

ASSESSMENT

Multi-model assessment of the impact of newborn RSV immunisation on hospitalisation burden in the EU/EEA

Scenario projections from the 2025/26 RespiCompass RSV round

Key findings

- Model-based projections indicate that universal RSV immunisation of newborns during the winter season with either long-acting monoclonal antibodies (la-mAbs) or maternal vaccination (MV) could substantially reduce RSV-associated infant hospitalisations across the EU/EEA. Models assumed immunisation effectiveness (IE) against hospitalisation in infants for la-mAbs of 87% (95% CI: 81–91%) and of 71.3% (95% CI: 53.3–82.3) for MV. Under a high coverage assumption (90%), la-mAbs are projected to avert, on average across individual models, 61% (min-max spread across model means: 38%–85%) of RSV-related hospitalisations during the winter season among infants aged 0–2 months, compared to 52% (29%–73%) for MV. Under low coverage (20%), the projected decrease to 14% (8%–19%) and 12% (6%–18%), respectively.
- For both la-mAbs and MV, the reduction of RSV hospitalisations achieved by universal RSV immunisation of newborns during the winter season is projected to be strongly concentrated in the first months of life. Approximately 80% of the total averted burden is expected to occur among infants aged 0–2 months, with a further 15% in those aged 3–5 months. Consistent with the newborn-only target population considered in this analysis (without catch-up immunisation of infants born outside of the winter season), the impact of newborn RSV immunisation is driven by preventing hospitalisation burden in very young infants, while projected benefits beyond the first months of life are limited.
- La-mAbs are projected to achieve a slightly greater impact per dose than MV across all high and low coverage scenarios and countries. This means that fewer newborns need to be immunised with la-mAbs to prevent one RSV-related hospitalisation. This finding was consistent over the 10 models used for these analyses. This result partly reflects the higher immunisation effectiveness assumed for la-mAbs, although it is not a trivial consequence of that assumption alone. La-mAbs and MV have different waning profiles, and MV may produce stronger indirect effects through immunisation of mothers, both of which the models can capture.
- In high coverage scenarios, the pooled average number needed to immunise (NNI) across all models was estimated at 37 (min-max spread across model: 22–55) for la-mAbs and at 44 (23–67) for MV. Almost identical estimates are obtained in the low coverage scenarios. An important limitation of using NNI as an efficiency measure is that it implicitly assumes that la-mAbs and MV are equally costly to implement per dose. Currently la-mAbs list price per dose is substantially higher than that of MV. This aspect should be considered alongside these estimates.
- The projections modelled are broadly consistent with emerging real-world impact from countries that have already introduced universal RSV immunisation programmes. In line with the modelled

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projections, early post-implementation observations indicate that the introduction of la-mAbs for newborns or young infants in these countries is followed by a decrease of RSV-associated hospitalisations during the RSV season. Estimated NNIs compare well with those of other well-established interventions in Europe.

Conclusions: The outputs obtained from the model projections highlight the potential of the introduction of universal newborn RSV immunisation strategies to reduce RSV hospitalisation burden across the EU/EEA at achievable coverage levels. La-mAbs project a slightly higher impact than MV under equivalent coverage and higher immunisation effectiveness assumptions. The two strategies vary largely in procurement costs due to differing product prices, programmatic requirements and implementation pathways, which are relevant considerations for country-level decision-making beyond the modelled impact estimates. These findings provide a quantitative foundation to support the introduction and design of national RSV immunisation programmes.

Introduction

Respiratory Syncytial Virus (RSV) is a major cause of respiratory infections across the EU/EEA, representing a recurrent source of pressure on healthcare systems. The burden of disease is particularly high in older adults, people with underlying comorbidities, and young children, resulting in increased demand for hospital care, especially for paediatric admissions [1-4]. Depending on the country, RSV-related hospitalisations have been estimated to account for 7% to 52% of all paediatric respiratory hospitalisations, representing approximately 250 000 hospital admissions per year in the EU/EEA [1]. Newborns have the highest per-capita rate of RSV-related hospitalisations, making immunisation strategies targeting infants in early life a central strategy to reduce hospital burden and ease healthcare demand [1].

RSV passive immunisation options for infants have been available since 1999, when palivizumab, a monoclonal antibody with a half-life of approximately 20 days, received authorisation from the European Commission (EC). Due to its short half-life, palivizumab requires up to five monthly injections throughout the RSV season and provides only seasonal protection [5]. Its use has been restricted to at-risk infants, such as those born prematurely, with bronchopulmonary dysplasia, congenital heart disease, or severe immunodeficiency.

In October 2022, a new extended half-life monoclonal antibody, nirsevimab (Beyfortus, AstraZeneca/Sanofi), was authorised in the EU for children up to the age of 24 months [6]. This product provides passive immunisation to protect neonates and infants who are vulnerable to severe RSV [7]. In June 2026, the EC approved another monoclonal antibody, clesrovimab (Enflonsia, MSD) in newborns and infants during their first RSV season [8]. In June 2023, a maternal RSV vaccine (Abrysvo, Pfizer) was also authorised in the EU [9]. Vaccination of pregnant individuals between 24 and 36 weeks of gestation with this product has been shown to significantly reduce severe RSV-related respiratory infections in their infants during the first six months of life [10, 11].

With the recent EU authorisation of the first RSV immunisation products intended for general population implementation, several EU/EEA countries have started or will soon begin the decision-making process on whether and how to introduce them into national programmes. Decisions on changing national immunisation programmes require consideration of multiple factors, such as the disease burden and epidemiology, the efficacy, effectiveness, cost-effectiveness and safety of new interventions, impact of the vaccine as estimated through transmission modelling and health economic/cost-effectiveness evaluations, ease of implementation, population acceptance, and national health priorities.

In this context, mathematical and health economic modelling plays a key role by translating epidemiological evidence into estimates of preventable hospital burden. It also helps to assess the potential impact of interventions of health outcomes and healthcare systems and enables the comparison between alternative immunisation strategies under different coverage assumptions. By quantifying outcomes such as hospitalisations averted and the number needed to immunise (NNI), modelling can provide a framework to support cost-effectiveness projections, exploration of uncertainty, prioritisation and resource allocation decisions, and comparison across different policy options [12-15].

The expected impact of universal newborn RSV immunisation strategies was quantified using a collaborative, scenario-based modelling approach through RespiCompass, the European respiratory diseases scenario modelling hub (<https://respicompass.ecdc.europa.eu>). RespiCompass facilitates international modelling collaboration to address priority public-health questions, using common scenarios to assess the potential outcomes of the immunisation strategies.

This analysis aims to support country-level evaluations and policy decision-making around the introduction of universal RSV immunisation interventions for protecting newborns in the EU/EEA, using a multi-model approach that synthesises results from several independently developed models [15-19]. Specifically, this assessment wants to answer the following question: How many RSV hospitalisations can be averted in EU/EEA countries via immunisation of newborns with either long-acting monoclonal antibodies (la-mAbs) or maternal vaccination (MV) compared to no intervention? To address this question, the scenario modelling assessment compares the two

interventions for immunising newborns against RSV (i.e. MV or long-acting monoclonal antibodies) to a status-quo baseline without universal immunisation of newborns (i.e. targeting all newborns, not just those at increased risk) in the EU/EEA across different immunisation coverage levels. The analysis evaluates the impact of these interventions on prevented RSV related hospitalisation and associated economic outcomes across multiple age groups (0–2 months, 3–5 months, 6–11 months, 1–4 years, 5–65 years, and 65+ years old). Through the application of the same scenarios and standardised key assumptions, this approach allows the comparability of results, providing a consistent evidence base to inform on planning, design and implementation of RSV prevention strategies.

Methods

This analysis was coordinated through RespiCompass, the European respiratory diseases scenario modelling hub. RespiCompass is a multi-model scenario hub launched by ECDC in 2024 to estimate the burden of respiratory diseases and the impact of interventions in the EU/EEA [20]. Collaborative modelling approaches such as RespiCompass combine projections from independently developed models to explore a range of plausible epidemic trajectories and capture different sources of uncertainty in a structured way [21–23].

