Cost and clinical impact of screening for CPE in hospitals: a cost-effectiveness model

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INTRODUCTION

Carbapenemase-producing Enterobacterales (CPE) bacteria produce carbapenemase enzymes that give them resistance to carbapenems, a class of antibiotic used to treat severe infections [1].

CPE is spreading internationally and poses a serious threat to public health, with infections due to these organisms associated with considerable morbidity and mortality [2].

Despite this, evidence on the transmission of CPE in hospitals and the effectiveness of control measures is limited. Cost-effectiveness evidence of such interventions is even more sparse [3].

METHODS

Compartmental model simulating the spread of CPE in a typical UK hospital over five years, including patient and background transmission (**Figure 1**).

Hospital perspective costs, including outbreak costs in sensitivity analysis (**Table 1**).

Partial rank correlation coefficients (PRCCs) to assess impact of parameters on total CPE infections.

Parameters from literature and primary data where available.

Routine hospital costs		Outbreak hospital costs
Excess bed-days	Room cleaning	Closed ward bed-days
Anti-infective treatment	Waste disposal	Cancelled procedures
Screening	IPC staff	Ward decontamination
PPE		Other staff (e.g., management)

Table 1. Hospital costs

Key model assumptions
- Colonised and infected patients transmit CPE at an equal rate.
- Enhanced IPC stops transmission.
- Patients awaiting test results receive enhanced IPC.
- Patients who test positive receive enhanced IPC.
- Patients with a CPE infection require intensive care.

