The Costing Model

This document describes the costing model that is used in the CEPI application.

1 Parameters

Table 1: Notation and parametric assumptions for inputs to the costing model. Parameters are used as follows: uniform distributions go from Parameter 1 to Parameter 2. Triangular distributions go from Parameter 1 to Parameter 3 with a peak at Parameter 2. Multinomial distributions have equally probable values listed individually. Exponential distributions have as a mean Parameter 1. Inverse Gaussian distributions have as a mean Parameter 1, and as a shape Parameter 2. Log normal distributions have as a mean Parameter 1, and as a standard deviation Parameter 2. PearsonV distributions have shape Parameter 1, scale Parameter 2, and location 0. PearsonVI distributions have shape Parameters 1 and 2, scale Parameter 3, and location 0. Where given, distributions are truncated at bounds.

Math notation	Description	Distribution	Parameters	Source
$N^{(\text{BPSV})}$	Number of BPSV candidates	Constant	14	
$N^{(\text{BPSV-1})}$	Number of BPSV candidates starting at phase 1	Constant	1	
$P_0^{(\text{BPSV})}$	Probability of success; preclinical	Multinomial	0.40, 0.41, 0.41, 0.42, 0.48, 0.57	Gouglas et al. [2018]
$P_1^{(\text{BPSV})}$	Probability of success; Phase I	Multinomial	0.33, 0.40, 0.50, 0.68, 0.70, 0.72, 0.74, 0.77, 0.81, 0.90	Gouglas et al. [2018]
$P_2^{(\text{BPSV})}$	Probability of success; Phase II	Multinomial	0.22, 0.31, 0.33, 0.43, 0.46, 0.54, 0.58, 0.58, 0.74, 0.79	Gouglas et al. [2018]
$Y_0^{(B)}$	BPSV preclinical duration; years	Multinomial	1, 2	CEPI [2022]
$Y_1^{(B)}$	BPSV Phase I duration; years	Multinomial	1, 2	CEPI [2022]
$Y_2^{(B)}$	BPSV Phase II duration; years	Constant	2	CEPI [2022]
$Y_3^{(B)}$	BPSV Phase III duration; years	Multinomial	3, 4	CEPI [2022]
$W_3^{(B)}$	BPSV response Phase III duration; weeks	Constant	18	

Math notation	Description	Distribution	Parameters	Source
$Q^{(\mathrm{SSV})}$	Probability of N or more SSV successes	Constant	0.9	Model choice
$n^{(\mathrm{SSV})}$	Number of SSV successes	Constant	5	Model choice
X_0	COVID-19 candidates failed at preclinical	Constant	33	Linksbridge SPC [2025]
X_1	COVID-19 candidates failed at Phase 1	Constant	20	Linksbridge SPC [2025]
X_2	COVID-19 candidates failed at Phase 2	Constant	8	Linksbridge SPC [2025]
X_3	COVID-19 candidates failed at Phase 3	Constant	8	Linksbridge SPC [2025]
X_4	COVID-19 candidates successful	Constant	27	Linksbridge SPC [2025]
$Y^{(200)}$	Years of R&D to 200-day readiness	Constant	5	
$Y^{(100)}$	Years of R&D to 100-day readiness	Constant	15	
E	Enabling activities; million USD per year	Constant	700	CEPI [2021]
$W^{(S)}_{0;365}$	SSV preclinical duration (365); weeks	Constant	14	
$W^{(S)}_{0;200}$	SSV preclinical duration (200 days); weeks	Constant	5	
$W^{(S)}_{0;100}$	SSV preclinical duration (100 days); weeks	Constant	5	
$W^{(S)}_{1;365}$	SSV phase I duration (365); weeks	Constant	0	
$W^{(S)}_{1;200}$	SSV phase I duration (200 days); weeks	Constant	0	
$W^{(S)}_{1;100}$	SSV phase I duration (100 days); weeks	Constant	0	
$W^{(S)}_{2;365}$	SSV phase II duration (365); weeks	Constant	19	
$W^{(S)}_{2;200}$	SSV phase II duration (200 days); weeks	Constant	7	
$W^{(S)}_{2;100}$	SSV phase II duration (100 days); weeks	Constant	0	
$W^{(S)}_{3;365}$	SSV phase III duration (365); weeks	Constant	16	
$W^{(S)}_{3;200}$	SSV phase III duration (200 days); weeks	Constant	15	
$W^{(S)}_{3;100}$	SSV phase III duration (100 days); weeks	Constant	8	

Math notation	Description	Distribution	Parameters	Source
$T_0^{(e)}$	Cost, preclinical, experienced manufacturer; USD	Exponential	24213683	Gouglas et al. [2018]
$T_0^{(n)}$	Cost, preclinical, inexperienced manufacturer; USD	Inverse Gaussian	7882792, 13455907	Gouglas et al. [2018]
$T_1^{(e)}$	Cost, Phase I, experienced manufacturer; USD	Inverse Gaussian	15339198, 8076755	Gouglas et al. [2018]
$T_1^{(n)}$	Cost, Phase I, inexperienced manufacturer; USD	PearsonV	2.2774, 9799081	Gouglas et al. [2018]
$T_2^{(e)}$	Cost, Phase II, experienced manufacturer; USD	Log normal	28297339, 24061641	Gouglas et al. [2018]
$T_2^{(n)}$	Cost, Phase II, inexperienced manufacturer; USD	Inverse Gaussian	17124622, 35918793	Gouglas et al. [2018]
$T_3^{(e)}$	Cost, Phase III, experienced manufacturer; USD	PearsonV	1.3147, 51397313	Gouglas et al. [2018]
T_4	Licensure cost, 2018; USD	Constant	287750	Gouglas et al. [2018]
I	Inflation (2018 t0 2025)	Constant	0.28000000000000003	U.S. BLS [2025]
ω	Share of manufacturers that are inexperienced	Constant	0.92307692307692313	See Table 2
r	Discount rate	Uniform	0.02, 0.06	Glennerster et al. [2023]
A_4	Size of BPSV investigational reserve, doses	Constant	100000	Model choice
A_1	Annual BPSV reservation cost, USD per dose	Constant	1.0121363333333333E-2	
A_5	BPSV reserve upfront cost, USD per dose	Constant	0.115	
Y_{rep}	Years after which BPSV doses are to be replaced	Constant	3	
A_2	Advanced capacity reservation fee; USD per dose per year	Constant	0.53169230769230769	Pfizer [2023]
A_3	Reserved capacity for HIC, billions	Constant	0.5	
S_U	SSV procurement price, reactive capacity; USD per dose	Constant	18.9392	Linksbridge SPC [2025]

Math notation	Description	Distribution	Parameters	Source
G	Drug substance cost; USD per dose	Constant	4.68	Kazaz [2021]
M_p	Profit margin	Constant	0.2	Kazaz [2021]
M_f	Fill/finish cost	Constant	0.13980000000000001	Kazaz [2021]
M_t	Cost to transport product	Constant	0.12	Kazaz [2021]
M_G	Global annual manufacturing volume; billion doses	Constant	15	Linksbridge SPC [2025]
M_C	Current annual manufacturing volume; billion doses	Constant	9	Linksbridge SPC [2025]
λ	Final vaccine coverage, proportion of population	Constant	0.8	Model choice
δ	Fraction of BPSV expected to go to waste	Constant	0.31425320000000001	Model choice
$N^{(\text{boost})}$	Number of boosters given, one per year	Constant	2	Model choice
I_0	Facility transition start; weeks before vaccine approval	Constant	7	
I_R	Weeks to initial manufacturing, reserved infrastructure	Constant	12	Vaccines Europe [2023]
$I_{E,0}$	Weeks to initial manufacturing when there's no BPSV, existing and unreserved infrastructure	Constant	30	Vaccines Europe [2023]
$I_{E,1}$	Weeks to initial manufacturing when there's BPSV, existing and unreserved infrastructure	Constant	12	Vaccines Europe [2023]
I_B	Weeks to initial manufacturing, built and unreserved infrastructure	Constant	48	
C_R	Weeks to scale up to full capacity, reserved infrastructure	Constant	10	Vaccines Europe [2023]
C_E	Weeks to scale up to full capacity, existing and unreserved infrastructure	Constant	16	
C_B	Weeks to scale up to full capacity, built and unreserved infrastructure	Constant	16	

Math notation	Description	Distribution	Parameters	Source
$V_{L;0}$	Cost of vaccine delivery at start up (0–10%) in LIC; USD per dose	Triangular	1, 1.5, 2	See Table 5
$V_{L;11}$	Cost of vaccine delivery during ramp up (11–30%) in LIC; USD per dose	Triangular	0.75, 1, 1.5	See Table 5
$V_{L;31}$	Cost of vaccine delivery getting to scale (31% and over) in LIC; USD per dose	Triangular	1, 2, 4	See Table 5
$V_{LM;0}$	Cost of vaccine delivery at start up (0–10%) in LMIC; USD per dose	Triangular	3, 4.5, 6	See Table 5
$V_{LM;11}$	Cost of vaccine delivery during ramp up (11–30%) in LMIC; USD per dose	Triangular	2.25, 3, 4.5	See Table 5
$V_{LM;31}$	Cost of vaccine delivery getting to scale (31% and over) in LMIC; USD per dose	Triangular	1.5, 2, 2.5	See Table 5
$V_{UM;0}$	Cost of vaccine delivery at start up (0–10%) in UMIC; USD per dose	Triangular	6, 9, 12	See Table 5
$V_{UM;11}$	Cost of vaccine delivery during ramp up (11–30%) in UMIC; USD per dose	Triangular	4.5, 6, 9	See Table 5
$V_{UM;31}$	Cost of vaccine delivery getting to scale (31% and over) in UMIC; USD per dose	Triangular	3, 4, 5	See Table 5
$V_{H;0}$	Cost of vaccine delivery at start up (0–10%) in HIC; USD per dose	Triangular	30, 40, 75	See Table 5
$V_{H;11}$	Cost of vaccine delivery during ramp up (11–30%) in HIC; USD per dose	Triangular	30, 40, 75	See Table 5
$V_{H;31}$	Cost of vaccine delivery getting to scale (31% and over) in HIC; USD per dose	Triangular	30, 40, 75	See Table 5
$N^{(0)}_{HIC}$	Population, HIC	Constant	1260028362	
$N^{(0)}_{UMIC}$	Population, UMIC	Constant	2854556263.5	

Math notation	Description	Distribution	Parameters	Source
$N_{LMIC}^{(0)}$	Population, LMIC	Constant	3314048516	
$N_{LIC}^{(0)}$	Population, LIC	Constant	762656294.5	
$N_{HIC}^{(15)}$	Population aged 15 and older, HIC	Constant	1064531991.5	
$N_{UMIC}^{(15)}$	Population aged 15 and older, UMIC	Constant	2308984518	
$N_{LMIC}^{(15)}$	Population aged 15 and older, LMIC	Constant	2363976954.5	
$N_{LIC}^{(15)}$	Population aged 15 and older, LIC	Constant	450976596.5	
$N_{HIC}^{(65)}$	Population aged 65 and older, HIC	Constant	256715334	
$N_{UMIC}^{(65)}$	Population aged 65 and older, UMIC	Constant	359824402.5	
$N_{LMIC}^{(65)}$	Population aged 65 and older, LMIC	Constant	215830985.5	
$N_{LIC}^{(65)}$	Population aged 65 and older, LIC	Constant	24812768	

2 Preparedness cost equation

We can write the total preparedness cost for scenario s in year y as

$$D_y^{(\text{prep})} = \frac{1}{(1+r)^y} \left(D_s^{(\text{BP-adRD})} + D_{s,y}^{(\text{BP-man})} + D_{s,y}^{(\text{BP-inv})} + D_s^{(\text{S-cap})} + D_{s,y}^{(\text{en})} \right)$$

where:

- $D_s^{(\text{BP-adRD})}$ is the R&D cost of BPSV prior to an outbreak; see Equation (1)
- $D_{s,y}^{(\text{BP-man})}$ is the upfront cost of maintaining an investigational reserve of 100,000 BPSV doses; see Equation (2)
- $D_{s,y}^{(\text{BP-inv})}$ is the annual cost of maintaining an investigational reserve of 100,000 BPSV doses; see Equation (3)
- $D_s^{(\text{S-cap})}$ is the cost of reserved capacity for SSV; see Equation (4)
- $D_{s,y}^{(text(en)}$ is the annual cost of enabling activities; see Equation (5).

2.1 BPSV advanced R&D

These values match the spreadsheet results

Advanced R&D for BPSVs consists of Phases 0 to II, for which we add up costs that depend on (a) the number of candidates, (b) the cost per phase for experienced and inexperienced developers, and (c) the probability of success in each phase. The final cost therefore reflects the number of candidates that progressed through the developmental pipeline.

Probabilities of success for preclinical and Phase I are $P_0^{(\text{BPSV})}$ and $P_1^{(\text{BPSV})}$. Then probabilities of phase occurrence are:

$$\hat{P}_i^{(0)} = \begin{cases} 1 & i = 0 \\ \prod_{j=0}^{i-1} P_j^{(\text{BPSV})} & i \in \{1, 2\} \end{cases}$$

For $N^{(\text{BPSV-1})} = 1$ candidate(s), which have already been through the preclinical phase, we have

$$\hat{P}_i^{(1)} = \begin{cases} 1 & i = 1 \\ \prod_{j=1}^{i-1} P_j^{(\text{BPSV})} & i > 1 \end{cases}$$

The cost of each phase is T_i, a weighted average of experienced and inexperienced manufacturers. Assuming that $N^{(\text{BPSV})} - N^{(\text{BPSV-1})} =$ candidates start in the preclinical phase, and only one so far has experience with licensure (Table 2), we take $\omega = 0.92$;

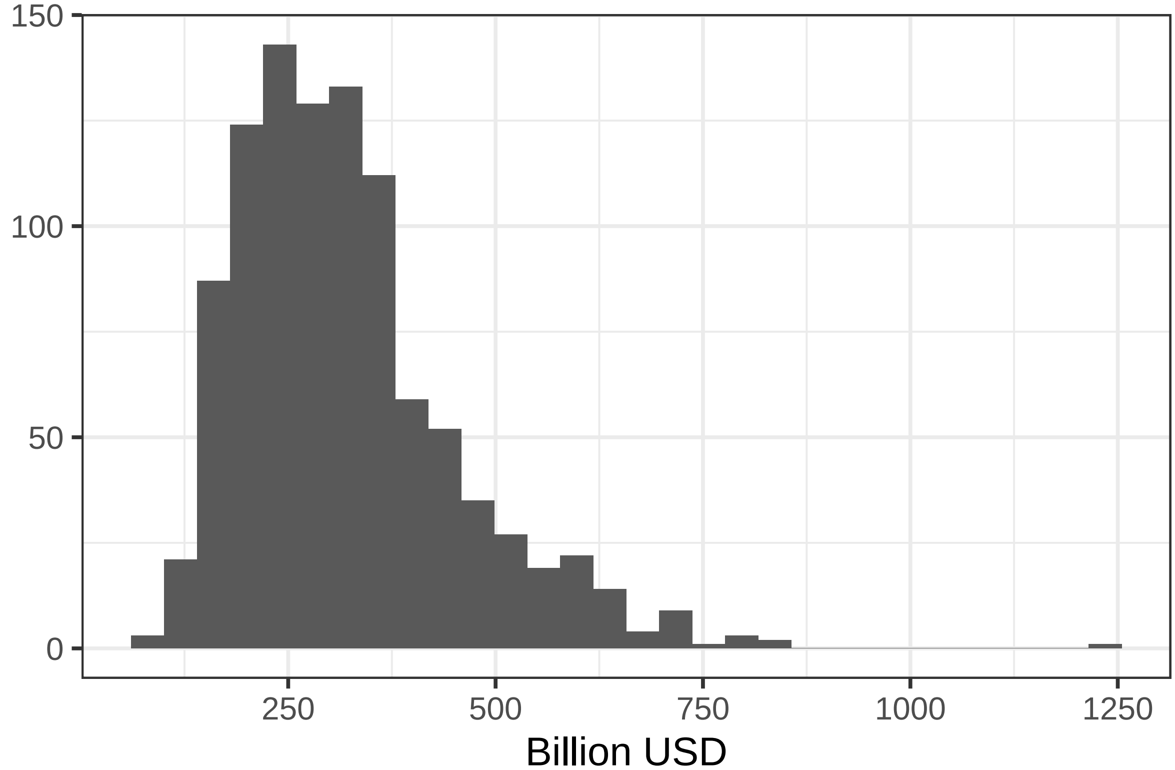
$$T_i = (1 + I) \left(\omega T_i^{(n)} + (1 - \omega) T_i^{(e)} \right)$$

where $I = 0.28$ is inflation from 2018 to 2025. Then the total weighted cost for phases 0 through 2 for $N^{(\text{BPSV})}$ candidates is

$$D_s^{(\text{BP-adRD})} = \begin{cases} \left(N^{(\text{BPSV})} - N^{(\text{BPSV-1})} \right) \sum_{i=0}^{2} \hat{P}_i^{(0)} T_i + N^{(\text{BPSV-1})} \sum_{i=1}^{2} \hat{P}_i^{(1)} T_i & s = 1 \\ 0 & s \neq 1 \end{cases} \tag{1}$$

Table 2: Manufacturers working on BPSV and whether or not they have licensure experience

Developer	Licensure Experience
CalTech	No
SK Bio	Yes
Codiak	No
Panacea	No
NEC Onco	No
Intravacc	No
VIDO	No
IVI	No



Min. 1st Qu. Median Mean 3rd Qu. Max. 80.68 223.61 297.93 319.18 378.17 1234.67

Target: 146 (103 135 177)

2.2 BPSV investigational reserve

The annual cost annual is correct, at around 162 thousand, but the total cost is slightly too high

Denoting the duration of each Phase i as $Y_i^{(B)}$, the time taken to complete development of the BPSV up to the end of phase II, from which point it is manufactured to be held in an investigational reserve, is:

$$Y^{(B)} = Y_0^{(B)} + Y_1^{(B)} + Y_2^{(B)}.$$

The upfront cost of securing the investigational reserve is

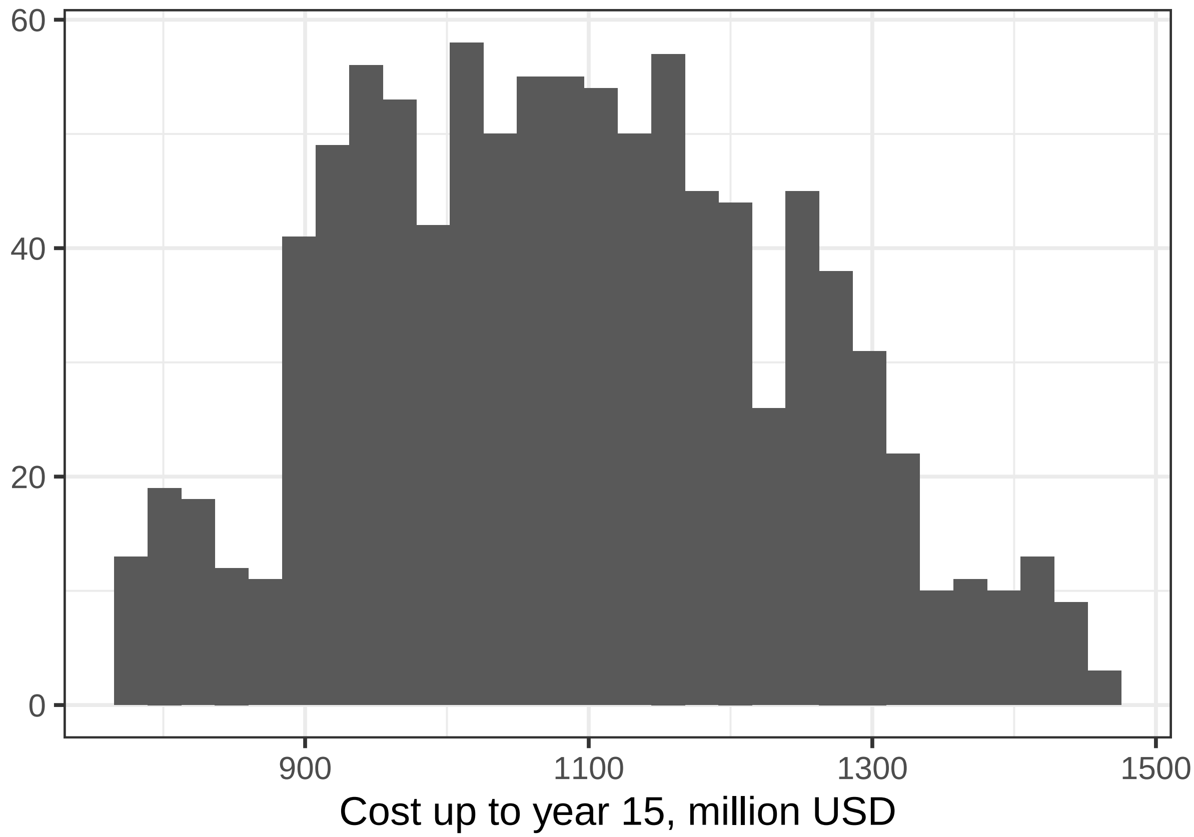
$$D_{s,y}^{(\text{BP-man})} = \begin{cases} A_4 A_5 & s = 1 \ \& \ y = Y^{(B)} + 1 \\ 0 & s \neq 1 \ \| \ y \neq Y^{(B)} + 1 \end{cases} \tag{2}$$

where $A_4 = 100,000$ is the size of the reserve and $A_5 = 0.115$ is the cost per dose in USD.

