Supplementary material to: The impact and cost-effectiveness of pneumococcal immunisation strategies for the elderly in England

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Modelling combined strategies

We note that in the combined modelling scenarios, we did not model consecutive vaccination with one vaccine (PPV23 in our case) followed by the other (PCV15 or PCV20). Instead, we used the background immunity in the population from PPV23 vaccine as a proxy for PPV23 vaccination, on top of which PCV15 or PCV20 was administered. This was modelled to capture immunity from the ongoing PPV23 immunisation campaign in England.

Specifically, the incidence data over this period inherently contained immunity from PPV23 and hence we used incidence data as a proxy for PPV23 vaccination in the combined strategies. We then explicitly modelled vaccination with PCV15 or PCV20 on this data to capture combined vaccination with PCV15 or PCV20 and PPV23. We note that this is different to giving PPV23 vaccination to a naive population, and then sometime later additionally vaccinating with PCV15 or PCV20. And this is also different to giving the PCV15/PCV20 vaccine to a fully naive cohort, which is how we modelled individual vaccination with PPV23, PCV15 or PCV20.

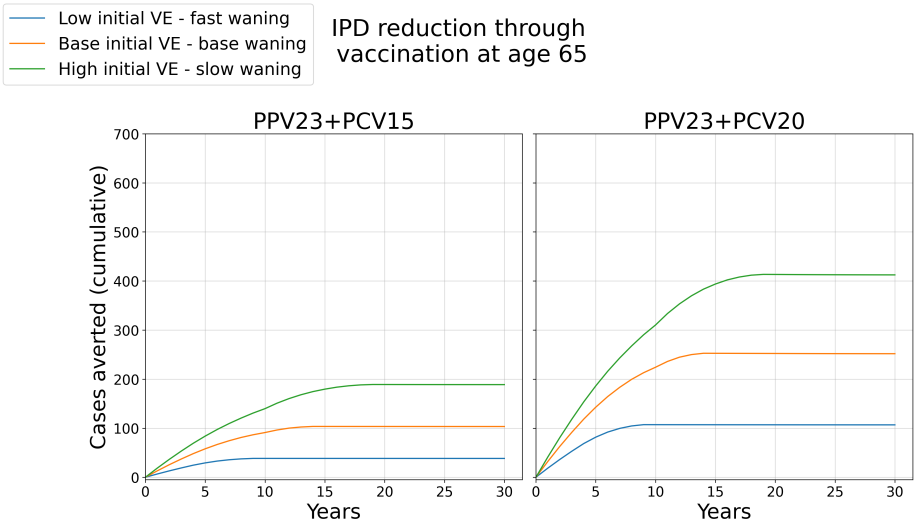
By modelling the combined strategies in this way, we note that while the individual vaccine strategy captures the benefits of a single vaccine relative to no vaccination, the combined strategies compare vaccination with PCV15/20 on top of PPV23 to vaccination with PPV23 only. Hence in the supplementary material results presented in the table and figures here, we use the notation PPV23+PCV15/20 to refer to the combined vaccine scenarios.

Overall our results suggest that strategies using individual PCV15, PCV20 or PPV23 (shown in the main manuscript text), administered to a naive cohort, averted more IPD and CAP cases than the combined strategies of vaccinating with PCV15 or PCV20 a cohort already vaccinated with PPV23 (shown in this supplementary material).

	Incidence (per 100,000)			CFR		
Vaccine	65 - 74	75 - 84	85+	65 - 74	75 - 84	85+
PCV15 (observed data, IPD)	4.00	6.16	12.91	0.17	0.21	0.36
PCV15 (observed data, CAP)	12.3	36.1	24.8	0.1	0.1	0.1
PCV15 (naive population, IPD)	5.56	9.43	18.75	0.17	0.21	0.36
PCV15 (naive population, CAP)	14.0	42.4	28.6	0.1	0.1	0.1
PCV20 (observed data, IPD)	10.79	15.43	27.44	0.14	0.20	0.35
PCV20 (observed data, CAP)	38.6	56.8	43.5	0.1	0.1	0.1
PCV20 (naive population, IPD)	15.02	23.65	39.98	0.14	0.20	0.35
PCV20 (naive population, CAP)	43.9	66.8	50.2	0.1	0.1	0.1
PPV23 (naive population, IPD)	17.65	29.21	50.58	0.14	0.19	0.33
PPV23 (naive population, CAP)	56.2	81.9	100.3	0.1	0.1	0.1
serotype 3 (observed data, IPD)	2.54	4.20	8.73	0.15	0.39	0.5
serotype 3 (observed data, CAP)	15.5	49.1	68.3	0.1	0.1	0.1
serotype 3 (naive population, IPD)	3.54	6.45	12.76	0.15	0.39	0.5
serotype 3 (naive population, CAP)	17.6	57.7	78.8	0.1	0.1	0.1
All serotypes (observed data, IPD)	20.30	32.36	65.94	0.16	0.23	0.37
All serotypes (observed data, CAP)	111.4	209.2	298.1	-	-	-

