MDR TB bedaquiline or amikacin costing study: Generating patient-level cost data

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This document gives some of the methods and data of the initial part of the analysis for circulation.

Look-up costs

The cost have been obtained from 4 centres. They are not complete at time of writing. I have therefore crudely used the minimum, maximum and mean value across observed values in centres.

Also, hospital stay costs are scaled from 4% to 24% for different centre. Baseline values are fixed £2429 for stays under 20 days and £208 for each day thereafter.

The raw, and minimum, mean and maximum imputed cost matrices are:

centre_costid	centre_patientid	bed_under20d	bed_over20d	PICC	hick	OPAT	blood_amak	blood_liver	b
1	1	3016.089	258.2736	69	0	102	7.50	3.80	
2	4	2945.162	252.2000	NA	NA	148	7.50	2.65	
3	2	2538.062	217.3392	NA	NA	100	NA	NA	
4	3	2962.408	253.6768	200	200	NA	29.56	11.82	

Table 1: Original data

centre_costid	centre_patientid	bed_under20d	bed_over20d	PICC	hick	OPAT	blood_amak	blood_liver	b
1	1	3016.09	258.27	69	0	102	7.50	3.80	
2	4	2945.16	252.20	69	0	148	7.50	2.65	
3	2	2538.06	217.34	69	0	100	7.50	2.65	
4	3	2962.41	253.68	200	200	100	29.56	11.82	

Table 2: Fill with minimum values

centre_costid	centre_patientid	bed_under20d	bed_over20d	PICC	hick	OPAT	blood_amak	blood_liver	b
1	1	3016.09	258.27	69.0	0	102.00	7.50	3.80	
2	4	2945.16	252.20	134.5	100	148.00	7.50	2.65	
3	2	2538.06	217.34	134.5	100	100.00	14.85	6.09	
4	3	2962.41	253.68	200.0	200	116.67	29.56	11.82	

Table 3: Fill with mean values

centre_costid	centre_patientid	bed_under20d	bed_over20d	PICC	hick	OPAT	blood_amak	blood_liver	b
1	1	3016.09	258.27	69	0	102	7.50	3.80	
2	4	2945.16	252.20	200	200	148	7.50	2.65	
3	2	2538.06	217.34	200	200	100	29.56	11.82	

centre_costid	centre_patientid	bed_under20d	bed_over20d	PICC	hick	OPAT	blood_amak	blood_liver	b
4	3	2962.41	253.68	200	200	148	29.56	11.82	

Table 4: Fill with maximum values

- `bed_under20d` is cost of hosptial stay fixed up to 19 days
- `bed_over20d` is the daily cost of hospital stay for every day over 19 days
- `PICC` is the cost of a PICC line
- `hick` is the cost of a Hickman line
- `blood amik` is the cost of a blood test
- `blood liver` is the cost of a blood test
- `blood renal` is the cost of a blood test
- `hear` is the cost of a hearing test
- `ECG` is the cost of an ECG
- `scaling` is the centre specific cost scaling

Note that the provided cost and patient data do not use the same ids (represented here by `centre_costid` and `centre_patientid`).

The total cost of bedaquiline treatment is £18000 for a duration of 24 weeks. The idealised duration of amikacin treatment is 24 or 32 weeks. Therefore, we scale the bedaquiline cost for an equivalent 32 weeks period of £24000 too.

Scenarios

Cost are considered for 12 main scenarios. These can be grouped in to observed injection vs ideal injection scenarios, and observed injection vs tablets scenarios. For the comparison bedaquiline scenarios hospital length of stay is scaled by a predefined value to represent shorter symptom duration.

No.	Baseline	Comparison
1a	Amikacin injection observed	Bedaquiline tablets 6 months; same hospital length of stay
1b	Amikacin injection observed	Bedaquiline tablets 6 months; 90% hospital length of stay
1c	Amikacin injection observed	Bedaquiline tablets 6 months; 66% hospital length of stay
2a	Amikacin injection ideal 6 months	Bedaquiline tablets 6 months; same hospital length of stay
2b	Amikacin injection ideal 6 months	Bedaquiline tablets 6 months; 90% hospital length of stay
2c	Amikacin injection ideal 6 months	Bedaquiline tablets 6 months; 66% hospital length of stay
3a	Amikacin injection ideal 8 months	Bedaquiline tablets 8 months; same hospital length of stay
3b	Amikacin injection ideal 8 months	Bedaquiline tablets 8 months; 90% hospital length of stay
3c	Amikacin injection ideal 8 months	Bedaquiline tablets 8 months; 66% hospital length of stay

So, for each set of costs (minimum, mean, maximum) and each treatment scenario, in total there are 9 x 3 =

27 scenarios to consider.

