

Open Research Online

The Open University's repository of research publications and other research outputs

Multiple Imputation of Composite Covariates in Survival Studies

Journal Item

How to cite:

Clements, Lily; Kimber, Alan C. and Biedermann, Stefanie (2022). Multiple Imputation of Composite Covariates in Survival Studies. *Stats*, 5(2) pp. 358–370.

For guidance on citations see [FAQs](#).

© 2022 The Authors



<https://creativecommons.org/licenses/by/4.0/>

Version: Supplementary Material

Link(s) to article on publisher's website:
<http://dx.doi.org/doi:10.3390/stats5020020>

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online's data [policy](#) on reuse of materials please consult the policies page.

oro.open.ac.uk

Supplementary Materials: Multiple Imputation of Composite Covariates in Survival Studies

Lily Clements¹, Alan C. Kimber^{2,*} and Stefanie Biedermann³

Table S1. PB, CR, and AW for the estimated coefficients of the composite covariate in a exponential AFT substantive model when N = 500 and 10% of observations are censored.

			No Auxiliary Variables			One Auxiliary Variable		
			PB	CR (%)	AW	PB	CR (%)	AW
FCS-BLR	MCAR	AWO	0.46	96.3	0.0468	0.08	96.2	0.0452
		APA	0.26	96.3	0.0449	0.24	96.0	0.0439
		PNP	2.07	96.4	0.0447	1.75	96.3	0.0438
	MAR1	LNP	0.78	96.6	0.0451	1.01	96.0	0.0442
		AWO	1.88	95.8	0.0452	0.47	95.8	0.0440
		APA	1.23	94.7	0.0436	0.44	95.1	0.0429
	MAR2	PNP	0.69	95.5	0.0435	1.61	95.1	0.0426
		LNP	2.85	94.7	0.0440	1.98	95.3	0.0432
		AWO	4.91	93.5	0.0439	2.01	94.5	0.0428
		APA	3.13	93.8	0.0427	1.44	95.0	0.0421
		PNP	0.96	94.5	0.0424	0.75	95.3	0.0417
		LNP	5.33	93.3	0.0431	3.54	94.4	0.0425
FCS-PMM	MCAR	AWO	1.47	96.4	0.0465	0.77	96.2	0.0454
		APA	2.54	96.1	0.0453	2.12	95.4	0.0443
		PNP	1.79	96.3	0.0452	1.22	95.2	0.0440
	MAR1	LNP	0.64	96.3	0.0449	0.77	95.5	0.0441
		AWO	2.67	95.5	0.0453	1.82	94.9	0.0443
		APA	5.11	93.7	0.0442	3.18	94.7	0.0434
	MAR2	PNP	4.48	94.4	0.0440	2.48	94.7	0.0431
		LNP	3.22	93.9	0.0439	2.09	94.8	0.0432
		AWO	0.38	92.4	0.0447	3.90	93.6	0.0434
		APA	7.79	92.0	0.0435	5.30	93.5	0.0428
		PNP	7.16	92.7	0.0433	4.39	93.8	0.0425
		LNP	5.88	93.0	0.0432	3.92	93.7	0.0426
SMCFCs-BLR	MCAR	PNP	1.06	94.0	0.0446	2.62	94.9	0.0439
		LNP	0.78	94.8	0.0449	1.60	94.9	0.0435
	MAR1	PNP	0.13	94.9	0.0433	1.00	94.6	0.0428
		LNP	0.58	93.6	0.0437	0.25	94.8	0.0423
	MAR2	PNP	0.76	94.4	0.0429	0.67	94.1	0.0422
		LNP	0.05	95.1	0.0426	0.81	94.7	0.0417

Table S2. PB, CR, and AW for the estimated coefficients of the composite covariate in a exponential AFT substantive model when N = 500 and 15% of observations are censored.

