

Supporting Information for “Robust semiparametric
gene-environment interaction analysis using sparse boosting” by
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This file contains additional simulation and data analysis results.

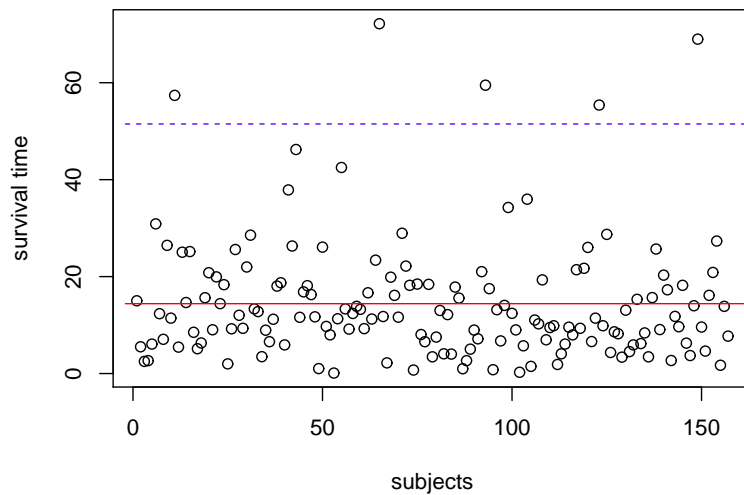


Figure S1: Analysis of STAD data. Scatter plot of survival time with the solid horizontal line indicating $\text{mean}(\text{survival time})$ and dashed horizontal line indicating $\text{mean}(\text{survival time}) + 3\text{sd}(\text{survival time})$.

Table S1: Summary of simulation settings. Table: Table number of the results; Missing: presence of missingness; Distribution: Distribution of G variables; Model: Model for the response; Error: Error distribution.

Table	Missing	Scenario	Distribution	Model	Error
1	No	1	Continuous	Linear	$N(0, 1)$
1	No	2	Continuous	Linear	$90\%N(0, 1) + 10\%Cauchy(0, 5)$
1	No	3	Continuous	Linear	$90\%N(0, 1) + 10\%LogNormal(0, 3)$
1	No	4	Continuous	Linear	$90\%N(0, 1) + 10\%Slash$
2	No	5	Continuous	AFT	$N(0, 1)$
2	No	6	Continuous	AFT	$90\%N(0, 1) + 10\%Cauchy(0, 5)$
2	No	7	Continuous	AFT	$90\%N(0, 1) + 10\%LogNormal(0, 3)$
2	No	8	Continuous	AFT	$90\%N(0, 1) + 10\%Slash$
S2	No	9	Categorical	Linear	$N(0, 1)$
S2	No	10	Categorical	Linear	$90\%N(0, 1) + 10\%Cauchy(0, 5)$
S2	No	11	Categorical	Linear	$90\%N(0, 1) + 10\%LogNormal(0, 3)$
S2	No	12	Categorical	Linear	$90\%N(0, 1) + 10\%Slash$
S3	No	13	Categorical	AFT	$N(0, 1)$
S3	No	14	Categorical	AFT	$90\%N(0, 1) + 10\%Cauchy(0, 5)$
S3	No	15	Categorical	AFT	$90\%N(0, 1) + 10\%LogNormal(0, 3)$
S3	No	16	Categorical	AFT	$90\%N(0, 1) + 10\%Slash$
S4	Yes	1	Continuous	Linear	$N(0, 1)$
S5	Yes	2	Continuous	Linear	$90\%N(0, 1) + 10\%Cauchy(0, 5)$
S6	Yes	3	Continuous	Linear	$90\%N(0, 1) + 10\%LogNormal(0, 3)$
S7	Yes	4	Continuous	Linear	$90\%N(0, 1) + 10\%Slash$
S8	Yes	5	Continuous	AFT	$N(0, 1)$
S9	Yes	6	Continuous	AFT	$90\%N(0, 1) + 10\%Cauchy(0, 5)$
S10	Yes	7	Continuous	AFT	$90\%N(0, 1) + 10\%LogNormal(0, 3)$
S11	Yes	8	Continuous	AFT	$90\%N(0, 1) + 10\%Slash$
S12	Yes	9	Categorical	Linear	$N(0, 1)$
S13	Yes	10	Categorical	Linear	$90\%N(0, 1) + 10\%Cauchy(0, 5)$
S14	Yes	11	Categorical	Linear	$90\%N(0, 1) + 10\%LogNormal(0, 3)$
S15	Yes	12	Categorical	Linear	$90\%N(0, 1) + 10\%Slash$
S16	Yes	13	Categorical	AFT	$N(0, 1)$
S17	Yes	14	Categorical	AFT	$90\%N(0, 1) + 10\%Cauchy(0, 5)$
S18	Yes	15	Categorical	AFT	$90\%N(0, 1) + 10\%LogNormal(0, 3)$
S19	Yes	16	Categorical	AFT	$90\%N(0, 1) + 10\%Slash$

Table S2: Simulation Scenarios 9-12 without missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
Scenario 9						
A1	8.5(1.7)	8.7(1.5)	9.8(4.1)	0.72(0.24)	1.14(0.66)	4.49(1.73)
A2	6.9(1.1)	2.1(0.3)	14.2(3.4)	1.59(0.33)	38.52(6.80)	13.94(3.65)
A3	8.6(2.0)	8.7(1.6)	23.3(5.0)	0.77(0.29)	1.22(0.65)	5.23(2.45)
A4	4.2(1.4)	3.8(1.3)	33.2(2.4)	1.24(0.31)	2.39(0.72)	12.98(5.05)
A5	3.0(1.2)	4.5(0.9)	30.0(8.5)	1.56(0.25)	44.57(7.64)	9.56(3.44)
Scenario 10						
A1	7.6(1.4)	7.6(1.9)	12.6(4.7)	0.89(0.26)	1.39(0.75)	7.75(3.47)
A2	6.3(1.4)	2.0(0.1)	14.6(3.5)	1.86(0.43)	38.12(7.42)	18.40(4.67)
A3	4.2(2.6)	3.9(2.5)	31.4(9.8)	4.32(7.64)	21.81(54.36)	67.92(135.54)
A4	3.2(0.9)	2.8(1.0)	33.3(2.9)	1.35(0.26)	3.14(1.19)	20.25(3.86)
A5	1.1(1.2)	2.0(1.5)	18.8(12.4)	1.83(0.45)	22.67(16.15)	39.49(55.92)
Scenario 11						
A1	8.2(1.6)	8.4(1.7)	10.5(4.0)	0.78(0.24)	1.26(0.75)	5.92(2.55)
A2	6.6(1.2)	2.0(0.2)	13.8(3.1)	1.73(0.35)	37.88(7.75)	16.00(4.48)
A3	3.2(2.7)	2.9(2.5)	33.9(9.7)	20.56(80.97)	65.44(187.42)	114.39(200.46)
A4	3.8(1.5)	3.6(0.8)	32.0(5.1)	1.31(0.25)	3.12(1.03)	16.47(5.83)
A5	0.8(1.1)	1.3(1.5)	10.5(11.4)	1.66(0.22)	13.59(13.95)	56.48(76.65)
Scenario 12						
A1	8.6(1.7)	8.4(1.8)	10.3(3.6)	0.74(0.25)	1.16(0.59)	5.74(2.63)
A2	6.9(1.2)	2.0(0.2)	13.6(3.5)	1.61(0.30)	39.02(7.59)	15.59(5.14)
A3	7.4(2.9)	7.2(2.7)	27.2(7.3)	1.31(1.22)	2.96(4.09)	13.67(16.54)
A4	3.4(2.1)	3.1(1.1)	34.7(2.4)	1.35(0.39)	2.75(0.98)	17.47(8.04)
A5	2.5(1.4)	3.6(1.6)	25.3(11.6)	1.64(0.41)	37.34(13.25)	14.92(10.65)

Table S3: Simulation Scenarios 13-16 without missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
Scenario 13						
A1	8.5(1.3)	8.9(1.1)	9.8(3.5)	0.72(0.19)	1.47(0.58)	0.87(0.03)
A2	7.1(1.3)	2.4(0.6)	13.4(3.2)	1.21(0.26)	27.74(4.76)	0.79(0.06)
A3	8.8(1.6)	9.4(0.9)	18.7(5.4)	0.70(0.22)	1.51(0.68)	0.87(0.05)
A4	4.1(1.6)	3.4(1.2)	33.4(5.5)	1.25(0.17)	2.57(0.55)	0.77(0.05)
A5	2.9(1.1)	5.1(0.7)	36.2(13.1)	1.46(0.22)	34.65(4.35)	0.85(0.03)
Scenario 14						
A1	8.2(1.2)	7.9(1.7)	11.1(4.2)	0.78(0.19)	1.72(0.69)	0.82(0.09)
A2	6.8(1.2)	2.3(0.5)	13.2(3.8)	1.35(0.25)	26.99(5.07)	0.76(0.07)
A3	5.2(2.8)	4.7(2.6)	29.4(7.6)	4.95(18.70)	20.34(84.19)	0.68(0.12)
A4	2.8(1.6)	3.5(0.8)	34.5(3.8)	1.44(0.30)	3.38(0.69)	0.70(0.04)
A5	1.5(1.4)	2.6(1.9)	26.6(17.7)	1.67(0.34)	17.90(13.73)	0.69(0.11)
Scenario 15						
A1	8.6(1.5)	8.9(1.1)	10.0(4.0)	0.70(0.22)	1.35(0.69)	0.86(0.05)
A2	7.0(1.2)	2.4(0.5)	13.8(3.0)	1.27(0.26)	28.80(5.31)	0.77(0.08)
A3	8.5(1.3)	9.2(0.9)	20.2(5.9)	0.72(0.20)	1.46(0.76)	0.85(0.07)
A4	4.1(2.0)	3.7(1.2)	32.3(2.1)	1.29(0.37)	2.48(0.71)	0.76(0.06)
A5	2.6(1.0)	5.0(0.9)	36.1(10.8)	1.47(0.20)	34.29(4.43)	0.83(0.05)
Scenario 16						
A1	8.3(1.3)	8.5(1.5)	10.4(3.9)	0.74(0.18)	1.62(0.78)	0.86(0.05)
A2	7.2(1.1)	2.3(0.6)	12.8(3.6)	1.20(0.21)	28.66(5.98)	0.79(0.03)
A3	7.4(2.6)	7.3(2.7)	23.2(7.1)	1.13(1.01)	6.40(20.78)	0.81(0.10)
A4	3.9(1.6)	3.8(1.2)	33.1(3.8)	1.25(0.28)	2.86(0.78)	0.75(0.06)
A5	2.1(1.3)	4.0(1.6)	37.8(15.5)	1.61(0.28)	30.40(10.44)	0.79(0.10)