Patient-level cost calculation

The costs for each scenario consist of the following:

Observed and idealised injectable

- Time in hospital (from observed data)
- OPAT daily in discharge period (observed, up to 6 or 8 months)
- Number of lines (Hickman, PICC) in discharge period (observed, up to 6 or 8 months)
- Number of monthly hearing tests in discharge period (observed, up to 6 or 8 months)
- Number of weekly blood tests (observed, up to 6 or 8 months)

Bedaquiline

- Time in hospital from observed data (possible scaled downwards)
- Monthly ECG and blood tests (renal, LFT) in discharge period (up to 6 or 8 months)
- Total fixed cost of treatment (up to 6 or 8 months)

Estimated number of events

For the idealised scenarios we need to estimate how many Hickman and PICC lines would occur for each individual in the fixed period. We do this by estimating a pooled weekly rate for each from the total sample. We then calculate each according to their duration on treatment after hospital discharge.

Patient time to event equations

Initial hospital length of stay

$$t_{adm} = d_{hosp\_end} - d_{IV\_start}$$

Out-patient (OP) duration

$$t_{OP} = \begin{cases} d_{IV\_end} - d_{hosp\_end} & \text{for observed scenarios} \\ t_{Tx} - t_{adm} & \text{for non-observed scenarios} \end{cases}$$

where

$$t_{Tx} = 24, 32$$

Total hospital length of stay including readmissions

$$t_{adm}^{inj} = t_{adm} + t_{readm}$$

Total hospital length of stay for bedaquiline

$$t_{adm}^{bdq} = \rho t_{adm} + t_{readm}, \ \ 0 \leq \rho \leq 1$$

Total out-patient duration for amikacin

$$t_{OP}^{inj} = \max \left\{ t_{OP} - t_{readm}, 0 \right\}$$

Total out-patient duration for bedaquiline

$$t_{OP}^{bdq} = \max\left\{t_{OP} - t_{readm} + (1 - \rho)t_{adm}, 0\right\}$$

Estimated number of Hickman and PICC lines

$$\hat{n}_{hick} = t_{OP}^{inj}\frac{\sum n_{hick}}{\sum t_{OP}^{inj}}, \quad \hat{n}_{PICC} = t_{OP}^{inj}\frac{\sum n_{PICC}}{\sum t_{OP}^{inj}}$$

Total cost equations

- Bedaquiline tablets

$$c_{bdq}^i = \left[c_{bed<20} + \max\left\{t_{adm}^{bdq} - 19, 0\right\}c_{bed\not<20}\right] + \left\lfloor\frac{t_{OP}^{bdq}}{7}\right\rfloor(c_{ECG} + c_{renal} + c_{liver}) + c_{bdq}$$

- Observed injectible amikacin

$$c_{amik}^i = \left[c_{bed<20} + \max\left\{t_{adm}^{inj} - 19, 0\right\}c_{bed\not<20}\right] + c_{hick}n_{hick}^i + c_{PICC}n_{PICC}^i + c_{OP}t_{OP}^i + c_{hear}n_{hear}^i$$

- Ideal injectible amikacin

$$c_{amik,ideal}^i = \left[c_{bed<20} + \max\left\{t_{adm}^{inj} - 19, 0\right\}c_{bed\not<20}\right] + c_{hick}\hat{n}_{hick}^i + c_{PICC}\hat{n}_{PICC}^i + c_{OPAT}\hat{t}_{OP}^i + c_{hear}\hat{n}_{hear}^i$$

Patient-level data

Each patient's cost is calculated using the costs for their particular site. Their times to events and counts are available (`obs`). The analysis data thus consist of the original recorded data, the derived counts and times and the total cost per patient.

