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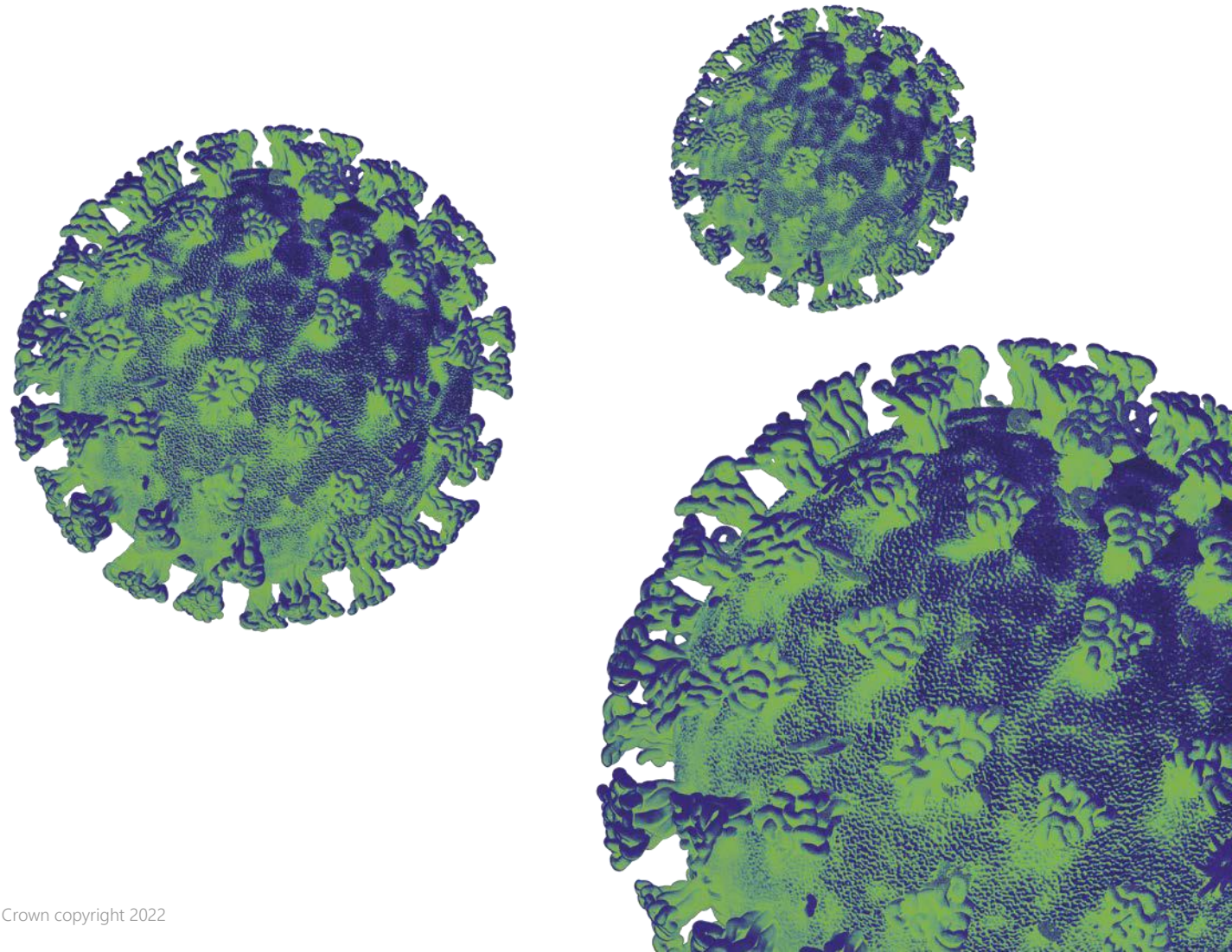
Technical Advisory Group

Modelled Levels of Protection Against COVID-19 Infection and Severe Disease in Wales

28 June 2022



Modelled Levels of Protection Against COVID-19 Infection and Severe Disease in Wales

TAG Modelling Sub Cell

28 June 2022

Contents

Key points

- The objective of this paper is to estimate the proportion of the population that have a level of protection against being infected and hospitalised with COVID-19 – based on the current dominant Omicron variant. This is to inform decision-making around COVID-19 protections, preparation for the NHS in terms of the risk of a surge in COVID-19 admissions, and vaccination programme.
- In Wales, 69% [54%, 84%] of people aged 12 and over were estimated to have some protection against COVID-19 infection at 2 April 2022, compared with 0% before the pandemic.
- Protection levels varied across age groups. The highest protection against COVID-19 infection was estimated in individuals aged 20 to 59 at 78% [61%, 94%] at 2 April 2022, driven by a large increase in natural protection arising from high infection rates in early 2022 and high vaccination uptake. The lowest protection was estimated in individuals aged 0 to 19 at 40% [31%, 50%] at 2 April 2022.
- Risk of hospitalisation due to COVID-19 disease varies greatly across age groups. Individuals aged 0 to 19 were estimated to have the lowest risk of COVID-19 hospitalisation with only 0.1% of individuals estimated to be at-risk at 2 April 2022, compared with 0.2% at the start of the pandemic. Individuals aged 60 and over were estimated to have the highest risk of COVID-19 hospitalisation with 1.7% of individuals estimated to be at-risk at 2 April 2022, compared with 25.1% at the start of the pandemic.
- Averaged over the Welsh population, 0.6% [0.2%, 0.9%] of people aged 12 and over were estimated to be at-risk of COVID-19 hospitalisation at 2 April 2022, compared with 9.3% at the start of the pandemic.[1]
- Put another way, 99.4% [99.1%, 99.8%] of people aged 12 and over in Wales were estimated to have some protection against COVID-19 hospitalisation at 2 April 2022. In comparison, at the start of the pandemic, it was estimated that 90.7% of people aged 12 and over would not have been at-risk of COVID-19 hospitalisation.
- Protection levels in the population increased significantly throughout spring to September 2021 due to the initial vaccine rollout. Protection estimates received another significant boost in early 2022 due to natural protection being built from high infection rates, vaccine boosters reducing the effect of waning protection from the initial vaccine rollout and changes to vaccination policy for younger children.
- A scenario analysis was conducted in which protection was assumed to wane after 9 months from 100% to 35% (following an effective Pfizer or Moderna vaccination, or COVID-19 infection) or 43% (following an effective AstraZeneca vaccination), rather than waning to 0% as in the main analysis.

[1] Calculated using the admission/infection ratio by age group in England October to November 2020. The proportion of infections that led to COVID-19 admissions varied from 0.2% in 0 to 17 year olds, to 35.4% in those aged 70 years and over.

Additionally, it was assumed that from 1 March 2022, 5% of infections were captured by a COVID-19 PCR test, down from 19% as in the main analysis.

- In this scenario analysis, 81% [63%, 99%] of individuals aged 12 and over in Wales were estimated to have protection against COVID-19 infection at 2 April 2022, compared with 69% [54%, 84%] in the main analysis.

Background

During the two years of the COVID-19 pandemic in Wales, people have been protected by vaccinations[2] and natural protection, which has built up in the population following infection with SARS-CoV-2. Upon infection with SARS-CoV-2, individuals could become ill and develop the symptoms and disease of COVID-19.

The vaccination rollout launched in December 2020 in priority group order. Prioritisation for the vaccine rollout was based on COVID-19 disease risk groups. Since COVID-19 disease risk was identified to increase with age, this led to older age groups being among the top priority groups (along with vulnerable groups, care home residents and healthcare workers) upon vaccination launch. In the first two months of the vaccination rollout to 7 February 2021, 50% of individuals aged 60 and over received a first vaccination dose. In contrast, 12% of individuals aged 20-59 received a first vaccination dose in the first two months of rollout. By the end of May 2021, 90% of individuals aged 60 and over, and 23% of individuals aged 20-59, had received two vaccine doses.