During the 2024/25 round, RespiCompass provided multi-model estimates to quantify the impact of vaccination on COVID-19 and influenza hospitalisations among older adults in the EU/EEA [18]. In its 2025/26 round, RespiCompass focused on how many RSV hospitalisations can be averted in EU/EEA countries via universal immunisation of newborns with either long-acting monoclonal antibodies (la-mAbs) or MV compared to no universal intervention. Beyond hospitalisation burden, this round aimed to provide inputs for health economic evaluations, including estimates of the number of doses needed per averted hospitalisation, to support country-level cost-effectiveness assessments.

To achieve these goals, a group of international modelling teams developed 11 individual models in accordance with five standardised scenarios (Scenarios A to E). In the following, we describe the scenarios, shared assumptions, and data that guided participating modelling teams, along with the methods used to analyse their outputs.

Scenario definition

We developed five standardised scenarios (Scenarios A to E) to explore uncertainty related to immunisation coverage and type of intervention. These scenarios are presented in Table 1. Each scenario defines a common set of modelling assumptions to ensure comparability across individual models. More in detail, scenarios are defined along two axes: i) the immunisation coverage axis, which accounts for two different coverage levels of the intervention (high vs. low), and ii) the intervention type axis, defining which immunisation product between long-acting monoclonal antibodies or MV is considered. The combination of these assumptions leads to four scenarios (A to D) used to evaluate the range of possible outcomes under different coverages and immunisation products considered. Additionally, Scenario E serves as a baseline assuming no universal RSV immunisation strategy is in place.

Table 1. Scenario matrix for assessing the impact of newborn immunisation strategies RSV hospitalisation burden in the EU/EEA

	High Coverage Coverage of the intervention assumed to be at 90% of the target population	Low Coverage Coverage of the intervention assumed to be at 20% of the target population
La-mAbs only La-mAbs administered to newborns at birth starting on 1 September 2025 and ending on 31 March 2026	Scenario A (High Coverage, la-mAbs only)	Scenario B (Low Coverage, la-mAbs only)
MV only MV administered during antenatal care visits, with immunisation campaigns such that first immunised newborns are born on 1 September 2025, and the last immunised newborns are born on 31 March 2026	Scenario C (High Coverage, MV only)	Scenario D (Low Coverage, MV only)
No Universal Immunisation No universal RSV immunisation is implemented	Scenario E (Baseline)	

Immunisation coverage

Expected immunisation coverage is a key uncertainty in any new immunisation programme. We consider two distinct levels to increase the country-relevance of the results: 90% and 20% as proxies for, respectively, *high* and *low* coverage. These coverage levels are computed with respect to the number of newborns that in model simulations are born between 1 September 2025 and 31 March 2026. The two coverage values were identified based on the heterogeneous coverage of various proxy immunisation programmes across EU/EEA countries (e.g. DTP3, pneumococcal, rotavirus, PCVs vaccines, and maternal influenza/pertussis vaccination) [24-27] as well as the early adoption of novel RSV interventions where already implemented [28-31]. We used two contrasting levels rather than additional intermediate values, as these are sufficient to span the plausible range of uptake while limiting the computational burden on participating teams. The near-linear relationship between coverage and averted burden that emerged from the analysis (see Results) further indicates that outcomes at intermediate coverage can be reasonably approximated from these two bounding scenarios.

Immunisation product

The scenario design focuses on comparing the two main new options for immunising newborns against severe RSV, namely la-mAbs and MV, to a baseline scenario without universal interventions. This choice reflects the current different stages of RSV immunisation policies implemented across countries in the EU/EEA, e.g. whether to introduce any RSV intervention and which strategy to prioritise. In this modelling round, we considered each immunisation product as a separate intervention, excluding scenarios combining both interventions. This choice ensures a symmetrical and directly comparable evaluation of the two immunisation options.

Baseline scenario (E)

Scenario E assumes a status-quo with no universal immunisation, in which neither MV nor la-mAbs are universally given. We assume immunisation of at-risk newborns if this is current country practice. This is needed to establish a counterfactual reference point for estimating the public health impact and added value of universal immunisation strategies offered to newborns. In other words, model projections for scenario E must reproduce target epidemiological data, which represent expected RSV hospitalisation burden before the introduction of universal MV or la-mAbs.

Throughout this report, we use 'universal immunisation' to refer to interventions targeting all newborns regardless of coverage achieved, as opposed to the status-quo in the baseline scenario where only at-risk infants are immunised in line with current country practice.

Modelling assumptions

Administration and eligible population

The target group for the universal intervention tested in the scenarios are newborns born during the RSV season. We assumed that immunisation campaigns are implemented in such a way that the first immunised newborns are born on 1 September and the last immunised newborns are born on 31 March of the next year across scenarios A to D, with related coverage stated in Table 1. All models assumed a common birth cohort considering most recent data (2024) from Eurostat [32]. La-mAbs were assumed to be administered at birth, while MVs were administered during antenatal care visits between 24 and 36 weeks of gestation. All models assumed constant coverage over the intervention period and no shortage of la-mAbs or MV in the EU/EEA at any time during the scenario period. We acknowledge that foetal, perinatal, and neonatal mortality may have a minor effect on immunisation coverage and impact of MV programmes. However, these rates are very low and can be considered negligible for the purposes of this scenario round [33].

Similarly, preterm births, where the interval between MV and delivery may be too short for sufficient antibody transfer to the newborn, reducing MV protection, represent a small fraction of the birth cohort and were likewise assumed to be negligible for the purposes of this scenario round. Finally, we assume no catch-up immunisation of infants born outside of the intervention window, and no universal RSV interventions in the older age groups (e.g. RSV vaccine for older adults) are implemented during the scenario period and that the target data (see below) are representative of the typical RSV hospitalisation patterns in absence of such interventions across all age groups.

Immunisation effectiveness and waning of immunity

Participating modelling teams were advised to consider common immunisation effectiveness (IE) values. For la-mAbs, shared IE against RSV-associated hospitalisations in infants was set to 87% (95% CI: 81–91%), based on meta-analysis presented in Li et al [34], while for MV shared IE was set to 71.3% (95% CI: 53.3–82.3%) based on a test-negative effectiveness study that included infants below six months through one RSV season [11].

Teams were strongly encouraged to account for the uncertainty in the IE estimates in their modelling. By the nature of effectiveness studies, both IE estimates inherently include the effect of waning protection within the follow-up period, ranging between four and eight months. Teams were advised to account for waning of immunisation-induced protection at their own discretion in their models [35].

Other assumptions

Additional effects of the interventions, such as the reduced infectiousness of vaccinated individuals if they become infected and protection against infection, were allowed and encouraged but left to the modeller's judgement.

We left the implementation details concerning immunisation of pregnant individuals (including the precise timing and immunisation effect in those individuals) to the discretion of the modelling teams.

Teams were advised in the inclusion of demographic effects, including age-specific mortality (e.g. non-RSV related) in their models.

Target epidemiological data

Teams were provided with weekly RSV-associated hospital admissions for each country and age-specific aggregated burden for the period 1 September 2025 to 31 May 2026, in absence of universal RSV immunisation interventions. These data were used to calibrate models to the baseline scenario (Scenario E).

RSV surveillance systems and laboratory surveillance practices vary substantially across EU/EEA countries, while under-ascertainment has been documented in some settings [36, 37]. These factors contribute to an overall scarcity of RSV surveillance data in the EU/EEA and limited cross-country comparability of available data. For these reasons, we opted for a combination of yearly hospitalisation estimates by age [1, 2] and standardised hospitalisation time-series [40] to obtain country-specific RSV hospitalisation burden accounting for under-reporting. In other words, we synthetically generated weekly RSV hospitalisation data for each country and age-specific burden using robust estimates from the literature. In this sense, the target data are a synthetic proxy of the true hospitalisation burden in absence of intervention and should not be considered as a direct observation nor a prediction for the 2025/26 RSV season.