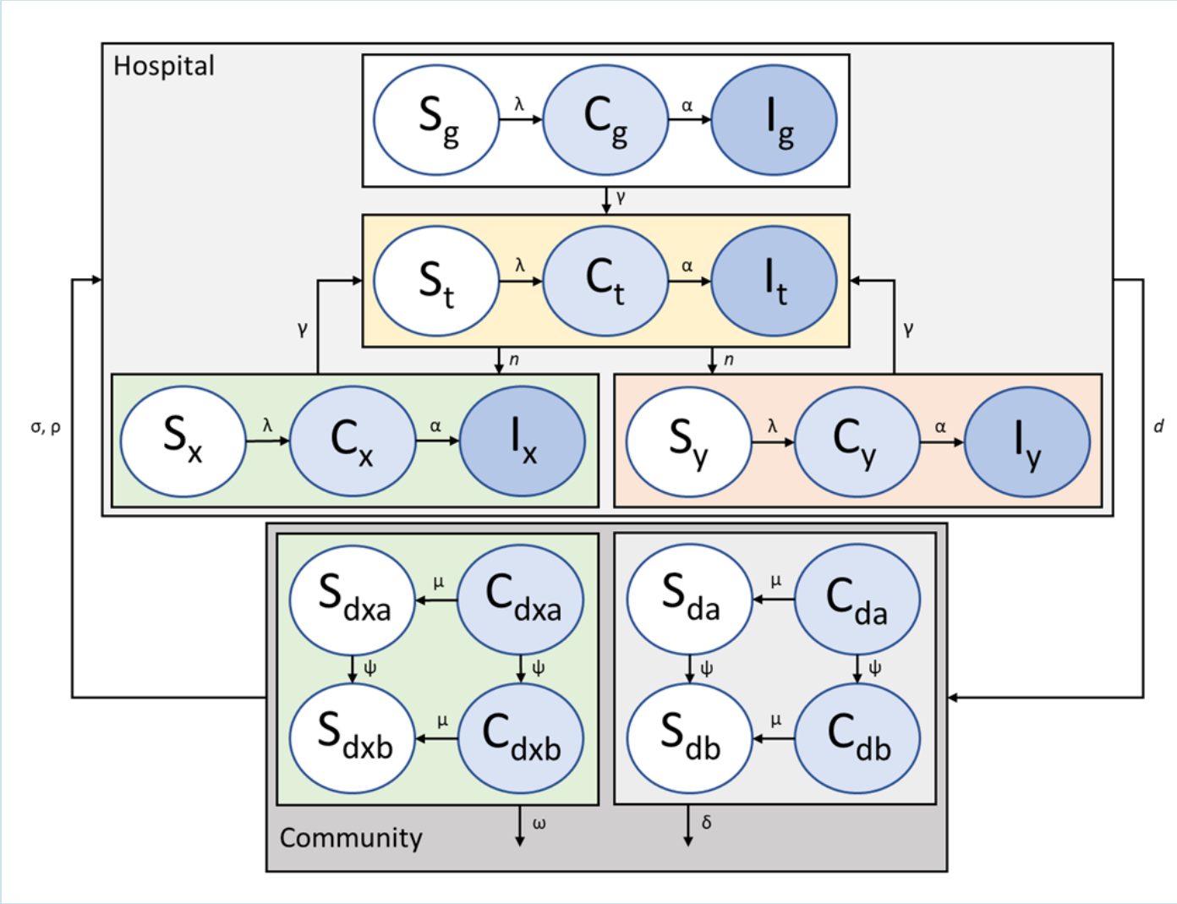
METHODS

Estimated the cost-effectiveness of three screening strategies compared to no enhanced screening:
1) Universal admission screening
2) Admission screening patients with a hospital stay and/or CPE positive result in the past year
3) Admission screening patients with a CPE positive result in the past year

For a variety of CPE transmission and progression, and prevalence scenarios (**Table 2**).

CPE parameter		Low	Ref	Middle	Ref	High	Ref
Background transmission	β_0	0.00001	[4]	0.00067359	[1,4,5]	0.0026	[5]
Patient transmission	β_1	0.00037131	[1]	0.00548294	[1,5,6,7]	0.03	[6]
Infection progression	α	0.0003042	[1]	0.00978552	[8,9]	0.0346	[8]
Prevalence on admission	σ_c	0.000532	[1]	0.001248	[10]	0.01394	[11]