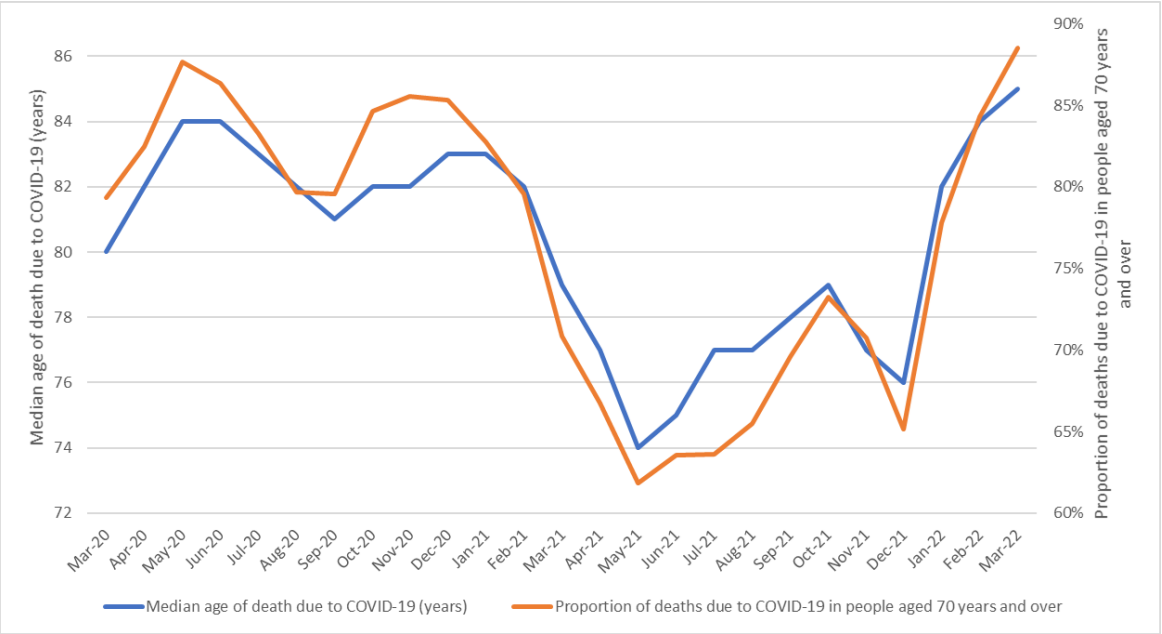
The proportion of deaths due to COVID-19 occurring in people aged 70 years and over decreased from 86% in November 2020 before the vaccine rollout, to 80% in February 2021 and decreased further to 62% by May 2021 (Figure 1). Similarly, the median age of death of people who died from COVID-19 disease decreased from 82 years in November 2020 before the vaccine rollout, to 74 years in May 2021 (Figure 1). The reduction during 2021 of the proportion of COVID-19 deaths occurring in people aged 70 years and over and the median age of people who died of COVID-19 may indicate that vaccination of older age groups successfully reduced COVID-19 mortality in older people in 2021. A smaller, similar effect can be observed in late 2021 which may be due to the autumn booster campaign that prioritised older age groups.

The proportion of deaths due to COVID-19 occurring in people aged 70 years and over and the median age of those dying from COVID-19 decreased from October 2021 to December 2021, which corresponded to older people receiving their vaccine booster and restoration of protection that had waned during 2021. The proportion of deaths due to COVID-19 occurring in people aged 70 years and over and the median age of those dying from COVID-19 has been increasing since December 2021, indicating that protection may be waning in older age groups. In March 2022, the government announced plans to offer a spring booster to those aged 75 years

[2] In this paper, “vaccinations” refer to COVID-19 vaccinations. Vaccination with Oxford-AstraZeneca, Pfizer-BioNTech and Moderna vaccines are included in this model. Other COVID-19 vaccinations and vaccines administered during clinical trials are excluded from this analysis.

and over and older residents in care homes to boost protection against COVID-19 mortality.[3]

Figure 1: Median age of death of people whose death was due to COVID-19 and proportion of deaths due to COVID-19 in people aged 70 years and over, England and Wales, deaths registered in March 2020 to March 2022

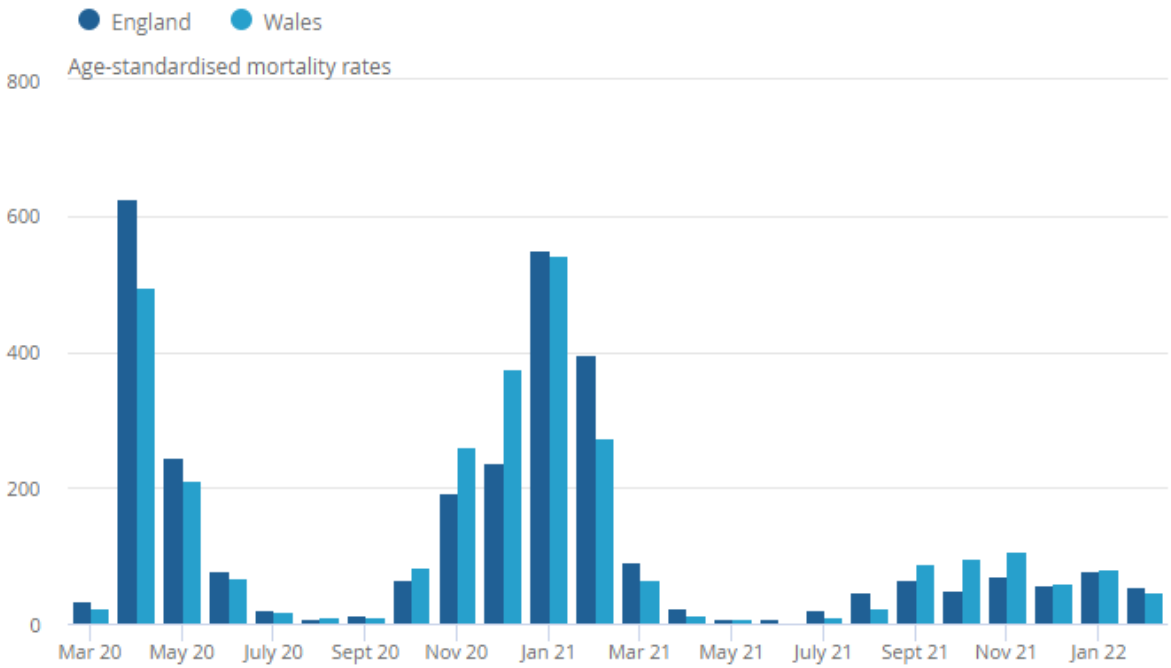


Source: [Single year of age and average age of death of people whose death was due to or involved COVID-19 - Office for National Statistics (ons.gov.uk)]

Additionally, there is evidence that COVID-19 mortality has generally decreased since the start of the pandemic, due to increased protection from vaccination, natural protection following infection and improved COVID-19 hospital treatment. Age-standardised mortality rates (Figure 2) show increases and decreases that broadly reflect rising and falling infection rates. However, although infection rates have remained high throughout winter 2021 and early 2022, COVID-19 mortality rates have remained low compared with periods of similar infection rates in 2020 and early 2021. This is likely due to increased protection from vaccination and built natural protection following infection, combined with the reduced severity of disease caused by Omicron compared with previous variants. For example, the 7-day rolling sum case rate for Wales was similar on 15 December 2020 and 15 December 2021 (620 vs 550 per 100,000 individuals). However, COVID-19 mortality was much higher on the same date in 2020 than in 2021 (375.8 vs 59.3 per 100,000 individuals).

[3] A guide to the spring booster for those aged 75 years and older and older residents in care homes - GOV.UK (www.gov.uk)

Figure 2: Age-standardised mortality rates for deaths due to COVID-19, per 100,000 people, England and Wales, deaths registered in March 2020 to February 2022



Source: [Monthly mortality analysis, England and Wales - Office for National Statistics (ons.gov.uk)]

Methods

Two analyses are presented in this paper: “protection against COVID-19 infection”, in which protection refers to individuals who are no longer able to be infected with COVID-19 (until an individual’s protection starts to wane over time) and “protection against COVID-19 hospitalisation”, in which protection refers to individuals who are modelled to be not at-risk of hospitalisation if infected with COVID-19, or put another way, individuals who have some “protection against COVID-19 hospitalisation”.

The proportion of Wales’ population with some protection again COVID-19 infection and hospitalisation between early 2020 and 2 April 2022 was estimated. In this model, individuals were considered to build protection 14 days after a COVID-19 infection or an effective COVID-19 vaccination. Individuals were modelled to remain protected for 270 days (9 months) following successful vaccination or infection. When an individual’s protection waned, they were modelled to move from the “protected” population to the “susceptible” population. See

Model assumptions for more information on waning protection assumptions.

Protection levels have been estimated for the following age groups in Wales: total population, individuals aged 12 and over, individuals aged 0 to 19, 20 to 59 and individuals aged 60 and over. Assumptions for waning protection, percentage of COVID-19 infections leading to protection, vaccine efficacy and the time it takes to build protection following a COVID-19 infection or vaccination were kept constant for all age groups.