Our synthetic data generation approach works as follows. We consider as inputs:

- $h^{c,a}$: Annual estimated (median) RSV-hospitalisations per 1 000 in country c and age group a from Del Riccio et al. [1] for infants and Osei-Yeboah et al. [2] in adults. These studies use robust national estimates of RSV-associated paediatric and adult RSV hospitalisations from *high-surveillance* countries and extrapolate those estimates to missing countries using a number of matching and imputation methods¹.
- $h_{ref}(t)$: Total RSV-hospitalisations observed in week t of a reference season from Johannesen et al. [38]. This study considers a multi-season regression analysis to reconstruct RSV hospitalisations time-series in six European countries. We consider the time series averages across considered countries and seasons as our reference.
- $P^{c,a}$: Population (2025) by country c and age group a , sourced from Eurostat [39].

Then, we compute:

1. Total annual RSV-hospitalisations by country c and age group a (rounded to the nearest integer):

$$H^{c,a} = \frac{h^{c,a}}{1,000} \times P^{c,a}$$
2. Total annual RSV-hospitalisations as the sum of RSV-hospitalisations in all age groups for a given country c : $H^c = \sum_a H^{c,a}$
3. The share of RSV-hospitalisations observed in each week t of the reference season: $\psi(t) = \frac{h_{ref}(t)}{\sum_{t'} h_{ref}(t')}$
4. Weekly RSV-hospitalisations for each week t for country c considering a multinomial distribution:

$$(H^c(t_1), H^c(t_2), \dots, H^c(t_f)) \sim Mult\left(H^c, (\psi(t_1), \psi(t_2), \dots, \psi(t_f))\right)$$

The multinomial sample allows for the introduction of limited level of stochastic noise.

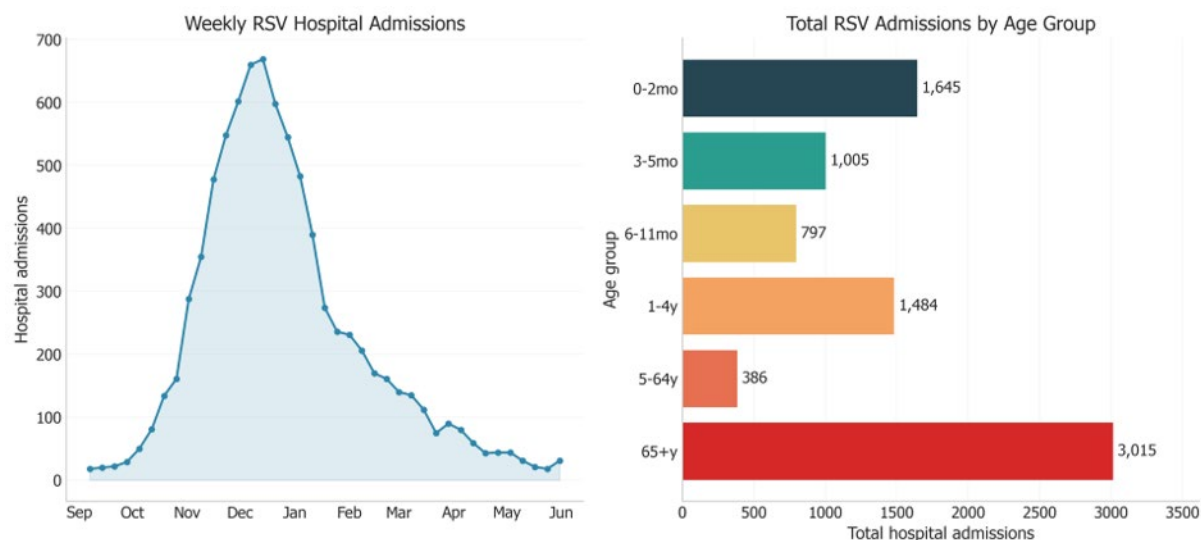
This procedure outputs:

- The time series of total weekly RSV-associated hospitalisations for a given country c (i.e. $(H^c(t_1), H^c(t_2), \dots, H^c(t_f))$)
- The total yearly RSV-associated hospitalisations per each age group for a given country c (i.e. $H^{c,a}$)

¹ We consider the following eight age groups: 0 to 2 months, 3 to 5 months, 6 to 11 months, 1 to 2 years, 3 to 5 years, 6 to 17 years, 18 to 64 years, 65+ years.

To summarise, our approach considers published RSV hospitalisation burden estimates by age group and country per 1 000, turn it into an absolute number of hospitalisations using recent population data, and spread this burden over the weeks using the profile of a reference season. Figure 1 shows an example of synthetic time series of weekly RSV-associated hospitalisations and the age specific yearly hospitalisation burden for Sweden.

Figure 1. Example synthetic time series of weekly RSV-associated hospitalisations and age-specific yearly hospitalisation burden for Sweden



Submissions from modelling teams

We received projections from 11 independent models: three static models, six dynamic transmission models, and two agent-based models. Static models estimate the direct impact of immunisation by applying effectiveness parameters to age-specific hospitalisation rates without simulating transmission dynamics. They are computationally efficient but do not capture indirect protection effects such as herd immunity. Dynamic compartmental models explicitly represent transmission between age groups and can therefore project both direct and indirect effects of immunisation. However, they require more expensive calibration to epidemiological data. Agent-based models (ABM) simulate interactions between individual agents and can capture fine-grained heterogeneity in contact patterns and immune status, at the cost of greater computational complexity and data needed for parametrisation. The inclusion of all three model classes in this analysis reflects a broad range of structural assumptions about RSV transmission and the mechanisms through which immunisation reduces hospitalisation burden. One dynamic model was excluded from the analysis because it generated (inexplicable) counter-intuitive model outputs, which could not be sufficiently addressed before the project deadline [16].

Six models submitted projections for all 28 countries² for which target data were available, one covered three, and the remaining three models each covered a single country. Further model details are available on the RespiCompass GitHub repository [40]. Table 2 summarises the submitting models.

All models submitted weekly RSV hospitalisations stratified by age group and immunisation status, alongside weekly administered doses between 1 September 2025, and 31 May 2026. Projections were provided as 100 to 300 trajectories per scenario and country, allowing uncertainty to be captured across multiple realisations. Submissions were made via the RespiCompass GitHub repository, where each upload automatically triggered a series of validation checks. These were followed by manual inspection to verify overall submission quality and adherence to shared modelling assumptions (i.e. administered doses followed the agreed schedule, that target coverage was correctly implemented for each scenario, and that projected RSV hospitalisations under Scenario E matched the provided target data).

In the following, we will refer to individual models with their model type (static, dynamic, and ABM) followed by a unique number identifier (e.g. Static 1). In Supplementary Table 2 we provide a correspondence between the model names used in this report and original model names.

² List of countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden.

Table 2. Models contributing to the analysis

Model names	Model type	Countries	Targets
Static 1	Static	28	hospitalisations, doses
Static 2	Static	28	hospitalisations, doses
Static 3	Static	30*	hospitalisations, doses, infections
Dynamic 1	Dynamic (compartmental)	28	hospitalisations, doses
Dynamic 2	Dynamic (compartmental)	3 (DE, IT, SE)	hospitalisations, doses
Dynamic 3	Dynamic (compartmental)	30*	hospitalisations, doses, infections
Dynamic 4	Dynamic (compartmental)	28	hospitalisations, doses, infections
Dynamic 5	Dynamic (compartmental)	1 (DE)	hospitalisations, doses, infections
ABM 1	Agent-based	1 (IT)	hospitalisations, doses, infections
ABM 2	Agent-based	1 (DE)	hospitalisations, doses

* Two models also submitted projections for Lichtenstein and Iceland for which target data are not available. These two countries will be excluded from analysis.