Table 2. Model parameter scenarios



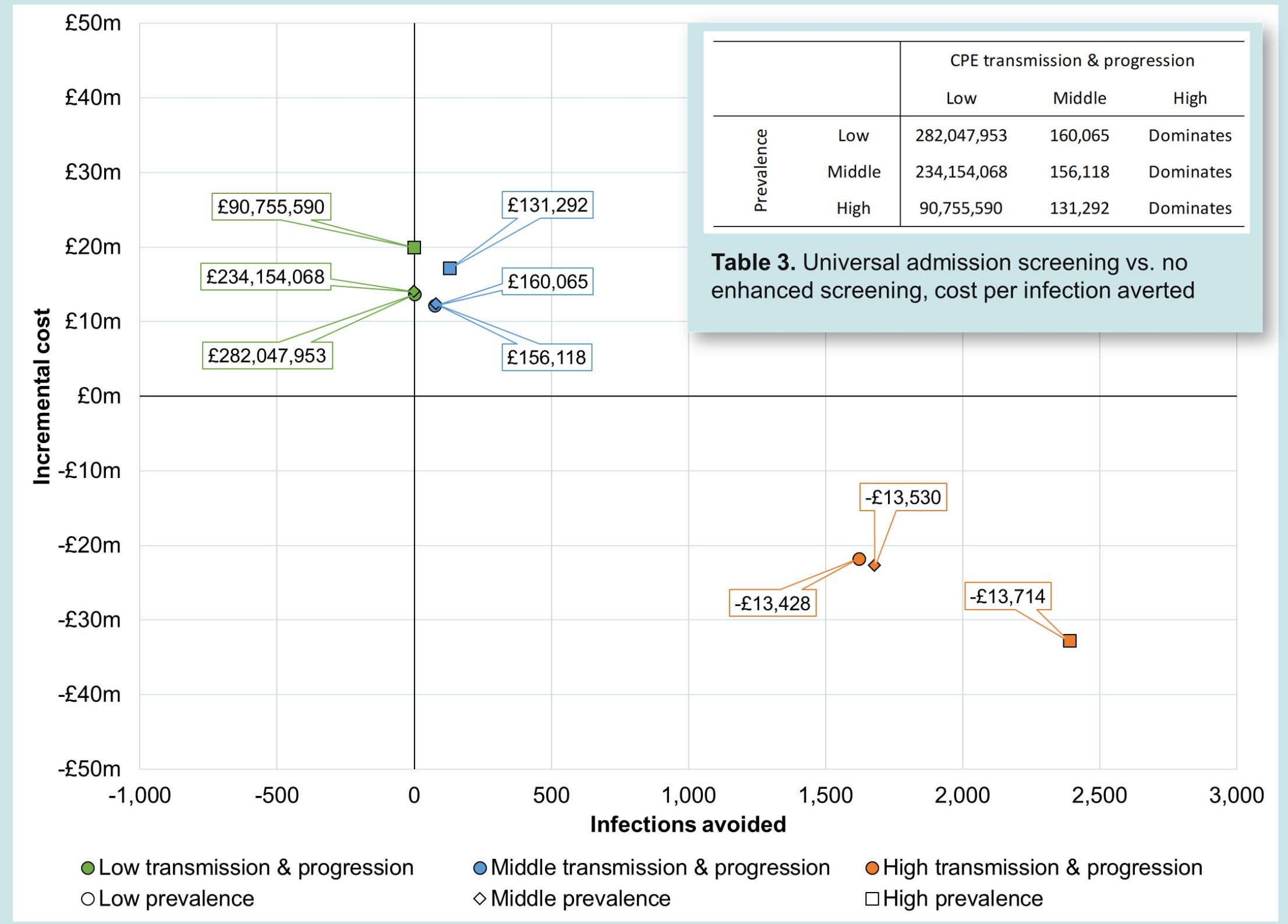
Biological states:
- S: susceptible to CPE
- C: colonised with CPE
- I: infected with CPE

Patient groups:
- g: general hospital
- t: awaiting test results
- x: tested CPE positive
- y: tested CPE negative
- dxa: recently discharged w/+ve flag
- dxb: non-recently discharged w/+ve flag
- da: recently discharged w/o +ve flag
- db: non-recently discharged w/o +ve flag

