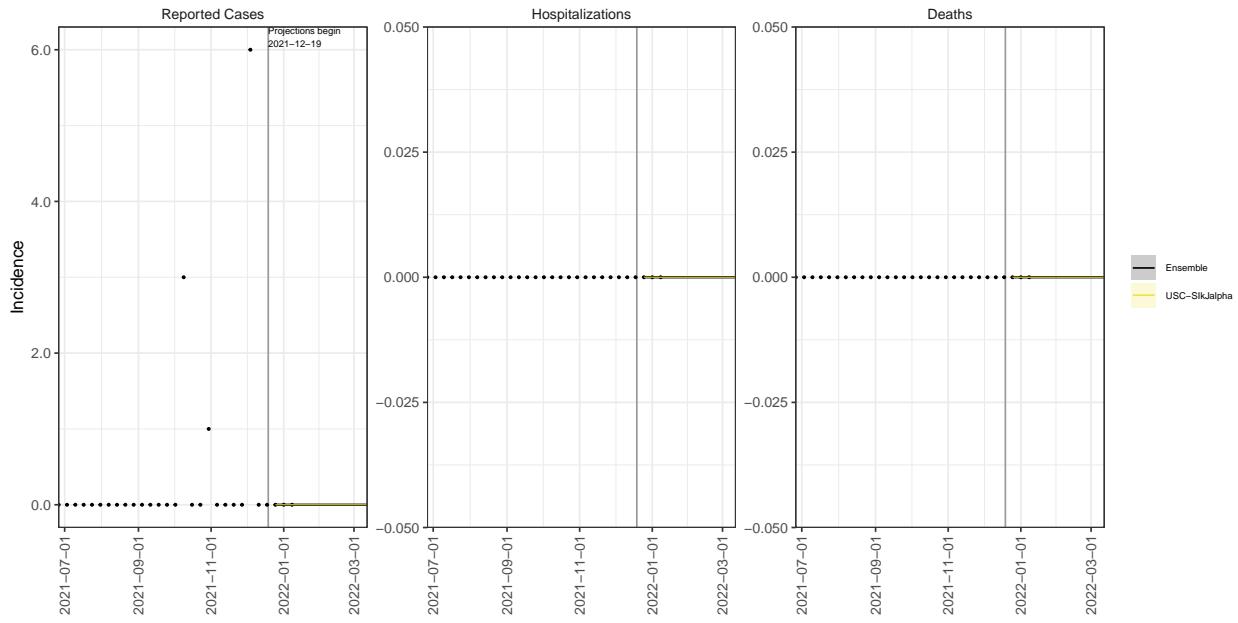
WI model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



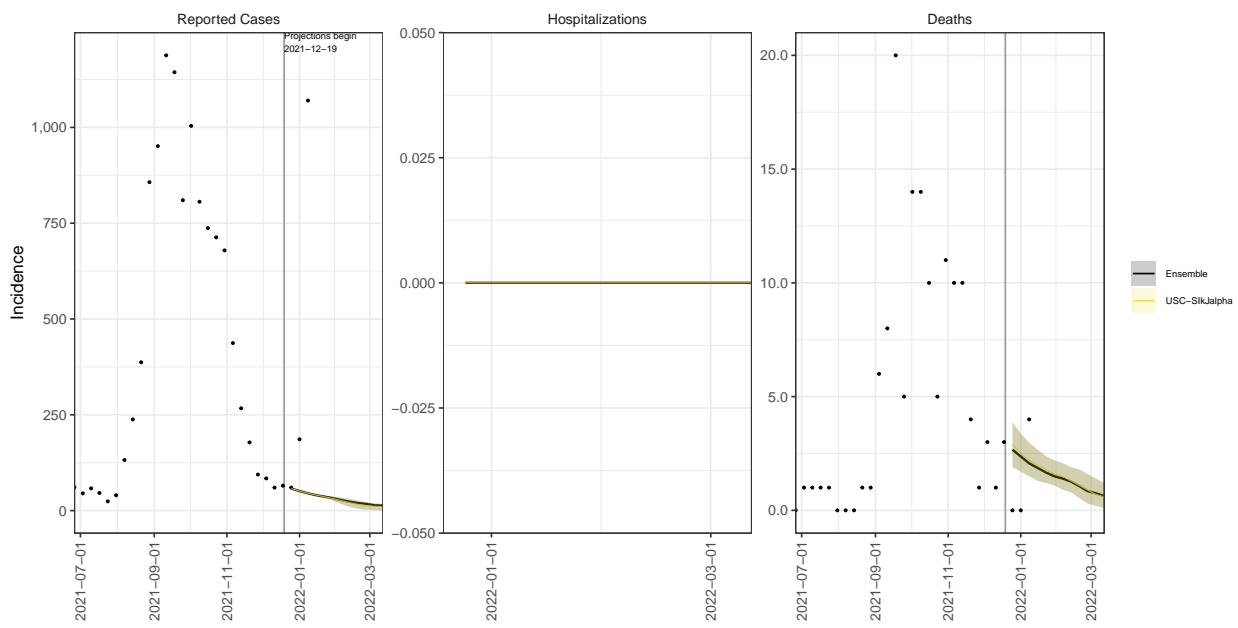
WY model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



