ASSESSMENT

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

November 2025

Executive summary

Influenza vaccine coverage remains below the World Health Organization (WHO)-recommended threshold for risk groups in most EU/EEA countries, while COVID-19 vaccine coverage is declining across most countries. Despite the role that vaccines play in reducing severe disease, a comprehensive EU/EEA-wide quantification and assessment of the impact of influenza and COVID-19 vaccination programmes on hospitalisations is currently lacking.

To address this, we quantified the expected impact of vaccination programmes using a collaborative modelling approach through RespiCompass, the European respiratory diseases scenario modelling hub (https://respicompass.ecdc.europa.eu). This hub coordinated the development of multiple mechanistic disease transmission models by international modelling teams to simulate scenarios designed to assess vaccination impact. This assessment provides evidence to inform national public health institutes, vaccination programme managers, healthcare professionals, science communicators and public health advocates.

Our analysis suggests a clear reduction in influenza and COVID-19 hospitalisations due to vaccination in the EU/EEA between 5 August 2024 and 1 June 2025. This reduction varies strongly between countries with different vaccine coverage levels. For individuals 65 years old and above, influenza vaccination was projected to prevent – on average across EU/EEA countries – between 26% and 41% of influenza-related hospitalisations over the 2024/25 epidemiological season, depending on assumed country-specific vaccine coverage and viral transmissibility. For COVID-19, the projected reduction in hospitalisations for individuals 65 years old and above was between 14% and 20% across EU/EEA countries, depending on assumed country-specific vaccine coverage and assumptions related to waning immunity.

A large heterogeneity across countries was observed for the impact of vaccination on both diseases, reflecting differences in vaccine coverage. Depending on the modelled scenario, the difference in averted hospitalisations between the country with highest versus lowest averted burden was between 48 and 70 percentage points for influenza, and between 37 and 54 percentage points for COVID-19.

This inter-country variation highlights the untapped potential to reduce hospital burden in the EU/EEA through established programmes, such as seasonal influenza vaccination, as well as newer interventions like COVID-19 vaccination. At a time when a number of EU/EEA countries are assessing routine immunisation schedules for COVID-19, these findings can underpin national and subnational cost-effectiveness calculations to guide resource allocation for vaccination campaigns and support messaging efforts.

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Introduction

Vaccine coverage for both influenza and COVID-19 varies widely across EU/EEA countries [1-3], influenced by factors such as national immunisation policies [4,5], public perception, logistical constraints and pandemic fatigue [6-8]. In particular, COVID-19 booster dose coverage has decreased over recent successive campaigns, despite continued recommendations for high-risk and priority groups. This declining coverage raises concerns about the potential resurgence of severe disease burden, particularly among older adults (aged 60 years old and above) and other high-risk groups [9,10]. For COVID-19 vaccination, countries also differ in the extent to which strategies have been consolidated into routine immunisation schedules. While some have integrated COVID-19 vaccinations into their routine calendars [1,10-12], others are still considering whether to adopt annual campaigns similar to those for influenza [10]. These differing approaches reflect local assessments of epidemiological data, vaccine effectiveness studies, public acceptance, healthcare capacity and evolving public health priorities [10].

While empirical evaluations such as clinical vaccine effectiveness studies conducted at representative primary and secondary care sentinel surveillance sites provide valuable real-world evidence, they face important limitations. These studies are not meant to assess the impact of vaccination programmes, but the effectiveness of vaccines in preventing specific outcomes. Additionally, it is difficult for these studies to achieve sufficient sample sizes or extrapolate results across countries in a region, and results can be influenced by confounding factors such as concurrent public health measures or prior infection levels. Ethical constraints also limit the range of scenarios that can be studied, such as withholding vaccination or restricting contact patterns. In contrast, modelling offers a complementary approach that enables the structured assessment of vaccine impact under a range of hypothetical conditions. By integrating key drivers of disease dynamics – including transmission patterns, waning immunity, vaccine effectiveness and country-specific factors – modelling can help to quantify both direct and indirect effects of vaccination on hospitalisation burden [13-20].

The purpose of this analysis was to estimate the impact of influenza and COVID-19 vaccination on hospitalisation burden among older adults in the EU/EEA using a multi-model approach that combined results from several independently developed models to generate aggregated ensemble estimates [21-24]. This assessment provides evidence to inform a range of stakeholders, including national public health institutes, national vaccination programme managers and advisors, healthcare professionals, health communication specialists, and those involved in public health advocacy.

Methods

The modelling effort for 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 assess respiratory disease burden and intervention impacts in the EU/EEA [25]. 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 [26-28].

Hospitalisation burden is a critical metric to assess the public health impact of vaccination because it is a robust indicator of severe disease and healthcare system strain, as well as economic costs [50-52]. Therefore, this analysis focused on the question: what is the averted hospitalisation burden of COVID-19 and influenza due to vaccination among those 65 years old and above in winter 2024/25? To address this question, a group of international modelling teams developed individual models in accordance with six standardised scenarios (Scenarios A to F) per disease. In total, six teams submitted influenza modelling results and seven teams COVID-19 modelling results. Model details are available on the RespiCompass GitHub repository [41].

