Appendix 1: estimation of number needed to vaccinate to prevent a COVID-19 hospitalisation for primary vaccination, booster vaccination (3rd dose), autumn 2022 and spring 2023 booster for those newly in a risk group

Based on a UK Health Security Agency (UKHSA) presentation to the Joint Committee on Vaccination and Immunisation (JCVI) on 25 October 2022.

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In order to consider the benefits of continued offers of primary vaccination, booster vaccination, the autumn booster, and potential boosting in the spring of 2023 (for example, for those newly entering a risk group) calculation of numbers needed to vaccinate (NNV) were completed. To do this calculation, the following information was used:

- rates of COVID-19 and severe COVID-19 hospitalisation per million population in July 2022 by vaccination status. 'Severe' was taken to mean there were codes to indicate use of oxygen or ventilation and admission to intensive care (ICU).

- vaccine effectiveness for 2 doses and 2+1 doses by time since the last dose against COVID-19 hospitalisation and against severe COVID-19 hospitalisation

To estimate the rates of hospitalisation, patients with a respiratory discharge diagnosis as the main diagnosis who also tested positive for SARS-CoV-2 and had at least a 2-day hospital stay, were identified from the secondary user service (SUS) for admissions in July 2022. This was the most recent month where data should be near complete. Rates in this month will reflect rates according to the recent immune status of the population. Using only those with a respiratory code as the main diagnosis and 2 days stay aligns the rates with

the outcomes used for vaccine effectiveness and is substantially lower than all hospitalisations with a recent positive test which can include many individuals hospitalised with, rather than because of, COVID-19.

The data were linked to the national immunisation register (NIMS) to allow rates to be estimated by vaccination status (unvaccinated, 1 or 2 doses, 3 or more doses). The NIMS data also had data on whether individuals were in a clinical risk group (for adults) so could be used to stratify rates by risk group. The rates used are given in Table 1. For the NNV calculation it was assumed these rates would apply for the year following vaccination.

Table 1: rates per million of COVID-19 hospitalisation and severe COVID-19 hospitalisation by age and risk group (for ages 20 to 59). Rates are for July 2022

Hospitalisation									
	All			Clinical risk group			Not clinical risk group		
age	0 doses	1or2 doses	3+ doses	0 doses	1or2 doses	3+ doses	0 doses	1or2 doses	3+ doses
5 to 11 years	4.2	3.4							
12 to 15 years	4.6	2.4	0.0						
16 to 19 years	12.9	2.5	3.9						
20 to 29 years	10.9	10.9	7.0	60.1	56.3	38.3	7.3	5.7	1.7
30 to 39 years	14.6	12.6	8.0	93.4	62.7	36.7	6.7	3.6	1.4
40 to 49 years	14.5	20.1	13.8	66.7	76.8	47.4	6.7	4.3	3.1
50 to 59 years	47.6	63.7	35.8	174.5	164.5	93.4	13.3	12.2	6.6
60 to 69 years	119.0	183.9	80.5						
70 years plus	414.5	382.3	342.7						
Severe Hospitalisation									
	All			Clinical risk group			Not clinical risk group		
age	0 doses	1or2 doses	3+ doses	0 doses	1or2 doses	3+ doses	0 doses	1or2 doses	3+ doses
5 to 11 years	1.1	1.7							
12 to 15 years	0.8	0.6	0.0						
16 to 19 years	1.2	0.8	1.3						
20 to 29 years	0.8	0.4	0.9	10.9	3.8	4.0	0.0	0.0	0.3
30 to 39 years	1.4	0.9	1.1	11.7	5.7	5.9	0.4	0.0	0.0
40 to 49 years	2.3	4.0	1.4	13.3	15.4	4.8	0.7	0.9	0.3
50 to 59 years	6.7	10.1	5.0	22.4	26.9	12.9	2.4	1.5	0.9
60 to 69 years	21.8	17.8	8.8						
70 years plus	50.9	15.6	32.0						

Note that the rates given in Table 1 are crude rates by age and vaccination status and should not be compared with one another to infer vaccine effectiveness. Rates will be affected by previous infections and other differences between groups. For example, those unvaccinated are likely to have had higher prior infection rates than those vaccinated which can reduce recent incidence in this group.