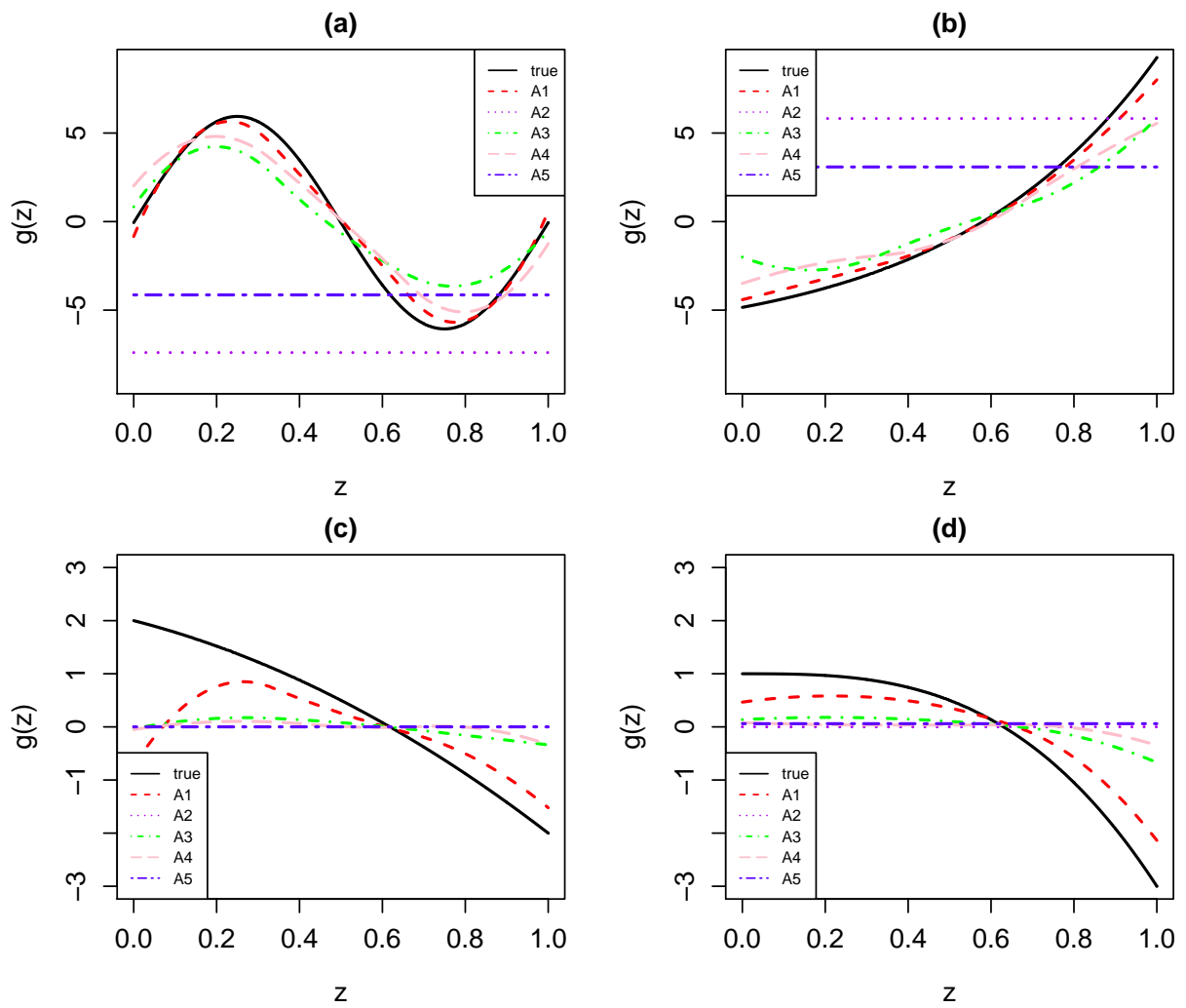


Figure S2: Simulation under Scenario 3: estimation of nonlinear effects. (a) $g(z) = 6 \sin(2\pi z) - 0.06$, (b) $g(z) = 6 \exp(2z - 1) - 7.05$, (c) $g(z) = -2z(1 + z) + 2$, and (d) $g(z) = -4z^3 + 1$.

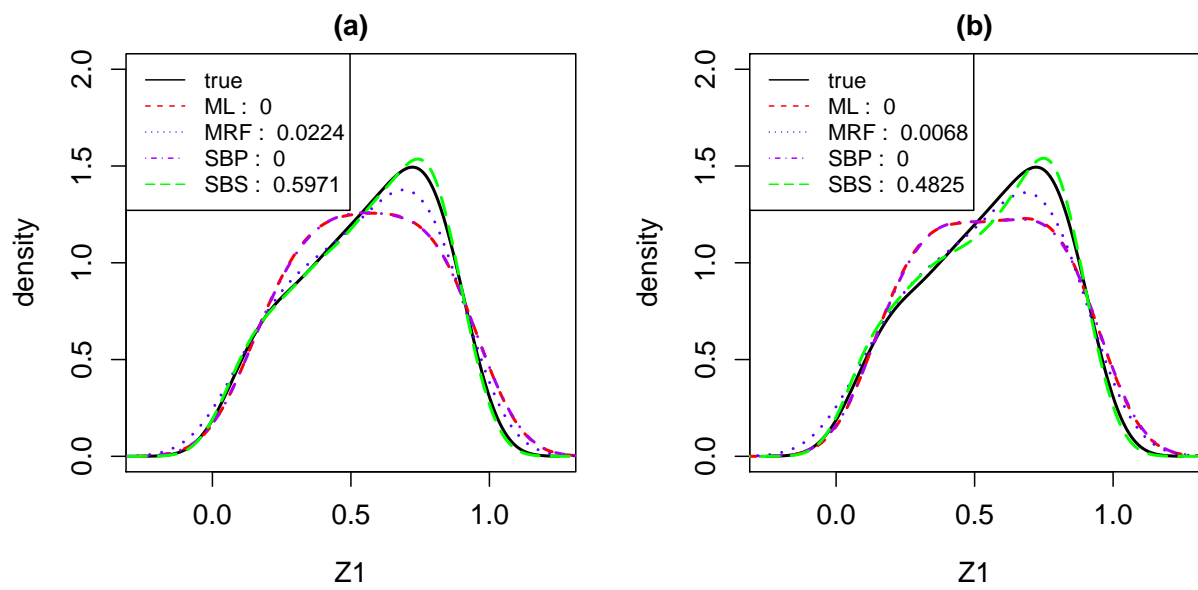


Figure S3: Simulation: density functions of imputed and true z_1 based on 200 replicates. (a) M1; (b) M2.

Table S4: Simulation Scenario 1 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.9(1.7)	9.0(1.4)	9.5(3.8)	0.67(0.23)	1.00(0.58)	4.18(1.65)
CC-A1	7.4(1.2)	7.1(1.9)	14.1(3.4)	0.78(0.25)	1.48(0.79)	7.42(2.58)
ML-A2	7.4(0.9)	2.2(0.5)	24.4(4.3)	1.52(0.31)	37.36(6.80)	13.39(4.12)
SBP-A2	7.5(1.0)	2.3(0.5)	24.6(5.4)	1.53(0.31)	37.24(6.75)	13.13(3.80)
MRF-A1	8.5(1.1)	8.6(1.6)	13.3(4.3)	0.70(0.21)	1.26(0.82)	4.92(1.42)
SBS-A3	9.3(1.7)	9.2(1.4)	13.3(4.0)	0.64(0.23)	1.03(0.56)	4.05(1.59)
SBS-A4	4.8(1.1)	4.2(1.4)	19.8(3.3)	1.22(0.23)	2.24(1.28)	10.29(9.50)
M2						
SBS-A1	8.6(1.5)	8.7(1.5)	8.0(3.5)	0.68(0.24)	1.09(0.94)	4.54(1.61)
CC-A1	5.2(1.1)	4.7(1.4)	20.7(4.7)	0.85(0.29)	2.17(1.49)	12.46(4.39)
ML-A2	7.2(1.1)	2.1(0.5)	13.5(3.1)	1.50(0.34)	36.28(7.20)	13.16(4.72)
SBP-A2	7.0(1.0)	2.1(0.5)	13.7(3.5)	1.52(0.33)	35.82(7.07)	12.96(3.95)
MRF-A1	7.7(1.0)	6.1(1.8)	9.1(4.6)	0.72(0.23)	1.84(0.78)	6.57(2.23)
SBS-A3	9.3(1.6)	9.2(1.3)	16.1(6.1)	0.64(0.20)	1.13(0.82)	4.33(1.65)
SBS-A4	2.4(1.1)	4.1(1.7)	17.4(2.1)	1.25(0.26)	2.22(1.20)	10.28(7.16)
M3						
SBS-A1	8.6(1.3)	8.8(1.3)	12.3(3.1)	0.69(0.24)	1.15(0.60)	4.58(1.46)
CC-A1	7.5(1.5)	7.4(2.0)	13.9(4.3)	0.75(0.24)	1.40(0.87)	7.30(3.47)
ML-A2	7.2(1.1)	2.2(0.5)	17.4(3.3)	1.48(0.31)	37.62(7.50)	12.93(4.17)
SBP-A2	7.0(1.0)	2.2(0.5)	18.3(3.8)	1.48(0.31)	37.45(8.03)	13.21(3.95)
MRF-A1	8.3(1.2)	8.3(1.6)	11.5(3.4)	0.70(0.23)	1.19(0.67)	5.22(1.69)
SBS-A3	8.9(1.4)	9.0(1.4)	23.0(4.8)	0.66(0.20)	1.24(0.56)	4.99(1.52)
SBS-A4	6.4(2.1)	4.1(1.4)	14.2(5.1)	1.20(0.42)	2.36(1.74)	8.09(4.12)
M4						
SBS-A1	7.9(1.0)	7.9(1.6)	11.3(3.7)	0.72(0.23)	1.51(0.69)	6.03(1.84)
CC-A1	5.2(1.5)	4.9(1.7)	21.0(4.0)	0.87(0.37)	2.09(1.26)	13.44(4.60)
ML-A2	7.0(0.9)	2.1(0.4)	17.5(3.1)	1.55(0.32)	36.73(7.22)	13.77(3.70)
SBP-A2	6.8(1.0)	2.1(0.4)	17.3(2.9)	1.56(0.31)	36.77(7.67)	14.03(3.92)
MRF-A1	7.7(0.9)	7.0(1.6)	12.3(3.4)	0.74(0.22)	1.59(0.75)	7.05(2.09)
SBS-A3	8.3(1.2)	8.1(1.8)	22.2(5.6)	0.69(0.20)	1.66(0.67)	6.49(2.27)
SBS-A4	4.8(1.9)	4.1(1.0)	9.4(2.1)	1.25(0.51)	2.59(0.78)	13.05(10.12)

Table S5: Simulation Scenario 2 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	7.5(1.6)	7.7(1.8)	11.5(4.1)	0.87(0.26)	1.29(0.53)	8.03(4.09)
CC-A1	6.1(1.4)	5.9(1.9)	15.5(4.8)	1.01(0.37)	1.90(0.79)	12.55(5.61)
ML-A2	6.6(1.1)	2.4(0.4)	23.3(5.7)	1.71(0.40)	36.21(7.43)	16.73(5.22)
SBP-A2	6.6(1.2)	2.4(0.5)	23.6(5.3)	1.71(0.40)	36.08(7.25)	16.24(4.49)
MRF-A1	7.5(1.4)	7.5(1.8)	15.1(4.1)	0.89(0.26)	1.46(0.57)	8.49(3.37)
SBS-A3	5.4(2.8)	5.0(2.7)	38.6(7.8)	39.25(204.24)	51.88(205.38)	169.61(712.66)
SBS-A4	6.0(2.4)	2.9(1.1)	23.2(3.8)	1.37(0.30)	2.62(0.49)	14.44(2.82)
M2						
SBS-A1	7.4(1.4)	7.4(1.8)	10.5(5.0)	0.87(0.27)	1.36(0.61)	7.94(3.65)
CC-A1	4.8(1.5)	4.2(1.5)	21.2(5.1)	1.40(1.02)	1.85(1.41)	18.53(7.51)
ML-A2	6.2(1.3)	2.2(0.4)	13.1(3.7)	1.70(0.40)	35.44(7.52)	16.61(4.80)
SBP-A2	6.2(1.3)	2.3(0.4)	12.9(3.6)	1.71(0.42)	35.95(7.47)	16.69(4.84)
MRF-A1	6.8(1.1)	4.8(1.7)	10.8(5.4)	0.93(0.28)	2.10(0.56)	9.90(3.31)
SBS-A3	5.0(2.6)	4.7(2.7)	28.2(10.6)	18.35(82.15)	97.50(429.42)	80.07(254.10)
SBS-A4	4.8(2.4)	2.8(1.0)	21.1(4.6)	1.38(0.33)	2.55(0.40)	13.40(2.84)
M3						
SBS-A1	7.1(1.3)	6.9(1.9)	9.1(3.3)	0.91(0.28)	1.50(0.62)	8.15(3.40)
CC-A1	6.1(1.6)	5.8(1.9)	15.7(5.3)	1.02(0.31)	1.75(0.63)	12.01(4.71)
ML-A2	6.2(1.3)	2.1(0.4)	12.5(3.6)	1.74(0.44)	36.48(7.21)	16.69(4.41)
SBP-A2	5.9(1.2)	2.1(0.4)	12.5(3.7)	1.76(0.43)	36.34(7.54)	16.74(5.02)
MRF-A1	7.0(1.3)	6.6(1.9)	8.9(3.3)	0.93(0.29)	1.50(0.56)	9.03(3.45)
SBS-A3	5.0(2.5)	4.5(2.6)	24.1(9.0)	36.63(190.32)	53.06(227.49)	148.34(620.87)
SBS-A4	6.0(3.4)	2.6(1.4)	15.2(6.6)	1.36(0.25)	2.89(0.54)	17.96(3.21)
M4						
SBS-A1	6.8(1.2)	6.5(1.6)	12.6(3.2)	0.97(0.31)	1.84(0.65)	9.82(3.17)
CC-A1	4.5(1.5)	4.0(1.5)	21.0(5.8)	1.08(0.32)	2.54(1.04)	19.38(7.25)
ML-A2	6.2(1.1)	2.2(0.4)	16.4(4.0)	1.81(0.50)	35.18(7.83)	17.13(5.20)
SBP-A2	6.0(1.3)	2.1(0.4)	16.4(4.4)	1.83(0.53)	36.08(8.85)	17.38(5.24)
MRF-A1	6.6(1.3)	5.8(1.7)	14.1(3.9)	0.98(0.29)	1.93(0.64)	10.38(3.12)
SBS-A3	5.0(2.5)	4.3(2.2)	33.6(9.2)	34.89(175.99)	47.69(195.19)	138.46(570.54)
SBS-A4	6.0(3.4)	2.0(0.8)	14.2(3.0)	1.37(0.25)	3.04(0.45)	18.49(0.74)