Figure 1. Model schematic

RESULTS

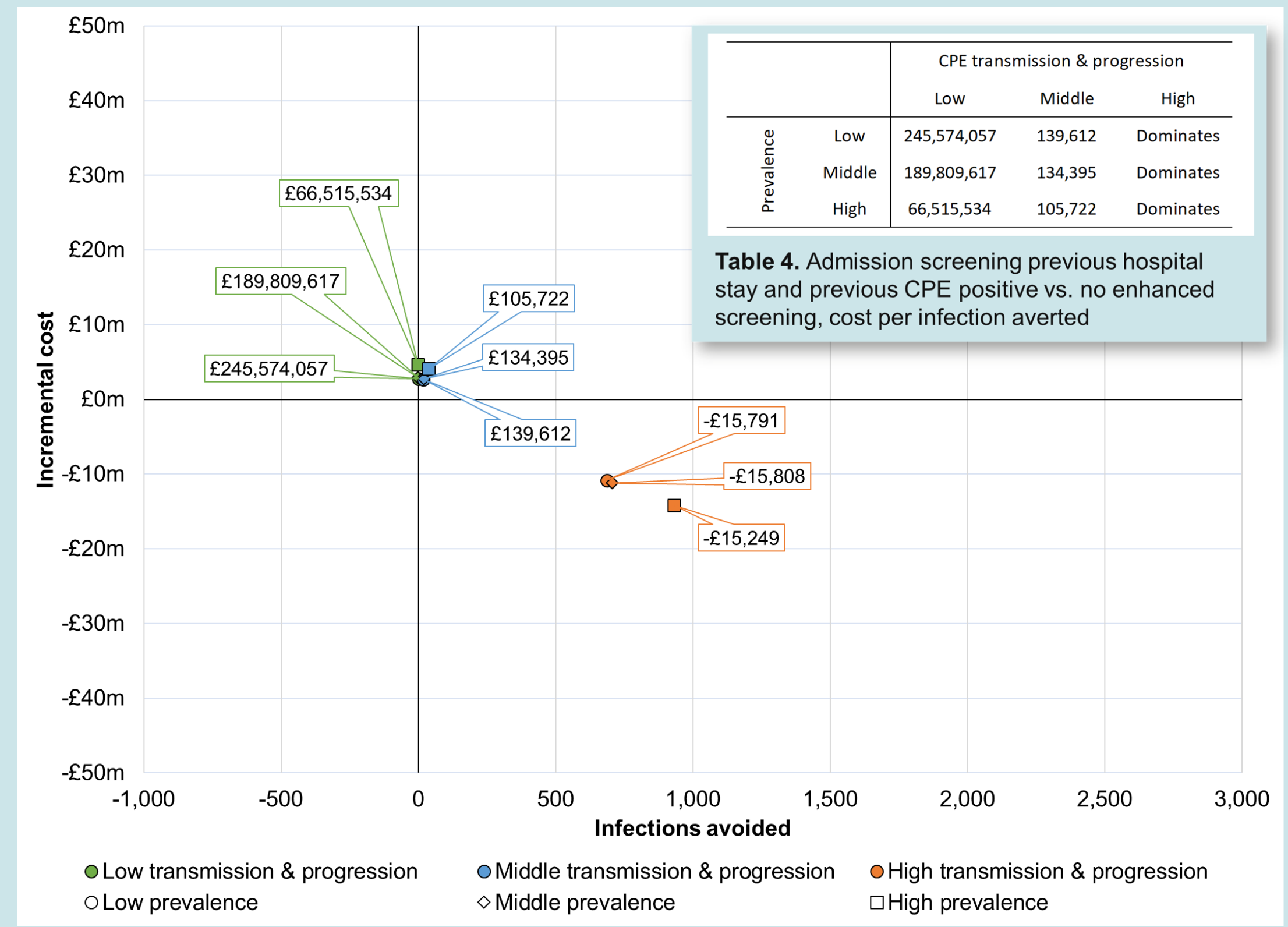
- The cost-effectiveness of screening varies considerably according to the rate of CPE transmission and progression. It also varies by admission prevalence, but to a lesser extent.
- As screening becomes more targeted the cost-effectiveness improves.
- There is considerable uncertainty in the cost-effectiveness point estimates (e.g., **Figure 5**).
- When crude outbreak costs are considered [12], the cost-effectiveness improves considerably in middle and high transmission and progression settings (e.g., **Figure 6**).
- Uncertainty in the total number of CPE infections was largely driven by CPE natural history parameters (**Figure 7**).



		CPE transmission & progression		
		Low	Middle	High
Prevalence	Low	282,047,953	160,065	Dominates
	Middle	234,154,068	156,118	Dominates
	High	90,755,590	131,292	Dominates

Table 3. Universal admission screening vs. no enhanced screening, cost per infection averted

