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Results of Evaluation Trials for Addressing Delayed Surveys with the Bowhead Strike Limit Algorithm

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ABSTRACT

The IWC Scientific Committee has agreed to examine the performance of an 'interim allowance' strategy for adapting the Bowhead Strike Limit Algorithm (SLA) in the case that an abundance estimate is not available within ten years of the previous one and a third block quota (for a 'grace period') is required. Simulation methods for testing this approach are described by Punt (2015). Here we graph the results using standard methods agreed by the Scientific Committee. Both the interim allowance strategy and a previously proposed 'phase-out' strategy exhibit satisfactory conservation performance that is very similar to what was originally approved for the Bowhead SLA and virtually indistinguishable from simulations with no delayed surveys. The interim allowance strategy provides superior satisfaction of aboriginal need than if phase-out is applied during grace periods, and acceptable need satisfaction overall.

KEYWORDS: BOWHEAD WHALE, MANAGEMENT, INDIGENOUS WHALING

INTRODUCTION

The Bowhead Strike Limit Algorithm (SLA) was adopted by the IWC in 2002 as the basis for recommending block quotas for subsistence hunting of Bering-Chukchi-Beaufort Seas bowhead whales (IWC, 2003). At that time, the IWC Scientific Committee also recommended a set of related rules and procedures: the scientific aspects of an Aboriginal Whaling Scheme (AWS). The rules pertained to the carryover of unused strikes, guidelines for surveys, data standards, *Implementation Reviews* and so forth.

The Bowhead SLA requires periodic new abundance estimates. Perhaps the most contentious AWS topic is what should be done when a new abundance survey is not available within 10 years of the most recent one. The North Slope Borough Department of Wildlife Management, in coordination with the Alaska Eskimo Whaling Commission and the U.S. National Oceanic and Atmospheric Administration (NOAA), conducts research in an effort to meet all requests from the Scientific Committee. This includes concerted efforts to produce a successful survey and abundance estimate at least once per decade, hopefully more frequently. Since 1977, there have been 21 survey attempts. The average years between survey attempts is 1.6 (though since 1993 the interval has been roughly 6-8 years), and the success rate is 57% (12/21).

Nevertheless, it is possible to envision situations where the 10-year interval requirement might not be met despite researchers' best efforts and despite planning ahead. These include:

(1) several consecutive years of bad weather and/or poor or unsafe ice conditions;

(2) lack of sufficient funding - it costs more than $1 million USD over 1-3 seasons to produce a successful ice-based abundance estimate (including analysis);

(3) domestic or international political paralysis, or failure of the IWC to adopt an acceptable abundance estimate.

Given their lack of control over these issues, hunters are concerned that strike limits should not be unreasonably reduced due to the whims of nature, funding or politics. While recognizing the hunters' concern, the Scientific Committee has noted that it is important to consider reductions in aboriginal whaling quotas in the long-term absence of data as well as when there is evidence of conservation risk.

The 2002 AWS proposal included such a block quota reduction. At that time, quotas were established in 5-year blocks and if no new abundance estimate was obtained by the end of the second block (i.e., within 10 years), then the

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third block (years 11-15) was termed a ‘grace period’. During the grace period, the block quota was to be reduced by 50%, which we call ‘phase-out’. This proposal was not adopted by the IWC.

Since 2002, the status of the BCB bowhead population has changed markedly. In 2001, abundance was estimated to be 10,545 (95% CI; (8200, 13500)) with an annual rate of increase of 3.4% (95% CI; (1.7%, 5.0%)). The most recent estimate is a 2011 abundance of 16,820 (15176, 18643) with an annual rate of increase of 3.7% (2.9%, 4.6%) (Givens et al., 2015). Lingering questions of stock structure have also been resolved (IWC, 2008). Considering the improved status of the stock now, it is possible that the balance between conservation and need satisfaction reflected in the Scientific Committee’s 2002 grace period proposal is unnecessarily precautionary.

Thus the Scientific Committee agreed to investigate a new grace period approach termed ‘interim allowance’ (IWC, 2016a, b). This approach would be to use the Bowhead SLA on an interim basis for up to one (now 6-year) additional block (the grace period block) when an abundance estimate has not been obtained within ten years despite concerted efforts to produce one. When a new abundance estimate is obtained within the grace period block, the quota is reset by the Bowhead SLA at the beginning of the next block. This differs from the phase-out option where the Bowhead SLA is used to generate a new quota immediately when a new abundance estimate is agreed.

SIMULATION TRIALS

To test the interim allowance strategy the Scientific Committee designed a simulation testing framework and trials based on the ones used to evaluate the Bowhead SLA (IWC, 2016a,b). Table 1 lists the agreed trials. Each of these trials is paired with four scenarios regarding survey intervals (Table 2). In the baseline scenario, surveys occur every 9 years and an abundance estimate is ready for use in the year after the survey. In the most extreme scenario (case 4), surveys are frequently late and estimates are delayed to the extent that the implementation of phase-out would result in 15 years (scattered across the 100 years simulated) where strike limits would be zero (assuming hunters maximized strike limit utilization during the early portion of the grace period). The two other scenarios are intermediate cases.

Punt (2015) implemented the simulation testing framework, ran the trials, and tabled key results. Here we display results graphically and offer some interpretation. The performance statistics we examine are a subset of those used by IWC (2003). They are listed in Table 3, with terminology and notation drawn from IWC (2003).

PLOTS

Figures 1-27 show plots of the summary statistics. Each plot includes 9 panels. Reading from left to right and then top to bottom, the panels pertain to performance statistics: D1 (1+ population), D1 (mature female population), D8, D10, R1 (1+ population), R1 (mature female population), N9 (20 years), N9 (100 years), and N12. Each panel is split into four portions, corresponding to the four scenarios for survey timing (Table 2). Within each portion are results for phase-out (PO) and interim allowance (IA). The results are summarized in a modified boxplot. The quartiles are indicated by the edges of the box and the red median line. From the edges of the box extend heavy black lines stretching to the 5^{th} and 95^{th} percentiles of the performance statistic. Thin black lines extend further to the minimum and maximum values seen in the 100 simulations.

Figures 28-54 show plots of age 1+ population trajectories. Trials, survey timing cases and management options are labelled as previously. The horizontal axis indicates time, with time=0 corresponding to the year 2019.

Figures 55-58 show plots of age 1+ population trajectories under a scenario of zero catches. Aside from the lack of simulated catch, the plots are analogous to the previous trajectory plots.

DISCUSSION

It is worth noting that the baseline survey timing scenario (shown in the leftmost quarter of any panel in Figures 1-27) represents the performance of the Bowhead SLA in the absence of any grace periods but with 6-year blocks. This performance is very similar to that accepted by the IWC (2003). There is nothing seen in these trials that casts doubt on the Bowhead SLA.

Now we turn to the grace period options. The level of conservation achieved in these trials is very similar to what was achieved in the 2002 performance evaluation. If PO (phase-out) and IA (interim allowance) were two strike limit algorithms, both would likely be judged to have adequate conservation performance according to past standards. The cases where the simulated stock fails to increase much meet all of the following conditions: (i) they are the same cases where this behaviour was originally seen for the Bowhead SLA, (ii) MSYR=1% is used despite its increased implausibility given the 2011 estimates, and (iii) the stock cannot recover to near carrying capacity even with zero catch. Need satisfaction is also similar to the past.

Across all trials for survey timing scenarios 2, 3, and 4, IA achieves conservation performance that is virtually indistinguishable from what is achieved in the baseline survey timing scenario when there are no grace periods (so PO or IA is never activated). In these scenarios, the conservation performance of PO is even better, which is not surprising since PO sometimes results in zero quotas.

However, since PO and IA both exhibit acceptable conservation performance, the question of need satisfaction becomes important. The results indicate that IA provides substantially better need satisfaction over 20 years in survey scenario 4 and over 100 years in survey scenarios 3 and 4. We conclude that IA represents a grace period option that maintains the stock at levels very similar to what would occur if no grace periods were invoked, while permitting substantially better need satisfaction than if PO was applied during grace periods.

ACKNOWLEDGMENTS

This work was supported by the North Slope Borough (Alaska) and the National Oceanic and Atmospheric Administration (through the Alaska Eskimo Whaling Commission). The authors thank Cherry Allison for providing code for the Bowhead SLA.

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Table 1
The *Evaluation Trials* on which the analyses are based. For these trials need is set for 6-year blocks.

Trial No.	Old Trial No.	Trial parameters are based on[&]	Description	Model	$MSYR_{1+}$	$MSYL_{1+}$	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)
BE01A*	BE01		Base case	D	2.5%	0.6	134	1	1	0.25, 0.25
BE01B*	BE01		Base case	S_E	2.5%	0.6	134	1	1	0.25, 0.25
BE02A	BE02	BE01A	Constant need	D	2.5%	0.6	**67**	1	1	0.25, 0.25
BE03A	BE03	BE01A	Future +ve bias	D	2.5%	0.6	134	1	**1→1.5 in yr 25**	0.25, 0.25
BE03B	BE03	BE01B	Future +ve bias	S_E	2.5%	0.6	134	1	**1→1.5 in yr 25**	0.25, 0.25
BE04A	BE04	BE01A	Future –ve bias	D	2.5%	0.6	134	1	**1→.67 in yr 25**	0.25, 0.25
BE05A	BE05	BE01A	Underestimated *CV*s	D	2.5%	0.6	134	1	1	**0.25, 0.10**
BE06A*	BE07		$MSYL_{1+}$ = 0.8	D	2.5%	**0.8**	134	1	1	0.25, 0.25
BE07A*	BE09		$MSYR_{1+}$ = 1%	D	**1%**	0.6	134	**0.5 → 1**[1]	1	0.25, 0.25
BE07B*	BE09		$MSYR_{1+}$ = 1%	S_E	**1%**	0.6	134	**0.5 → 1**[1]	1	0.25, 0.25
BE08A*	BE09		$MSYR_{1+}$ = 1.5%	D	**1.5%**	0.6	134	**0.67 → 1**[2]	1	0.25, 0.25
BE08B*	BE09		$MSYR_{1+}$ = 1.5%	S_E	**1.5%**	0.6	134	**0.67 → 1**[2]	1	0.25, 0.25
BE09A*	BE10		$MSYR_{1+}$ = 4%	D	**4%**	**0.8**	134	1	1	0.25, 0.25
BE10A	BE11	BE01A	Bad data	D	2.5%	0.6	134	1	**1→1.5 in yr 25**	**0.25, 0.10**
BE11A*	BE12		Difficult 1%	D	**1%**	0.6	134	**1 → 2**	**2**	**0.25, 0.10**
BE12A*	BE12		Difficult 1.5%	D	**1.5%**	0.6	134	**1 → 1.5**	**1.5**	**0.25, 0.10**
BE12B*	BE12		Difficult 1.5%	S_E	**1.5%**	0.6	134	**1 → 1.5**	**1.5**	**0.25, 0.10**
BE13A	BE13	BE11A	Difficult 1%; constant need	D	**1%**	0.6	**67**	**1 → 2**	**2**	**0.25, 0.10**
BE14A	BE13	BE13A	Difficult 1.5%; const need	D	**1.5%**	0.6	**67**	**1 → 1.5**	**1.5**	**0.25, 0.10**
BE15A	BE14	BE01A	Need increases to 201	D	2.5%	0.6	**201**	1	1	0.25, 0.25
BE16A	BE16	BE07A	$MSYR_{1+}$ = 1%; 201 need	D	**1%**	0.6	**201**	**0.5 → 1**	1	0.25, 0.25
BE16B	BE16	BE07B	$MSYR_{1+}$ = 1%; 201 need	S_E	**1%**	0.6	**201**	**0.5 → 1**	1	0.25, 0.25
BE17A	BE16	BE08A	$MSYR_{1+}$ = 1.5%; 201 need	D	**1.5%**	0.6	**201**	**0.67 → 1**	1	0.25, 0.25
BE17B	BE16	BE08B	$MSYR_{1+}$ = 1.5%; 201 need	S_E	**1.5%**	0.6	**201**	**0.67 → 1**	1	0.25, 0.25
BE18A	BE20	BE09A	$MSYR_{1+}$ = 4%; 201 need	D	**4%**	**0.8**	**201**	1	1	0.25, 0.25
BE19A*	BE21		Integrated	D	**U[1,4%]**	**U[.4-.8]**	134	1	1	0.25, 0.25
BE20A*	BE22		20yr time lag	D	2.5%	0.6	134	1	1	0.25, 0.25

& A blank entry means that the parameter values for the trial concerned are based on that trial.
* Requires conditioning.
[1] Bias equals 1 in 2018.
[2] Bias equals 1 in 2007.

Table 2
Specifications for future surveys

	Scenario			
	Baseline 9-1-18	Case 2 10-2-20	Case 3 13-3-17	Case 4 12-4-20
Next survey	2018	2020	2017	2020
Survey frequency	9	10	13	12
Time until estimate becomes available	1	2	3	4

Table 3
The performance statistics displayed in the figures. The following notation is used. P_t, C_t and Q_t are the population size, strike limit and need in year *t*, respectively. T=100 is the final year of simulation (except when T=20 for N9). P_t^* is the population size in year *t* under a scenario of zero strikes during the simulation period. Finally, K is carrying capacity.

ID	Name	Pop. Component	Time Periods	Details
D1	Final Depletion	1+, mature	100	P_T / K
D8	Rescaled final Depletion	1+	100	P_T / P_T^*
D10	Relative Increase	1+	100	P_T / P_0
N9	Average need satisfaction		20, 100	$\frac{1}{T}\sum_{t=0}^{T-1}\frac{C_t}{Q_t}$
N12	Mean downstep		100	$\sum_{t=-1}^{T-2} \lvert\min(C_{t+1}-C_t,0)\rvert \Big/ \sum_{t=-1}^{T-2} C_t$
R1	Relative Recovery	1+	100	$P_{t_r^*} / P_{t_r^*}^*$ where t_r^* = first year in which P_t^* passes through *MSYL*

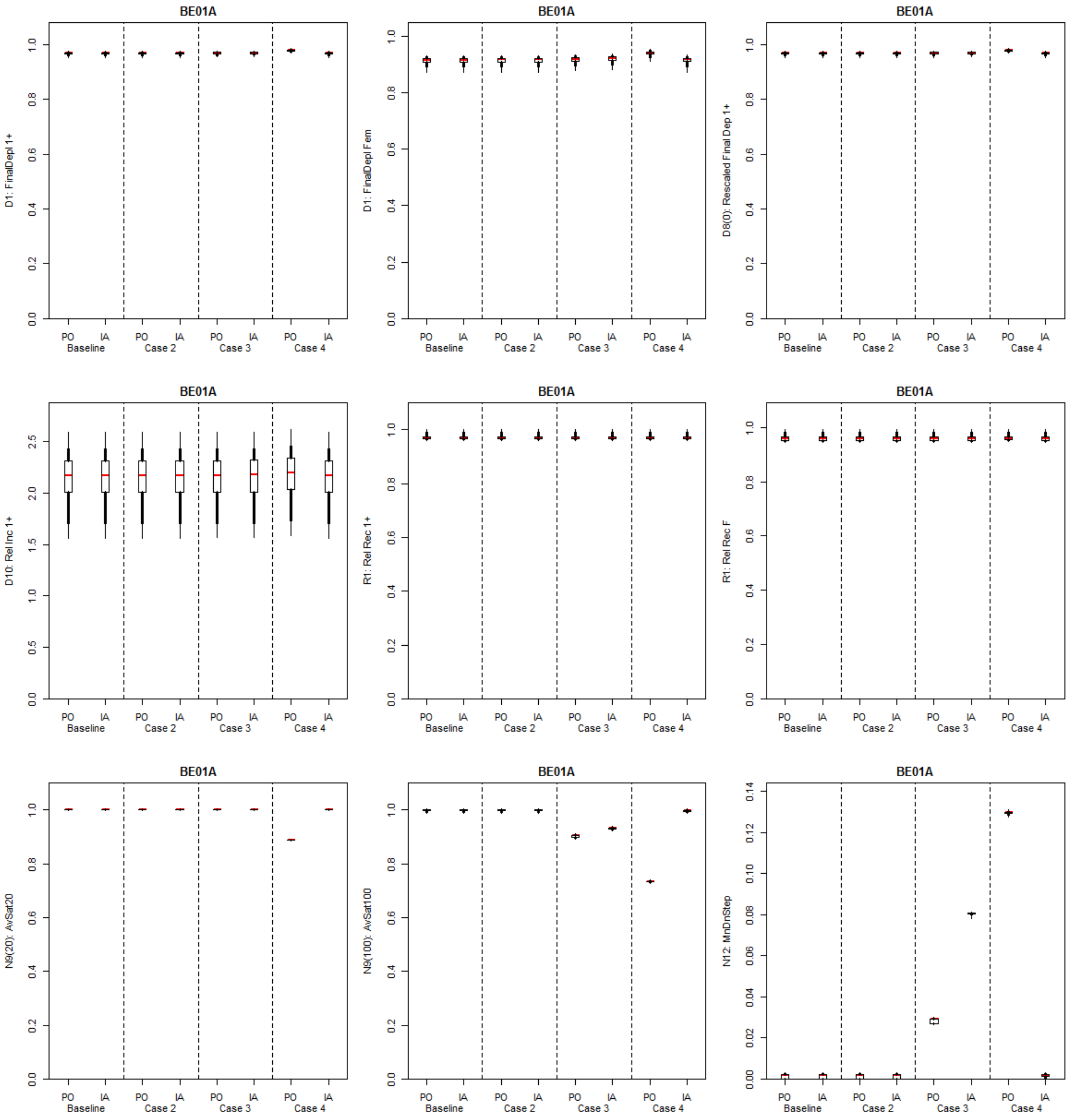

Figure 1: Performance plots for trial BE01A.

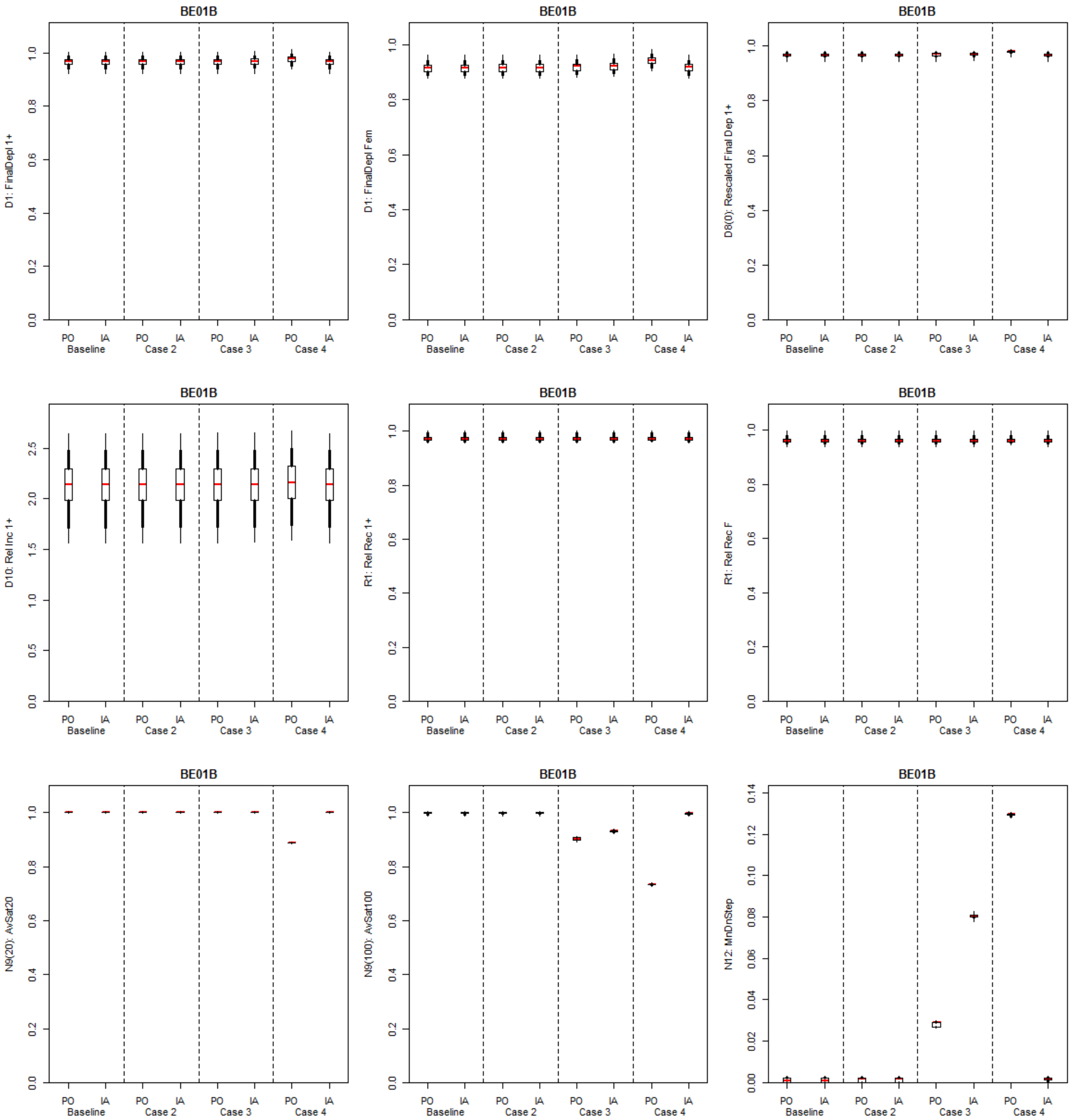

Figure 2: Performance plots for trial BE01B.

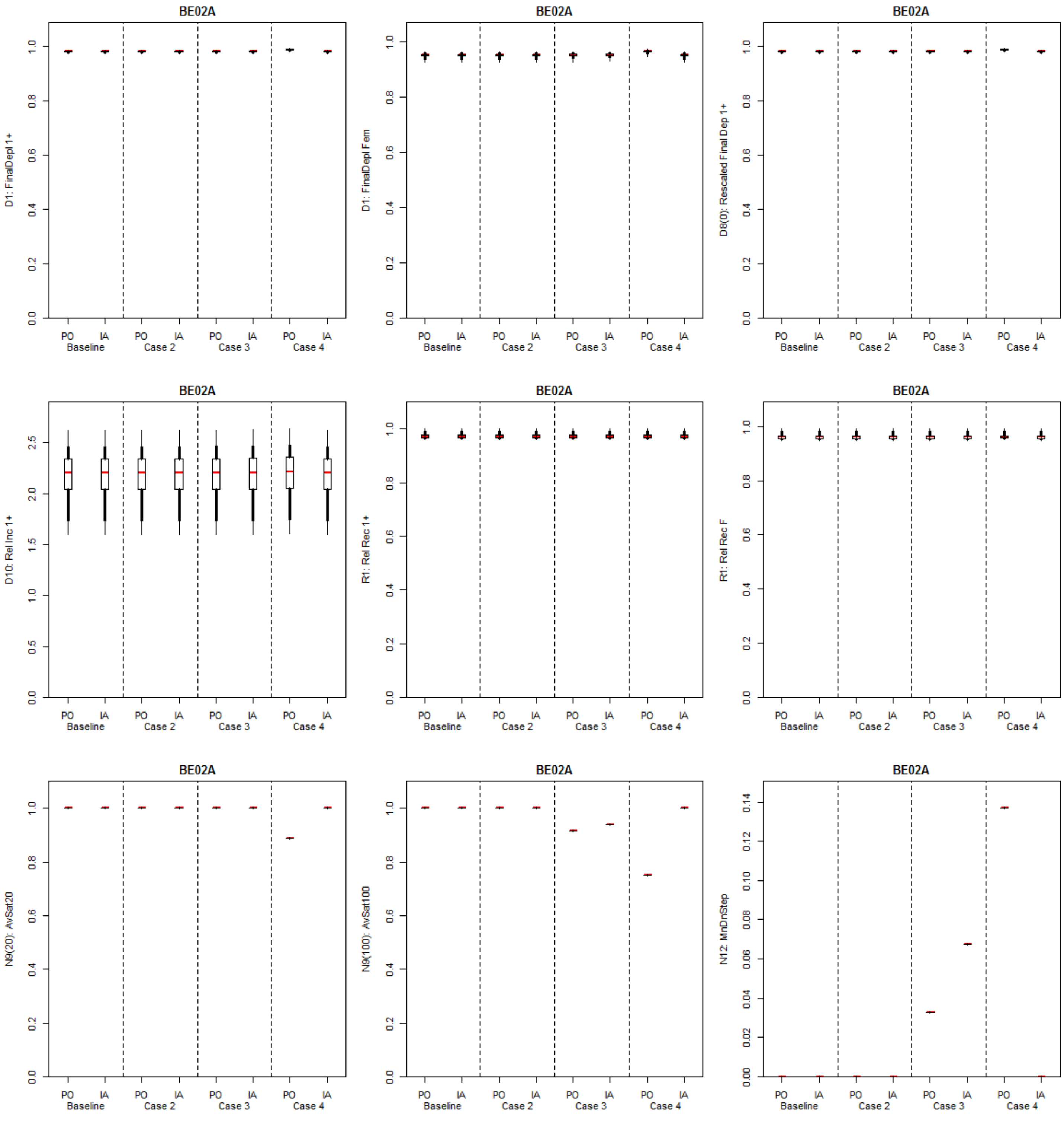

Figure 3: Performance plots for trial BE02A.

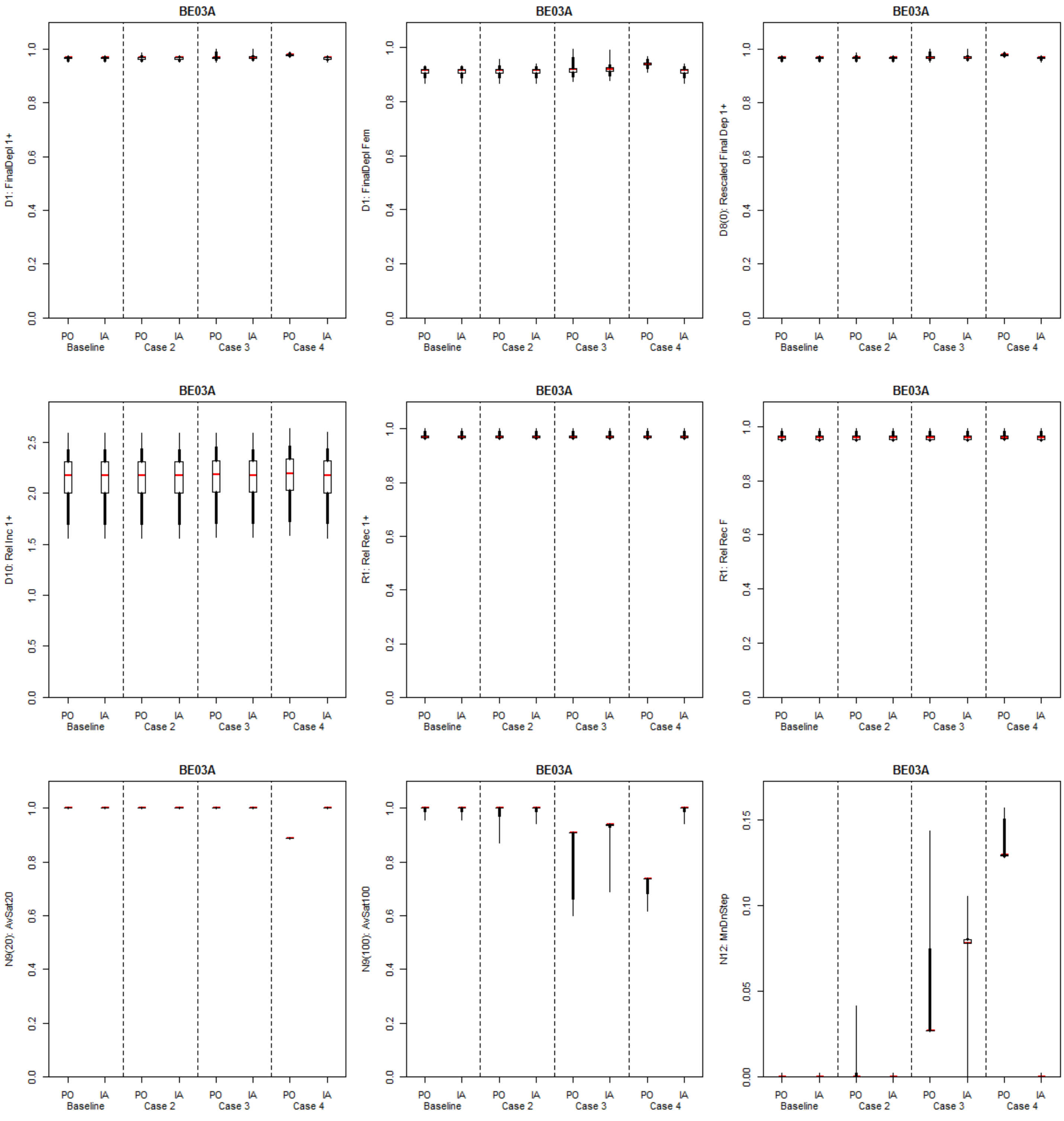

Figure 4: Performance plots for trial BE03A.