The cost of goods supplied is $G = 4.68$. Then the cost of drug substance, accounting for the fill/finish cost $M_f = 0.14$ and the profit margin $M_p = 0.2$, is $G(1 - M_f)(1 + M_p) = 4.83$ USD per dose. The reserve is replenished every $Y_{rep} = 3$ years. Then the annual cost to maintain the reserve of $A_4 = 100,000$ doses is

$$D_{s,y}^{(\text{BP-inv})} = \begin{cases} \frac{A_4}{Y_{rep}} G(1-M_f)(1+M_p) + A_1 & s = 1 \ \& \ y > Y^{(B)} \\ 0 & s \neq 1 \ \| \ y \leq Y^{(B)} \end{cases} \tag{3}$$

where $A_1 = 0.01$ USD is the annual reservation cost per dose.



Min. 1st Qu. Median Mean 3rd Qu. Max. 777.2 969.4 1084.5 1088.5 1196.7 1463.7

Target: 1 (0.9 1 1.1)

2.3 SSV capacity reservation

This matches the spreadsheet results.

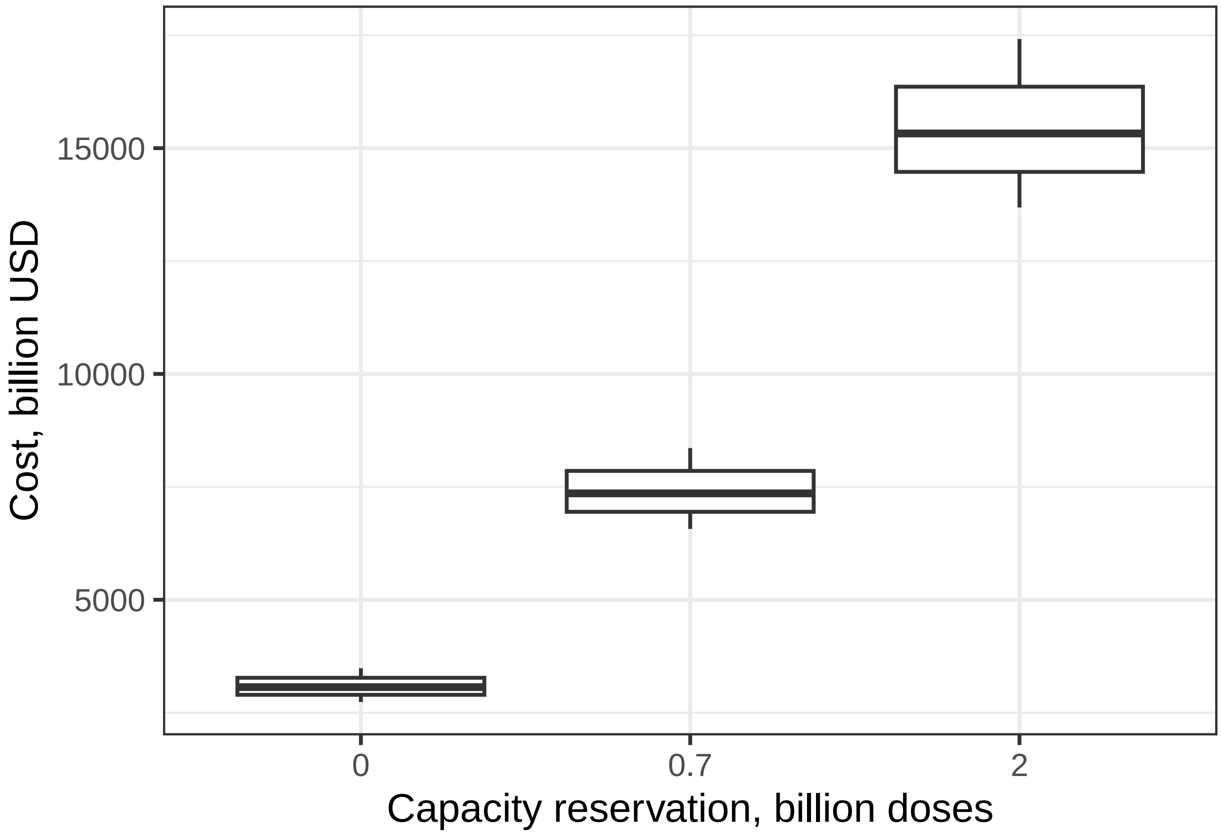
The cost per dose reservation per year is $A_2 = 0.53$ USD. Reservation sizes, in billions, depend on scenarios, including the $A_3 = 0.5$ billion doses reserved for HIC, as follows:

$$M_{R,s} = \begin{cases} A_3 & s \in \{0, 1, 4, 7, 10\} \\ A_3 + 0.7 & s \in \{2, 5, 8\} \\ A_3 + 2 & s \in \{3, 6, 9\} \end{cases}$$

Then the total cost per year is

$$D_s^{(\text{S-cap})} = M_{R,s} A_2 \tag{4}$$

The annual costs in billion USD are 0.27, 0.64, and 1.33, respectively.



0 Min. 1st Qu. Median Mean 3rd Qu. Max. 2737 2895 3065 3083 3272 3483

0.7 Min. 1st Qu. Median Mean 3rd Qu. Max. 6570 6948 7356 7399 7853 8360

2 Min. 1st Qu. Median Mean 3rd Qu. Max. 13687 14475 15326 15415 16361 17416

Targets: 3,086 (2,897 3,074 3,269)

7,407 (6,954 7,378 7,845)

15,431 (14,487 15,370 16,344)

2.4 Enabling activities

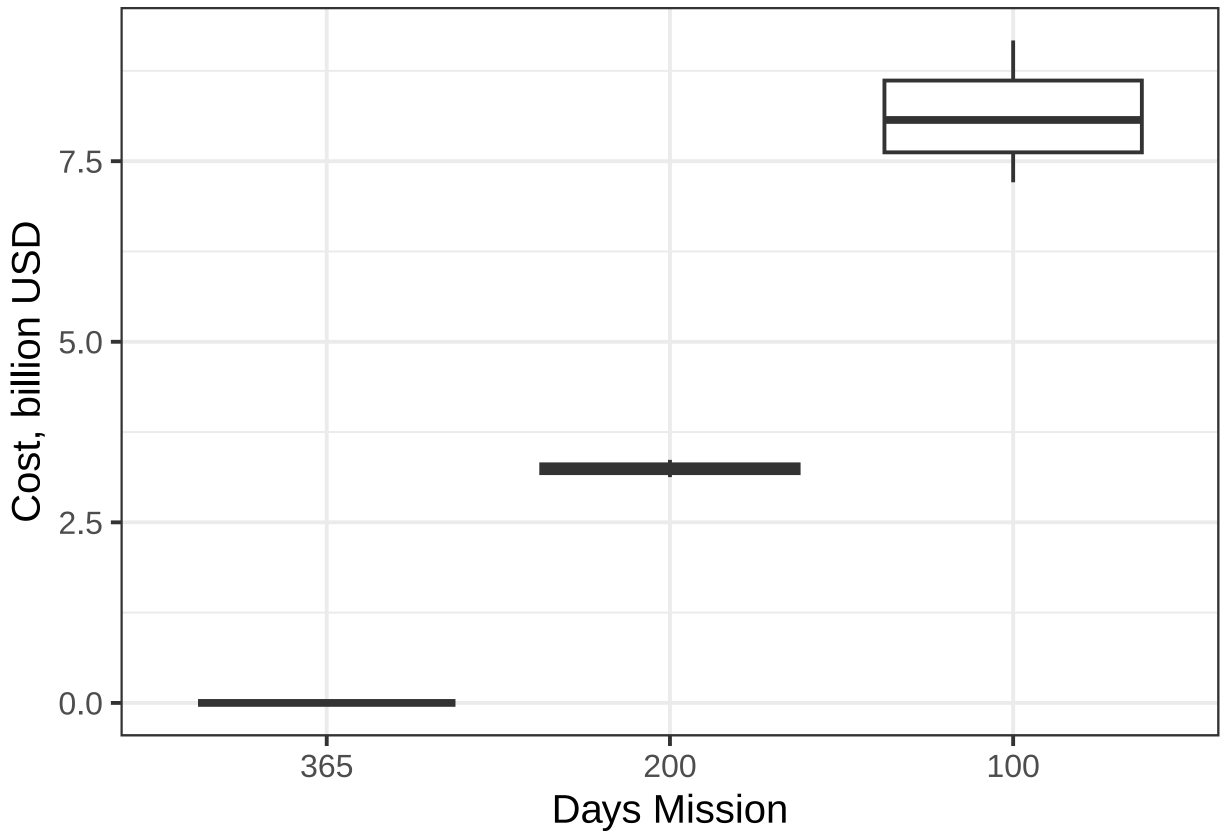
This matches the spreadsheet results

Denote the target "days to SSV" by ζ, so that $\zeta \in \{365, 200, 100\}$, which are the three variations we consider enabling activities might achieve. We assume that $Y^{(200)} = 5$ years are required to achieve 200 days to SSV, and $Y^{(100)} = 15$ years are required to achieve 200 days to SSV. Then annual costs, $E = 700$ million, accumulate depending on the year and the mission:

$$D^{(\mathrm{en})}_{s,y} = \begin{cases} E & \zeta(s) = 200 \;\&\; y \leq Y^{(200)} \mid \zeta(s) = 100 \;\&\; y \leq Y^{(100)} \\ 0 & \zeta(s) = 365 \mid y > Y^{(100)} \mid \zeta(s) = 200 \;\&\; y \;>\; Y^{(200)} \end{cases} \tag{5}$$

For our scenarios, we have

$$
\zeta(s) = \begin{cases} 365 & s \in \{0, 1, 2, 3, 10\} \\ 200 & s \in \{4, 5, 6\} \\ 100 & s \in \{7, 8, 9\} \end{cases}
$$



365 Min. 1st Qu. Median Mean 3rd Qu. Max. 0 0 0 0 0 0

200 Min. 1st Qu. Median Mean 3rd Qu. Max. 3.13 3.18 3.24 3.24 3.30 3.37

100 Min. 1st Qu. Median Mean 3rd Qu. Max. 7.21 7.62 8.07 8.12 8.62 9.17

Targets:

3,242 (3,182 3,241 3,302)

8,126 (7,629 8,094 8,607)

3 Response cost equation

We write total response costs as

$$
D_{s,y}^{(\text{res})} = \frac{1}{(1+r)^y} \left(D_{s,y}^{(\text{BP-resRD})} + D_{s,y}^{(\text{S-RD})} + D_{s,y}^{(\text{BP-proc})} + D_{s,y}^{(\text{S-proc})} + D_{s,y}^{(\text{BP-del})} + D_{s,y}^{(\text{S-del})} \right)
$$

where

- $D_{s,y}^{(\text{BP-resRD})}$ is the R&D cost of BPSV after an outbreak; see Equation (7)

- $D_{s,y}^{(\text{S-RD})}$ is the R&D cost for SSV; see Equation (6)
- $D_{s,y}^{(\text{BP-proc})}$ is the cost of procuring BPSV; see Equation (9)
- $D_{s,y}^{(\text{S-proc})}$ is the cost of procuring SSV; see Equation (8)
- $D_{s,y}^{(\text{BP-del})}$ is the cost of delivering BPSV; see Equation (11)
- $D_{s,y}^{(\text{S-del})}$ is the cost of delivering SSV; see Equation (10)

3.1 Risk-adjusted R&D cost per candidate calculation

3.1.1 SSV

These don't match the spreadsheet results. Values too low.

Trial costs are adjusted for the duration of the trial, which depend on the R&D investment, denoted $\zeta \in \{365, 200, 100\}$:

$$T_{\zeta,i}^{(e)} = (1+I)\frac{W_{i;\zeta}^{(S)}}{52Y_i^{(B)}}T_i^{(e)}$$

where $I = 0.28$ is inflation from 2018 to 2025, $T_i^{(e)}$ is the cost per Phase i of experienced developers, $Y_i^{(B)}$ is the expected phase duration in years, and $W_{i;\zeta}^{(S)}$ is its expected duration in weeks given enabling investments made prior to the outbreak.

The probability of success of each phase comes from COVID-19 data.

$$P_i^{(\text{SSV})} \sim \text{Beta}\left(\sum_{j=i+1}^{4} X_j + 1, X_i + 1\right)$$

for $i \in \{0, 1, 2, 3\}$ where X_i is the number of candidates that failed in phase i and X_4 the number that succeeded to licensure.

The probabilities of phase occurrence are:

$$\hat{P}_i^{(\text{SSV})} = \begin{cases} 1 & i = 0 \\ \prod_{j=0}^{i-1} P_j^{(\text{SSV})} & i \in \{1,2,3,4\} \end{cases}$$

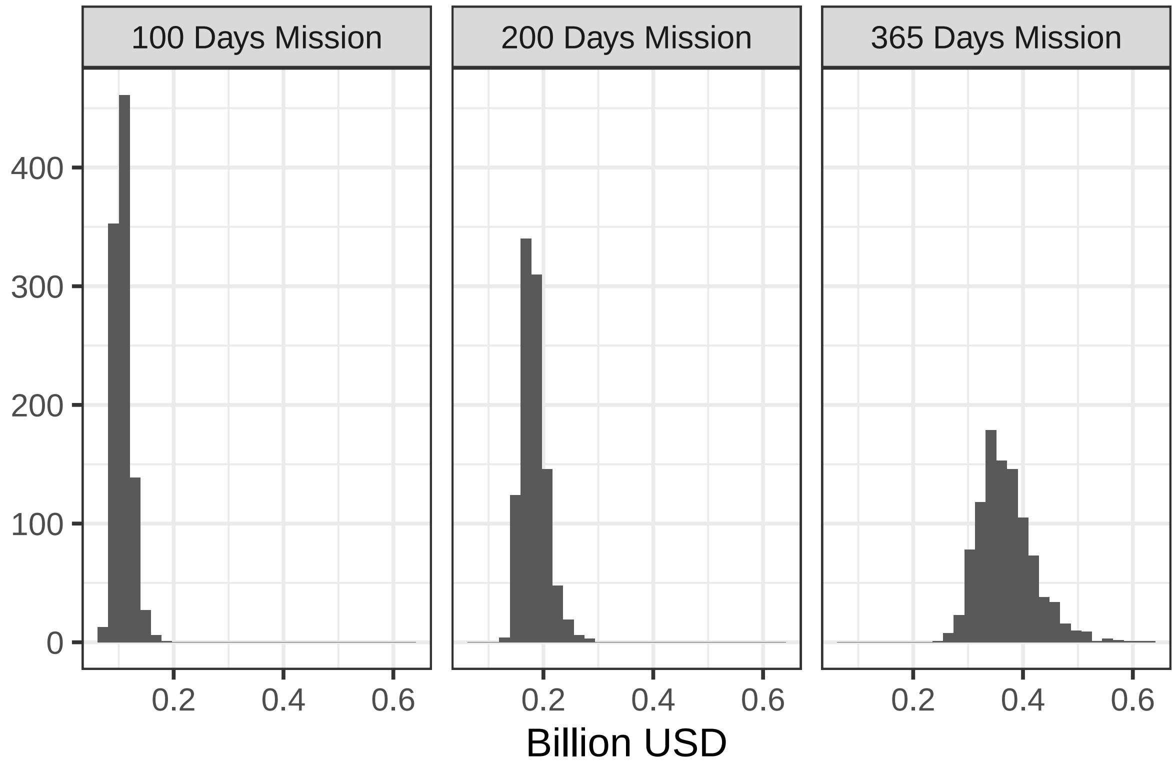
Then the total cost is

$$D_s^{(\text{S-RD})} = N^{(\text{SSV})}\left(\sum_{i=0}^{3} \hat{P}_i^{(\text{SSV})} \cdot T_{\zeta(s),i}^{(e)} + \hat{P}_4^{(\text{SSV})} T_4\right) \tag{6}$$

where T_4 is the cost of licensure. We multiply by the number of candidates, $N^{(\text{SSV})}$, to get the total cost from the weighted average per candidate, where

$$N^{(\text{SSV})} = n^{(\text{SSV})} + F_{NegBin}^{-1}\left(Q^{(\text{SSV})}; n^{(\text{SSV})}, \hat{P}_4^{(\text{SSV})}\right)$$

is chosen to secure at least $n^{(\text{SSV})} = 5$ successful candidates with probability $Q^{(\text{SSV})} = 90\%$. Here, $F_{NegBin}^{-1}(q; n, p)$ is the cumulative density of a negative binomial distribution with parameters n and p evaluated at quantile q.



3.2

DM	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
365	118	172	203	208	237	386

200 60 85 100 103 117 180

3.3 100 35 50 59 60 69 113

Targets:

284 (105 170 283)

195 (61 97 164)

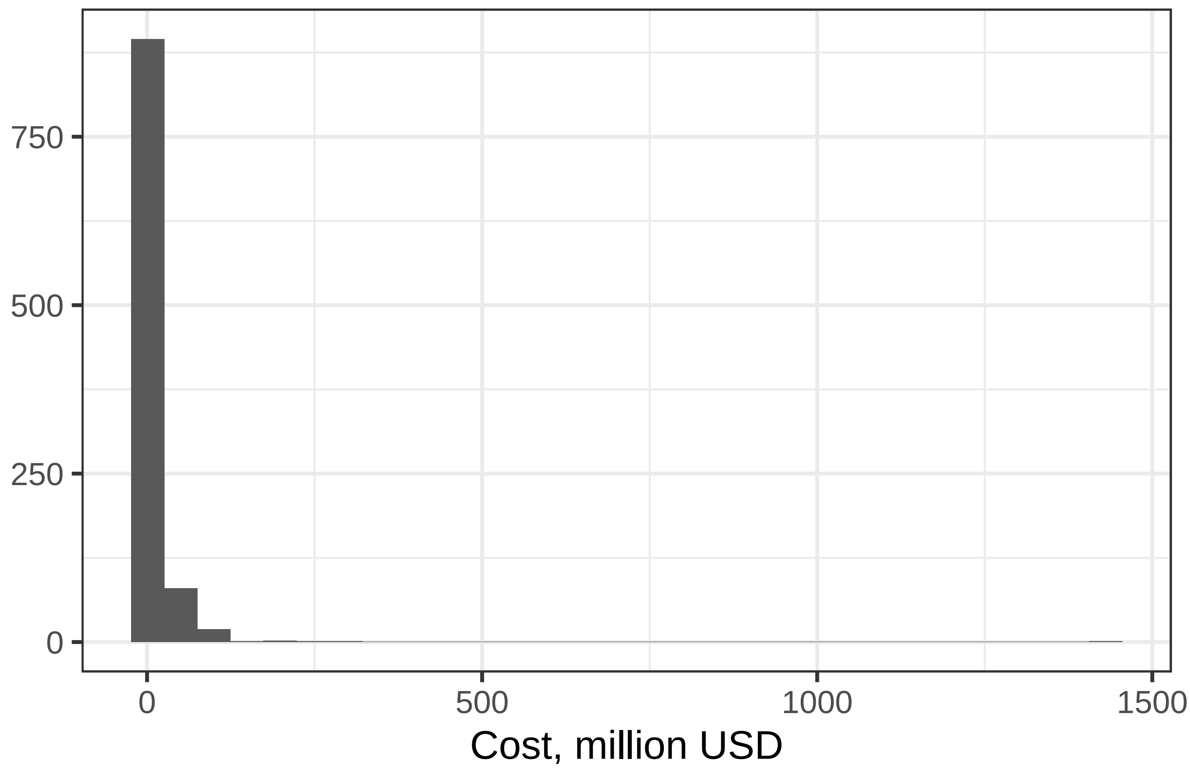
118 (35 61 108)

3.3.1 BPSV

This is a little higher than the spreadsheet results

One BPSV candidate that has passed through phases 0 to 2 prior to the outbreak goes through Phase III during the response. The duration is $W_3^{(B)} = 18$ weeks. Thus we write the BPSV R&D response cost

$$D_s^{(\text{BP-resRD})} = \begin{cases} \left((1+I) \frac{W_3^{(B)}}{52 Y_3^{(B)}} T_3^{(e)} + P_3 T_4 \right) & s = 1 \\ 0 & s \neq 1 \end{cases} \tag{7}$$



Min. 1st Qu. Median Mean 3rd Qu. Max. 0.5 2.0 3.7 8.4 7.1 936.9

Target: 14 (3 5 10)

3.4 Procurement cost calculation

The cost per dose comes from the cost of goods supplied ($G = 4.68$) adjusted for profits ($M_p = 0.2$) and the transportation cost ($M_t = 0.12$).

