EPH257

Public health impact of UK COVID-19 booster vaccination programs during Omicron predominance

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INTRODUCTION

- The UK has successfully administered primary series[1] and booster[2-4] vaccination campaigns against SARS-CoV-2.
- The SARS-CoV-2 Omicron variant (B.1.1.529)[5] became predominant by mid-December 2021[6] and has been associated with lower rates of severe disease outcomes[7,8] but higher transmissibility than earlier variants.[5,9]
- Early data indicated that boosters provided lower and shorter-lived protection against Omicron, which led the UK to offer subsequent booster doses in 2022 to enhance protection.[10]
- In the UK Spring 2022 booster program, a second booster was offered to the most vulnerable populations: individuals aged ≥75 years; individuals residing in a care home; and severely immunosuppressed individuals aged ≥12 years.[11-12]
- The Autumn 2022 booster program offered boosters to a wider group of higher-risk populations, including individuals aged ≥50 years and individuals aged ≥5 years in a clinical risk group.[13]
- Little is known about the public health impact of the UK Spring and Autumn 2022 (Spring & Autumn 2022) booster programs, or how this impact might differ if program eligibility criteria or uptake had been different.

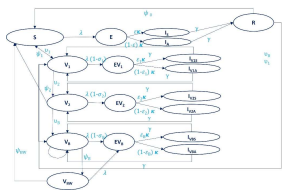
OBJECTIVE

- To estimate the public health impact of Spring and Autumn 2022 booster vaccination against COVID-19 in the UK during Omicron predominance.
- To explore how the impact might have varied in counterfactual scenarios with different booster eligibility criteria or increased uptake.

METHODS

- A dynamic transmission model **(Figure 1)** was developed to compare public health outcomes for actual and counterfactual UK Spring and Autumn 2022 booster programs **(Figure 2)**.

Figure 1. Dynamic transmission model structure



Compartments – further stratified by age
S – susceptible
V – vaccinated (dose 1, dose 2, boosted, boosted with waned protection against infection)
E – exposed by vaccination status
I – infectious (symptomatic, asymptomatic)
Parameters: ω– coverage by vaccination status; λ – force of infection; σ– vaccine effectiveness against infection; ψ– waning rate (1/duration of immunity); ε – probability of symptoms; γ – recovery rate (1/duration of symptoms); κ – rate of progression to infectious disease

METHODS (continued)

Figure 2. Actual and counterfactual scenarios modelled for the UK Spring and Autumn 2022 booster programs

	Actual Program	Counterfactual Programs			
Parameters	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Eligibility	Spring 2022: age ≥75 years and/or severely immunocompromised (aged ≥12 years) Autumn 2022: age ≥50 years and/or high-risk (aged ≥5 years)	Spring & Autumn 2022 age ≥5 years	Spring & Autumn 2022 age ≥5 years	Spring & Autumn 2022 High-risk only (aged ≥5 years)	Spring & Autumn 2022 High-risk only (aged ≥5 years)
Uptake	Predicted Spring: [9–16] ; Autumn: [17–19]	Predicted 15,19	Increased 15,20	Predicted 18	Increased 18

Model overview

- The model captured direct (individual-level) and indirect (herd-level) effects of SARS-CoV-2 transmission in the entire UK population.
- Scenario 1 estimated the impact of the actual UK Spring and Autumn 2022 booster programs compared to a counterfactual 'No booster' scenario.
- Counterfactual scenarios (Scenarios 2–5) varied booster eligibility and/or uptake **(Figure 2)**.

Outcomes estimated

- Outcomes were estimated over an extended time horizon from **April 4, 2022–April 2, 2023**, assuming continued Omicron predominance.
- Health outcomes averted:
  - symptomatic and asymptomatic cases
  - hospitalizations
  - long covid cases
  - deaths
- National Health Service (NHS) resource use outcomes averted:
  - bed days in general ward and intensive care units
  - general practitioner visits
- Patient productivity loss averted:
  - productive days lost for those in and outside the paid work force
    - included days lost due to hospitalization or death, but did not capture days lost or presenteeism due to illness experienced outside of the hospital (e.g., long COVID)

Model inputs

- Vaccine effectiveness was based on brand-agnostic (BNT162b2 and mRNA-1273 vaccines) estimates from UK weekly vaccine surveillance reports and published UK-specific literature.
- Health, NHS resource use, and productivity inputs were based on UK-specific, age-stratified data. Uptake was based on UK uptake data stratified by age group and risk group, and scenario-specific assumptions **(Table 1)**.

Table 1. Booster uptake inputs: proportion of UK population receiving boosters during the model time horizon

			Age group (years)									
	Analysis	Program	< 0.5	0.5–4	5–11	12–15	16–17	18–29	30–49	50–64	65–74	≥ 75
	Scenario 1[a]	Spring 2022	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	73.40%
		Autumn 2022	0.00%	0.00%	3.40%	3.40%	3.40%	4.80%	9.80%	77.30%	88.20%	92.70%
	Scenario 2[b]	Spring 2022	0.00%	0.00%	9.10%	13.20%	13.20%	35.70%	52.30%	77.30%	88.40%	92.70%
		Autumn 2022	0.00%	0.00%	9.10%	13.20%	13.20%	35.70%	52.30%	77.30%	88.40%	92.70%
	Scenario 3[c]	Spring 2022	0.00%	0.00%	57.20%	57.20%	35.00%	49.90%	64.30%	72.10%	87.20%	92.40%
		Autumn 2022	0.00%	0.00%	57.20%	57.20%	35.00%	49.90%	64.30%	72.10%	87.20%	92.40%
	Scenario 4[d]	Spring 2022	0.00%	0.00%	6.20%	6.70%	7.80%	11.80%	18.40%	28.40%	40.90%	53.30%
		Autumn 2022	0.00%	0.00%	6.20%	6.70%	7.80%	11.80%	18.40%	28.40%	40.90%	53.30%
	Scenario 5[e]	Spring 2022	0.00%	0.00%	7.60%	8.10%	9.50%	14.30%	22.30%	34.40%	49.60%	64.70%
		Autumn 2022	0.00%	0.00%	7.60%	8.10%	9.50%	14.30%	22.30%	34.40%	49.60%	64.70%