In reality, waning protection may be different for natural infections and for different types of vaccine, and different for different age groups. In this analysis, the same waning protection assumption is applied across all age groups for infections and vaccinations as data is not yet available to separate these out.

The vaccine rollout began on 7 December 2020. *Table 1*, *Table 2* and *Table 3* report the vaccine efficacy assumptions used in the model for the central, lower and higher protection against infection estimates, respectively. *Table 4*, *Table 5* and *Table 6* report the vaccine efficacy assumptions used in the model for the central, lower and higher protection against hospitalisation estimates, respectively. In all scenarios, a 14-day time period was used to account for time between vaccine administrations and building of protection.

Table 1: Vaccine efficacy against COVID-19 Omicron infection, used for central estimate[4]

Vaccine	Reduction in risk of infection		
	First dose	Second dose	Third/booster dose
Oxford-AstraZeneca	5%	25%	25%
Pfizer-BioNTech	10%	53%	60%
Moderna	10%	53%	60%

Table 2: Vaccine efficacy against COVID-19 Omicron infection, used for lower estimate

Vaccine	Reduction in risk of infection		
	First dose	Second dose	Third/booster dose
Oxford-AstraZeneca	3%	15%	15%
Pfizer-BioNTech	5%	43%	50%
Moderna	5%	43%	50%

Table 3: Vaccine efficacy against COVID-19 Omicron infection, used for higher estimate

Vaccine	Reduction in risk of infection		
	First dose	Second dose	Third/booster dose
Oxford-AstraZeneca	8%	35%	35%
Pfizer-BioNTech	15%	63%	70%
Moderna	15%	63%	70%

[4] SPI-M-O Medium-Term Projections - 2 February 2022 (publishing.service.gov.uk)

Table 4: Vaccine efficacy against COVID-19 Omicron hospitalisation, used for central estimate[5]

Vaccine	Reduction in risk of hospitalisation		
	First dose	Second dose	Third/booster dose
Oxford-AstraZeneca	40%	75%	75%
Pfizer-BioNTech	40%	80%	95%
Moderna	40%	80%	95%

Table 5: Vaccine efficacy against COVID-19 Omicron hospitalisation, used for lower estimate

Vaccine	Reduction in risk of hospitalisation		
	First dose	Second dose	Third/booster dose
Oxford-AstraZeneca	30%	70%	70%
Pfizer-BioNTech	30%	80%	92%
Moderna	30%	80%	92%

Table 6: Vaccine efficacy against COVID-19 Omicron hospitalisation, used for higher estimate

Vaccine	Reduction in risk of hospitalisation		
	First dose	Second dose	Third/booster dose
Oxford-AstraZeneca	50%	80%	80%
Pfizer-BioNTech	50%	90%	98%
Moderna	50%	90%	98%

The following formula was used to calculate the number of people in Wales who had some protection against COVID-19 infection or hospitalisation on a given date:

Number protected against COVID-19 = **Number protected following infection** (Proportion of infections leading to protection[6]) + **Number protected following effective vaccination** (using vaccine efficacy data) - **Number protected from infection and vaccination** (to prevent double-counting of protection)

[5] SPI-M-O Medium-Term Projections - 2 February 2022 (publishing.service.gov.uk)

[6] SARS-CoV-2 infection rates of antibody-positive compared with antibody-negative health-care workers in England: a large, multicentre, prospective cohort study (SIREN) - The Lancet

Table 7: Data sources used in the model

Data source	Description
PHW vaccine data	First, second, third and booster doses by vaccine type, date of administration and age group of recipient
PHW cases data	PCR-confirmed positive coronavirus tests by date of result authorisation and age group of individual
ONS population estimates: mid-2020	Used to estimate the population size of each age group in Wales
Swansea University modelled cases	Most Likely Scenario as at November 2020 used to estimate the true number of infections between January 2020 and December 2020 before widespread community testing was available

Model assumptions

Table 1 to *Table 6* show the vaccine efficacy assumptions used in the model to determine the number of individuals that had some protection against COVID-19 infection or hospitalisation, respectively, following vaccination for the central, lower and higher protection estimates.

Protection was assumed to wane (from 100% to 0% protected) after 270 days (9 months) had passed since protection was first built. In reality, protection is not binary and would wane slowly over a period of time. Studies have reported that antibodies are detectable for at least 6 months and probably 8 months or more.[7] The SIREN study reported that a previous history of SARS-CoV-2 infection was associated with median protective effect observed 7 months following primary infection.[8] The Vivaldi study reported that natural protection against COVID-19 substantially reduced the risk of reinfection for approximately 10 months following primary infection.[9] In the Technical Advisory Group Policy Modelling Update on 30 November 2021[10], it was reported that the models Swansea University produce for Welsh Government modelling the COVID-19 pandemic had been updated to include waning protection from COVID-19 infection and vaccination. Swansea University model protection as waning 9 months following vaccination or infection. Therefore, for consistency, protection was assumed to wane after 9 months (270 days) in this analysis.

In addition to the vaccine efficacy and waning protection assumptions, Table 8 reports the assumptions applied to all age groups in the model for calculating the estimated protection against COVID-19 infection and hospitalisation in the population of Wales. *Table 9* reports additional model assumptions used for calculating the estimated protection against COVID-19 infection. Table 10 reports additional model

[7] NERVTAG: Immunity certification update, 4 February 2021 - GOV.UK (www.gov.uk)

[8] SARS-CoV-2 infection rates of antibody-positive compared with antibody-negative health-care workers in England: a large, multicentre, prospective cohort study (SIREN) - The Lancet

[9] Vivaldi 2: COVID-19 reinfection in care homes study report - GOV.UK (www.gov.uk)

[10] technical-advisory-group-policy-modelling-update-30-november.pdf (gov.wales)

assumptions used for calculating the estimated protection against COVID-19 hospitalisation.

Table 8: Model assumptions applied to all age groups in Wales to model protection against COVID-19 infection and hospitalisation

Assumption	**Value**
Population size in Wales	ONS mid-2020 population estimates[11] were used. It was assumed there had been no change in the population size of each age group. This is believed to be an under-estimate of the population
Pre-5 December 2020 proportion of infections	Proportion of cases attributed to each age group was determined as the percentage of the population in that age group
Pre-5 December 2020 number of infections	Number of infections estimated by Swansea University Epidemiological models from November 2020[12] multiplied by the assumed proportion of infections in that age group
Post-4 December 2020 number of infections	PHW ICNet cases data, excluding cases labelled as "Outside Wales" or “Unknown”, divided by the percentage of infections captured by a PCR test
Number of first and second vaccine doses administered in Wales	PHW vaccines data, excluding cases labelled as "Outside Wales" or “Unknown”
Percentage of infections captured by a COVID-19 PCR test	40%[13] up to 5 January 2022. 19%[14] from 6 January 2022 onwards
Proportion of infections that are reinfections	1.4% up to 15 November 2021. 10% from 16 November 2021 onwards[15]

[11] Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland - Office for National Statistics (ons.gov.uk)

[12] https://gov.wales/technical-advisory-cell-modelling-update-12-february-2021

[13] Approximated using the average positive test count (UK Gov dashboard, cases by specimen date) / incidence in population (ONS CIS) ratio in England for the week to 28 March 2021 (data as at 10 May 2021). England data was used as the ONS COVID-19 Infection Survey did not estimate incidence for Wales at the time due to low numbers.

[14] Approximated using the average positive test count (UK Gov dashboard, cases by specimen date) / incidence in population (ONS CIS) ratio in Wales for the week to 2 February 2022 (data as at 12 April 2022).

[15] COVID-19 daily dashboard amended to include reinfections - GOV.UK (www.gov.uk)

Length of time for protection to build following a positive PCR test result for COVID-19 infection	14 days
Length of time for protection to build following a vaccine dose	14 days
Building protection after a COVID-19 infection or effective vaccination	An individual's protection is assumed to build from 0% to 100% protected on the date modelled to build protection
Losing protection from a COVID-19 infection or effective vaccination	An individual's protection is assumed to wane from 100% to 0% protected on the date modelled to lose protection
Length of time for protection to wane	270 days (9 months)[16]
Vaccine-derived and infection-derived protection overlap assumption	A percentage of those vaccinated will have already acquired protection from a natural COVID-19 infection. The number of people moving from infection-derived protection to vaccine-derived protection is calculated as the number of people gaining protection today from a vaccination, multiplied by the current protection level from infections alone, multiplied by the percentage of people who have not already received at least one vaccine dose. This prevents double-counting of protection levels in the population from natural infection and vaccination.