$S_R = G(1 + M_p)(1 + M_t)$ evaluates to 6.29.

This cost is used both for SSV doses manufactured using reserved capacity, and all newly manufactured BPSV doses.

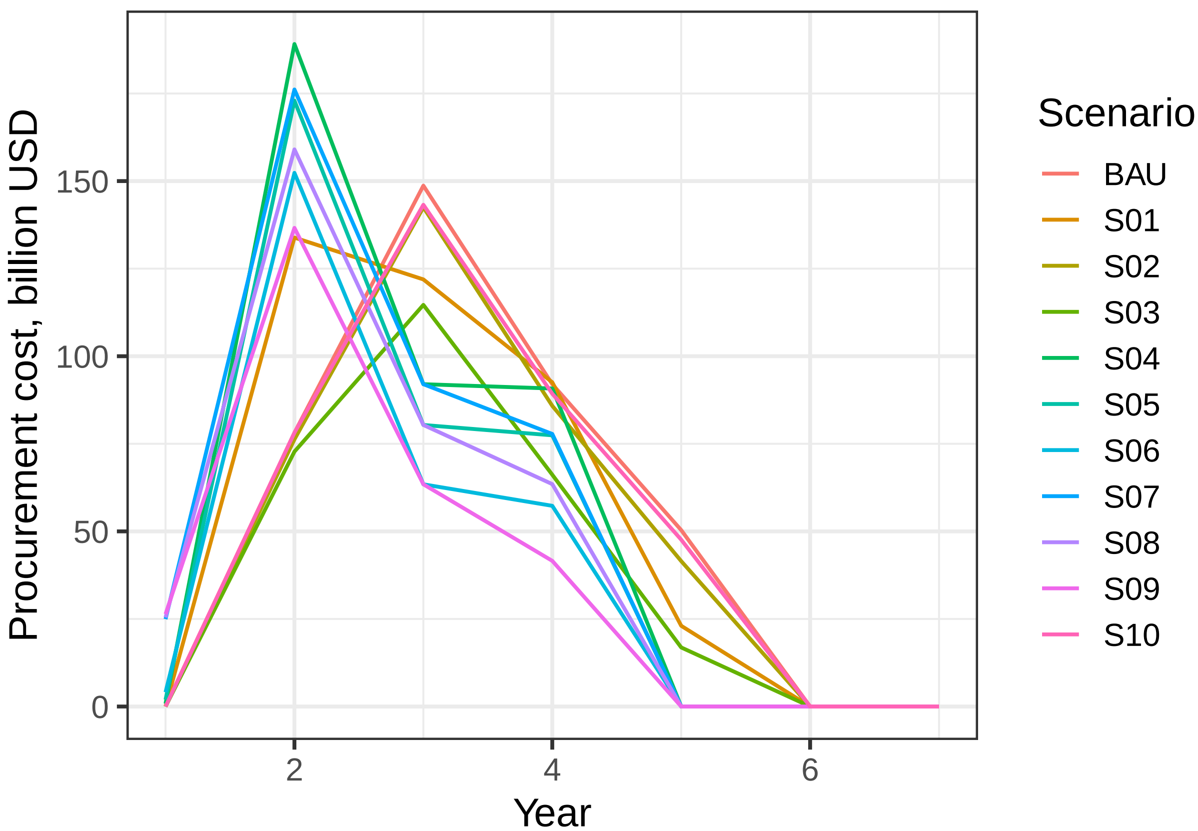
3.4.1 SSV

These values are close, but not identical, to the spreadsheet results if I adjust for the total demand

We write billion doses procured from channel $x \in \{R, E, B\}$ in year y and scenario s as $A_{x,s,y}$ (see Equation (12)). Then the total cost, in billion USD, is:

$$D^{(\text{S-proc})}_{s,y} = A_{R,s,y} S_R + \sum_{x \in \{E,B\}} A_{x,s,y} S_U \tag{8}$$

Here, $S_R = 6.29$ is the cost per reserved dose and $S_U = 18.94$ the cost per unreserved dose in USD.



3.5

Scenario	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
BAU	134252	159130	188416	193659	227378	270758

S01 137394 162408 191773 196956 230728 273971

S02 126163 149484 176927 181830 213423 254038

S03 99526 117747 139155 142949 167579 199157

S04 140126 165219 194599 199714 233466 276490

S05 125310 147707 173924 178481 208595 246964

S06 104828 123480 145299 149078 174133 206019

S07 140537 165492 194675 199724 233233 275861

S08 124746 146834 172653 177110 206751 244431

S09 102454 120478 141527 145142 169297 199951

3.6 S10 130381 154522 182937 188021 220736 262815

Table: Costs summed and discounted from year 16 to year 20, million USD

Targets:

184,127 (151,271 180,171 214,966) 187,255 (154,376 183,358 218,147) 167,519 (137,713 163,938 195,495) 135,910 (111,925 133,050 158,444) 189,820 (157,000 185,976 220,684) 169,549 (140,293 166,133 197,067)

141,440 (117,134 138,613 164,309) 189,878 (157,295 186,091 220,526) 168,378 (139,564 165,035 195,494) 137,984 (114,513 135,278 160,078) 178,766 (146,883 174,927 208,686)

3.6.1 BPSV

This is pretty close

The cost of BPSV doses is the sum of new doses supplied, $A_{BPSV,s}$, at the reserved-capacity cost per dose, and the doses held in the investigational reserve, for which fill/finish, transport and profit margin costs are due.

$$D_s^{(\text{BP-proc})} = \begin{cases} A_{BPSV,s} \cdot S_R + A_4(M_f + M_t)(1 + M_p)G & s = 1 \\ 0 & s \neq 1 \end{cases} \tag{9}$$

For a world population aged 65 and over of 0.86 billion, an uptake of 80% (accounting for wastage of 31%), and a cost per dose of $S_R = 6.29$ USD (the same as for SSV via reserved capacity), the procurement cost for BPSV is 6.68 billion USD.

In our model, 1.0625 billion doses are manufactured, as manufacturing stops once one billion doses have been made.

Min. 1st Qu. Median Mean 3rd Qu. Max. 2790 3208 3685 3758 4300 4962

Target: 3,628 (3,062 3,568 4,165)

3.7 Delivery Cost Equation

3.7.1 SSV

These values are ballpark correct but too concentrated

For populations aged 15 and above $N_i^{(15)}$, we write

$$L_i = 2 \cdot \lambda \cdot N_i^{(15)}$$

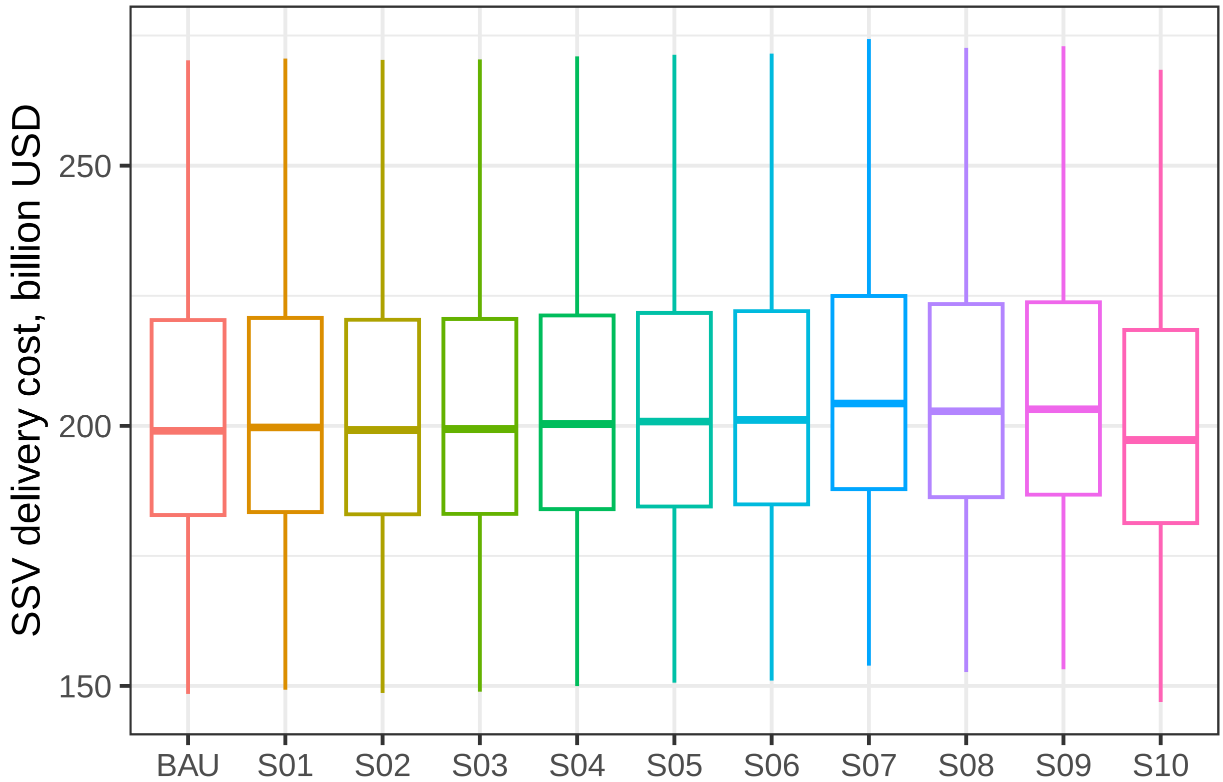
as the total demand for first-schedule doses for income group $i \in \{\text{LIC, LMIC, UMIC, HIC}\}$, representing two doses each for $\lambda = 80\%$ of the population.

We write the delivery cost for $h_{s,i,w}$ doses given in week w and country type i as follows. There are three cost tiers, the first of which, $V_{i;0}$, is applied to the first 10% of L_i, the second ($V_{i;10}$) to the subsequent 20%, and the third ($V_{i;30}$) to all doses thereafter. The same costing schedule applies both to the first-schedule plus booster SSV doses and the BPSV rollout.

$$H_{s,i,w} = \begin{cases} V_{i;0} h_{s,i,w} & \sum_{j=1}^{w-1} h_{s,i,w} \leq \frac{1}{10} L_i \\ V_{i;10} h_{s,i,w} & \frac{1}{10} L_i < \sum_{j=1}^{w-1} h_{s,i,w} \leq \frac{3}{10} L_i \\ V_{i;30} h_{s,i,w} & \frac{3}{10} L_i < \sum_{j=1}^{w-1} h_{s,i,w} \end{cases}$$

Then the delivery cost in year y and scenario s is

$$D_{s,y}^{(\text{S-del})} = \sum_{w \in y} \sum_i H_{s,i,w} \tag{10}$$



BAU Min. : 64160 1st Qu.: 94621 Median :110310 Mean :114254
S01 Min. : 64505 1st Qu.: 94996 Median :110672 Mean :114586
S02 Min. : 64240 1st Qu.: 94710 Median :110394 Mean :114330
S03 Min. : 64342 1st Qu.: 94820 Median :110498 Mean :114424
S04 Min. : 64809 1st Qu.: 95402 Median :111018 Mean :114916
S05 Min. : 65090 1st Qu.: 95726 Median :111324 Mean :115187
S06 Min. : 65262 1st Qu.: 95925 Median :111522 Mean :115369
S07 Min. : 66504 1st Qu.: 97669 Median :113239 Mean :117044
S08 Min. : 65980 1st Qu.: 96758 Median :112249 Mean :116167
S09 Min. : 66202 1st Qu.: 96989 Median :112466 Mean :116407
S10 Min. : 63488 1st Qu.: 93615 Median :109264 Mean :113248

```
BAU 3rd Qu.:130779   Max.   :196492
S01 3rd Qu.:131087   Max.   :196757
S02 3rd Qu.:130848   Max.   :196550
S03 3rd Qu.:130938   Max.   :196624
S04 3rd Qu.:131399   Max.   :197057
S05 3rd Qu.:131681   Max.   :197276
S06 3rd Qu.:131891   Max.   :197435
S07 3rd Qu.:133474   Max.   :199217
S08 3rd Qu.:132690   Max.   :198177
S09 3rd Qu.:132874   Max.   :198397
S10 3rd Qu.:129996   Max.   :195357
```

Targets:

114,526 (90,654 110,005 134,444) 114,771 (91,321 111,130 134,341) 114,769 (91,620 110,604 133,752)
114,811 (91,647 110,815 133,856) 114,527 (91,170 110,664 133,720) 114,615 (91,074 110,653 133,836)

115,095 (91,858 111,205 134,355) 115,634 (92,514 111,639 134,375) 116,385 (93,116 112,183 135,664) 117,196 (93,427 113,114 136,861) 116,913 (93,536 112,957 136,414) 118,141 (94,682 114,649 137,100) 113,540 (89,745 109,012 132,595)

3.7.2 BPSV

These values match the spreadsheet results. (NB: more doses are purchased and delivered than there are eligible people in the population)

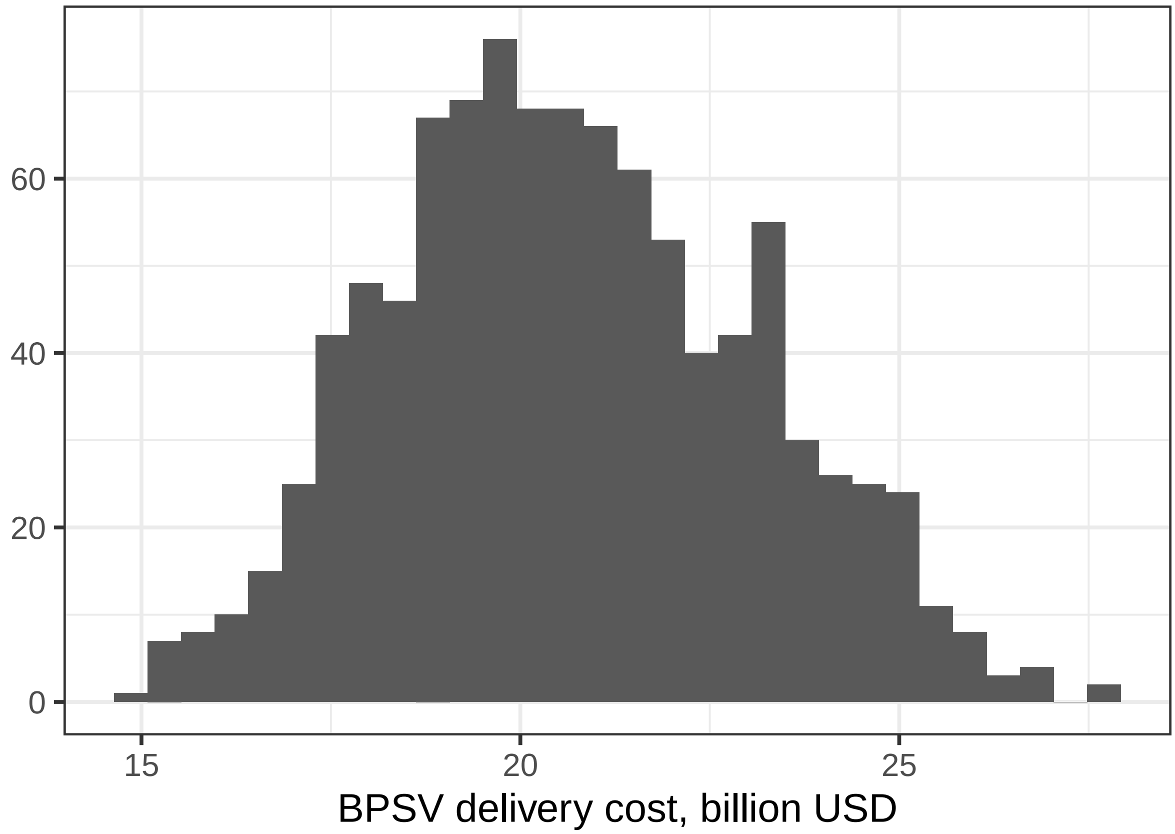
For the BPSV, which goes only to people aged 65 or older, with populations $N_i^{(65)}$, coverage is reached earlier in the process, so the cost is weighted more heavily towards start up and ramp up:

$$D_s^{(\text{BP-del})} = \begin{cases} \sum_i D_{\text{BPSV},i} & s = 1 \\ 0 & s \neq 1 \end{cases} \tag{11}$$

$$D_{\text{BPSV},i} = \begin{cases} N_i^{(65)} V_{i;0} & N_i^{(65)} \leq \frac{1}{10} N_i^{(15)} \\ \frac{N_i^{(15)}}{10} V_{i;0} + \left(N_i^{(65)} - \frac{N_i^{(15)}}{10} \right) V_{i;11} & \frac{1}{10} N_i^{(15)} < N_i^{(65)} \leq \frac{3}{10} N_i^{(15)} \\ \frac{N_i^{(15)}}{10} V_{i;0} + \frac{2}{10} N_i^{(15)} V_{i;11} + \left(N_i^{(65)} - \frac{3}{10} N_i^{(15)} \right) V_{i;31} & N_i^{(65)} > \frac{3}{10} N_i^{(15)} \end{cases}$$

The logic of this is as follows:

- The increments in cost correspond to numbers of eligible people in the whole population, namely those aged 15 and above.
- If the number of people eligible for the BPSV is less than 10% of the population aged 15 and over, then all doses cost the "start up" amount.
- If the number of people eligible for the BPSV is more than 10% and less than 30% of the 15+ population, then cost of the first doses, a number equal to 10% of the 15+ population, is the "start up" amount. All remaining doses cost the "ramp up" amount.
- If the number of people eligible for the BPSV is more than 30% of the 15+ population, then the cost of the first doses, a number equal to 10% of the 15+ population, is the "start up" amount. The cost of the second tranche of doses, a number equal to 20% of the 15+ population, is the "ramp up" amount. All remaining doses cost the "getting to scale" amount.



Min. 1st Qu. Median Mean 3rd Qu. Max. 6379 9907 11394 11614 13150 19017

Target: 11,206 (9,037 10,865 13,054)

Table 5: Literature review of global and country-specific delivery costs

Country	Country status	Study type	Financial Cost per dose (USD)	Source
WHO, Gavi, and UNICEF AMC Estimate	AMC	Top down	1.66	Griffiths et al. [2021]
UNICEF Global Estimate	All	Model	0.73	Oyatoye [2023]
DRC	LIC	Bottom up	1.91	Moi et al. [2024]
Malawi	LIC	Bottom up	4.55	Ruisch et al. [2025]
Mozambique	LIC	Bottom up	0.5	Namalela et al. [2025]
Uganda	LIC	Bottom up	0.79	Tumusiime et al. [2024]
Bangladesh	LMIC	Bottom up	0.29	Yesmin et al. [2024]
Cote d'Ivoire	LMIC	Bottom up	0.67	Vaughan et al. [2023]
Nigeria	LMIC	Bottom up	0.84	Noh et al. [2024]
Philippines	LMIC	Bottom up	2.16	Banks et al. [2023]

Country	Country status	Study type	Financial Cost per dose (USD)	Source
Vietnam	LMIC	Bottom up	1.73	Nguyen et al. [2024]
Ghana	LMIC	CVIC tool	2.2–2.3	Nonvignon et al. [2022]
Lao PDR	LMIC	CVIC tool	0.79–0.81	Yeung et al. [2023]
Kenya	LMIC	Top down	3.29–4.28	Orangi et al. [2022]
Botswana	UMIC	Mixed	19	Vaughan et al. [2025]
South Africa	UMIC	Top down	3.84	Edoka et al. [2024]

Table 6: Cost differences: investments vs. BAU, for different types of investment.

timing	category	type	Cost vs. BAU
Upfront	Manufacturing	BPSV	0.000012
Upfront	R&D	BPSV	$0.31\ (0.24, 0.4)$
Upfront	R&D	200 days to SSV	3.5
Upfront	R&D	100 days to SSV	10
Per year	Manufacturing	BPSV	0.16
Per year	Manufacturing	0.7 billion capacity	0.37
Per year	Manufacturing	2 billion capacity	1.1
Per pandemic	Delivery	BPSV	$20\ (19, 22)$
Per pandemic	Delivery	0.7 billion capacity	$0.14\ (0.11, 0.17)$
Per pandemic	Delivery	2 billion capacity	$0.32\ (0.24, 0.38)$
Per pandemic	Delivery	Equality + Delivery	$-1.8\ (-2.3, -1.4)$
Per pandemic	Manufacturing	BPSV	6.7
Per pandemic	Manufacturing	0.7 billion capacity	-23
Per pandemic	Manufacturing	2 billion capacity	-99
Per pandemic	R&D	BPSV	$0.0064\ (0.0037, 0.013)$
Per pandemic	R&D	200 days to SSV	$-0.18\ (-0.2, -0.17)$
Per pandemic	R&D	100 days to SSV	$-0.26\ (-0.28, -0.24)$

4 SSV delivery

Table 7: Manufacturing response timeline assumptions

Category	Reserved capacity	Private response (existing capacity)	Private response (built capacity)
Annual manufacturing volume	By scenario (0.5–2.5B)	9B minus reserved volume	6B
Facility transition start	7 weeks before vaccine approval	7 weeks before vaccine approval	7 weeks before vaccine approval
Weeks to initial manufacturing	12	12 (BPSV) or 30 (no BPSV)	48
Scale-up weeks to full capacity	10	16	16

Table 8: Vaccine Production Timeline when there is no BPSV. When BPSV is also modelled, Existing Private Capacity scales from 0 to 100 in weeks 12–21.