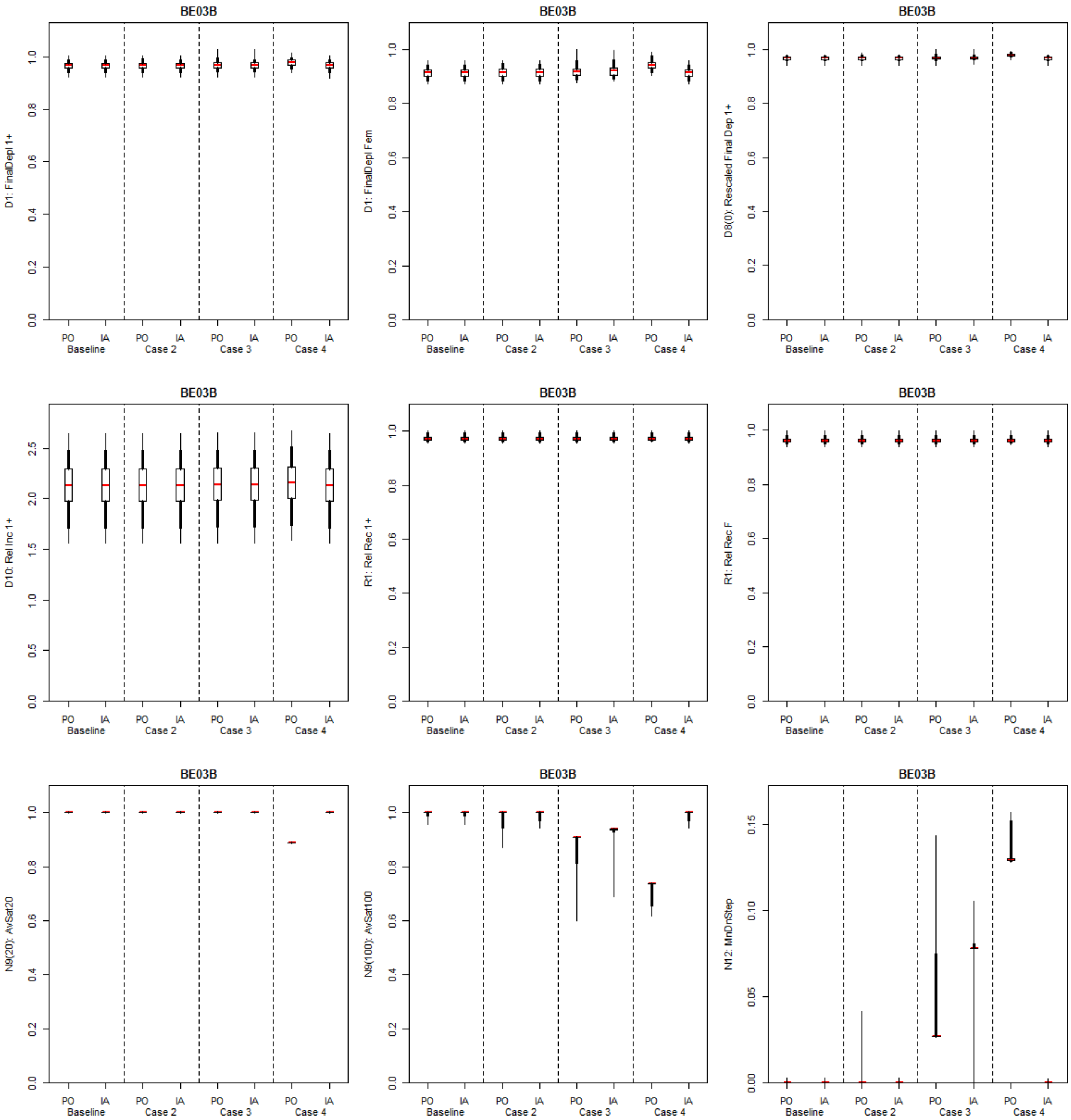

Figure 5: Performance plots for trial BE03B.

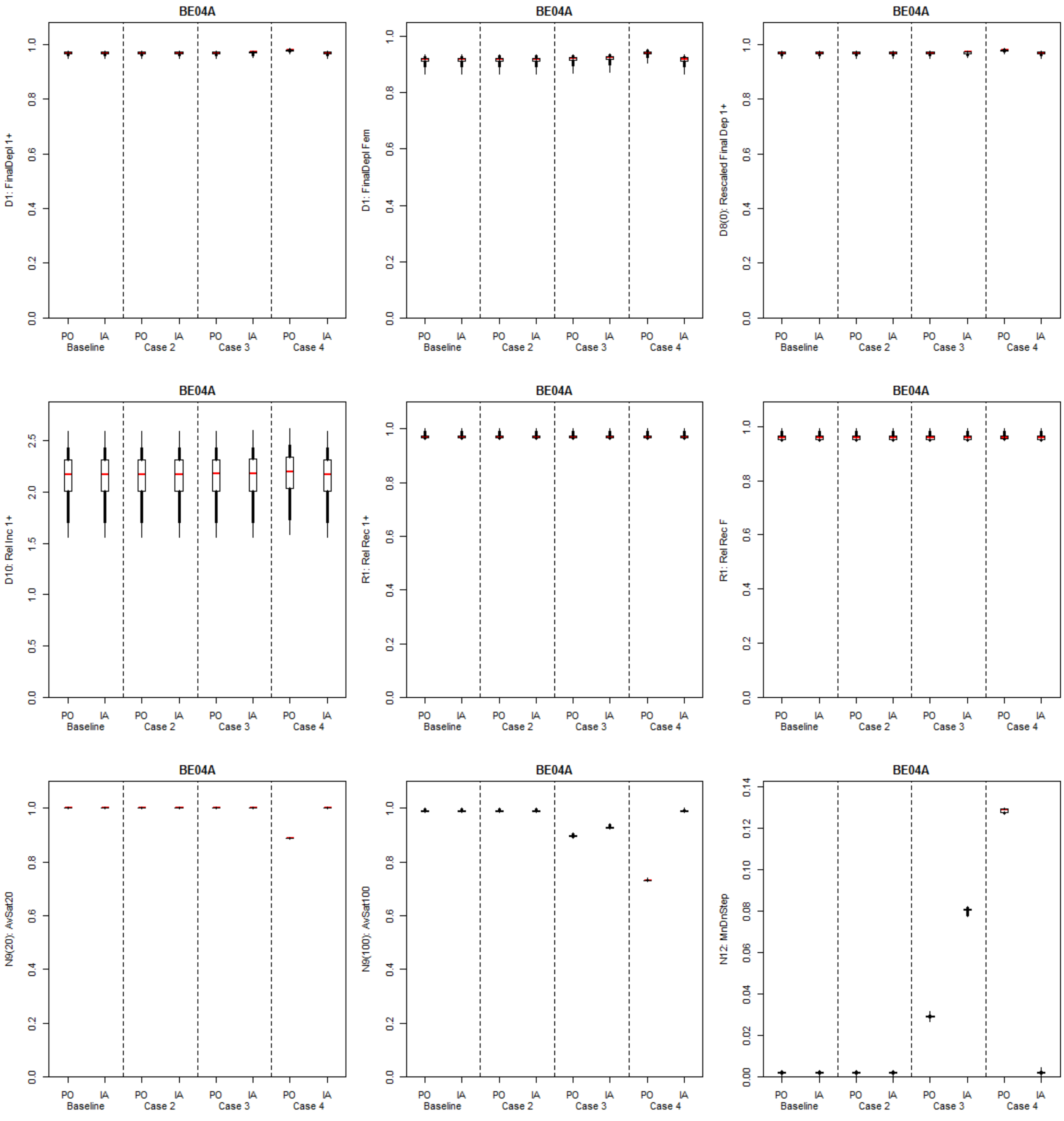

Figure 6: Performance plots for trial BE04A.

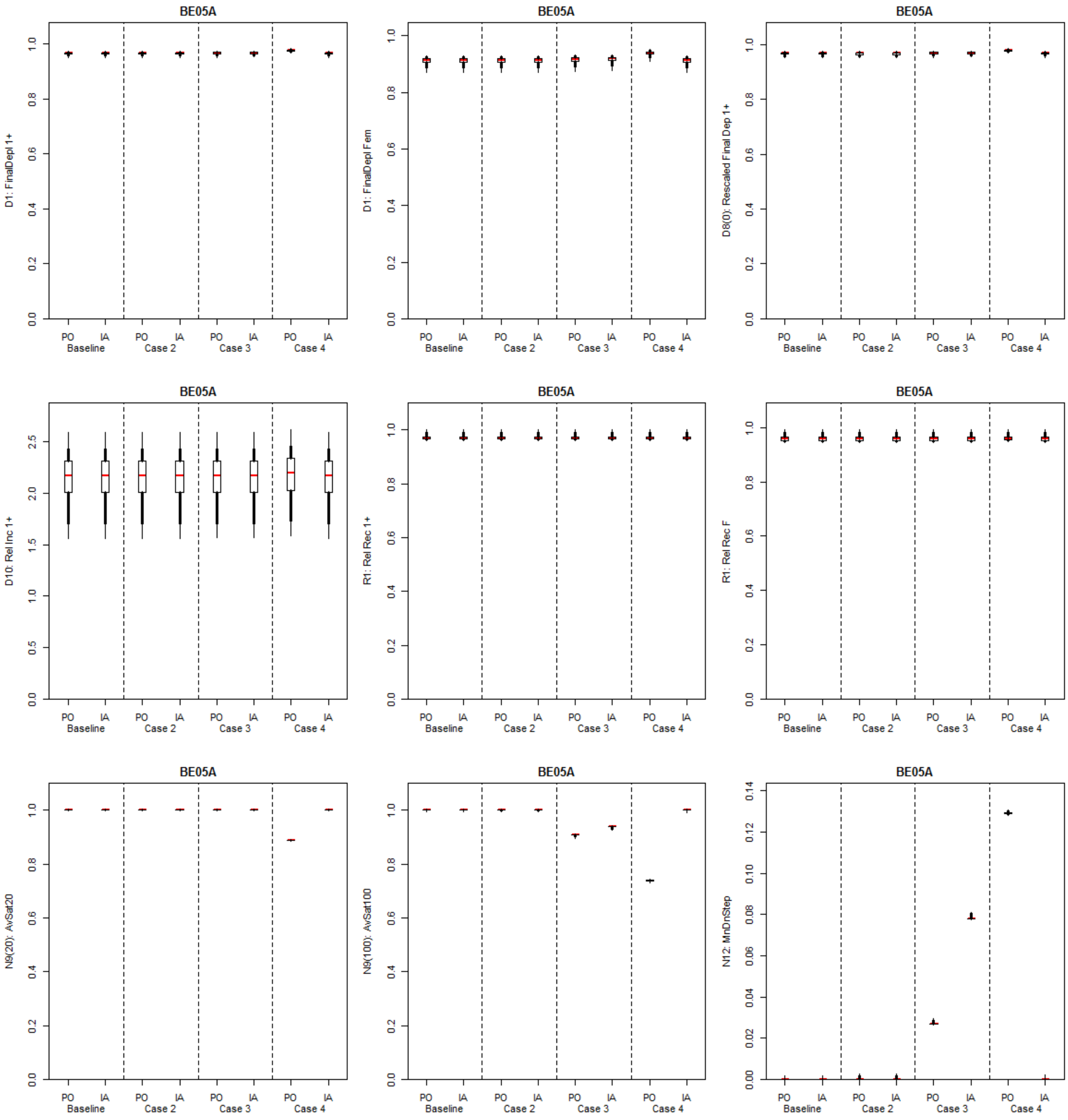

Figure 7: Performance plots for trial BE05A.

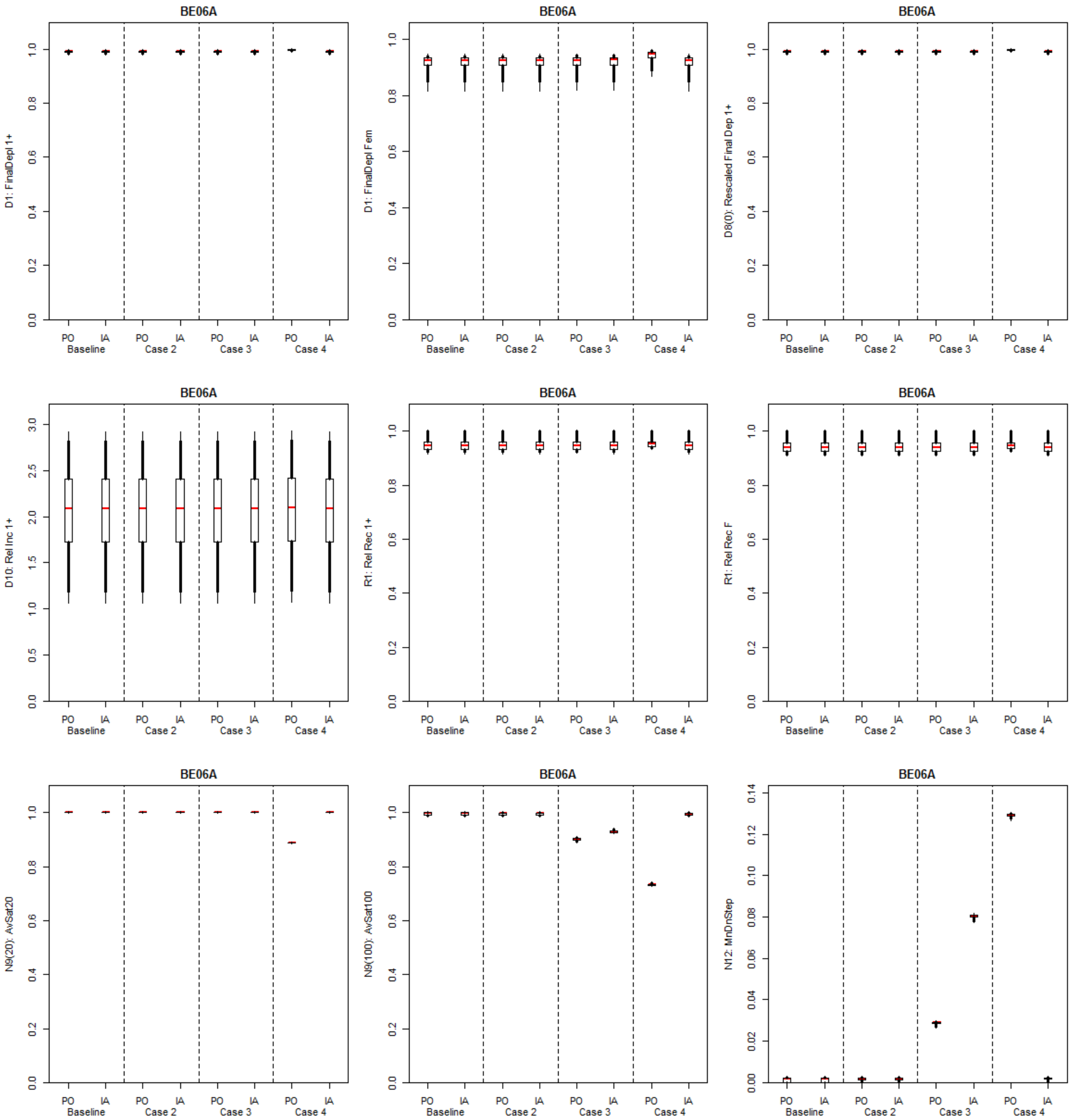

Figure 8: Performance plots for trial BE06A.

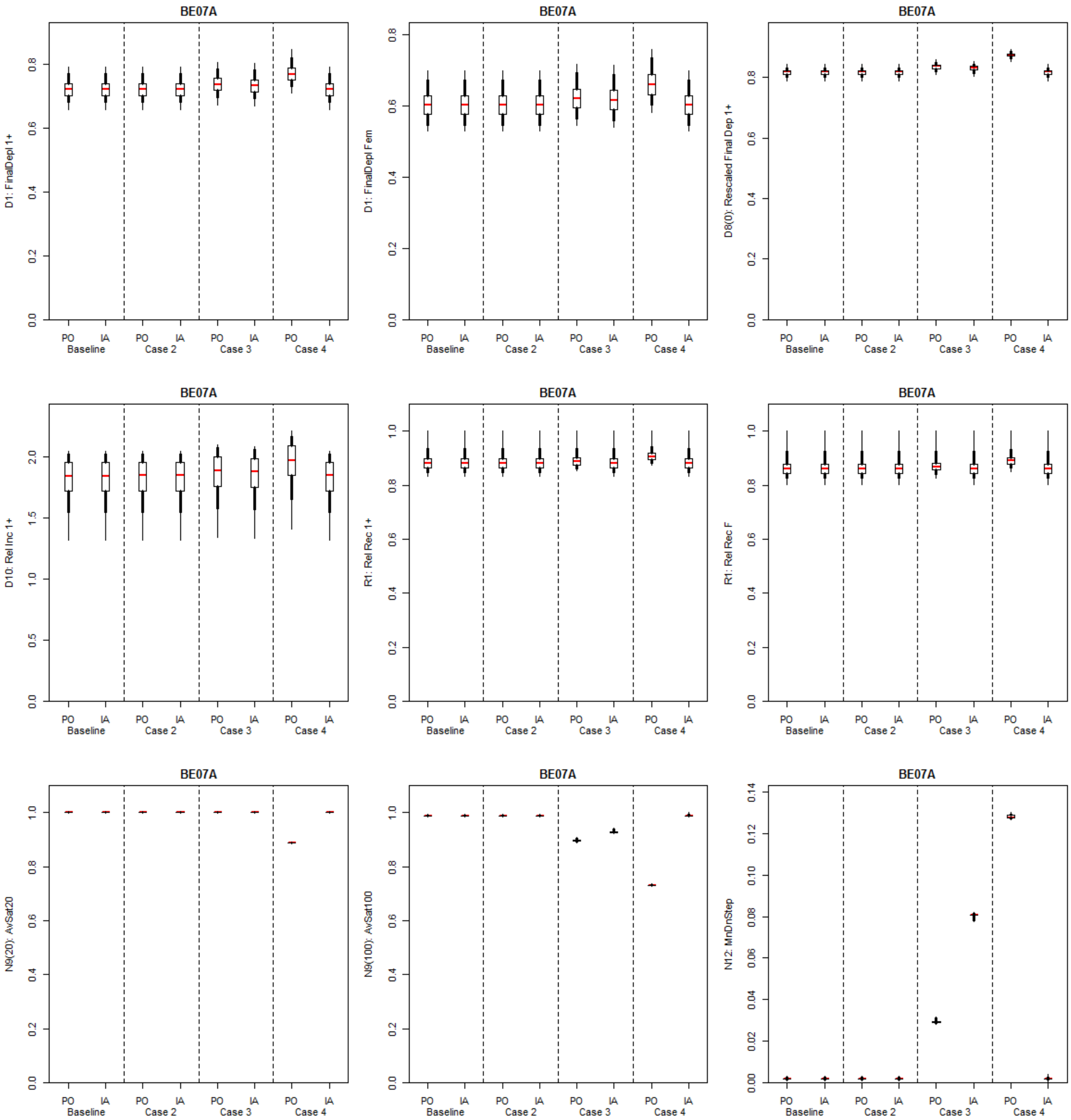

Figure 9: Performance plots for trial BE07A.

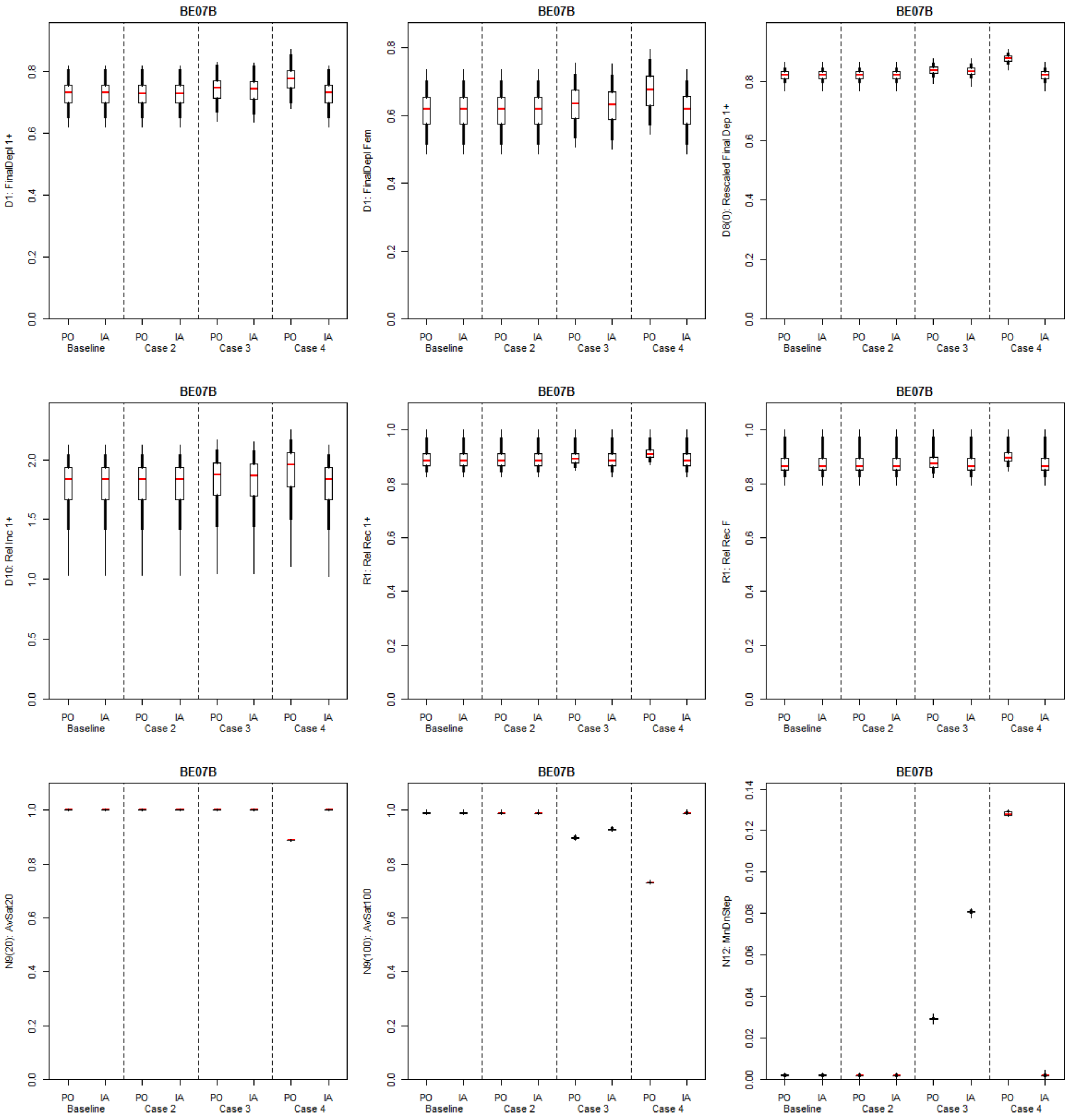

Figure 10: Performance plots for trial BE07B.

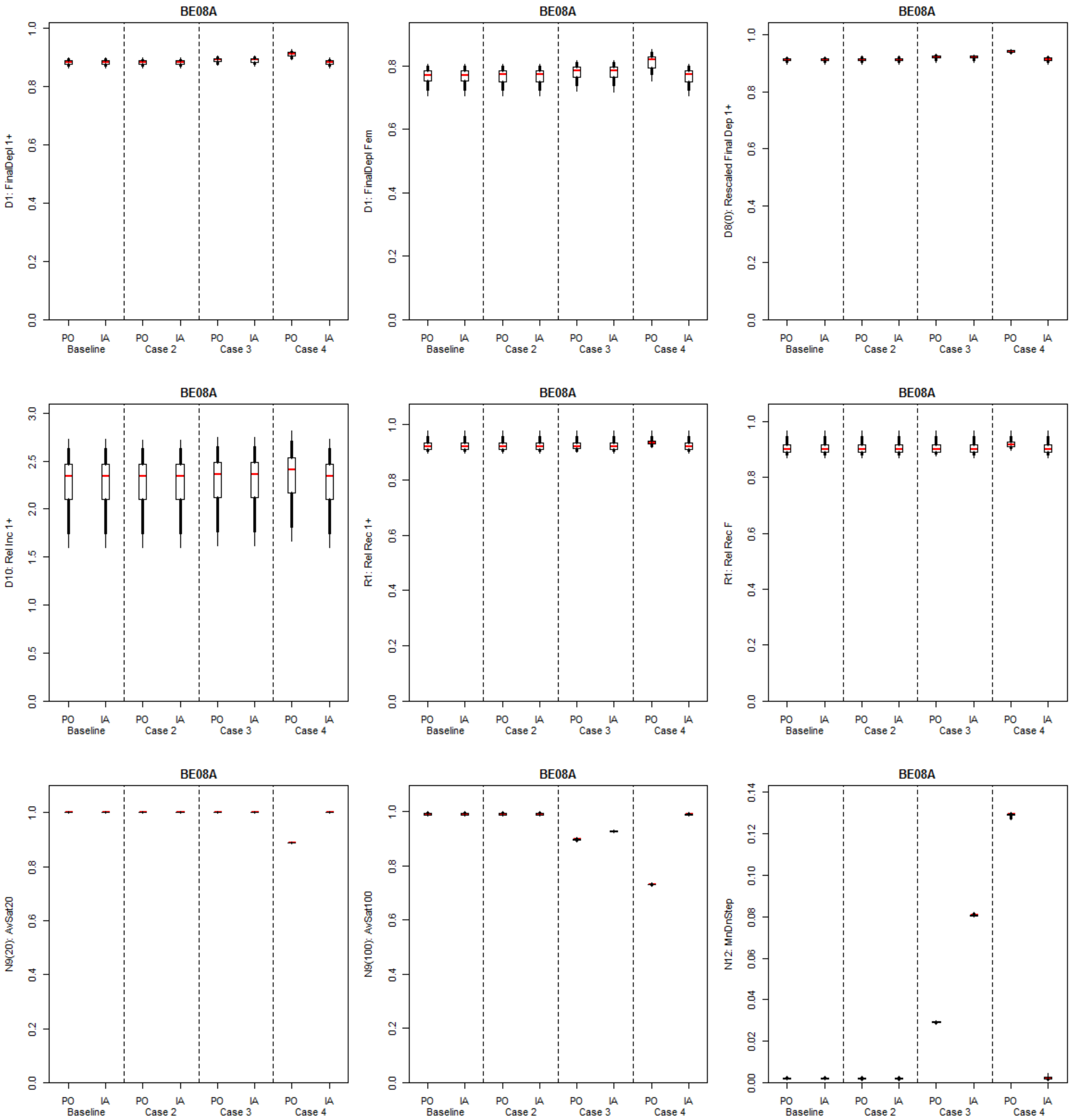

Figure 11: Performance plots for trial BE08A.

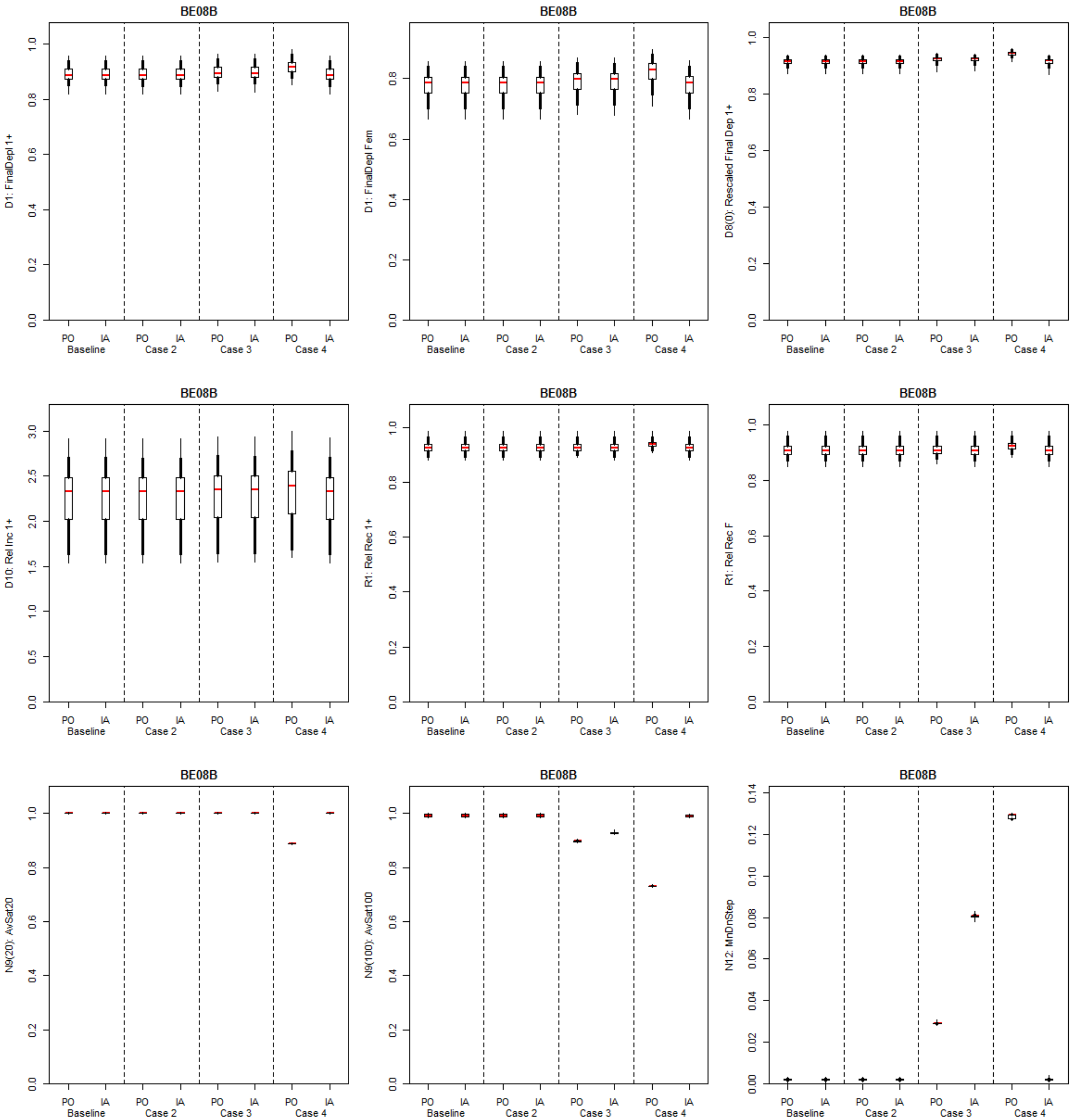

Figure 12: Performance plots for trial BE08B.

