Key drivers of the economically justifiable price of the COVID-19 vaccine in England

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OBJECTIVES

The early rollout of the COVID-19 vaccine in England helped mitigate the effects of the pandemic. However, limited evidence is available on the cost-effectiveness of alternative vaccination strategies. The economically justifiable prices (EJP) of COVID-19 vaccines was retrospectively assessed based on past epidemiological data. Key drivers of these prices were identified.

METHODS

Dynamic transmission model

An economic module was integrated into a transmission-dynamic model previously developed by Davis 2021.[1] The epidemiological model was for England and calibrated using data observed in the prevaccination period. Details are described elsewhere [1].

Perspective and timeframe

The analysis was conducted from the perspective of NHS England. The evaluation period was from 1 January 2020 to 31 March 2021, with an assumed start of vaccination campaign mid 2020. Potential years of life lost after March 2021 were ignored.

COVID-19 dynamic modelling

Each variant of coronavirus was characterized by transmission rates for symptomatic and asymptomatic cases, probability of hospitalization conditional upon symptomatic infection, proportion of ICU admissions and case fatality rates. The transmission rate associated with asymptomatic cases was assumed 50% lower than with symptomatic cases. Different vaccine effectiveness rates against asymptomatic and symptomatic cases were considered. The probabilities of hospitalization and death among symptomatic cases were assumed independent of vaccination.

Vaccines

Parameters characterizing the vector-based and mRNA vaccines were based on data published for the AstraZeneca and Pfizer BioNTech products respectively. The vaccine uptake was assumed to reach a maximum of 70%, based on the uptake reported in England in July 2021 [7].

Costs

Healthcare costs and public health impact associated with confirmed COVID-19 infection (stratified by fatal, hospitalized, ICU, symptomatic and asymptomatic cases) and vaccination were considered. For serious adverse events (SAE), the same costs and QALY loss as for ICU admission were assumed. Input parameters are presented in Table 1. In the sensitivity analysis, the impact of variations of +/−20% around uncertain input parameters was explored.

Strategies compared

Due to low vaccine uptake late in the third wave, the impact of the vaccination program on the disease burden was limited. To investigate key drivers of the EJPs of vaccines in a hypothetical future situation where the majority of the population is vaccinated before the outbreak, an earlier roll-out of the COVID-19 vaccine was considered (Table 2).

Table 1. Input parameters

Parameter	Base-case	Source
Costs		
ICU hospitalization, per day	£1,240	NHS [6], Zala 2020 [8]
Non-ICU hospitalization, per day	£1,087	NHS [6], Zala 2020 [8]
Home-recovery, per day	£0	Assumption
Cost of vector-based vaccine, per dose	£2.17	Brooks 2021 [9]
Cost of mRNA-based vaccine, per dose	£15	Brooks 2021 [9]
Administration, per vaccination	£12.85	Iacobucci 2020 [10]
Utilities		
General population utility	Age-dependent	Ara 2021 [3]
QALY loss for non-ICU hospitalization, per day	-0.00002	Zala 2020 [8]
QALY loss for ICU hospitalization, per day	-0.0011	Zala 2020 [8]
Clinical parameters		
VE, Wuhan - mRNA, all cases	0.84	Imai 2021 [2]
Risk reduction of symptoms, Wuhan – mRNA	0.95	Imai 2021 [2]
VE, Wuhan - vector-based, all cases	0.64	Imai 2021 [2]
Risk reduction of symptoms, Wuhan – vector-based	0.77	Imai 2021 [2]
VE, Alpha - mRNA, all cases	0.87	Imai 2021 [2]
Risk reduction of symptoms, Alpha – mRNA	0.89	Imai 2021 [2]
VE, for Alpha - vector-based, all cases	0.77	Imai 2021 [2]
Risk reduction of symptoms, Alpha – vector-based	0.77	Imai 2021 [2]
Waning rate of mRNA vaccine, per day	0.00828	Pouwels 2021 [5]
Waning rate of vector-based vaccine, per day	0.00242	Pouwels 2021 [5]
SAE rate for vector-based vaccine, per 1 dose	273.5/10^7	Bhatia 2021 [4]
SAE rate for mRNA vaccine, per 1 dose	178.4/10^7	Bhatia 2021 [4]
Duration of AE, per event	3 days	Assumption

Strategies including either vector-based or mRNA-based vaccine were compared with no vaccination and between each other (with vector-based as the reference, as it is the cheaper COVID-19 vaccine) and were estimated at various levels of vaccine effectiveness, coverage, duration of immunity and virus characteristics.