			No Auxiliary Variables			One Auxiliary Variable		
			PB	CR (%)	AW	PB	CR (%)	AW
FCS-BLR	MCAR	AWO	3.37	94.8	0.0484	2.17	95.9	0.0467
		APA	2.47	95.8	0.0462	1.88	95.9	0.0451
		PNP	4.02	95.0	0.0460	3.89	95.9	0.0450
	MAR1	LNP	1.01	94.7	0.0465	0.94	95.6	0.0456
		AWO	0.59	95.5	0.0465	0.21	94.9	0.0451
		APA	0.25	94.8	0.0449	0.51	94.6	0.0440
	MAR2	PNP	1.60	95.2	0.0447	2.46	95.0	0.0438
		LNP	2.22	93.7	0.0453	1.18	94.5	0.0445
		AWO	4.22	94.4	0.0452	1.54	95.1	0.0442
		APA	2.18	94.6	0.0440	0.82	95.1	0.0433
		PNP	0.00	94.7	0.0437	1.48	95.4	0.0430
		LNP	4.46	94.4	0.0444	2.81	94.8	0.0438
FCS-PMM	MCAR	AWO	2.77	95.1	0.0481	2.85	95.3	0.0467
		APA	0.40	94.7	0.0467	0.05	95.1	0.0456
		PNP	0.21	94.7	0.0465	0.62	95.7	0.0454
	MAR1	LNP	1.55	94.9	0.0463	1.09	95.6	0.0454
		AWO	2.36	94.5	0.0468	1.41	94.7	0.0456
		APA	4.34	93.0	0.0456	2.61	94.0	0.0445
	MAR2	PNP	3.69	93.5	0.0454	1.68	94.4	0.0444
		LNP	2.42	94.1	0.0453	1.34	94.1	0.0445
		AWO	0.08	89.5	0.0461	3.36	94.4	0.0447
		APA	7.02	93.2	0.0448	4.46	94.2	0.0440
		PNP	6.27	93.5	0.0446	3.68	94.8	0.0437
		LNP	4.93	93.9	0.0444	3.31	94.3	0.0439
SMCFCs-BLR	MCAR	PNP	0.45	94.3	0.0438	0.91	95.4	0.0449
		LNP	0.28	95.4	0.0435	0.25	95.6	0.0452
	MAR1	PNP	0.68	94.9	0.0443	1.52	94.7	0.0438
		LNP	0.09	94.8	0.0440	0.20	95.2	0.0443
	MAR2	PNP	0.39	94.4	0.0441	2.27	95.2	0.0426
		LNP	0.40	94.5	0.0438	0.67	95.2	0.0431

Table S3. PB, CR, and AW for the estimated coefficients of the composite covariate in a exponential AFT substantive model when N = 500 and 20% of observations are censored.

			No Auxiliary Variables			One Auxiliary Variable			
			PB	CR (%)	AW	PB	CR (%)	AW	
FCS-BLR	MCAR	AWO	4.01	95.3	0.0502	2.86	94.7	0.0485	
		APA	3.41	94.5	0.0481	2.70	94.7	0.0470	
		PNP	4.97	93.8	0.0478	4.64	95.0	0.0468	
	MAR1	LNP	1.89	94.5	0.0483	1.51	94.8	0.0474	
		AWO	0.57	94.5	0.0485	0.98	94.2	0.0470	
		APA	1.13	93.9	0.0468	1.49	94.1	0.0459	
	MAR2	PNP	2.91	93.9	0.0465	3.70	93.9	0.0455	
		LNP	1.00	93.3	0.0472	0.21	94.2	0.0464	
		AWO	2.51	94.2	0.0470	0.32	94.9	0.0459	
	FCS-PMM	MCAR	APA	1.12	95.2	0.0458	0.61	95.3	0.0450
			PNP	1.17	96.0	0.0455	2.79	95.2	0.0446
			LNP	3.27	94.7	0.0461	1.53	95.2	0.0455
MAR1		AWO	3.93	93.9	0.0499	3.42	95.0	0.0486	
		APA	0.65	94.5	0.0486	0.78	94.1	0.0474	
		PNP	1.19	94.4	0.0485	1.64	94.7	0.0472	
MAR2		LNP	2.29	93.7	0.0483	1.85	95.2	0.0472	
		AWO	0.86	94.3	0.0487	0.55	94.5	0.0474	
		APA	3.18	93.4	0.0475	1.39	93.8	0.0464	
SMCFCs-BLR		MCAR	PNP	2.51	94.3	0.0474	0.64	93.9	0.0463
			LNP	1.29	93.7	0.0472	0.49	93.7	0.0463
			AWO	2.52	90.4	0.0479	1.45	94.7	0.0464
	MAR1	APA	5.49	93.1	0.0466	2.96	94.6	0.0457	
		PNP	4.92	93.2	0.0463	2.08	94.5	0.0455	
		LNP	3.76	93.9	0.0462	1.92	94.9	0.0454	
	MAR2	PNP	0.47	94.7	0.0460	0.38	93.5	0.0458	
		LNP	0.97	94.0	0.0457	1.57	94.1	0.0453	
		PNP	0.59	93.6	0.0463	0.82	93.8	0.0459	
	MAR2	LNP	1.08	93.6	0.0461	2.14	93.5	0.0454	
		PNP	0.73	93.5	0.0462	1.20	94.4	0.0453	
		LNP	1.29	93.6	0.0459	2.65	94.1	0.0448	

Table S4. PB, CR, and AW for the estimated coefficients of the composite covariate in a exponential AFT substantive model when N = 1000 and 10% of observations are censored.