Table 9: Additional model assumptions applied to all age groups in model for protection against COVID-19 infection

Assumption	**Value**
Percentage of vaccine doses that lead to protection	Vaccine efficacy assumptions in *Table 1*, *Table 2* and *Table 3*
Percentage of COVID-19 infections that lead to protection against COVID-19 infection before	19%[17] - central estimate 9% - lower estimate 29% - higher estimate

[16] technical-advisory-group-policy-modelling-update-30-november.pdf (gov.wales)

[17] Omicron largely evades immunity from past infection or two vaccine doses | Imperial News | Imperial College London

Omicron became dominant in mid-Dec 2021	
Percentage of COVID-19 infections that lead to protection against COVID-19 infection after Omicron became dominant in mid-Dec 2021 (assuming any future reinfections had Omicron primary infection)	60%[18] - central estimate 50% - lower estimate 70% - higher estimate

Table 10: Additional model assumptions applied to all age groups in model for protection against COVID-19 hospitalisation

Assumption	**Value**
Percentage of vaccine doses that lead to protection	Vaccine efficacy assumptions in *Table 4*, *Table 5* and *Table 6*
Percentage of individuals who required COVID-19 hospitalisation who will require hospitalisation if re-infected	10%[19]
Percentage of COVID-19 infections that lead to protection against COVID-19 hospitalisation before Omicron became dominant in mid-Dec 2021	50%[20] - central estimate 40% - lower estimate 60% - higher estimate
Percentage of COVID-19 infections that lead to protection against COVID-19 hospitalisation after Omicron became dominant in mid-Dec 2021 (assuming any future reinfections had Omicron primary infection)	69%[21] - central estimate 59% - lower estimate 79% - higher estimate
Likelihood of requiring hospitalisation following a COVID-19 infection at the start of the pandemic	Admission/Infection ratio for England (data not available for Wales at the start of the pandemic) by age group

[18] The model assumed that protection built following natural infection was similar to the vaccine efficacy of a third/booster dose of a Pfizer/Moderna vaccine

[19] Severity of SARS-CoV-2 Reinfections as Compared with Primary Infections | NEJM

[20] S1461_Imperial_Hospitalisation_risk_for_Omicron_cases_in_England.pdf (publishing.service.gov.uk)

[21] S1461_Imperial_Hospitalisation_risk_for_Omicron_cases_in_England.pdf (publishing.service.gov.uk)

Omicron causes less severe disease than previous variants. Severity factor of disease relative to 2 December 2021	Based on the percentage of COVID-19 admissions that are nosocomial. Calculated using PHW hospital data.

Early in the pandemic, it was identified that older age groups faced a higher risk of hospitalisation with COVID-19 than younger age groups. The number of individuals in each age group estimated to require hospitalisation if infected with COVID-19 at the start of the pandemic was calculated using the admission/infection ratio by age band using England data after mass testing was available and prior to the vaccine rollout (12/10/2020 – 11/11/2020). However, by May 2021, the admission/infection ratio had significantly decreased as protection in the population increased. Therefore, for every new COVID-19 infection, the likelihood of that individual requiring hospitalisation for COVID-19 was lower in 2021 compared with 2020 and hence the additional amount of “protection” built from a new COVID-19 infection would be less in 2021 than in 2020. The percentage of the population at-risk of hospitalisation for COVID-19 following infection from 1 May 2021 was estimated using the admission/infection ratio using England data (25/05/2021 – 24/06/2021).

This method of using ‘real world’ data on the ratio of infections to hospitalisations means that it controls, to some degree, for the finding that older people or shielding people, who are more likely be admitted once infected, may be more cautious in their behaviour, which would bias any estimate using the rate of admissions alone. However, it should be noted that this calculation assumes the risk is uniform within each age group (0 to 17, 18 to 24, 25 to 34, 35 to 49, 50 to 69, and 70 years and over), whereas in reality some individuals within each group will be at higher risk of serious illness due being clinically vulnerable. This calculation also assumes that each admission is for a unique individual. However, some individuals may be hospitalised for a primary COVID-19 infection and for a second infection. The admission/infection ratio was therefore calculated over the time period of a month to mitigate for this possibility, since it has been shown that the likelihood of reinfection is low immediately after a previous infection.

Since December 2021, the proportion of individuals admitted to hospital who test positive for COVID-19 while in-hospital (i.e. nosocomial admissions, primarily being treated for non-COVID-19 reasons) has steadily increased. This coincided with Omicron becoming dominant in the UK. It has been reported that Omicron appears to cause less severe disease than previous variants and is more transmissible, leading to high infection rates but a reduced risk of hospitalisation.

Model limitations

The number of infections prior to vaccination rollout in December 2020 were estimated by apportioning the Swansea University Nov-2020 epidemiological Most Likely Scenario model by the proportion of actual confirmed COVID-19 cases by age band. This is a limitation because cases in certain age groups are more likely to be detected than in others (i.e. older adults are more likely to be symptomatic and get tested for COVID-19 than younger adults).

There is still a large amount of uncertainty in the effectiveness of COVID-19 vaccines. When new variants arise, it can take time to gather enough data to obtain accurate vaccine efficacy estimates. Therefore, vaccine effectiveness estimates are updated frequently as new evidence becomes available and as new variants of SARS-CoV-2 appear.

Protection was assumed to increase from 0% to 100% after 14 days following either an effective vaccination or following a COVID-19 infection that leads to protection. Similarly, protection was assumed to wane from 100% to 0% after a defined number of days since last infection or vaccination. In reality, protection will build or taper over time. Additionally, the reinfection rate for Omicron appears to be higher than for previous COVID-19 variants, which makes it more challenging to estimate an individual's protection against reinfection with Omicron following a prior infection with another variant.[22]

Vaccine-derived protection was assumed to wane after the same time period as protection from natural infection. However, it is likely that vaccine-derived protection will wane earlier as most vaccines target the spike protein whereas natural infection gives a broader repertoire of responses to fight the virus.

In this analysis, individuals were not followed day-by-day; individuals were modelled as a proportion of the population. Therefore, this model produced protection estimates as an average for the population. In reality, protection will vary between individuals – an individual may be less likely to be infected after exposure or vaccination, but it will depend on many factors, such as how many times they encounter an infectious individual, what kind of contact they have and what viral load the infectious individual has. Being exposed to the virus may boost protection in individuals without them becoming infected. So an individual may have 60% protection, but this may not be the same as 60% of a population being protected.

[22] COVID-19 daily dashboard amended to include reinfections - GOV.UK (www.gov.uk)

Results

Vaccination status

Figure 3: Vaccination uptake of first, second and third/booster doses for individuals aged 12 and over in Wales, to 2 April 2022