Table 2. Compared strategies

Strategies	
No vaccination strategy	Strategy with no vaccination but the same control measures as imposed in England in the considered period (contacts pattern change over time was updated using the most recent data [11]).
Vaccination strategy	Hypothetical vaccination program which would have started early enough (mid-2020) to achieve 50% of citizens vaccinated at the beginning of the third wave and control measures as in no vaccination strategy. Vaccine effectiveness and the variant characteristics were assumed as reported for the Alpha variant.

Outcomes

- QALYs (quality-adjusted life years) gained were used as a measure of health outcomes.
- The EJP was defined as the maximum price for which the vaccine would be cost-effective compared to the comparator from a healthcare payer perspective, considering a threshold of £20,000 per QALY gained.

RESULTS

Base case results

- In the base case, both strategies with vector-based and mRNA vaccines dominated the no vaccination strategy, as associated with a gain in QALY and savings in costs.
- The vector-based vaccine dominated the mRNA-based vaccine in the base case.

Category	Vector-based vaccine vs no vaccination	mRNA vaccine vs no vaccination	mRNA vaccine vs vector-based vaccine
Incremental QALY	13,453	13,074	-393
Incremental costs (£ billion)	-2.38	-1.23	1.14
ICER	Dominant	Dominant	Dominated
EJP per dose (£)	35.60	33.89	0.46