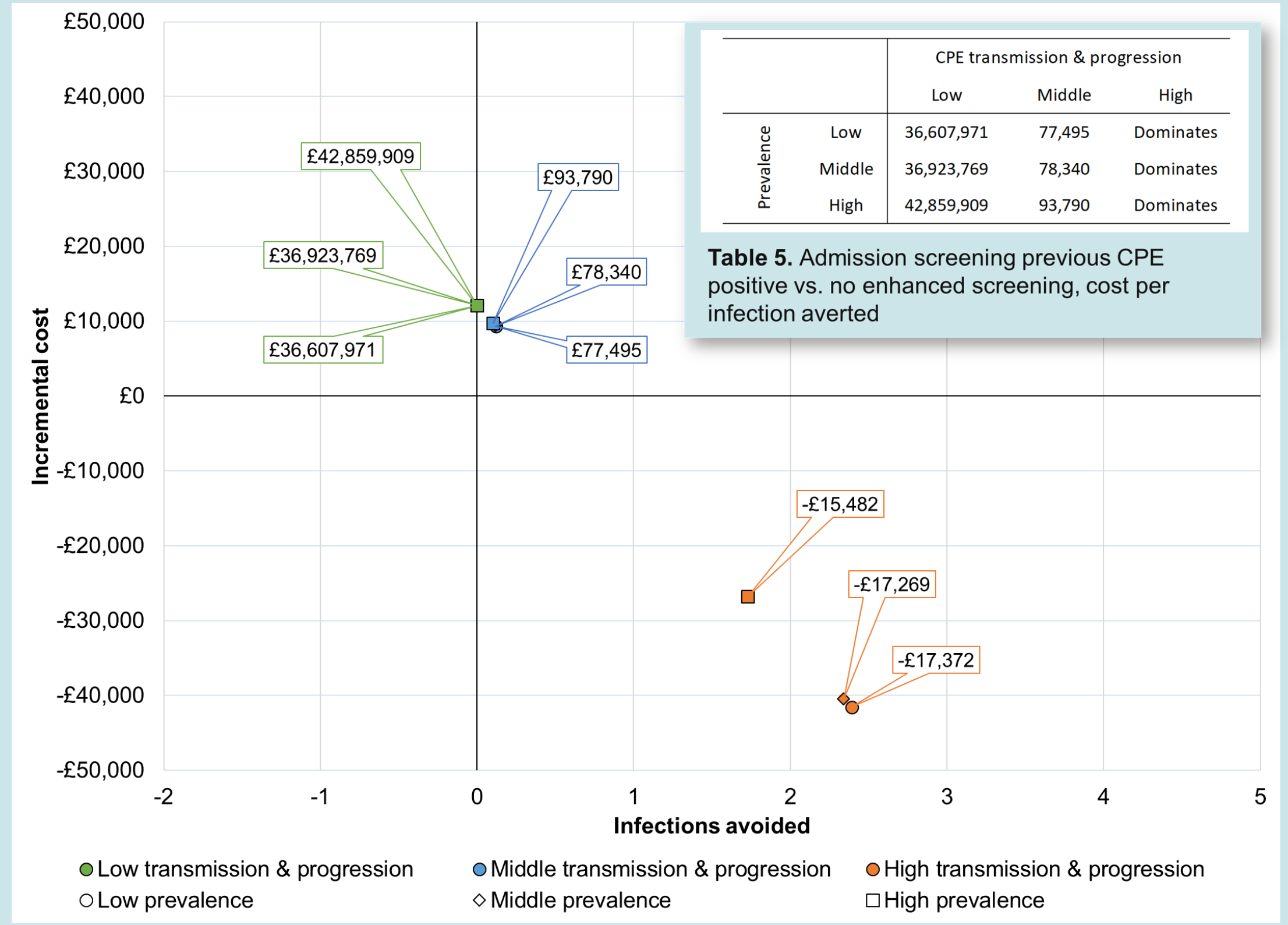
Figure 2. Cost-effectiveness plane of universal admission screening vs. no enhanced screening, for each prevalence and transmission/progression scenario



		CPE transmission & progression		
		Low	Middle	High
Prevalence	Low	245,574,057	139,612	Dominates
	Middle	189,809,617	134,395	Dominates
	High	66,515,534	105,722	Dominates

Table 4. Admission screening previous hospital stay and previous CPE positive vs. no enhanced screening, cost per infection averted

Figure 3. Cost-effectiveness plane of admission screening previous hospital stay and/or previous CPE positive vs. no enhanced screening, for each prevalence and transmission/progression scenario