Weeks from transition start	Reserved Capacity (%)	Existing Private Capacity (%)	Response Private Capacity (%)
0–11			
12–21	Scales from 0 to 100		
22–29	100		
30–45	100	Scales from 0 to 100	
46–47	100	100	
48–63	100	100	Scales from 0 to 100
64+	100	100	100

4.1 Timing

Facility transition occurs $I_0 = 7$ weeks before vaccine approval, which in turn depends on R&D investments. We have three levels in our scenarios, corresponding to SSVs available in 100 days, 200 days, and 365 days. The total weeks taken for vaccine approval can be written as follows:

$$W_\zeta^{(S)} = \sum_{i=0}^{3} W_{i;\zeta}^{(S)}$$

for $\zeta \in \{365, 200, 100\}$. These work out as 52, 29, and 14 weeks, respectively. Thus "week 0" for manufacturing occurs 45, 22, and 7 weeks, respectively, after the new pathogen has been sequenced. We denote this variable $w_s^{(0)}$:

$$w_s^{(0)} = W_{\zeta(s)}^{(S)} - 7 = \begin{cases} 45 & s \in \{0,1,2,3,10\} \\ 22 & s \in \{4,5,6\} \\ 7 & s \in \{7,8,9\} \end{cases}$$

4.2 Production

The total global manufacturing volume is $M_G = 15$ billion doses. The amount that is reserved, in billion doses, including the HIC-specific reservation of $A_3 = 0.5$ billion doses, depends on the scenarios as follows:

$$M_{R,s} = \begin{cases} A_3 & s \in \{0,1,4,7,10\} \\ A_3 + 0.7 & s \in \{2,5,8\} \\ A_3 + 2 & s \in \{3,6,9\} \end{cases}$$

where $s = 0$ denotes the BAU scenario. By definition, $M_{E,s} = M_C - M_{R,s}$ (existing unreserved capacity equals the total currently existing minus reserved capacity), and $M_B = M_G - M_C$ (newly built manufacturing equals the global total minus the existing capacity).

Then the number of doses, in billions, that are made from capacity $x \in \{R, E, B\}$ in week w of scenario s is:

$$Z_{x,s,w} = \begin{cases} 0 & w - w_s^{(0)} \leq I_x \\ \frac{1}{52} \frac{w - w_s^{(0)} - I_x}{C_x} M_{x,s} & w - w_s^{(0)} \in (I_x, I_x + C_x] \\ \frac{1}{52} M_{x,s} & w - w_s^{(0)} > I_x + C_x \end{cases}$$

where $I_R = 12$ is the number of weeks to initial manufacturing for reserved capacity, and $C_R = 10$ is its number of weeks to scale up to full capacity; $I_B = 48$ is the number of weeks to initial manufacturing for newly built (and, therefore, unreserved) capacity, and $C_B = 16$ is its number of weeks to scale up to full capacity; and

$$I_E = \begin{cases} I_{E,1} & s = 1 \\ I_{E,0} & s \neq 1 \end{cases}$$

where $I_{E,0} = 30$ and $I_{E,1} = 12$ are the number of weeks to initial manufacturing for existing and unreserved capacity, and $C_E = 16$ is its number of weeks to scale up to full capacity.

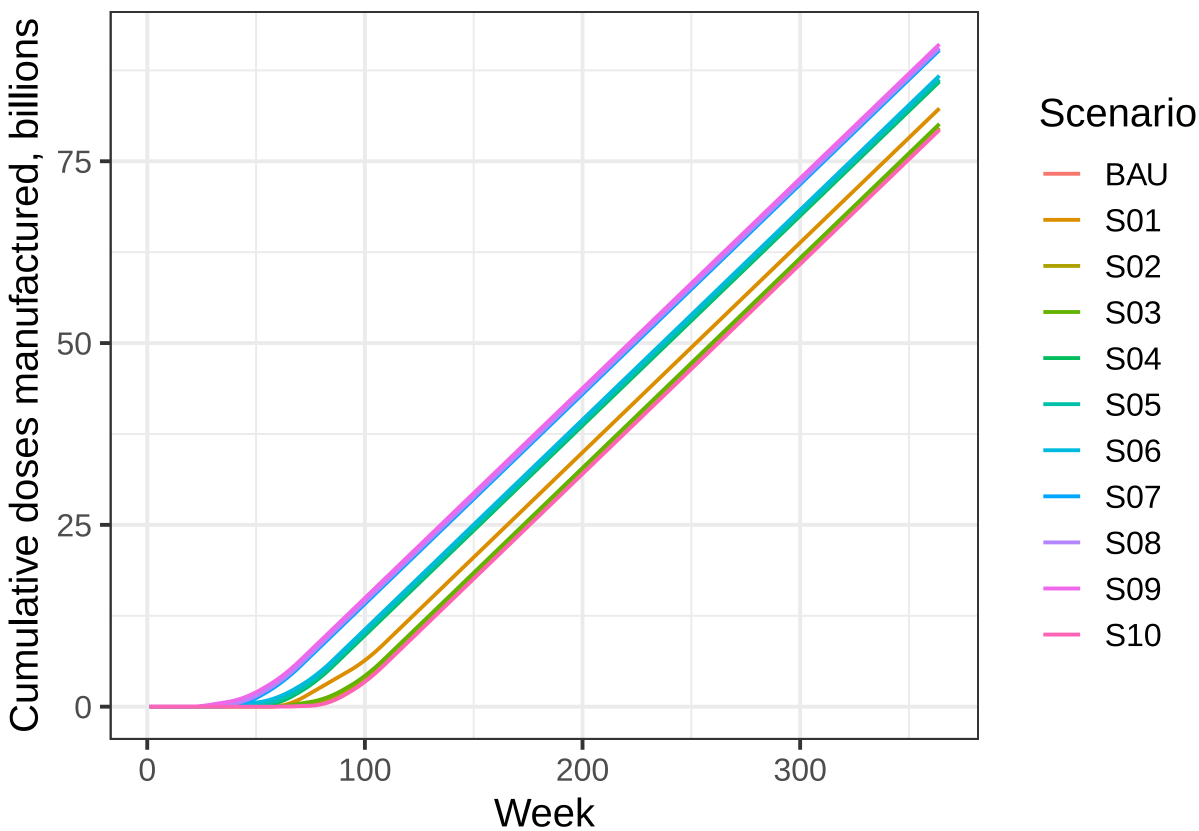


Figure 1: Doses made available from manufacturing per scenario. Weeks are in reference to the sequencing of the pathogen.

4.3 Allocation

Denote the weekly allocated doses at week w from capacity x to income level i $k_{s,x,i,w}$, and the cumulative number $K_{s,i,w}$, such that

$$K_{s,i,w} = \sum_{x \in \{R,E,B\}} \sum_{j=0}^{w} k_{s,x,i,j}.$$

$$
k_{s,R,i,w} = \begin{cases}
\left(\frac{A_3}{M_{R,s}} + \frac{M_{R,s}-A_3}{M_{R,s}}\frac{N_{HIC}}{N_T}\right) Z_{R,s,w} & K_{s,\text{HIC},w} < L_{\text{HIC}} \ \& \ i = \text{HIC} \\
\frac{M_{R,s}-A_3}{M_{R,s}}\frac{N_i}{N_T} Z_{R,s,w} & K_{s,\text{HIC},w} < L_{\text{HIC}} \ \& \ i \neq \text{HIC} \\
0 & K_{s,\text{HIC},w} \geq L_{\text{HIC}} \ \& \ i = \text{HIC} \\
\frac{N_i}{N_{UMIC}+N_{LMIC}+N_{LIC}} Z_{R,s,w} & K_{s,\text{HIC},w} \geq L_{\text{HIC}} \ \& \ K_{s,\text{UMIC},w} < L_{\text{UMIC}} \ \& \ i \neq \text{HIC} \\
0 & K_{s,\text{UMIC},w} \geq L_{\text{UMIC}} \ \& \ i = \text{UMIC} \\
\frac{N_i}{N_{LMIC}+N_{LIC}} Z_{R,s,w} & K_{s,\text{UMIC},w} \geq L_{\text{UMIC}} \ \& \ K_{s,\text{LMIC},w} < L_{\text{LMIC}} \ \& \ i \notin \{\text{HIC}, \text{UMIC}\} \\
0 & K_{s,\text{LMIC},w} \geq L_{\text{LMIC}} \ \& \ i = \text{LMIC} \\
Z_{R,s,w} & K_{s,\text{LMIC},w} \geq L_{\text{LMIC}} \ \& \ K_{s,\text{LIC},w} < L_{\text{LIC}} \ \& \ i = \text{LIC} \\
0 & K_{s,\text{LIC},w} \geq L_{\text{LIC}}
\end{cases}
$$

where $N_T = \sum_{i \in \{\text{HIC,UMIC,LMIC,LIC}\}} N_i$.

The logic of this reads as follows:

- $A_3 = 0.5$ billion doses per year from reserved capacity go exclusively to HIC, which is expressed as a fraction of the total reservation, $M_{R,s}$
- Any remaining reserved capacity doses are allocated according to population
- Once HIC reach their total demand, doses from reserved capacity are split proportional to population between UMIC, LMIC and LIC, and so on

For $x \in \{E, B\}$,

$$
k_{s,x,i,w} = \begin{cases}
Z_{x,s,w} & K_{s,\text{HIC},w} < L_{\text{HIC}} \ \& \ i = \text{HIC} \\
0 & K_{s,\text{HIC},w} < L_{\text{HIC}} \ \& \ i \neq \text{HIC} \\
Z_{x,s,w} & K_{s,\text{HIC},w} \geq L_{\text{HIC}} \ \& \ K_{s,\text{UMIC},w} < L_{\text{UMIC}} \ \& \ i = \text{UMIC} \\
0 & K_{s,\text{HIC},w} \geq L_{\text{HIC}} \ \& \ K_{s,\text{UMIC},w} < L_{\text{UMIC}} \ \& \ i \neq \text{UMIC} \\
Z_{x,s,w} & K_{s,\text{UMIC},w} \geq L_{\text{UMIC}} \ \& \ K_{s,\text{LMIC},w} < L_{\text{LMIC}} \ \& \ i = \text{LMIC} \\
0 & K_{s,\text{UMIC},w} \geq L_{\text{UMIC}} \ \& \ K_{s,\text{LMIC},w} < L_{\text{LMIC}} \ \& \ i \neq \text{LMIC} \\
Z_{x,s,w} & K_{s,\text{LMIC},w} \geq L_{\text{LMIC}} \ \& \ i = \text{LIC} \\
0 & K_{s,\text{LMIC},w} \geq L_{\text{LMIC}} \ \& \ i \neq \text{LIC}
\end{cases}
$$

The logic of this reads as follows:

- Until HIC demand is reached, all doses from unreserved capacity go to HIC. None go to UMIC, LMIC and LIC.
- Once HIC demand has been met and until UMIC demand is reached, all doses from unreserved capacity go to UMIC. None go to HIC, LMIC and LIC.
- Once HIC and UMIC demand have been met and until LMIC demand is reached, all doses from unreserved capacity go to LMIC. None go to HIC, UMIC and LIC.
- Once HIC, UMIC and LMIC demand have been met, all remaining doses from unreserved capacity go to LIC. None go to LMIC, UMIC and HIC.

Total supply of first-schedule doses in each year period is

$$
A^{(1)}_{x,s,y} = \sum_i \sum_{w \in y} k_{s,x,i,w}.
$$

We assume, for every second dose of SSV, a booster will be given one year later for $N^{(\text{boost})} = 2$ years.

Thus

$$A^{(2)}_{s,y} = \begin{cases} \frac{1}{2}\sum_x A^{(1)}_{x,s,y-1} & y = 2 \\ \frac{1}{2}\sum_x \left(A^{(1)}_{x,s,y-1} + A^{(1)}_{x,s,y-2}\right) & y > 2 \end{cases}$$

and

$$A^{(2)}_{x,s,y} = \min(A^{(2)}_{s,y}, M_R - A^{(1)}_{R,s,y})$$

for $x = R$ and

$$A^{(2)}_{x,s,y} = \max(A^{(2)}_{s,y} - A^{(2)}_{R,s,y}, 0)$$

for $x \in \{E, B\}$.

Then

$$A_{x,s,y} = A^{(1)}_{x,s,y} + A^{(2)}_{x,s,y}. \tag{12}$$

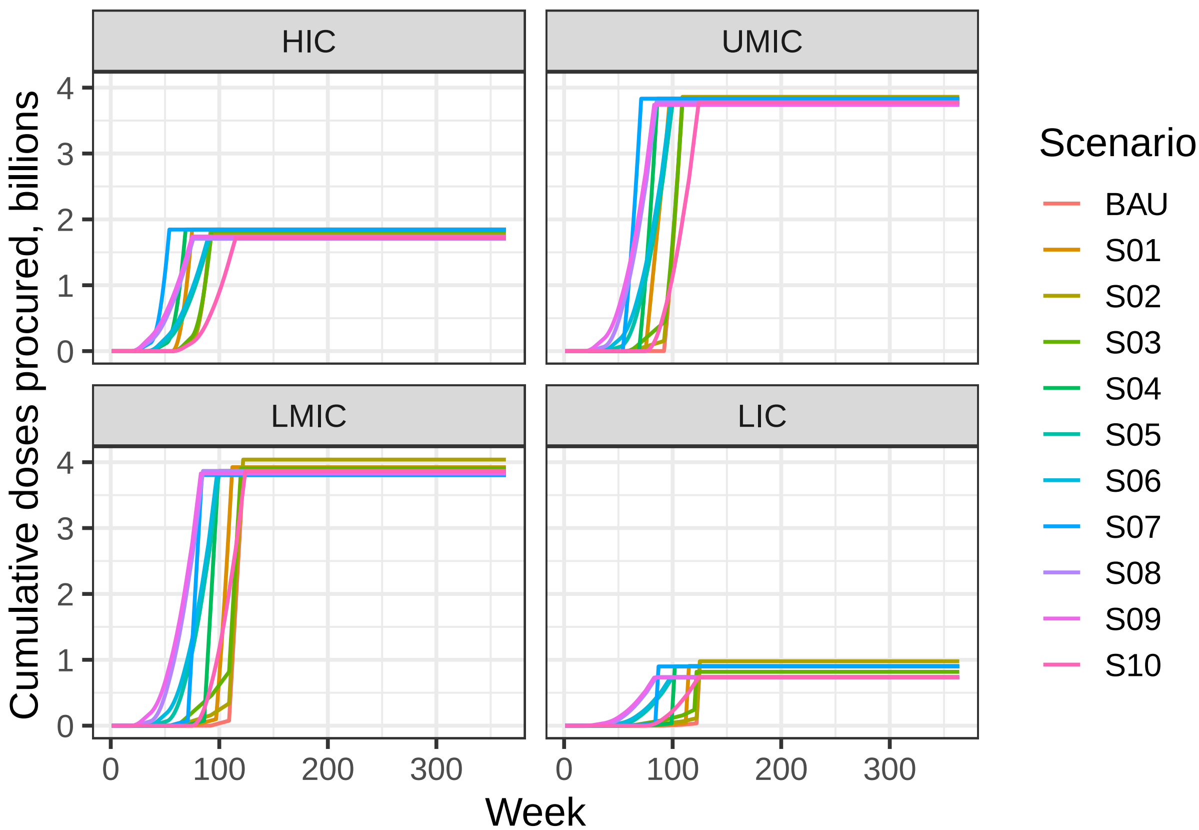


Figure 2: Doses procured by country income level

4.4 Delivery

These values do not look correct

Delivery is written as $h_{s,i,w}^{(j)}$ doses delivered in scenario s, income group i and week w for schedule j, which is $j = 1$ for first-dose SSV, $j = 2$ for second-dose SSV, and $j = 2 + k$ for $k = \{1, ..., N^{(boost)}\}$.

The second dose is prioritised over the first, and follows the first by four weeks, so

$$h_{s,i,w}^{(2)} = h_{s,i,w-4}^{(1)}.$$

Available doses are $K_{s,i,w}$, the cumulative doses allocated to income group i by week w, minus doses given so far. First doses stop being given once $L_i/2$ is reached.

$$h_{s,i,w}^{(1)} = \max\left(0, \min\left(K_{s,i,w} - h_{s,i,w}^{(2)} - \sum_{j=1}^{2}\sum_{k=1}^{w-1} h_{s,i,k}^{(j)}, L_i/2 - \sum_{k=1}^{w-1} h_{s,i,k}^{(1)}\right)\right)$$

Booster doses are given for $j = 2 + k$ for $k = \{1, ..., N^{(boost)}\}$:

$$h_{s,i,w}^{(2+k)} = h_{s,i,w-52k}^{(2)}.$$

Total doses are therefore

$$h_{s,i,w} = \sum_{j=1}^{2+N^{(boost)}} h_{s,i,w}^{(j)}.$$

5 BPSV delivery

5.1 Timing

The duration of the Phase III trial is $W_3^{(B)} = 18$ weeks. The time to manufacturing transition is $I_R = 12$ weeks, and the time to manufacturing scale-up $C_R = 10$ weeks; these are the same as the reserved-capacity times for SSV.

Facility transition occurs in week 1. Thus manufacturing begins in week $1 + I_R = 13$ and dose distribution begins in week $1 + W_3^{(B)} = 19$.

5.2 Production

The number of doses, in billions, that are made in week w is:

$$Z_w = \begin{cases} 0 & w < I_R \\ \frac{1}{52}\frac{w-I_x+1}{C_x}M_{x,s} & w \in [I_R, I_R + C_R) \\ \frac{1}{52}M_{x,s} & w - 1 \geq I_R + C_xR \end{cases}$$

5.3 Allocation

Doses are all allocated in proportion to the eligible population.