Below, we describe the scenarios and assumptions that guided the work of modelling teams, the supporting data and modelling outputs, as well as the methods used to analyse the modelling outputs. References to 'season' when discussing disease epidemiology or vaccine coverage follow the definitions given in Box 1. Note that while our results focus on the population 65 years old and above, the underlying modelling included all age groups in order to capture disease transmission dynamics that cross age-group boundaries.

Box 1. Definitions of 'season' in this report

In this document, we use the terms 'season' and 'seasonal' in two different contexts:

Disease epidemiology: In the context of disease epidemiology, 'season' refers to the period when seasonal respiratory viruses – such as influenza – typically circulate at higher levels. For the scenario projections presented in this report, the 2024/25 season was defined as 5 August 2024 (week 32, 2024) to 1 June 2025 (week 22, 2025), allowing for the possibility of early or late peaks in viral activity. While influenza shows a clear seasonal pattern, COVID-19 activity remains more variable, and a consistent seasonal trend has not been observed.

Vaccine coverage: In the context of immunisation campaigns, 'season' refers to the reporting period for vaccine coverage. For example, coverage for the 2023/24 season corresponds to vaccinations administered between 1 September 2023 and 31 July 2024, in line with ECDC reporting standards [11]. We define vaccine coverage as the percentage of individuals of a certain population group that receive a vaccine.

Standardised scenarios for influenza and COVID-19

For each disease, six standardised scenarios (Scenarios A to F) were developed to explore key uncertainties related to vaccine coverage and epidemiological conditions. A representation of the scenarios for both influenza and COVID-19 is provided in Figure 1. Each scenario specified a core set of modelling assumptions to ensure comparability across the teams' individual models. Flexibility was allowed for other assumptions, where various methods or interpretations were plausible, to account for epistemological uncertainty – that is, uncertainty arising from limited knowledge or data related to, for example, human-to-human contact patterns or travel behaviour [29].

Figure 1. Scenario matrix for assessing the impact of vaccination on influenza (A) and COVID-19 (B) hospitalisation burden in the EU/EEA, 2024/25 epidemiological season

A.

Vaccination axis →

Biological axis ↓

Influenza	Optimistic vaccination Coverage in adults aged **65+** is **15%** higher than in last season	Pessimistic vaccination Coverage in adults aged **65+** is **15%** lower than in last season	No vaccination (counterfactual)
Typical transmission potential Influenza transmission potential is **similar** to the last three seasons, excluding COVID-19 pandemic years.	Scenario A	Scenario C	Scenario E
Pessimistic transmission potential Influenza transmission potential is **10% higher** relative to the last three seasons, excluding COVID-19 pandemic years.	Scenario B	Scenario D	Scenario F

B.

Vaccination axis →

Biological axis ↓

COVID-19	Optimistic vaccination Coverage in adults aged **60+** is **15%** higher than 2023/24 season	Pessimistic vaccination Coverage in adults aged **60+** is **15%** lower than 2023/24 season	No vaccination (counterfactual)
Optimistic waning Vaccine-induced immunity against infection: **6 months** median time to **50%** of initial immunity. **No waning** of vaccine-induced immunity against severe outcomes.	Scenario A	Scenario C	Scenario E
Pessimistic waning Vaccine-induced immunity against infection: **6 months** median time to **30%** of initial immunity. Vaccine-induced immunity against severe outcomes: **6 months** median time to **60%** of initial immunity.	Scenario B	Scenario D	Scenario F

Scenarios are defined along two axes: the vaccination axis, which varies coverage levels in older adults (optimistic, pessimistic, and no vaccination (counterfactual)), and the biological axis, which accounts for differences in transmission potential for influenza or immunity waning for COVID-19. The combination of these factors results in six scenarios (A–F) used to evaluate the range of possible outcomes under different epidemiological and vaccination conditions.

Vaccine coverage

Seasonal vaccine coverage rates in EU/EEA countries for all age groups were taken from ECDC's COVID-19 vaccination tracker for COVID-19 [30] and from Eurostat for influenza [31]. Due to how ages were grouped in the available datasets, COVID-19 vaccine coverage scenarios defined 'older adults' as 60 years old and above, while the influenza scenarios defined this population as 65 years old and above. As demonstrated in a previous ECDC report that modelled vaccination's impact on COVID-19 [9], this five-year difference between age group cut-offs can be considered small and is expected to have a relatively muted impact on hospital burden. In all scenarios, coverage for other age groups matched the latest available data [1,31,32]. 'Most recent season' was defined as 2021/22 for influenza and 2023/24 for COVID-19.

Scenarios A and B assumed optimistic vaccine coverage that was 15% higher than the rate reported in the most recent season for older adults. **Scenarios C and D** assumed pessimistic coverage that was 15% lower than the rate reported in the most recent season for older adults.