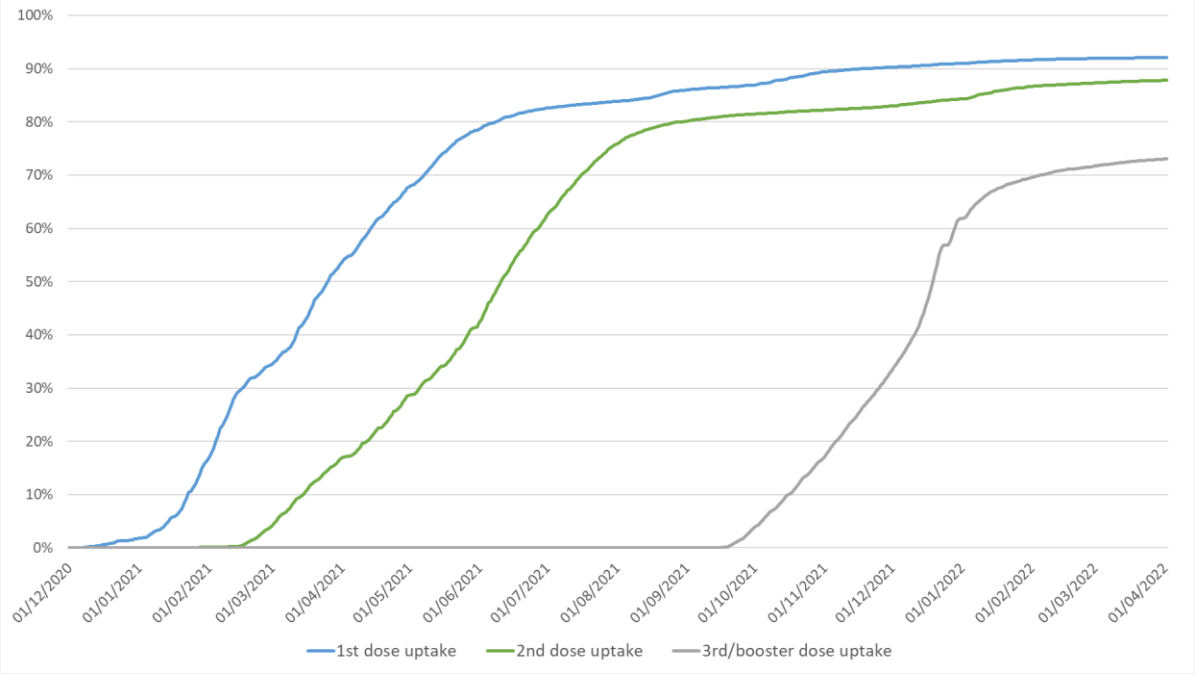
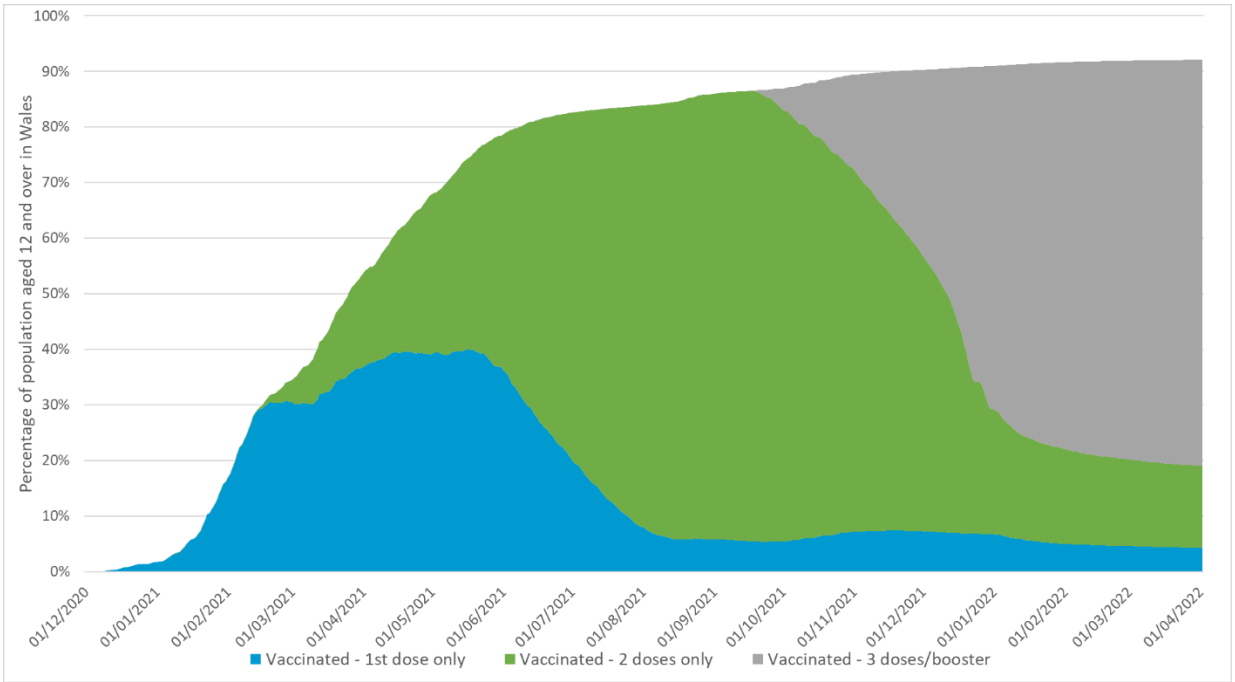


Figure 3 shows that administration of first COVID-19 vaccine doses for those aged 12 and over in Wales slowed shortly after vaccinations were opened to the final age group (aged 18 and over) in May 2021. In autumn 2021, the autumn booster campaign launched and third dose uptake sharply increased throughout late 2021 before slowing in 2022. At 2 April 2022, 88% of people aged 12 and over had received a second dose, and 73% had received a third/booster dose, although uptake appears to be plateauing.

Figure 4: Vaccination status of individuals aged 12 and over in Wales, to 2 April 2022



The slowing of first dose administration in summer 2021 can be observed in *Figure 4* by the blue wedge, which tapered down as a higher percentage of individuals received their second vaccine dose. Similarly, the launch of third dose and booster administration can be observed in late 2021 by the increase in size of the grey wedge. As at 2 April 2022, 92% of people aged 12 and over had received at least one COVID-19 vaccine dose in Wales; 4% of people aged 12 and over had exactly one vaccine dose, 15% had exactly 2 vaccine doses and 73% had received a third or booster vaccine dose.

Protection against COVID-19 infection estimates

Table 11 shows that 69% of individuals aged 12 and over in Wales and 63% of the total population in Wales were estimated to have protection against COVID-19 infection as at 2 April 2022.

Table 11: Protection against COVID-19 infection estimates as at 2 April 2022 in Wales

Age group	Protection [lower, upper] estimate	Percentage vaccinated with a 3rd/booster dose
0-19	40% [31%, 50%]	7%
20-59	78% [61%, 94%]	69%
60+	54% [41%, 67%]	99%
Total (all ages)	63% [49%, 77%]	63%
Total (12+)	69% [54%, 84%]	73%

Figure 5: Protection against COVID-19 infection estimates, individuals aged 12 and over in Wales, to 2 April 2022

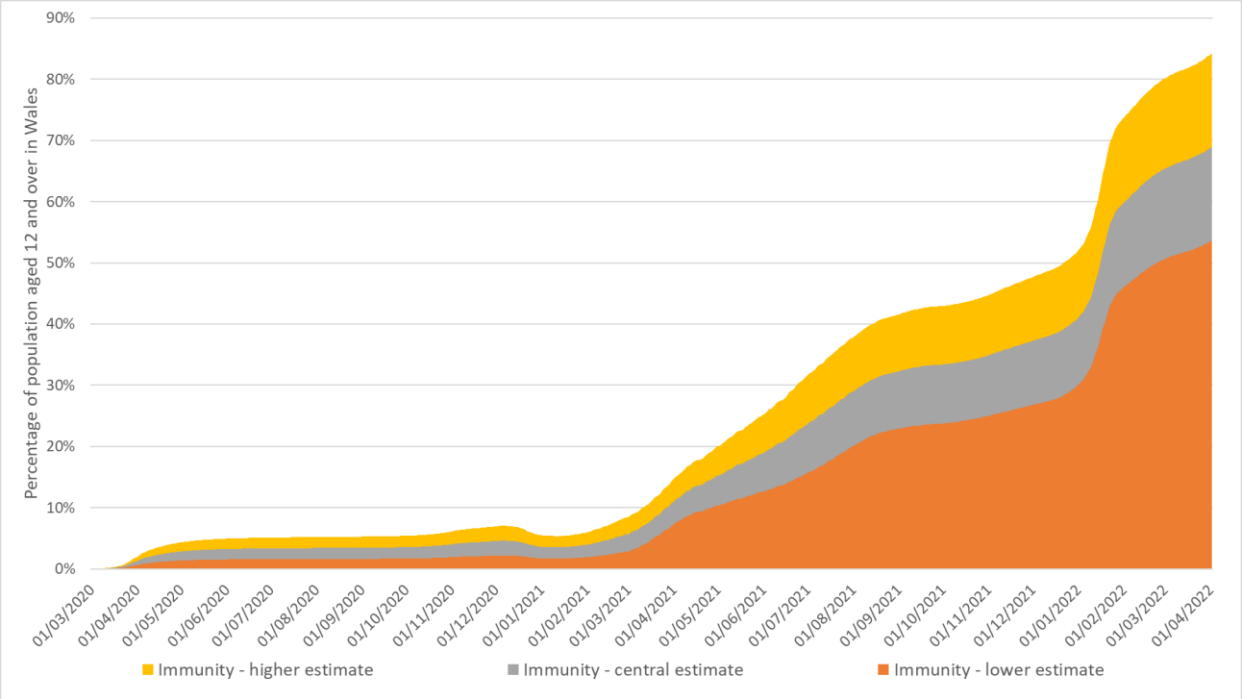


Figure 5 shows how the percentage of individuals aged 12 and over in Wales estimated to have protection against COVID-19 infection has changed over time. The estimated protection level significantly increased during 2021 following the launch of the vaccination programme in December 2020. Protection arising from high infection rates drove an increase in the estimated protection level in early 2022. At 2 April 2022, 69% [54%, 84%] of individuals aged 12 and over in Wales were estimated to have protection against COVID-19 infection, compared with 5% at the time of vaccination launch in December 2020.