Epidemiological analysis

Estimation of averted hospitalisation burden

We define averted hospitalisations as the difference in projected hospitalisations between the baseline scenario (Scenario E) and each scenario of interest. As model outputs and input parameters carry inherent uncertainty, we apply a non-parametric bootstrap approach to compute summary statistics of mean averted hospitalisations per model m , country c , scenario s , and age group a . We repeat for B (100) times the calculation of mean cumulative hospitalisations over R realisations bootstrapped from the 100 to 300 trajectories provided by individual models for each country, scenario, and age group:

$$\bar{H}_{m,s,c,a}^{(b)} = \frac{1}{R} \sum_{r=1}^R H_{m,s,c,a}^{(r)}$$

We compute the relative averted hospitalisations with respect to Scenario E, for bootstrap iteration b as:

$$\Delta H_{m,s,c,a}^{(b)} = 100 \times \frac{\bar{H}_{m,E,c,a}^{(b)} - \bar{H}_{m,s,c,a}^{(b)}}{\bar{H}_{m,E,c,a}^{(b)}}$$

Finally, we compute mean and other summary statistics on the set of bootstrapped relative averted hospitalisations $[\Delta H_{m,s,c,a}^{(1)}, \dots, \Delta H_{m,s,c,a}^{(B)}]$.

Health economics analysis

A full cost-effectiveness analysis would require extensions to the epidemiological models and is beyond the scope and timeline of this assessment. We, therefore, focused on a simpler measure, the number needed to immunise (NNI), which indicates how many people need to be immunised to prevent one RSV-related outcome, i.e. hospitalisation, for all age groups included.

Estimation of the number needed to immunise

The NNI was used as a simple measure of technical efficiency, reflecting how effectively competing interventions convert resources (i.e. doses administered) into a common health outcome metrics (i.e. hospitalisations averted). The NNI has been used regularly in the context of vaccination, where it is often termed as the Number Needed to Vaccinate (NNV) [41] and is derived from the ubiquitous Number Needed to Treat (NNT) concept in clinical care [42]. In their UK analysis of infant RSV immunisation, Hodgson et al [35] reported well aligned NNI and cost-effectiveness estimates.

The NNI to prevent one hospitalisation was calculated based on R model outputs, by model and country for each intervention strategy A, B, C, D relative to E (no universal immunisation) as:

- Step 1: The expected number of doses (D) and hospitalisations averted (ΔH) are defined for each model, country, scenario, and age group:

$$\mathbb{E}(D) = \frac{1}{R} \sum_{r=1}^R D^{(r)}, \quad \mathbb{E}(\Delta H) = \frac{1}{R} \sum_{r=1}^R \Delta H^{(r)}$$

- Step 2: The expected NNI is defined as the ratio of expected quantities

$$NNI = \frac{\mathbb{E}(D)}{\mathbb{E}(\Delta H)}$$

- Step 3: Using a non-parametric bootstrap approach, the mean and quantiles on $NNI(1)$, $NNI(2)$, ..., $NNI(B)$ are computed

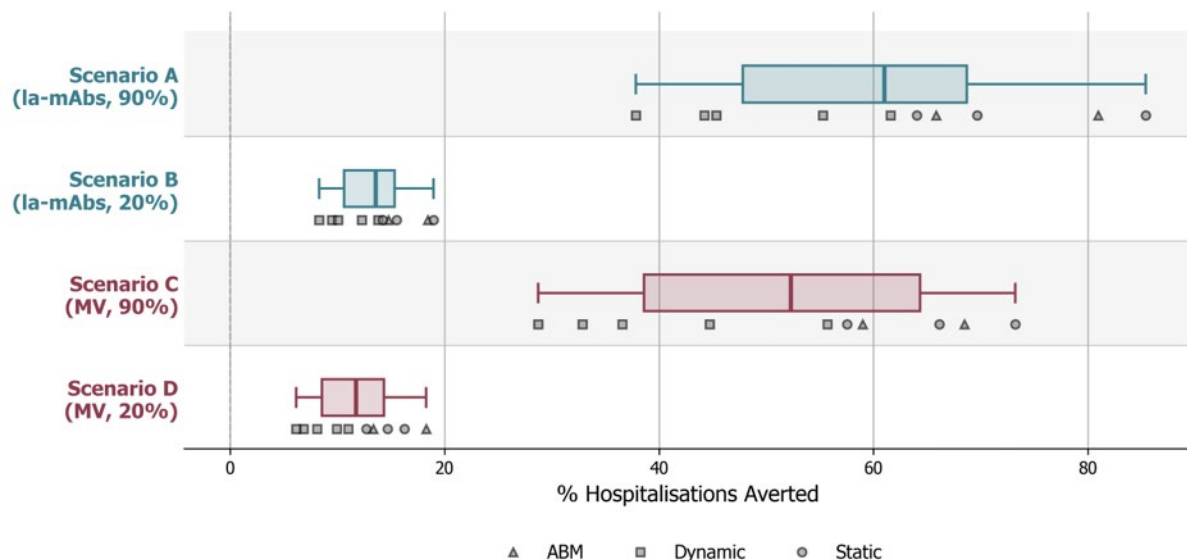
Country- and model-specific estimates of the NNI per hospitalisation prevented (and where applicable, per additional infection prevented) were generated for Scenarios A–D. Scenario E represented the no-universal-immunisation reference scenario, for which the NNI was 0 by definition.

Results

Epidemiological impact

Figure 2 shows that, across all scenarios, the model estimates consistently indicate a meaningful reduction in RSV hospitalisations in the 0–2 months age group. High-coverage scenarios (90%) for both monoclonal antibodies and MV yield considerably larger burden averted estimates, with average across models reaching 61% (min-max spread across model means: 38%–85%) for la-mAbs and 52% [29–73] for MV. Reducing coverage to 20% expectedly attenuates the projected impact, with mean estimates across models of 14% (8–19) and 12% (6–18), respectively. Between-model heterogeneity emerges, particularly between dynamic and static models, with the first ones typically projecting smaller estimates of averted hospitalisations. Table 3 reports mean and min-max range across countries for each individual model. Supplementary Table 3 reports the analogous per-model estimates of averted RSV hospitalisations for the 3–5 months age group, presented in the same format (mean, with min-max range across countries, for each individual model and scenario).

Figure 2. Projected percentage of RSV hospitalisations averted in infants aged 0–2 months under four immunisation scenarios



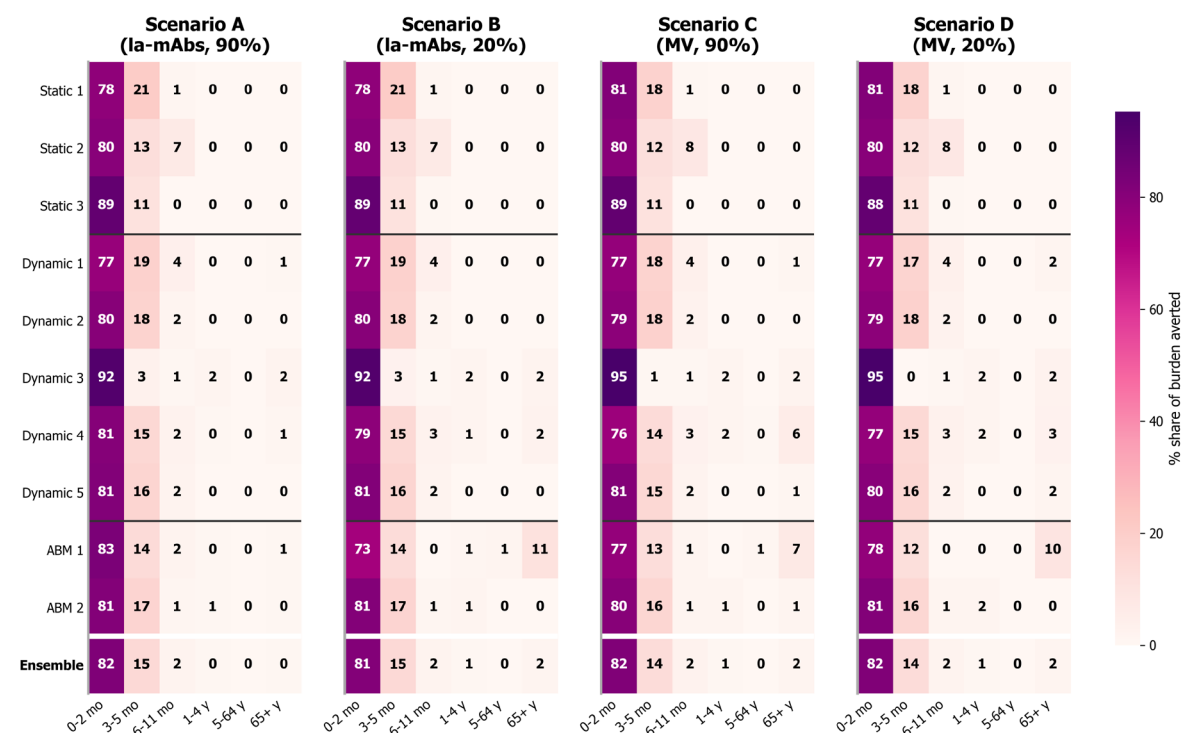
Each row corresponds to one scenario: Scenarios A and B deploy long-acting monoclonal antibodies (la-mAbs) at 90% and 20% coverage, respectively; Scenarios C and D deploy MV at 90% and 20% coverage. Boxes span the interquartile range of model-specific mean estimates across 10 contributing models; vertical lines indicate the ensemble mean. Individual model estimates are shown as dots below each box (circles: static models; squares: dynamic models; triangles: ABMs).