Deterministic sensitivity analysis

Figure 1. Tornado chart: Vector-based vaccine vs no vaccination; EJP

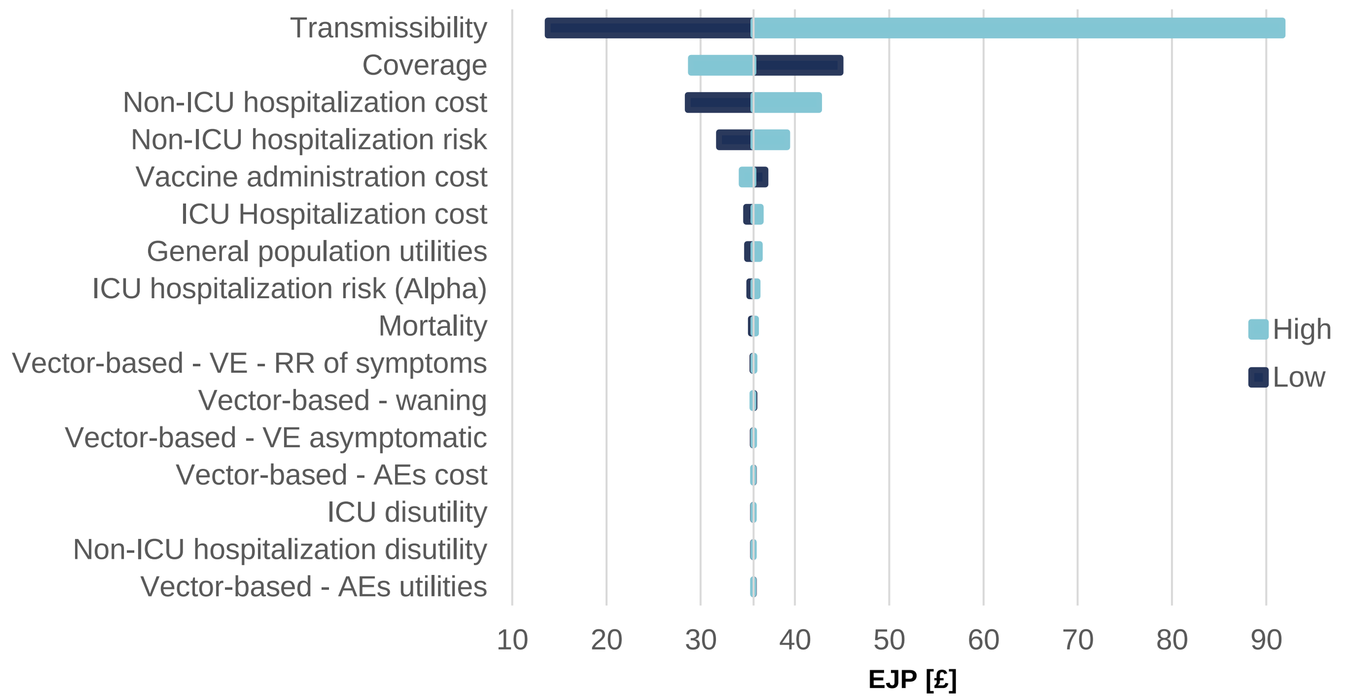


Figure 2. Tornado chart: mRNA vaccine vs no vaccination; EJP

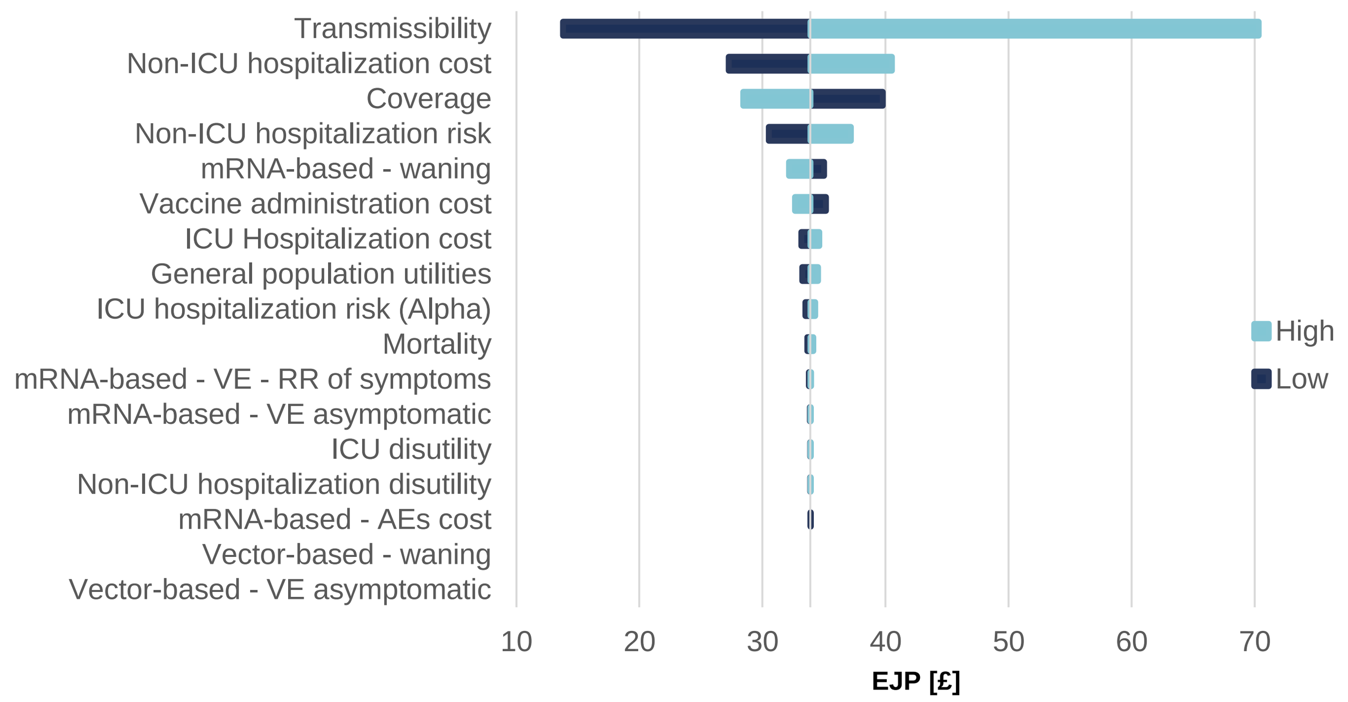
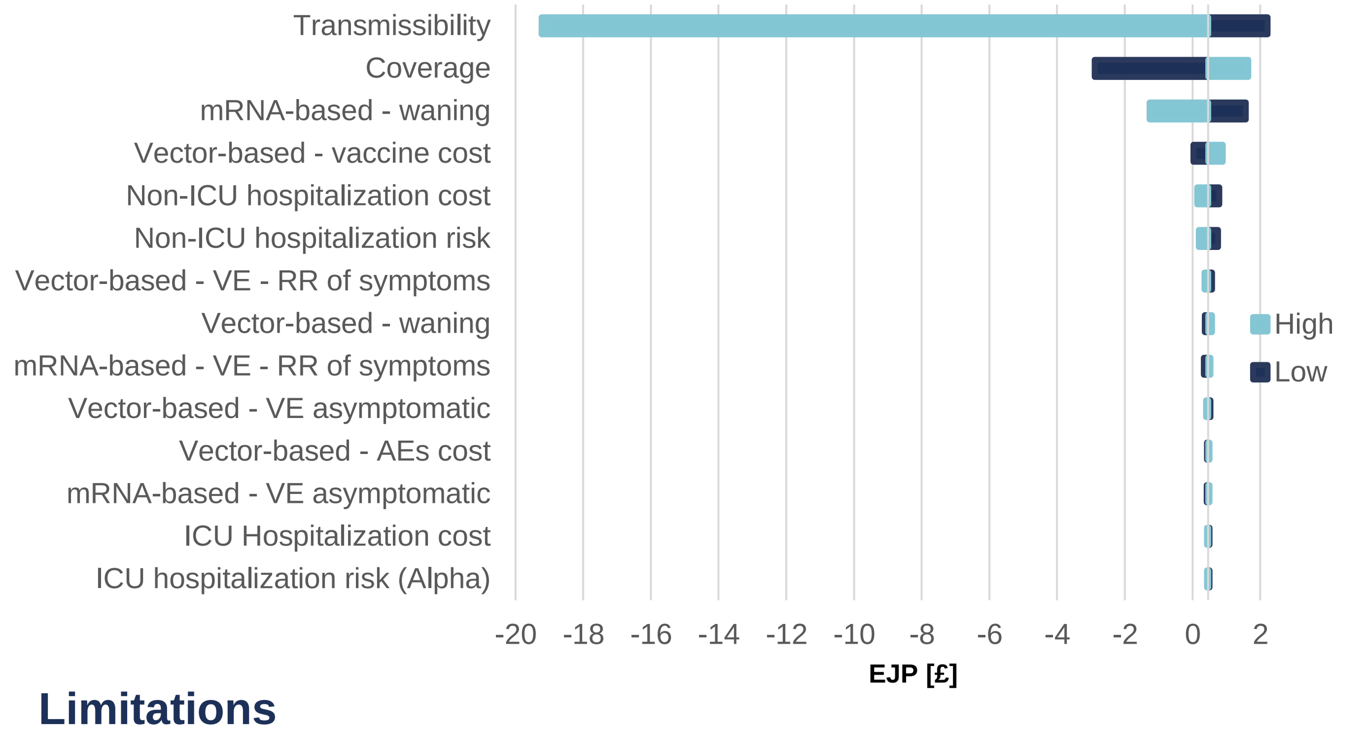


Figure 3. Tornado chart: mRNA vaccine vs vector-based vaccine; EJP



Limitations

- Time frame of this study is limited to waves driven by the Wuhan and Alpha variants. Taking into account efficacy waning and upcoming Delta variant, the impact of vaccination may differ in a longer time frame.
- Waning rates are based on initial efficacy against the Delta variant.
- The model did not allow for lower probabilities of hospitalisation and death among vaccinated vs. non-vaccinated symptomatic cases.

CONCLUSIONS

- Despite lower initial effectiveness, the vector-based vaccine dominated the mRNA vaccine in the base case due to a faster waning of mRNA vaccine effectiveness.
- The EJPs of the COVID-19 vaccines were highly sensitive to the variant transmissibility, non-ICU hospitalization-related parameters and vaccine coverage.
- Additionally, when comparing between vaccines, effectiveness and waning were important drivers of the EJP.
- The prices of the COVID-19 vaccines in England appear to be acceptable when compared to no vaccination, but this study raises doubts as to whether the price premium for mRNA vaccines over vector-based vaccines is justified.
- Results of this analysis should be interpreted with caution, considering limitations with regards to uncertainty around the waning parameters and transferability of findings to a future COVID-19 outbreak.

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