The 15% variations in Scenarios A to D reflect realistic year-to-year fluctuations observed historically across EU/EEA countries. This percentage was chosen to span a meaningful range while also allowing clear differentiation between scenarios.

Counterfactual scenarios E and F assumed no vaccination in all age groups. These scenarios were included as baselines to allow quantification of the full population-level benefit of pessimistic or optimistic vaccine coverage versus no vaccination.

Details of vaccination implementation – such as the timing of vaccine rollout and additional effects (e.g. reduced infectiousness in vaccinated individuals) – were left to the discretion of the modelling teams.

Biological uncertainties

In addition to vaccine coverage, the scenarios explored key biological uncertainties for both influenza and COVID-19, such as vaccine effectiveness against symptomatic infection and transmission potential.

Influenza vaccine effectiveness against symptomatic infection was assumed to be 40% for all age groups, based on current evidence [33-35]. For influenza, we focused on uncertainty around transmission potential, which includes transmission-altering factors excluding vaccination – such as climatic conditions, human contact patterns and the intrinsic transmissibility of circulating strains. Scenarios A and C assumed typical transmission potential, inferred from the three most recent influenza seasons not strongly affected by the COVID-19 pandemic (2017–2018, 2018–2019 and 2023–2024), which were defined as baseline seasons. Scenarios B and D assumed a pessimistic transmission potential that was 10% higher than the three baseline seasons, representing a plausible increase in influenza activity based on historical variability in seasonal intensity.

COVID-19 vaccine effectiveness was assumed to be 50% against infection and 75% against COVID-19-related hospitalisation for all age groups, based on current evidence [36-40]. For COVID-19, the biological uncertainty centred on immunity waning following infection or vaccination. In Scenarios A and C, vaccine protection against infection was assumed to decline to 50% of its initial level within six months, while protection against hospitalisation remained stable. In Scenarios B and D, faster waning was assumed: vaccine protection against infection dropped to 30% in six months, and protection against hospitalisation declined to 60% over the same period. These assumptions reflect a plausible range informed by current evidence [41-44]. The modelling teams were instructed to include waning of natural immunity, with the requirement that the rate of waning for natural immunity be slower than for vaccine-induced immunity.

Supporting data

To align the models' scenario assumptions, the modelling teams were provided with scenario-adjusted vaccine coverage data for individuals 65 years old and above for influenza [31], and 60 years old and above for COVID-19 [30]. Modelling teams could then directly load and use these coverage data in their model simulations. Additional auxiliary datasets included:

- Historical influenza-like illness (ILI) and acute respiratory infection (ARI) consultation rates by age, pathogen positivity rates, and COVID-19 intensive care unit admissions and deaths from the European Respiratory Virus Surveillance Summary (ERVISS) GitHub repository [45];
- Vaccine coverage for other age groups [2,30];
- Population distributions by age group across EU/EEA countries [46]; and
- References to external resources such as contact matrices useful for modelling [47-49].

Submissions from modelling teams

For all COVID-19 scenarios, the modelling teams submitted projections of weekly COVID-19 hospital admissions between 5 August 2024 and 1 June 2025 in the EU/EEA (either all countries or a subset). The teams were provided with historical COVID-19 hospital admissions by age group since 2020 from the ERVISS GitHub repository [45] for model calibration.

Influenza hospital admissions data with sufficient geographical coverage were not available, as only eight EU/EEA countries reported this indicator for the baseline seasons. Therefore, for influenza we focused on a proxy indicator – referred to as 'influenza-like illness +' (ILI+) – that we could compute for 26 EU/EEA countries, which allowed us to compute the relative reduction in influenza hospitalisations retrospectively. For all of the influenza scenarios, modelling teams submitted weekly estimates of ILI+ incidence between 5 August 2024 and 1 June 2025 in the EU/EEA (either all countries or a subset). ILI+ in week t ($ILI_+(t)$) was calculated as:

$$ILI_+(t) = ILI(t) \times \frac{Positivity_{Influenza}(t)}{100},$$

where $ILI(t)$ is the reported number of ILI consultations in week t, and $\text{Positivity}_{\text{Influenza}}(t)$ is the influenza test positivity as a percentage in week t, calculated from pathogen testing data of national surveillance systems. For most countries, ILI consultations were given per 100 000 population; however, Cyprus, Luxembourg, Malta and Finland expressed this data relative to consultations [53]. However, as this analysis exclusively computes relative reductions in hospitalisation burden, the denominator cancels out mathematically.

Influenza test positivity was obtained by dividing the number of influenza positive tests by the total number of tests performed for influenza. Sentinel surveillance data were used for influenza test positivity; in countries where these were not available (Malta, Iceland, Croatia, Romania, Latvia and Finland), non-sentinel data were used instead.

The rationale for using ILI+ instead of ILI lies in the increased non-specificity of ILI following the arrival of SARS-CoV-2. Weekly, country-specific ILI consultation rates (by age group) and influenza test positivity (aggregated over all ages) were sourced from the ERVISS GitHub repository [45]. Computed ILI+ consultation rates over the 2017–2018, 2018–2019, and 2023–2024 seasons were provided to the modelling teams for model calibration.