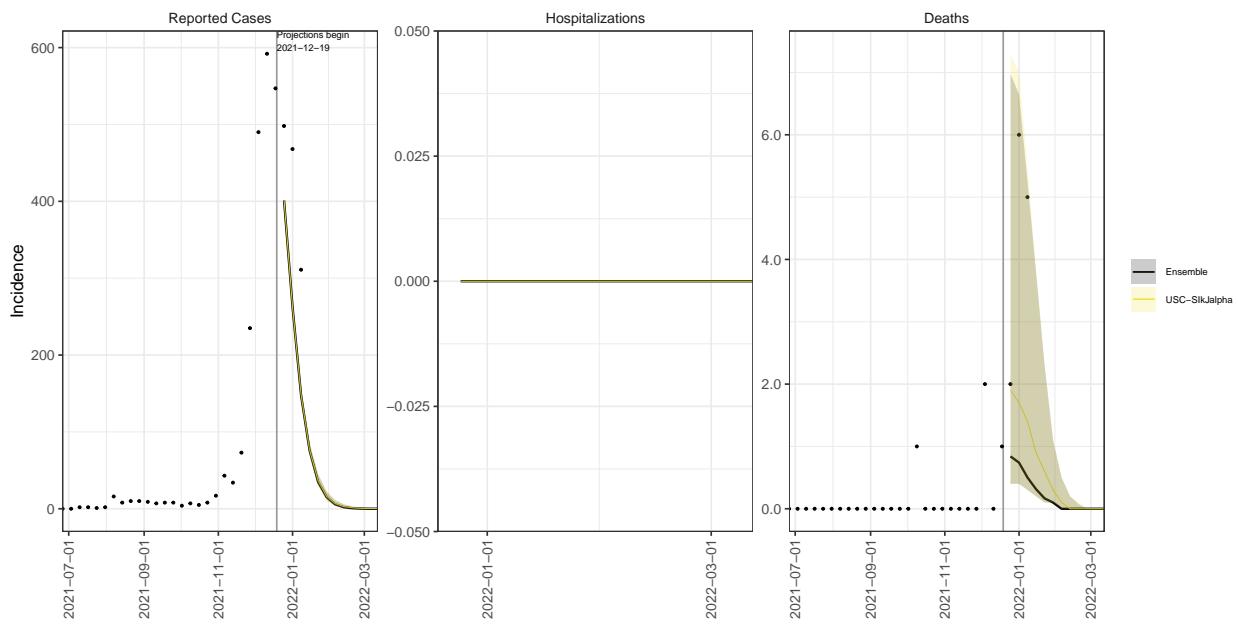
AS model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



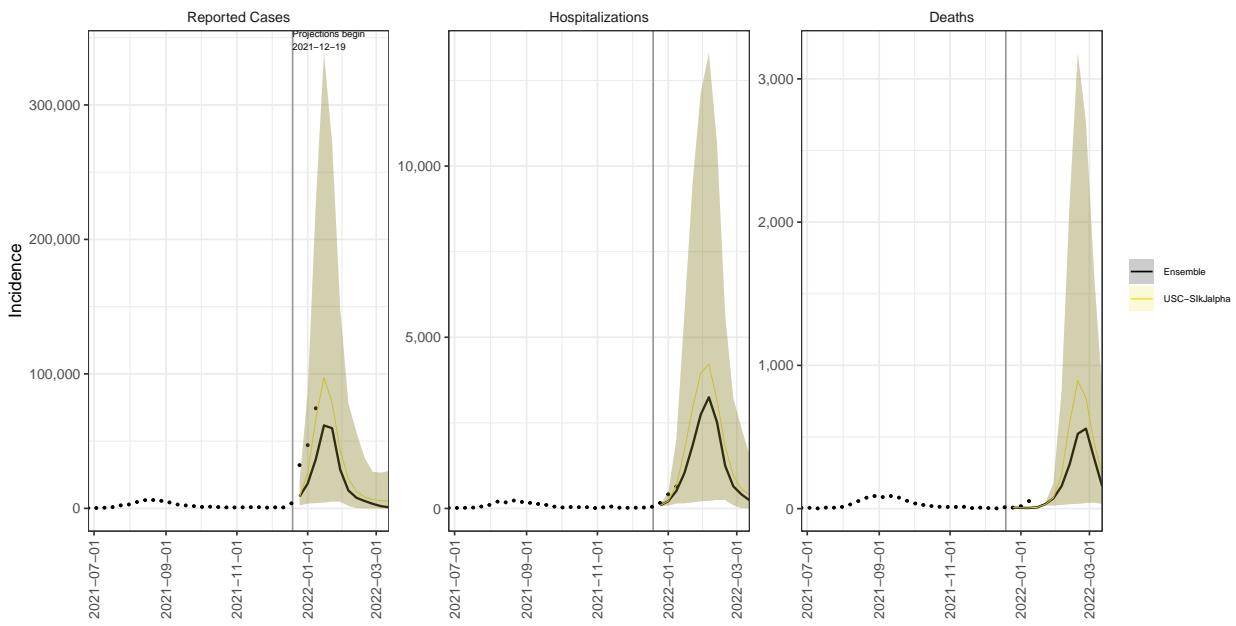
GU model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