		CPE transmission & progression		
		Low	Middle	High
Prevalence	Low	36,607,971	77,495	Dominates
	Middle	36,923,769	78,340	Dominates
	High	42,859,909	93,790	Dominates

Table 5. Admission screening previous CPE positive vs. no enhanced screening, cost per infection averted

Figure 4. Cost-effectiveness plane of admission screening previous CPE positive vs. no enhanced screening, for each prevalence and transmission/progression scenario

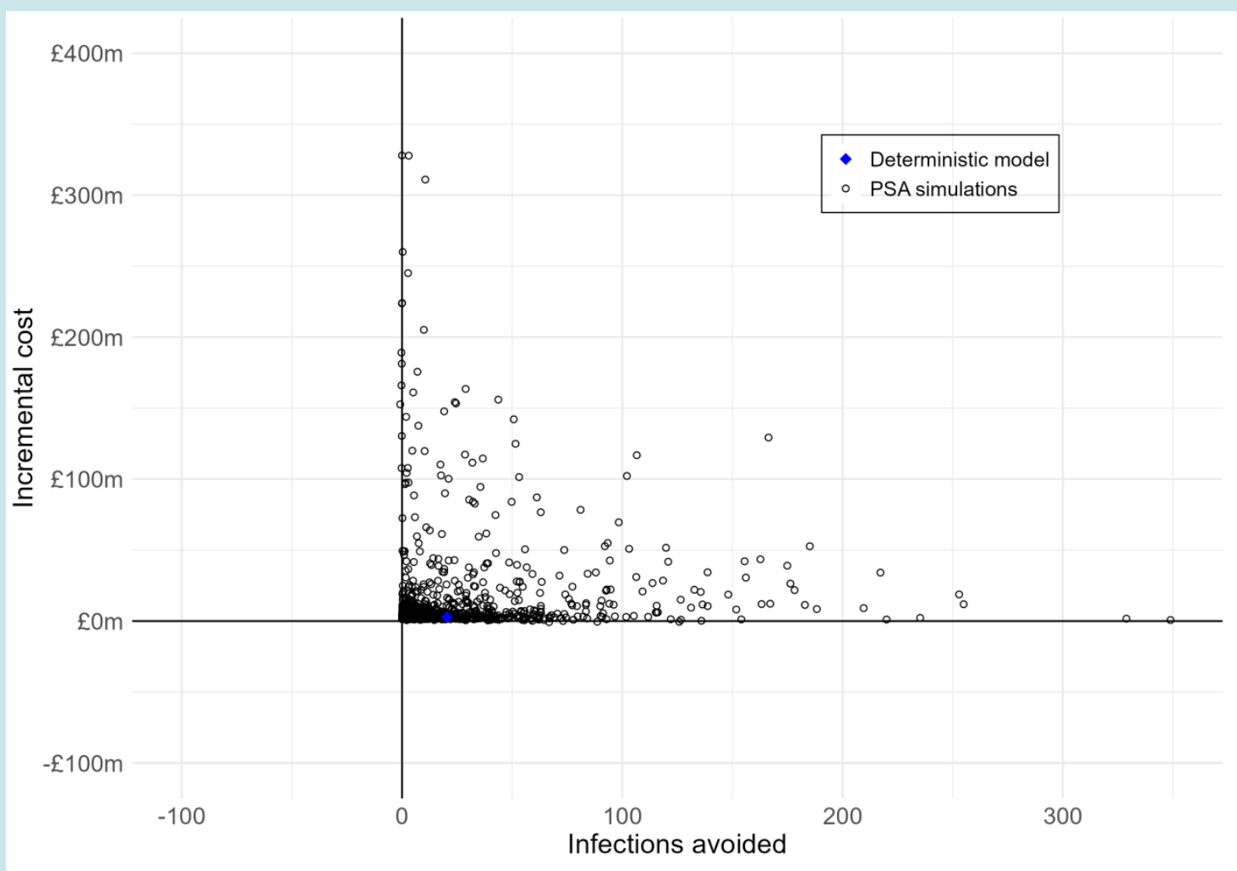


Figure 5. Cost-effectiveness plane of admission screening previous hospital stay and/or previous CPE positive vs. no enhanced screening; middle CPE transmission and progression, and middle prevalence