The submitted COVID-19 and influenza projections and estimates were specifically for the population aged 65 years old and above, and disaggregated by vaccination status.

Estimation of averted hospitalisation burden and ensemble estimates

Vaccination impact was assessed by estimating relative averted hospitalisations in Scenarios A to D versus the corresponding counterfactual scenarios that assumed no vaccination (Scenarios E or F). Specifically, Scenarios A and C were compared with Scenario E, which shares the same biological assumptions (i.e. typical transmission potential for influenza and optimistic waning for COVID-19). Scenarios B and D were compared with Scenario F, which shares the assumptions of higher influenza transmission potential and more pessimistic waning of COVID-19 immunity. Hospitalisation burden was calculated as a cumulative figure for the duration of the period being assessed (5 August 2024 to 1 June 2025).

For COVID-19, the relative difference in averted hospitalisations for the age group 65 years old and above was computed, for each country and each model, as:

$$\Delta H^{COVID}{}_S = 100 \times \frac{H_{CF} - H_S}{H_{CF}}$$

where *S* represents Scenario A, B, C or D, and *CF* is the corresponding counterfactual scenario that assumes no vaccination.

For influenza, modelling teams submitted estimates of ILI+ incidence, representing the estimated rate of symptomatic influenza cases per 100 000 population. From this quantity, relative reductions in influenza hospitalisations can be calculated because ILI+ incidence was submitted disaggregated by vaccination status, and because a key unknown quantity (probability of hospitalisation of an ILI+ case) cancels itself out. We show this below where we describe the required steps for this calculation.

As a first step, we converted ILI+ incidence for the age group 65 years old and above into the total number of ILI+ cases during the period being assessed to obtain the absolute cumulative number of cases by vaccination status in that age group. We denote this quantity for this age group with ${C^{Vax}}_S$ (${C^{NoVax}}_S$), where *S* denotes a given scenario, superscript *Vax* denotes cases in the vaccinated group, and superscript *NoVax* denotes cases in the unvaccinated group.

Next, we computed the absolute number of hospitalisations in this age group by multiplying the absolute cumulative number of ILI+ cases with the probability of hospitalisation of an unvaccinated ILI+ case. For cases occurring in the vaccinated group, the probability of hospitalisation was further multiplied by one minus the reduction in hospitalisation risk if a breakthrough infection occurred ($VE_{H|B}$). Thus, hospitalisations in the unvaccinated group are given as ${C^{NoVax}}_S \nu_{NoVax}$, where ν_{NoVax} denotes the probability of hospitalisation of an unvaccinated ILI+ case. Hospitalisations in the vaccinated groups are given as ${C^{Vax}}_S (1 - VE_{H|B}) \nu_{NoVax}$. The reduction in hospitalisation risk if a breakthrough infection occurred is given as $VE_{H|B}$= 1 - [(1 - VE_H) / (1 - VE_S)], where VE_H is vaccine effectiveness against hospitalisation, and VE_S is vaccine effectiveness against symptomatic cases. Assuming VE_H=60% and VE_S=40%, based on available literature [33-35], we obtain $VE_{H|B}$=33%.

Next, we computed the relative reduction in hospitalisations between scenario *S* and its corresponding counterfactual scenario *CF*, as follows:

$$\Delta H^{Influenza}{}_S = \frac{{C^{Vax}}_S (1 - VE_{H|B}) \nu_{NoVax} + {C^{NoVax}}_S \nu_{NoVax}}{{C^{Total}}_{CF} \nu_{NoVax}}$$

where ${C^{Vax}}_S$ and ${C^{NoVax}}_S$ represent the cumulative number of vaccinated and unvaccinated ILI+ cases, respectively, occurring during the period being assessed in scenario *S*. $VE_{H|B}$ is the vaccine effectiveness against hospitalisation if a breakthrough infection occurred, ${C^{Total}}_{CF}$ is the total cumulative number of ILI+ cases in the counterfactual scenario, and ν_{NoVax} is the probability of hospitalisation of an unvaccinated ILI+ case. Following our scenario definitions, Scenario E was the counterfactual (representing no vaccination) for Scenarios A and C, and Scenario F was the counterfactual for Scenarios B and D.

Next, we noted that the probability of hospitalisation of an unvaccinated ILI+ case cancels out from the above equation, as it appears as a common factor across all expressions. In lieu of influenza hospitalisation data, this method provided a rational approach to estimate relative reductions in influenza hospitalisations based on proxy primary care incidence estimates in older adults for each model and each country, relying solely on the assumed VE against hospitalisation and symptomatic infection.

