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CORRECTION

Correction to: Improved precision in the analysis of randomized trials with survival outcomes, without assuming proportional hazards

Iván Díaz[1] · Elizabeth Colantuoni[2] · Daniel F. Hanley[3] · Michael Rosenblum[2]

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Correction to: Lifetime Data Anal (2019) 25:439–468 https://doi.org/10.1007/s10985-018-9428-5

The original version of this article unfortunately contains mistakes. It has been corrected with this Correction.

Summary

The R code used for the data analysis and simulations in our manuscript (Díaz et al. 2018) had two errors, which we have corrected. All of the theoretical results in the paper are correct. It is our implementation of these in R code that had the errors, which impacts the data analysis and simulation results in Section 6. This erratum describes the errors and presents the updated results of the data analysis and simulations with the errors corrected.

The two errors were (i) incorrect coding of the auxiliary variable H used in the TMLE estimator, and (ii) incorrect coding of time t as numeric instead of as a factor in the adjusted estimators. These were corrected and the updated code is available at (Díaz 2018a). The updated results, given below, are qualitatively similar to the original results (i.e., there are no changes to our conclusions in the paper) except for the following: the updated TMLE ($\hat{\theta}_{\text{adj,eff}}$) confidence interval coverage probabilities ranged from 93 to 95% (previously 94–95%); the updated bias of the TMLE $\hat{\theta}_{\text{adj,eff}}$

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✉ Iván Díaz
ild2005@med.cornell.edu

1 Division of Biostatistics and Epidemiology, Weill Cornell Medicine, New York, NY, USA

2 Department of Biostatistics, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

3 Division of Brain Injury Outcomes, Johns Hopkins Medical Institutions, Baltimore, MD, USA

Table 1 Estimated RMST (standard error) with 95% bias-corrected and accelerated (BCa) bootstrap confidence intervals based on the CLEAR III trial

Estimator	RMST (SE)	95% BCa confidence interval
KM	14.9 (5.3)	(5.6, 26.2)
IPW	14.9 (5.3)	(5.6, 26.2)
Adj. IPW	15.5 (5.6)	(6.0, 27.9)
AIPW	14.5 (5.2)	(4.9, 25.1)
TMLE	14.4 (5.0)	(5.4, 24.7)

was sometimes larger but still small (at most 3%) as a fraction of the treatment effect (14.9 days) and had negligible influence on the mean squared error; the adjusted inverse probability weighted estimator $\hat{\theta}_{\text{adj,ipw}}$ (which was not the focus of the paper) had larger variance in the updated results compared to the original results, leading to lower relative efficiency.

Corrections to R code

First, the R code for computing the auxiliary variable $H(m, A, W)$ involved in the algorithm for our proposed estimator $\hat{\theta}_{\text{adj,eff}}$ did not match the (correct) formula (17) from the paper. We have fixed this error in the R package (Díaz 2018a). Please refer to the GitHub commit given in that citation at the end of this erratum for the specific lines of code that were corrected.

Second, when computing all adjusted estimators, including $\hat{\theta}_{\text{adj,ipw}}$ and $\hat{\theta}_{\text{adj,eff}}$, the time t should have entered our R code (in the working models for g_A, g_R) as a variable of type factor rather than as numeric (see Díaz 2018b). This is needed in order to satisfy the requirement in Theorem 2 that dropout probabilities are estimated using models with saturated terms for time, treatment, and their interaction.

We have fixed the above two errors and reported the results of our revised analyses in Tables 1 through 3, whose numbering corresponds to the labels of tables in the original paper. Corresponding to our fix of the second error, the sentence "The model for g_R for the adjusted estimators includes main terms for time (linear), treatment and their interaction, in addition to main terms for W_1 and W_5 and a treatment by W_3 interaction." from Section 6.3 should now have "(linear)" replaced by "(factor)".

CLEAR III trial data analysis

The results of analyzing the CLEAR III trial data were qualitatively similar to our initial findings. The Kaplan–Meier estimate of the RMST is 14.9 days (SE 5.3, 95% BCa CI 5.6–26.2). Our TMLE estimator $\hat{\theta}_{\text{adj,eff}}$ has an estimated variance that is roughly 13% smaller than the (unadjusted) RMST difference based on the cMeier estimator (compared to 16% smaller as reported in the original manuscript).