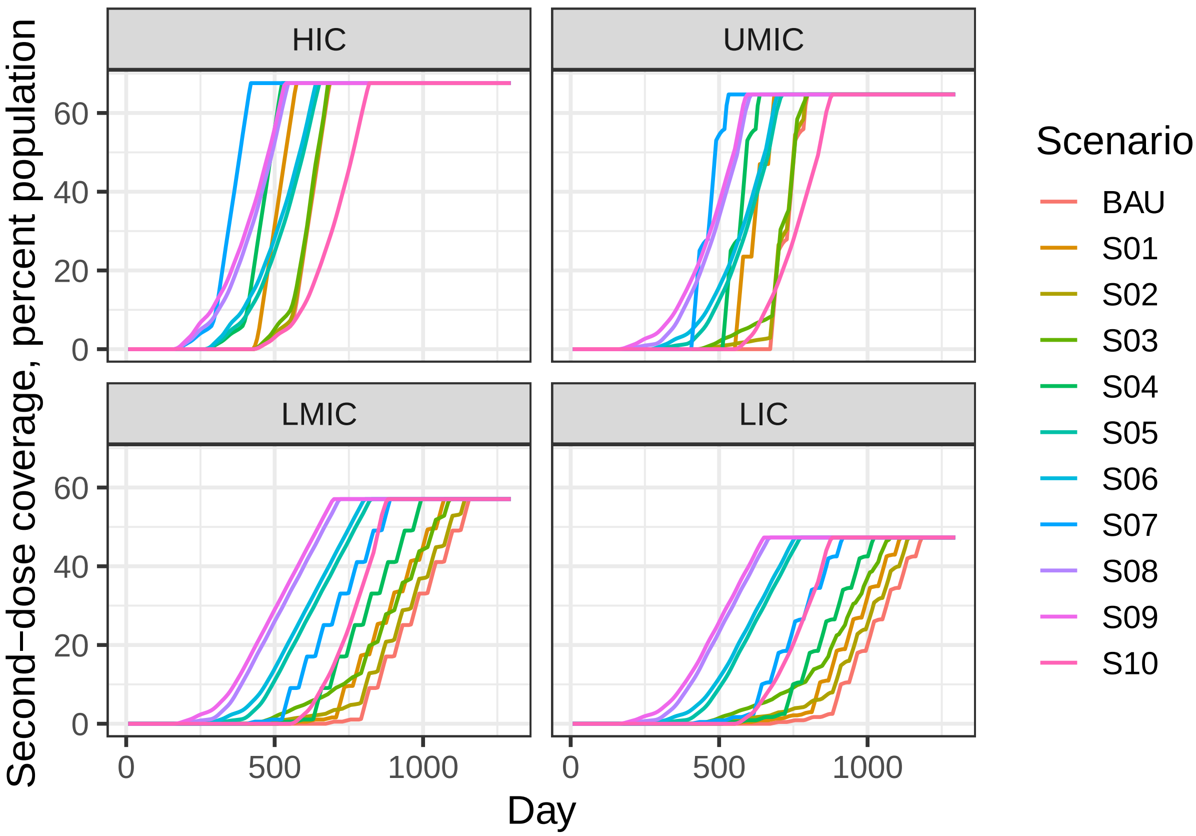


Figure 3: Cumulative vaccine coverage (second SSV dose) by country income level

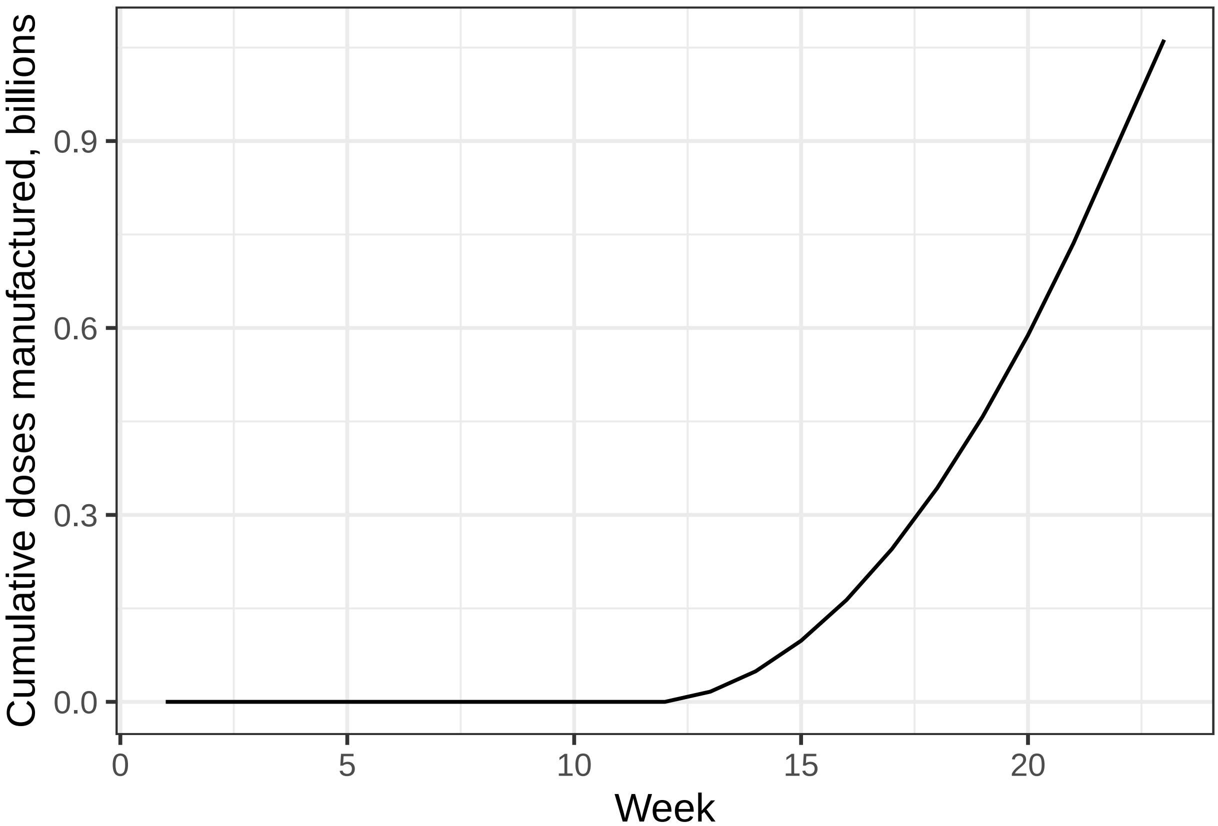


Figure 4: BPSV doses made available from manufacturing per scenario. Weeks are in reference to the sequencing of the pathogen.

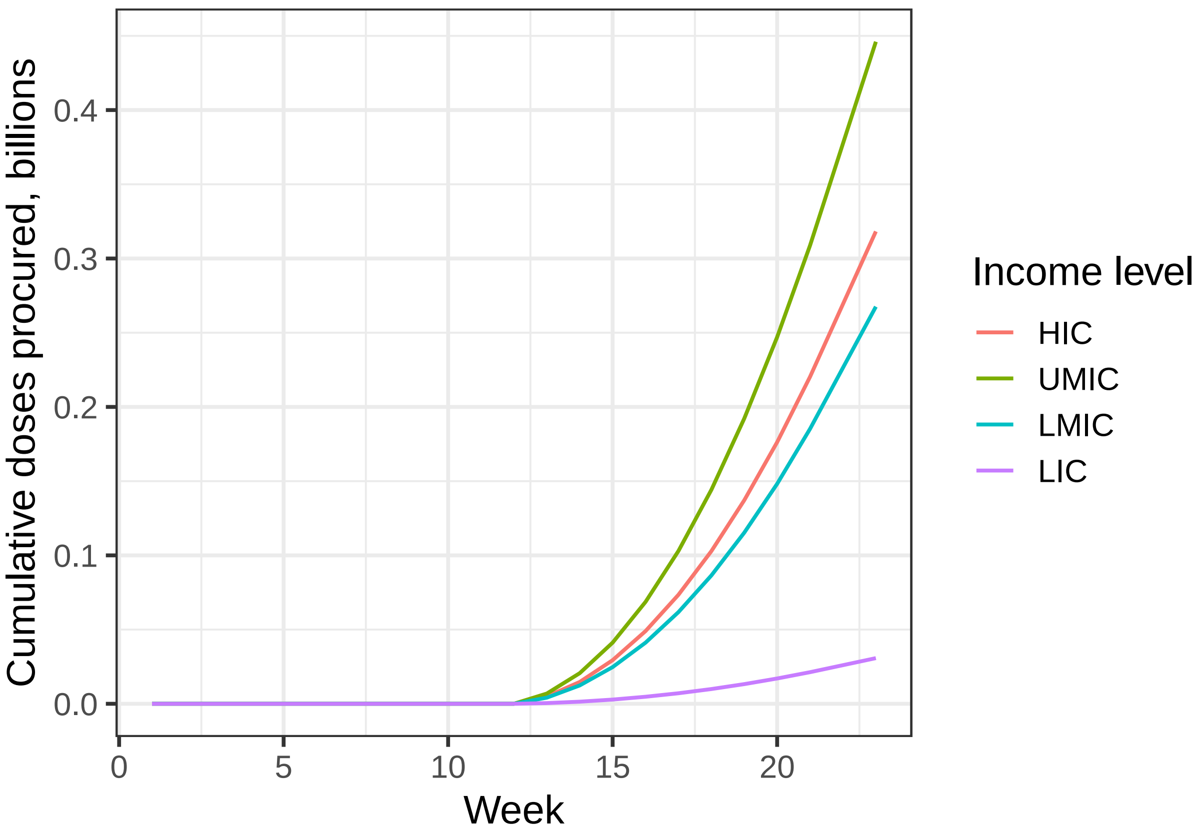


Figure 5: BPSV doses procured by country income level

5.4 Delivery

These values do not look correct

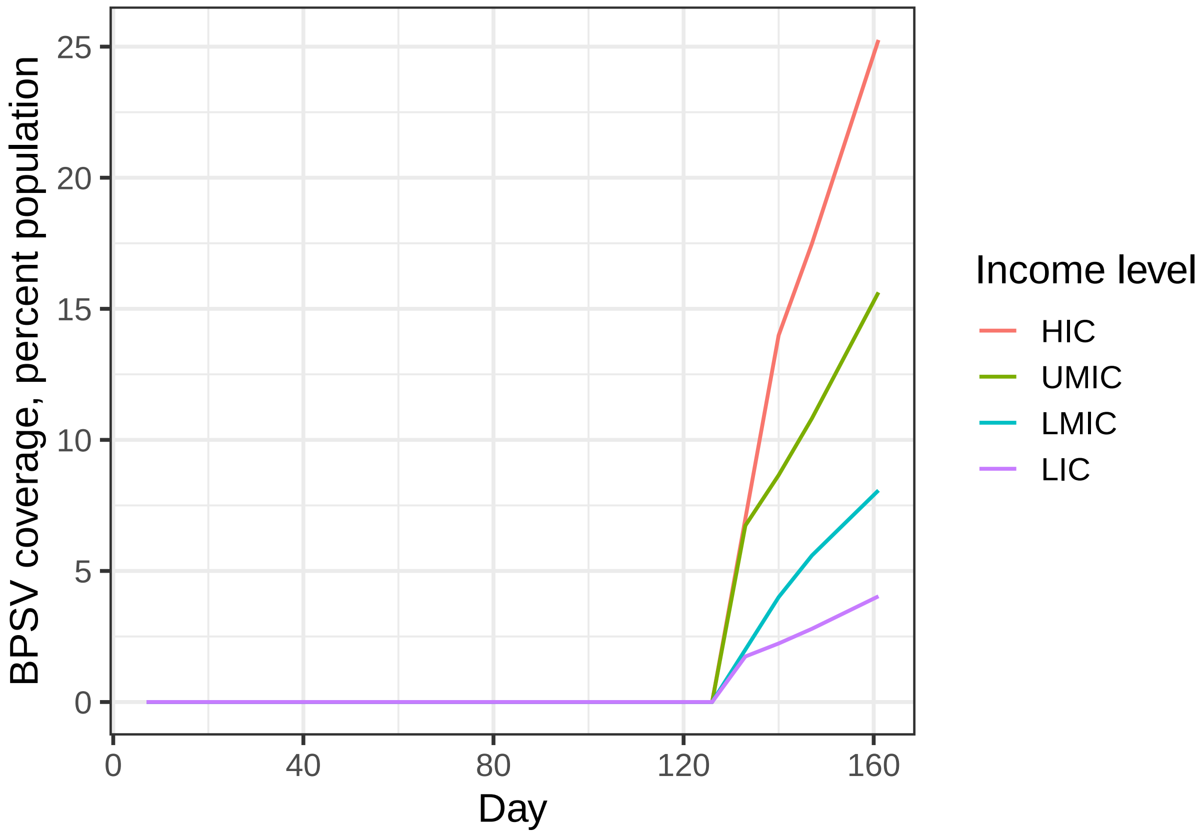
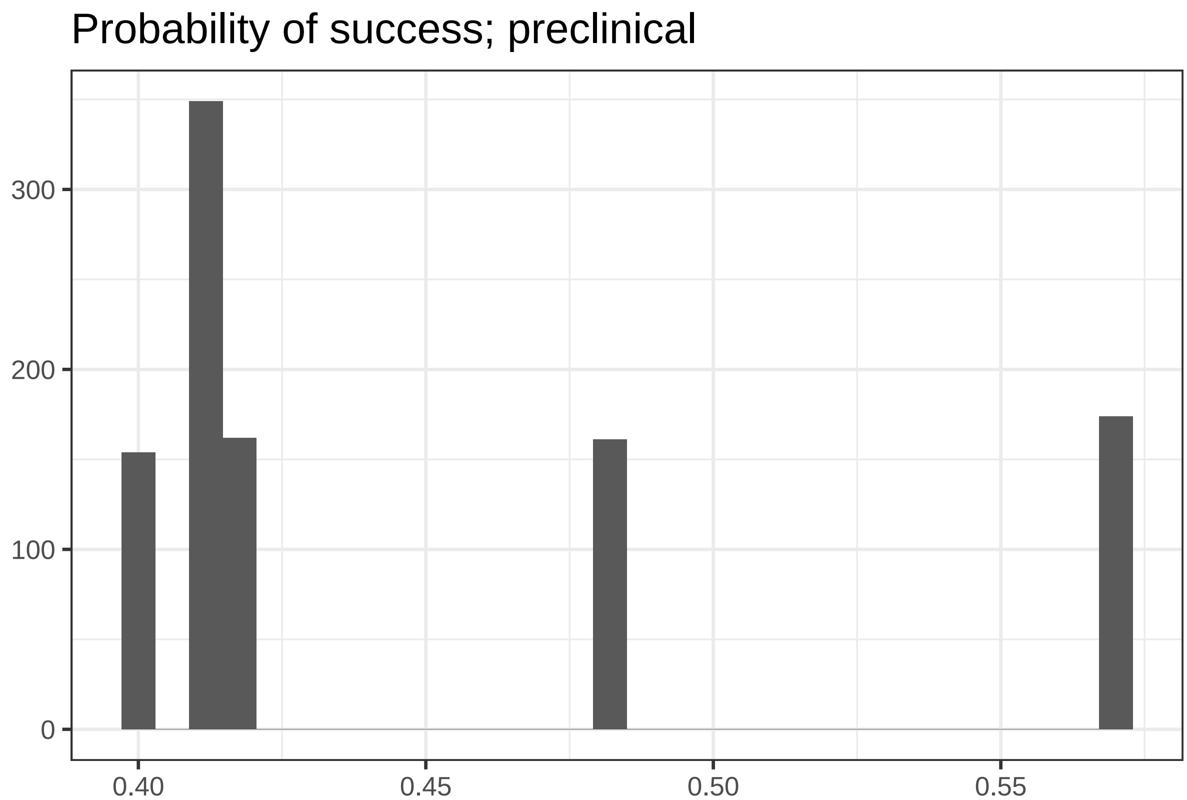
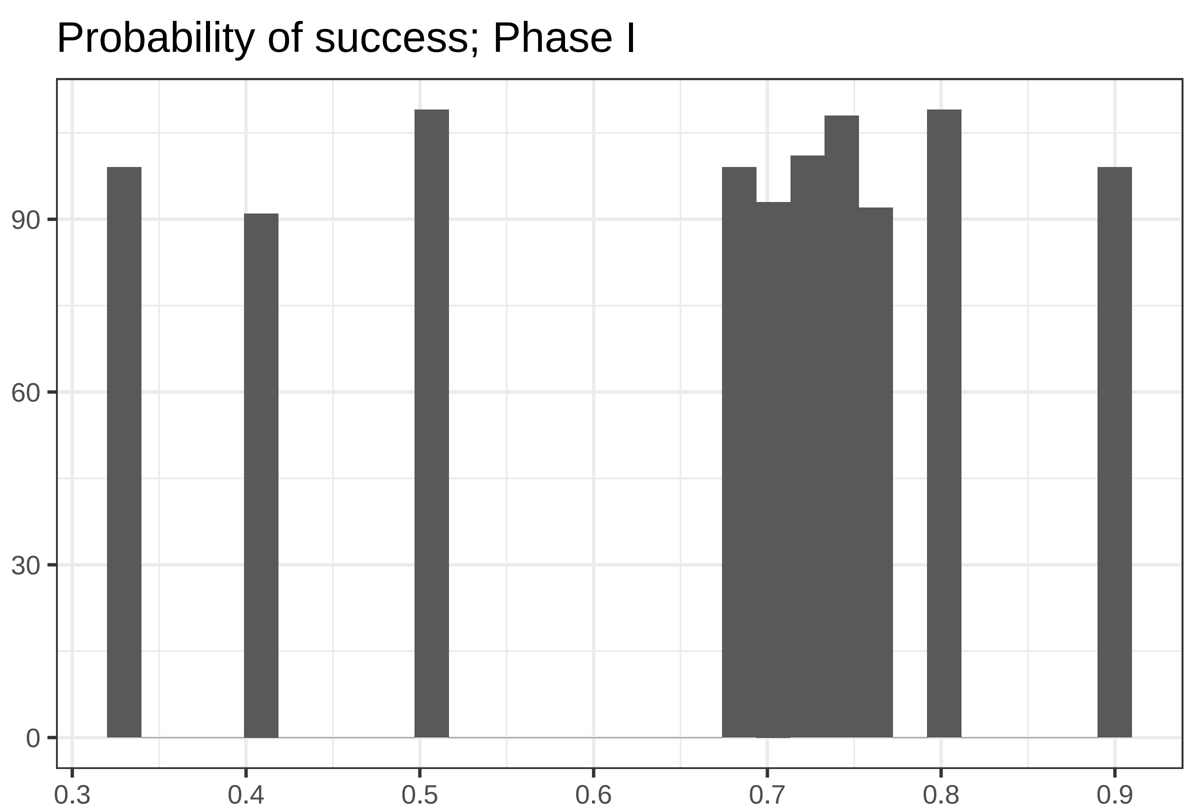


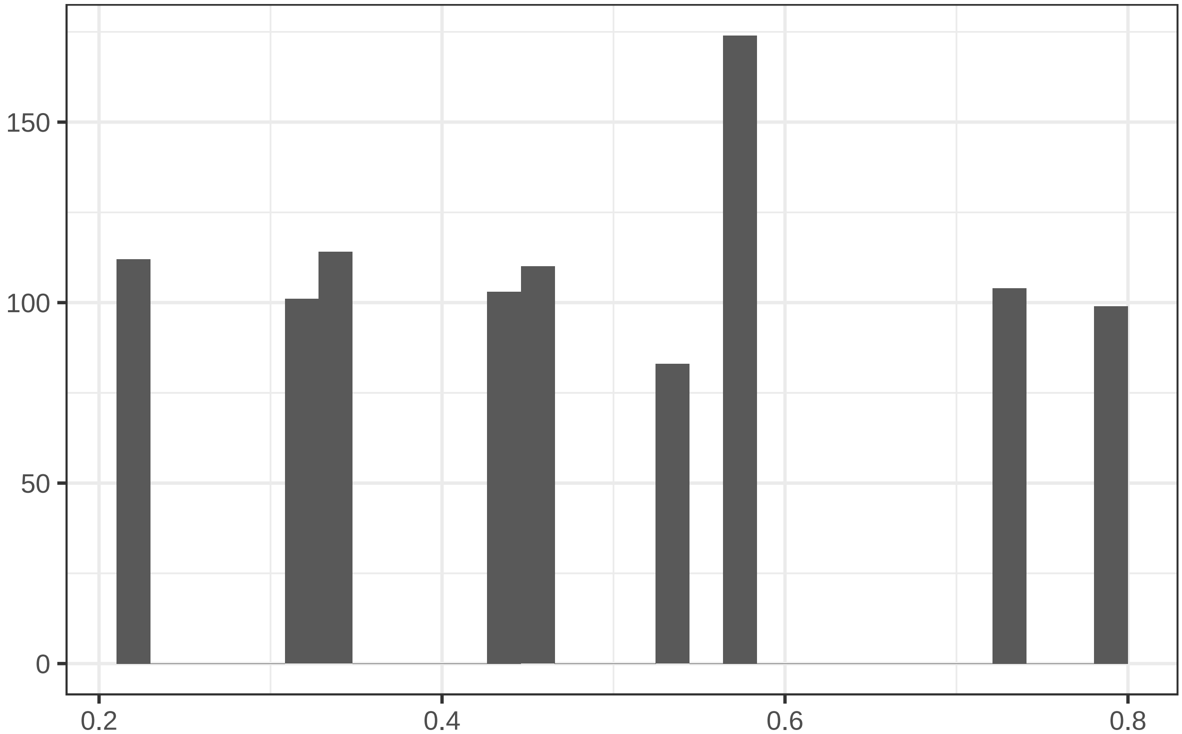
Figure 6: BPSV vaccine coverage by country income level