Ensemble estimates were generated by aggregating the individual modelling teams' estimates for a given quantity in question (e.g. percentage of averted hospitalisations for COVID-19) using empirical cumulative distribution functions (ECDFs). Each model's ECDF was weighted via a linear opinion pool [16,54]:

$$F_{Ensemble}(x) = \sum_{m \in M} w_m F_m(x)$$

A trimming procedure was applied to identify outliers before computing the ensemble. Specifically, a model's estimate x_m was considered an outlier if it satisfied the following condition:

$$x_m < Q_1 - 1.5 \times IQR \vee x_m > Q_3 + 1.5 \times IQR$$

where Q_1 is the first quartile, Q_3 is the third quartile, and IQR is the interquartile range computed over all model submissions. Outliers received zero weight ($w_m = 0$); all others were equally weighted. From the final ensemble ECDF, 300 samples were drawn to estimate the ensemble distribution of relative averted hospitalisations for both diseases.

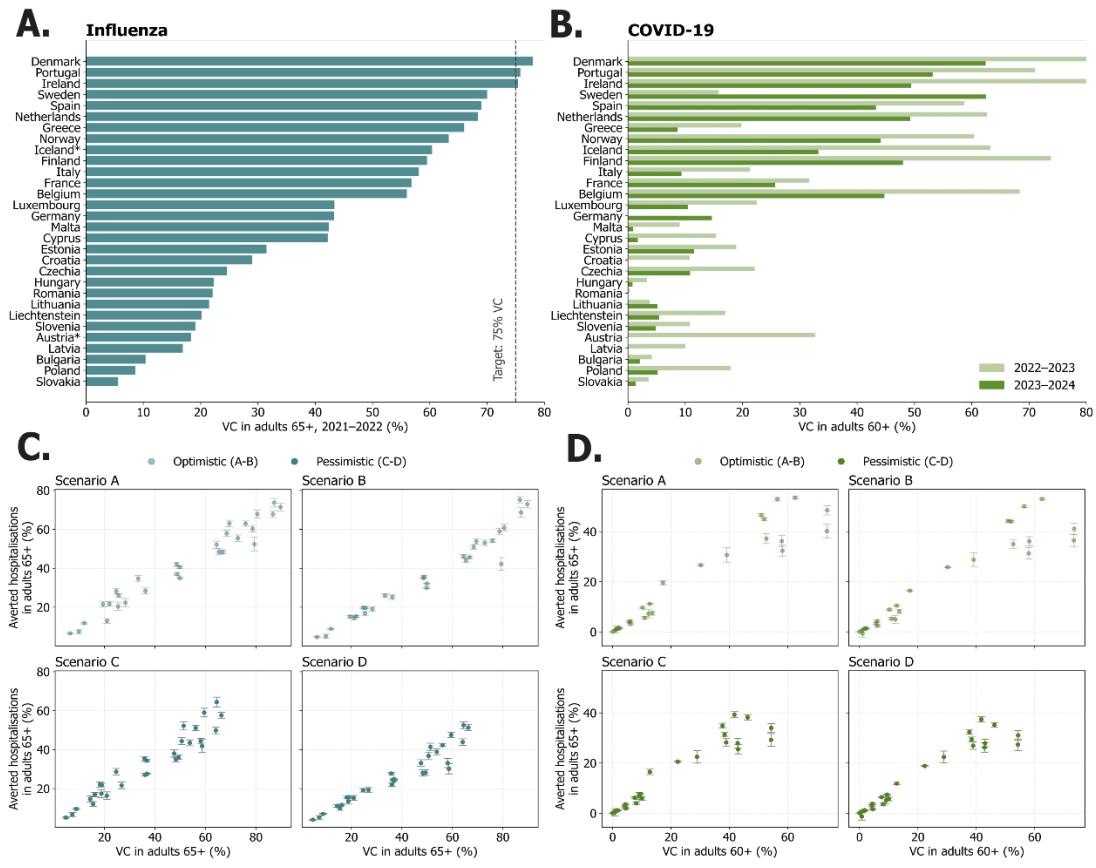
In summary, we first computed the distribution of averted hospitalisations for each model across different scenarios. We then aggregated the individual models' estimates by constructing an ensemble distribution using a trimming procedure. Finally, we sampled from this ensemble distribution to obtain estimates of relative averted hospitalisations.

Standard errors associated with the mean of a quantity x (i.e. averted hospitalisations, as shown in Figures 2C and 2D in the Results section) were computed as $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$, where σ is the standard deviation of the sample and n is the sample size.

Results

Ensemble estimates of averted hospitalisations for individual countries across scenarios are shown in Figure 2 (Figure 2C for influenza and and Figure 2D for COVID-19). Figure 2 also presents the reported influenza and COVID-19 vaccine coverage, by country, for the most recent season with available data (Figure 2A for influenza and 2B for COVID-19; vaccine coverage details are given in Box 2); coverage varied substantially across European countries. Table 1 shows a high-level summary of average averted hospitalisations across countries for the different scenarios. In the Annex, Tables 1A and 2A offer country-specific estimates of averted hospitalisations under the individual scenarios.

Figure 2. Vaccine coverage and estimated averted hospitalisations for influenza (A, C) and COVID-19 (B, D) across EU/EEA countries



VC: vaccine coverage.