The effectiveness of primary vaccination and doses 3 and 4 by time since vaccination used in the calculations are given in Table 2. These are based on estimated effectiveness of vaccination against the Omicron variant - see COVID-19 vaccine surveillance report: 4 November 2021 (week 44). Note that when considering the effect of doses 3 and 4 it is assumed that there is residual long-term protection as shown in the table at the longer intervals after these doses. Therefore, for example, the benefit of a booster (dose 3) is to

increase effectiveness from the waned second dose level to the third dose level (for example, from 50% to 90%).

Table 2: vaccine effectiveness estimates (%) used in the calculations

	Hospitalisation			Severe Hospitalisation		
month	primary	booster (dose 3)	booster (dose 4)	primary	booster (dose 3)	booster (dose 4)
1	0	80	80	0	85	85
2	60 (1 dose)	90	90	70 (d1)	95	95
3	60 (1 dose)	90	90	70 (d1)	95	95
4	80	80	80	90	90	90
5	80	80	80	90	90	90
6	80	70	70	90	80	80
7	60	70	70	70	80	80
8	60	60	60	70	70	70
9	60	60		70	70	
10	50	60		60	70	
11	50	60		60	70	
12	50	60		60	70	

The time horizon for benefits was taken to be a year following vaccination. To estimate cases prevented per million doses (or courses of 2 doses for primary vaccination) the effectiveness in each month (Table 2) was applied to the relevant rates from Table 1. For example, for assessing the booster (dose 3) against hospitalisation 3 months after it is given in 60 to 69 year olds, we use the rate of 183.9 per million from Table 1 as the non-boosted rate and use the effectiveness of a booster after 3 months (90%) compared to waned effectiveness of 2 doses of 50% to give a relative effectiveness of 80% (note 0.8 = 1 – (1-0.9)/(1-0.5)). An 80% reduction on 183.9 means 147.1 prevented from 1 million vaccinated. The prevented cases are summed over the 12 months to give a total prevented per million doses and this is then inverted to give NNV to prevent a case.

The results of NNV by age and clinical risk groups are shown in Tables 3 and 4. Strong age effects are seen as well as large differences within adults ages by clinical risk group. The oldest age groups and the older individuals in clinical risk groups have the lowest NNV. There are also higher NNVs when moving from primary to each booster dose.

Table 3: NNV for prevention of hospitalisation for different programmes

	Programme			
Age	Primary	Booster (2+1)	Autumn 2022 boost	Spring 2023 boost
5 to 11	34200			
12 to 15	31400			
16 to 19	11200	76000	73500	
20 to 29	13300	17600	40900	
30 to 39	9900	15300	35900	
40 to 49	10000	9600	20600	
50 to 59	3000	3000	8000	
60 to 69	1200	1000	3600	
70+	300	500	800	
In a risk group	Primary	Booster (2+1)	Autumn 2022 boost	Spring 2023 boost
20 to 29	2400	3400	7500	7500
30 to 39	1600	3100	7800	7800
40 to 49	2200	2500	6000	6000
50 to 59	800	1200	3100	3100
No risk group	Primary	Booster (2+1)	Autumn 2022 boost	Spring 2023 boost
20 to 29	19900	33900	168200	
30 to 39	21700	53800	210400	
40 to 49	21700	44900	92500	
50 to 59	10900	15800	43600	

Table 4: NNV for prevention of severe hospitalisation for different programmes

	Programme			
Age	Primary	Booster (2+1)	Autumn 2022 boost	Spring 2023 boost
5 to 11	112200			
12 to 15	162600			
16 to 19	106500	193500	185100	
20 to 29	166200	418100	275200	
30 to 39	87600	188500	217300	
40 to 49	53700	40600	175900	
50 to 59	18700	16200	48300	
60 to 69	5700	9200	27300	
70+	2500	10400	7500	
In a risk group	Primary	Booster (2+1)	Autumn 2022 boost	Spring 2023 boost
20 to 29	11400	43500	59500	59500
30 to 39	10700	28600	40500	40500
40 to 49	9400	10600	49800	49800
50 to 59	5600	6100	18600	18600
No risk group	Primary	Booster (2+1)	Autumn 2022 boost	Spring 2023 boost
20 to 29	no cases	no cases	706500	
30 to 39	318400	no cases	no cases	
40 to 49	186800	190400	932500	
50 to 59	51600	107000	256400	

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