Table S6: Simulation Scenario 3 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.2(1.4)	8.3(1.4)	9.5(3.1)	0.77(0.26)	1.19(0.76)	5.59(2.52)
CC-A1	6.8(1.4)	6.3(1.7)	14.8(4.2)	0.86(0.33)	1.81(0.97)	9.70(3.32)
ML-A2	6.8(1.0)	2.1(0.3)	22.0(6.6)	1.63(0.37)	36.74(6.59)	14.69(3.30)
SBP-A2	6.7(1.1)	2.1(0.4)	22.1(5.7)	1.63(0.37)	36.65(6.37)	14.34(3.38)
MRF-A1	8.0(1.1)	8.2(1.4)	13.8(3.9)	0.79(0.25)	1.44(0.81)	6.38(2.16)
SBS-A3	3.4(2.5)	3.1(2.6)	23.6(12.3)	40.94(129.57)	61.66(219.16)	161.04(373.70)
SBS-A4	4.3(4.0)	2.9(1.2)	18.6(13.9)	1.28(0.37)	2.51(0.30)	12.56(7.81)
M2						
SBS-A1	8.0(1.4)	8.0(1.7)	9.1(3.6)	0.77(0.27)	1.30(1.06)	5.82(2.34)
CC-A1	4.8(1.3)	4.6(1.4)	19.1(4.8)	0.96(0.41)	2.75(2.13)	15.67(6.92)
ML-A2	6.4(1.1)	2.0(0.3)	12.5(4.4)	1.62(0.36)	35.26(6.51)	14.56(3.63)
SBP-A2	6.5(0.9)	2.1(0.3)	12.6(3.9)	1.62(0.38)	35.07(6.68)	14.33(3.67)
MRF-A1	7.5(1.2)	5.7(1.4)	9.3(4.6)	0.81(0.26)	2.12(0.97)	8.03(2.92)
SBS-A3	3.5(2.6)	3.0(2.5)	22.9(14.0)	41.78(132.35)	55.65(189.52)	162.34(384.84)
SBS-A4	0.0(0.0)	3.4(1.6)	17.0(5.0)	1.36(0.09)	2.26(0.19)	16.94(8.76)
M3						
SBS-A1	7.7(1.2)	7.6(1.6)	8.0(2.9)	0.78(0.27)	1.39(0.76)	6.31(2.56)
CC-A1	6.6(1.6)	6.4(1.8)	15.7(5.0)	0.87(0.27)	1.97(1.54)	10.30(5.48)
ML-A2	6.3(1.1)	2.1(0.3)	11.7(3.8)	1.61(0.40)	36.45(7.03)	14.02(3.23)
SBP-A2	6.2(0.9)	2.0(0.3)	11.7(3.7)	1.62(0.39)	36.80(7.62)	14.46(3.44)
MRF-A1	7.6(1.2)	7.3(1.6)	7.6(2.5)	0.79(0.26)	1.46(0.90)	6.81(2.41)
SBS-A3	3.7(2.5)	3.1(2.5)	28.3(9.5)	37.42(109.63)	55.83(219.77)	142.32(312.29)
SBS-A4	6.8(4.0)	2.8(0.5)	11.6(4.3)	1.27(0.28)	2.57(0.48)	14.20(3.22)
M4						
SBS-A1	7.5(1.2)	7.2(1.6)	10.8(3.3)	0.82(0.29)	1.73(0.80)	7.35(2.50)
CC-A1	4.7(1.5)	4.4(1.5)	20.1(5.3)	0.98(0.42)	2.76(2.00)	17.63(8.57)
ML-A2	6.4(1.0)	2.1(0.3)	15.5(4.1)	1.70(0.39)	35.17(6.74)	15.01(3.55)
SBP-A2	6.3(0.9)	2.1(0.3)	15.7(4.1)	1.70(0.38)	35.93(7.76)	15.58(3.82)
MRF-A1	7.3(1.2)	6.5(1.5)	12.1(3.3)	0.83(0.27)	1.85(0.92)	8.81(3.17)
SBS-A3	3.9(2.5)	3.3(2.5)	35.9(8.2)	47.90(175.16)	45.79(190.14)	189.34(562.70)
SBS-A4	1.7(2.0)	2.5(1.1)	10.5(13.6)	1.29(0.42)	2.86(0.23)	22.06(8.78)

Table S7: Simulation Scenario 4 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.6(1.6)	8.6(1.4)	9.0(3.9)	0.72(0.24)	1.08(0.68)	5.42(2.43)
CC-A1	7.3(1.4)	7.1(1.7)	13.5(4.5)	0.83(0.27)	1.55(1.42)	8.63(3.57)
ML-A2	7.2(1.0)	2.3(0.5)	24.1(4.9)	1.64(0.33)	37.51(6.95)	15.02(4.40)
SBP-A2	7.2(1.0)	2.3(0.5)	24.4(5.2)	1.63(0.32)	37.60(6.74)	14.97(4.50)
MRF-A1	8.3(1.3)	8.3(1.6)	12.3(4.7)	0.76(0.23)	1.23(0.59)	5.99(2.29)
SBS-A3	8.1(2.5)	7.7(2.4)	17.6(6.6)	1.06(0.92)	2.42(2.84)	8.54(6.27)
SBS-A4	2.6(1.3)	3.8(1.6)	20.8(3.3)	1.34(0.17)	2.67(0.55)	18.12(12.26)
M2						
SBS-A1	8.3(1.6)	8.5(1.4)	8.1(3.2)	0.74(0.24)	1.06(0.50)	5.43(2.47)
CC-A1	5.1(1.3)	4.7(1.5)	19.8(5.2)	0.92(0.35)	2.31(1.63)	15.66(6.04)
ML-A2	6.7(1.1)	2.1(0.4)	13.3(2.7)	1.61(0.29)	36.31(6.56)	15.19(4.67)
SBP-A2	6.7(1.0)	2.1(0.4)	13.4(2.9)	1.61(0.29)	36.51(6.46)	14.82(4.77)
MRF-A1	7.5(1.0)	5.8(1.6)	8.5(5.1)	0.80(0.23)	1.84(0.88)	8.21(3.19)
SBS-A3	8.0(2.5)	7.7(2.4)	21.0(6.7)	1.07(0.95)	2.26(2.39)	9.13(8.18)
SBS-A4	2.6(1.3)	3.9(1.0)	16.0(2.9)	1.33(0.09)	2.54(0.80)	17.60(5.75)
M3						
SBS-A1	8.0(1.3)	7.9(1.5)	7.3(2.6)	0.76(0.24)	1.21(0.53)	6.26(2.34)
CC-A1	6.7(1.1)	6.5(1.6)	13.9(4.1)	0.87(0.26)	1.64(1.27)	9.03(3.43)
ML-A2	6.8(1.0)	2.1(0.4)	12.4(3.2)	1.58(0.31)	37.41(6.84)	14.57(3.61)
SBP-A2	6.8(1.0)	2.1(0.4)	12.2(3.1)	1.60(0.29)	37.82(7.07)	14.53(4.15)
MRF-A1	8.0(1.4)	7.8(1.4)	7.5(2.8)	0.76(0.23)	1.29(0.74)	6.60(2.44)
SBS-A3	7.8(2.4)	7.0(2.4)	17.3(5.6)	1.07(0.78)	2.40(2.72)	8.98(6.71)
SBS-A4	2.6(1.3)	3.9(2.2)	13.0(3.0)	1.33(0.09)	2.53(0.61)	20.39(4.71)
M4						
SBS-A1	7.9(1.1)	7.7(1.4)	10.8(3.2)	0.80(0.26)	1.52(0.69)	7.66(2.76)
CC-A1	5.3(1.3)	4.6(1.6)	19.8(4.6)	0.93(0.33)	2.01(1.03)	15.42(6.00)
ML-A2	6.8(1.0)	2.1(0.4)	17.2(3.6)	1.65(0.29)	36.12(6.79)	15.30(3.81)
SBP-A2	6.6(1.0)	2.1(0.4)	17.3(3.4)	1.67(0.32)	36.54(6.93)	15.50(4.28)
MRF-A1	7.5(0.9)	6.6(1.4)	11.7(3.4)	0.82(0.25)	1.69(0.73)	8.66(2.82)
SBS-A3	7.7(2.0)	6.8(2.3)	26.5(6.3)	1.12(0.91)	2.73(2.59)	9.68(6.26)
SBS-A4	4.1(2.1)	3.4(2.6)	13.2(2.9)	1.29(0.14)	3.43(1.30)	29.07(4.02)