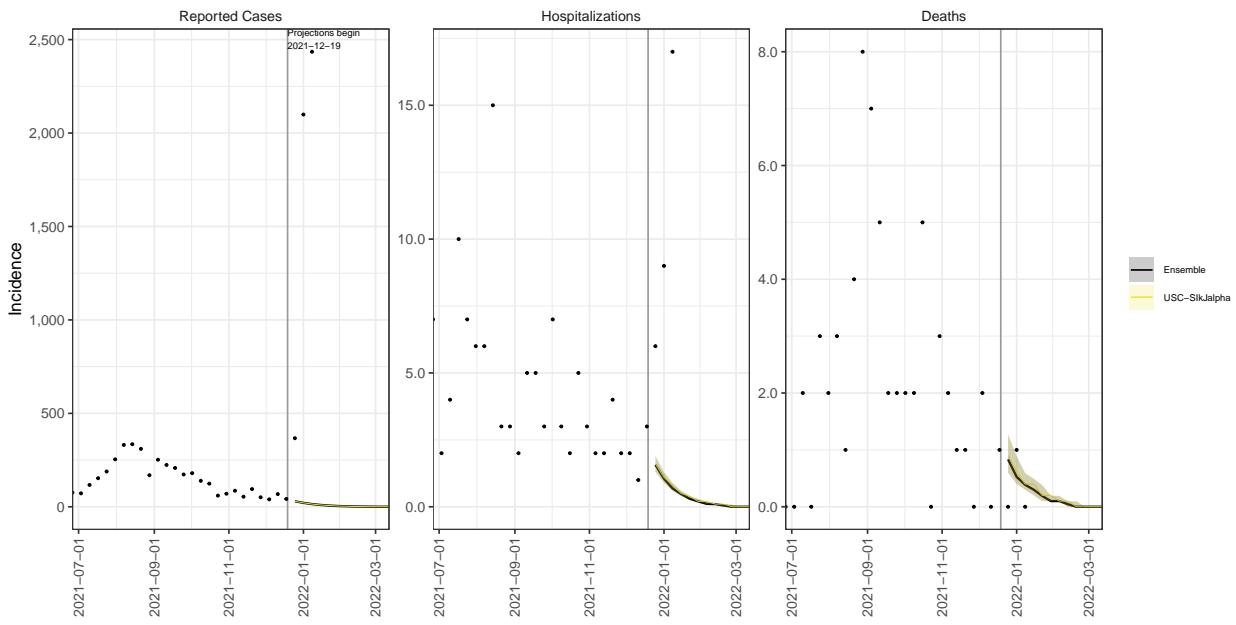
MP model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



PR model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



VI model variance & 95% projection intervals – Optimistic severity, low immune escape & high transmissibility



Teams and models

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 - Joseph C. Lemaitre (EPFL), Allison Hill (Johns Hopkins Infectious Disease Dynamics), Juan Dent Hulse (Johns Hopkins Infectious Disease Dynamics), Joshua Kaminsky (Johns Hopkins Infectious Disease Dynamics), Elizabeth C. Lee (Johns Hopkins Infectious Disease Dynamics), Justin Lessler (Johns Hopkins Infectious Disease Dynamics, University of North Carolina at Chapel Hill), Claire P. Smith (Johns Hopkins Infectious Disease Dynamics), Shaun Truelove (Johns Hopkins Infectious Disease Dynamics)

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