Table 1: Incidence and Case Fatality Rate (CFR) by age group and vaccine type (with serotype 3 separated). Vaccination is assumed to not affect mortality so the CFR is the same for the scenarios with and without replacement. IPD values and CAP incidence are calculated based on number of cases or deaths per serotype, CAP CFR is an assumption. Observed data represents the raw data as given in Figure 1(b) and 1(c). Naive population indicates incidence in a population without any vaccination, its calculation is described in Section 2.1.2. Pneumococcal incidence across all serotypes is given to provide an indication of the total burden of disease but is not used throughout the analysis.

Since the impact analysis revealed the individual immunisation strategies to be more impactful than the combined immunisation strategies, the main cost-effectiveness analyses focused on the individual vaccine strategies with the results presented in the main body of the manuscript. This supplementary material additionally, contains the cost-effectiveness analyses for the combined vaccine strategies.



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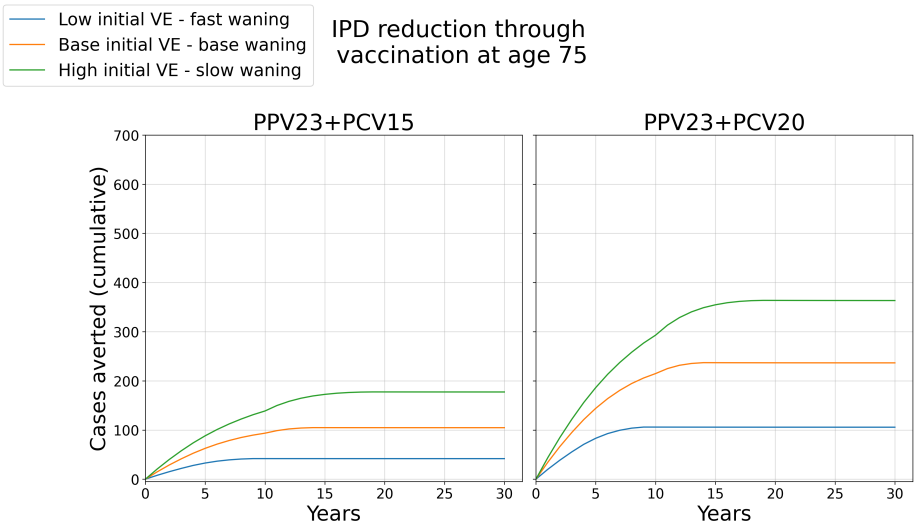
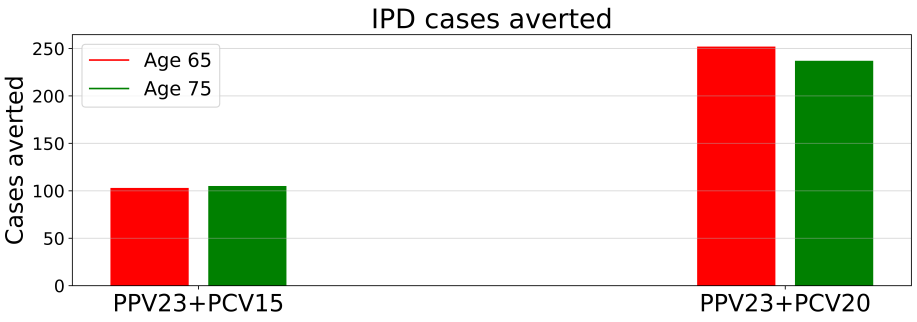
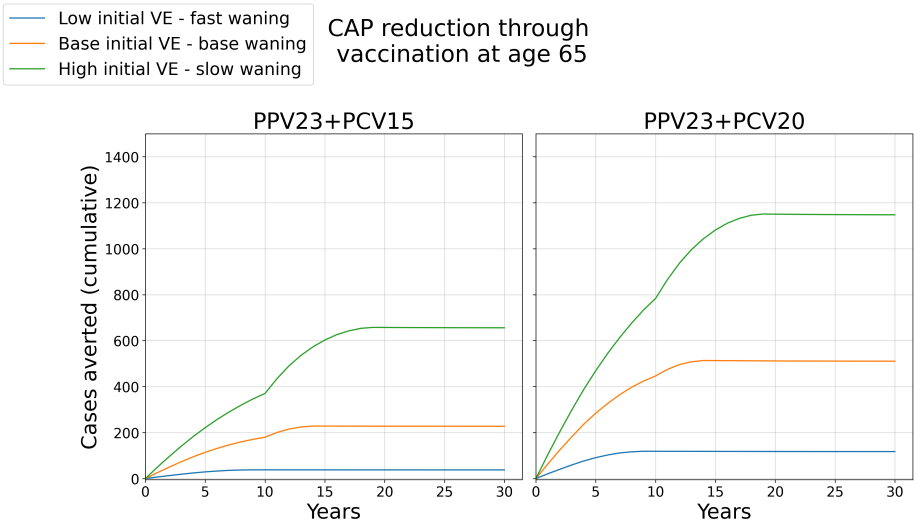