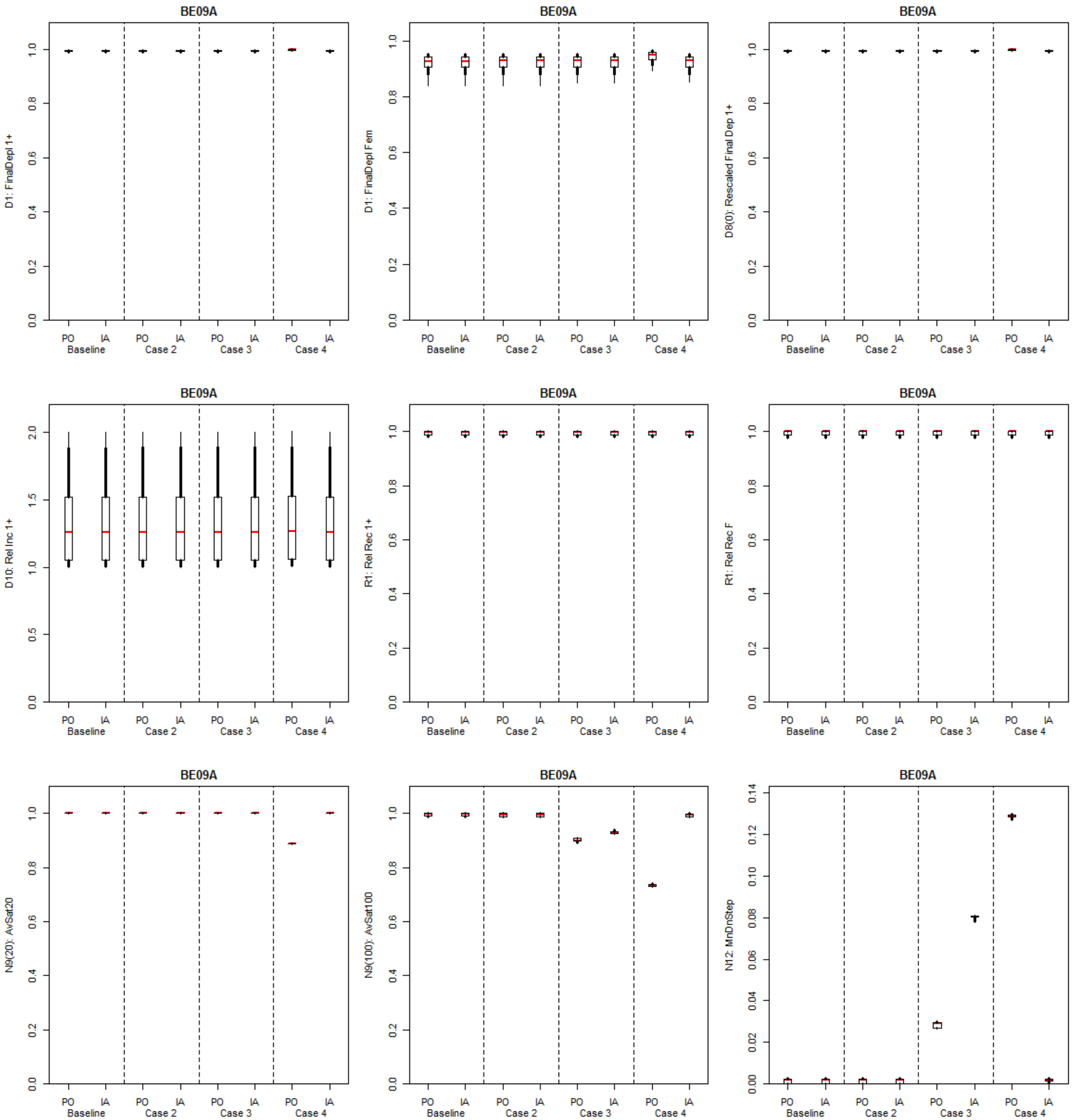

Figure 13: Performance plots for trial BE09A.

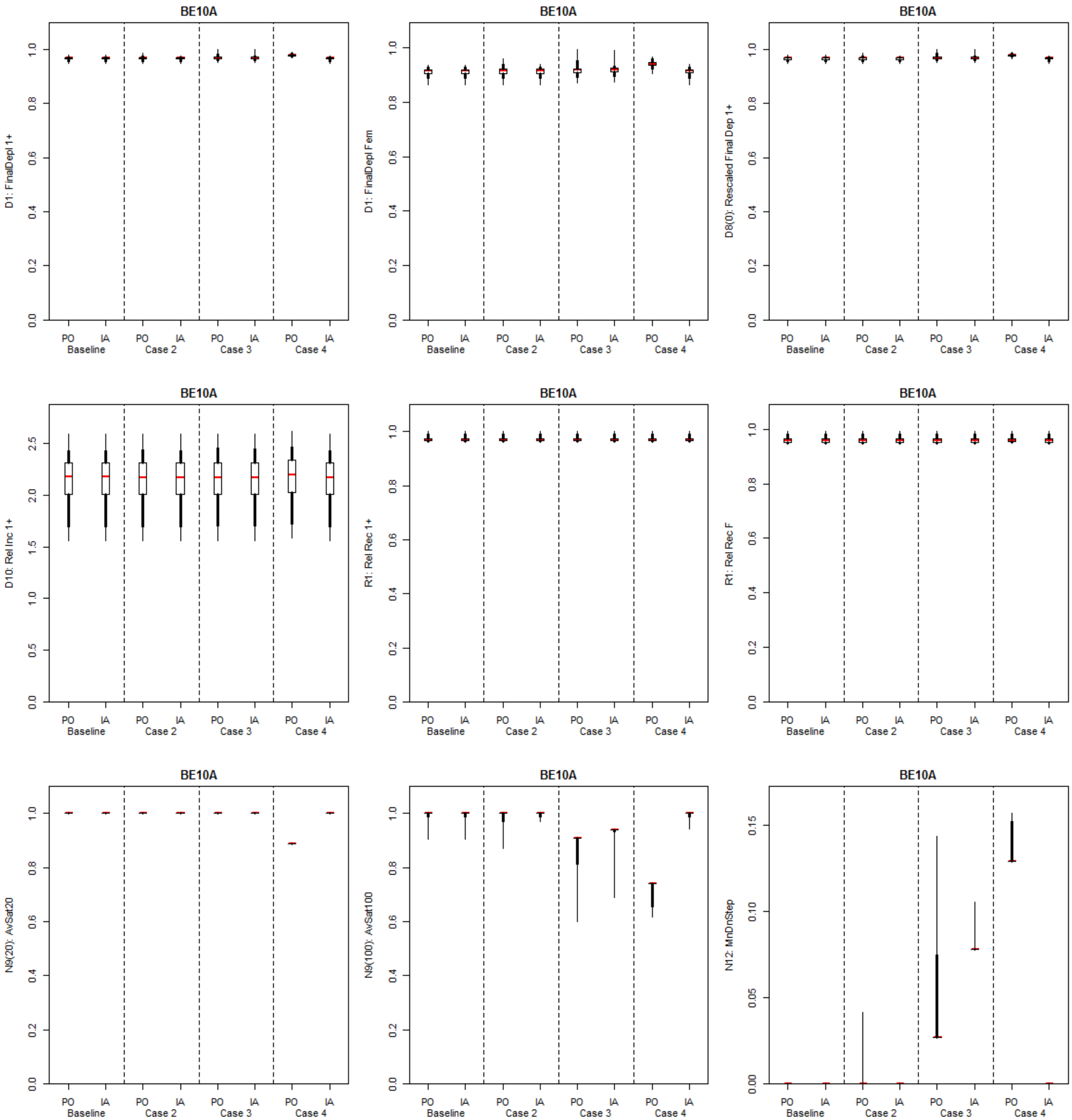

Figure 14: Performance plots for trial BE10A.

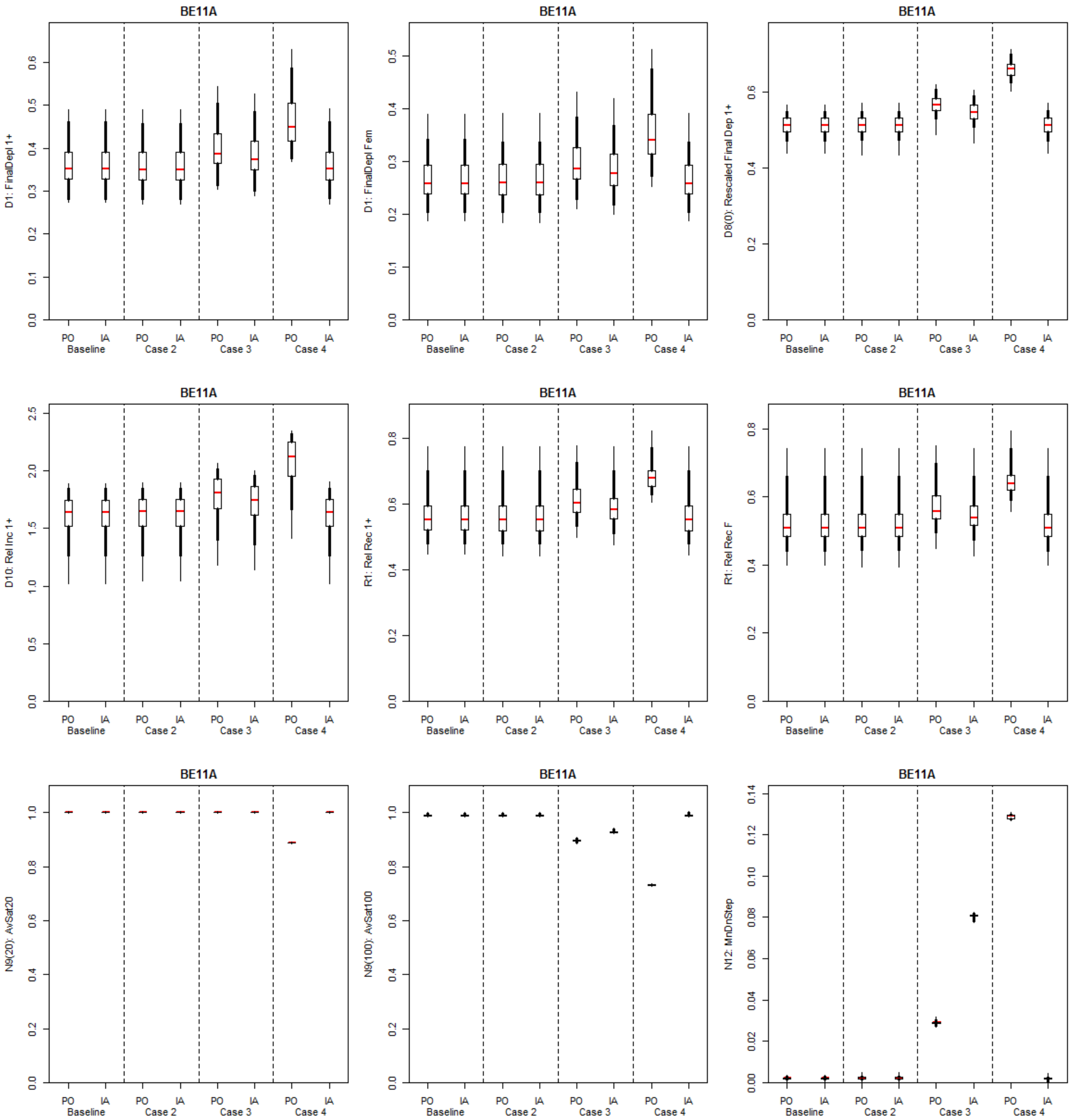

Figure 15: Performance plots for trial BE11A.

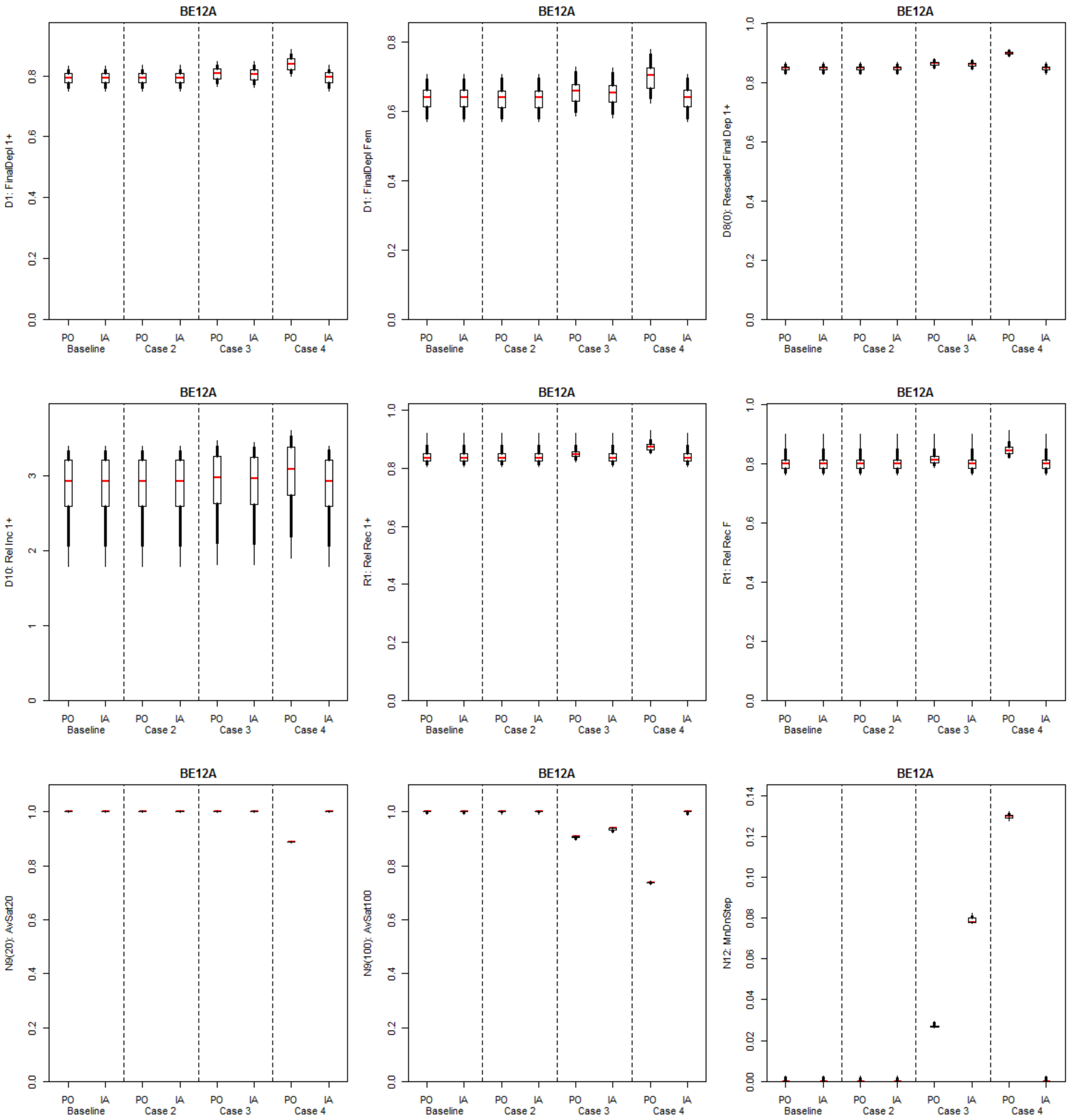

Figure 16: Performance plots for trial BE12A.

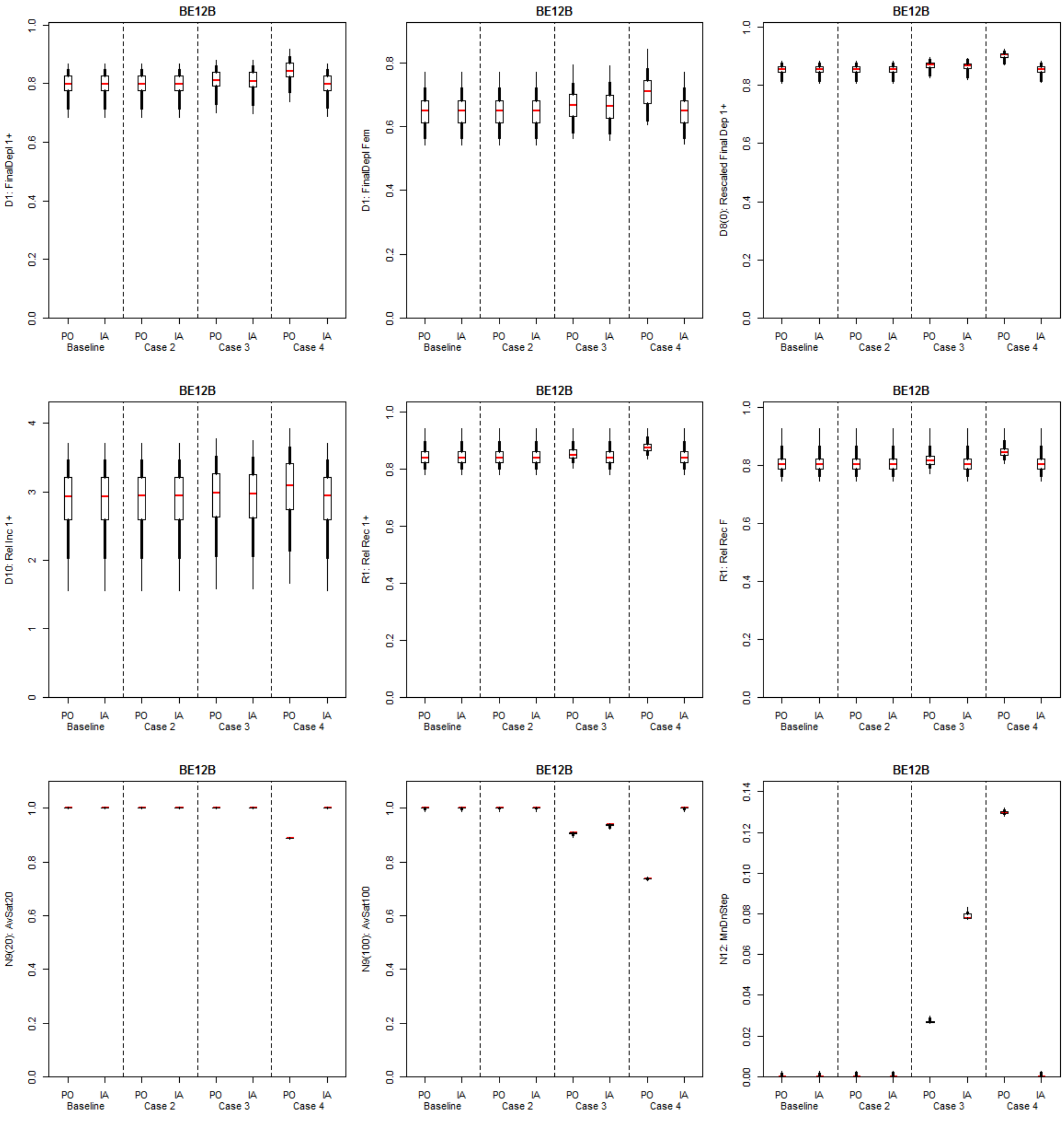

Figure 17: Performance plots for trial BE12B.

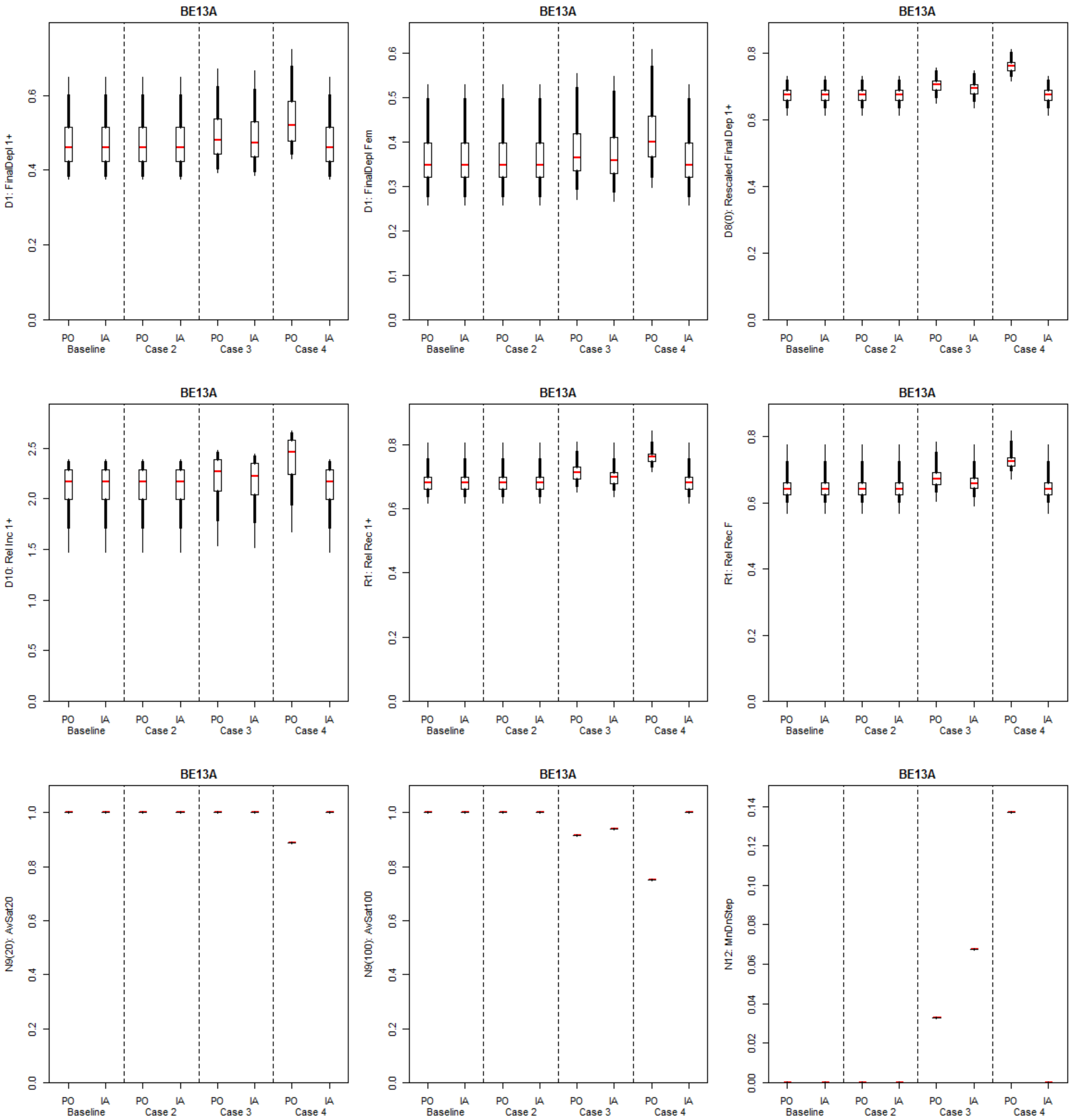

Figure 18: Performance plots for trial BE13A.

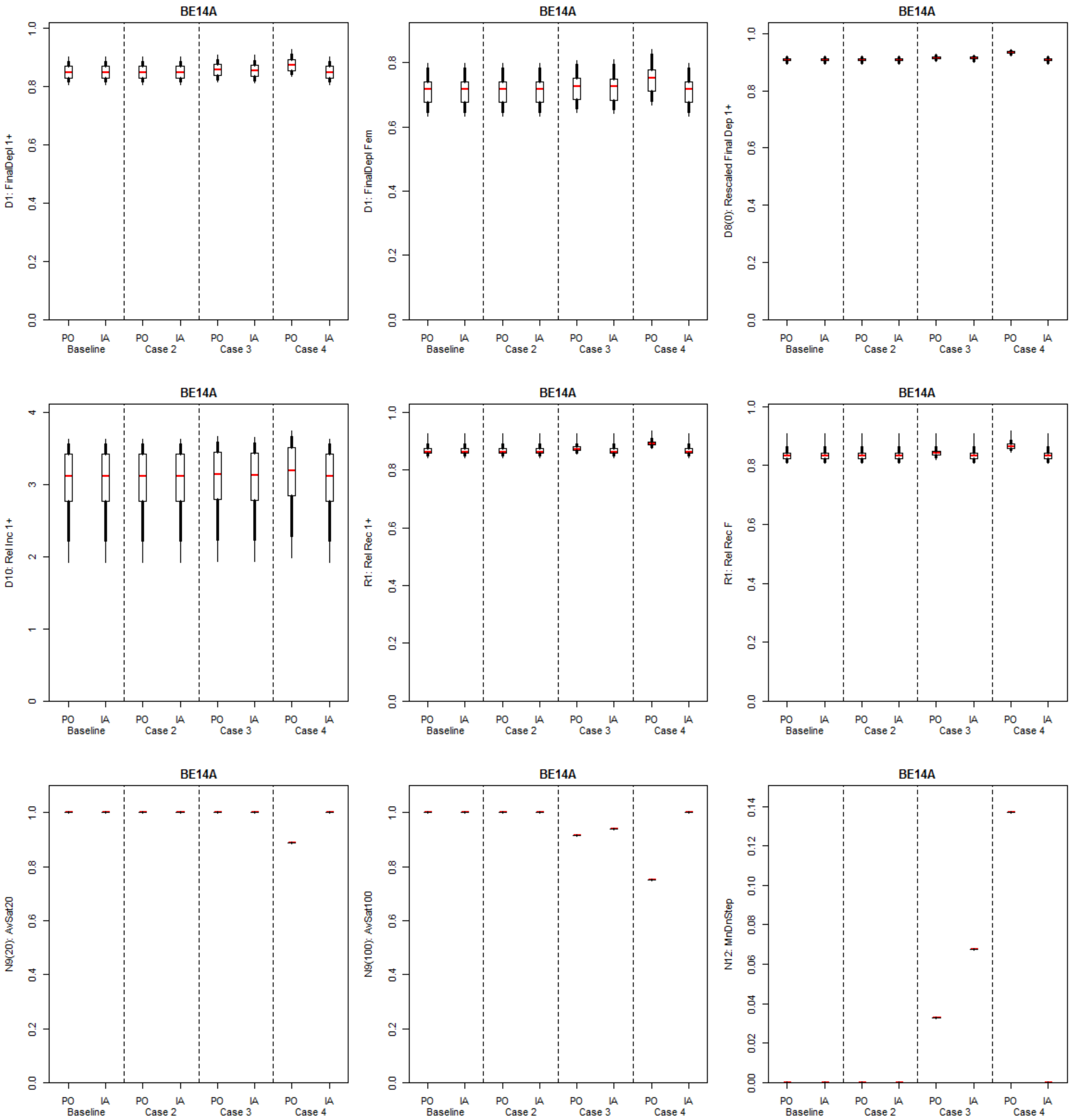

Figure 19: Performance plots for trial BE14A.