Table S8: Simulation Scenario 5 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.5(1.4)	9.2(1.0)	8.0(2.5)	0.71(0.17)	1.43(0.47)	0.88(0.05)
CC-A1	7.0(1.3)	6.9(1.7)	9.1(2.9)	0.81(0.17)	1.95(0.56)	0.84(0.06)
ML-A2	7.1(1.2)	2.5(0.5)	13.2(3.2)	1.16(0.29)	26.88(4.47)	0.79(0.02)
SBP-A2	7.2(1.2)	2.5(0.6)	12.8(2.9)	1.16(0.28)	26.85(4.39)	0.79(0.03)
MRF-A1	8.0(0.9)	8.2(1.4)	9.1(2.7)	0.74(0.12)	1.72(0.52)	0.87(0.04)
SBS-A3	9.2(1.6)	9.6(0.7)	15.5(4.3)	0.65(0.19)	1.27(0.40)	0.89(0.04)
SBS-A4	5.9(0.9)	3.9(1.3)	25.3(3.9)	1.23(0.21)	2.22(1.64)	0.83(0.02)
M2						
SBS-A1	8.4(1.1)	9.0(1.0)	8.1(2.3)	0.71(0.14)	1.46(0.53)	0.88(0.04)
CC-A1	4.4(1.3)	3.9(1.2)	9.5(2.2)	0.93(0.28)	3.02(0.98)	0.76(0.06)
ML-A2	7.3(1.2)	2.5(0.5)	12.8(2.9)	1.16(0.29)	25.33(4.59)	0.79(0.02)
SBP-A2	7.2(1.1)	2.5(0.5)	12.9(3.2)	1.16(0.28)	25.36(4.83)	0.80(0.02)
MRF-A1	7.6(0.7)	5.8(1.6)	12.3(2.9)	0.78(0.15)	2.69(0.62)	0.85(0.05)
SBS-A3	9.3(1.6)	9.5(0.7)	14.5(4.1)	0.66(0.19)	1.26(0.39)	0.89(0.04)
SBS-A4	5.9(0.9)	3.6(1.6)	24.2(1.8)	1.23(0.21)	2.23(1.46)	0.83(0.01)
M3						
SBS-A1	8.0(1.1)	8.5(1.2)	7.8(2.7)	0.72(0.14)	1.70(0.44)	0.87(0.04)
CC-A1	6.9(1.3)	6.9(1.6)	9.5(3.1)	0.79(0.19)	1.94(0.68)	0.83(0.07)
ML-A2	7.0(1.1)	2.3(0.5)	13.2(3.0)	1.18(0.29)	27.02(4.76)	0.79(0.03)
SBP-A2	6.8(1.1)	2.2(0.5)	13.2(3.0)	1.19(0.29)	27.22(4.65)	0.79(0.02)
MRF-A1	7.7(0.7)	8.1(1.3)	8.3(2.2)	0.74(0.11)	1.76(0.47)	0.86(0.05)
SBS-A3	8.7(1.3)	9.5(0.7)	12.3(3.7)	0.68(0.18)	1.45(0.40)	0.89(0.03)
SBS-A4	5.9(0.9)	3.5(1.7)	16.8(2.0)	1.24(0.21)	2.45(1.56)	0.82(0.02)
M4						
SBS-A1	7.6(0.9)	7.4(1.2)	12.2(3.4)	0.75(0.15)	2.14(0.40)	0.84(0.05)
CC-A1	4.6(1.6)	4.3(1.4)	9.5(3.1)	0.94(0.27)	3.69(4.03)	0.75(0.09)
ML-A2	6.9(1.1)	2.2(0.5)	17.4(3.5)	1.25(0.31)	25.98(4.66)	0.78(0.03)
SBP-A2	6.7(1.0)	2.0(0.5)	17.1(3.8)	1.27(0.31)	26.01(4.89)	0.78(0.02)
MRF-A1	7.2(0.8)	6.4(1.5)	13.6(3.1)	0.77(0.15)	2.48(0.65)	0.83(0.05)
SBS-A3	8.4(1.1)	9.1(0.8)	11.4(3.4)	0.70(0.15)	1.77(0.40)	0.88(0.04)
SBS-A4	5.9(0.9)	3.6(0.8)	16.8(2.3)	1.24(0.19)	2.84(1.68)	0.80(0.04)

Table S9: Simulation Scenario 6 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.1(1.1)	8.6(1.6)	7.8(3.4)	0.77(0.19)	1.59(0.80)	0.84(0.05)
CC-A1	6.2(1.6)	5.7(1.7)	8.7(3.4)	0.86(0.25)	2.40(1.54)	0.79(0.06)
ML-A2	6.4(1.0)	2.5(0.5)	13.0(4.0)	1.29(0.28)	26.30(5.50)	0.76(0.07)
SBP-A2	6.5(1.0)	2.5(0.5)	12.7(3.9)	1.27(0.28)	26.16(5.45)	0.77(0.07)
MRF-A1	7.7(1.1)	7.4(1.9)	7.8(3.4)	0.78(0.20)	1.92(1.08)	0.83(0.06)
SBS-A3	5.6(3.2)	5.3(2.8)	25.6(7.8)	9.26(77.94)	22.91(83.68)	0.71(0.14)
SBS-A4	4.1(0.8)	4.2(0.4)	24.7(2.3)	1.45(0.42)	2.21(0.40)	0.81(0.01)
M2						
SBS-A1	8.1(1.1)	8.4(1.6)	7.7(3.4)	0.77(0.19)	1.62(0.75)	0.84(0.06)
CC-A1	3.9(1.6)	3.7(1.2)	8.0(3.5)	1.01(0.39)	3.87(4.25)	0.73(0.05)
ML-A2	6.5(1.0)	2.4(0.5)	12.2(3.7)	1.29(0.30)	24.96(5.11)	0.77(0.07)
SBP-A2	6.5(1.0)	2.5(0.6)	12.3(3.9)	1.30(0.31)	24.88(4.62)	0.77(0.07)
MRF-A1	7.5(1.0)	5.3(1.5)	10.7(3.6)	0.81(0.21)	2.74(1.12)	0.81(0.06)
SBS-A3	5.6(3.1)	5.4(2.8)	24.6(7.4)	9.08(78.24)	22.88(88.04)	0.72(0.13)
SBS-A4	2.6(0.9)	4.2(0.4)	24.0(2.2)	1.49(0.31)	2.22(0.36)	0.80(0.01)
M3						
SBS-A1	7.8(1.0)	7.8(1.5)	7.6(2.7)	0.77(0.19)	1.87(0.80)	0.83(0.06)
CC-A1	6.3(1.5)	5.9(1.6)	8.4(3.7)	0.89(0.22)	2.34(1.59)	0.78(0.07)
ML-A2	6.3(1.2)	2.3(0.6)	12.5(3.7)	1.29(0.25)	27.27(5.40)	0.76(0.07)
SBP-A2	6.3(1.1)	2.2(0.6)	12.1(3.5)	1.30(0.26)	27.35(5.50)	0.76(0.06)
MRF-A1	7.5(1.1)	7.1(1.6)	7.3(2.6)	0.78(0.20)	1.98(0.87)	0.82(0.06)
SBS-A3	5.7(3.3)	5.1(2.7)	21.9(7.8)	9.72(89.04)	21.31(79.54)	0.71(0.16)
SBS-A4	4.1(0.8)	4.2(0.4)	18.0(2.9)	1.47(0.40)	2.30(0.36)	0.80(0.01)
M4						
SBS-A1	7.6(1.0)	6.8(1.4)	10.9(3.9)	0.81(0.19)	2.26(0.89)	0.81(0.06)
CC-A1	3.7(1.5)	3.6(1.2)	7.6(3.3)	0.98(0.29)	4.36(8.10)	0.71(0.07)
ML-A2	6.1(1.1)	2.2(0.5)	15.6(4.6)	1.39(0.32)	25.66(5.53)	0.75(0.06)
SBP-A2	6.0(1.3)	2.1(0.6)	15.4(4.5)	1.41(0.34)	26.31(5.34)	0.74(0.06)
MRF-A1	7.0(1.3)	5.9(1.5)	11.4(3.8)	0.81(0.18)	2.56(1.08)	0.80(0.06)
SBS-A3	5.4(2.8)	4.9(2.7)	20.1(6.3)	8.43(76.13)	21.73(80.50)	0.72(0.13)
SBS-A4	2.6(0.9)	4.0(0.7)	17.6(1.4)	1.50(0.35)	2.62(0.34)	0.80(0.01)

Table S10: Simulation Scenario 7 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.8(1.7)	9.1(1.4)	7.2(3.3)	0.69(0.19)	1.50(0.81)	0.87(0.04)
CC-A1	7.1(1.6)	6.8(1.6)	7.6(3.6)	0.80(0.25)	2.15(1.52)	0.82(0.07)
ML-A2	7.0(0.9)	2.4(0.6)	12.2(3.9)	1.25(0.26)	27.82(4.97)	0.79(0.04)
SBP-A2	7.0(1.0)	2.4(0.5)	11.4(3.8)	1.25(0.25)	27.73(4.88)	0.79(0.04)
MRF-A1	8.1(1.3)	8.1(1.6)	7.9(3.1)	0.73(0.16)	1.84(1.08)	0.86(0.05)
SBS-A3	8.2(1.4)	8.6(1.3)	12.8(4.9)	0.75(0.24)	1.37(0.65)	0.85(0.03)
SBS-A4	5.4(1.1)	4.1(3.8)	27.9(4.9)	1.27(0.31)	2.01(1.10)	0.79(0.05)
M2						
SBS-A1	8.7(1.5)	8.9(1.2)	7.1(3.2)	0.70(0.17)	1.53(0.76)	0.87(0.04)
CC-A1	4.3(1.6)	3.8(1.2)	7.7(3.4)	0.91(0.37)	3.98(6.14)	0.76(0.06)
ML-A2	6.9(1.1)	2.3(0.6)	12.2(3.8)	1.25(0.28)	26.25(4.97)	0.79(0.04)
SBP-A2	6.8(1.0)	2.2(0.6)	12.2(3.6)	1.27(0.28)	26.36(4.96)	0.78(0.04)
MRF-A1	7.8(1.0)	5.8(1.6)	10.4(3.1)	0.77(0.18)	2.79(1.17)	0.84(0.05)
SBS-A3	8.1(1.4)	8.4(1.4)	13.0(4.0)	0.75(0.24)	1.37(0.56)	0.85(0.03)
SBS-A4	5.4(1.1)	4.3(2.7)	23.4(3.9)	1.27(0.31)	1.96(1.03)	0.79(0.05)
M3						
SBS-A1	8.4(1.5)	8.4(1.5)	7.1(2.9)	0.71(0.17)	1.82(1.00)	0.85(0.05)
CC-A1	7.2(1.6)	6.9(1.6)	8.0(3.8)	0.78(0.19)	2.01(1.19)	0.83(0.06)
ML-A2	6.8(1.1)	2.2(0.5)	11.7(3.8)	1.25(0.26)	27.75(4.70)	0.78(0.04)
SBP-A2	6.7(0.9)	2.1(0.5)	11.9(3.8)	1.26(0.26)	27.94(4.72)	0.78(0.05)
MRF-A1	8.1(1.5)	7.7(1.7)	6.9(3.0)	0.72(0.16)	1.95(1.19)	0.85(0.06)
SBS-A3	8.1(1.4)	8.2(1.4)	11.8(4.2)	0.76(0.24)	1.56(0.64)	0.84(0.04)
SBS-A4	5.4(1.1)	3.9(2.8)	19.5(5.2)	1.27(0.29)	2.31(1.26)	0.79(0.05)
M4						
SBS-A1	7.9(1.3)	7.5(1.6)	10.2(4.0)	0.74(0.18)	2.33(1.03)	0.84(0.05)
CC-A1	4.6(1.7)	3.9(1.2)	8.1(3.5)	0.92(0.38)	3.58(2.60)	0.76(0.07)
ML-A2	6.6(1.2)	2.1(0.6)	15.2(5.4)	1.32(0.27)	26.88(5.26)	0.77(0.04)
SBP-A2	6.5(1.1)	2.0(0.5)	15.2(4.0)	1.36(0.29)	26.92(5.35)	0.77(0.04)
MRF-A1	7.4(1.2)	6.5(1.6)	11.4(3.7)	0.76(0.18)	2.63(1.26)	0.83(0.05)
SBS-A3	7.8(1.2)	7.7(1.5)	11.1(4.2)	0.79(0.23)	1.93(0.66)	0.84(0.03)
SBS-A4	2.1(0.9)	4.3(3.0)	17.5(5.8)	1.29(0.25)	2.55(0.84)	0.77(0.04)