Table 3. Percentage of RSV hospitalisations averted in infants aged 0–2 months under four intervention scenarios, as estimated by each participating model

Model	Scenario A	Scenario B	Scenario C	Scenario D
Static 1	64.0% (63.0–65.9)	14.3% (13.9–14.6)	66.1% (65.0–67.9)	14.7% (14.5–15.1)
Static 2	85.4% (84.4–86.8)	19.0% (18.4–19.6)	73.2% (72.0–74.5)	16.3% (15.6–16.9)
Static 3	69.6% (69.3–70.4)	15.5% (15.4–16.0)	57.5% (57.2–58.2)	12.7% (12.6–13.2)
Dynamic 1	44.2% (42.2–45.5)	9.5% (7.8–10.1)	32.8% (30.8–33.8)	6.9% (4.8–7.5)
Dynamic 2	45.3% (43.8–46.2)	10.1% (9.8–10.3)	36.6% (35.3–37.3)	8.1% (7.9–8.3)
Dynamic 3	61.6% (58.9–63.2)	13.8% (13.1–14.1)	44.7% (41.4–47.2)	9.9% (9.1–10.3)
Dynamic 4	37.8% (34.7–39.7)	8.3% (6.0–9.3)	28.7% (25.7–31.3)	6.2% (3.5–8.2)
Dynamic 5	55.3% (-)	12.3% (-)	55.7% (-)	11.0% (-)
ABM 1	80.9% (-)	18.4% (-)	68.4% (-)	18.2% (-)
ABM 2	65.9% (-)	14.8% (-)	59.0% (-)	13.4% (-)

Values represent the mean % averted hospitalisations relative to the no-intervention baseline (Scenario E), with the min-max spread across countries in parentheses. Mean and min-max ranges are computed across all countries in EU/EEA included in each model; a dash ("-") indicates a single-country model for which a cross-country interval cannot be computed. Scenario A: long-acting monoclonal antibodies (la-mAbs) at 90% coverage; Scenario B: la-mAbs at 20% coverage; Scenario C: MV at 90% coverage; Scenario D: MV at 20% coverage.

Figure 3 shows the share of averted RSV hospitalisations across all age groups, by model and scenario. Across the board, approximately 80% of total averted burden is in the 0–2 months age group, with a further ~15% in the 3–5 months group, reflecting the targeting of both interventions on infants in the first months of life. This distribution is highly consistent across scenarios and coverage levels and shows little variation across models. Older age groups (>5 months) account for a smaller proportion of averted burden, with almost negligible contributions in most models. A modest effect in other age groups is observed only for some dynamic and agent-based models, although the age groups in which these additional benefits occur are not consistent across models.

Figure 3. Age distribution of averted RSV hospitalisation burden by model and scenario

Each cell shows the percentage of total averted hospitalisations attributed to a given age group for each model (rows) and scenario (columns). Colour intensity reflects the share magnitude (white = low, dark purple = high). Models are grouped by type: Static (1–3), Dynamic (1–5), and ABM (1–2); the bottom row ("Ensemble") reports the mean share across all models. Scenarios A and B assume long-acting monoclonal antibodies (la-mAbs) at 90% and 20% coverage, respectively; Scenarios C and D assume MV at 90% and 20% coverage.

Economic evaluation

In this section, we report the NNI required to prevent one hospitalisation and the choice of the most efficient intervention strategy across models and countries.

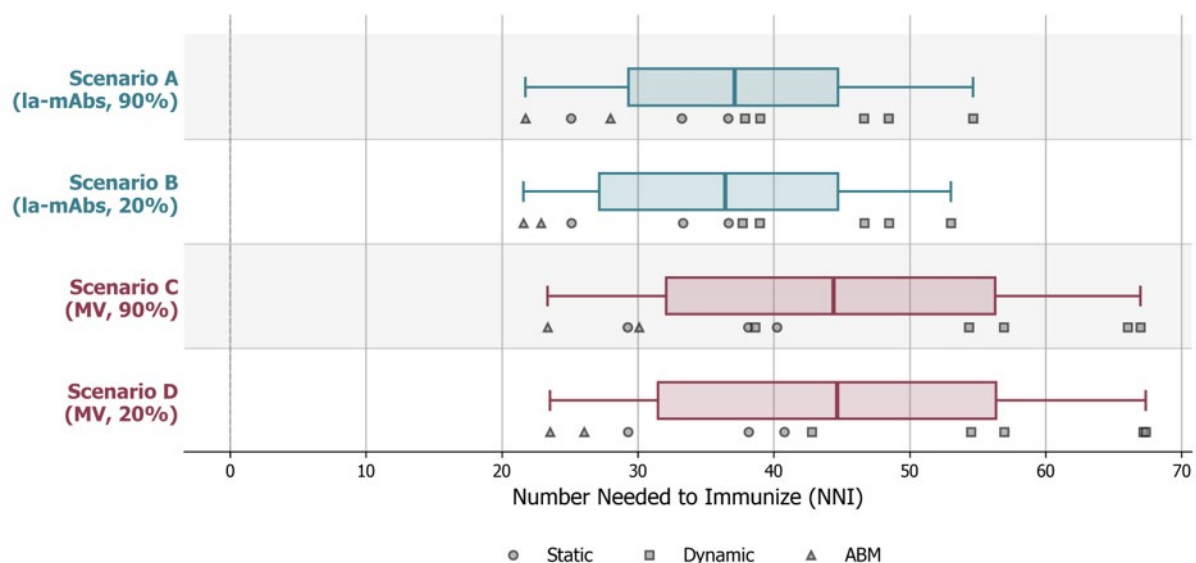
Number needed to immunise (NNI)

NNI was analysed by model and country. As variation between models' outputs was larger than variation between countries for a given model, the NNIs are shown by model in Figure 4. It shows the estimated NNI to avert one hospitalisation in any age group for scenarios A to D compared to no universal RSV immunisation strategy (Scenario E). All models showed NNIs below 70 for Scenarios A–D, meaning that typically fewer than 70 doses were needed to prevent one hospitalisation in any age group for both MV and la-mAbs. Across all models, generally slightly lower NNIs were reported for la-mAbs than for MV (Scenario A-B vs. C-D). In other words, la-mAbs required slightly fewer doses than MV to prevent one hospitalisation. This finding should be interpreted in light of the higher IE assumed for la-mAbs (see Assessment and conclusions). Given the high coverage scenarios (90%) the mean NNI across models was 37 (min-max spread across model means: 22–55) for la-mAbs and 44 (23–67) for MV. Given the low coverage scenarios (20%), these numbers slightly change to 36 (22–53) and 45 (23–67) for la-mAbs and MV, respectively.

For both immunisation strategies, the majority of models accounting for herd immunity impacts (i.e. dynamic models) yielded higher NNI estimates. This likely reflects the tendency of such type of models to underestimate disease burden in the youngest age groups [43]. Although the ranges of the mean NNIs overlap, each individual model's ranking of the strategies was consistently showing lower NNIs for la-mAbs than for MV. More detailed analyses are provided in the Supplementary Material.