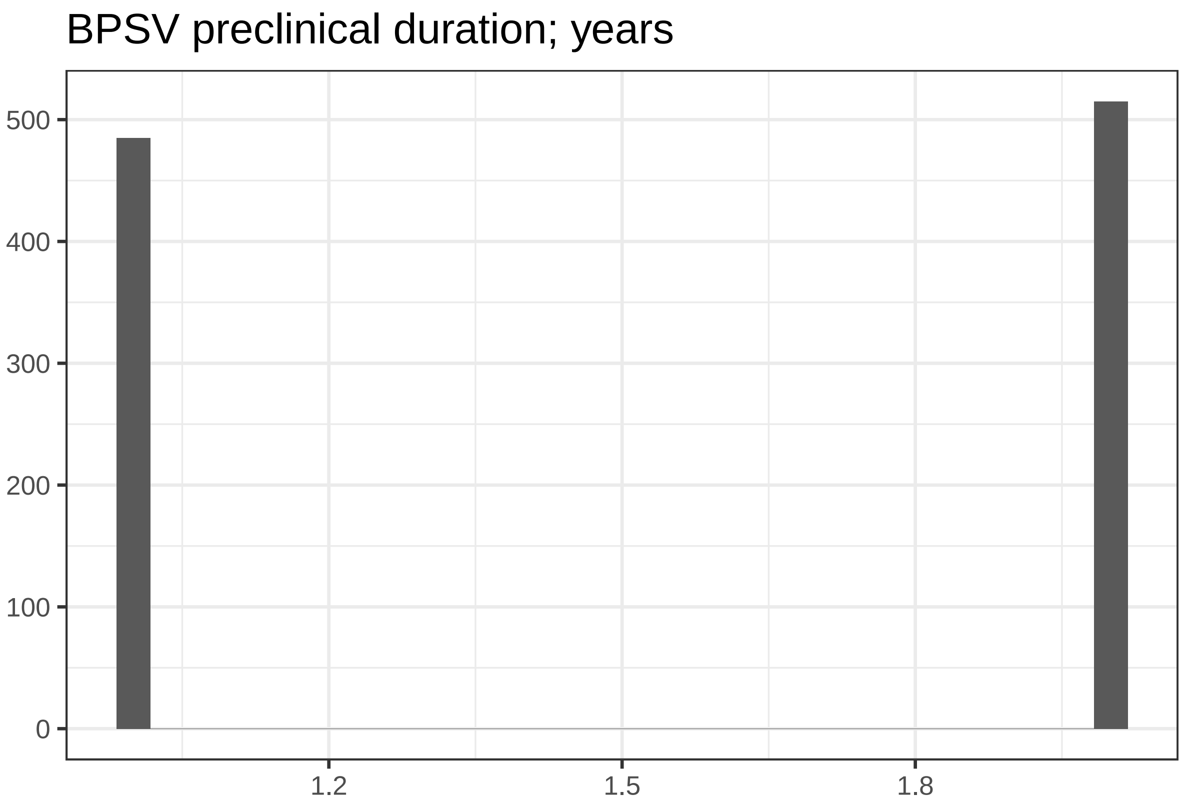
6 Parameter samples





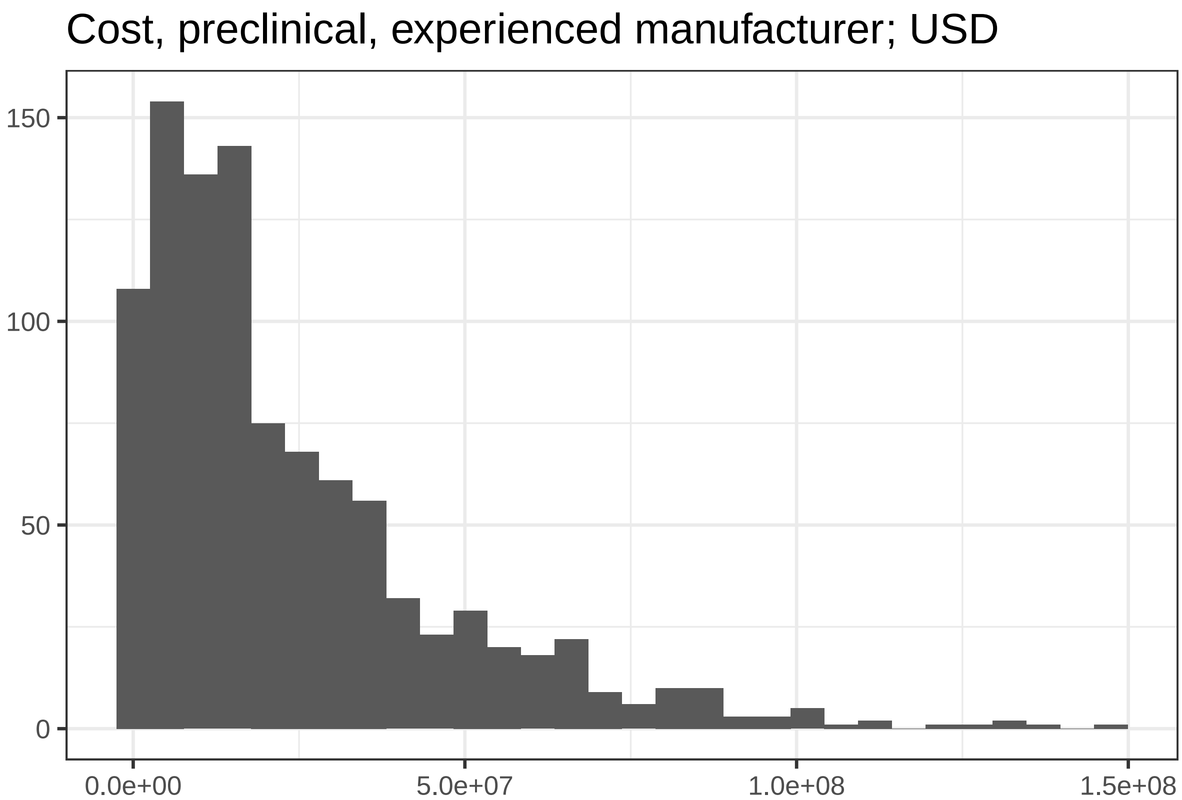
Probability of success; Phase II

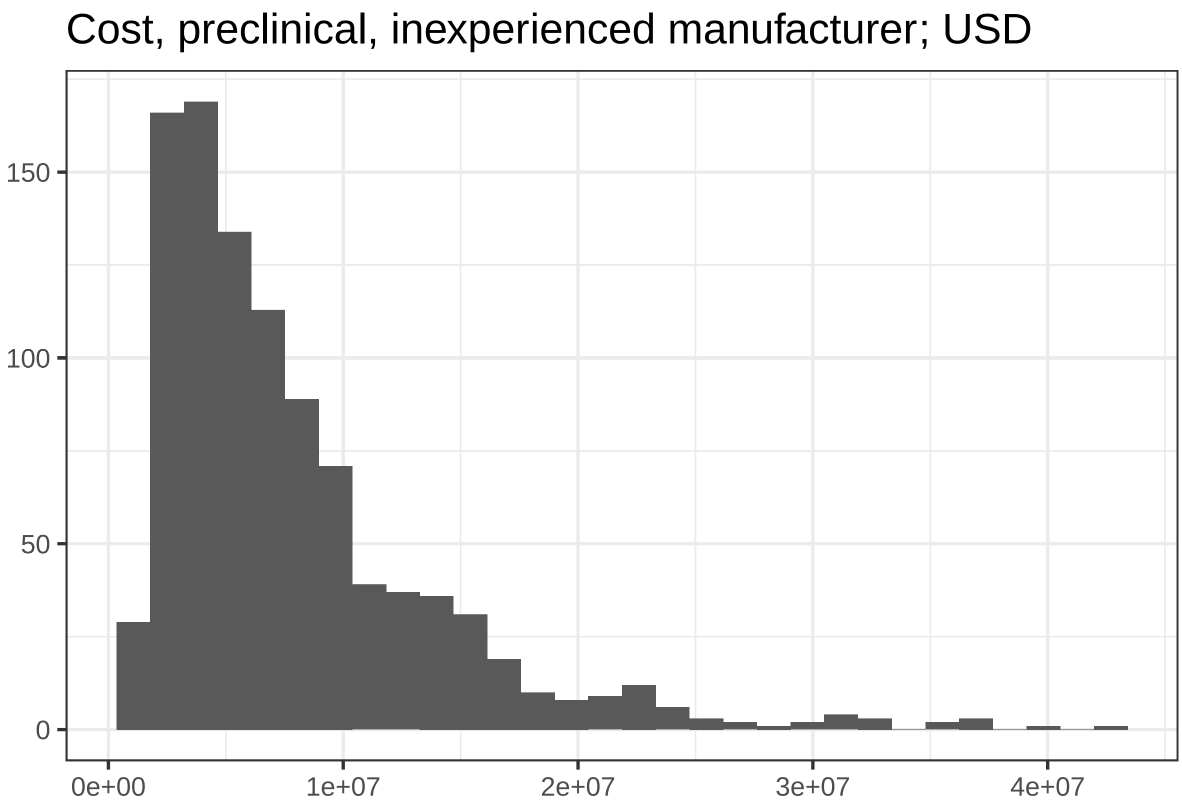



BPSV preclinical duration; years
500
400
300
200
100
0
1.2
1.5
1.8

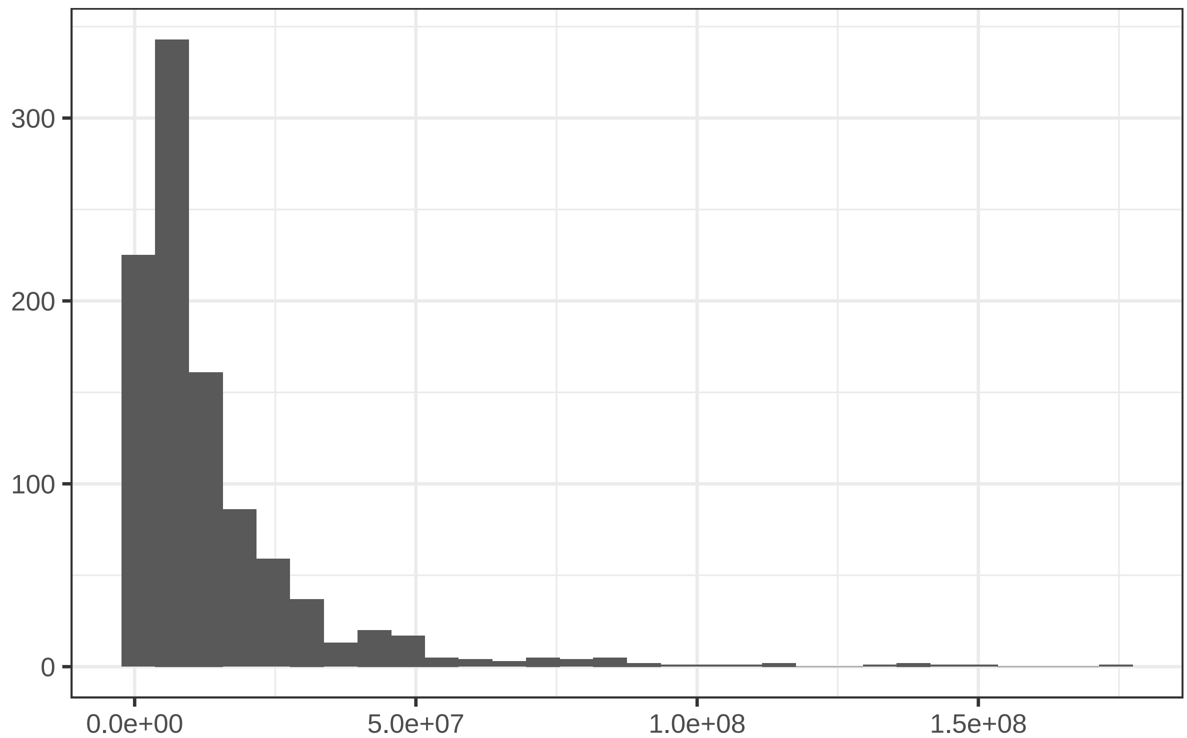

BPSV Phase I duration; years
500
400
300
200
100
0
1.2
1.5
1.8

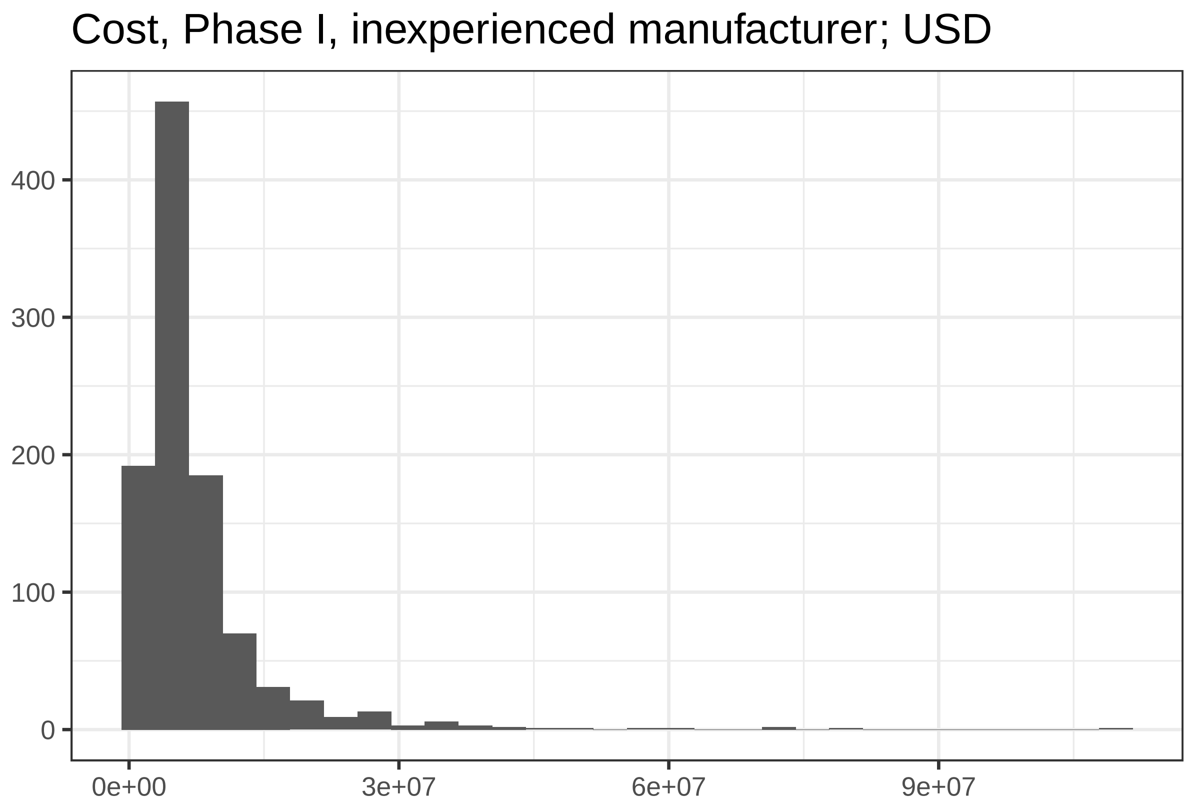

BPSV Phase III duration; years
500
400
300
200
100
0
3.00
3.25
3.50
3.75
4.00


Cost, preclinical, experienced manufacturer; USD
150
100
50
0
0.0e+00
5.0e+07
1.0e+08
1.5e+08

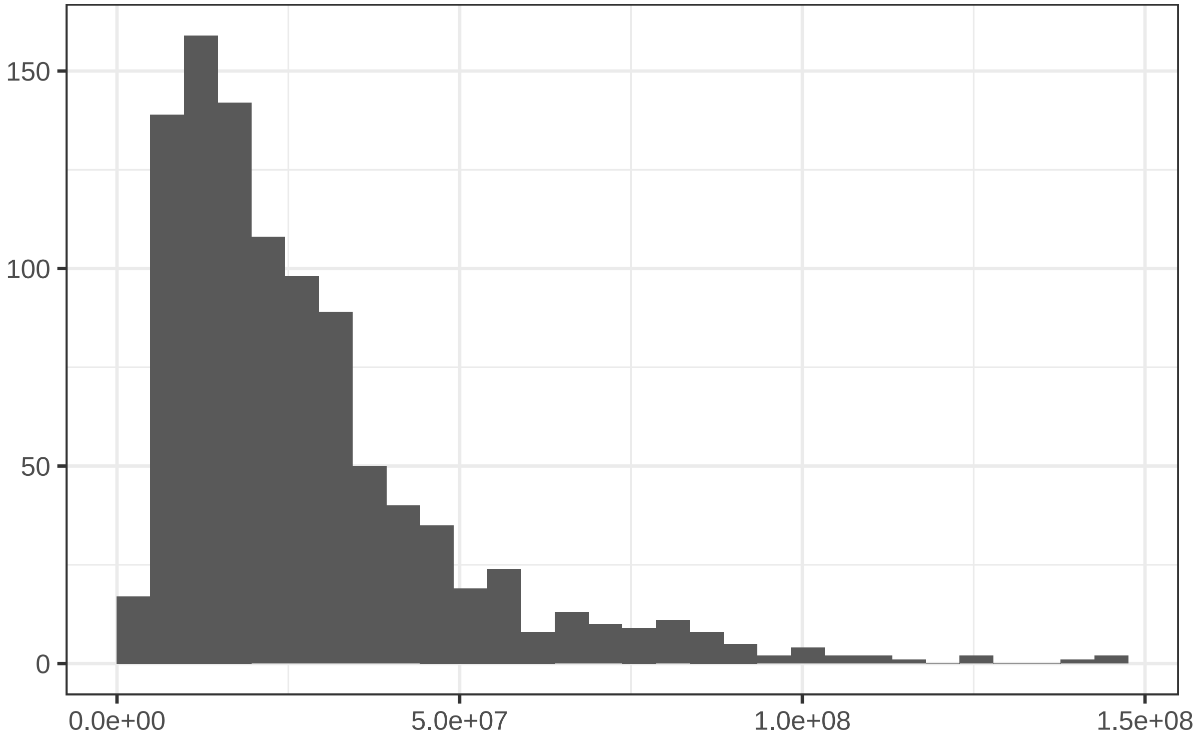

Cost, preclinical, inexperienced manufacturer; USD
150
100
50
0
0e+00
1e+07
2e+07
3e+07
4e+07

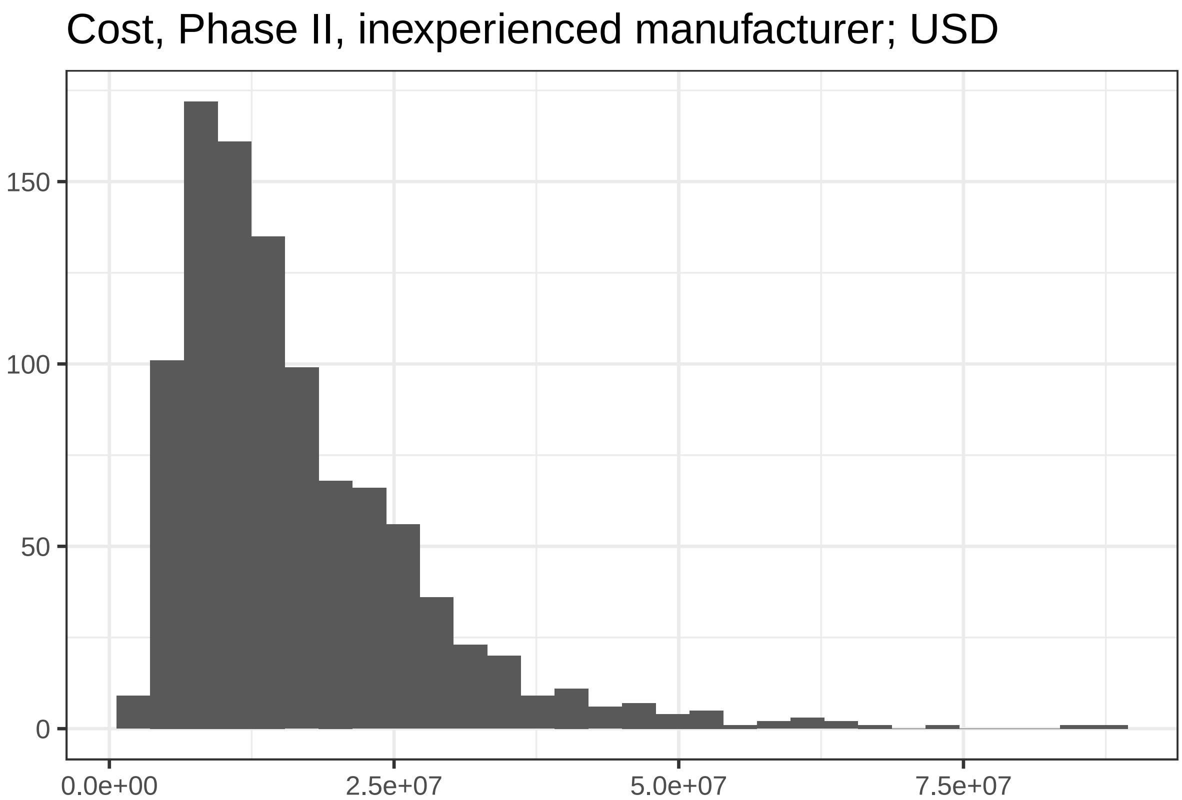
Cost, Phase I, experienced manufacturer; USD




Cost, Phase I, inexperienced manufacturer; USD
400
300
200
100
0
0e+00
3e+07
6e+07
9e+07