			No Auxiliary Variables			One Auxiliary Variable		
			PB	CR (%)	AW	PB	CR (%)	AW
FCS-BLR	MCAR	AWO	1.86	95.1	0.0338	0.80	95.2	0.0317
		APA	2.27	95.7	0.0314	0.32	95.0	0.0308
		PNP	4.33	95.5	0.0314	2.05	95.5	0.0307
	MAR1	LNP	1.45	95.6	0.0317	0.68	96.0	0.0310
		AWO	0.73	95.5	0.0327	0.37	95.6	0.0307
		APA	0.15	95.8	0.0306	0.53	95.3	0.0301
	MAR2	PNP	2.15	96.1	0.0304	1.44	96.1	0.0299
		LNP	1.43	95.3	0.0309	2.13	95.4	0.0303
		AWO	5.02	93.6	0.0308	2.08	94.6	0.0302
		APA	3.15	94.3	0.0300	1.44	94.0	0.0296
		PNP	0.82	94.9	0.0299	0.76	94.4	0.0293
		LNP	5.06	92.6	0.0302	3.34	93.6	0.0298
FCS-PMM	MCAR	AWO	2.14	94.6	0.0325	1.60	95.3	0.0318
		APA	1.57	95.0	0.0317	1.16	95.3	0.0310
		PNP	1.09	95.3	0.0317	0.74	95.6	0.0309
	MAR1	LNP	0.23	95.8	0.0315	0.19	95.5	0.0309
		AWO	2.51	94.9	0.0318	1.65	95.1	0.0310
		APA	5.07	93.7	0.0311	3.25	95.3	0.0304
	MAR2	PNP	4.66	94.2	0.0309	2.66	95.3	0.0303
		LNP	3.16	94.8	0.0309	2.18	95.4	0.0304
		AWO	1.04	86.4	0.0316	3.76	93.9	0.0305
		APA	7.89	91.1	0.0306	4.91	93.5	0.0300
		PNP	7.33	91.6	0.0304	4.30	93.6	0.0299
		LNP	5.69	92.4	0.0303	3.69	93.8	0.0299
SMCFCs-BLR	MCAR	PNP	1.10	95.5	0.0315	1.20	94.4	0.0453
		LNP	0.48	95.9	0.0313	2.65	94.1	0.0448
	MAR1	PNP	1.09	95.1	0.0307	1.20	94.4	0.0453
		LNP	0.40	95.8	0.0304	2.65	94.1	0.0448
	MAR2	PNP	0.34	94.9	0.0300	0.74	94.4	0.0453
		LNP	0.35	94.8	0.0298	2.65	94.1	0.0448

Table S5. PB, CR, and AW for the estimated coefficients of the composite covariate in a exponential AFT substantive model when N = 1000 and 15% of observations are censored.

			No Auxiliary Variables			One Auxiliary Variable		
			PB	CR (%)	AW	PB	CR (%)	AW
FCS-BLR	MCAR	AWO	1.86	95.1	0.0338	1.41	95.7	0.0328
		APA	3.02	96.1	0.0324	1.07	96.1	0.0317
		PNP	5.02	96.1	0.0324	2.90	96.2	0.0316
	MAR1	LNP	2.13	96.3	0.0327	0.08	96.3	0.0320
		AWO	0.73	95.5	0.0327	0.51	94.6	0.0318
		APA	1.41	95.1	0.0315	0.74	95.2	0.0310
		PNP	3.65	95.1	0.0314	2.75	95.1	0.0309
		LNP	0.22	95.2	0.0319	0.85	95.0	0.0313
		AWO	3.83	93.9	0.0318	1.07	94.0	0.0310
	MAR2	APA	1.27	94.4	0.0309	0.72	94.4	0.0305
		PNP	1.01	94.8	0.0307	1.53	95.0	0.0302
		LNP	3.18	93.9	0.0313	2.71	93.7	0.0308
FCS-PMM	MCAR	AWO	2.30	95.2	0.0337	2.20	95.1	0.0327
		APA	0.95	95.8	0.0329	0.60	95.5	0.0320
		PNP	0.49	95.4	0.0328	0.02	95.9	0.0319
		LNP	0.71	95.9	0.0326	0.28	96.2	0.0319
	MAR1	AWO	1.45	95.0	0.0328	0.81	94.7	0.0321
		APA	3.75	93.7	0.0321	2.03	94.7	0.0314
		PNP	3.29	94.0	0.0320	1.40	94.5	0.0312
		LNP	1.83	94.7	0.0319	0.96	95.0	0.0313
	MAR2	AWO	0.76	84.6	0.0325	2.81	92.5	0.0314
		APA	6.92	91.3	0.0316	4.26	92.7	0.0309
		PNP	6.46	91.5	0.0314	3.61	93.7	0.0308
		LNP	4.89	93.1	0.0313	3.11	93.6	0.0308
SMCFCs-BLR	MCAR	PNP	0.80	94.1	0.0317	1.10	95.4	0.0344
		LNP	0.12	94.2	0.0315	2.67	93.9	0.0342
	MAR1	PNP	0.13	94.7	0.0317	0.43	94.5	0.0338
		LNP	0.47	94.5	0.0314	1.74	94.8	0.0334
	MAR2	PNP	0.14	95.2	0.0308	1.20	94.8	0.0326
		LNP	0.98	95.0	0.0306	3.27	94.1	0.0330