Top panels show reported vaccine coverage for influenza (A) and COVID-19 (B), highlighting substantial variability between countries. Panel A presents influenza coverage in older adults (65 years old and above) for the 2021–2022 season; for countries marked with an asterisk (*), we used data from an earlier season (Austria: 2018–2019; Iceland: 2020–2021). The dashed line represents the EU target of 75% coverage in older adults [2]. Panel B shows COVID-19 booster coverage in adults 60 years old and above for the 2022–2023 season (striped bars) and the 2023–2024 season (solid bars), illustrating a decline across most countries. Bottom panels (C, D) display the relationship between vaccine coverage and ensemble estimates of averted hospitalisations across the four modelled scenarios. Each point represents a country's mean estimate; error bars indicate ±1.96 standard error from the mean.

Box 2. Vaccine coverage details

Influenza vaccine coverage among adults 65 years old and above in the most recent available season (2021–22 for most countries; 2018–19 for Austria and 2020–21 for Iceland) ranged from 6% to 78%, with a median of 43%. Only three countries – Denmark, Portugal and Ireland – met the European Union target of 75% vaccine coverage for key target groups such as older adults [2].

COVID-19 vaccine coverage among adults 60 years old and above during the 2023–24 season also showed significant variability, ranging from <1% to 64%, with a median coverage of 11%. Notably, nine countries (Bulgaria, Cyprus, Hungary, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia) reported coverage levels of 5% or below. Figure 2B also shows the declining trend in COVID-19 vaccine coverage. In nearly all countries, the coverage observed in the 2023–24 season was lower than in the 2022–23 season. These data formed the basis for pessimistic (-15%) and optimistic (+15%) coverage levels assumed in the modelled scenarios.

Table 1. Estimated average percentages of hospitalisations averted by seasonal vaccination programmes for influenza and COVID-19 under four scenarios, based on ensemble estimates, EU/EEA, 2024/25

Scenario	Average averted hospitalisations across countries	Minimum–maximum range across countries
Influenza		
***A** (Higher Coverage, Typical Transmission)*	41%	7–74%
***B** (Higher Coverage, Higher Transmission)*	36%	5–75%
***C** (Lower Coverage, Typical Transmission)*	32%	5–64%
***D** (Lower Coverage, Higher Transmission)*	26%	4–52%
COVID-19		
***A** (Higher Coverage, Optimistic Waning)*	20%	<1–54%
***B** (Higher Coverage, Pessimistic Waning)*	19%	<1–53%
***C** (Lower Coverage, Optimistic Waning)*	15%	<1–39%
***D** (Lower Coverage, Pessimistic Waning)*	14%	<1–37%

Average and minimum-maximum ranges of mean estimates of averted hospitalisations over all countries are reported.

For influenza, vaccination in autumn/winter 2024 was projected to prevent, on average across all countries, between 26% and 41% of influenza-related hospitalisations among individuals 65 years old and above throughout the 2024/25 epidemiological season. The expected reduction in hospitalisations was lower in the high transmissibility scenarios (Scenarios B and D) compared with the typical transmissibility scenarios (Scenarios A and C) when evaluated using the same vaccine coverage. Differences in assumed influenza transmission potential had a smaller impact on estimated hospitalisations compared with assumed differences in vaccination uptake. We emphasise that these are relative averted burdens, calculated with respect to counterfactual Scenarios E and F, which assume no vaccination but the same corresponding transmission potentials.

A consistent pattern in country-level estimates of averted influenza hospitalisations can be observed in Figure 2C. The five countries with the highest vaccination coverage (>68% coverage) among adults 65 years old and above experienced the greatest benefit, with an estimated average reduction in hospitalisations of 45% to 67% (depending on the scenario) in this age group compared with the counterfactual scenarios that assumed no vaccination. Approximately 40% of countries with moderate coverage levels (42–68%) experienced an average reduction in hospitalisations of 32% to 50%, depending on the scenario. In contrast, the remaining countries with lower coverage (<32%) showed only a limited reduction in hospitalisations, averaging 12% to 20%.

For COVID-19, vaccination in autumn/winter 2024 was projected to prevent, on average across countries, 14% to 20% of COVID-19 hospitalisations among individuals 65 years old and above during winter and spring 2024/25, depending on the assumed scenario (see Table 1). As with influenza, the estimates of averted burden show greater variation across scenarios with different coverage levels than between those with differing biological assumptions (i.e. waning immunity scenarios, see Table 1). Figure 2D shows heterogeneity across countries. The five countries with the highest vaccine coverage (>49%) achieved an average of 30% to 42% reduction in hospitalisations, depending on the scenario. In contrast, approximately 70% of countries with the lowest coverage (<33%) experienced minimal benefit, with an average reduction of just 4% to 7%, depending on the scenario.

Discussion

This multi-model analysis estimated the impact of influenza and COVID-19 vaccination on hospitalisation burden among older adults in the EU/EEA using an ensemble approach. The results reveal a marked heterogeneity of the impact of influenza and COVID-19 vaccination between countries.