(b)

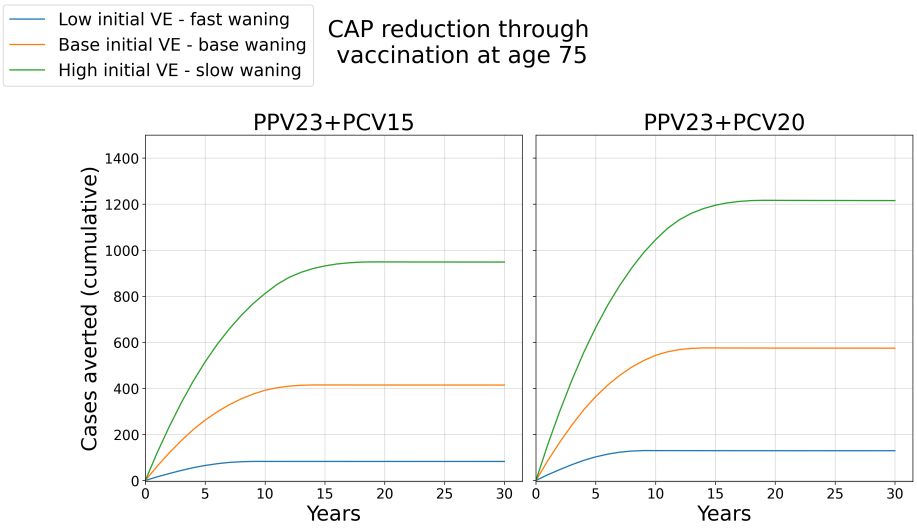


(c)

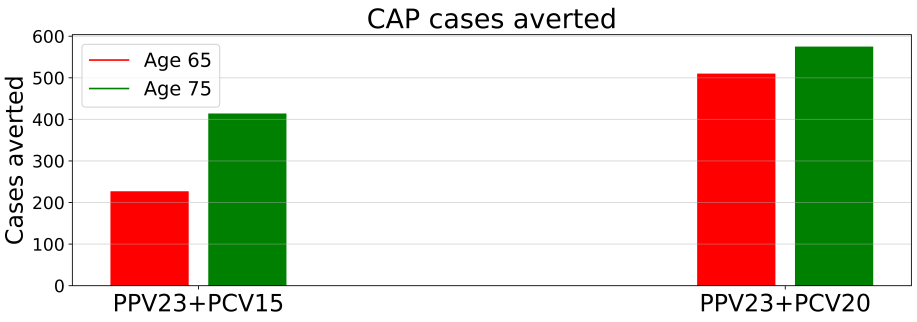
Figure 1: Number of IPD cases averted through vaccination across the two combined immunisation strategies when vaccinating 65-year-olds (a), 75-year-olds (b) and comparing the total reduction over the 30 years of simulation under base vaccine effectiveness assumptions (c). The combined strategies (PPCV23+PCV15 and PPV23+PCV20) give the number averted by using PCV15/20 in addition to PPV23 compared to that of only using PPV23. Plots over time are given for the worst, base and best overall vaccine effectiveness (blue, yellow and green respectively).