Table S6. PB, CR, and AW for the estimated coefficients of the composite covariate in a exponential AFT substantive model when N = 1000 and 20% of observations are censored.

			No Auxiliary Variables			One Auxiliary Variable		
			PB	CR (%)	AW	PB	CR (%)	AW
FCS-BLR	MCAR	AWO	1.24	95.3	0.0354	1.20	94.2	0.0342
		APA	2.31	94.6	0.0339	0.86	94.4	0.0331
		PNP	4.35	94.7	0.0337	2.75	94.4	0.0329
	MAR1	LNP	1.26	94.5	0.0342	0.17	94.3	0.0334
		AWO	0.52	94.2	0.0340	0.93	94.4	0.0331
		APA	1.46	94.8	0.0329	0.86	94.6	0.0324
	MAR2	PNP	3.53	95.2	0.0328	2.84	94.3	0.0321
		LNP	0.33	94.6	0.0333	0.94	94.7	0.0326
		AWO	3.69	93.3	0.0331	0.64	94.7	0.0323
		APA	1.30	94.5	0.0322	0.38	95.0	0.0318
		PNP	1.03	94.9	0.0319	1.72	95.1	0.0315
		LNP	3.34	93.4	0.0325	2.55	93.7	0.0321
FCS-PMM	MCAR	AWO	1.58	95.3	0.0353	1.89	94.4	0.0343
		APA	1.74	93.8	0.0343	0.82	94.1	0.0334
		PNP	1.33	94.7	0.0343	0.32	94.8	0.0333
	MAR1	LNP	0.10	94.3	0.0341	0.02	94.5	0.0333
		AWO	1.40	93.8	0.0343	0.63	94.4	0.0335
		APA	3.84	93.5	0.0336	1.97	93.4	0.0328
		PNP	3.38	93.7	0.0334	1.44	94.6	0.0326
		LNP	1.95	94.3	0.0332	1.12	93.9	0.0326
		AWO	1.64	86.1	0.0338	2.36	93.4	0.0326
	MAR2	APA	6.86	91.7	0.0329	3.94	93.5	0.0323
		PNP	6.36	91.8	0.0327	3.38	93.6	0.0321
		LNP	4.92	92.3	0.0326	2.96	93.5	0.0321
SMCFCs-BLR	MCAR	PNP	1.01	94.5	0.0340	1.41	94.1	0.0337
		LNP	0.49	93.9	0.0338	0.74	93.6	0.0333
	MAR1	PNP	0.09	94.7	0.0331	0.34	94.3	0.0329
		LNP	0.69	95.0	0.0328	0.09	94.3	0.0326
	MAR2	PNP	0.10	94.6	0.0323	0.77	94.4	0.0321
		LNP	0.63	94.6	0.0320	2.56	93.9	0.0319

Table S7. PB, CR, and AW for the estimated coefficients of the composite covariate in a exponential AFT substantive model when N = 2000 and 10% of observations are censored.