Countries with higher vaccination coverage consistently achieved large reductions in hospitalisations among older adults, while those with moderate or low coverage saw only modest or minimal benefits. This pattern was evident for both influenza and COVID-19, with the contrast particularly pronounced for COVID-19.

These findings have direct policy implications for public health authorities and decision-makers responsible for optimising and justifying vaccination strategies, procurement and allocation. First, the observed variation in impact of vaccination underscores a missed opportunity to reduce hospital burden through both long-established programmes like seasonal influenza vaccination and newer strategies like COVID-19 vaccination. Second, these results provide a structured, data-driven foundation for national decision-making on vaccine procurement, allocation and communication strategies, helping policymakers assess the trade-offs between vaccine investments and expected health benefits. In particular, by translating vaccine effectiveness into population-level burden reduction, this analysis has the potential to directly support national and subnational cost-benefit assessments that often inform policy recommendations, making a stronger case for sustained or increased investment in vaccination programmes in Europe. Beyond its policy relevance, this study also establishes a methodological foundation for assessing other respiratory interventions, such as vaccination programmes for respiratory syncytial virus (RSV) or pneumococcal disease.

As with all modelling studies, this analysis has limitations. The results are contingent on assumed vaccine effectiveness (VE), transmission dynamics and immunity waning patterns, which are subject to uncertainties. While a collaborative modelling approach has its advantages, it also demands a pragmatic and simplified approach to model assumptions to allow multiple modelling teams to adhere to shared modelling conditions. In this study we used single-point estimates for VE supported by the literature. However, this approach does not address the potential for VE to vary from season to season, nor does it reflect uncertainty around VE point estimates. This approach does not capture the variability introduced by this uncertainty, and differentially impacts scenario estimates for influenza hospitalisations when compared with COVID hospitalisations.

While our analyses utilised directly reported COVID-19 hospitalisation data, influenza hospitalisations were derived through calculation by utilising proxy primary care incidence (ILI+) – a calculation relying on fixed-point estimates for both VE against symptomatic cases and VE against hospitalisation, given a breakthrough symptomatic infection. While this limitation exists, it is partially mitigated by the study's design. By using a multi-model ensemble approach, the analysis incorporates a range of structural and parameter assumptions from different models that determine how single VE assumptions translate into viral circulation and severe outcomes. A future round of scenarios could specifically address sensitivity of model outcomes by exploring different VE values in different scenarios. Differences in national healthcare systems, surveillance systems and data availability may also introduce variability not fully captured by the models.

Despite these limitations, this study provides robust, policy-relevant evidence estimating the population-wide impact of vaccine coverage for both influenza and COVID-19. As seasonal respiratory viruses continue to pose a substantial burden on healthcare systems, up-to-date assessment of real-world vaccination programmes in the EU/EEA remains a key public health priority. Although results were obtained for a specific season (winter 2024/25), their relevance for future years likely differs for influenza and COVID-19. For influenza, the model components used are not season-specific, so the findings are likely to remain broadly generalisable, provided there are no major shifts in population immunity, circulating strains or vaccine characteristics. For COVID-19, where a predictable seasonal pattern of transmission has not been established, the outlook is more dynamic. Realistic vaccine coverage and patterns of circulation may continue to evolve, which will impact population immunity and the underlying epidemiological conditions. This potential variability warrants more frequent multi-model analyses like this one for COVID-19 to ensure that policy decisions are based on the most current evidence.

ECDC assessment and conclusions

This analysis quantifies the contribution of vaccination in reducing COVID-19 and influenza hospitalisation burden among older adults (65 years old and above) across the EU/EEA. Employing a multi-model collaborative scenario approach allowed for deliberate and structured consideration of key uncertainties, like those related to natural immunity, epidemiological variability or immunity waning.

Nonetheless, significant data gaps remain. Most contributing models submitted results for only a subset of EU/EEA countries due to incomplete reporting or insufficient surveillance data. This may introduce biases and limit the generalisability of our findings. Addressing such data gaps through strengthened surveillance infrastructure and improved data harmonisation remains a critical priority for future work.

The implications of our results directly relate to vaccination programme management and health communication across the EU/EEA. The comparable relative hospitalisation reductions observed for influenza and COVID-19 vaccination underscores the importance of maintaining robust vaccination programmes for both diseases. Public health communication strategies may benefit from explicitly communicating the substantial hospitalisation reductions achievable through even modest increases in vaccine coverage, potentially counteracting vaccine fatigue and complacency. These findings can also inform long-term planning and resource allocation by illustrating the direct relationship between vaccine coverage and reduced healthcare burden.

Our findings offer input for subsequent economic evaluations conducted locally, including cost-effectiveness analyses, which may guide investments in influenza and COVID-19 vaccination programmes. The combination of a multi-model ensemble approach and structured scenario analysis provides a scalable framework that can be adapted to evaluate a range of vaccination programmes beyond influenza and COVID-19 in the European context.