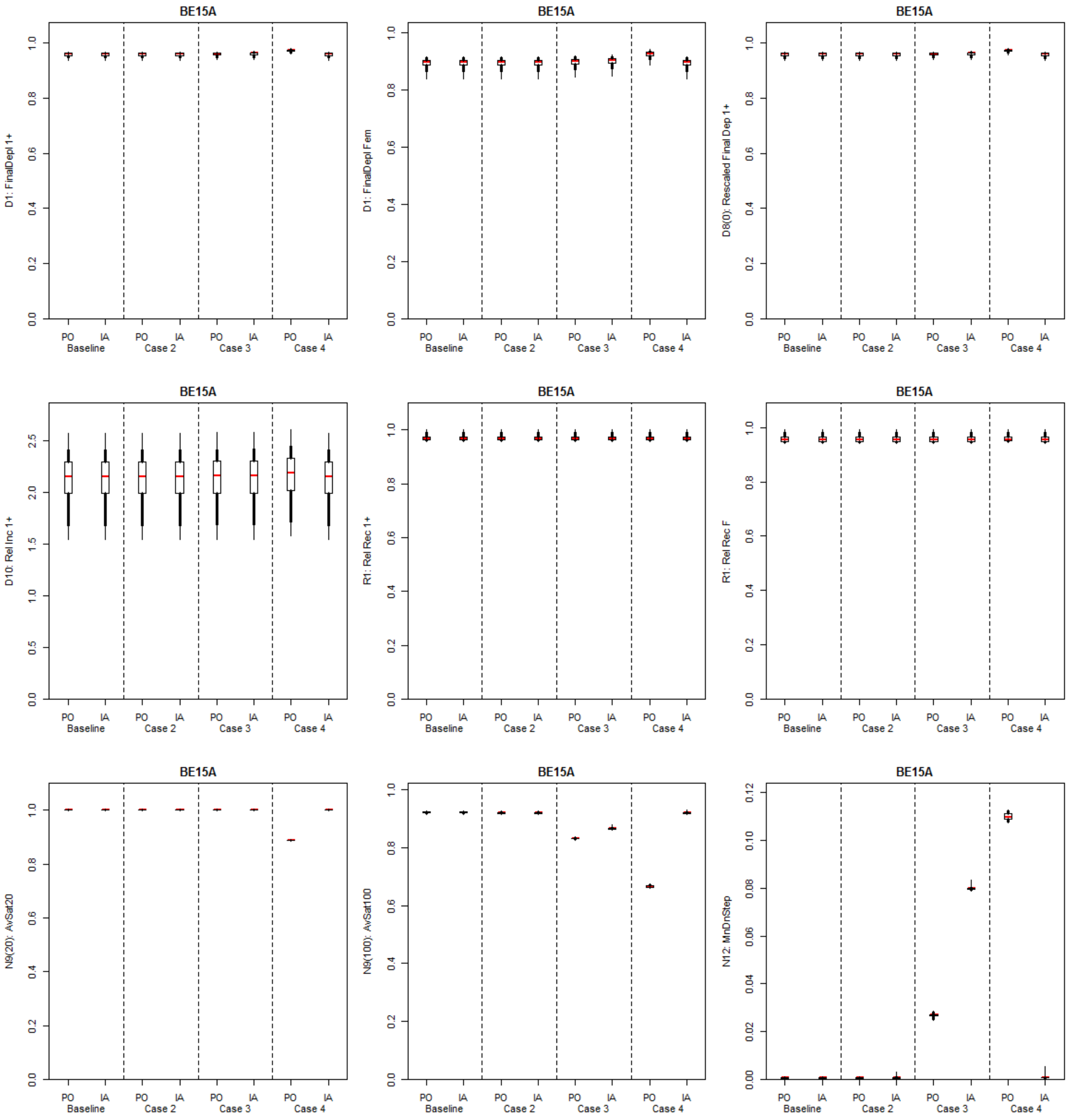

Figure 20: Performance plots for trial BE15A.

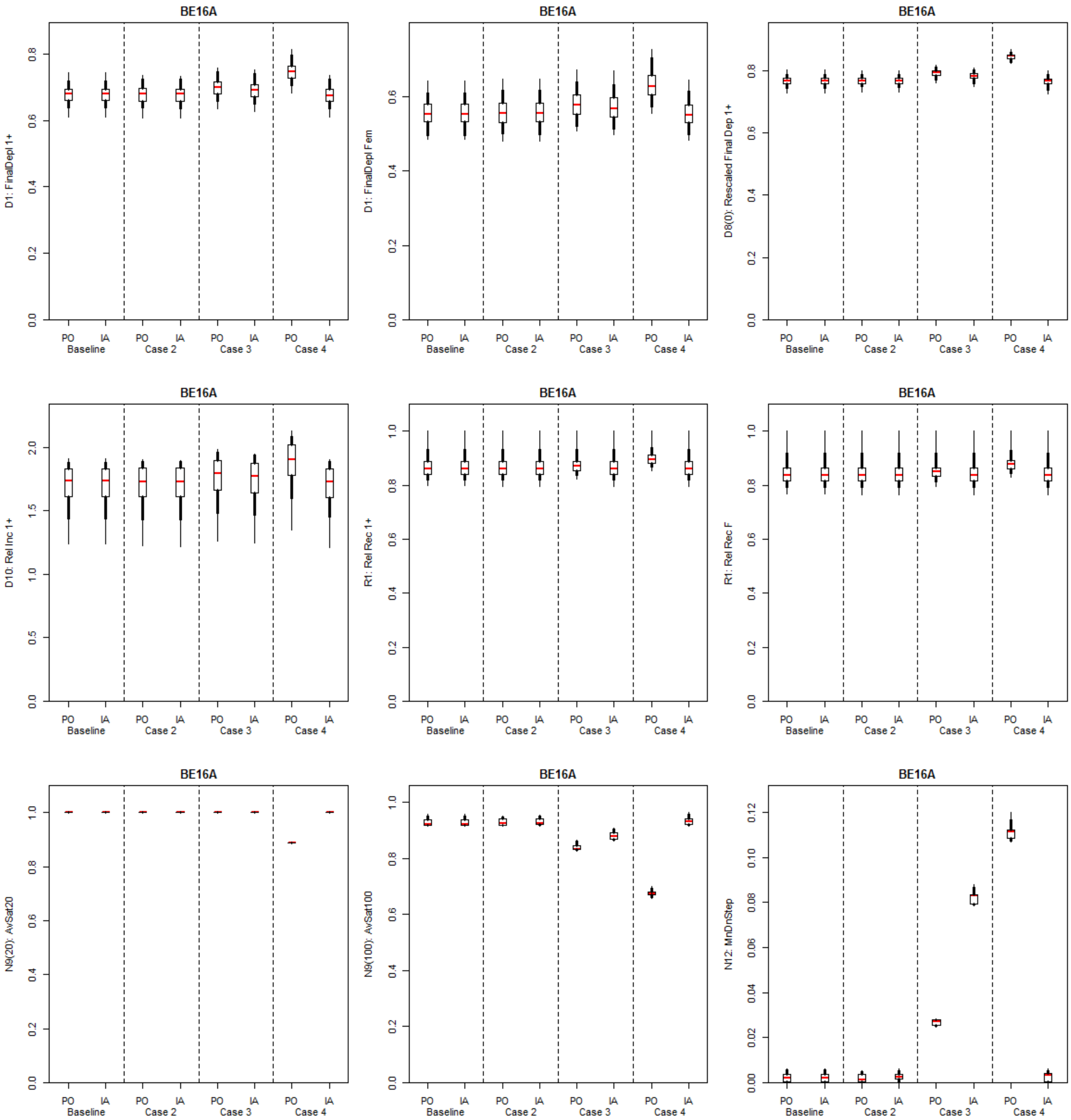

Figure 21: Performance plots for trial BE16A.

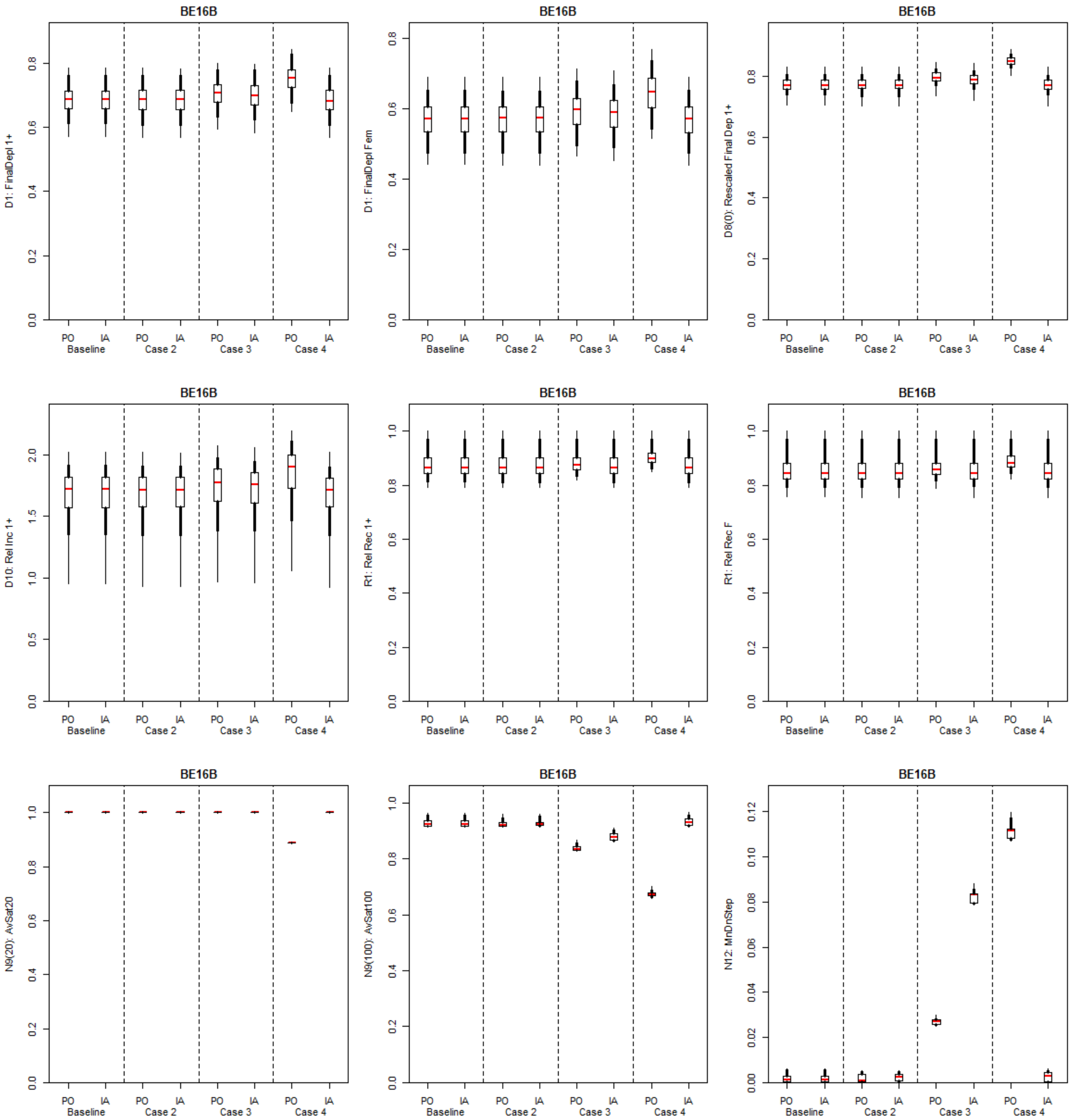

Figure 22: Performance plots for trial BE16B.

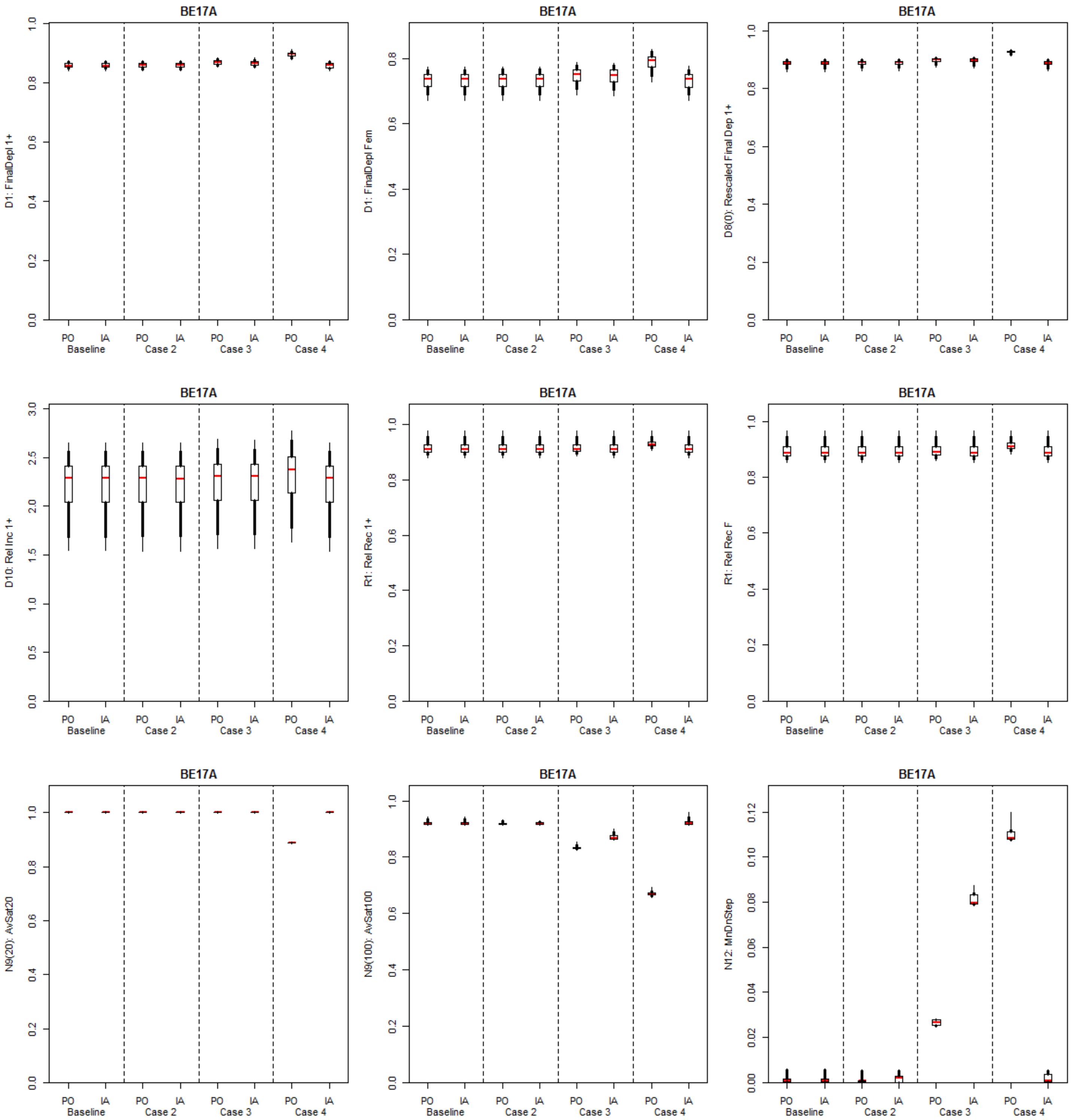

Figure 23: Performance plots for trial BE17A.

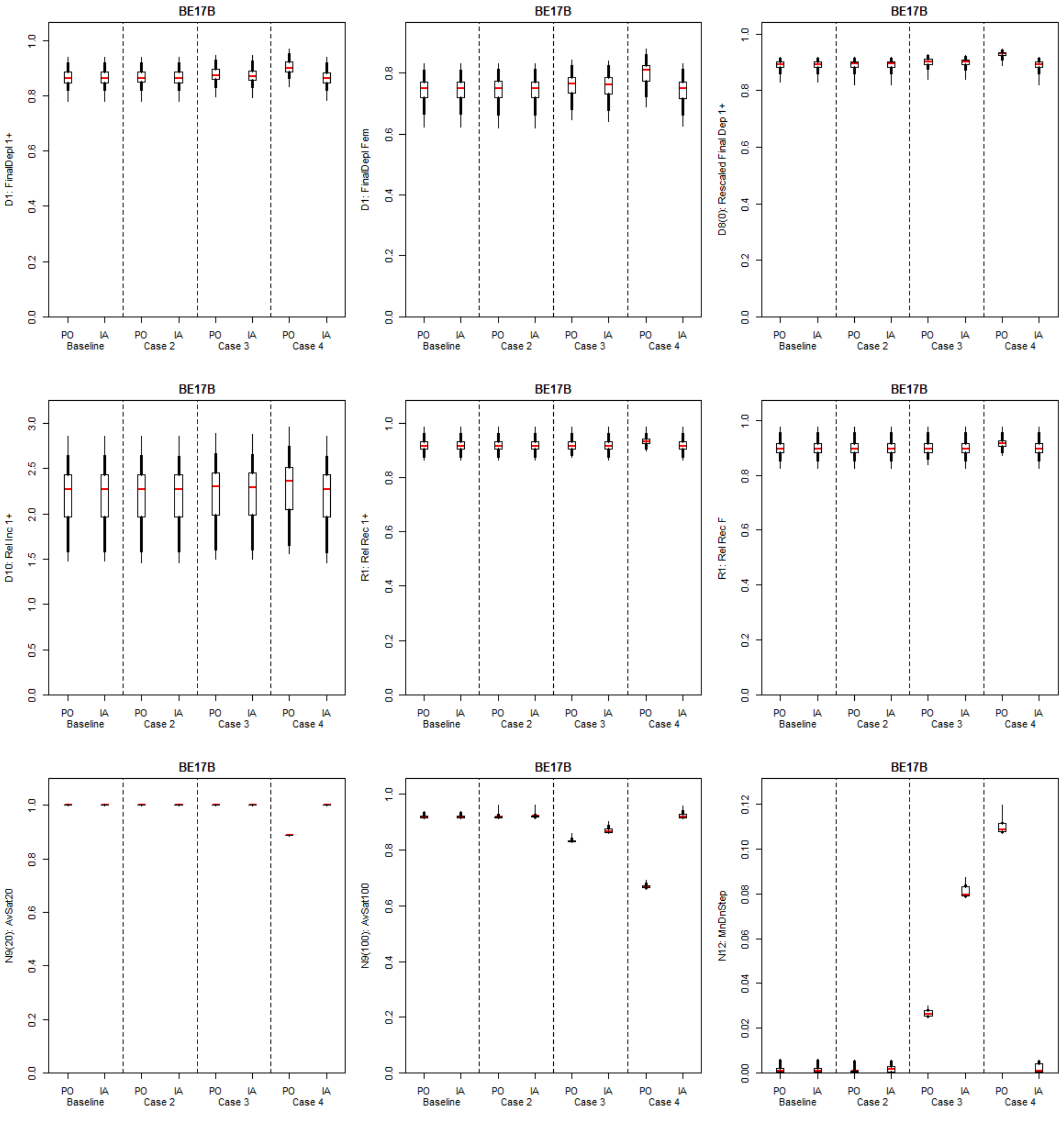

Figure 24: Performance plots for trial BE17B.

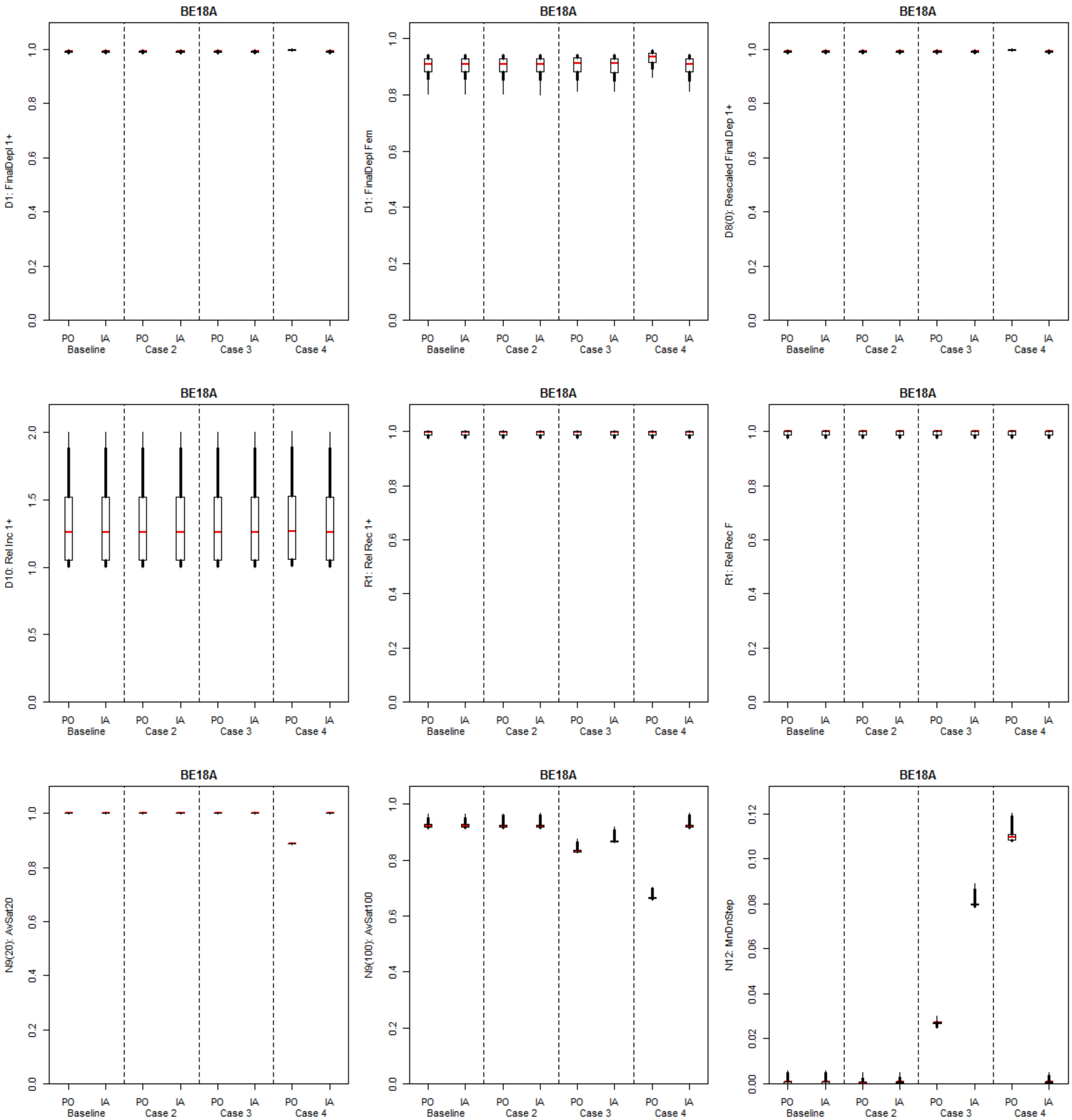

Figure 25: Performance plots for trial BE18A.

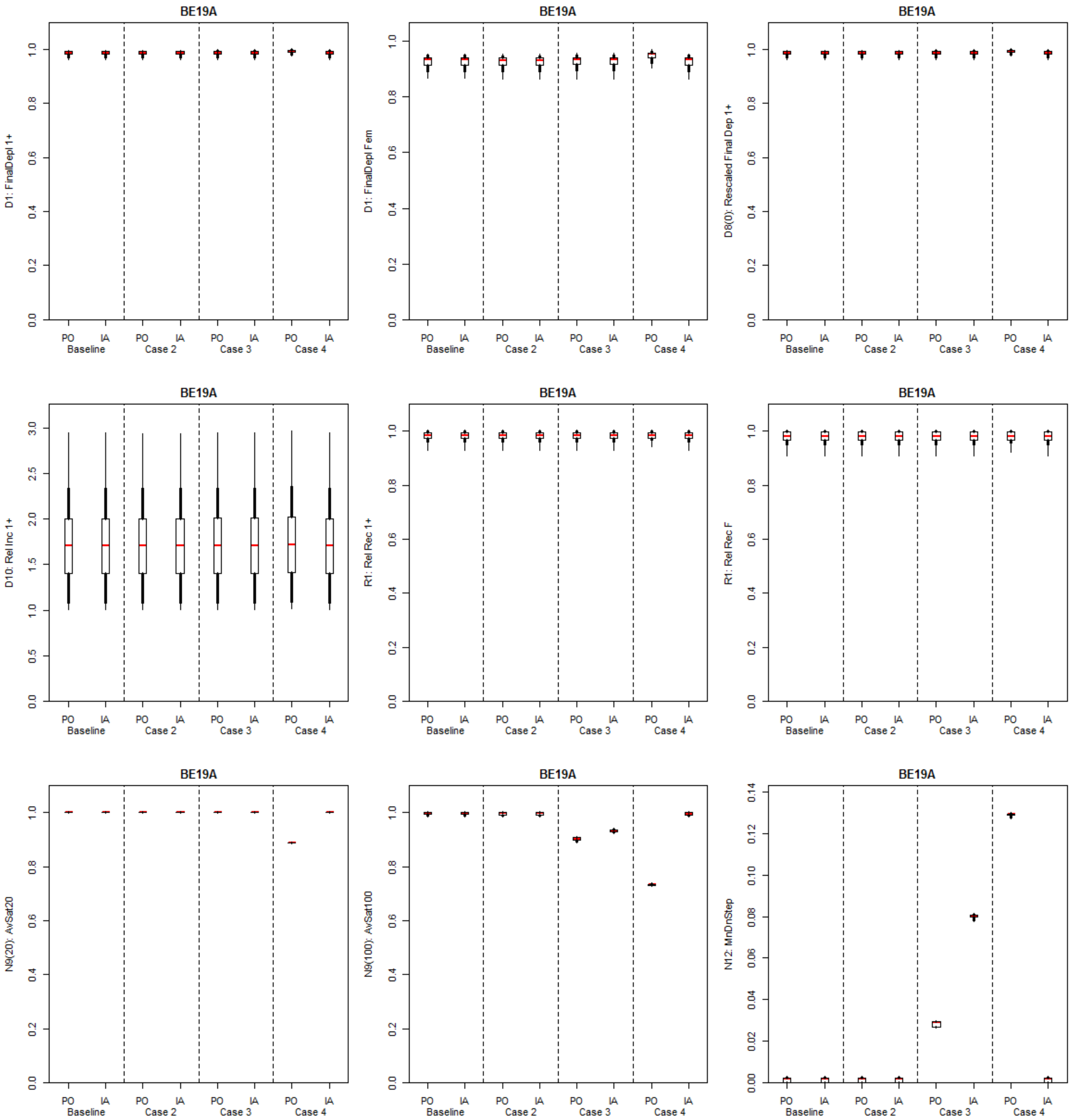

Figure 26: Performance plots for trial BE19A.

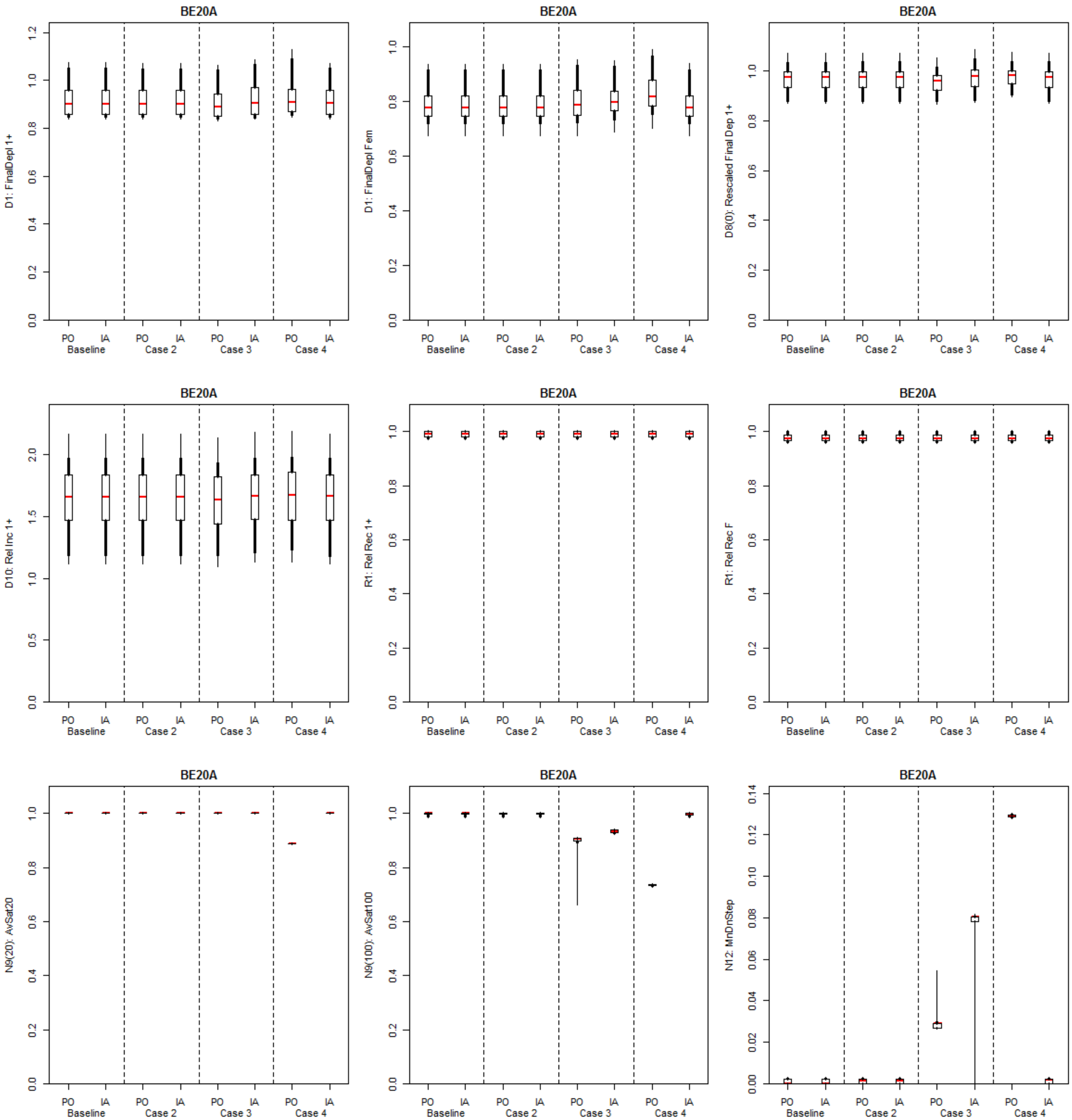

Figure 27: Performance plots for trial BE20A.