Table S11: Simulation Scenario 8 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.2(1.1)	8.8(1.3)	8.5(3.1)	0.71(0.15)	1.54(0.62)	0.86(0.07)
CC-A1	6.8(1.2)	6.7(1.6)	10.2(3.5)	0.80(0.18)	2.20(1.19)	0.81(0.11)
ML-A2	7.0(1.1)	2.3(0.6)	13.7(3.4)	1.22(0.28)	27.11(5.79)	0.79(0.05)
SBP-A2	7.1(1.1)	2.4(0.6)	13.7(3.3)	1.22(0.28)	27.15(5.62)	0.80(0.05)
MRF-A1	7.6(0.7)	8.0(1.6)	9.0(2.7)	0.74(0.14)	1.84(0.68)	0.84(0.08)
SBS-A3	8.2(2.0)	8.3(2.1)	18.9(9.6)	23.57(935.83)	95.92(4417.74)	0.82(0.10)
SBS-A4	9.8(0.0)	4.0(0.3)	26.4(2.2)	1.36(0.05)	2.38(0.32)	0.82(0.03)
M2						
SBS-A1	7.8(0.8)	8.6(1.3)	8.8(3.6)	0.73(0.14)	1.52(0.60)	0.85(0.08)
CC-A1	3.8(1.2)	3.5(1.3)	9.4(2.7)	0.96(0.34)	3.49(1.36)	0.72(0.08)
ML-A2	7.1(1.1)	2.3(0.7)	13.9(3.3)	1.22(0.27)	26.06(6.11)	0.79(0.05)
SBP-A2	7.0(1.1)	2.3(0.7)	13.6(3.1)	1.22(0.27)	26.02(6.16)	0.80(0.04)
MRF-A1	7.4(0.8)	5.7(1.7)	12.0(3.3)	0.76(0.15)	2.64(0.76)	0.83(0.08)
SBS-A3	8.2(2.0)	8.3(2.1)	17.5(9.1)	23.43(935.83)	95.61(4417.99)	0.83(0.09)
SBS-A4	9.8(0.0)	3.6(0.6)	21.3(1.4)	1.36(0.05)	2.51(0.35)	0.81(0.00)
M3						
SBS-A1	7.7(0.7)	8.1(1.3)	7.8(2.5)	0.72(0.14)	1.80(0.47)	0.84(0.08)
CC-A1	6.7(1.0)	6.5(1.7)	10.0(3.4)	0.78(0.16)	2.12(0.64)	0.81(0.09)
ML-A2	6.9(1.1)	2.1(0.6)	13.6(2.8)	1.26(0.27)	27.43(5.99)	0.79(0.05)
SBP-A2	6.7(1.1)	2.0(0.7)	13.6(3.5)	1.28(0.29)	27.66(6.03)	0.78(0.04)
MRF-A1	7.5(0.7)	7.5(1.2)	8.3(2.7)	0.73(0.15)	1.95(0.53)	0.83(0.09)
SBS-A3	7.9(1.7)	8.2(2.1)	16.8(9.2)	23.52(939.62)	96.94(4385.45)	0.82(0.09)
SBS-A4	9.8(0.0)	3.5(0.5)	21.3(2.2)	1.36(0.04)	2.81(0.46)	0.80(0.03)
M4						
SBS-A1	7.4(0.8)	6.9(1.3)	12.0(3.5)	0.75(0.15)	2.25(0.50)	0.82(0.07)
CC-A1	4.2(1.1)	3.9(1.1)	9.5(3.1)	0.91(0.27)	3.08(1.44)	0.74(0.07)
ML-A2	6.9(1.1)	2.1(0.7)	17.5(3.5)	1.30(0.28)	26.31(5.61)	0.78(0.05)
SBP-A2	6.6(1.1)	1.9(0.5)	17.6(3.7)	1.38(0.33)	26.50(5.89)	0.77(0.05)
MRF-A1	7.0(0.7)	6.1(1.5)	13.6(3.1)	0.76(0.15)	2.50(0.77)	0.81(0.08)
SBS-A3	7.7(1.8)	7.7(2.2)	15.3(8.8)	23.76(939.62)	94.32(4106.00)	0.81(0.10)
SBS-A4	7.8(1.5)	3.8(0.3)	14.7(1.8)	1.38(0.03)	3.13(0.33)	0.79(0.03)

Table S12: Simulation Scenario 9 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.6(1.6)	8.9(1.4)	8.6(3.1)	0.71(0.21)	1.14(0.72)	4.23(1.24)
CC-A1	7.4(1.6)	7.2(2.3)	12.8(4.3)	0.82(0.24)	1.73(1.12)	6.80(2.15)
ML-A2	7.0(1.0)	2.1(0.3)	14.7(3.5)	1.45(0.31)	37.21(6.03)	12.97(3.62)
SBP-A2	7.0(1.0)	2.1(0.3)	15.2(3.4)	1.45(0.32)	37.24(6.12)	12.91(3.77)
MRF-A1	8.0(1.4)	8.0(2.1)	8.3(3.7)	0.75(0.18)	1.54(1.28)	5.49(1.64)
SBS-A3	9.3(1.8)	9.2(1.1)	18.2(3.9)	0.74(0.25)	1.13(0.69)	3.90(1.26)
SBS-A4	8.4(2.8)	4.5(1.2)	15.7(3.0)	1.16(0.52)	2.34(1.16)	11.84(6.24)
M2						
SBS-A1	8.3(1.4)	8.6(1.6)	7.9(3.0)	0.73(0.19)	1.23(0.90)	4.55(1.50)
CC-A1	5.2(1.7)	4.9(2.3)	19.2(4.9)	0.91(0.21)	2.66(2.06)	14.43(4.85)
ML-A2	7.2(1.1)	2.2(0.3)	14.2(3.2)	1.45(0.32)	36.21(6.71)	12.51(3.83)
SBP-A2	7.1(1.1)	2.1(0.4)	14.5(3.6)	1.45(0.31)	35.84(6.48)	12.77(3.96)
MRF-A1	7.6(1.2)	6.5(2.0)	11.6(3.9)	0.79(0.18)	2.23(1.07)	6.85(2.01)
SBS-A3	8.9(1.8)	9.0(1.5)	16.2(3.7)	0.75(0.24)	1.26(0.99)	4.30(1.54)
SBS-A4	8.4(2.8)	3.9(1.8)	17.2(5.6)	1.15(0.48)	2.50(1.27)	11.26(5.62)
M3						
SBS-A1	7.9(1.3)	8.6(1.4)	7.2(2.7)	0.74(0.17)	1.35(0.71)	4.98(1.47)
CC-A1	7.1(1.4)	6.9(2.3)	13.9(4.8)	0.83(0.17)	1.69(1.13)	7.55(2.76)
ML-A2	6.9(1.3)	2.1(0.3)	13.4(3.1)	1.45(0.26)	36.93(7.11)	13.78(4.37)
SBP-A2	6.8(1.3)	2.1(0.3)	13.3(2.8)	1.47(0.31)	36.97(7.45)	13.85(4.22)
MRF-A1	7.8(1.2)	8.1(1.8)	6.9(3.1)	0.75(0.16)	1.40(0.76)	5.65(1.65)
SBS-A3	8.3(1.5)	8.7(1.5)	14.1(3.5)	0.78(0.20)	1.42(0.75)	5.31(1.76)
SBS-A4	8.4(2.8)	3.0(1.4)	12.8(2.2)	1.16(0.45)	2.95(2.43)	12.00(8.62)
M4						
SBS-A1	7.2(1.0)	7.4(2.1)	6.1(2.4)	0.79(0.18)	1.80(0.82)	6.34(1.88)
CC-A1	4.6(1.4)	4.0(2.0)	20.8(5.3)	0.94(0.29)	2.86(2.68)	14.42(4.35)
ML-A2	6.8(1.1)	2.0(0.3)	12.8(2.9)	1.51(0.30)	36.14(6.50)	14.09(4.83)
SBP-A2	6.7(1.1)	1.9(0.3)	12.9(3.3)	1.52(0.30)	36.41(7.05)	14.36(4.04)
MRF-A1	7.0(1.1)	6.3(2.4)	6.9(3.3)	0.81(0.18)	1.97(0.96)	7.69(2.11)
SBS-A3	7.6(0.9)	7.6(2.0)	12.9(3.2)	0.82(0.22)	1.89(0.84)	6.57(1.71)
SBS-A4	8.4(2.8)	3.2(1.7)	9.0(1.5)	1.17(0.52)	3.02(1.10)	13.53(9.26)

Table S13: Simulation Scenario 10 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	7.6(1.3)	7.8(2.0)	10.9(3.9)	0.86(0.25)	1.29(0.69)	7.10(2.74)
CC-A1	6.2(1.5)	5.7(2.6)	16.2(5.3)	1.02(0.34)	1.93(1.21)	11.95(5.04)
ML-A2	6.3(1.3)	1.9(0.1)	14.5(3.9)	1.74(0.36)	36.91(7.04)	16.94(3.78)
SBP-A2	6.3(1.4)	2.0(0.1)	14.6(3.9)	1.72(0.36)	36.62(7.14)	17.23(4.16)
MRF-A1	7.1(1.3)	6.8(2.4)	9.4(3.5)	0.89(0.27)	1.53(0.70)	8.65(3.49)
SBS-A3	4.4(2.5)	3.9(2.5)	28.3(9.5)	3.43(4.47)	25.54(72.13)	61.17(123.88)
SBS-A4	16.0(3.1)	3.0(1.1)	19.4(2.9)	1.23(0.33)	3.13(0.80)	15.53(2.58)
M2						
SBS-A1	7.2(1.2)	7.5(1.9)	9.9(3.8)	0.87(0.27)	1.38(0.85)	7.91(3.31)
CC-A1	4.3(1.2)	3.9(1.4)	22.5(5.1)	1.13(0.49)	3.11(1.76)	18.61(5.69)
ML-A2	6.3(1.4)	2.0(0.1)	15.2(4.3)	1.71(0.36)	35.95(7.18)	17.35(4.03)
SBP-A2	6.3(1.4)	2.1(0.1)	14.4(4.2)	1.69(0.38)	36.16(7.16)	17.29(4.14)
MRF-A1	6.8(1.2)	5.1(2.0)	14.1(5.2)	0.94(0.29)	2.17(0.79)	10.55(4.01)
SBS-A3	4.5(2.5)	4.0(2.6)	26.6(9.3)	3.45(4.48)	40.72(159.17)	59.34(121.66)
SBS-A4	3.2(1.1)	2.8(1.4)	16.8(5.9)	1.30(0.24)	3.01(0.68)	17.36(1.78)
M3						
SBS-A1	7.1(1.1)	6.9(1.9)	8.7(3.5)	0.90(0.28)	1.47(0.67)	8.04(3.00)
CC-A1	5.9(1.3)	5.9(2.3)	16.6(4.1)	1.01(0.32)	1.79(0.84)	12.31(5.59)
ML-A2	6.3(1.4)	1.8(0.1)	13.5(3.6)	1.73(0.43)	37.12(6.77)	17.38(3.99)
SBP-A2	6.1(1.5)	1.8(0.1)	13.3(3.6)	1.74(0.44)	37.05(7.16)	17.82(4.20)
MRF-A1	6.8(1.1)	6.8(2.0)	9.0(3.5)	0.92(0.27)	1.53(0.71)	8.72(3.43)
SBS-A3	4.3(2.4)	3.7(2.4)	20.9(7.8)	3.00(3.21)	20.49(54.38)	49.78(90.77)
SBS-A4	3.2(1.1)	2.5(1.9)	14.1(2.0)	1.32(0.28)	3.27(1.19)	18.51(2.47)
M4						
SBS-A1	6.6(1.2)	6.2(2.0)	7.2(3.2)	0.96(0.33)	1.85(0.85)	9.96(3.20)
CC-A1	4.1(1.2)	3.8(1.7)	21.1(6.2)	1.10(0.35)	2.50(1.03)	19.18(7.13)
ML-A2	5.9(1.3)	1.7(0.1)	12.3(3.0)	1.76(0.42)	35.96(8.27)	17.77(4.20)
SBP-A2	5.8(1.3)	1.7(0.1)	12.9(3.5)	1.81(0.44)	36.33(8.70)	18.72(4.37)
MRF-A1	6.3(1.3)	5.1(2.0)	8.0(3.1)	0.98(0.31)	2.01(0.85)	11.36(3.31)
SBS-A3	4.2(2.3)	3.4(2.1)	19.5(7.8)	3.91(5.94)	18.23(44.97)	49.87(97.81)
SBS-A4	3.2(1.1)	2.0(0.7)	11.8(2.2)	1.32(0.26)	3.39(0.88)	23.85(4.11)