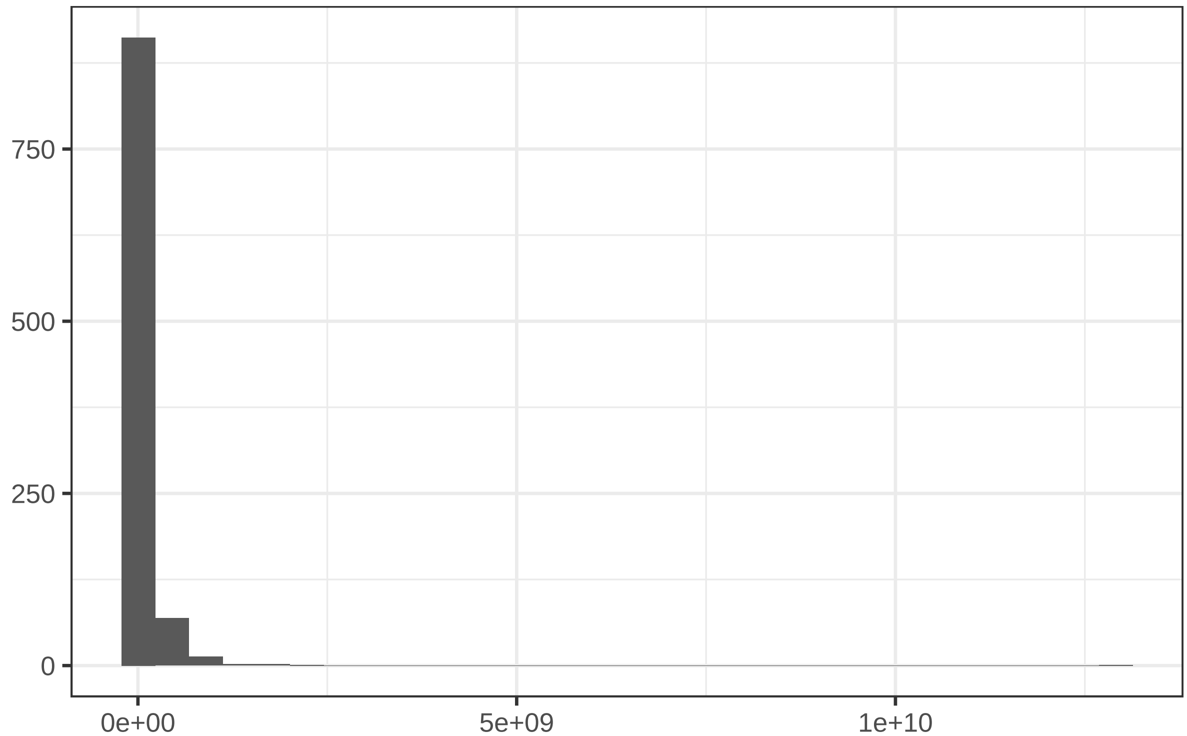
Cost, Phase II, experienced manufacturer; USD

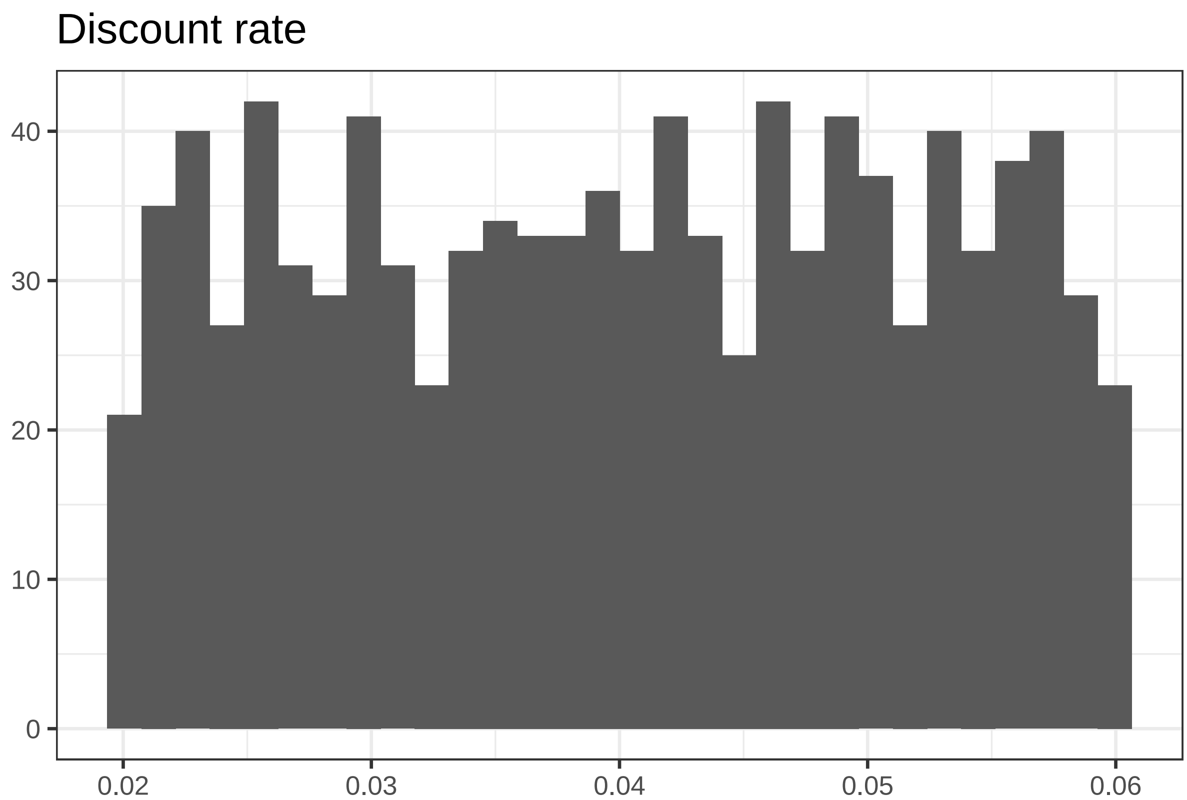


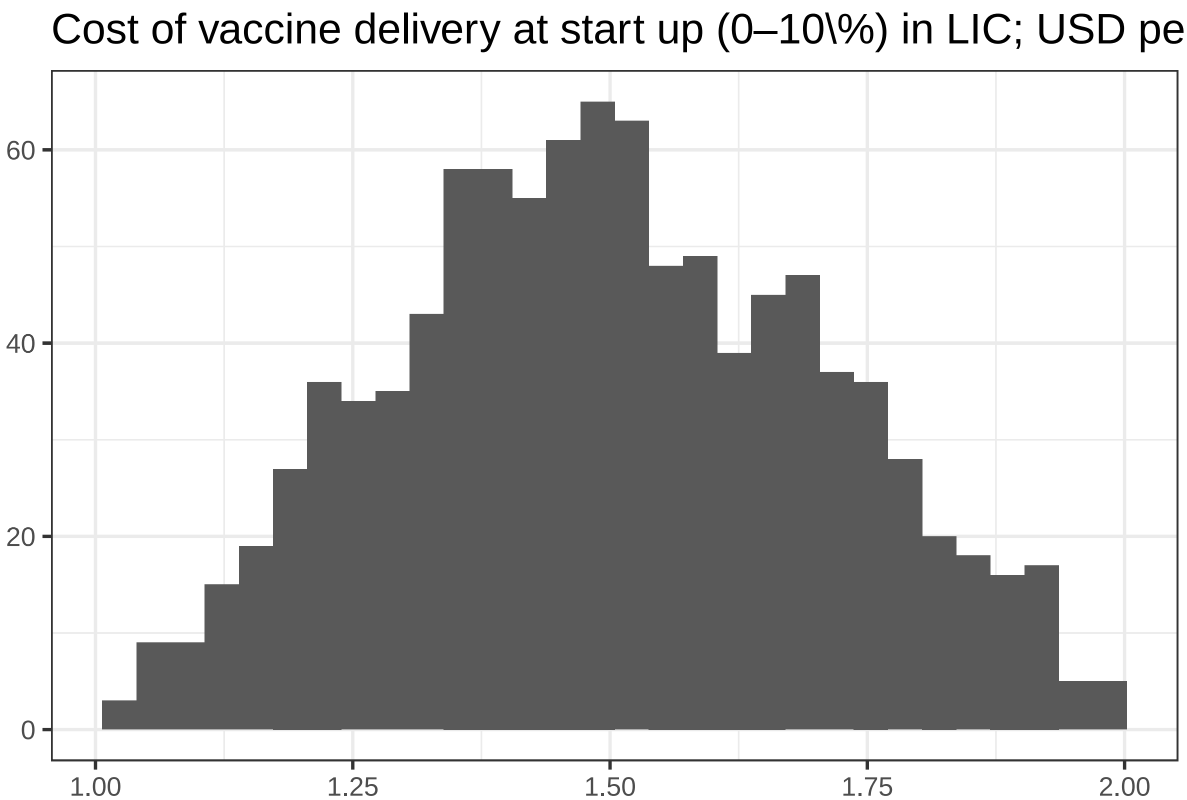


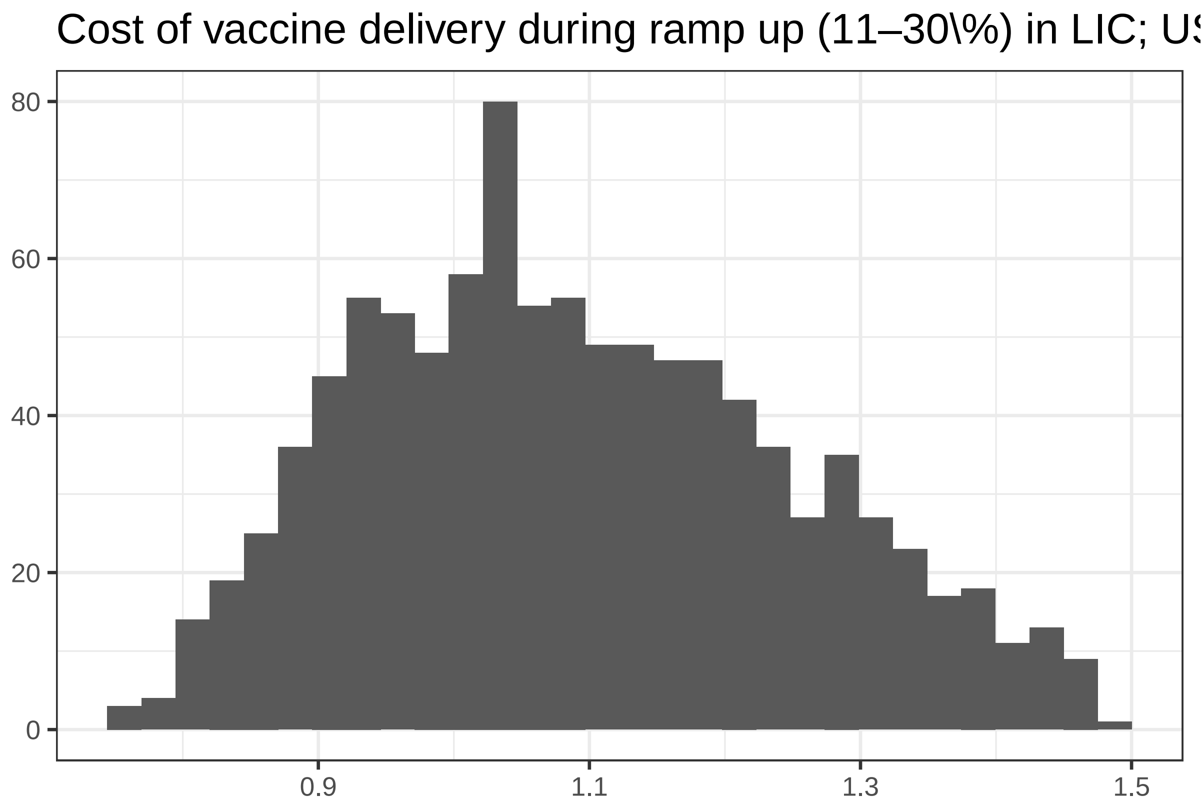
Cost, Phase II, inexperienced manufacturer; USD
150
100
50
0
0.0e+00
2.5e+07
5.0e+07
7.5e+07

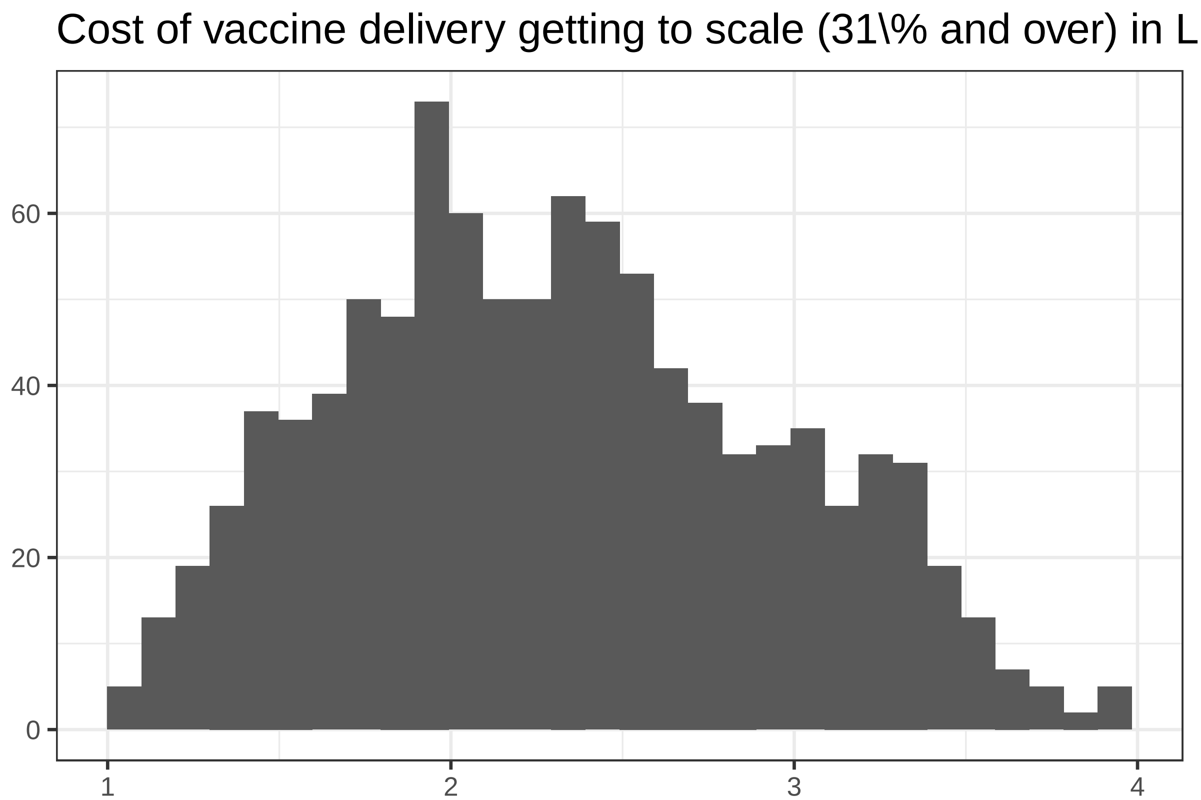
Cost, Phase III, experienced manufacturer; USD

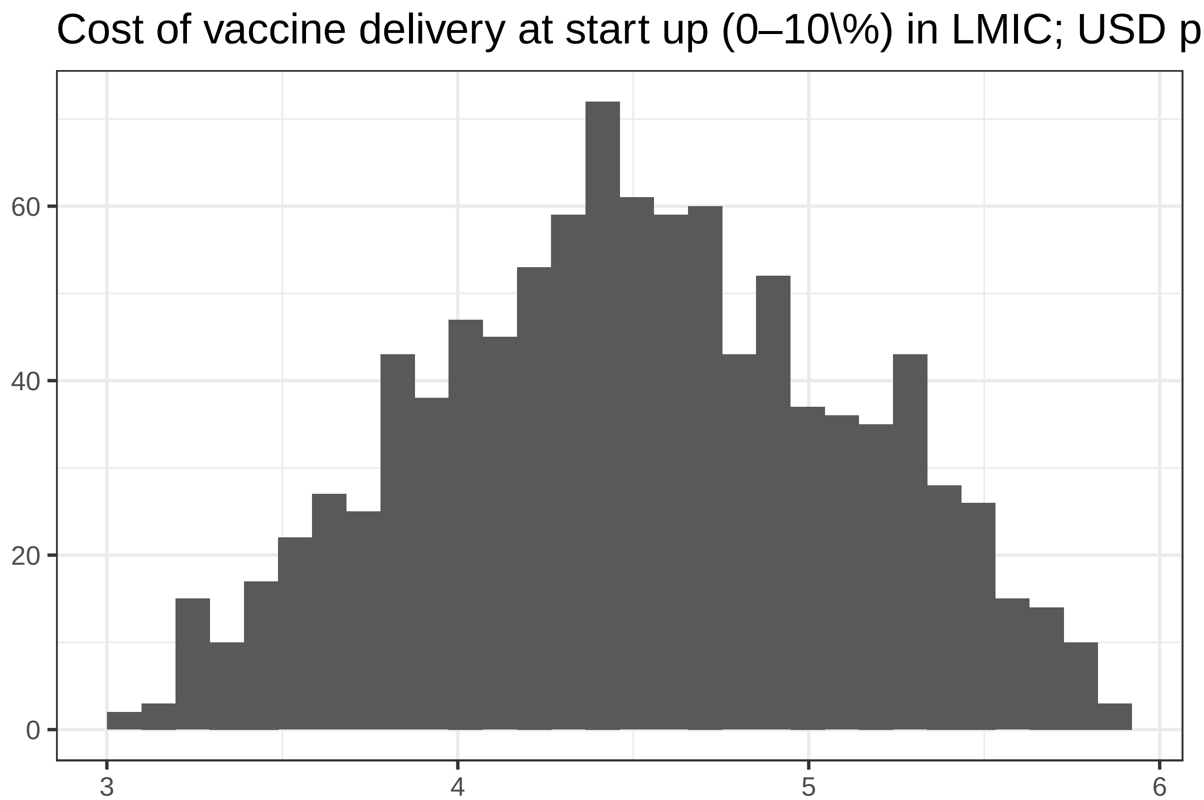



Discount rate
40
30
20
10
0
0.02
0.03
0.04
0.05
0.06

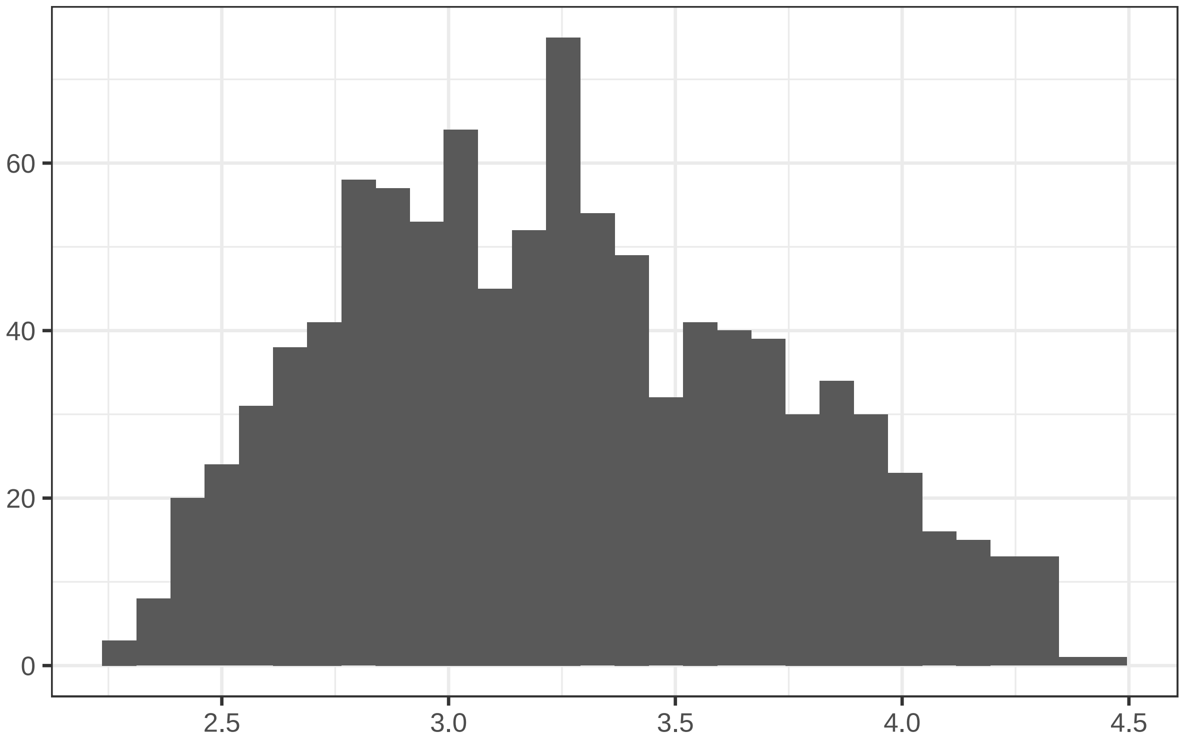

Cost of vaccine delivery at start up (0–10\%) in LIC; USD per
60
40
20
0
1.00
1.25
1.50
1.75
2.00