Simulation studies

Tables 2 and 3 display the new simulation results. The updated results were qualitatively similar to the original results, except for the following: the updated TMLE

Table 2 Revised simulation results for studies of size $n = 500$

Scenario	Estimator	Zero treatment effect ($\theta = 0$)					Positive treatment effect ($\theta = 14.9$)				
		Bias	Var	MSE	RMSE	CP	Bias	Var	MSE	RMSE	CP
Non-informative censoring, i.e., censoring independent of baseline variables											
A	KM	0.032	35.28	35.28	1.000	0.945	0.013	26.64	26.64	1.000	0.948
	IPW	0.033	35.64	35.64	0.990	0.944	0.044	26.96	26.96	0.988	0.946
	Adj. IPW	0.003	36.80	36.80	0.959	0.948	0.172	27.78	27.81	0.958	0.950
	AIPW	− 0.012	31.57	31.57	1.118	0.945	− 0.007	24.33	24.33	1.095	0.950
	TMLE	− 0.013	30.76	30.76	1.147	0.944	− 0.460	23.86	24.07	1.107	0.946
B	KM	0.069	36.10	36.11	1.000	0.942	− 0.068	27.34	27.35	1.000	0.951
	IPW	0.071	36.48	36.48	0.990	0.943	− 0.038	27.66	27.66	0.988	0.950
	Adj. IPW	0.039	37.77	37.78	0.956	0.945	0.064	28.66	28.67	0.954	0.954
	AIPW	0.077	36.10	36.10	1.000	0.940	− 0.020	27.22	27.22	1.005	0.953
	TMLE	0.076	35.13	35.14	1.028	0.932	− 0.494	26.67	26.91	1.016	0.949
C	KM	− 0.045	35.52	35.52	1.000	0.957	− 0.037	27.01	27.01	1.000	0.938
	IPW	− 0.046	35.89	35.90	0.990	0.958	− 0.006	27.32	27.32	0.989	0.939
	Adj. IPW	− 0.086	37.24	37.25	0.954	0.958	0.107	28.17	28.18	0.958	0.944
	AIPW	− 0.055	36.59	36.59	0.971	0.955	0.037	27.64	27.64	0.977	0.936
	TMLE	− 0.053	35.64	35.64	0.997	0.953	− 0.447	27.04	27.24	0.992	0.931

Table 2 continued

Scenario	Estimator	Zero treatment effect ($\theta = 0$)					Positive treatment effect ($\theta = 14.9$)				
		Bias	Var	MSE	RMSE	CP	Bias	Var	MSE	RMSE	CP
Informative censoring, i.e., censoring depends on baseline variables											
A	KM	0.801	31.37	32.02	1.000	0.952	1.762	22.44	25.54	1.000	0.945
	IPW	0.793	31.51	32.14	0.996	0.952	1.776	22.54	25.70	0.994	0.943
	Adj. IPW	− 0.106	34.45	34.47	0.929	0.953	0.216	26.01	26.06	0.980	0.954
	AIPW	− 0.045	29.54	29.55	1.084	0.944	0.105	22.68	22.70	1.125	0.949
	TMLE	− 0.060	28.73	28.73	1.114	0.936	− 0.292	22.11	22.20	1.151	0.948
B	KM	0.383	33.33	33.48	1.000	0.945	0.882	22.94	23.72	1.000	0.944
	IPW	0.372	33.48	33.62	0.996	0.944	0.893	23.05	23.85	0.995	0.943
	Adj. IPW	− 0.092	35.66	35.67	0.939	0.945	0.171	25.39	25.42	0.933	0.951
	AIPW	− 0.051	33.90	33.91	0.987	0.940	0.107	24.33	24.34	0.974	0.937
	TMLE	− 0.057	32.93	32.94	1.017	0.931	− 0.325	23.70	23.80	0.996	0.932
C	KM	0.041	31.77	31.77	1.000	0.955	0.025	23.89	23.89	1.000	0.951
	IPW	0.027	31.91	31.91	0.996	0.955	0.032	24.00	24.00	0.995	0.954
	Adj. IPW	0.011	33.31	33.31	0.954	0.957	0.172	25.49	25.52	0.936	0.957
	AIPW	0.034	32.90	32.90	0.965	0.949	0.116	25.09	25.11	0.952	0.949
	TMLE	0.034	31.94	31.94	0.995	0.944	− 0.327	24.45	24.56	0.973	0.941

The bias, variance (VAR), mean squared error (MSE) and coverage probabilities (CP) based on bias-corrected and accelerated bootstrap 95% confidence interval are displayed for the Kaplan–Meier (KM), unadjusted inverse probability weighted (IPW), adjusted IPW (Adj. IPW), augmented IPW (AIPW) and proposed targeted minimum loss based (TMLE) estimator. The relative MSE (RMSE) is the ratio of the MSE for the KM estimator to the other estimators