Table S14: Simulation Scenario 11 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.2(1.5)	8.7(1.7)	8.8(3.1)	0.77(0.23)	1.22(0.73)	5.72(2.27)
CC-A1	6.9(1.6)	6.7(1.6)	13.2(4.4)	0.88(0.31)	1.86(1.03)	9.51(4.09)
ML-A2	6.7(1.1)	2.0(0.2)	13.1(3.0)	1.62(0.34)	36.39(7.00)	14.52(4.43)
SBP-A2	6.7(1.2)	2.0(0.2)	13.3(3.2)	1.60(0.34)	36.47(7.09)	14.60(4.62)
MRF-A1	7.9(1.3)	7.9(1.8)	8.3(3.7)	0.79(0.22)	1.54(0.86)	6.79(2.12)
SBS-A3	3.4(2.8)	3.1(2.7)	29.2(10.0)	17.84(77.69)	64.26(192.44)	101.64(180.16)
SBS-A4	30.4(5.0)	4.7(1.3)	15.9(4.5)	1.20(0.27)	2.19(0.16)	12.15(7.37)
M2						
SBS-A1	7.9(1.5)	8.4(1.6)	8.5(2.9)	0.77(0.22)	1.31(0.85)	6.13(2.52)
CC-A1	5.0(1.7)	4.7(1.5)	18.7(4.9)	0.94(0.34)	3.73(8.71)	18.21(8.26)
ML-A2	6.7(1.2)	2.0(0.2)	12.6(2.8)	1.61(0.39)	35.37(7.55)	14.31(4.27)
SBP-A2	6.8(1.3)	2.0(0.2)	13.1(3.0)	1.62(0.39)	35.19(7.66)	14.40(4.27)
MRF-A1	7.6(1.2)	6.2(1.5)	11.2(4.0)	0.82(0.25)	2.22(0.99)	8.37(3.17)
SBS-A3	3.4(2.8)	3.1(2.7)	28.2(10.6)	17.74(75.49)	61.31(190.36)	97.56(188.71)
SBS-A4	38.0(7.0)	4.9(0.9)	17.3(6.6)	1.23(0.34)	1.92(0.14)	15.70(10.74)
M3						
SBS-A1	7.8(1.0)	8.4(1.4)	7.3(2.2)	0.77(0.19)	1.40(0.65)	6.26(1.93)
CC-A1	7.0(1.4)	7.1(1.8)	13.6(5.0)	0.88(0.26)	1.90(1.45)	9.18(3.52)
ML-A2	6.7(1.3)	2.0(0.2)	11.9(3.0)	1.55(0.33)	35.93(8.18)	15.34(4.20)
SBP-A2	6.6(1.3)	1.9(0.2)	11.6(2.9)	1.58(0.36)	36.29(8.58)	15.32(4.84)
MRF-A1	7.6(1.1)	7.7(1.7)	6.9(2.5)	0.79(0.20)	1.48(0.77)	7.11(2.65)
SBS-A3	3.3(2.8)	3.0(2.4)	21.5(9.1)	23.76(175.99)	30.77(63.03)	90.58(196.46)
SBS-A4	30.4(5.0)	4.3(0.8)	12.7(2.9)	1.20(0.30)	2.50(0.38)	15.12(7.71)
M4						
SBS-A1	7.4(1.0)	7.4(1.5)	6.2(2.0)	0.82(0.25)	1.81(0.77)	7.61(2.08)
CC-A1	4.4(1.6)	4.2(1.6)	18.8(4.6)	0.97(0.29)	3.11(2.72)	18.02(7.54)
ML-A2	6.4(1.2)	1.7(0.2)	11.7(2.9)	1.65(0.37)	34.95(7.79)	15.89(4.82)
SBP-A2	6.4(1.2)	1.8(0.2)	11.0(2.7)	1.67(0.39)	35.02(8.57)	16.93(5.83)
MRF-A1	7.2(1.1)	6.0(1.5)	6.6(2.6)	0.84(0.25)	1.92(0.82)	9.24(2.84)
SBS-A3	3.2(2.7)	2.8(2.5)	21.3(10.3)	51.50(544.98)	26.85(46.94)	137.35(535.10)
SBS-A4	30.4(5.0)	3.1(1.0)	11.1(2.2)	1.20(0.30)	2.70(0.21)	18.64(7.59)

Table S15: Simulation Scenario 12 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.8(1.7)	8.5(1.6)	9.1(3.0)	0.73(0.22)	1.15(0.65)	5.52(2.16)
CC-A1	7.4(1.6)	6.5(2.7)	14.8(3.8)	0.85(0.23)	1.72(1.06)	9.43(4.13)
ML-A2	7.0(1.2)	2.0(0.2)	13.1(2.9)	1.49(0.27)	37.99(7.30)	13.90(4.36)
SBP-A2	7.1(1.1)	2.1(0.2)	13.5(3.0)	1.50(0.27)	37.92(7.20)	14.24(4.80)
MRF-A1	8.4(1.3)	7.8(2.3)	8.8(3.4)	0.76(0.22)	1.46(0.91)	6.63(2.80)
SBS-A3	8.0(3.0)	7.8(2.6)	22.7(8.6)	1.09(0.58)	2.82(4.01)	9.46(11.98)
SBS-A4	20.4(6.8)	3.8(0.6)	18.1(4.3)	1.28(0.49)	2.61(1.06)	14.88(6.60)
M2						
SBS-A1	8.5(1.6)	8.3(1.8)	8.0(2.6)	0.74(0.20)	1.15(0.53)	5.88(2.17)
CC-A1	5.4(1.9)	4.6(2.5)	19.2(4.8)	0.95(0.39)	2.60(1.89)	16.88(7.28)
ML-A2	7.1(1.1)	2.0(0.2)	13.2(3.2)	1.49(0.26)	36.52(7.33)	14.49(5.43)
SBP-A2	7.0(1.1)	2.0(0.2)	13.0(3.3)	1.49(0.26)	36.83(7.22)	14.03(4.96)
MRF-A1	8.1(1.6)	5.8(2.7)	12.3(3.8)	0.80(0.27)	2.18(1.16)	8.45(3.41)
SBS-A3	7.8(3.2)	7.7(2.6)	21.2(11.3)	1.10(0.58)	2.63(3.43)	10.02(12.95)
SBS-A4	8.5(3.1)	3.5(1.6)	16.4(2.5)	1.36(0.29)	2.80(1.96)	16.63(8.20)
M3						
SBS-A1	8.3(1.7)	7.8(2.1)	7.1(2.6)	0.76(0.25)	1.37(0.60)	6.72(2.53)
CC-A1	7.1(1.6)	6.4(2.7)	13.6(4.2)	0.86(0.25)	1.75(1.08)	9.57(3.32)
ML-A2	6.9(1.1)	2.0(0.2)	12.2(3.0)	1.47(0.26)	37.63(7.30)	14.34(5.04)
SBP-A2	6.9(1.0)	2.0(0.2)	11.8(2.6)	1.48(0.26)	38.19(7.66)	14.70(5.34)
MRF-A1	8.1(1.6)	7.3(2.4)	7.1(2.2)	0.77(0.22)	1.43(0.80)	7.15(2.82)
SBS-A3	7.4(2.8)	7.3(2.7)	17.0(7.3)	1.09(0.43)	2.54(3.19)	8.55(6.63)
SBS-A4	17.0(4.2)	3.0(2.0)	13.2(3.4)	1.30(0.16)	2.89(1.55)	18.01(4.45)
M4						
SBS-A1	7.7(1.2)	6.8(2.4)	6.7(2.0)	0.81(0.25)	1.73(0.80)	8.15(2.89)
CC-A1	5.3(1.8)	4.2(2.5)	20.9(4.6)	0.95(0.33)	2.61(1.95)	15.92(5.44)
ML-A2	6.8(1.2)	1.8(0.2)	12.1(3.3)	1.55(0.28)	36.72(8.23)	14.16(4.14)
SBP-A2	6.7(1.1)	1.8(0.2)	11.0(3.0)	1.56(0.28)	37.12(8.12)	14.73(4.84)
MRF-A1	7.4(1.5)	5.8(2.5)	7.4(2.0)	0.83(0.25)	2.02(1.08)	9.94(3.49)
SBS-A3	7.0(2.5)	6.4(2.4)	15.3(6.4)	1.12(0.53)	2.93(3.50)	10.12(8.34)
SBS-A4	13.6(5.3)	2.4(1.3)	11.5(3.1)	1.31(0.52)	3.89(2.90)	26.92(8.79)

Table S16: Simulation Scenario 13 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.5(1.2)	9.5(1.1)	8.1(2.7)	0.71(0.16)	1.40(0.57)	0.89(0.02)
CC-A1	7.1(1.3)	7.3(1.5)	8.7(3.5)	0.78(0.19)	1.91(1.02)	0.84(0.01)
ML-A2	7.0(1.3)	2.5(0.5)	13.3(3.2)	1.13(0.24)	26.89(4.47)	0.82(0.04)
SBP-A2	7.0(1.2)	2.5(0.5)	13.6(3.2)	1.14(0.25)	27.01(4.61)	0.83(0.05)
MRF-A1	7.7(0.7)	8.5(1.4)	9.1(2.8)	0.75(0.15)	1.67(0.59)	0.86(0.03)
SBS-A3	8.9(1.6)	9.4(1.0)	15.2(4.5)	0.68(0.24)	1.33(0.58)	0.89(0.04)
SBS-A4	9.8(3.0)	3.7(2.3)	23.8(4.4)	1.18(0.27)	1.82(0.26)	0.85(0.03)
M2						
SBS-A1	8.1(0.9)	9.2(1.1)	8.2(2.6)	0.73(0.15)	1.41(0.48)	0.87(0.03)
CC-A1	4.2(1.3)	3.9(1.3)	8.7(2.7)	0.94(0.27)	3.04(1.12)	0.75(0.02)
ML-A2	6.9(1.3)	2.3(0.5)	13.4(3.5)	1.15(0.27)	25.88(4.55)	0.80(0.05)
SBP-A2	6.8(1.3)	2.3(0.6)	13.3(3.1)	1.16(0.27)	26.04(4.61)	0.80(0.05)
MRF-A1	7.5(0.6)	6.2(1.7)	11.5(3.0)	0.78(0.15)	2.41(0.56)	0.85(0.03)
SBS-A3	8.7(1.4)	9.4(1.0)	14.6(4.4)	0.69(0.22)	1.29(0.41)	0.88(0.04)
SBS-A4	9.8(3.0)	3.3(1.9)	23.1(2.0)	1.19(0.27)	1.91(0.32)	0.84(0.03)
M3						
SBS-A1	7.8(0.8)	8.7(1.1)	7.7(3.0)	0.73(0.13)	1.67(0.55)	0.86(0.03)
CC-A1	7.2(1.2)	7.3(1.7)	8.6(3.2)	0.79(0.20)	1.99(1.10)	0.84(0.02)
ML-A2	6.7(1.3)	2.2(0.5)	13.4(3.2)	1.16(0.25)	27.74(5.05)	0.79(0.06)
SBP-A2	6.7(1.3)	2.2(0.6)	13.2(3.0)	1.18(0.28)	27.84(4.96)	0.79(0.06)
MRF-A1	7.7(0.8)	8.3(1.2)	7.8(2.7)	0.75(0.15)	1.76(0.54)	0.85(0.03)
SBS-A3	8.7(1.4)	9.3(1.0)	12.1(4.0)	0.71(0.23)	1.55(0.53)	0.88(0.04)
SBS-A4	6.6(2.3)	3.7(2.3)	17.7(7.9)	1.22(0.24)	2.04(0.31)	0.84(0.03)
M4						
SBS-A1	7.4(0.7)	7.7(1.4)	11.6(3.4)	0.76(0.16)	2.09(0.50)	0.84(0.03)
CC-A1	3.6(1.2)	3.5(0.9)	8.7(2.8)	0.93(0.26)	3.07(0.95)	0.73(0.02)
ML-A2	6.7(1.3)	2.2(0.7)	17.2(3.4)	1.22(0.28)	26.68(5.23)	0.78(0.06)
SBP-A2	6.6(1.4)	2.0(0.7)	16.5(3.6)	1.24(0.28)	26.84(5.58)	0.78(0.06)
MRF-A1	7.1(0.7)	6.8(1.4)	13.3(3.2)	0.79(0.14)	2.42(0.47)	0.83(0.03)
SBS-A3	8.1(1.2)	8.7(1.3)	10.3(3.7)	0.74(0.23)	1.82(0.50)	0.86(0.04)
SBS-A4	4.1(1.4)	3.3(1.6)	13.6(3.5)	1.26(0.16)	2.29(0.40)	0.83(0.02)