(a)



(b)



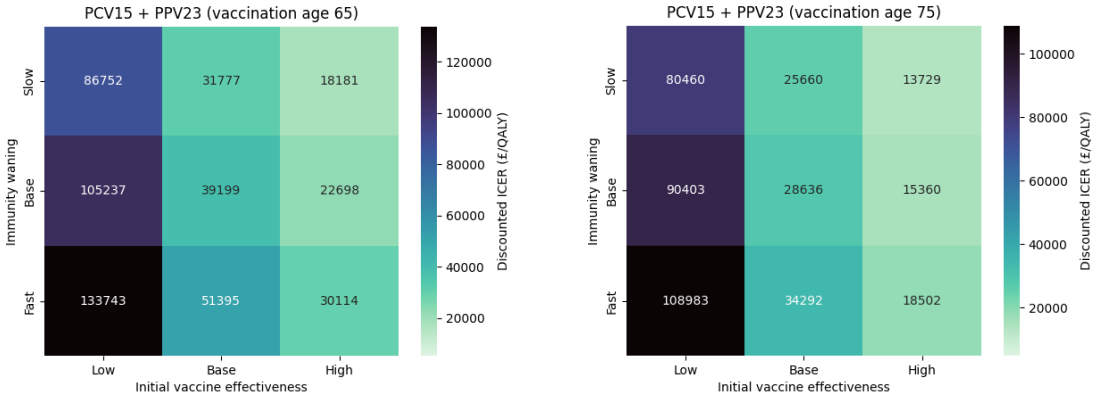
(c)

Figure 2: Number of CAP cases averted through vaccination across the two combined immunisation strategies when vaccinating 65-year-olds (a), 75-year-olds (b) and comparing the total reduction over the 30 years of simulation under base vaccine effectiveness assumptions (c). The two combined strategies (PPCV23+PCV15 and PPV23+PCV20) give the number averted by using PCV15/20 in addition to PPV23 compared to that of only using PPV23. Plots over time are given for the worst, base and best overall vaccine effectiveness (blue, yellow and green respectively).

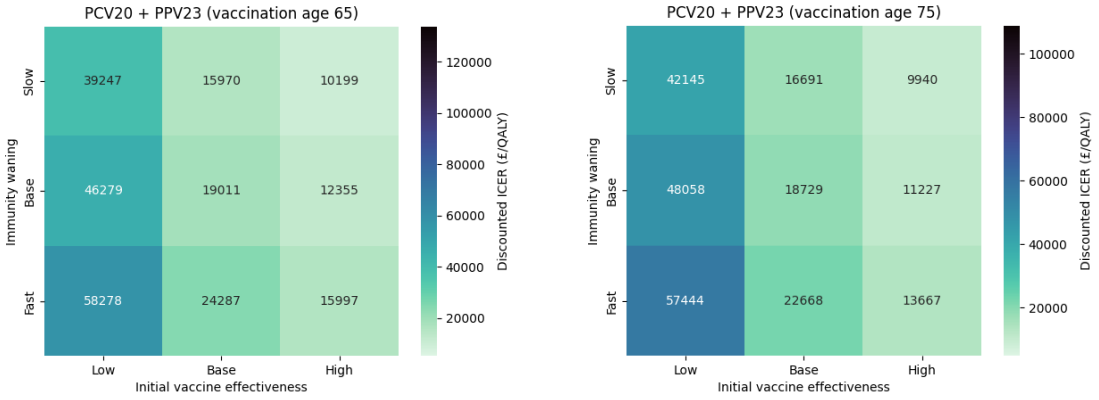
	Cases averted (for the cohort population, normalised per 100,000 in brackets)			
	Age 65		Age 75	
Immunisation strategy	IPD	CAP	IPD	CAP
PPV23+PCV15*	103 (18)	227 (40)	105 (22)	414 (89)
PPV23+PCV20*	252 (44)	511 (89)	237 (51)	575 (123)

* Cases averted relative to vaccination with PPV23.