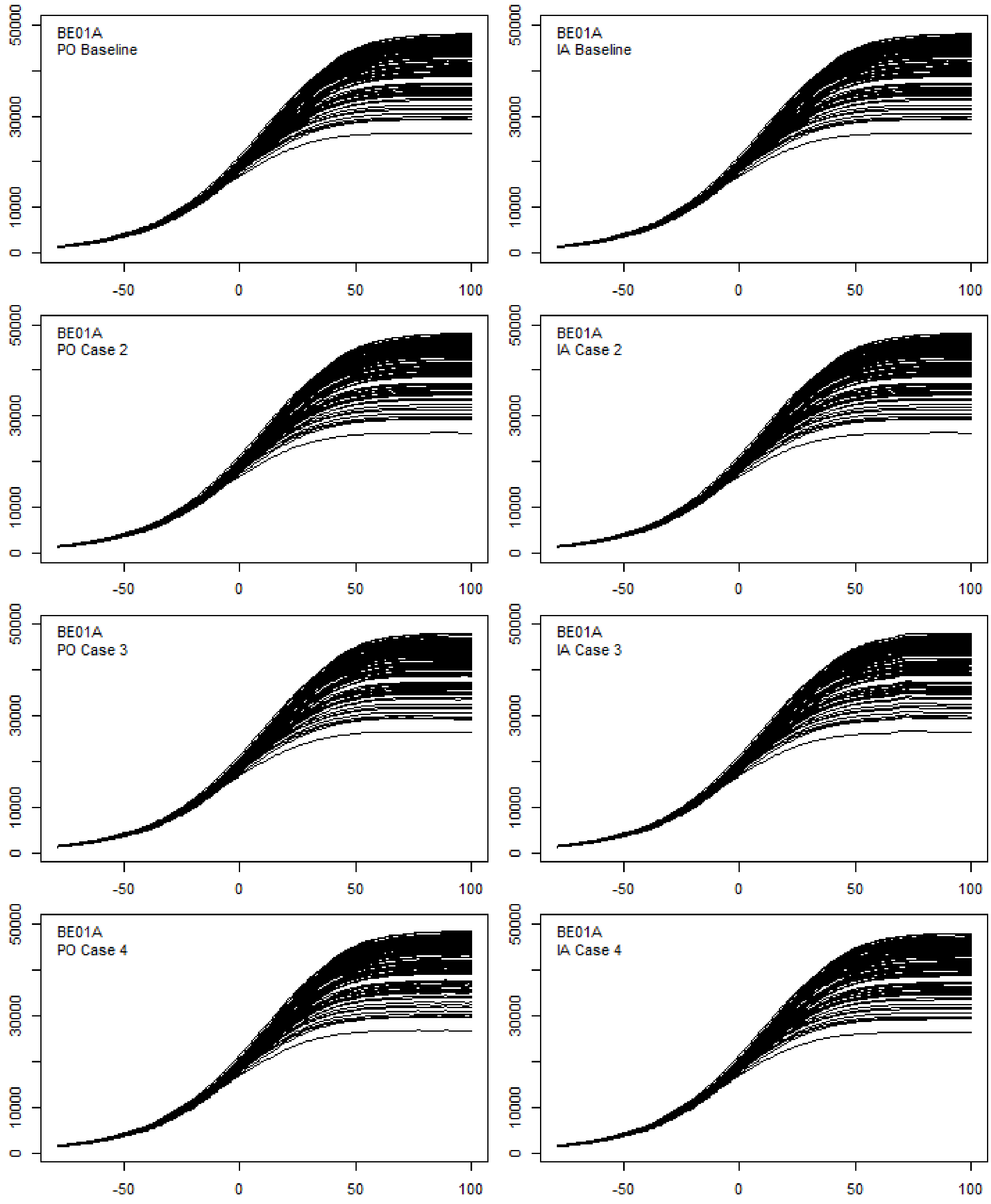

Figure 28: Set of 1+ population trajectories for trial BE01A.

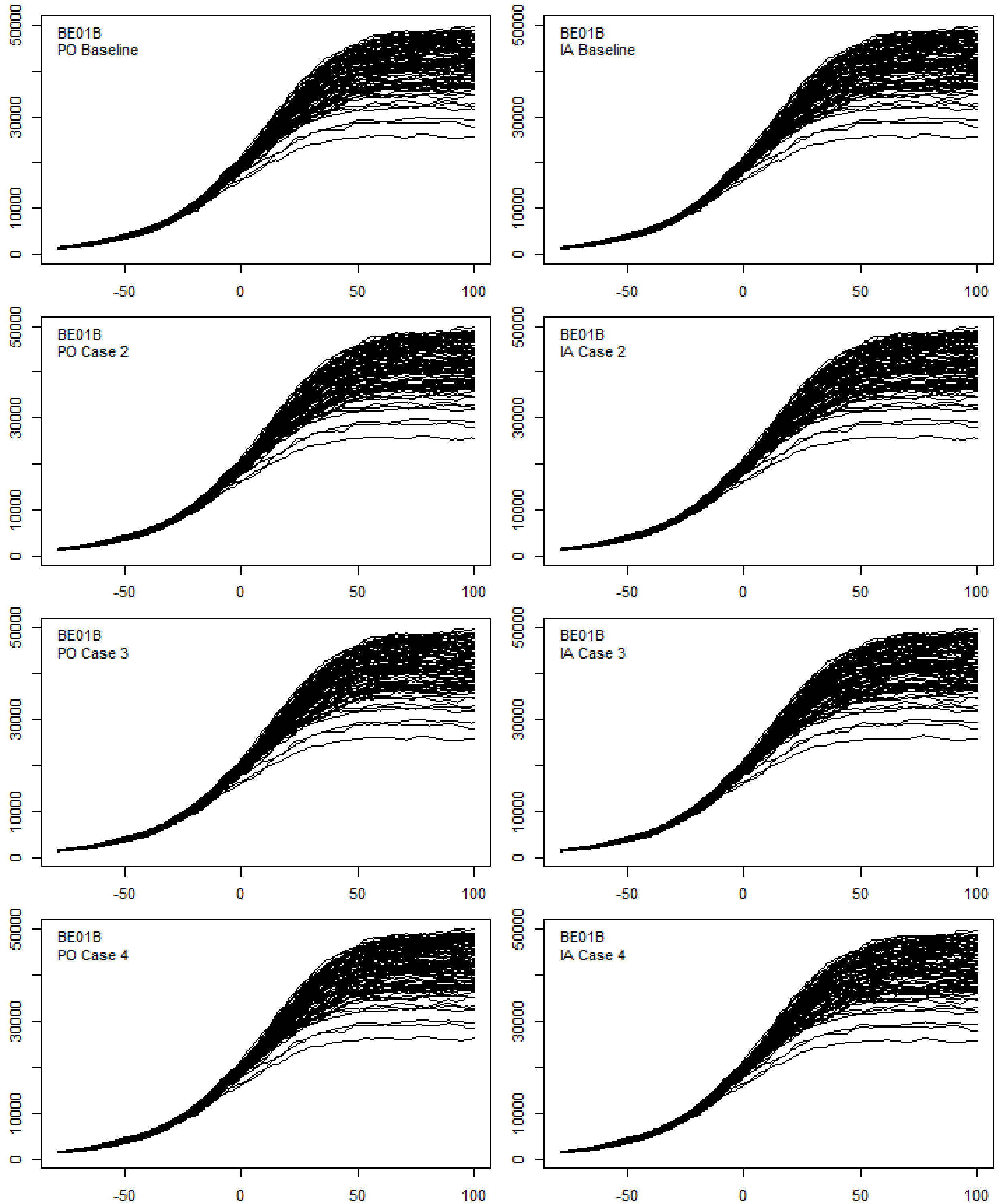

Figure 29: Set of 1+ population trajectories for trial BE01B.

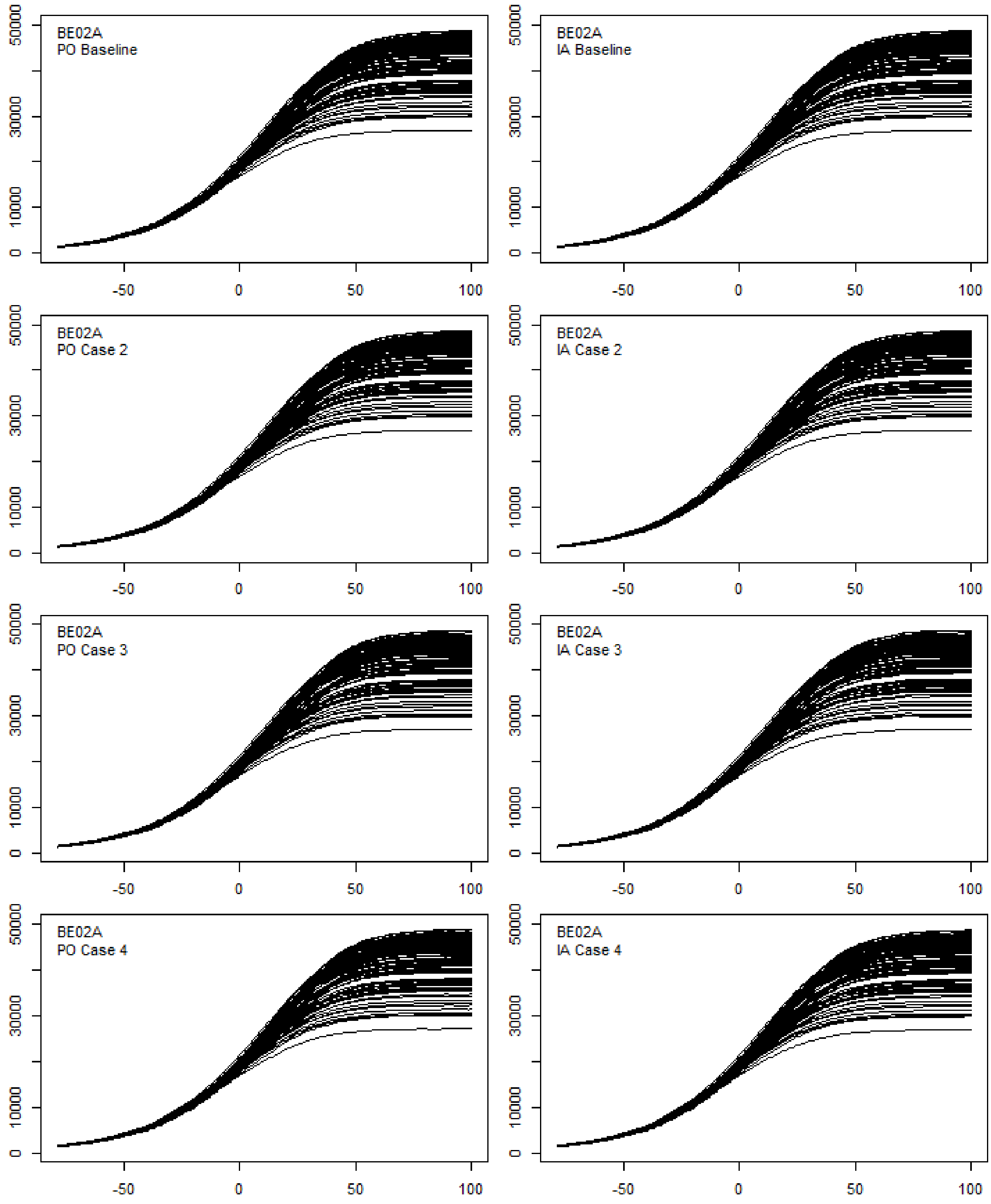

Figure 30: Set of 1+ population trajectories for trial BE02A.

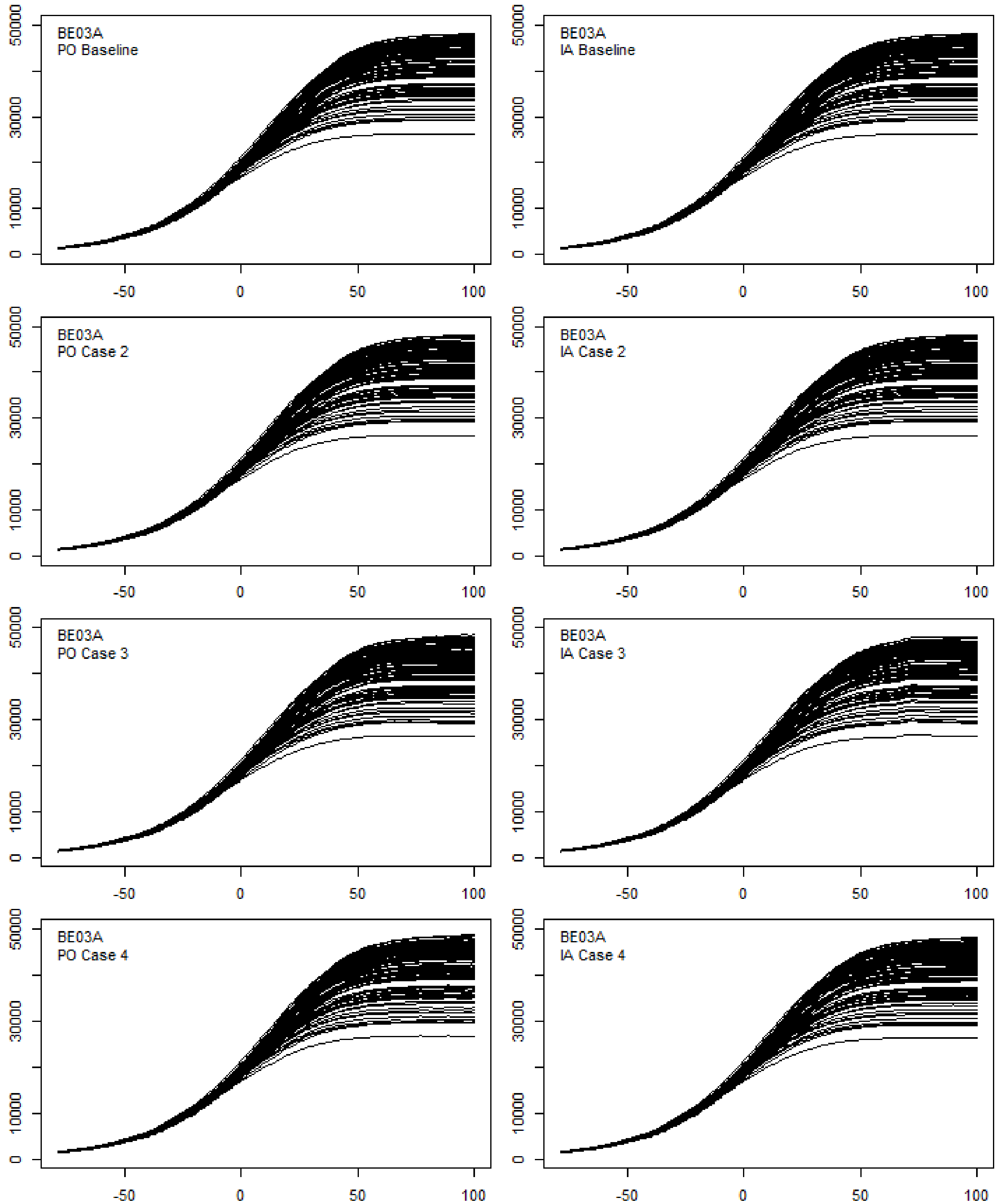

Figure 31: Set of 1+ population trajectories for trial BE03A.

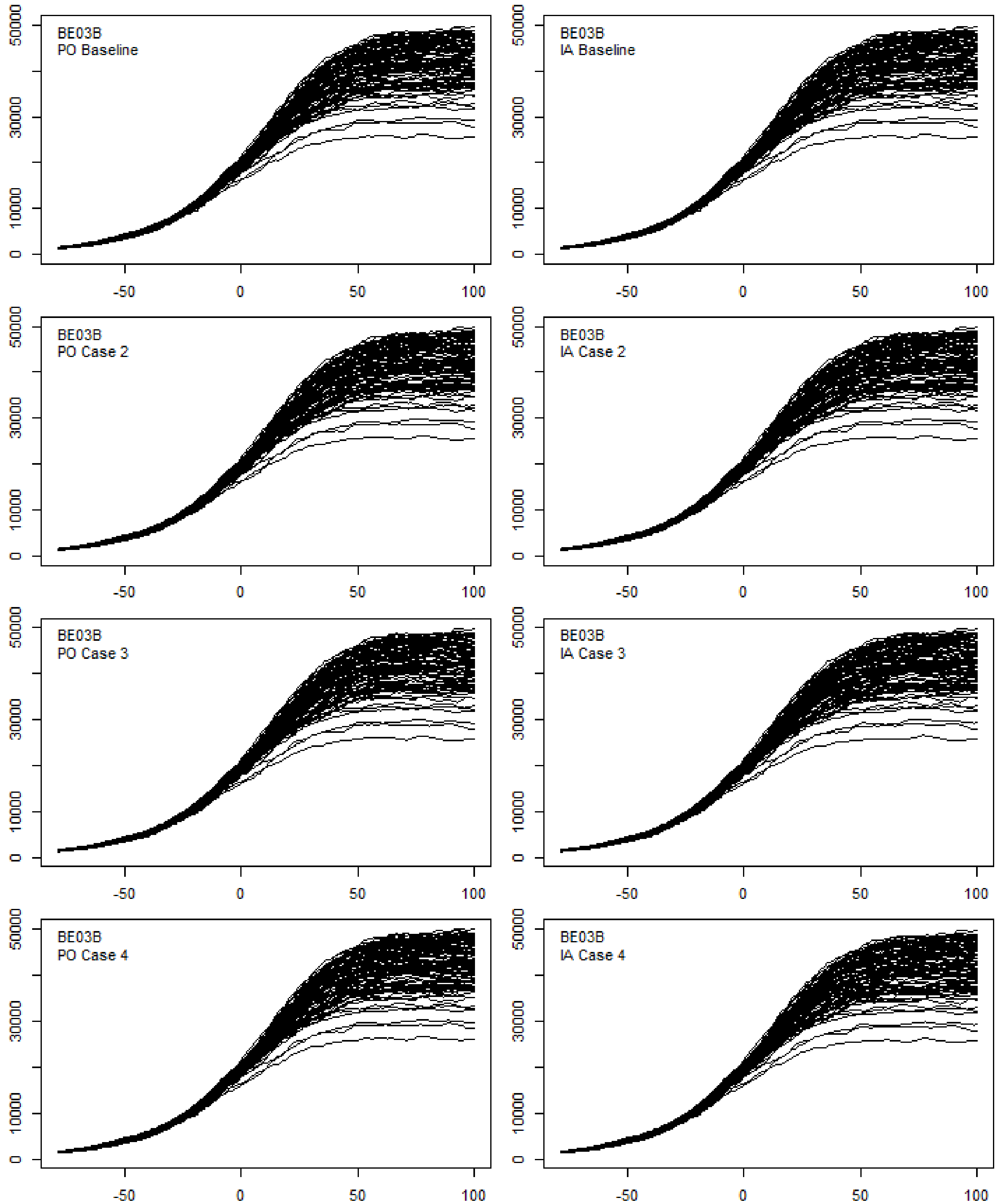

Figure 32: Set of 1+ population trajectories for trial BE03B.

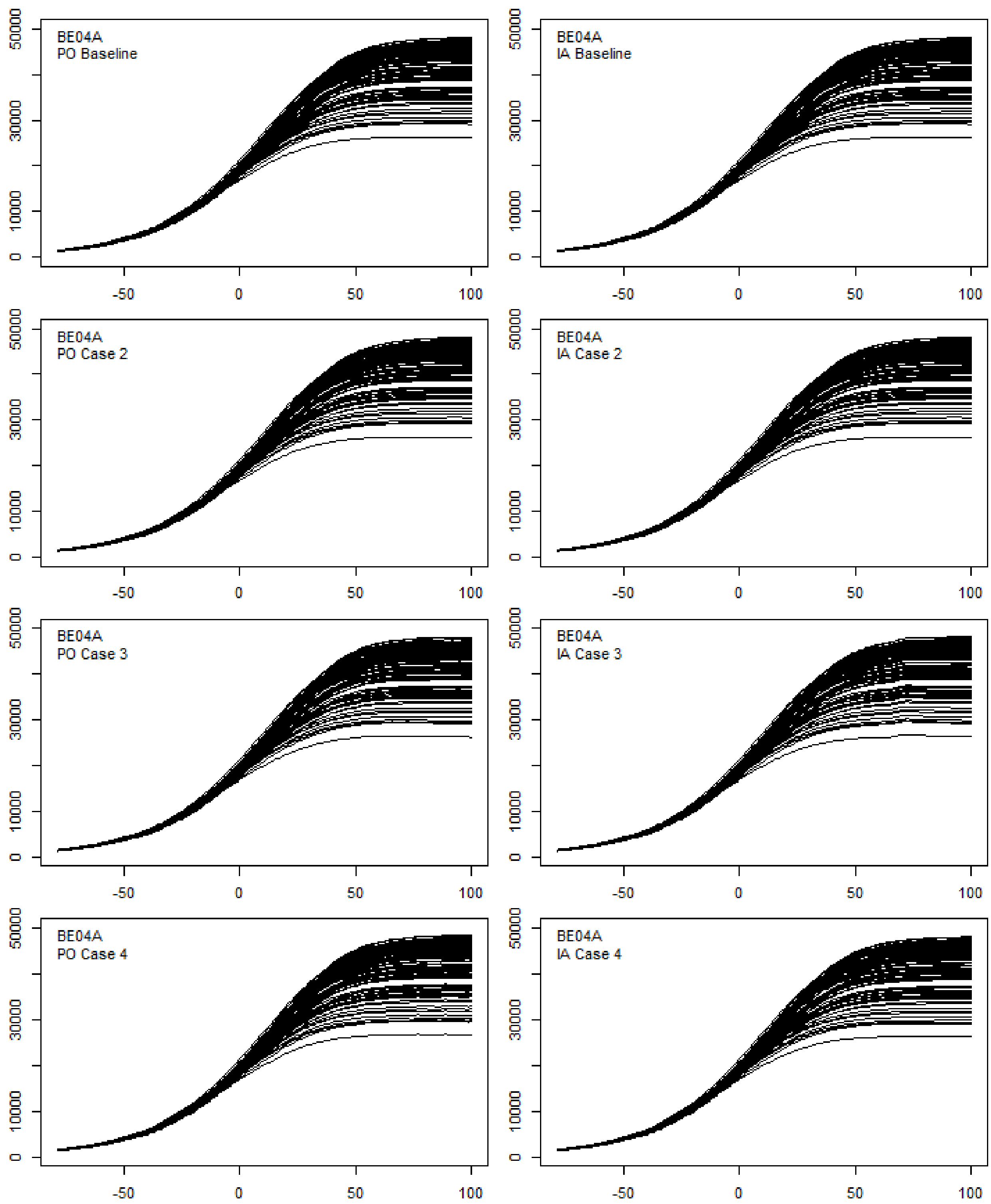

Figure 33: Set of 1+ population trajectories for trial BE04A.

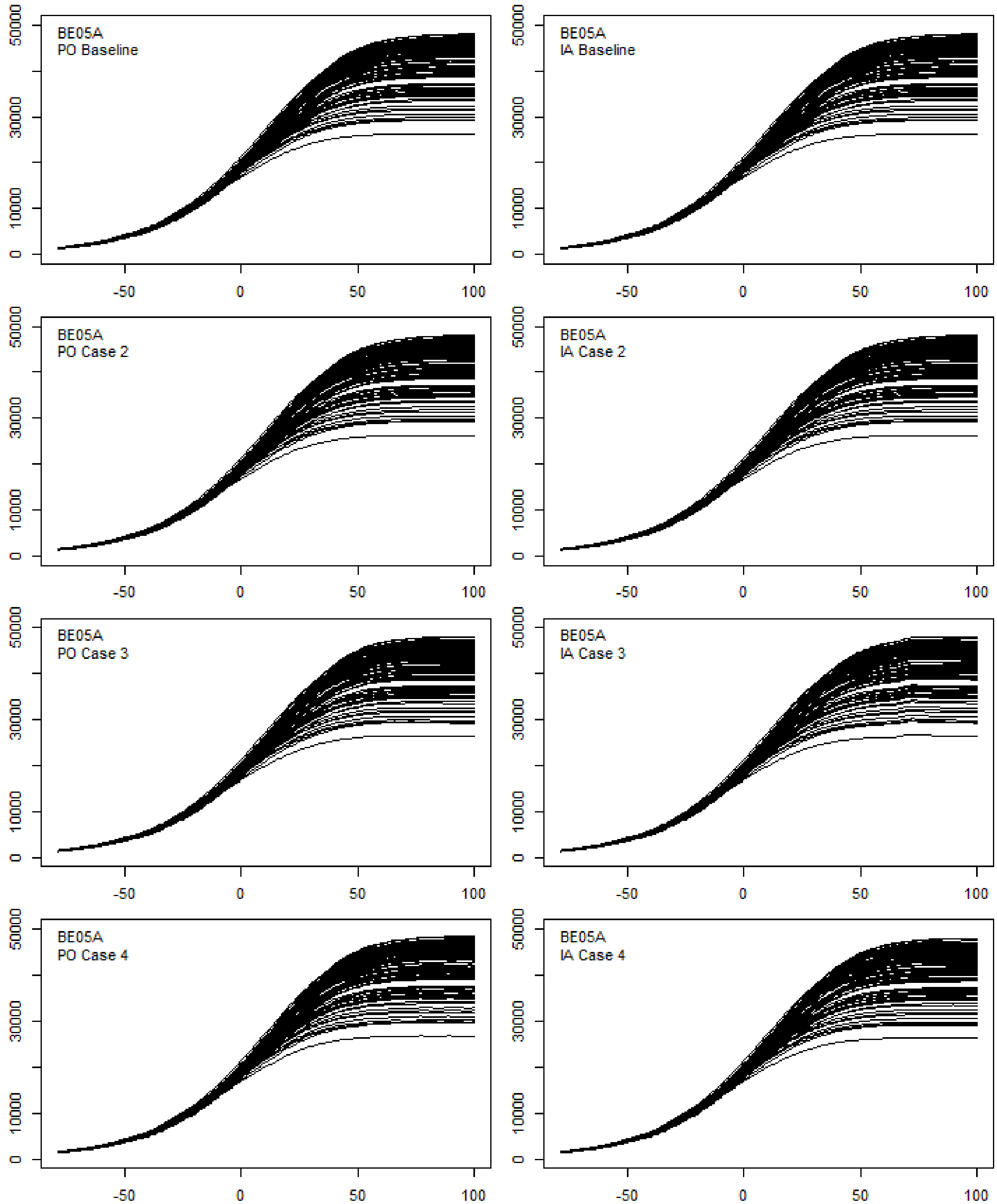

Figure 34: Set of 1+ population trajectories for trial BE05A.

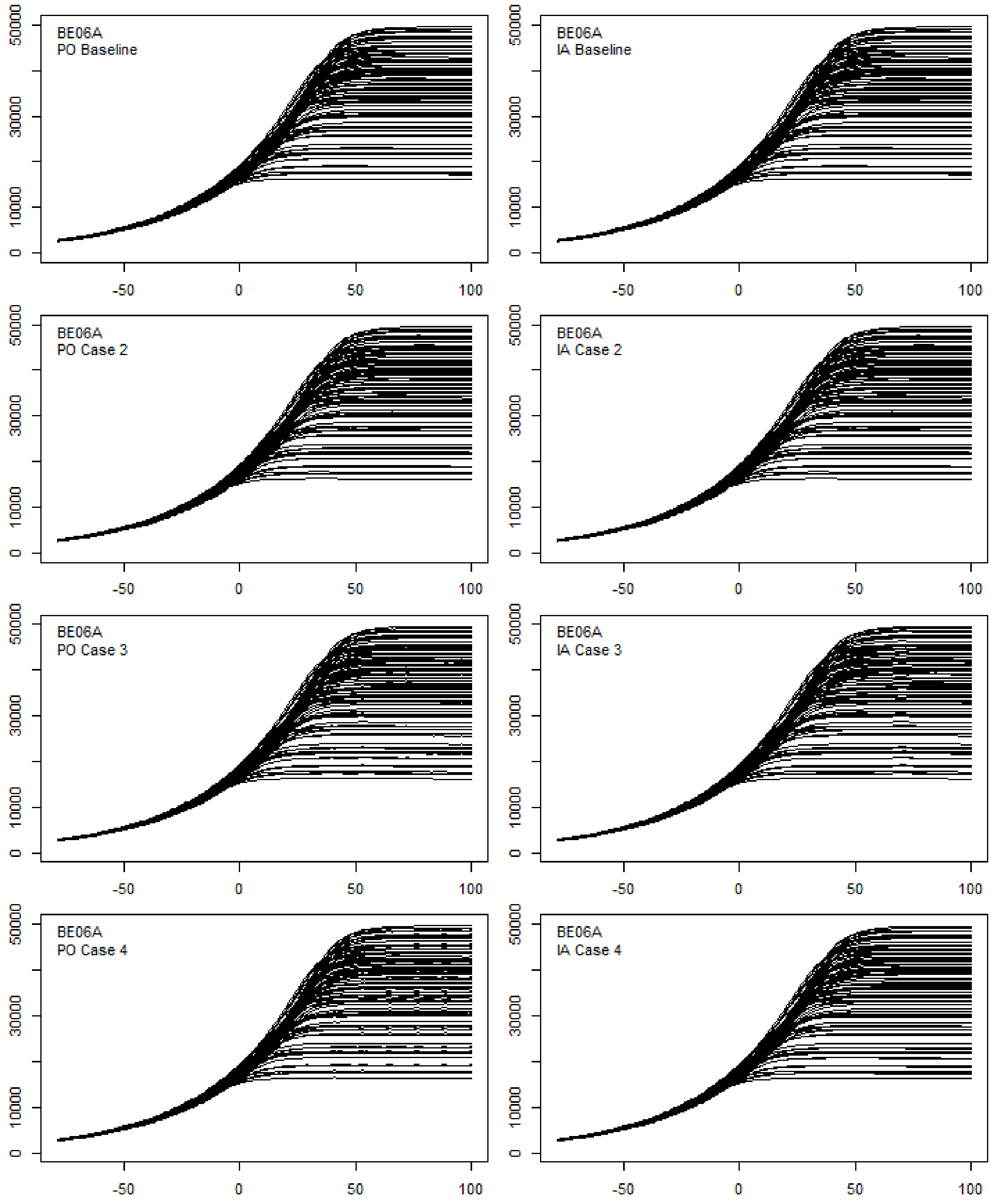

Figure 35: Set of 1+ population trajectories for trial BE06A.