Table S17: Simulation Scenario 14 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.0(0.9)	8.3(1.6)	8.7(3.5)	0.77(0.16)	1.66(0.53)	0.84(0.05)
CC-A1	6.4(1.5)	6.1(2.2)	8.9(3.8)	0.86(0.24)	2.26(0.73)	0.79(0.11)
ML-A2	7.2(1.2)	2.5(0.5)	12.7(3.3)	1.26(0.23)	25.53(5.42)	0.77(0.07)
SBP-A2	7.1(1.3)	2.4(0.5)	12.4(3.7)	1.27(0.23)	25.51(5.42)	0.78(0.07)
MRF-A1	7.5(0.7)	7.3(1.7)	8.8(3.3)	0.79(0.15)	1.90(0.55)	0.83(0.05)
SBS-A3	5.5(3.1)	5.5(3.2)	20.7(9.0)	5.54(41.09)	31.76(299.24)	0.71(0.14)
SBS-A4	5.6(1.6)	4.0(0.2)	25.6(0.8)	1.43(0.33)	1.99(0.24)	0.78(0.03)
M2						
SBS-A1	7.8(0.8)	8.2(1.5)	8.6(3.5)	0.78(0.16)	1.68(0.41)	0.84(0.05)
CC-A1	3.5(1.4)	3.3(1.5)	9.0(3.8)	1.03(0.24)	3.31(1.02)	0.72(0.11)
ML-A2	7.1(1.1)	2.4(0.5)	13.1(3.8)	1.26(0.22)	24.31(5.38)	0.77(0.05)
SBP-A2	7.0(1.2)	2.4(0.5)	12.3(3.7)	1.26(0.23)	24.67(5.30)	0.77(0.07)
MRF-A1	7.2(0.9)	5.3(2.1)	11.6(3.9)	0.84(0.18)	2.66(0.54)	0.81(0.07)
SBS-A3	5.4(3.0)	5.3(2.9)	19.0(8.2)	5.52(41.83)	40.20(516.42)	0.71(0.14)
SBS-A4	3.5(1.9)	4.3(0.3)	24.4(3.1)	1.45(0.38)	2.06(0.26)	0.78(0.03)
M3						
SBS-A1	7.5(0.7)	7.6(1.8)	8.0(3.3)	0.78(0.14)	1.92(0.50)	0.83(0.05)
CC-A1	6.4(1.5)	6.0(2.0)	8.7(3.7)	0.90(0.24)	2.71(2.55)	0.79(0.11)
ML-A2	7.0(1.1)	2.4(0.5)	11.7(3.1)	1.26(0.23)	26.50(5.49)	0.77(0.07)
SBP-A2	6.7(1.1)	2.3(0.5)	12.0(3.4)	1.28(0.22)	26.55(5.98)	0.77(0.07)
MRF-A1	7.3(0.8)	6.8(1.7)	7.5(2.7)	0.79(0.14)	1.99(0.54)	0.82(0.05)
SBS-A3	5.4(3.0)	5.3(2.9)	17.5(7.8)	5.12(43.06)	28.44(251.09)	0.71(0.14)
SBS-A4	3.5(1.9)	3.9(0.0)	18.2(3.1)	1.46(0.35)	2.14(0.25)	0.78(0.03)
M4						
SBS-A1	6.8(0.9)	6.3(1.6)	7.6(2.6)	0.80(0.15)	2.33(0.47)	0.81(0.05)
CC-A1	3.0(1.2)	2.7(1.2)	8.5(3.5)	1.04(0.34)	3.67(1.36)	0.71(0.11)
ML-A2	6.5(1.2)	2.1(0.5)	11.7(3.0)	1.32(0.25)	25.53(6.49)	0.76(0.05)
SBP-A2	6.2(1.3)	1.9(0.5)	11.3(3.6)	1.34(0.25)	25.78(7.03)	0.75(0.07)
MRF-A1	6.5(0.9)	5.2(1.5)	7.8(3.3)	0.82(0.17)	2.52(0.49)	0.80(0.05)
SBS-A3	5.2(2.9)	4.8(2.7)	15.9(6.4)	5.00(33.71)	29.41(277.44)	0.71(0.12)
SBS-A4	3.5(1.9)	3.7(0.2)	16.4(1.7)	1.43(0.44)	2.32(0.27)	0.77(0.03)

Table S18: Simulation Scenario 15 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.6(1.3)	9.3(0.9)	7.5(3.1)	0.68(0.20)	1.28(0.69)	0.87(0.05)
CC-A1	7.1(1.6)	7.1(1.4)	7.6(3.0)	0.78(0.27)	1.85(1.14)	0.83(0.07)
ML-A2	7.1(1.2)	2.5(0.5)	12.2(2.7)	1.17(0.20)	28.30(4.66)	0.78(0.08)
SBP-A2	7.1(1.3)	2.5(0.5)	12.1(2.9)	1.18(0.21)	28.31(4.68)	0.78(0.08)
MRF-A1	8.1(0.9)	8.4(1.2)	8.6(3.6)	0.72(0.20)	1.60(0.79)	0.86(0.05)
SBS-A3	8.3(1.1)	8.8(1.0)	13.4(4.5)	0.74(0.24)	1.27(0.56)	0.85(0.07)
SBS-A4	5.5(4.0)	4.1(1.1)	22.1(1.2)	1.31(0.28)	1.96(1.05)	0.82(0.02)
M2						
SBS-A1	8.3(1.1)	9.3(1.0)	7.2(2.9)	0.69(0.18)	1.32(0.71)	0.87(0.04)
CC-A1	4.0(1.3)	4.0(1.0)	8.5(2.9)	0.93(0.30)	3.26(2.30)	0.74(0.06)
ML-A2	7.1(1.2)	2.5(0.5)	12.7(3.4)	1.18(0.20)	26.91(5.18)	0.78(0.08)
SBP-A2	7.0(1.2)	2.6(0.5)	12.3(2.8)	1.18(0.19)	26.77(5.21)	0.78(0.08)
MRF-A1	7.7(0.8)	6.1(1.2)	11.3(3.0)	0.75(0.18)	2.43(0.85)	0.84(0.05)
SBS-A3	8.2(1.1)	8.7(1.1)	13.1(3.8)	0.74(0.23)	1.32(0.64)	0.85(0.05)
SBS-A4	4.8(4.8)	4.4(1.4)	22.4(1.3)	1.33(0.28)	2.16(0.76)	0.83(0.01)
M3						
SBS-A1	8.2(1.2)	8.5(1.1)	7.0(3.0)	0.69(0.18)	1.58(0.70)	0.86(0.05)
CC-A1	6.9(1.3)	6.6(1.6)	8.6(3.4)	0.79(0.24)	1.90(1.24)	0.82(0.07)
ML-A2	6.9(1.4)	2.3(0.5)	12.0(2.6)	1.20(0.22)	28.44(4.86)	0.78(0.08)
SBP-A2	6.8(1.3)	2.3(0.4)	11.6(2.7)	1.22(0.23)	28.81(4.95)	0.77(0.08)
MRF-A1	7.8(0.9)	8.1(1.2)	7.5(3.0)	0.72(0.18)	1.68(0.76)	0.85(0.05)
SBS-A3	8.0(1.3)	8.5(1.1)	12.3(4.7)	0.75(0.24)	1.48(0.68)	0.85(0.05)
SBS-A4	0.0(0.0)	3.5(1.4)	17.0(1.0)	1.41(0.12)	2.60(1.11)	0.82(0.02)
M4						
SBS-A1	7.5(0.9)	7.4(1.2)	11.3(3.8)	0.74(0.23)	2.08(0.90)	0.83(0.06)
CC-A1	4.3(1.6)	3.9(1.1)	7.9(3.0)	0.90(0.36)	3.17(2.01)	0.75(0.07)
ML-A2	6.7(1.4)	2.1(0.5)	15.6(2.9)	1.28(0.22)	27.36(5.51)	0.76(0.08)
SBP-A2	6.6(1.3)	2.1(0.4)	15.4(2.7)	1.30(0.22)	27.99(5.45)	0.76(0.10)
MRF-A1	7.3(0.9)	6.5(1.1)	12.1(3.7)	0.76(0.21)	2.30(0.84)	0.82(0.06)
SBS-A3	7.8(1.0)	8.1(1.1)	10.8(3.6)	0.77(0.22)	1.85(0.64)	0.84(0.07)
SBS-A4	0.0(0.0)	3.9(1.9)	16.3(1.6)	1.40(0.05)	2.62(0.90)	0.81(0.02)

Table S19: Simulation Scenario 16 with missingness. In each cell, mean (sd) based on 200 replicates.

	TP.L	TP.NL	FP	EMSE	EMISE	PMSE
M1						
SBS-A1	8.1(1.0)	8.9(1.3)	8.9(3.8)	0.73(0.14)	1.59(0.77)	0.86(0.05)
CC-A1	6.7(1.2)	6.4(2.0)	9.3(3.7)	0.83(0.21)	2.16(1.04)	0.82(0.06)
ML-A2	7.3(1.0)	2.4(0.6)	13.2(3.7)	1.16(0.20)	27.54(6.12)	0.79(0.02)
SBP-A2	7.2(1.1)	2.2(0.6)	13.1(3.1)	1.16(0.20)	27.69(6.01)	0.79(0.02)
MRF-A1	7.6(0.9)	7.9(1.8)	9.5(4.2)	0.76(0.14)	1.98(0.85)	0.85(0.04)
SBS-A3	7.7(2.7)	7.7(2.5)	17.0(6.4)	0.99(0.32)	7.53(60.60)	0.84(0.08)
SBS-A4	5.2(2.3)	4.4(0.4)	19.2(1.8)	1.40(0.04)	2.21(0.27)	0.84(0.01)
M2						
SBS-A1	7.8(0.9)	8.8(1.6)	8.2(3.9)	0.74(0.16)	1.59(0.81)	0.86(0.04)
CC-A1	3.7(1.6)	3.4(1.4)	9.8(4.1)	0.96(0.27)	3.94(2.35)	0.73(0.06)
ML-A2	7.1(0.9)	2.2(0.6)	12.6(3.4)	1.17(0.19)	26.03(6.16)	0.79(0.02)
SBP-A2	7.1(0.8)	2.3(0.6)	12.5(3.4)	1.16(0.20)	26.25(6.00)	0.79(0.02)
MRF-A1	7.4(0.7)	5.8(1.9)	12.4(4.2)	0.79(0.14)	2.83(0.87)	0.83(0.04)
SBS-A3	7.7(2.7)	7.6(2.5)	16.5(6.0)	0.98(0.30)	7.51(60.66)	0.84(0.09)
SBS-A4	4.5(2.7)	4.5(0.5)	16.5(3.8)	1.38(0.04)	2.30(0.21)	0.84(0.02)
M3						
SBS-A1	7.6(0.7)	8.2(1.6)	8.4(3.0)	0.75(0.14)	1.85(0.68)	0.85(0.04)
CC-A1	6.7(1.0)	6.4(2.0)	10.1(4.1)	0.83(0.23)	2.33(1.16)	0.82(0.05)
ML-A2	6.9(1.1)	2.1(0.5)	12.7(2.8)	1.17(0.20)	28.01(6.03)	0.78(0.03)
SBP-A2	6.9(0.9)	2.0(0.6)	12.8(3.5)	1.18(0.20)	28.38(6.20)	0.78(0.04)
MRF-A1	7.4(0.8)	7.5(1.7)	8.3(3.8)	0.76(0.14)	2.04(0.77)	0.84(0.04)
SBS-A3	7.7(2.7)	7.7(2.7)	13.8(5.5)	0.98(0.30)	7.73(60.38)	0.83(0.10)
SBS-A4	5.2(2.3)	4.6(0.5)	14.5(2.3)	1.40(0.03)	2.38(0.31)	0.84(0.02)
M4						
SBS-A1	7.3(0.8)	7.1(1.5)	12.7(4.9)	0.78(0.13)	2.41(0.67)	0.82(0.05)
CC-A1	4.2(1.5)	3.5(1.5)	9.2(3.7)	0.96(0.28)	3.68(2.45)	0.73(0.07)
ML-A2	6.7(0.9)	2.0(0.5)	16.2(4.5)	1.23(0.21)	26.86(6.30)	0.77(0.03)
SBP-A2	6.5(1.0)	1.9(0.7)	16.8(4.0)	1.25(0.20)	27.44(6.45)	0.76(0.03)
MRF-A1	7.0(0.9)	6.3(1.9)	13.5(4.8)	0.81(0.14)	2.64(0.84)	0.81(0.04)
SBS-A3	7.4(2.6)	7.0(2.4)	12.6(5.2)	1.01(0.29)	8.41(60.05)	0.82(0.09)
SBS-A4	4.5(2.7)	4.5(0.5)	14.0(3.3)	1.38(0.04)	3.03(0.26)	0.83(0.04)

Data analysis: recoding of E variables

The following variable recoding is conducted to facilitate analysis by reducing cells with very small counts.