Table 2: Number of CAP and IPD cases averted through vaccination after 30 years, for vaccination ages of 65 and 75. This is for the two combined immunisation strategies, with the reduction relative to vaccination with PPV23. Values are given for the entire cohort, with values normalised per 100,000 given in brackets. These results are given under base vaccine effectiveness assumptions.



(a) (b)



(c) (d)

Figure 3: ICERs for the combined vaccine strategies (PPV23+PCV15 and PPV23+PCV20) across the nine overall vaccine effectiveness scenarios, at vaccination ages of 65 ((a), (c)) and 75 ((b), (d)). These are calculated using current vaccine list prices of £50.30 and £56.80 for PCV15 and PCV20 respectively. Overall vaccine effectiveness is split into three scenarios each for initial vaccine effectiveness (x-axis) and immunity waning (y-axis).

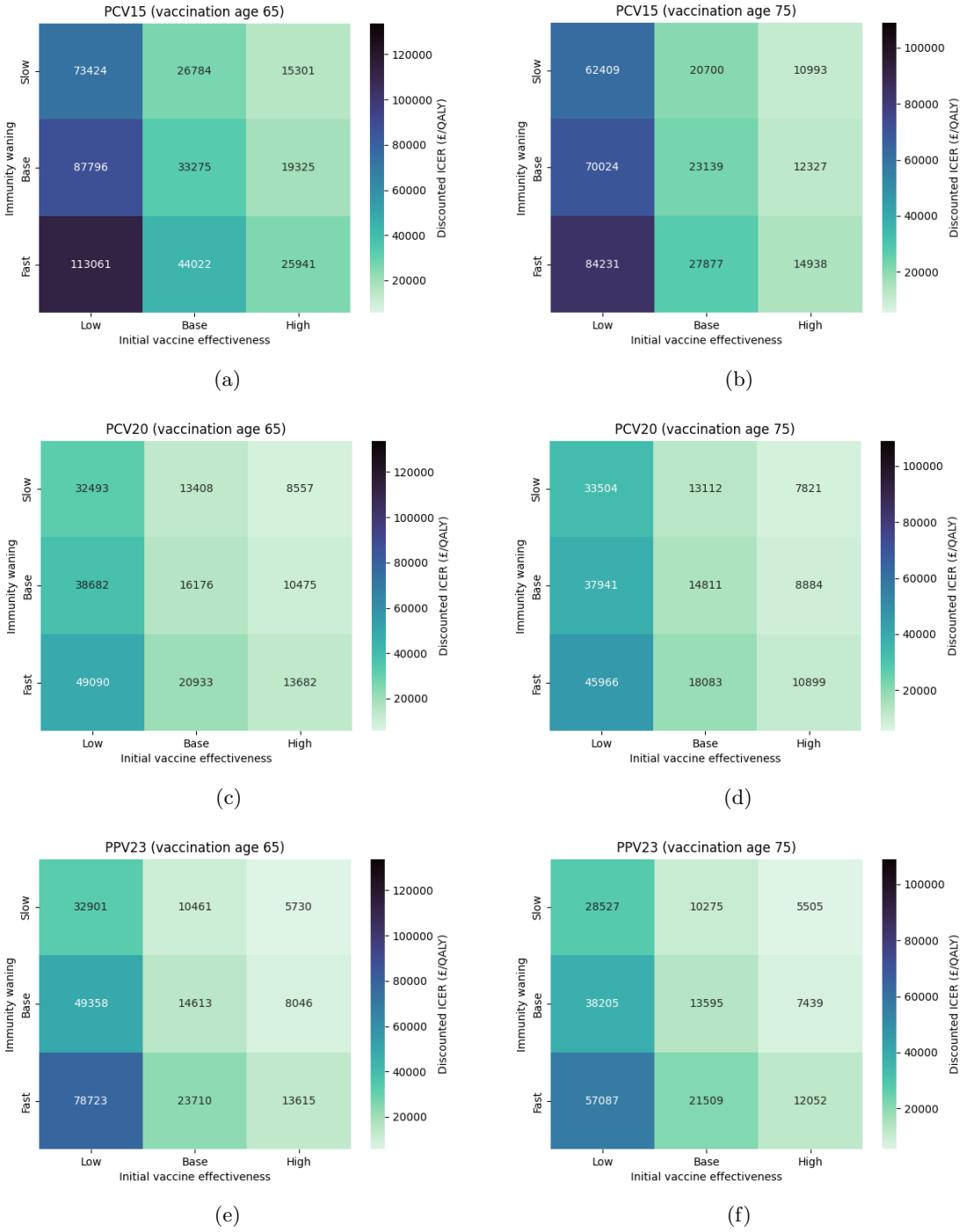
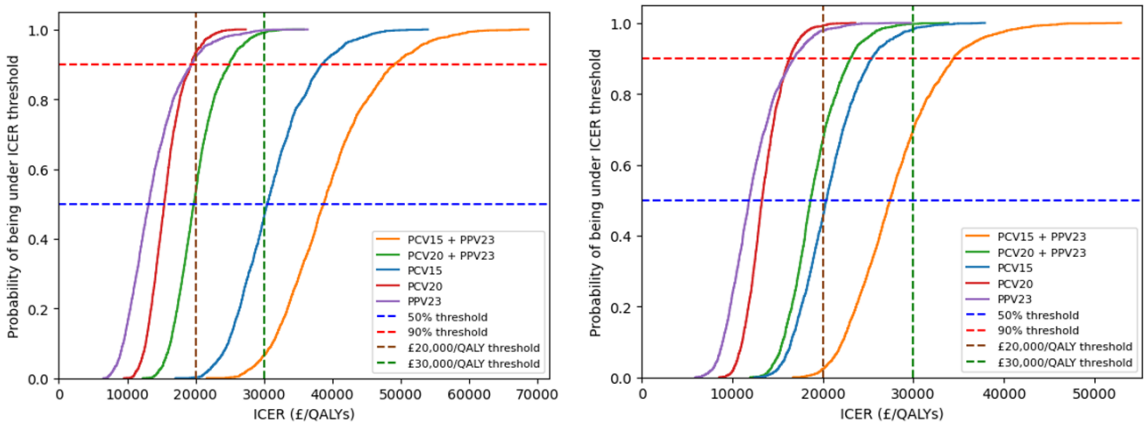
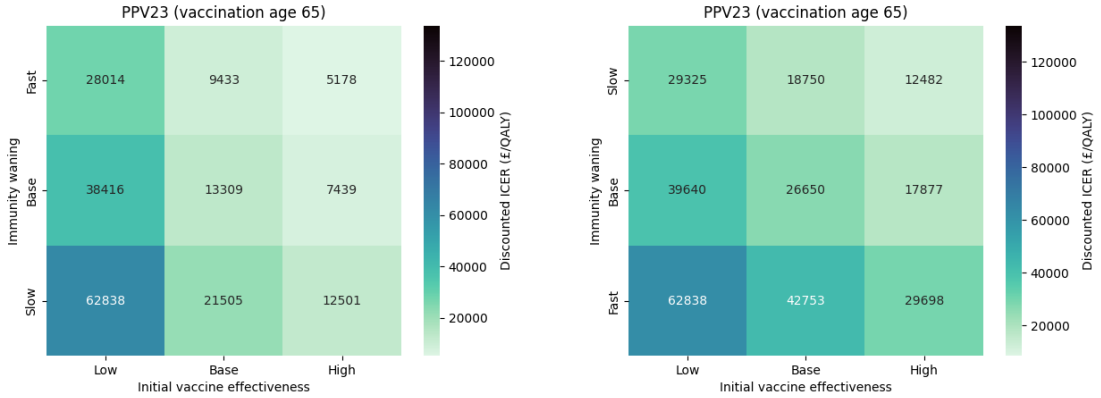


Figure 4: Sensitivity analysis for a lower vaccine effectiveness of 27% during the calculation of the incidence in naive population, giving the ICERs for the individual vaccine strategies (PCV15, PCV20 and PPV23) across the nine overall vaccine effectiveness scenarios, at vaccination ages of 65 ((a), (c), (e)) and 75 ((b), (d), (f)). These are calculated using current (as of May 2023) vaccine list prices of £50.30, £56.80 and £16.80 for PCV15, PCV20 and PPV23 respectively. Overall vaccine effectiveness is split into three scenarios each for initial vaccine effectiveness (x-axis) and immunity waning (y-axis).