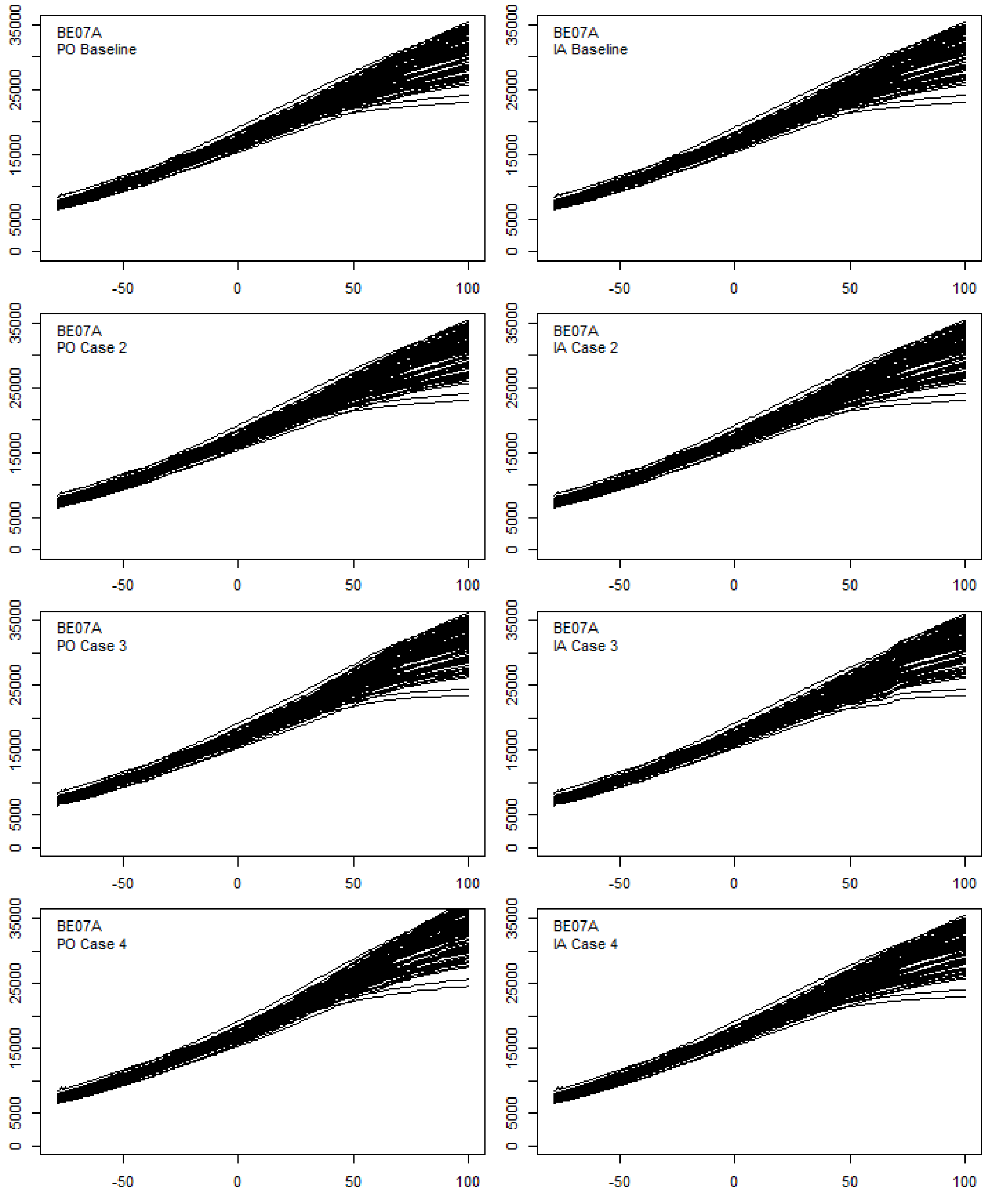

Figure 36: Set of 1+ population trajectories for trial BE07A.

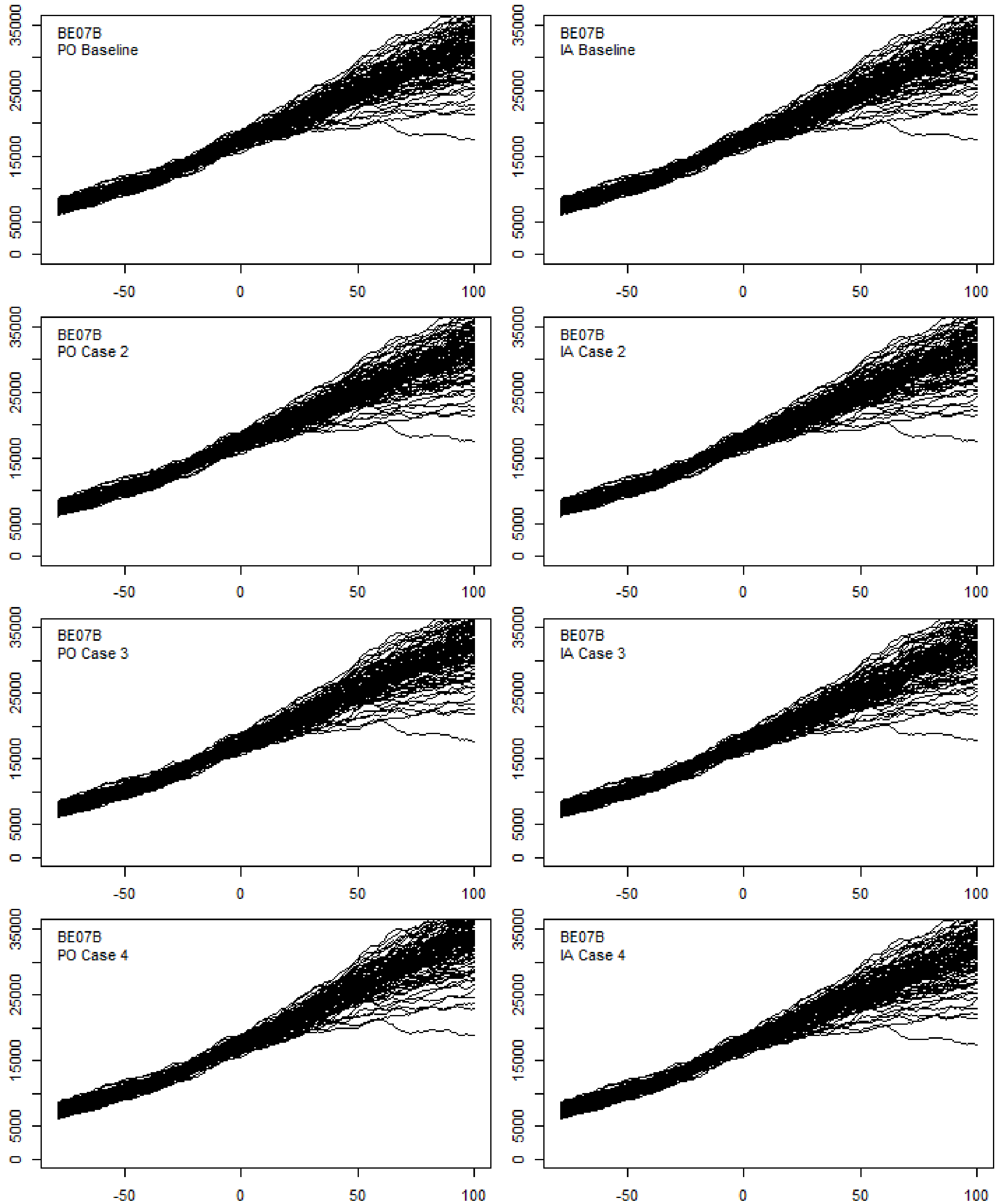

Figure 37: Set of 1+ population trajectories for trial BE07B.

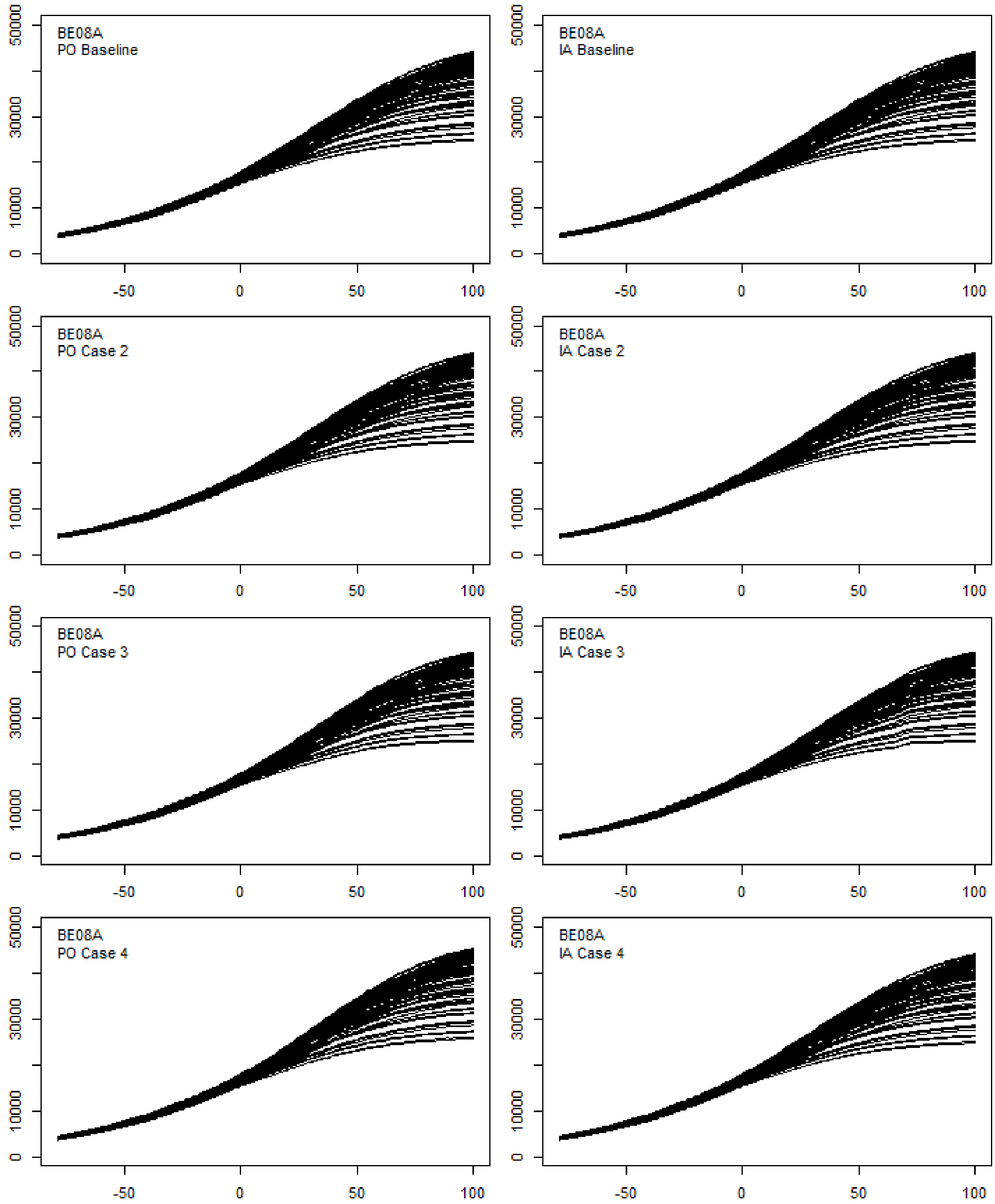

Figure 38: Set of 1+ population trajectories for trial BE08A.

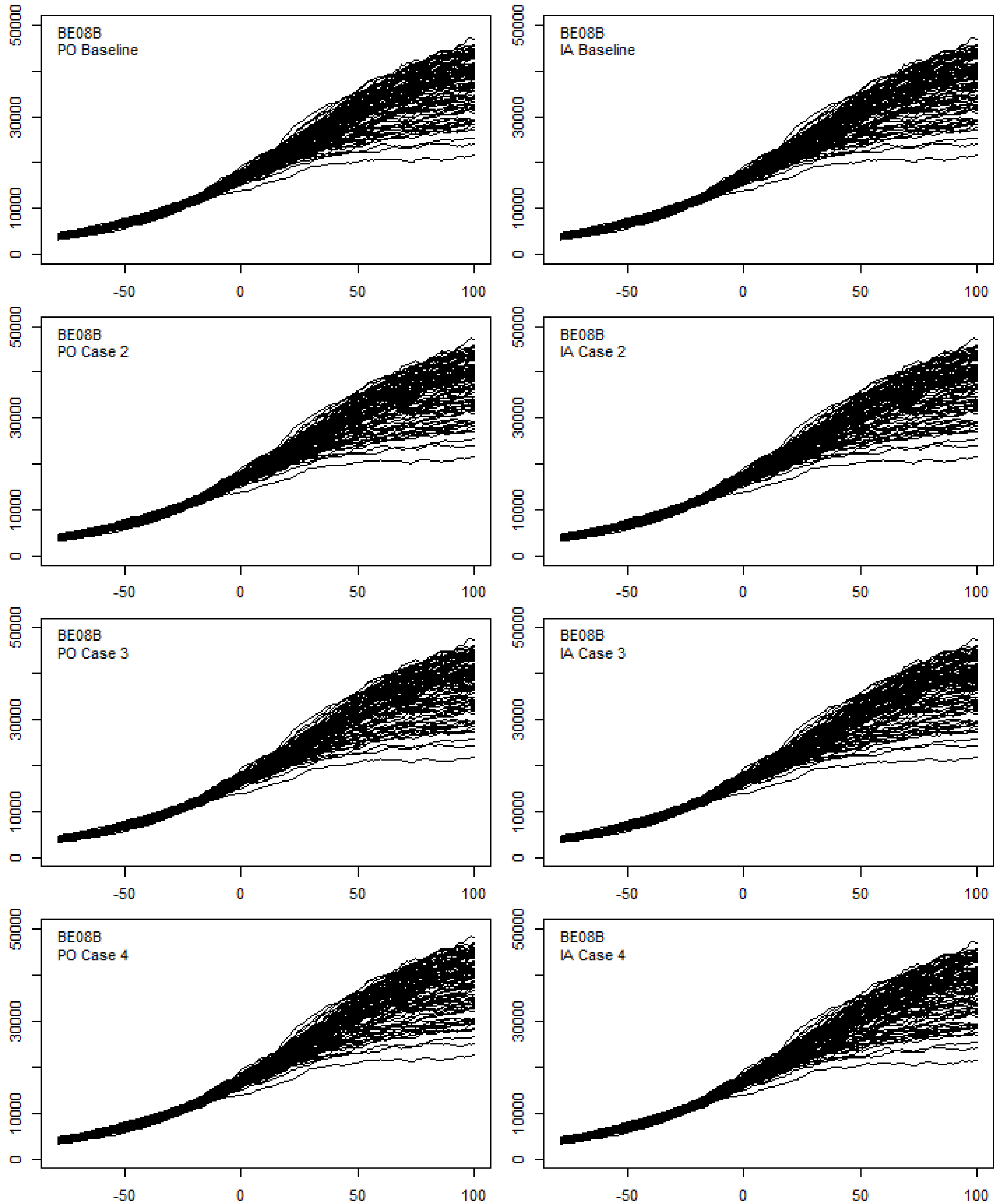

Figure 39: Set of 1+ population trajectories for trial BE08B.

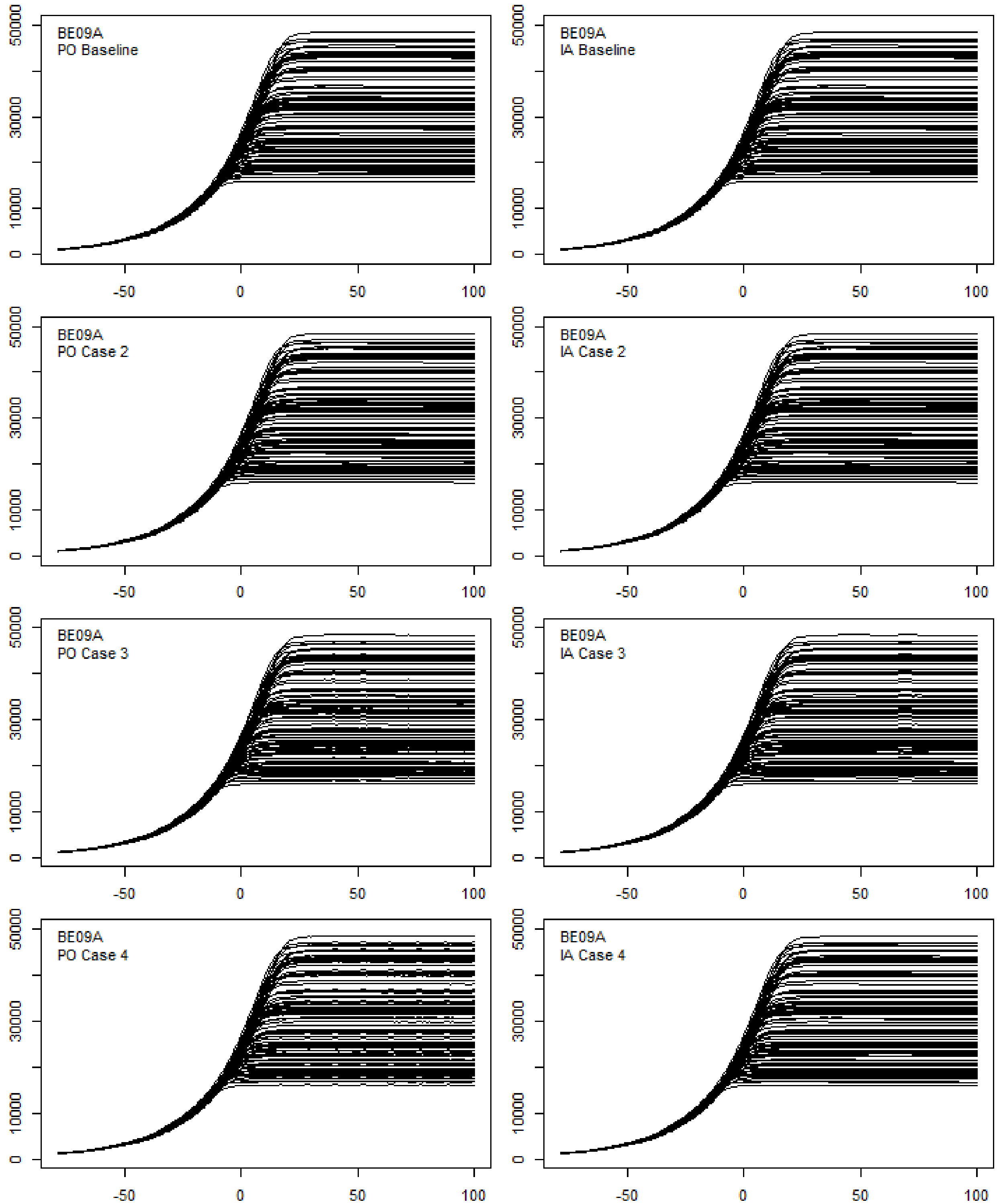

Figure 40: Set of 1+ population trajectories for trial BE09A.

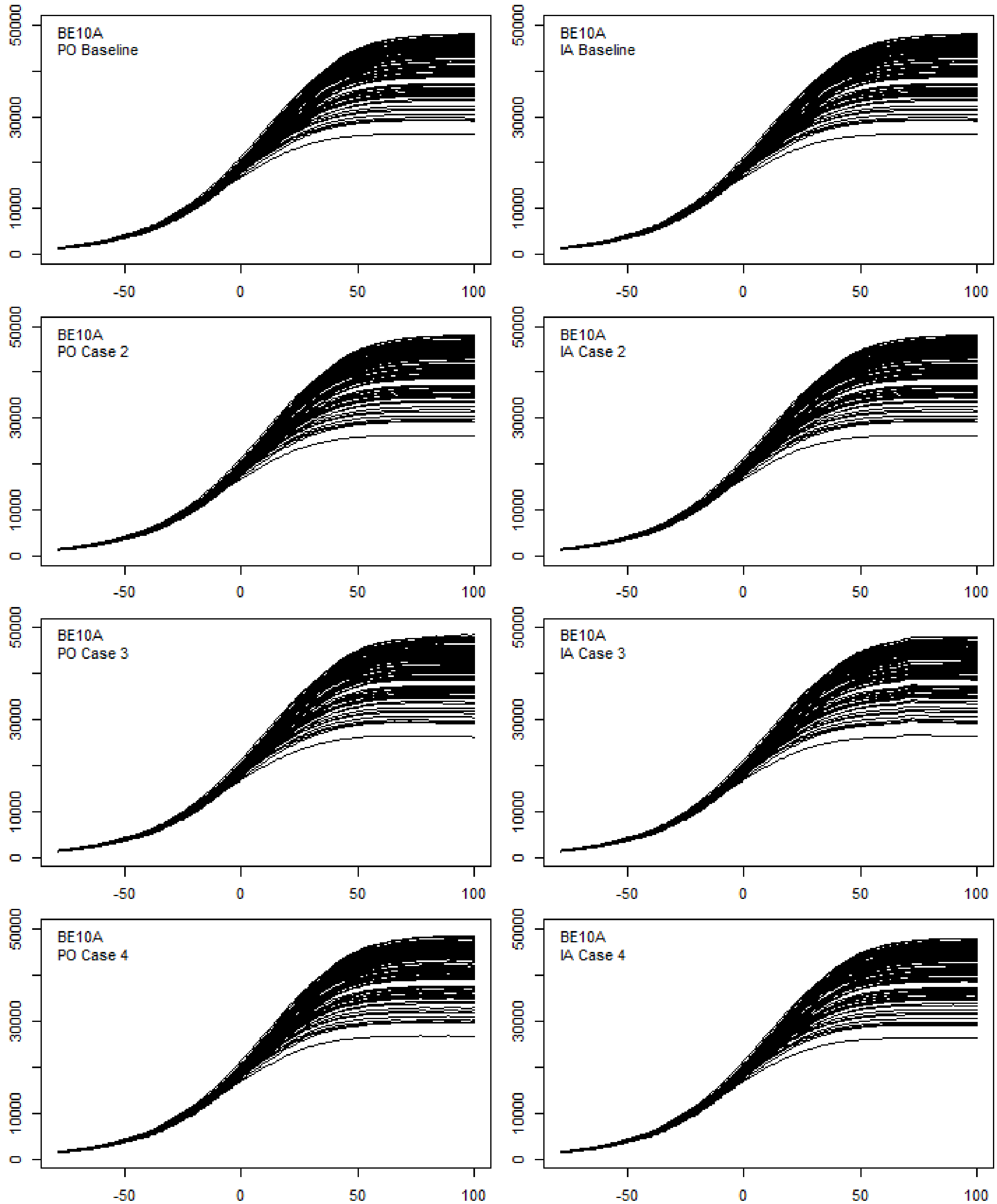

Figure 41: Set of 1+ population trajectories for trial BE10A.

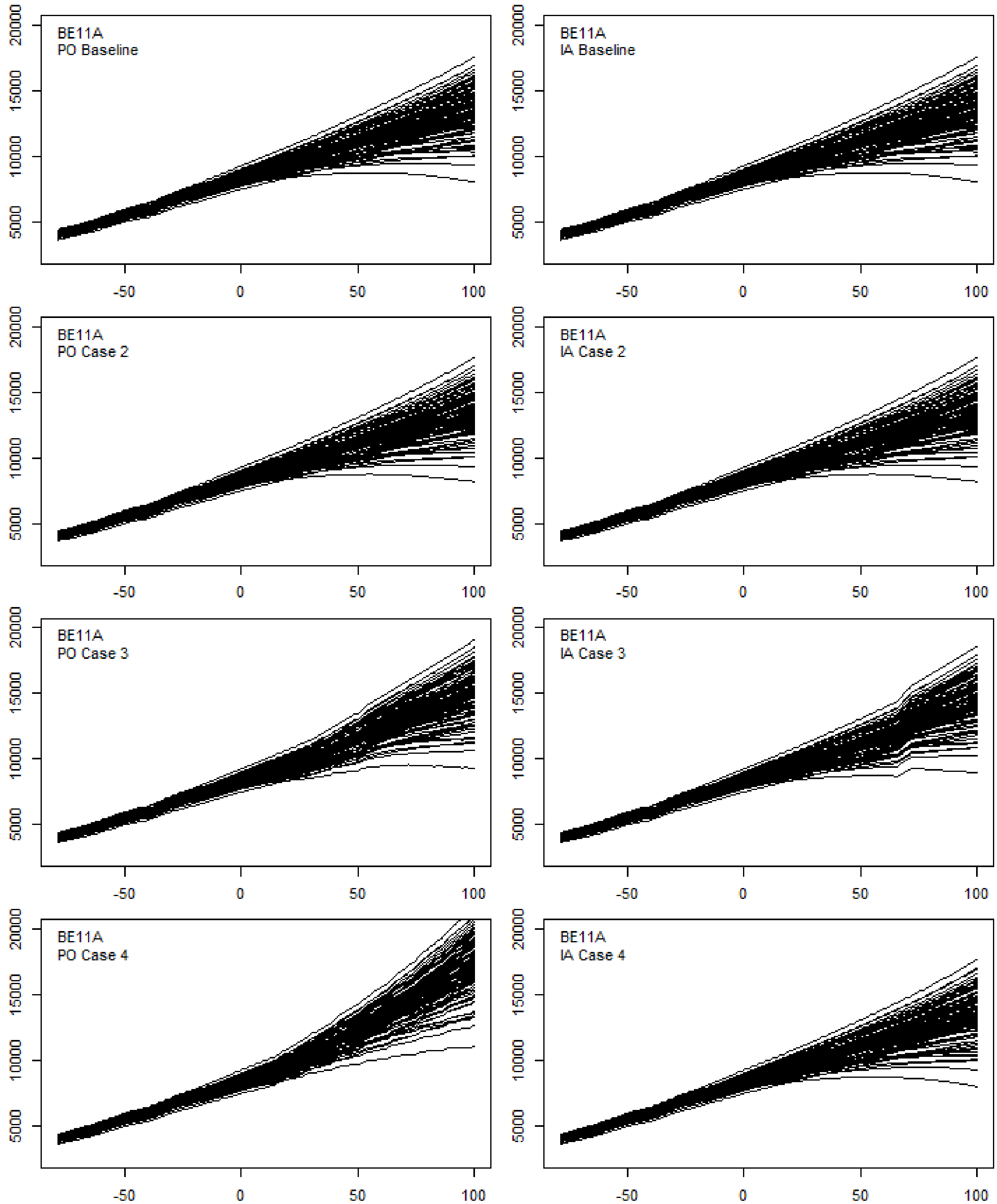

Figure 42: Set of 1+ population trajectories for trial BE11A.