Country-specific implementation costs and budget-impact estimates would need to be considered alongside the NNIs, if a full cost-effectiveness analysis is not feasible.

Figure 4. Number Needed to Immunise (NNI) to avert one RSV hospitalisation, across four immunisation scenarios



Abbreviations: NNI: number needed to immunise, ABM: Agent-based model.

Each row corresponds to one scenario: Scenarios A and B deploy long-acting monoclonal antibodies (la-mAbs) at 90% and 20% coverage, respectively; Scenarios C and D deploy MV at 90% and 20% coverage. Results are aggregated across all ages (total population). Boxes span the interquartile range of model-specific mean NNI estimates across 10 contributing models (means across countries in the EU/EEA included for each model); vertical lines indicate the ensemble's mean. Individual model estimates are shown as dots above each box (circles: static models; squares: dynamic models; triangles: ABMs).

Assessment and conclusions

This assessment examines the potential impact of universal newborn RSV immunisation on reducing RSV-related hospitalisation burden in all age groups across 28 EU/EEA countries versus no universal intervention. We used a multi-model collaborative approach to interpret four scenarios differing by immunisation coverage level and intervention type between long-acting monoclonal antibodies and MV. Our findings add to the evidence available to public health authorities and policy-makers responsible for planning and implementing universal newborn RSV immunisation strategies.

Both strategies provide substantial reduction in hospitalisation burden under all scenarios. At the same coverage level, the estimated epidemiological impact is slightly higher for la-mAbs with respect to MV across all models. When interpreting this finding, it must be considered that a higher *immunisation effectiveness* was assumed for la-mAbs than MV in this analysis, based on recent literature estimates. Observational studies from Argentina [11] and the UK [44] have reported lower effectiveness estimates for MV than for la-mAbs. This was confirmed by a recent comparative study from France, unless MV was administered at least eight weeks before delivery, in which case no longer a statistically significant difference between the two products was found [45]. The assumed effectiveness difference is not, however, the only factor contributing to this result. La-mAbs and MV have different waning profiles (with MV waning slower than La-mAbs [35]), and indirect effects may be stronger for MV through immunisation of pregnant individuals, both of which the models can capture.

A near-linear relationship between coverage and averted burden for both interventions was also observed. This indicates that impact scales predictably with uptake, underscoring the importance of achieving high coverage to reduce pressure on healthcare systems and support country-level planning under different programmatic assumptions.

In line with the observed differences in burden, the NNI was consistently lower for la-mAbs than MV across all models and countries. The health economics component of this analysis is limited to technical efficiency metrics and does not capture programmatic costs (vaccine and delivery), nor the cost of illness averted or different prices of the products. However, the outputs provide direct inputs for national cost-effectiveness and health technology assessments, supporting policy decisions on vaccination investment using a common, multi-model evidence base. For this purpose, we report estimates of the NNI for each country, separately as Supplementary Material. Note that country-level estimates for countries covered by fewer models should be interpreted with additional caution, as they reflect a narrower range of modelling assumptions.

All models consistently indicate that the projected averted burden is heavily concentrated in early infancy. Approximately 80% of total averted hospitalisations occur in the 0–2 months age group. This reflects the design of the modelling scenarios, which focus only on universal immunisation of newborns at birth and do not include catch-up programmes. Together with the linear scaling of coverage and burden reduction, it indicates limited indirect effects across models, with the estimated impact driven almost entirely by direct protection of immunised newborns. From a policy perspective, this implies that programme benefits are likely to scale predictably with coverage and, to a first approximation, with combinations of strategies. This highlights the importance of immunisation of newborns and suggest that extending strategies to catch-up cohorts – particularly in the 3–12 months age group where substantial hospital burden remain – or wider expected delivery dates for eligibility in the case of MV could be expected to further increase population-level benefits.

While the above-mentioned relative effects are consistent across models, we observe substantial heterogeneity in the magnitude of burden reduction between the different modelling approaches, reflecting structural uncertainty in how transmission dynamics, waning immunity, and indirect effects are represented. Overall, between-country variation in both burden reduction and NNI was smaller than between-model variation, reinforcing the robustness of the efficiency ranking to country-specific epidemiological and demographic contexts.

As with all modelling studies, this analysis has limitations. As it follows:

- The epidemiological data used for model calibration rely on robust EU-wide burden estimates but remain synthetic, constructed by combining published age- and country-specific hospitalisation rates with a reference RSV seasonal profile. As detailed country-level RSV surveillance data are lacking, a common seasonality was assumed across countries. Although RSV season onset and peak differ across Europe, country-to-country differences from the assumed common profile are expected to be small and of limited impact on the results [46, 47].
- The modelled interventions also make several simplifying assumptions compared to the real-world application of la-mAbs and MV. The scenarios take each intervention in isolation and do not evaluate combined or sequential approaches. Given the limited indirect effects observed, combined strategies are unlikely to substantially alter population-level impact relative to each intervention applied in isolation. However, potential behavioural responses – such as increased uptake when multiple options are available – were not explicitly modelled and could modify these outcomes in practice.

- The two interventions differ in the recipient of the intervention: la-mAbs are administered directly to newborns, while MV requires reaching pregnant individuals during a defined gestational window. These differences are likely to constrain achievable real-world uptake, even though identical coverage levels are assumed in the models. Additionally, this analysis assumes no universal RSV vaccination programme targeting older adults. Should such programmes be introduced, they would predominantly alter the disease burden among older adults but likely have only a limited impact on the circulation of RSV in infants.
- It should be noted that the health economics component of this analysis is limited. NNIs estimates and does not capture programmatic costs, healthcare system delivery pathways, or the cost of illness averted. A full cost-effectiveness analysis would require unit costs per dose, programme delivery costs, medical (and indirect) costs of RSV disease manifestations (including cases seen in primary care and cases for which no professional medical care is sought), as well as associated health utility estimates, which were beyond the scope of this scenario round. The NNI estimates presented here are nonetheless a direct and practical input for country-level cost-effectiveness models, enabling national health technology assessment bodies to parameterise and validate their analyses using a common, multi-model evidence base. However, comprehensive country-specific cost-effectiveness analyses remains desirable where data and resources permit.

Despite these limitations, we see that our projections are broadly consistent with early real-world evidence on nirsevimab effectiveness. Observational studies from Spain [48], Luxembourg [30], France [49], and Italy [50] reported substantial reductions in RSV-associated hospitalisations in infants during the first seasons of nirsevimab deployment, with effectiveness estimates against hospitalisation in line with the immunisation effectiveness assumptions used in this analysis. To contextualise these findings, it is also worth comparing our estimates against the available independent literature on the NNI or NNV to prevent one RSV-related hospitalisation. Comparable estimates have also been reported in other settings. Carazo et al. evaluated Quebec's universal nirsevimab programme using provincial health administrative data and estimated an NNI of 41 for at-birth immunisation to prevent one RSV hospitalisation among newborns [51]. Similarly, Hodgson et al. reported NNIs of 49 and 43 per hospitalisations averted for seasonal MV and seasonal la-mAbs, respectively, in England [35]. A Spanish real-world study also reported a comparable NNI of 41 for at-birth immunisation [52]. This suggests that the prophylactic strategies examined here offer hospitalisation-prevention efficiency that is both plausible and policy-relevant.

In conclusion, this multi-model assessment provides robust evidence that universal newborn RSV immunisation can substantially reduce RSV-associated hospitalisation across the EU/EEA. The consistency of findings across models supports universal immunisation of newborns at birth as an effective public health strategy, with la-mAbs demonstrating slightly higher epidemiological impact and greater NNI than MV. These results, along with other evidence, can provide a quantitative foundation to inform national decision-making on the introduction and design of RSV immunisation programmes.