[a]Spring: booster uptake as of June 2022 [15] x 79.2% [16]. Autumn aged ≥50 years: Autumn-Winter 2021-2022 booster uptake as of January 2022 [17]. Autumn high-risk aged 5-49 years: uptake as of May 2022: 70.0% [18].
[b]Age 5–11 years: dose 1 uptake as of June 2022 [15]. Age ≥12 years: ≥3 doses as of April 2022 [15, 19].
[c]Age 5–15 years: seasonal flu uptake from 2021-2022 [20]. Age ≥16 years: dose 2 uptake as of June 2022 [15].
[d]high-risk booster uptake as of May 2022 (70.0%) [18].
[e]high-risk primary series uptake as of May 2022 (64.9%) [18].

RESULTS

Health outcomes

- Actual Spring and Autumn 2022 programs (Scenario 1) were estimated to avert approximately 6.2 million cases, 716,000 hospitalizations **(Figure 3)**, and 125,000 deaths compared to not offering Spring or Autumn 2022 boosters **(Table 2; Figure 4)**.
- Assuming increased uptake alongside extended eligibility (Scenario 3) produced the greatest benefit of scenarios analyzed: 32.9 million infections, 1.6 million hospitalizations, and 228,000 deaths averted.
- The peak of weekly hospitalizations averted was predicted to occur in early 2023 **(Figure 3)**; Scenario 3 (eligibility for age ≥5 years alongside increased uptake) was estimated to produce the greatest benefit in hospitalizations averted.

NHS resource use outcomes

- Actual Spring and Autumn 2022 programs (Scenario 1) were estimated to free up 5.2 million general ward and 839,000 intensive care unit (ICU) bed days **(Table 3)**.
- All counterfactual scenarios freed up additional bed days, with the greatest benefit associated with Scenario 3 (11.5 million general ward and 2.3 million ICU bed days).

Productivity loss outcomes

- Actual Spring and Autumn 2022 programs were estimated to avert 165 million days of patient productivity loss **(Figure 5)**, consisting of 30 million unpaid days (18%) and 135 million paid days (82%).
- All counterfactual scenarios averted additional productivity loss, with the greatest benefit in Scenario 3 (953 million days, consisting of 171 million unpaid days and 782 million paid days).

Table 2. Modeled percent reduction in population-level health outcomes between April 2022 and April 2023 with Spring & Autumn 2022 booster program scenarios compared to a counterfactual 'No booster' scenario

Outcomes	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
COVID-19 cases	13%	64%	75%	27%	33%
Asymptomatic	12%	63%	74%	25%	31%
Symptomatic	15%	66%	76%	29%	34%
Hospitalizations	36%	78%	85%	48%	55%
General ward cases	37%	78%	85%	48%	55%
ICU cases	30%	78%	84%	47%	54%
Long COVID cases	15%	65%	75%	28%	33%
Deaths	45%	80%	88%	54%	62%

Abbreviations: COVID-19, coronavirus disease 2019; ICU, intensive care unit.

Figure 3. Projections for weekly hospitalizations averted

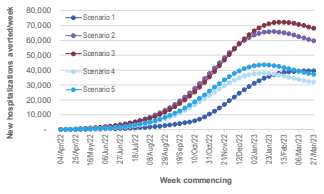


Figure 4. Modelled percent reduction in population-level deaths between April 2022 and April 2023 with Spring & Autumn 2022 booster program scenarios

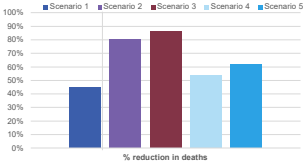
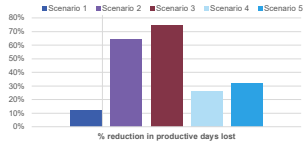


Table 3. Modelled percent reduction in population-level NHS resource use outcomes between April 2022 and April 2023 with Spring & Autumn 2022 booster program scenarios

Outcomes	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
GP visits	13%	65%	75%	27%	32%
Bed days general Ward	37%	78%	85%	48%	55%
Bed days in ICU	30%	78%	84%	47%	54%

Abbreviations: GP, general practitioner; ICU, intensive care unit.

Figure 5. Modelled percent reduction in population-level patient productivity loss outcomes between April 2022 and April 2023 with Spring & Autumn 2022 booster program scenarios



CONCLUSIONS

- **Actual UK Spring and Autumn 2022 booster programs were estimated to provide substantial benefit to public health during Omicron predominance, reducing COVID-19-related hospitalizations by 36% and deaths by 45% compared to no booster vaccination.**
- **Extending booster eligibility to those aged ≥5 years was estimated to avert about twice as many hospitalizations (2.2×) and deaths (1.8×) as the actual Spring and Autumn 2022 programs.**
- **Overall, the counterfactual scenarios explored here suggest that public health benefits could be maximized by extending booster eligibility to broader age groups and increasing uptake.**

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Disclosures

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