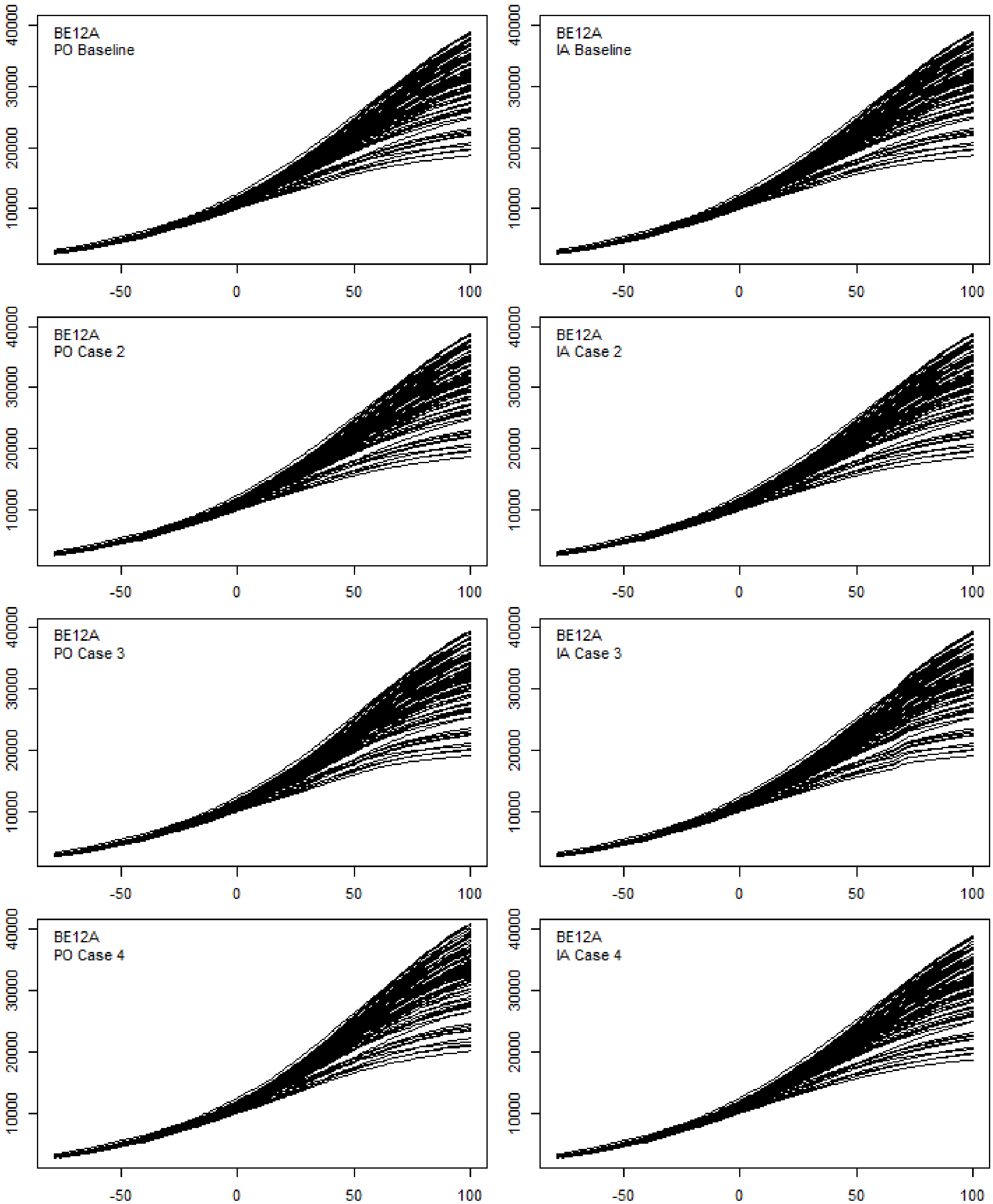

Figure 43: Set of 1+ population trajectories for trial BE12A.

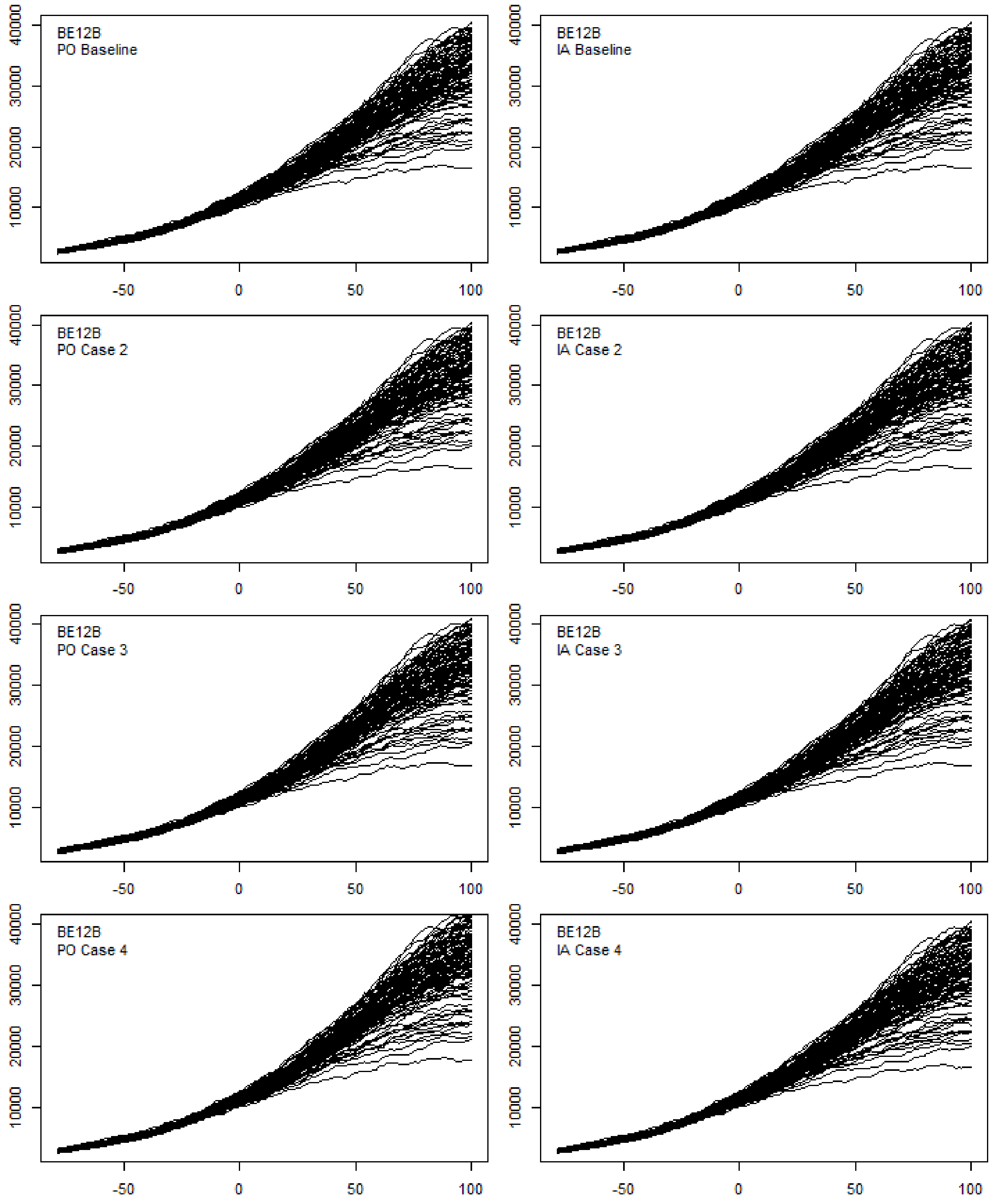

Figure 44: Set of 1+ population trajectories for trial BE12B.

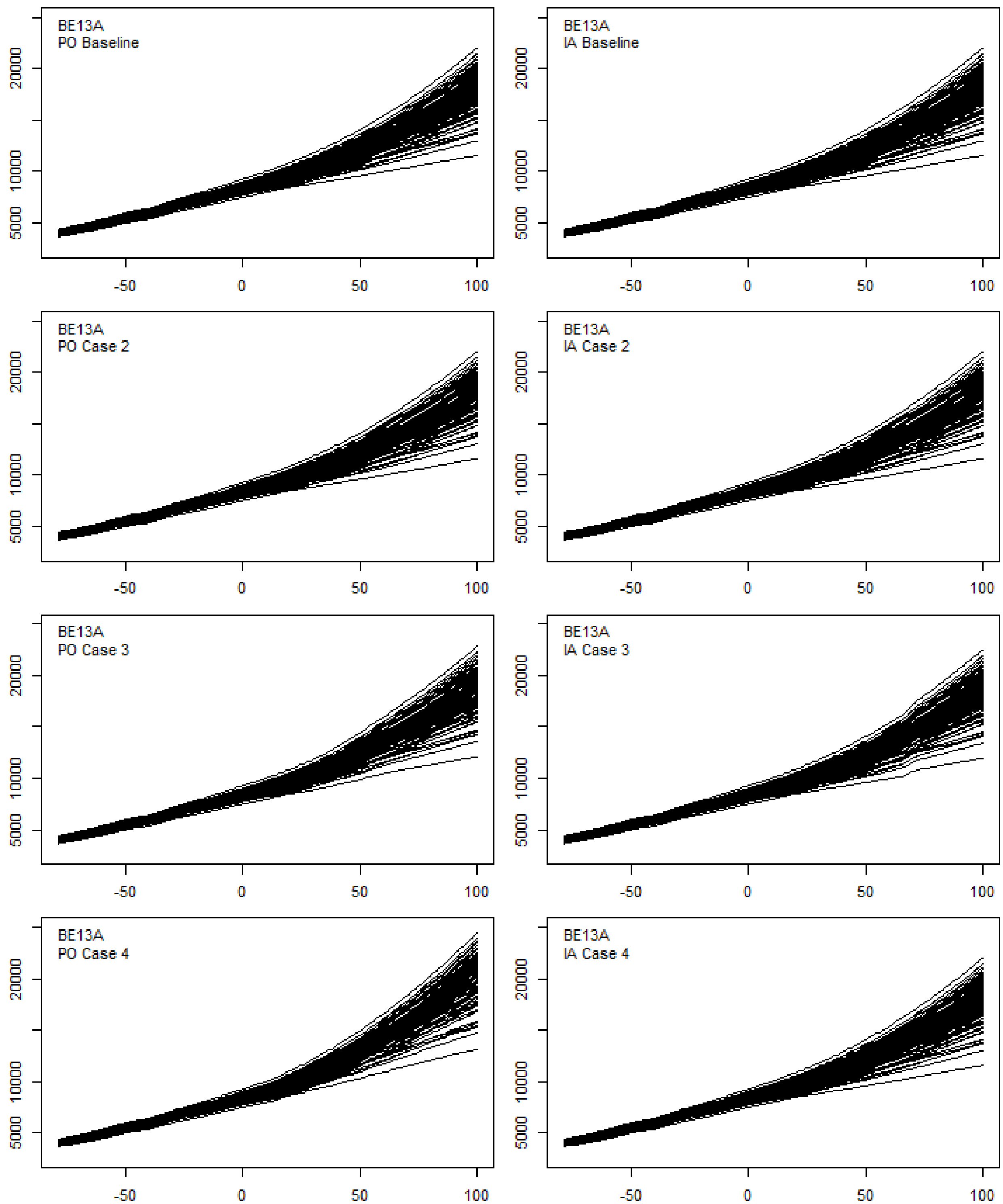

Figure 45: Set of 1+ population trajectories for trial BE13A.

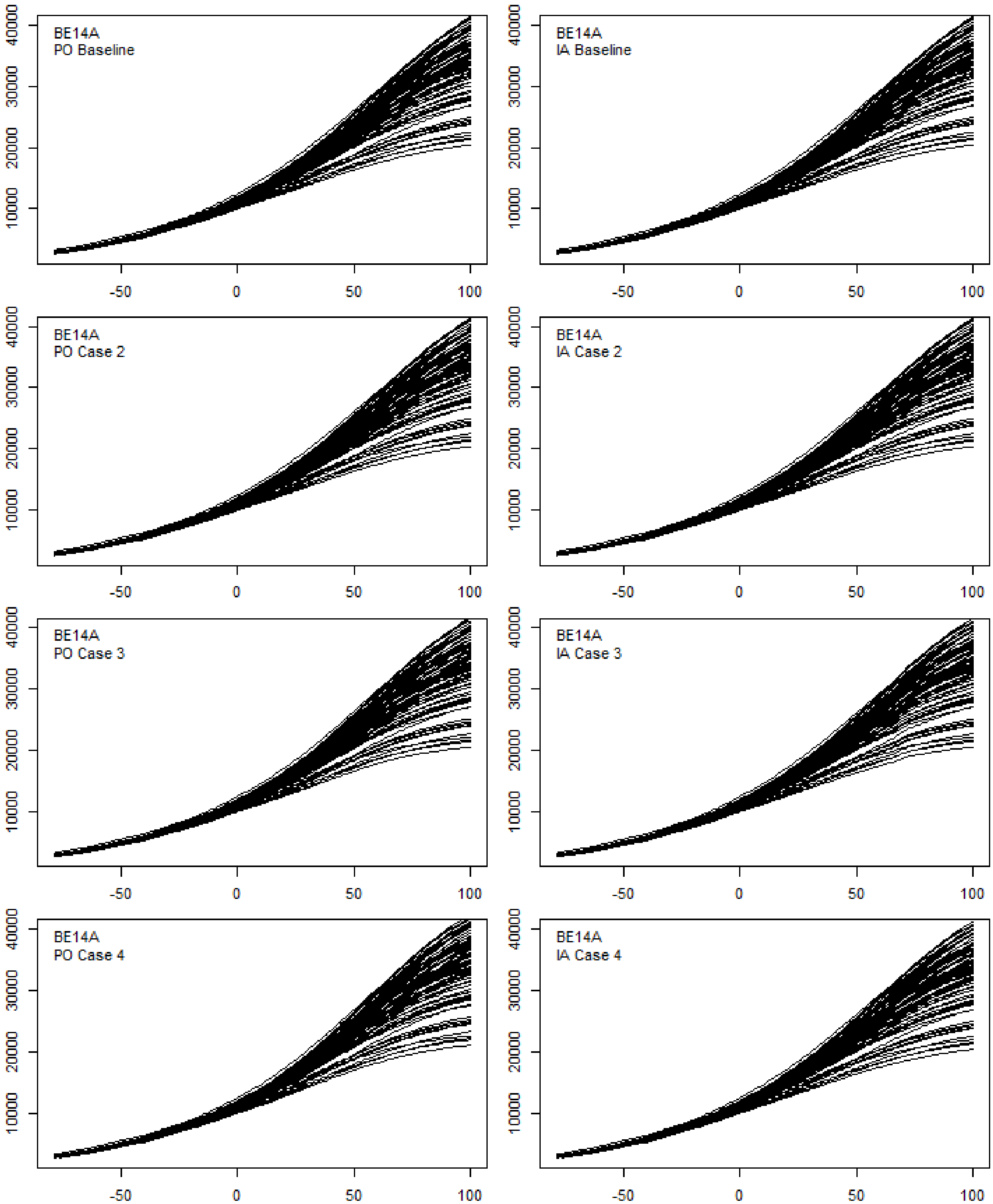

Figure 46: Set of 1+ population trajectories for trial BE14A.

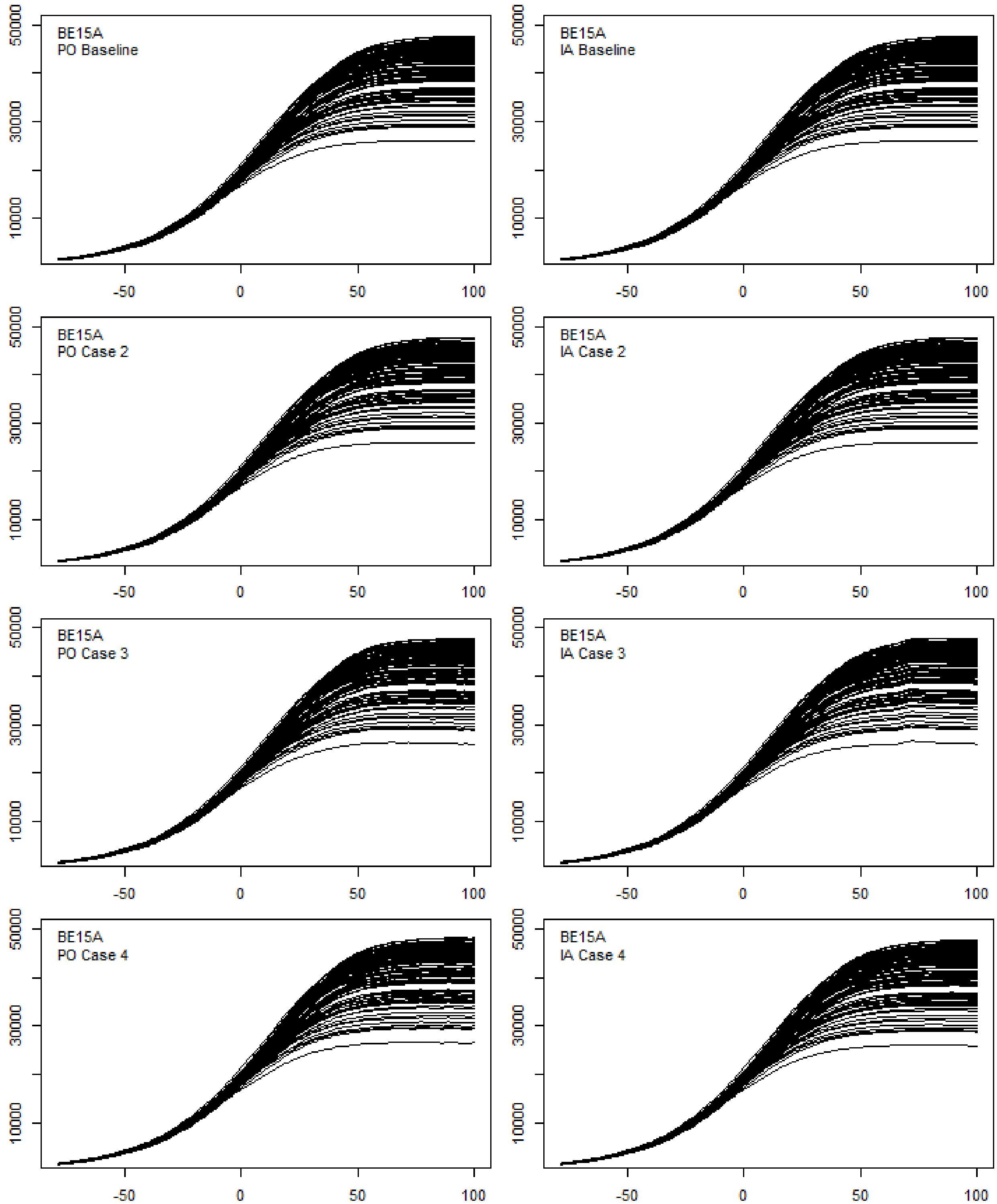

Figure 47: Set of 1+ population trajectories for trial BE15A.

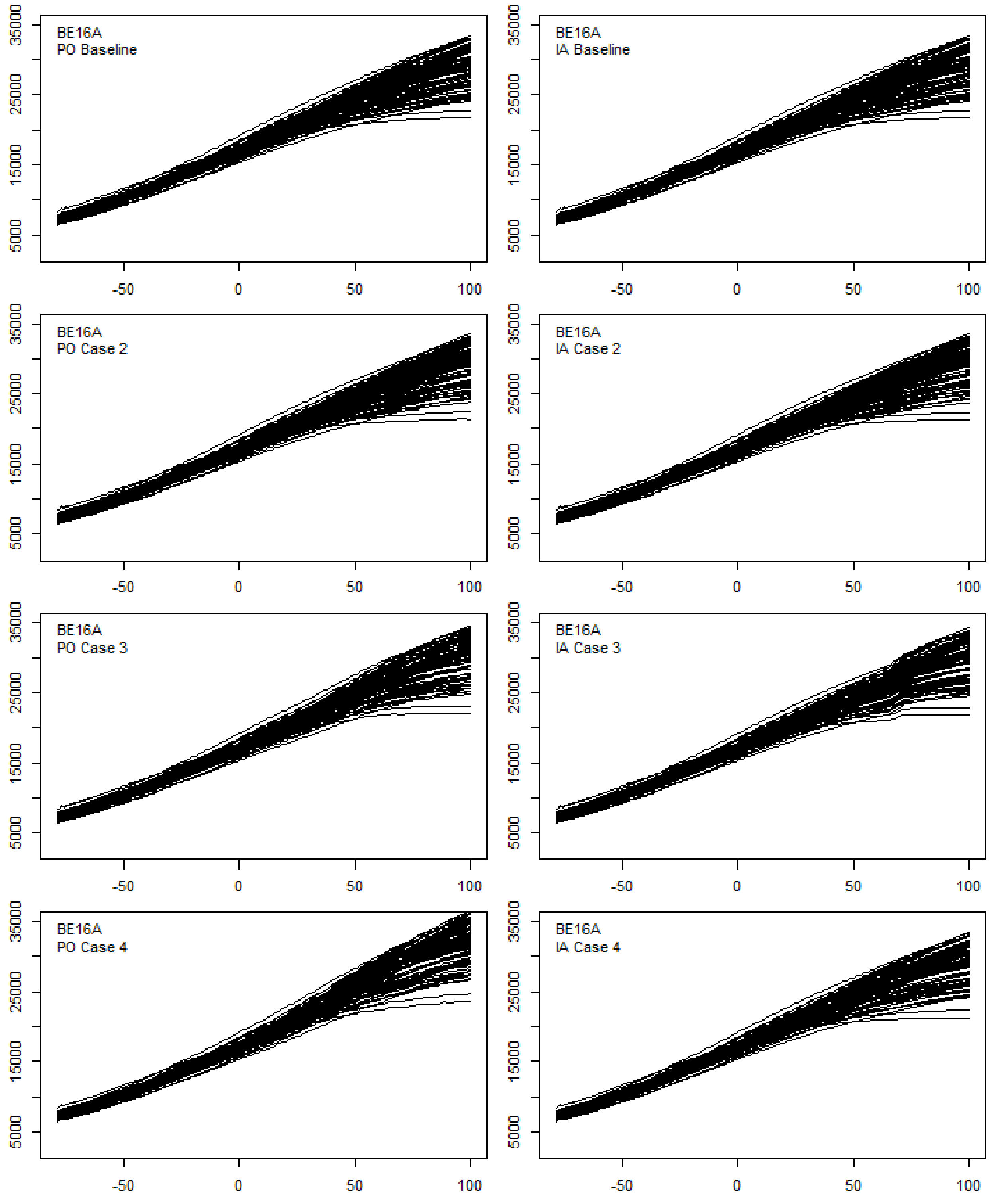

Figure 48: Set of 1+ population trajectories for trial BE16A.

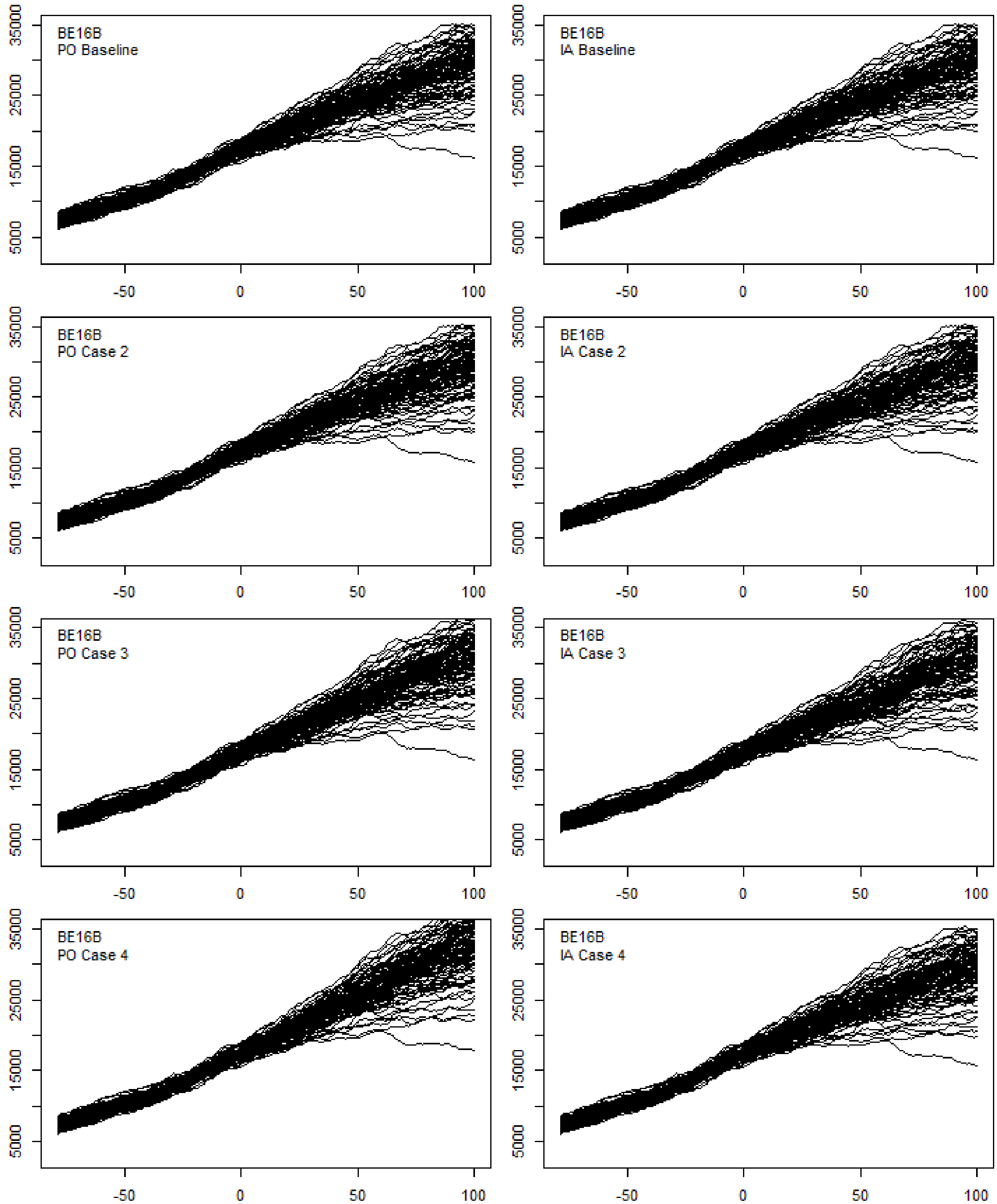

Figure 49: Set of 1+ population trajectories for trial BE16B.

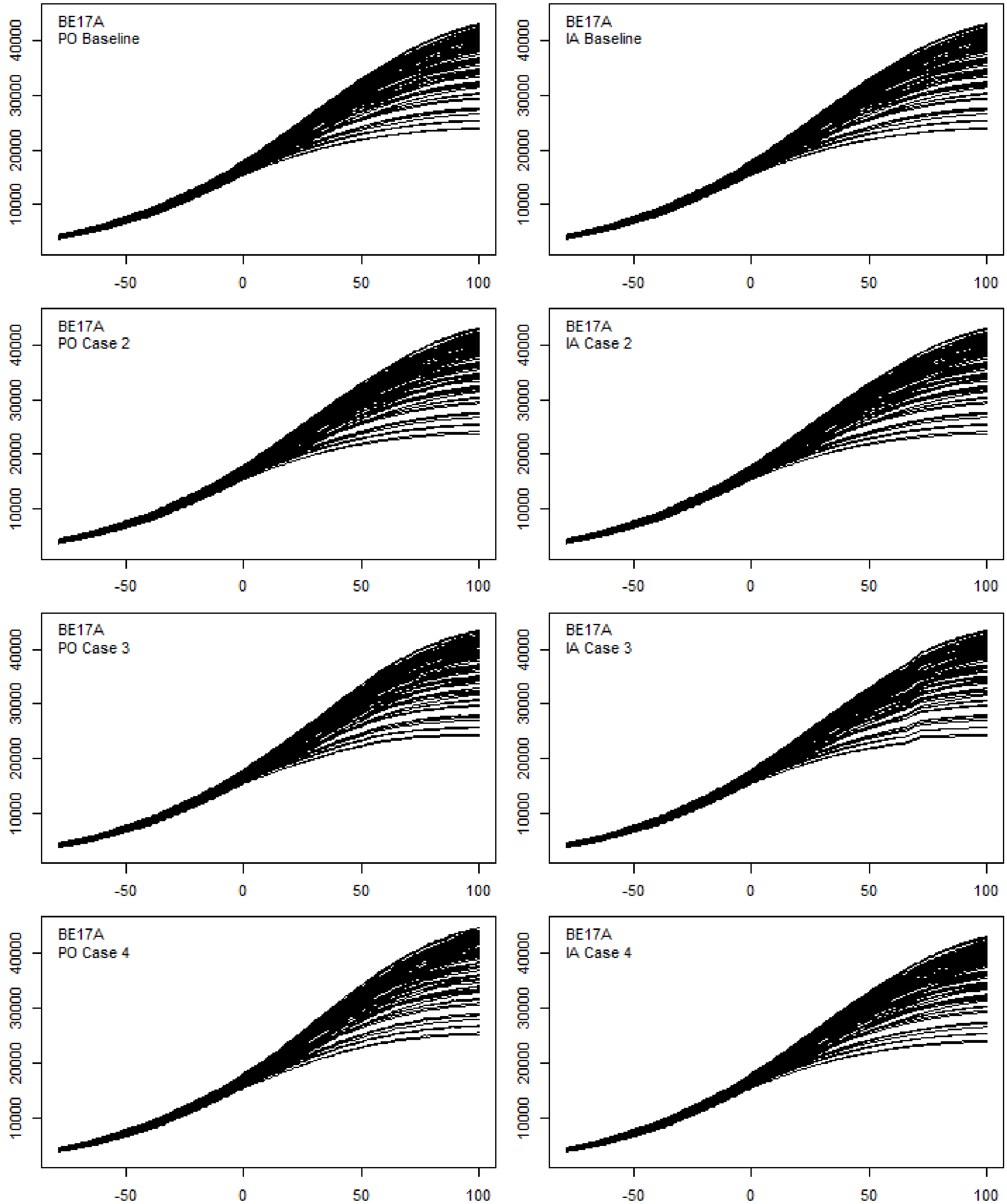

Figure 50: Set of 1+ population trajectories for trial BE17A.