Table 3 Revised simulation results for studies of size $n = 2000$

Scenario	Estimator	Zero treatment effect ($\theta = 0$)				Positive treatment effect ($\theta = 14.9$)			
		Bias	Var	MSE	RMSE	Bias	Var	MSE	RMSE
Non-informative censoring, i.e., censoring independent of baseline variables									
A	KM	−0.070	8.86	8.86	1.000	−0.018	6.79	6.79	1.000
	IPW	−0.070	8.95	8.95	0.990	0.013	6.88	6.88	0.988
	Adj. IPW	−0.059	9.00	9.01	0.984	0.060	6.88	6.89	0.986
	AIPW	−0.051	7.91	7.91	1.120	0.046	6.03	6.04	1.125
	TMLE	−0.051	7.83	7.83	1.131	−0.141	5.98	6.00	1.132
B	KM	0.020	8.92	8.92	1.000	−0.061	6.68	6.68	1.000
	IPW	0.021	9.01	9.01	0.990	−0.030	6.75	6.75	0.989
	Adj. IPW	0.031	9.09	9.09	0.981	0.009	6.79	6.79	0.984
	AIPW	0.014	8.74	8.74	1.020	0.003	6.52	6.52	1.024
	TMLE	0.014	8.65	8.65	1.031	−0.193	6.47	6.50	1.027
C	KM	−0.010	8.78	8.78	1.000	−0.037	6.77	6.77	1.000
	IPW	−0.010	8.87	8.87	0.990	−0.006	6.85	6.85	0.989
	Adj. IPW	0.002	8.94	8.94	0.982	0.033	6.89	6.89	0.982
	AIPW	−0.012	8.87	8.87	0.990	0.036	6.83	6.83	0.992
	TMLE	−0.012	8.78	8.78	1.000	−0.162	6.77	6.80	0.996

Table 3 continued

Scenario	Estimator	Zero treatment effect ($\theta = 0$)				Positive treatment effect ($\theta = 14.9$)			
		Bias	Var	MSE	RMSE	Bias	Var	MSE	RMSE
Informative censoring, i.e., censoring depends on baseline variables									
A	KM	0.799	7.78	8.42	1.000	1.648	5.65	8.36	1.000
	IPW	0.792	7.81	8.44	0.997	1.662	5.67	8.44	0.991
	Adj. IPW	− 0.091	8.32	8.33	1.011	− 0.031	6.35	6.35	1.317
	AIPW	− 0.021	7.23	7.23	1.165	0.028	5.56	5.56	1.503
	TMLE	− 0.026	7.16	7.16	1.176	− 0.123	5.53	5.54	1.509
B	KM	0.407	8.08	8.25	1.000	0.858	5.75	6.49	1.000
	IPW	0.396	8.12	8.28	0.997	0.869	5.78	6.53	0.993
	Adj. IPW	− 0.052	8.45	8.45	0.976	0.036	6.19	6.19	1.047
	AIPW	− 0.013	8.12	8.12	1.016	0.068	6.00	6.00	1.080
	TMLE	− 0.016	8.04	8.04	1.026	− 0.084	5.96	5.96	1.088
C	KM	− 0.009	8.11	8.11	1.000	− 0.009	5.87	5.87	1.000
	IPW	− 0.023	8.15	8.15	0.995	− 0.002	5.90	5.90	0.995
	Adj. IPW	− 0.026	8.27	8.27	0.981	0.020	6.04	6.04	0.972
	AIPW	− 0.006	8.22	8.22	0.987	0.033	6.01	6.01	0.977
	TMLE	− 0.005	8.14	8.14	0.996	− 0.116	5.96	5.97	0.984

The bias, variance (VAR), and mean squared error (MSE) are displayed for the Kaplan–Meier (KM), unadjusted inverse probability weighted (IPW), adjusted IPW (Adj. IPW), augmented IPW (AIPW) and proposed targeted minimum loss based (TMLE) estimator. The relative MSE (RMSE) is the ratio of the MSE for the KM estimator to the other estimators

($\hat{\theta}_{\text{adj,eff}}$) confidence interval coverage probabilities ranged from 93 to 95% (previously 94–95%); the updated TMLE bias was sometime larger (with maximum absolute value 0.494 in Table 2, top half, positive treatment effect, scenario B), but still was small (at most 3%) as a fraction of the treatment effect (14.9 days) and had negligible influence on the mean squared error; the adjusted inverse probability weighted (adjusted IPW) estimator $\hat{\theta}_{\text{adj,ipw}}$ had larger variance.

The most important numerical differences in comparison with our initial results are highlighted in boldface, and all involve the adjusted IPW estimator. The only qualitative change to the conclusions of our initial study is as follows. Inclusion of time as a non-parametric term in our models increased variability in the inverse probability weights of $\hat{\theta}_{\text{adj,ipw}}$. As a result, in most scenarios, this estimator was more variable. Most of the gains in MSE for the adjusted IPW compared to the Kaplan–Meier estimator that were reported in our original manuscript were not present after the errors were fixed.

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