Contributors

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References

1. Del Riccio M, Spreeuwenberg P, Osei-Yeboah R, Johannesen CK, Fernandez LV, Teirlinck AC, et al. Burden of Respiratory Syncytial Virus in the European Union: estimation of RSV-associated hospitalizations in children under 5 years. *J Infect Dis.* 2023;228(11):1528-38.
2. Osei-Yeboah R, Spreeuwenberg P, Del Riccio M, Fischer TK, Egeskov-Cavling AM, Boas H, et al. Estimation of the Number of Respiratory Syncytial Virus-Associated Hospitalizations in Adults in the European Union. *J Infect Dis.* 2023;228(11):1539-48.
3. Savic M, Penders Y, Shi T, Branche A, Pirçon JY. Respiratory syncytial virus disease burden in adults aged 60 years and older in high-income countries: A systematic literature review and meta-analysis. *Influenza Other Respir Viruses.* 2023;17(1):e13031.
4. Nguyen-Van-Tam JS, O'Leary M, Martin ET, Heijnen E, Callendret B, Fleischhackl R, et al. Burden of respiratory syncytial virus infection in older and high-risk adults: a systematic review and meta-analysis of the evidence from developed countries. *Eur Respir Rev.* 2022;31(166).
5. Reeves RM, van Wijhe M, Lehtonen T, Stona L, Teirlinck AC, Vazquez Fernandez L, et al. A Systematic Review of European Clinical Practice Guidelines for Respiratory Syncytial Virus Prophylaxis. *J Infect Dis.* 2022;226(Suppl 1):S110-S6.
6. European Medicines Agency (EMA). Beyfortus – nirsevimab: EPAR - Product Information 2022 Available at: <https://www.ema.europa.eu/en/medicines/human/EPAR/beyfortus>
7. Sumsuzzman DM, Wang Z, Langley JM, Moghadas SM. Real-world effectiveness of nirsevimab against respiratory syncytial virus disease in infants: a systematic review and meta-analysis. *Lancet Child Adolesc Health.* 2025;9(6):393-403.
8. European Medicines Agency (EMA). Enflonsia: EPAR - Product Information 2026. Available at: <https://www.ema.europa.eu/en/medicines/human/EPAR/Enflonsia>
9. European Medicines Agency (EMA). Abrysvo: EPAR - Product Information 2023. Available at: <https://www.ema.europa.eu/en/medicines/human/EPAR/abrysvo>
10. Mapindra MP, Mahindra MP, McNamara P, Semple MG, Clark H, Madsen J. Respiratory Syncytial Virus Maternal Vaccination in Infants below 6 Months of Age: Meta-Analysis of Safety, Immunogenicity, and Efficacy. *Neonatology.* 2024;121(3):271-82.
11. Perez Marc G, Vizzotti C, Fell DB, Di Nunzio L, Olszevicki S, Mankiewicz SW, et al. Real-world effectiveness of RSVpreF vaccination during pregnancy against RSV-associated lower respiratory tract disease leading to hospitalisation in infants during the 2024 RSV season in Argentina (BERNI study): a multicentre, retrospective, test-negative, case-control study. *Lancet Infect Dis.* 2025;25(9):1044-54.
12. Nohynek H, Wichmann O, F DA, Gatekeepers VN. National Advisory Groups and their role in immunization policy-making processes in European countries. *Clin Microbiol Infect.* 2013;19(12):1096-105.
13. European Centre for Prevention and Control (ECDC). Current practices in immunisation policymaking in European countries 2015. Available at: <https://www.ecdc.europa.eu/en/publications-data/current-practices-immunisation-policymaking-european-countries>
14. Runge MC, Shea K, Howerton E, Yan K, Hochheiser H, Rosenstrom E, et al. Scenario design for infectious disease projections: Integrating concepts from decision analysis and experimental design. *Epidemics.* 2024;47:100775.
15. Shea K, Borchering RK, Probert WJM, Howerton E, Bogich TL, Li SL, et al. Multiple models for outbreak decision support in the face of uncertainty. *Proc Natl Acad Sci U S A.* 2023;120(18):e2207537120.
16. Den Boon S, Jit M, Brisson M, Medley G, Beutels P, White R, et al. Guidelines for multi-model comparisons of the impact of infectious disease interventions. *BMC Med.* 2019;17(1):163.
17. Prasad PV, Steele MK, Reed C, Meyers LA, Du Z, Pasco R, et al. Multimodeling approach to evaluating the efficacy of layering pharmaceutical and nonpharmaceutical interventions for influenza pandemics. *Proc Natl Acad Sci U S A.* 2023;120(28):e2300590120.
18. European Centre for Prevention and Control (ECDC). Multi-model analysis to quantify the impact of vaccination on COVID-19 and influenza hospitalisation burden among older adults in the EU/EEA, 2024/25 Stockholm: ECDC; 2025. Available at: <https://www.ecdc.europa.eu/en/publications-data/multi-model-analysis-quantify-impact-vaccination-covid-19-and-influenza>
19. Loo SL, Howerton E, Contamin L, Smith CP, Borchering RK, Mullany LC, et al. The US COVID-19 and Influenza Scenario Modeling Hubs: Delivering long-term projections to guide policy. *Epidemics.* 2024;46:100738.
20. European Centre for Prevention and Control (ECDC). ECDC launches RespiCompass, a scenario modelling hub for respiratory diseases Stockholm: ECDC; 2024. Available at: <https://www.ecdc.europa.eu/en/news-events/ecdc-launches-respicompass-scenario-modelling-hub-respiratory-diseases>

21. Reich NG, Lessler J, Funk S, Viboud C, Vespignani A, Tibshirani RJ, et al. Collaborative Hubs: Making the Most of Predictive Epidemic Modeling. *Am J Public Health*. 2022;112(6):839-42.
22. Borchering RK, Healy JM, Cadwell BL, Johansson MA, Slayton RB, Wallace M, et al. Public health impact of the U.S. Scenario Modeling Hub. *Epidemics*. 2023;44:100705.
23. Shea K, Runge MC, Pannell D, Probert WJM, Li SL, Tildesley M, et al. Harnessing multiple models for outbreak management. *Science*. 2020;368(6491):577-9.
24. European Centre for Prevention and Control (ECDC). Vaccine scheduler. Available at: <https://vaccine-schedule.ecdc.europa.eu/Scheduler>
25. World Health Organization (WHO). Global vaccination coverage dashboard. Available at: <https://immunizationdata.who.int>
26. European Centre for Prevention and Control (ECDC). Increase of pertussis cases in the EU/EEA Stockholm: ECDC; 2024. Available at: <https://doi.org/10.2900/831122>
27. European Centre for Prevention and Control (ECDC). Survey report on national seasonal influenza vaccination recommendations and coverage rates in EU/EEA countries Stockholm: ECDC; 2024. Available at: <https://doi.org/10.2900/4063144>
28. Chauvel C, Horvat C, Javouhey E, Gillet Y, Hassenboehler J, Chakra CNA, et al. Changes in Respiratory Syncytial Virus-Associated Hospitalisations Epidemiology After Nirsevimab Introduction in Lyon, France. *Influenza Other Respir Viruses*. 2024;18(12):e70054.
29. Consolati A, Farinelli M, Serravalle P, Rollandin C, Apprato L, Esposito S, et al. Safety and Efficacy of Nirsevimab in a Universal Prevention Program of Respiratory Syncytial Virus Bronchiolitis in Newborns and Infants in the First Year of Life in the Valle d'Aosta Region, Italy, in the 2023-2024 Epidemic Season. *Vaccines (Basel)*. 2024;12(5).
30. Ernst C, Bejko D, Gaasch L, Hannelas E, Kahn I, Pierron C, et al. Impact of nirsevimab prophylaxis on paediatric respiratory syncytial virus (RSV)-related hospitalisations during the initial 2023/24 season in Luxembourg. *Euro Surveill*. 2024;29(4).
31. Lopez-Lacort M, Munoz-Quiles C, Mira-Iglesias A, Lopez-Labrador FX, Mengual-Chulia B, Fernandez-Garcia C, et al. Early estimates of nirsevimab immunoprophylaxis effectiveness against hospital admission for respiratory syncytial virus lower respiratory tract infections in infants, Spain, October 2023 to January 2024. *Euro Surveill*. 2024;29(6). Available at: <https://pmc.ncbi.nlm.nih.gov/articles/PMC10853977>
32. Eurostat. Live births (total) by month 2025 [Available at: https://doi.org/10.2908/DEMO_FM00TH].
33. Eurostat. Fetal, peri- and neonatal mortality rates by country of occurrence 2025. Available at: https://doi.org/10.2908/HLTH_CD_APERRTO
34. Li X, Dominique R, Bicke J, Castanares-Zapatero D, de Meester C, Mao Z, et al. Cost-effectiveness of new preventive options against RSV infections in Belgian infants. Brussels: Belgian Health Care Knowledge Centre (KCE); 2025. Available at: https://kce.fgov.be/sites/default/files/2025-06/KCE_402_RSV_Infections_Belgian_Infants_Report.pdf
35. Hodgson D, Wilkins N, van Leeuwen E, Watson CH, Crofts J, Flasche S, et al. Protecting infants against RSV disease: an impact and cost-effectiveness comparison of long-acting monoclonal antibodies and maternal vaccination. *Lancet Reg Health Eur*. 2024;38:100829.
36. Presser LD, van den Akker WMR, Meijer A, Investigators P. Respiratory Syncytial Virus European Laboratory Network 2022 Survey: Need for Harmonization and Enhanced Molecular Surveillance. *J Infect Dis*. 2024;229(Supplement_1):S34-S9.
37. Egeskov-Cavling AM, Johannesen CK, Lindegaard B, Fischer TK. Underreporting and misclassification of RSV-coded hospitalization among adults in Denmark between 2015/16 to 2017/18. *J Infect Dis*. 2023.
38. Johannesen CK, van Wijhe M, Tong S, Fernández LV, Heikkinen T, van Boven M, et al. Age-Specific Estimates of Respiratory Syncytial Virus-Associated Hospitalizations in 6 European Countries: A Time Series Analysis. *J Infect Dis*. 2022;226(Suppl 1):S29-s37.
39. Eurostat. Population by age and sex 2025 [Available at: https://doi.org/10.2908/DEMO_PJAN].
40. European Centre for Prevention and Control (ECDC). RespiCompass 2025–2026 Model Metadata Stockholm: ECDC; 2025. Available at: https://github.com/european-modelling-hubs/RespiCompass/tree/main/Previous_Rounds/2025-2026_round_1/model-metadata
41. Kelly H, Attia J, Andrews R, Heller RF. The number needed to vaccinate (NNV) and population extensions of the NNV: comparison of influenza and pneumococcal vaccine programmes for people aged 65 years and over. *Vaccine*. 2004;22(17-18):2192-8.
42. Mendes D, Alves C, Batel-Marques F. Number needed to treat (NNT) in clinical literature: an appraisal. *BMC Med*. 2017;15(1):112.