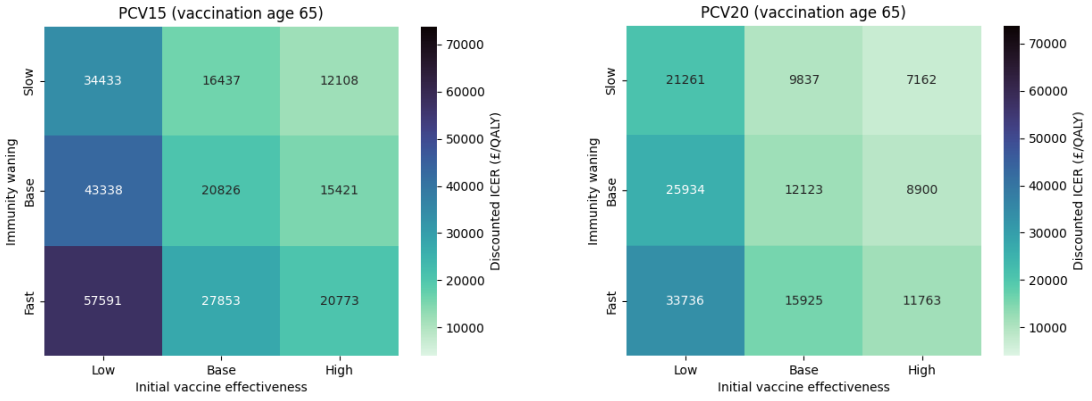
(a) (b)

Figure 5: ICER acceptability curves for the five immunisation strategies, vaccination ages of 65 (a) and 75 (b).



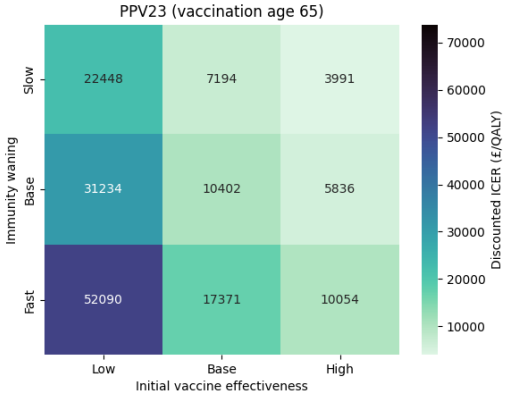
(a) (b)

Figure 6: ICER for PPV23 for a vaccination age of 65 as in the main analysis (a) and assuming no vaccine effectiveness against CAP (b). Note that, although not presented here, ICERs for PCV15/20 will also be worsened due to a lower CAP incidence through no backdating vaccine effectiveness.



(a)

(b)



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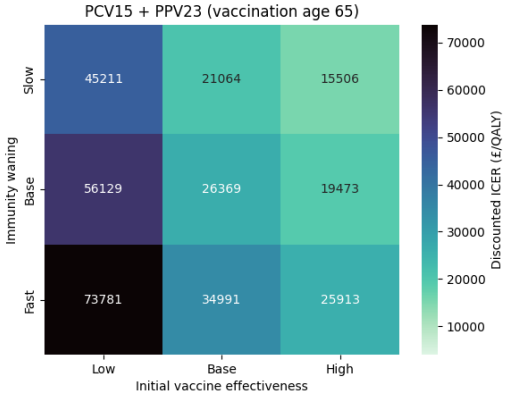

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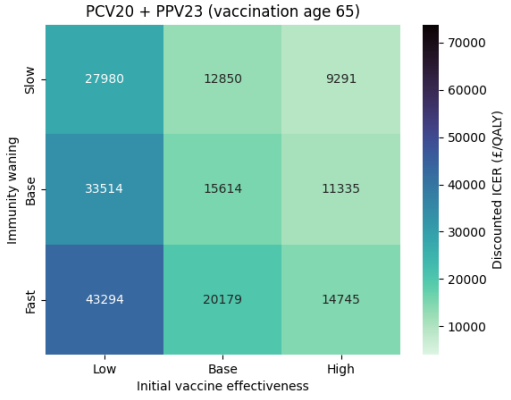

(e)

Figure 7: ICER calculated using vaccine list prices with identical vaccine effectiveness across all serotypes, as opposed to the main analysis where a lower vaccine effectiveness against serotype 3 is assumed, vaccination age of 65.