0	1	2	3	4	5	6	7	8	9	10	11	12	13
12	16	13	11	8	9	5	1	6	5	3	1	4	1

Table 5: Number of hearing tests

0	1	2	3
22	58	9	6

Table 6: Number of picc lines

0	1	2
87	7	1

Table 7: Number of Hickman lines

Each patients total cost by hospital LoS

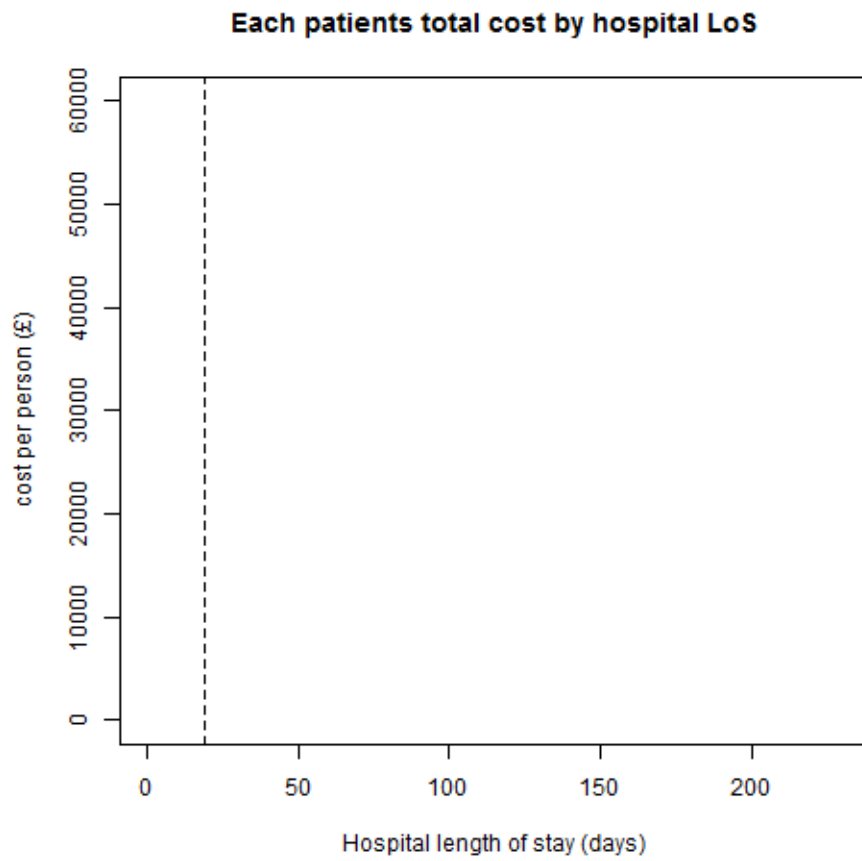cost per person (£)

Hospital length of stay (days)