Looking ahead, ECDC plans to leverage the analytical framework established here to explore the public health impact of newly available RSV immunisation strategies across the EU/EEA. Additionally, applying this robust, scenario-driven modelling approach to emerging respiratory threats can significantly enhance preparedness and response capabilities, further strengthening the EU/EEA's resilience against respiratory disease burdens.

Contributors

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Annex. Country-specific ensemble estimates

Table 1A. Country-specific ensemble estimates of averted influenza-related hospitalisations under the different scenarios

Country	Coverage	Averted influenza hospitalisations (mean ± 1.96 SE)			
		Scenario A (Optimistic)	Scenario B (Optimistic)	Scenario C (Pessimistic)	Scenario D (Pessimistic)
Denmark	78%	71±2	73±2	58±2	51±1
Portugal	76%	74±2	69±2	64±3	53±2
Ireland	75%	68±2	75±2	50±2	44±2
Sweden	70%	68±2	61±2	59±2	48±1
Spain	69%	52±4	42±3	42±3	30±3
Netherlands	68%	60±2	59±2	44±1	33±2
Greece	66%	63±1	54±1	51±1	42±1
Norway	63%	55±2	53±1	44±2	39±1
Iceland	60%	63±2	54±2	52±2	41±2
Finland	60%	58±2	51±1	44±2	37±2
Italy	58%	48±1	46±1	36±1	28±1
France	57%	48±2	44±1	35±1	28±2
Belgium	56%	52±2	46±1	38±2	33±2
Luxembourg	43%	35±0	32±0	28±0	25±0
Germany	43%	41±1	30±0	34±1	24±0
Malta	42%	37±1	36±1	27±1	22±1
Cyprus	42%	42±1	35±1	35±1	28±1
Estonia	32%	28±2	25±1	22±2	19±1
Croatia	29%	35±2	26±1	29±2	19±1
Czechia	25%	22±2	19±1	16±2	15±1
Hungary	22%	26±1	20±0	22±1	16±0
Romania	22%	20±2	17±1	17±2	13±1
Lithuania	21%	28±2	20±1	22±1	16±1
Slovenia	19%	22±1	15±1	17±1	12±0
Austria	18%	13±1	15±1	12±1	10±1
Latvia	17%	21±1	15±1	15±2	11±1
Bulgaria	10%	12±0	9±0	10±0	7±0
Poland	9%	7±1	5±1	7±1	5±1
Slovakia	6%	7±0	5±0	5±0	4±0

SE: standard error.
Ensemble estimates are expressed as percentage differences relative to the counterfactual scenarios without vaccination. Estimates are reported as mean ± 1.96 SE, as computed by the ensemble of models. Countries are listed from highest to lowest influenza vaccine coverage during the 2021/22 season (which served as the reference for defining coverage levels in the various scenarios).

Table 2A. Country-specific ensemble estimates of averted COVID-19 hospitalisations under the different scenarios

Country	Coverage	Averted COVID-19 hospitalisations (mean ± 1.96 SE)			
		Scenario A (Optimistic)	Scenario B (Optimistic)	Scenario C (Pessimistic)	Scenario D (Pessimistic)
Sweden	64%	48±2	41±2	34±2	31±2
Denmark	64%	40±3	36±2	29±3	27±2
Portugal	54%	54±0	53±0	38±1	35±1
Ireland	51%	32±2	36±2	25±2	28±2
Netherlands	50%	36±2	31±2	28±2	26±2
Finland	49%	53±1	50±0	39±1	37±1
Belgium	46%	37±2	35±2	28±2	27±1
Norway	45%	45±0	44±0	31±1	29±1
Spain	44%	47±1	44±0	35±1	32±1
Iceland	34%	31±3	29±3	22±2	22±2
France	26%	27±0	26±0	21±0	19±0
Germany	15%	20±1	16±0	16±1	12±0
Estonia	12%	7±1	8±1	6±1	6±1
Czechia	11%	11±0	10±0	8±0	7±0
Luxembourg	11%	7±2	5±2	7±1	5±1
Italy	10%	6±1	5±1	4±0	4±0
Greece	9%	10±0	9±0	6±0	6±0
Poland	5%	3±0	2±0	2±0	2±0
Lithuania	5%	4±0	4±0	4±0	4±0
Slovenia	5%	4±0	3±0	3±0	3±0
Bulgaria	2%	1±0	1±0	1±0	1±0
Cyprus	2%	2±0	1±0	1±0	1±0
Slovakia	1%	1±0	1±0	1±0	1±0
Malta	1%	1±1	<1±2	<1±2	<1±1
Hungary	1%	1±0	1±0	1±0	1±0
Romania	0%	<1±0	<1±0	<1±0	<1±0

SE: standard error.
Ensemble estimates are expressed as percentage differences relative to the counterfactual scenarios without vaccination. Estimates are reported as mean ± 1.96 SE, as computed by the ensemble models. Countries are listed from highest to lowest COVID-19 vaccine coverage during the 2023/24 season (which served as the reference for defining coverage levels in the various scenarios).