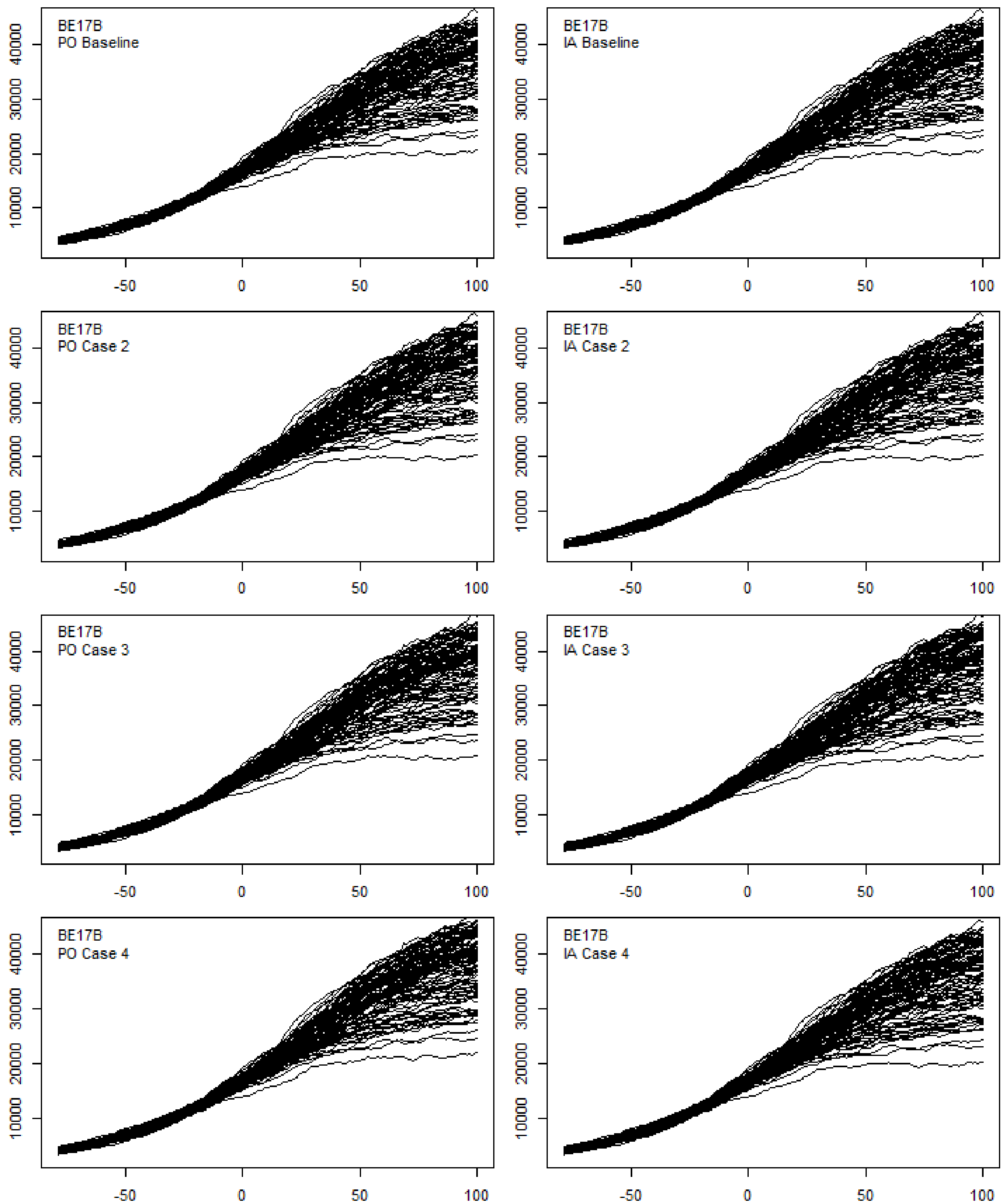

Figure 51: Set of 1+ population trajectories for trial BE17B.

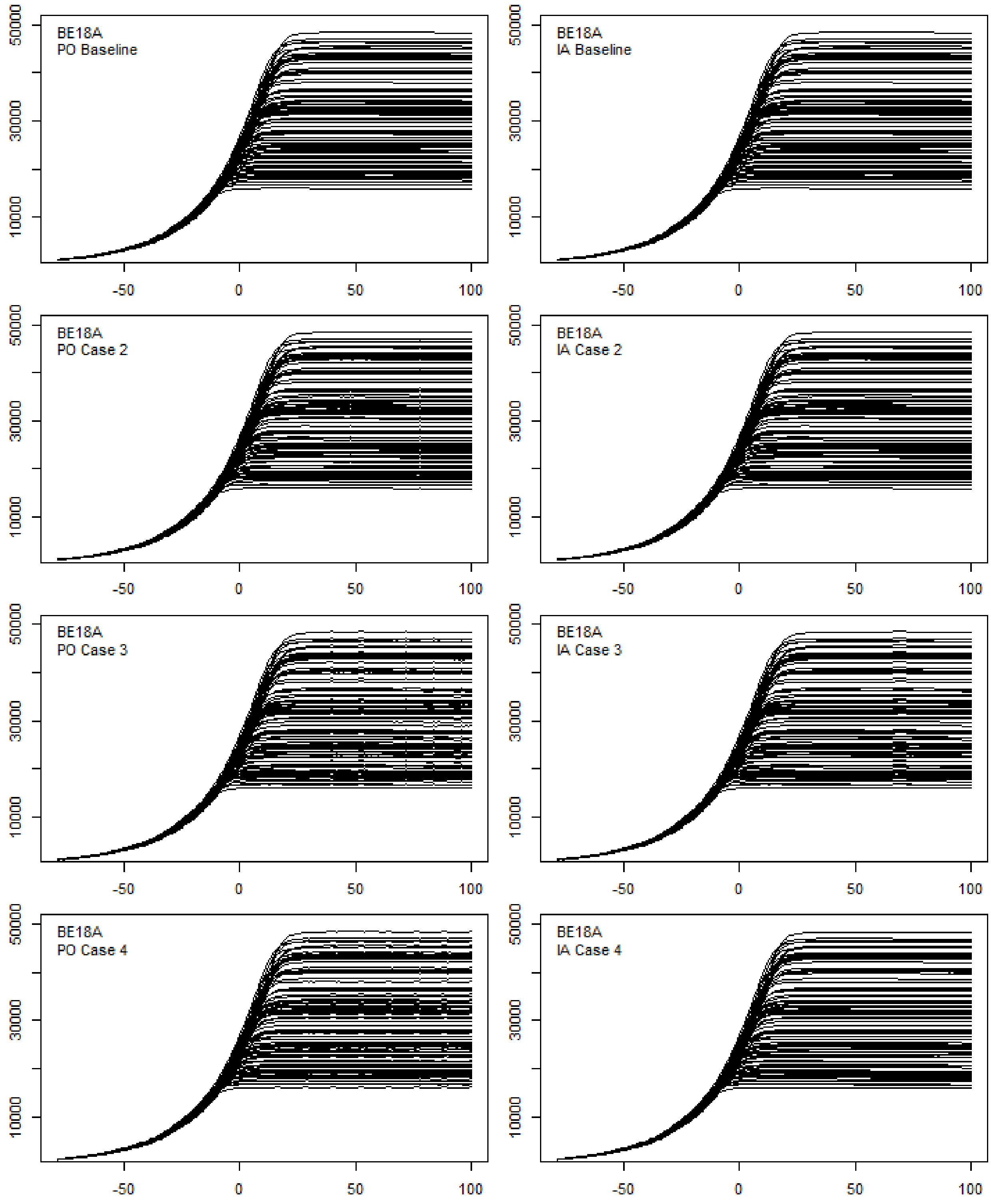

Figure 52: Set of 1+ population trajectories for trial BE18A.

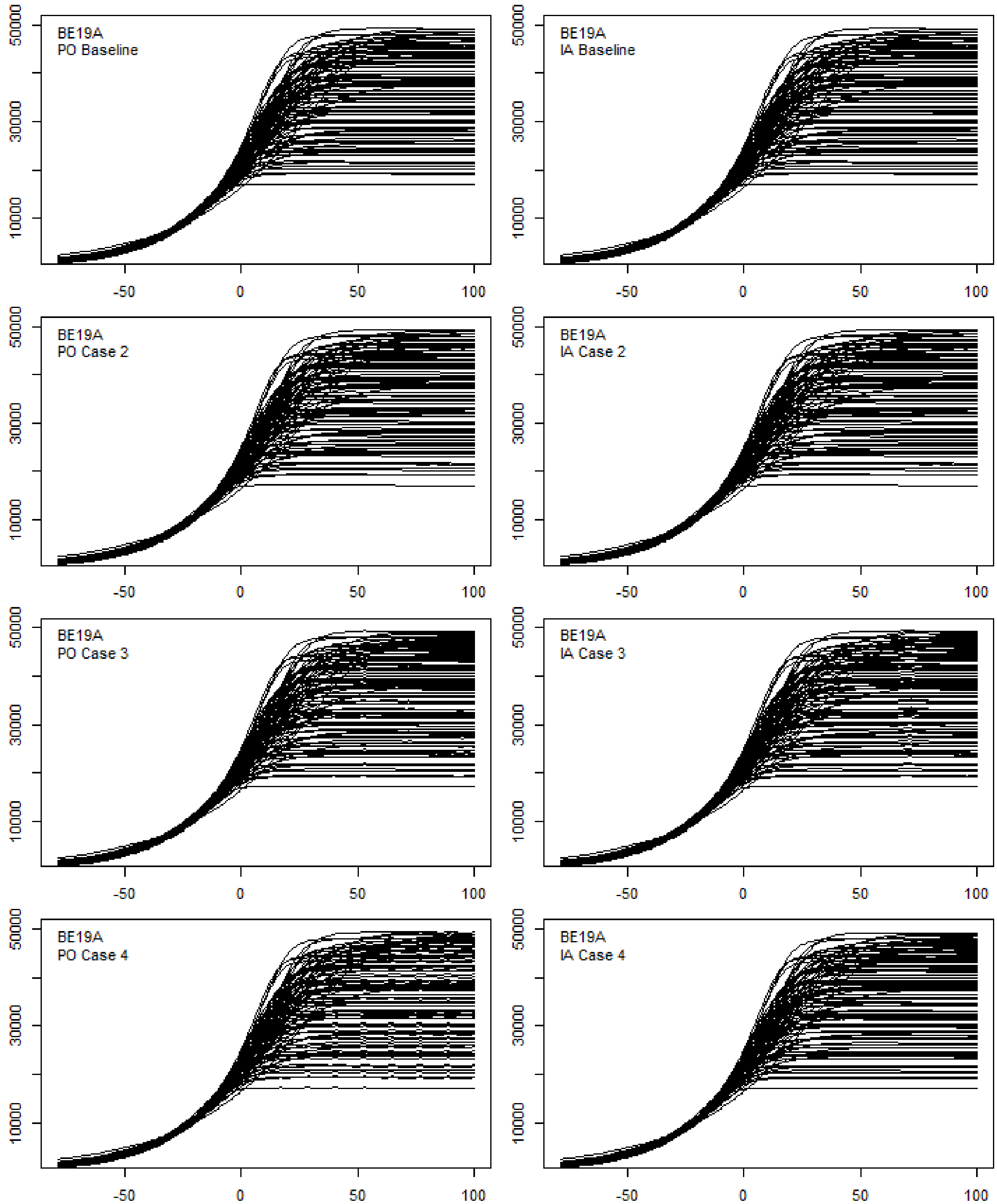

Figure 53: Set of 1+ population trajectories for trial BE19A.

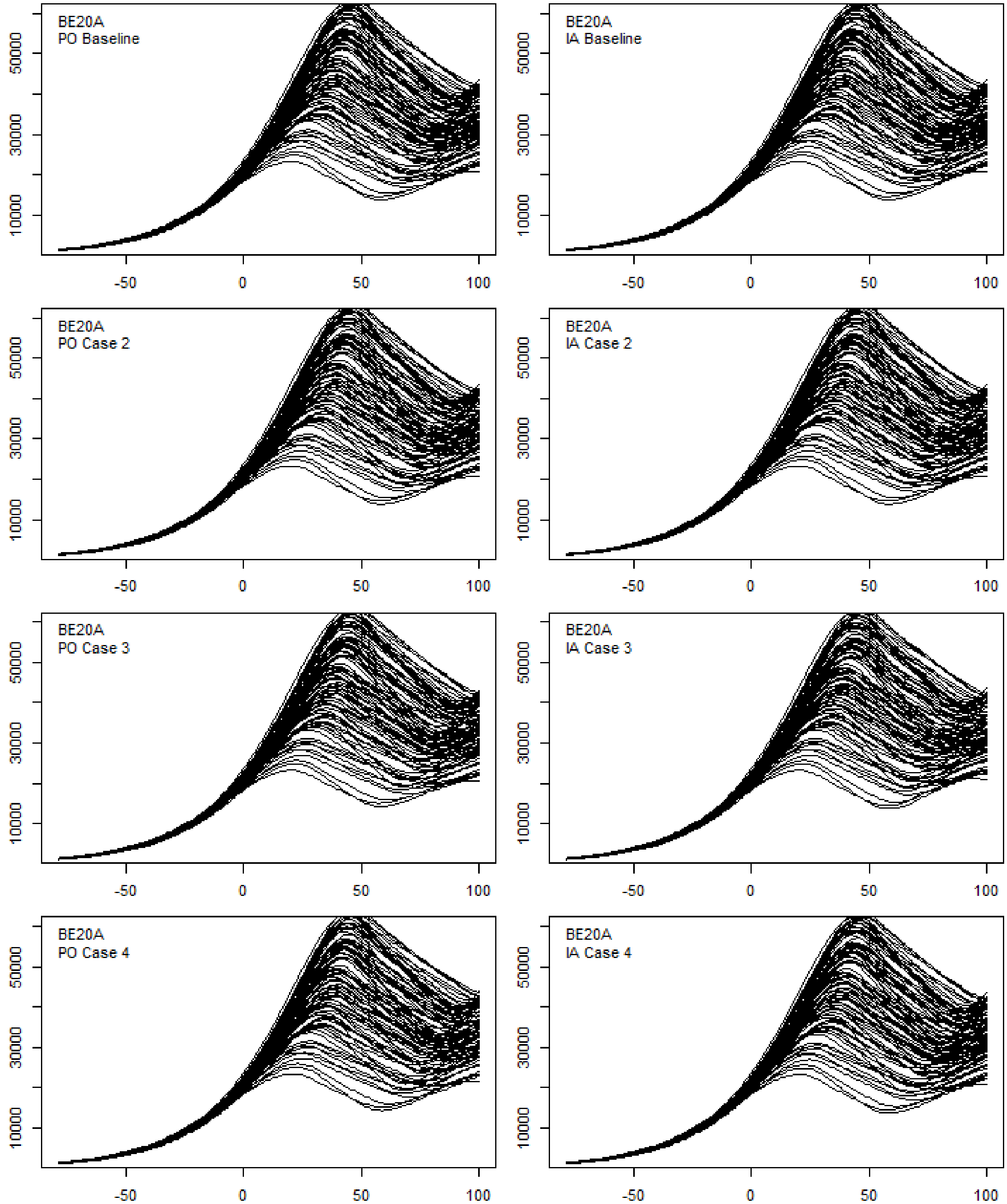

Figure 54: Set of 1+ population trajectories for trial BE20A.

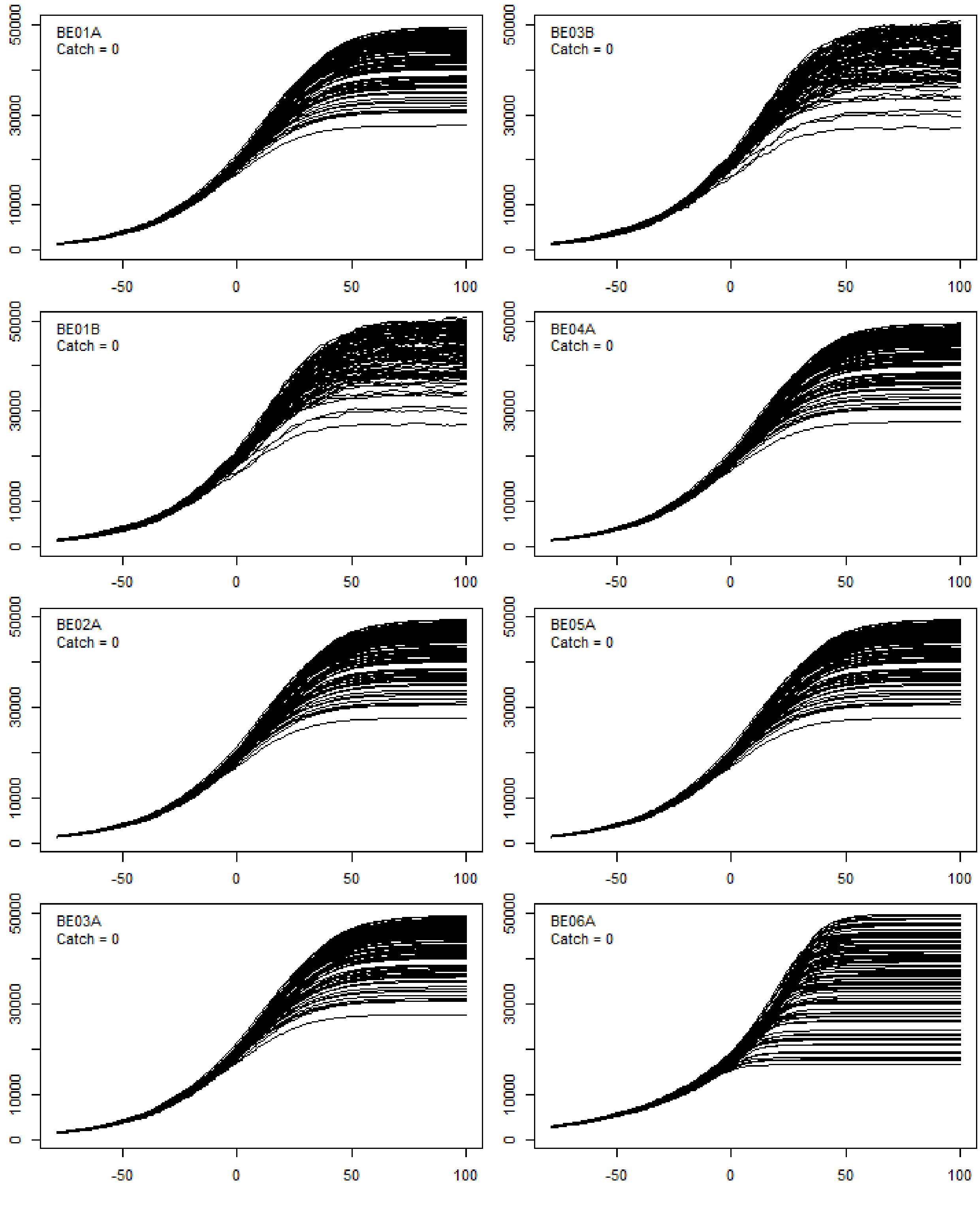

Figure 55: Age 1+ population trajectories for indicated trials.

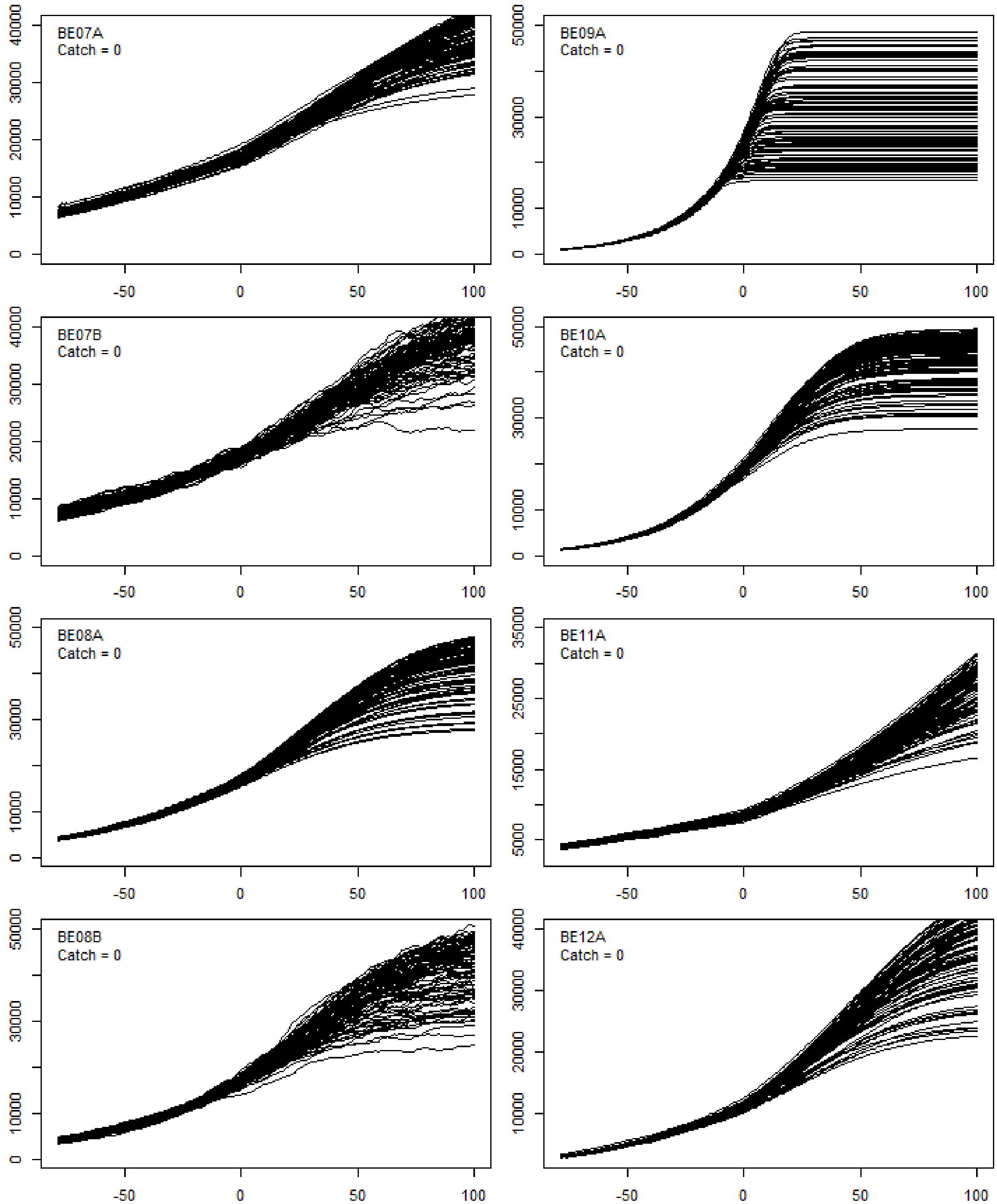

Figure 56: Age 1+ population trajectories for indicated trials.

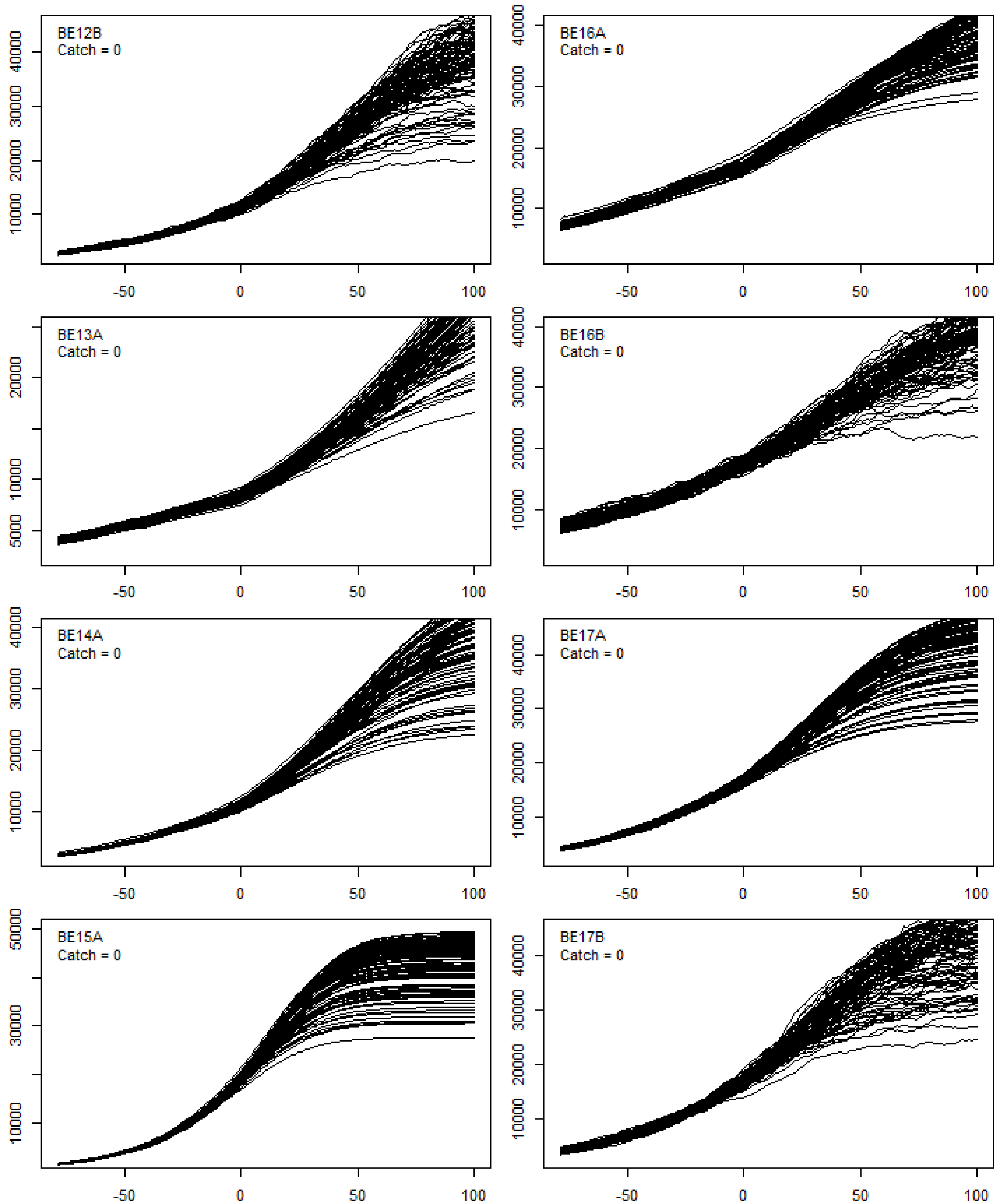

Figure 57: Age 1+ population trajectories for indicated trials.

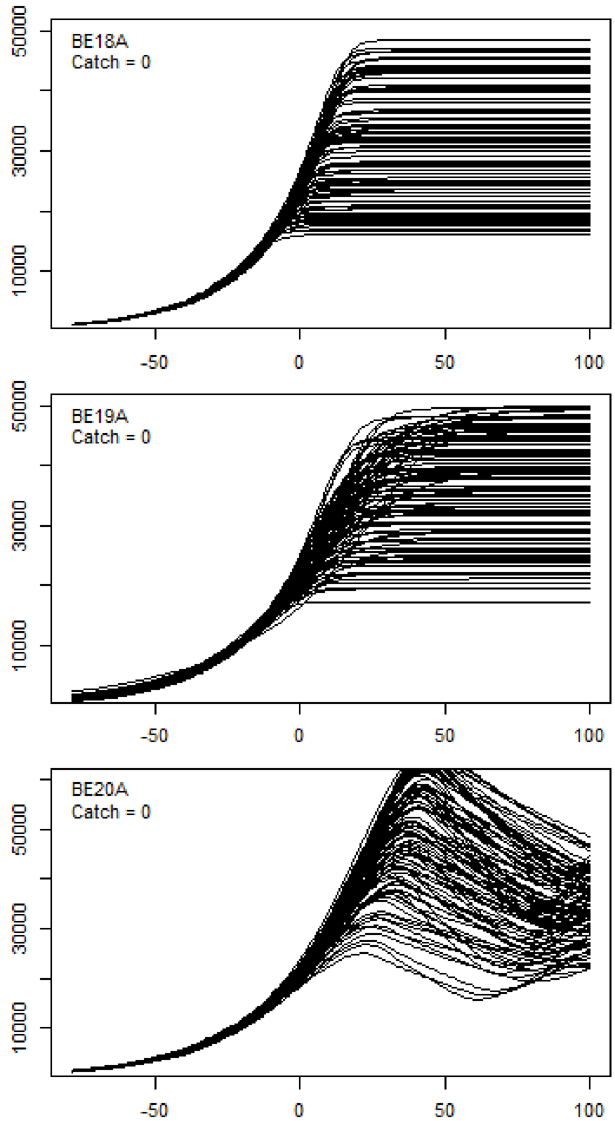

Figure 58: Age 1+ population trajectories for indicated trials.