Figure 6: Protection against COVID-19 infection estimates, individuals in Wales, by age group, to 2 April 2022

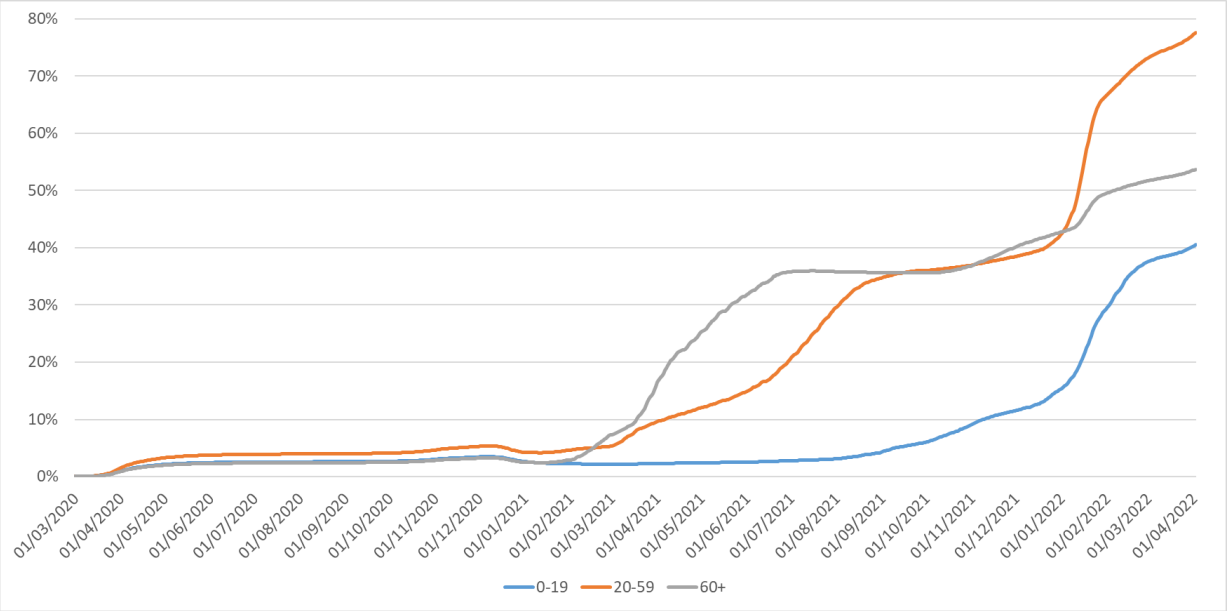


Figure 6 shows how protection levels changed in different age groups in Wales over time. Sharp increases in protection in individuals aged 60 and over during early 2021 reflect vaccine first dose uptake upon vaccination launch, which focused on the first priority groups (generally older age groups). Protection in the middle age group started to significantly increase in summer 2021 after lower priority groups were targeted in the vaccination rollout. Changes in COVID-19 vaccination policy from late 2021 drove increases in protection in the 0-19 year-old age group as first doses (and later, second doses) were offered to younger children.[23]

Evidence shows that infection with a previous variant offers limited protection against future infection with Omicron.[24] This, combined with easing of non-pharmaceutical interventions, drove COVID-19 infection rates to record highs in 2022 after Omicron became the dominant variant in the UK. High infection rates led to a sharp increase in natural-derived protection estimated by the model in early 2022.

Protection against COVID-19 hospitalisation estimates

Protection against hospitalisation in the Wales population as a whole

In Wales, 99.4% [99.1%, 99.8%] of people aged 12 and over were estimated to have some protection against COVID-19 hospitalisation at 2 April 2022. In comparison, at the start of the pandemic, it was estimated that 90.7% of people aged 12 and over would not have been at-risk of COVID-19 hospitalisation.

[23] JCVI statement on vaccination of children aged 5 to 11 years old - GOV.UK (www.gov.uk)

[24] Omicron largely evades immunity from past infection or two vaccine doses | Imperial News | Imperial College London

Put another way, in Wales, 0.6% [0.2%, 0.9%] of people aged 12 and over were estimated to be at-risk of COVID-19 hospitalisation at 2 April 2022, compared with 9.3% at the start of the pandemic.[25]

Risk of hospitalisation due to COVID-19 disease increases with age: 99.9% of all individuals aged 0 to 19 were estimated to have protection against COVID-19 hospitalisation as at 2 April 2022, 99.9% of all individuals aged 20-59 and 98.3% of all individuals aged 60 and over. Put another way, 0.1% of all individuals aged 0 to 19, 0.1% of individuals aged 20 to 59, and 1.7% of all individuals aged 60 and over were estimated to remain at-risk of COVID-19 hospitalisation as at 2 April 2022. In comparison, 0.2% of all individuals aged 0 to 19, 4.8% of individuals aged 20 to 59, and 25.1% of all individuals aged 60 and over were estimated to be susceptible to COVID-19 hospitalisation at the start of the pandemic.

Protection against hospitalisation in the Wales population considered to be susceptible to, and at-risk of, hospitalisation at the start of the pandemic (a proportion of the total population)

Of those at-risk of hospitalisation upon infection with COVID-19 at the start of the pandemic, 94% of individuals susceptible to hospitalisation aged 12 and over in Wales were estimated to have protection against hospitalisation for COVID-19 disease as at 2 April 2022. Put another way, 6% of at-risk individuals aged 12 and over in Wales were estimated to be susceptible to COVID-19 hospitalisation as at 2 April 2022.

Estimates varied greatly between age groups; 48% of at-risk individuals aged 0 to 19 were estimated to have protection against COVID-19 hospitalisation as at 2 April 2022, compared with 97% of at-risk individuals aged 20 to 59 and 93% of at-risk individuals aged 60 and over.

Table 12: Protection against COVID-19 hospitalisation estimates for those at-risk of hospitalisation as at 2 April 2022 in Wales

Age group	Protection [lower, upper] estimate	Percentage vaccinated with a 3rd/booster dose
0-19	48% [41%, 54%]	5%
20-59	97% [91%, 100%]	69%
60+	93% [90%, 97%]	99%
Total (12+)	94% [90%, 99%]	73%

[25] Calculated using the admission/infection ratio by age group in England October to November 2020. The proportion of infections that led to COVID-19 admissions varied from 0.2% in 0 to 17 year olds, to 35.4% in those aged 70 years and over.

Figure 7: Protection against COVID-19 hospitalisation estimates, individuals at-risk of hospitalisation aged 12 and over in Wales, to 2 April 2022

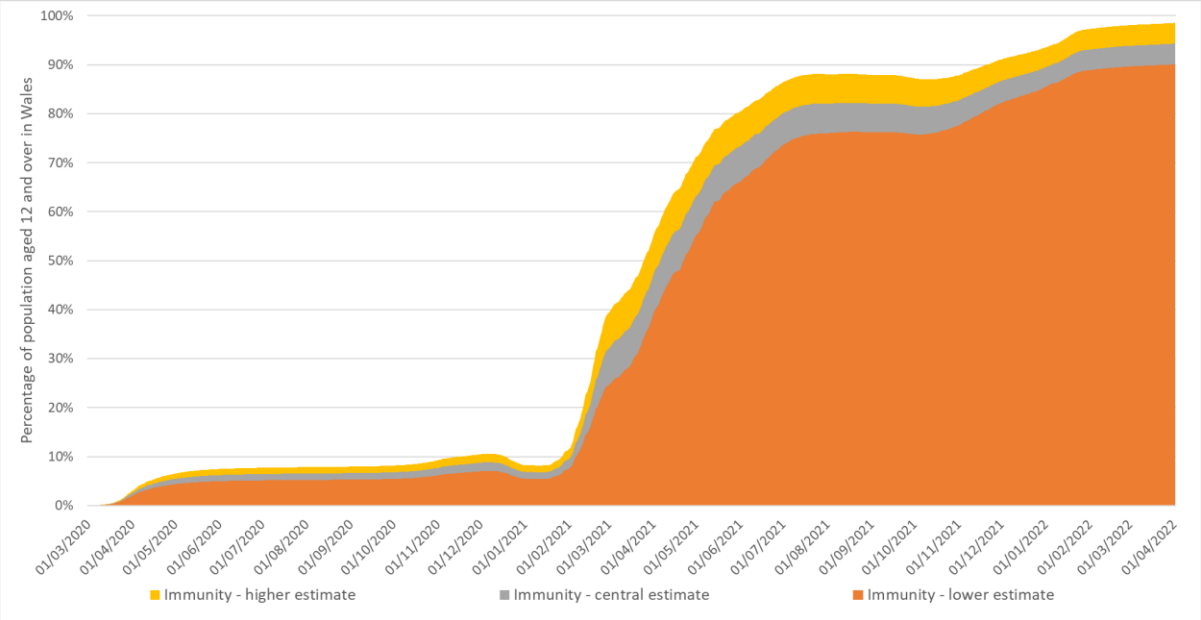


Figure 7 shows how protection against COVID-19 hospitalisation in individuals aged 12 and over who were at-risk of hospitalisation at the start of the pandemic in Wales has changed over time. At 2 April 2022, 94% of at-risk individuals aged 12 and over in Wales were estimated to have protection against hospitalisation. This corresponds to 99.4% of all individuals aged 12 and over being estimated as having protection against hospitalisation.