			No Auxiliary Variables			One Auxiliary Variable		
			PB	CR (%)	AW	PB	CR (%)	AW
FCS-BLR	MCAR	AWO	1.72	95.3	0.0231	1.33	95.8	0.0224
		APA	1.36	95.9	0.0223	1.16	95.1	0.0217
		PNP	3.14	94.8	0.0222	2.91	94.9	0.0217
	MAR1	LNP	0.45	95.3	0.0224	0.27	95.2	0.0219
		AWO	0.67	95.0	0.0223	0.75	95.0	0.0217
		APA	0.18	95.1	0.0216	0.84	95.5	0.0212
	MAR2	PNP	2.13	95.5	0.0215	2.74	95.3	0.0211
		LNP	1.43	94.2	0.0218	0.67	95.0	0.0214
		AWO	4.09	93.6	0.0217	1.19	95.1	0.0213
		APA	2.13	95.4	0.0212	0.37	95.4	0.0209
		PNP	0.00	95.3	0.0210	1.72	95.2	0.0207
		LNP	4.08	94.6	0.0214	2.32	95.3	0.0211
FCS-PMM	MCAR	AWO	2.29	95.0	0.0230	2.28	95.4	0.0224
		APA	0.79	95.1	0.0224	0.14	94.7	0.0219
		PNP	0.56	94.9	0.0224	0.10	95.3	0.0218
	MAR1	LNP	0.78	95.3	0.0223	0.55	95.2	0.0218
		AWO	1.37	95.2	0.0224	0.40	95.4	0.0220
		APA	3.48	93.6	0.0219	1.76	94.3	0.0215
	MAR2	PNP	3.24	93.6	0.0218	1.35	94.9	0.0214
		LNP	1.67	94.2	0.0218	0.84	95.2	0.0214
		AWO	0.63	79.2	0.0224	2.96	94.3	0.0216
		APA	6.78	90.7	0.0216	3.91	94.4	0.0212
		PNP	6.41	92.2	0.0215	3.36	94.1	0.0211
		LNP	4.75	93.9	0.0214	2.67	94.5	0.0211
SMCFCs-BLR	MCAR	PNP	0.52	95.6	0.0222	0.81	95.5	0.0217
		LNP	0.08	95.5	0.0221	0.15	95.0	0.0215
	MAR1	PNP	0.46	95.5	0.0216	0.68	95.3	0.0212
		LNP	1.15	95.5	0.0214	1.95	95.4	0.0209
	MAR2	PNP	0.61	95.3	0.0211	1.38	95.6	0.0208
		LNP	1.43	95.8	0.0210	2.98	94.7	0.0205

Table S8. PB, CR, and AW for the estimated coefficients of the composite covariate in a exponential AFT substantive model when N = 2000 and 20% of observations are censored.

			No Auxiliary Variables			One Auxiliary Variable		
			PB	CR (%)	AW	PB	CR (%)	AW
FCS-BLR	MCAR	AWO	1.83	94.6	0.0250	0.87	96.9	0.0231
		APA	1.69	95.3	0.0240	0.87	96.4	0.0225
		PNP	3.57	95.3	0.0238	2.75	95.0	0.0223
	MAR1	LNP	0.64	95.2	0.0241	0.07	97.0	0.0226
		AWO	0.42	94.8	0.0241	0.69	94.4	0.0233
		APA	0.00	94.3	0.0233	0.82	94.2	0.0228
	MAR2	PNP	2.07	94.8	0.0232	2.67	94.0	0.0227
		LNP	1.78	94.1	0.0235	0.99	94.3	0.0231
		AWO	3.23	93.5	0.0234	0.44	94.9	0.0228
		APA	1.69	94.4	0.0228	0.03	94.6	0.0225
		PNP	0.46	95.0	0.0227	2.12	94.4	0.0222
		LNP	3.90	93.2	0.0230	2.11	94.4	0.0227
FCS-PMM	MCAR	AWO	2.21	94.5	0.0249	2.21	94.0	0.0241
		APA	0.80	94.7	0.0243	0.15	94.5	0.0236
		PNP	0.45	94.6	0.0242	0.25	94.5	0.0236
	MAR1	LNP	0.82	94.7	0.0241	0.59	94.3	0.0235
		AWO	1.29	93.8	0.0242	0.59	93.6	0.0236
		APA	3.85	93.2	0.0237	1.95	93.9	0.0231
		PNP	3.45	93.4	0.0236	1.55	93.8	0.0231
		LNP	2.05	93.7	0.0235	1.15	94.6	0.0230
		AWO	1.74	78.5	0.0241	2.08	93.9	0.0231
	MAR2	APA	6.48	90.3	0.0232	3.52	93.6	0.0228
		PNP	6.07	90.6	0.0231	2.95	94.1	0.0227
		LNP	4.55	92.8	0.0230	2.52	94.7	0.0227
SMCFCs-BLR	MCAR	PNP	0.09	94.2	0.0240	0.34	94.3	0.0234
		LNP	0.53	94.2	0.0238	0.67	93.7	0.0232
	MAR1	PNP	0.26	94.6	0.0233	0.55	94.4	0.0228
		LNP	0.96	94.6	0.0231	1.86	93.8	0.0226
	MAR2	PNP	0.45	94.5	0.0227	1.34	93.5	0.0223
		LNP	1.21	94.0	0.0225	2.92	93.1	0.0221