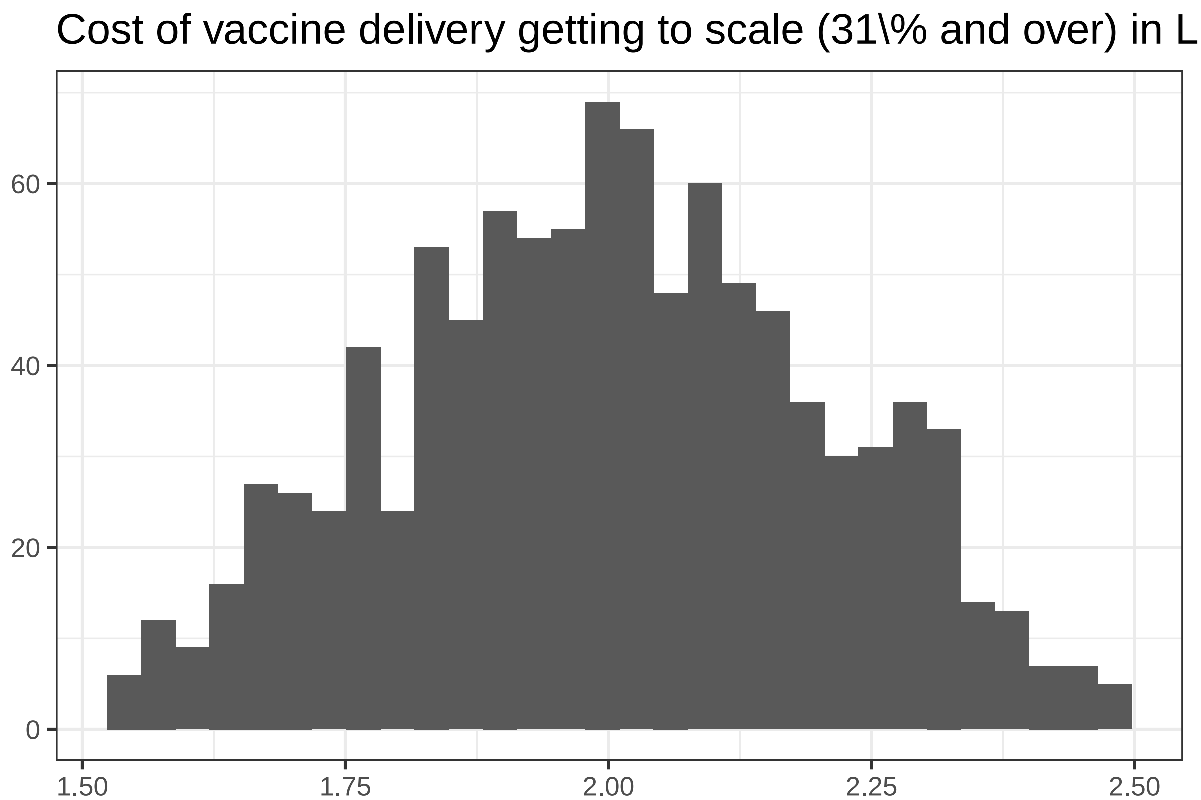

Cost of vaccine delivery during ramp up (11–30\%) in LIC; US
80
60
40
20
0
0.9
1.1
1.3
1.5


Cost of vaccine delivery getting to scale (31\% and over) in L
60
40
20
0
1
2
3
4

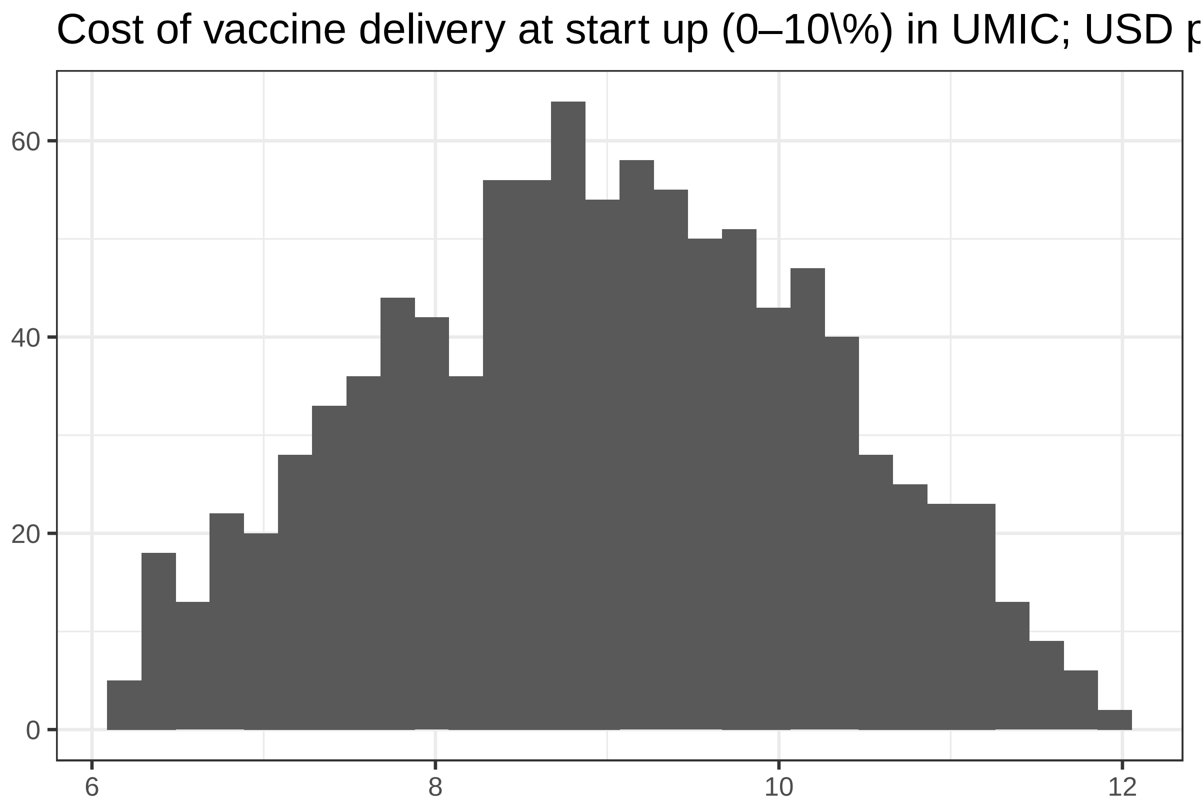

Cost of vaccine delivery at start up (0–10\%) in LMIC; USD p
0
20
40
60
3
4
5
6

Cost of vaccine delivery during ramp up (11–30\%) in LMIC;

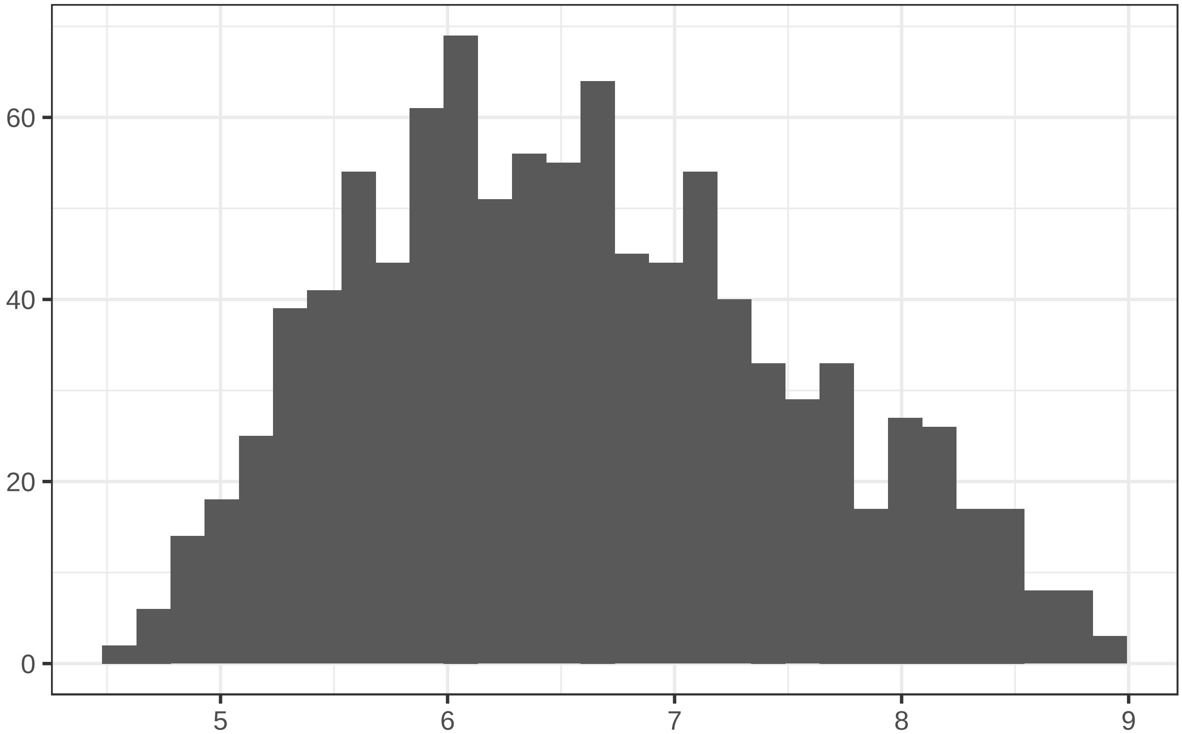


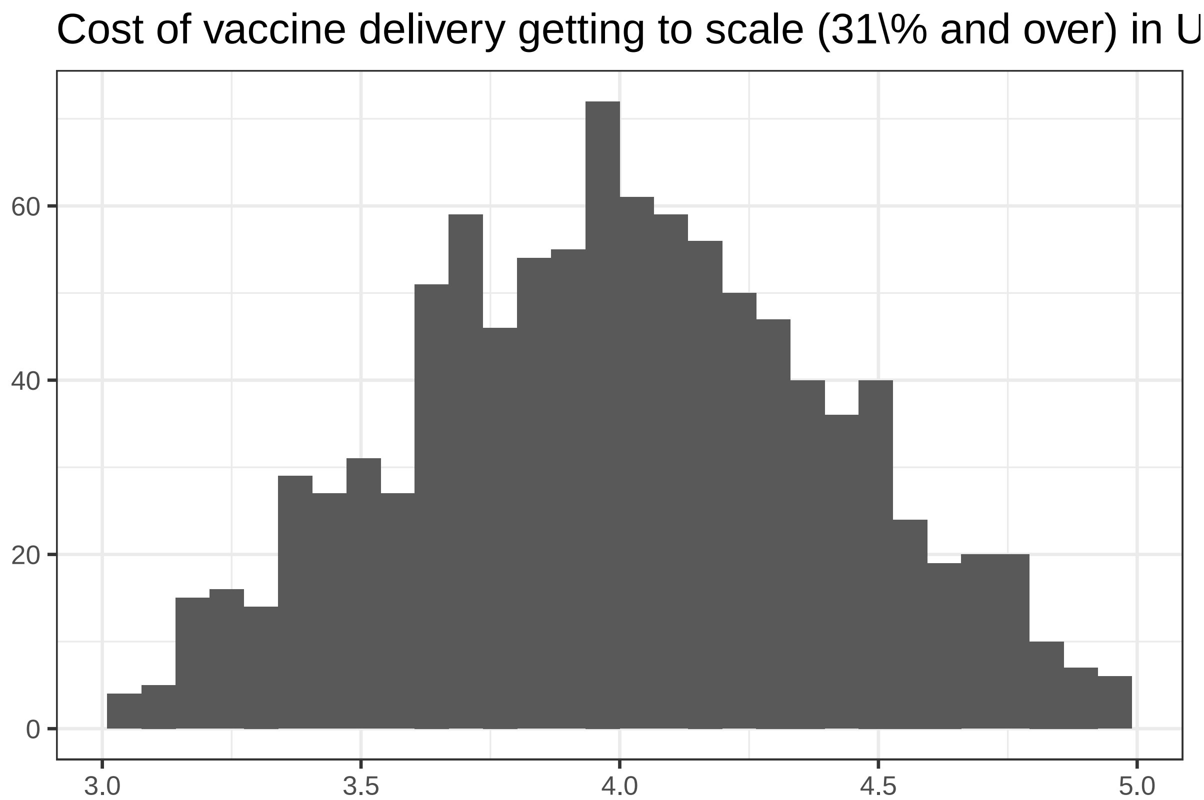


Cost of vaccine delivery getting to scale (31\% and over) in L
60
40
20
0
1.50
1.75
2.00
2.25
2.50

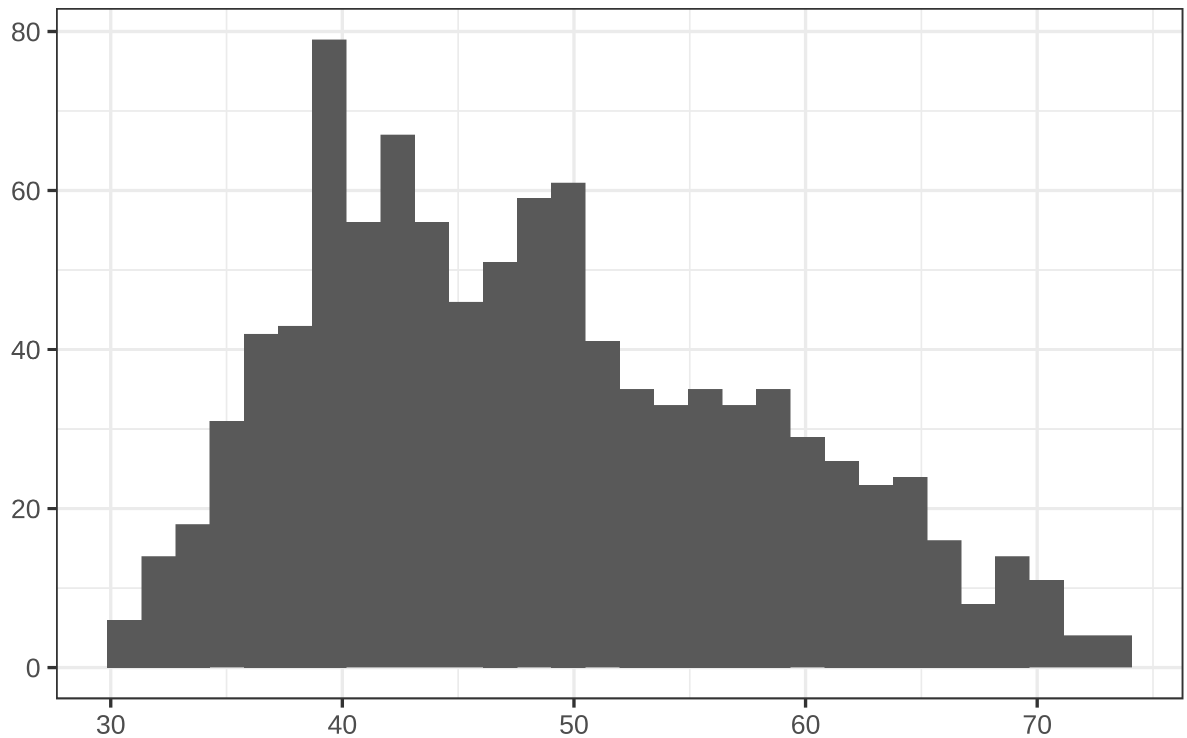

Cost of vaccine delivery at start up (0–10\%) in UMIC; USD p
60
40
20
0
6
8
10
12

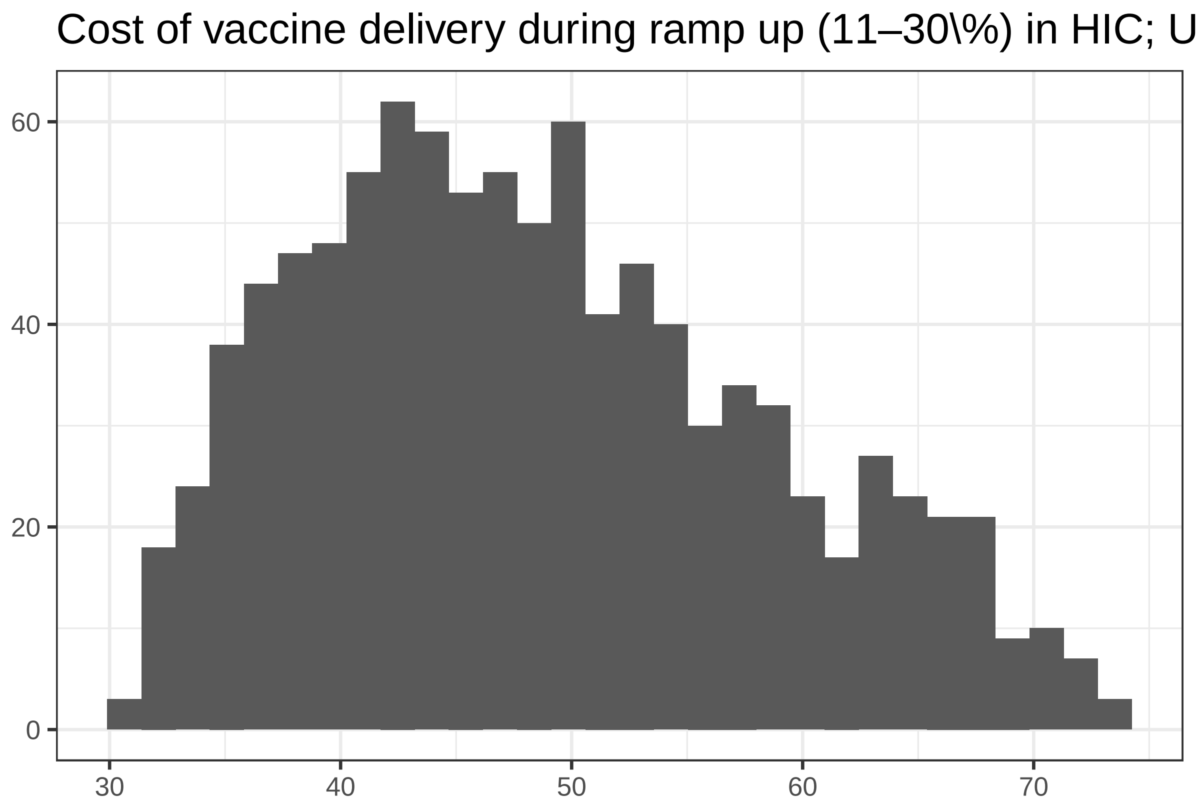
Cost of vaccine delivery during ramp up (11–30\%) in UMIC;

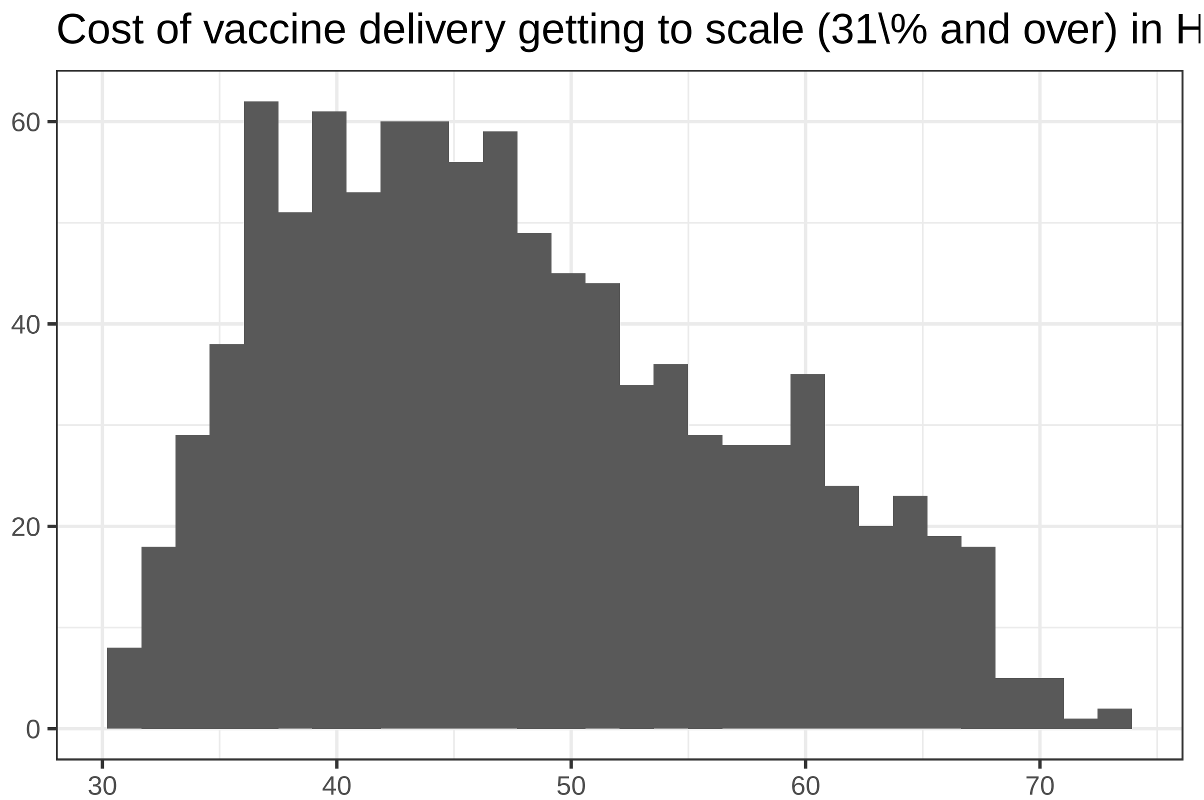



Cost of vaccine delivery getting to scale (31\% and over) in U
0
20
40
60
3.0
3.5
4.0
4.5
5.0

Cost of vaccine delivery at start up (0–10\%) in HIC; USD pe




Cost of vaccine delivery during ramp up (11–30\%) in HIC; U
60
40
20
0
30
40
50
60
70



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