Figure 8: Protection against COVID-19 hospitalisation estimates, individuals at-risk of hospitalisation in Wales, by age group, to 2 April 2022

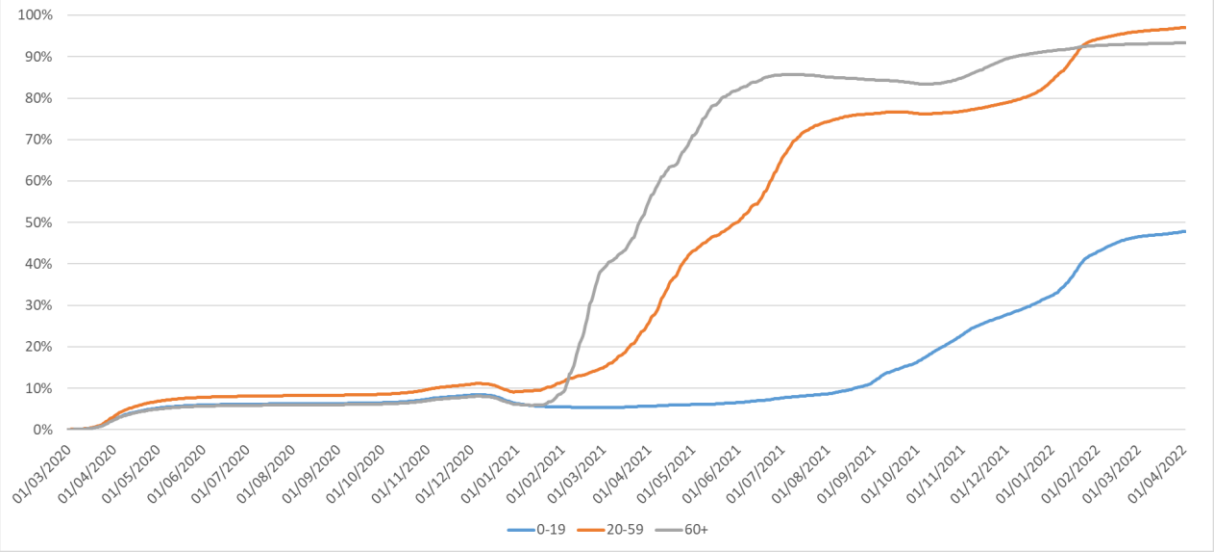


Figure 8 shows how protection against COVID-19 hospitalisation for those at-risk of hospitalisation was estimated to have changed in different age groups over time. Although only 48% of at-risk individuals aged 0 to 19 were estimated to have protection against COVID-19 hospitalisation as at 2 April 2022, it was estimated (using the admission/infection ratio for England between 12 October 2020 and 11

November 2020) that only 0.2% of all individuals aged 0 to 19 would require hospitalisation following COVID-19 infection. Therefore, although it was estimated that 52% of at-risk individuals aged 0 to 19 remained at-risk of hospitalisation, this corresponds to 0.1% of all individuals aged 0 to 19.

In comparison, 93% of at-risk individuals aged 60 and over were estimated to have protection against COVID-19 hospitalisation as at 2 April 2022. However, it was estimated that 25% of all individuals aged 60 and over would require hospitalisation following COVID-19 infection; a much greater proportion of the 60 and over population than for the 0 to 19 age group. Therefore, although it was estimated that at 2 April 2022 only 7% of at-risk individuals aged 60 and over remained at-risk of hospitalisation, this corresponds to 1.7% of all individuals aged 60 and over remaining at-risk of hospitalisation; a greater proportion of the 60 and over population than for the 0 to 19 age group.

This highlights the importance of protecting those most vulnerable to COVID-19 disease through booster vaccinations and other non-pharmaceutical interventions to protect lives and reduce pressure on the NHS healthcare system.

Conclusion

There are challenges in estimating protection levels due to model limitations, availability of data in an ambiguous topic and the emergence of new variants. This analysis finds evidence that the vaccination programme and booster campaign have been essential for increasing the levels of protection in the population against COVID-19 infection and hospitalisation.

This analysis finds that protection levels have increased throughout the pandemic, largely driven in 2021 by protection from vaccination and through increasing natural protection following infection in 2022 due to high COVID-19 infection rates. However, this analysis estimates that a significant proportion of the population remains vulnerable to COVID-19 infection and hospitalisation.

Despite COVID-19 infection rates reaching new record highs in 2022 with 1 in 13 people in Wales estimated to have COVID-19 in the week ending 2 April 2022, the age-standardised mortality rate for deaths due to COVID-19 remains low compared with previous waves due to protection built in the population over the last two years from vaccination and natural infection.[26,27] This highlights the effectiveness of vaccination and the importance of future boosters to prevent COVID-19 protection levels in the population from waning and increasing pressure on the NHS.

This model can be updated in the future with vaccine effectiveness estimates for future COVID-19 variants, but since community COVID-19 testing has largely ceased, this model would have to be adapted to utilise infection data from the ONS COVID-19 Infection Survey, rather than the more timely PHW cases data. Hence estimates would have a greater time lag in future.

[26] Coronavirus (COVID-19) Infection Survey, UK - Office for National Statistics

[27] Monthly mortality analysis, England and Wales - Office for National Statistics (ons.gov.uk)

Glossary of Terms

Term	Description
Susceptible population	The proportion of or number of people in Wales who do not have protection against infection from COVID-19.
Protected population	The proportion of or number of people in Wales who have at least some protection to COVID-19 disease due to vaccination or natural protection following infection. The term “protected against infection” used throughout this paper refers to individuals who are protected from being infected by COVID-19. The term “protected against hospitalisation” used throughout this paper refers to individuals who are protected from being hospitalised by COVID-19.
Efficacy	The proportion of people who, after 14 days following a COVID-19 vaccination dose, are considered to be protected against COVID-19 disease. For instance, for every 100 people given a 1st dose of a COVID-19 vaccine, after 14 days, 60 of those people are considered by the model to have protection against COVID-19 disease. Put another way, this means that 40 people are considered to still be susceptible to COVID-19 infection.

Appendix

An additional scenario analysis was conducted for protection against COVID-19 infection estimates. Changes to model assumptions used in the main analysis are described in *Table 13*.

In a paper published on 12 October 2021[28], vaccine efficacy from a Pfizer second dose was assumed to wane from 85% to 30% efficacy, a 65% reduction. Similarly, vaccine efficacy from an AstraZeneca second dose was assumed to wane from 70% to 30% efficacy, a 57% reduction. In this scenario analysis, protection from effective vaccination or natural infection was assumed, after 9 months, to decay by 65% (Pfizer, Moderna and infection) or 57% (AstraZeneca), rather than by 100% to 0% protection as in the main analysis.

Table 13: Model assumptions applied to all age groups in Wales to model protection against COVID-19 infection for scenario analysis

Assumption	Value
Percentage of infections captured by a COVID-19 PCR test	40%[29] up to 5 January 2022. 19%[30] from 6 January 2022 to 28 February 2022. 5%[31] from 1 March 2022 onwards.
Losing protection from a COVID-19 infection or effective vaccination	An individual's protection from an effective Pfizer vaccination, Moderna vaccination or COVID-19 infection is assumed to wane from 100% to 35%[32] protected on the date modelled to lose protection. An individual's protection from an effective AstraZeneca vaccination is assumed to wane from 100% to 43%[33] protected on the date modelled to lose protection.