43. Li X, Hodgson D, Flaig J, Kieffer A, Herring WL, Beyhaghi H, et al. Cost-Effectiveness of Respiratory Syncytial Virus Preventive Interventions in Children: A Model Comparison Study. *Value Health*. 2023;26(4):508-18.
44. McLachlan I, Robertson C, Morrison KE, McQueenie R, Hameed SS, Gibbons C, et al. Effectiveness of the maternal RSVpreF vaccine against severe disease in infants in Scotland, UK: a national, population-based case-control study and cohort analysis. *Lancet Infect Dis*. 2026;26(4):362-73.
45. Valtuille Z, Fafi I, Kaguelidou F, Levy C, Cohen R, Mandelbrot L, et al. Effectiveness of nirsevimab immunisation after birth versus RSVpreF maternal vaccination in preventing RSV-related hospitalisations in infants: a population-based retrospective cohort study. *Lancet Child Adolesc Health*. 2026;10(7):481-90.
46. Li Y, Wang X, Broberg EK, Campbell H, Nair H, European RSVSN. Seasonality of respiratory syncytial virus and its association with meteorological factors in 13 European countries, week 40 2010 to week 39 2019. *Euro Surveill*. 2022;27(16).
47. Broberg EK, Waris M, Johansen K, Snacken R, Penttinen P, European Influenza Surveillance N. Seasonality and geographical spread of respiratory syncytial virus epidemics in 15 European countries, 2010 to 2016. *Euro Surveill*. 2018;23(5).
48. Woo Kinshella ML, Allen J, Pawa J, Papenburg J, Jetty R, Dwilow R, et al. Hospital admissions for acute respiratory tract infections among infants from Nunavut and the burden of respiratory syncytial virus: a 10-year retrospective cohort study. *Lancet Reg Health Am*. 2025;43:101021.
49. Brault A, Pontais I, Enouf V, Debeuret C, Bloch E, Paireau J, et al. Effect of nirsevimab on hospitalisations for respiratory syncytial virus bronchiolitis in France, 2023-24: a modelling study. *Lancet Child Adolesc Health*. 2024;8(10):721-9.
50. Costantino C, Amodio E, Asciutto R, Affranchi C, Belbruno F, Bonaccorso N, et al. Impact of a Universal Nirsevimab Prevention Program Against Respiratory Syncytial Virus Bronchiolitis in Infants in Sicily (Italy) During the 2024-2025 Epidemic Season: A Retrospective Cohort Study. *Vaccines (Basel)*. 2025;13(12).
51. Carazo S, Ouakki M, Skowronski DM, Paquette M, Brousseau N, Talbot D, et al. Nirsevimab effectiveness, number needed to immunize and impact on severe RSV outcomes, a test-negative study in Quebec, Canada. *Lancet Reg Health Am*. 2026;57:101448.
52. Pastor-Barriuso R, Nunez O, Monge S, Nirsevimab Effectiveness Study C. Infants needed to immunise with nirsevimab to prevent one RSV hospitalisation, Spain, 2023/24 season. *Euro Surveill*. 2025;30(6).
53. Lewis EN, Griffin MR, Szilagyi PG, Zhu Y, Edwards KM, Poehling KA. Childhood influenza: number needed to vaccinate to prevent 1 hospitalization or outpatient visit. *Pediatrics*. 2007;120(3):467-72.
54. McMurray JJV, Solomon SD, Inzucchi SE, Kober L, Kosiborod MN, Martinez FA, et al. Dapagliflozin in Patients with Heart Failure and Reduced Ejection Fraction. *N Engl J Med*. 2019;381(21):1995-2008.
55. Li X, Willem L, Roberfroid D, Bilcke J, Castanares Zapatero D, De Meester C, et al. Cost-effectiveness of maternal vaccine and/or monoclonal antibody strategies against respiratory syncytial virus in Belgian infants. *NPJ Vaccines*. 2026;11(1):52.
56. Getaneh AM, Li X, Mao Z, Johannesen CK, Barbieri E, van Summeren J, et al. Cost-effectiveness of monoclonal antibody and maternal immunization against respiratory syncytial virus (RSV) in infants: Evaluation for six European countries. *Vaccine*. 2023;41(9):1623-1631..
57. Li X, Bilcke J, Vazquez Fernandez L, Bont L, Willem L, Wisloff T, et al. Cost-effectiveness of Respiratory Syncytial Virus Disease Prevention Strategies: Maternal Vaccine Versus Seasonal or Year-Round Monoclonal Antibody Program in Norwegian Children. *J Infect Dis*. 2022;226(Suppl 1):S95-S101.
58. Viola E, Mazzoli M, Paolotti D, Rizzo A, Zino L, Gozzi N. A continental-scale scenario modelling framework for evaluating infant RSV immunisation strategies across Europe. *medRxiv*. 2026:2026.06.10.26355338.
59. Singh DE, Olmedo Luceron C, Limia Sanchez A, Guzman Merino M, Duran Gonzalez C, Delgado-Sanz C, et al. Evaluation of vaccination strategies for the metropolitan area of Madrid via agent-based simulation. *BMJ Open*. 2022;12(12):e065937.
60. Ponge J, Suer J, Hellingrath B, Karch A. A Standardized Framework for Modeling Non-Pharmaceutical Interventions in Individual-Based Infectious Disease Simulations. *A Standardized Framework for Modeling Non-Pharmaceutical Interventions in Individual-Based Infectious Disease Simulations*; Orlando: United States; 2024. p. 1106-17.