Figure 1: Patient total costs by hospital length of stay for amikacin treatment. Blue and red lines are for 8 and 6 week regimens respectively.
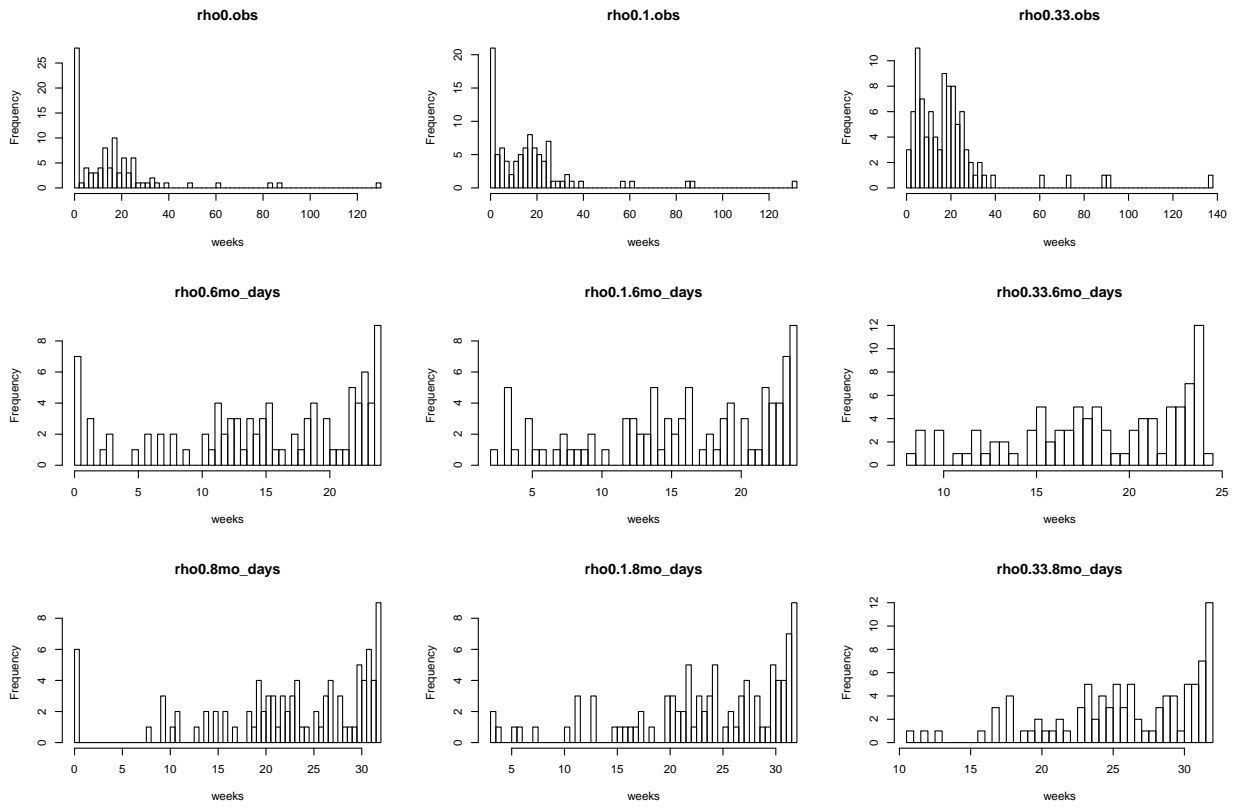