[28] S1384_Warwick_Autumn_and_Winter_scenarios.pdf (publishing.service.gov.uk)

[29] Approximated using the average positive test count (UK Gov dashboard, cases by specimen date) / incidence in population (ONS CIS) ratio in England for the week to 28 March 2021 (data as at 10 May 2021). England data was used as the ONS COVID-19 Infection Survey did not estimate incidence for Wales at the time due to low numbers.

[30] Approximated using the average positive test count (UK Gov dashboard, cases by specimen date) / incidence in population (ONS CIS) ratio in Wales for the week to 2 February 2022 (data as at 12 April 2022).

[31] Approximated using the average positive test count (UK Gov dashboard, cases by specimen date) / incidence in population (ONS CIS) ratio in Wales for the week to 9 March 2022 (data as at 12 April 2022).

[32] S1384_Warwick_Autumn_and_Winter_scenarios.pdf (publishing.service.gov.uk)

[33] S1384_Warwick_Autumn_and_Winter_scenarios.pdf (publishing.service.gov.uk)

Table 14 shows that under this scenario, 81% [63%, 99%] of individuals aged 12 and over in Wales and 74% [57%, 91%] of the total population in Wales were estimated to have protection against COVID-19 infection as at 2 April 2022.

Table 14: Protection against COVID-19 infection estimates as at 2 April 2022 in Wales, scenario analysis

Age group	Protection [lower, upper] estimate	Percentage vaccinated with a 3rd/booster dose
0-19	48% [37%, 60%]	7%
20-59	92% [72%, 100%]	69%
60+	61% [46%, 76%]	99%
Total (all ages)	74% [57%, 91%]	63%
Total (12+)	81% [63%, 99%]	73%

Figure 9: Protection against COVID-19 infection estimates, individuals aged 12 and over in Wales, to 2 April 2022, scenario analysis

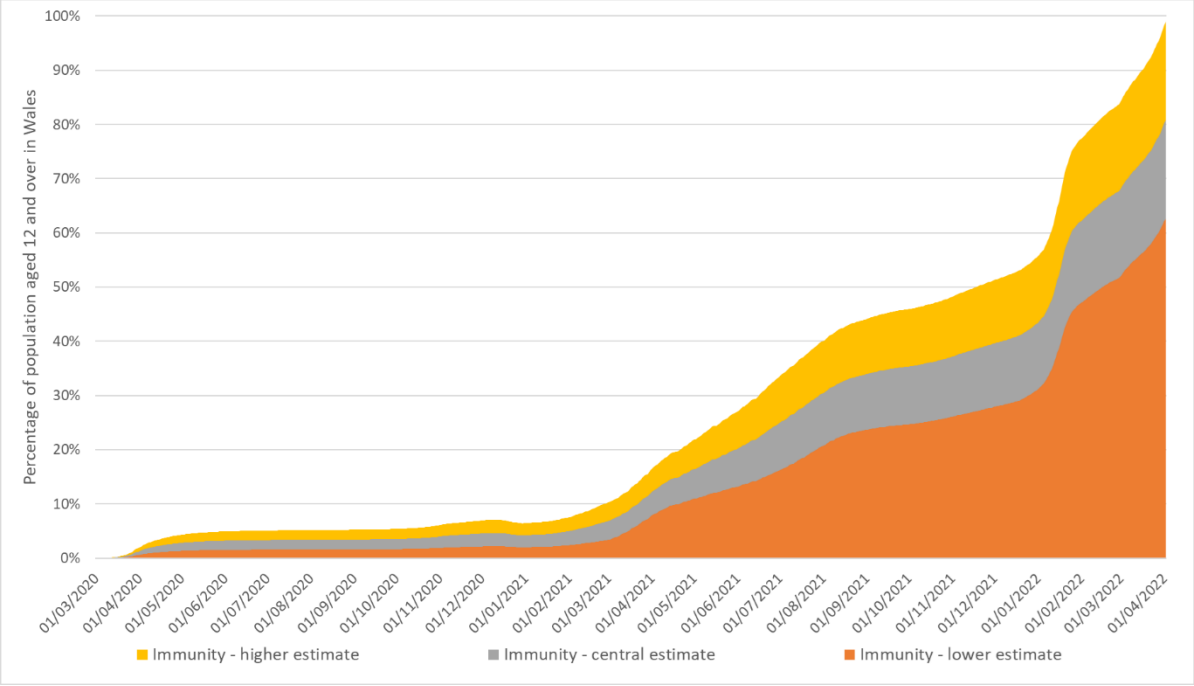


Figure 9 shows how the percentage of individuals aged 12 and over in Wales estimated to have protection against COVID-19 infection has changed over time. The estimated protection level significantly increased during 2021 following the launch of the vaccination programme in December 2020. Protection arising from high infection rates drove an increase in the estimated protection level in early 2022. At 2 April 2022, 81% [63%, 99%] of individuals aged 12 and over in Wales were estimated to have protection against COVID-19 infection, compared with 5% at the time of vaccination launch in December 2020.

Figure 10: Protection against COVID-19 infection estimates, individuals in Wales, by age group, to 2 April 2022, scenario analysis

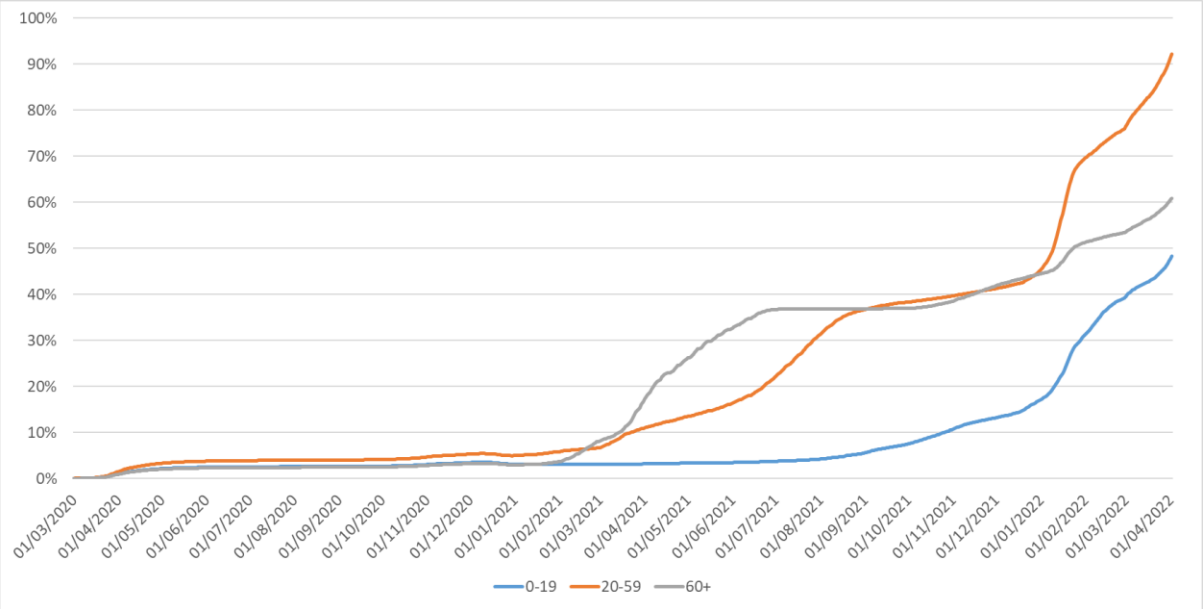


Figure 10 shows how protection levels changed in different age groups in Wales over time. Sharp increases in protection in individuals aged 60 and over during early 2021 reflect vaccine first dose uptake upon vaccination launch, which focused on the first priority groups (generally older age groups). Protection in the middle age group started to significantly increase in summer 2021 after lower priority groups were targeted in the vaccination rollout. Changes in COVID-19 vaccination policy from late 2021 drove increases in protection in the 0-19 year-old age group as first doses (and later, second doses) were offered to younger children.[34]

Evidence shows that infection with a previous variant offers limited protection against future infection with Omicron.[35] This, combined with easing of non-pharmaceutical interventions, drove COVID-19 infection rates to record highs in 2022 after Omicron became the dominant variant in the UK. High infection rates led to a sharp increase in natural-derived protection estimated by the model in early 2022, especially in younger age groups.

Protection against COVID-19 infection was estimated to vary by age group. As at 2 April 2022, protection was estimated to be greatest in individuals aged 20-59 years at 92% [72%, 100%] and lowest for individuals aged 0-19 years at 48% [37%, 60%].

[34] JCVI statement on vaccination of children aged 5 to 11 years old - GOV.UK (www.gov.uk)

[35] Omicron largely evades immunity from past infection or two vaccine doses | Imperial News | Imperial College London