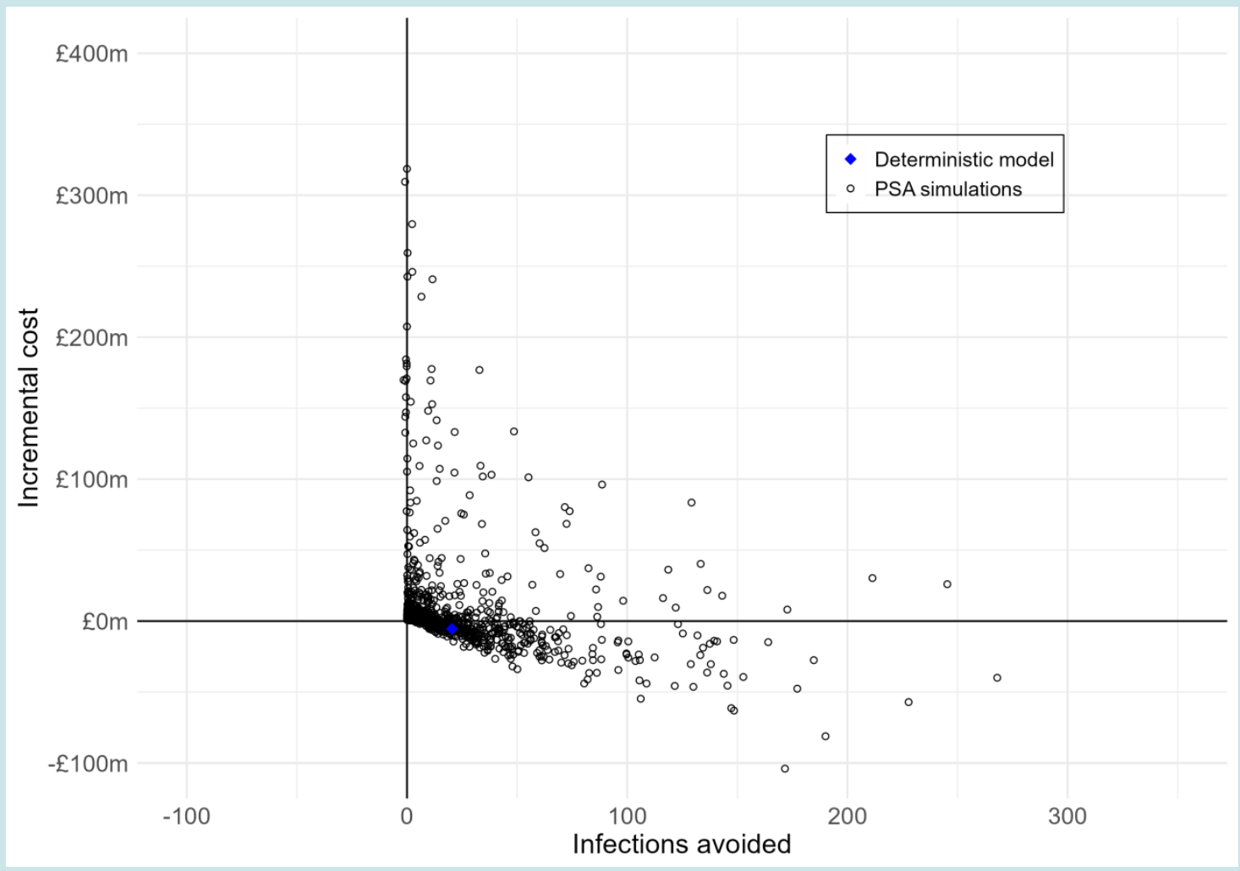


Figure 6. Cost-effectiveness plane of admission screening previous hospital stay and/or previous CPE positive vs. no enhanced screening; middle CPE transmission and progression, and middle prevalence; including crude outbreak costs