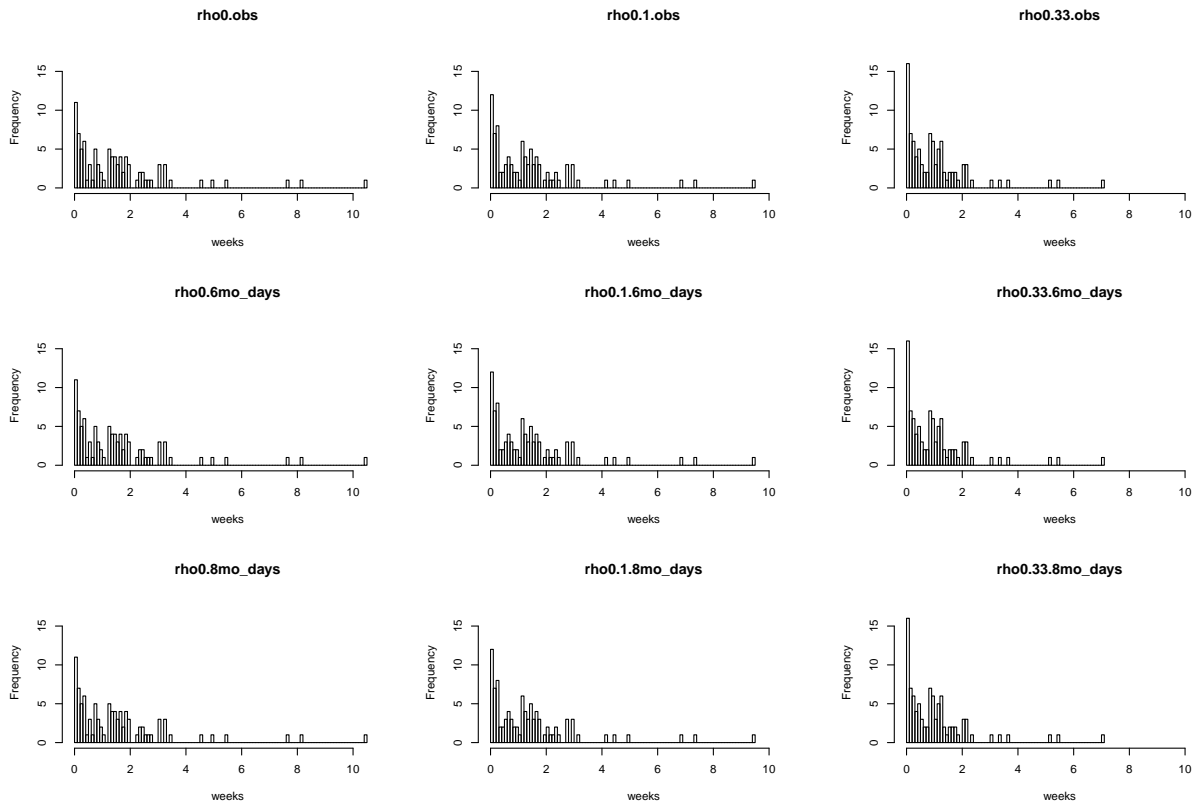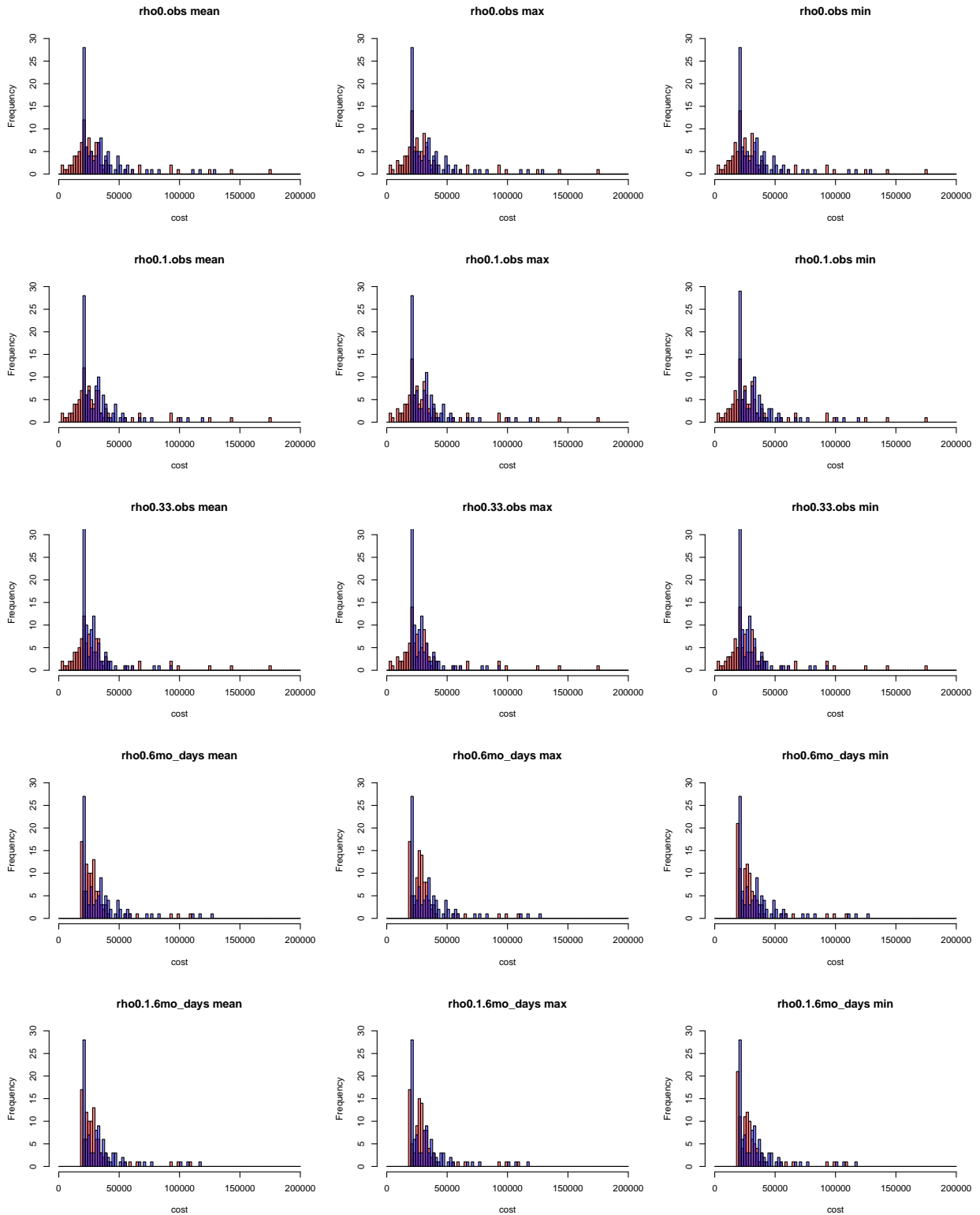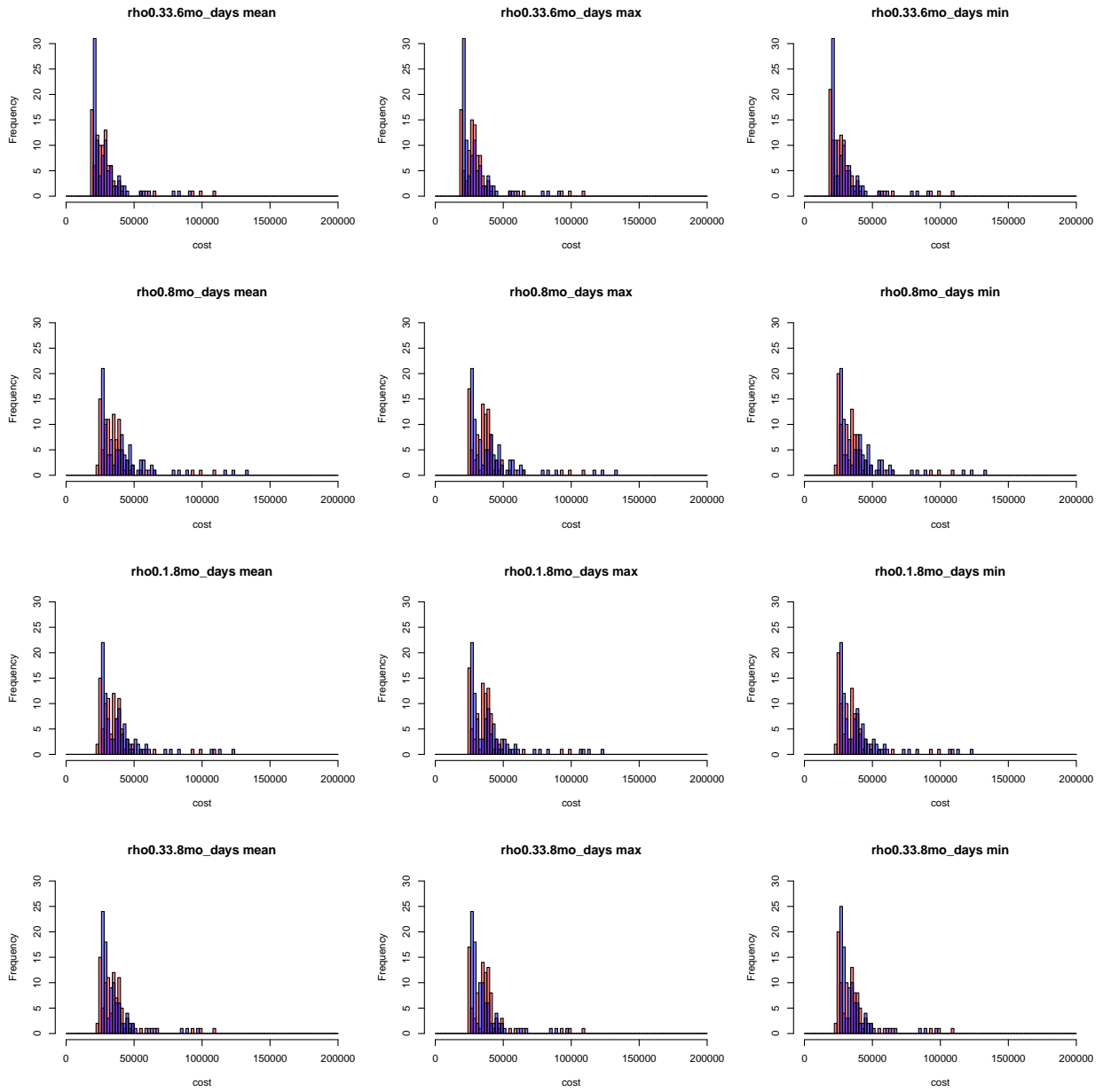
Figure 2: Out-patient days for bdq

Figure 3: Total admission weeks for bdq

Below we give the individual total costs for each scenario (unit cost table and length of stay) histograms for amikacin (red) vs bedaquiline (blue).

For each scenario the summary costs are given below.