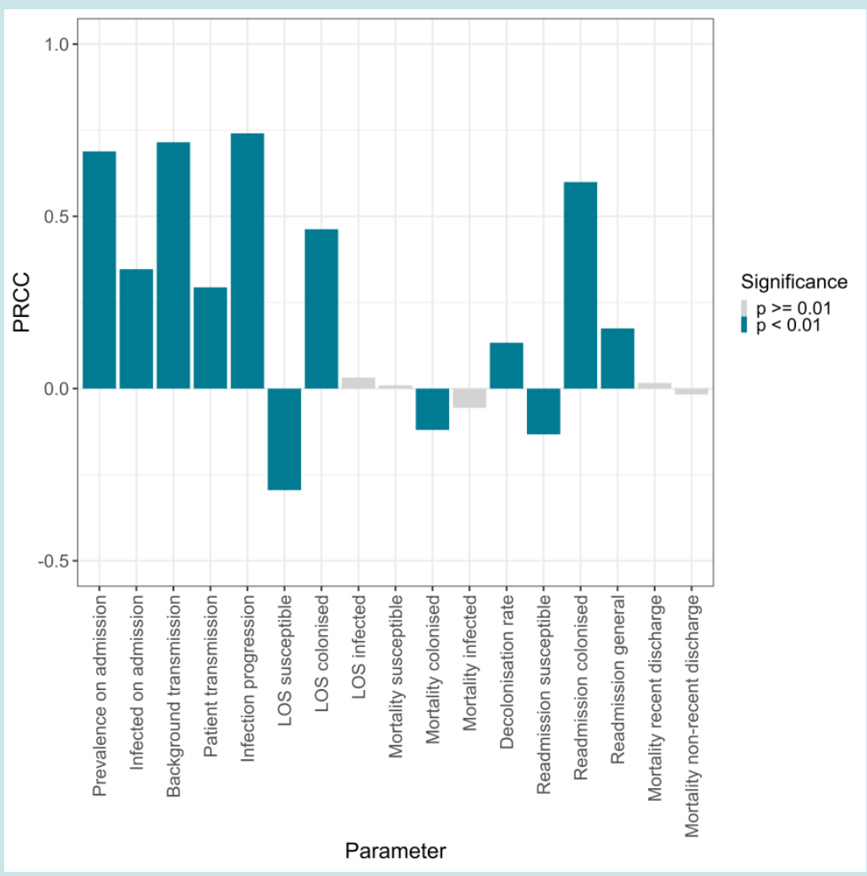


Figure 7. Partial rank correlation coefficients of total CPE infections

DISCUSSION

All three screening strategies dominate (i.e., are less costly and result in fewer infections) no enhanced screening in high transmission and progression settings, as the cost of screening is outweighed by the savings associated with the avoided infections.

Cost-effectiveness varied considerably by transmission and progression rate, and also, but less so, by admission prevalence. A similar Scottish study reported prevalence as a key driver of cost-effectiveness [9].

Understanding the transmission of CPE in hospitals is vital to identifying cost-effective interventions. However, the evidence base is limited, and enhanced surveillance of CPE generally only occurs in outbreak settings.

Incorporating crude outbreak costs improves the cost-effectiveness of screening strategies and may even change the policy decision. More work is needed to appropriately include these costs.

Future work will also incorporate quality-adjusted life years into the model, to support resource allocation across healthcare budgets.

CONCLUSIONS

- The cost-effectiveness of screening varied considerably by CPE transmission and progression, with strategies much more likely to be cost-effective as transmission and progression increased.
- The cost-effectiveness of screening improved as screening became more targeted.
- More evidence is needed on the transmission of CPE in hospitals and the impact of outbreak costs on cost-effectiveness.

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