STAD [1] AJCC metastasis pathologic stage is coded as 0 for M0, 1 for M1, and 2 for MX; [2] AJCC nodes pathologic stage is coded as 0 for N0, 1 for N1-N3, and 2 for NX; [3] AJCC tumor pathologic stage is coded as 0 for T1 and T2, 1 for T3 and T4, and 2 for TX; [4] Gender is coded as 0 for female, and 1 for male; [5] ICD O3 histology is coded as 0 for 814, and 1 for others; [6] ICD O3 site is coded as 0 for C16.0, 1 for C16.1, 2 for C16.2, 3 for C16.3, and 4 for C16.9; [7] History of other malignancy is coded as 0 for Yes, and 1 for NO.

SKCM [1] Clark level is coded as 0 for I-III, and 1 for IV and V; [2] AJCC metastasis pathologic stage is coded as 0 for M0, and 1 for M1; [3] AJCC nodes pathologic stage is coded as 0 for N0, 1 for N1-N3, and 2 for NX; [4] AJCC tumor pathologic stage is coded as 0 for T1 and T2, 1 for T3 and T4, and 2 for TX and Tis; [5] Gender is coded as 0 for female, and 1 for male; [6] Sample type is coded as 0 for metastatic and additional metastatic, and 1 for primary tumor.

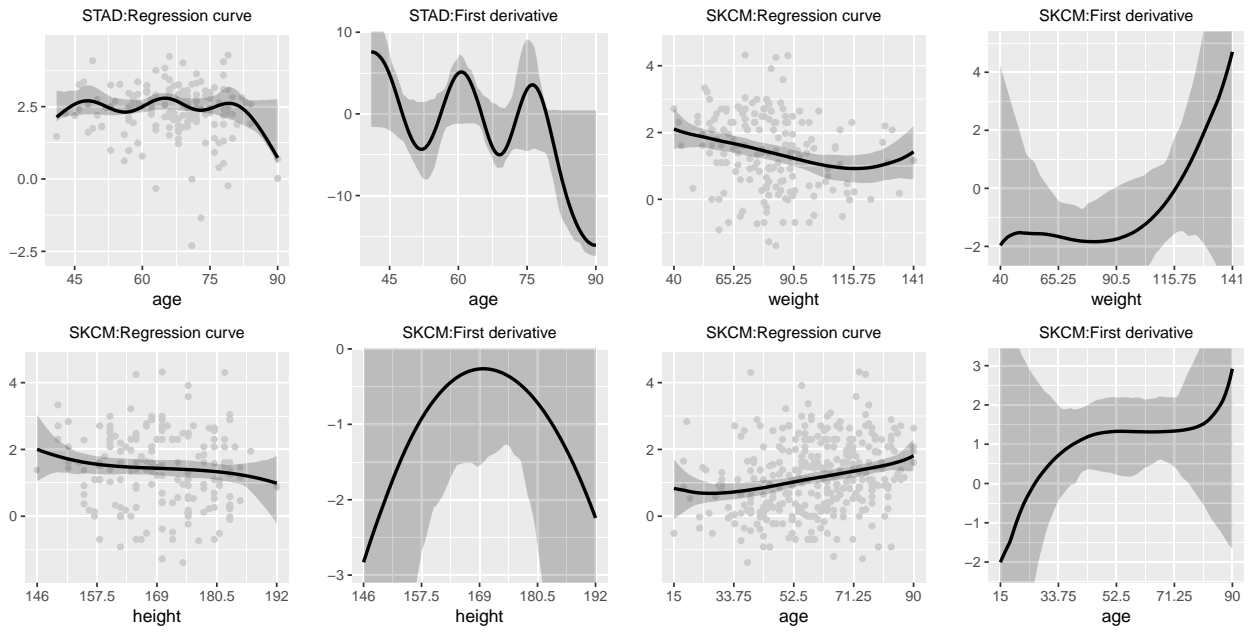


Figure S4: Data analysis. Regression curves and first order derivatives with wild bootstrap-based 95% confidence intervals (shaded area) for age of STAD data, and weight, height, and age of SKCM data.

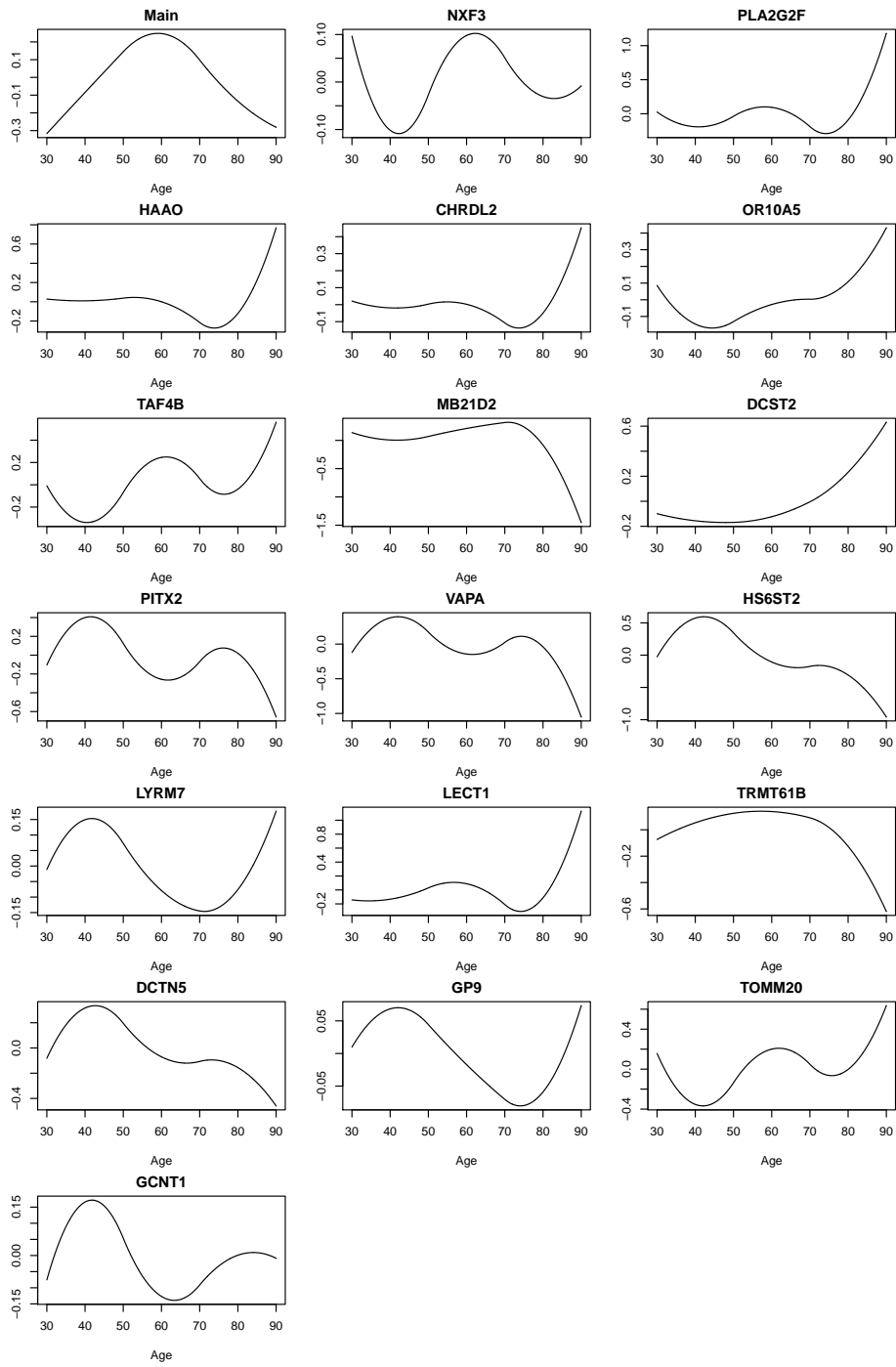


Figure S5: Analysis of STAD data: estimated nonlinear effects of age using the proposed approach.

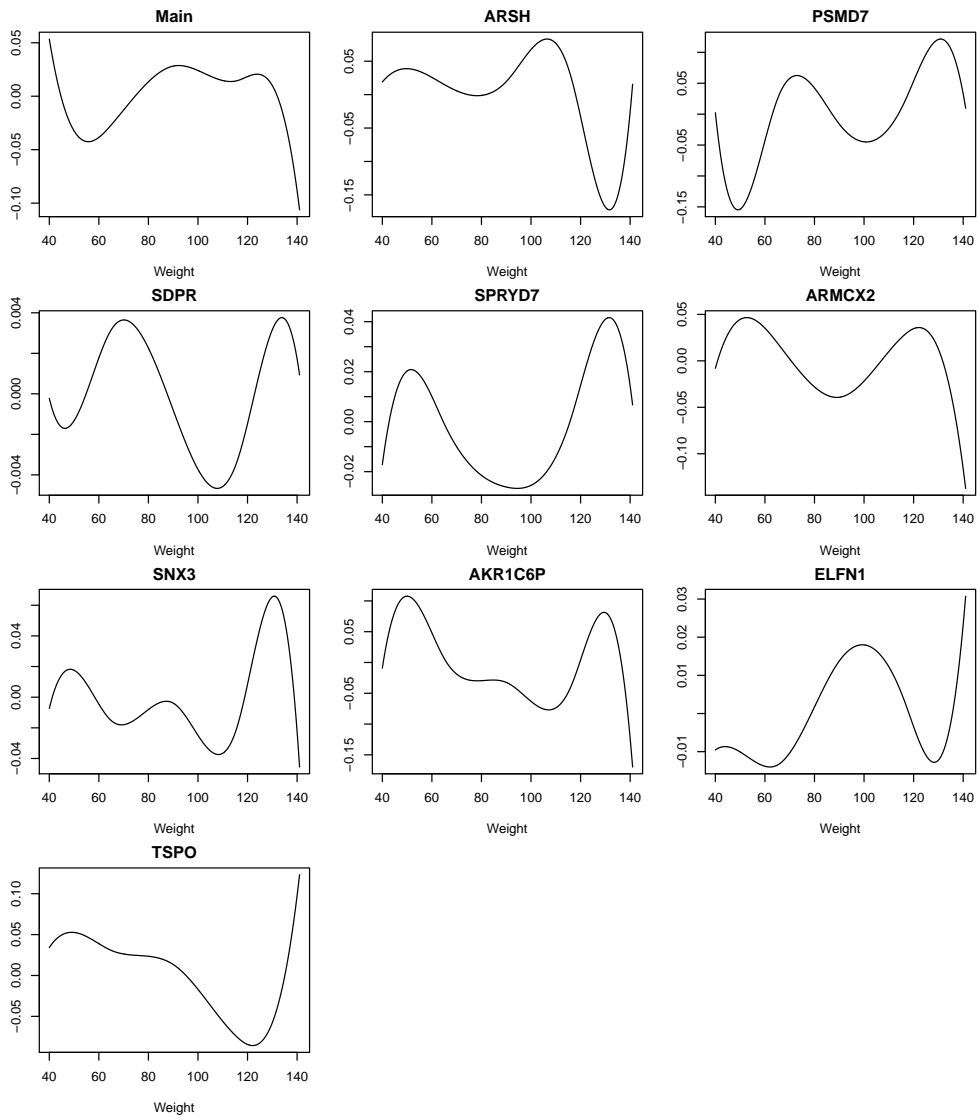


Figure S6: Analysis of SKCM data: estimated nonlinear effects of weight using the proposed approach.

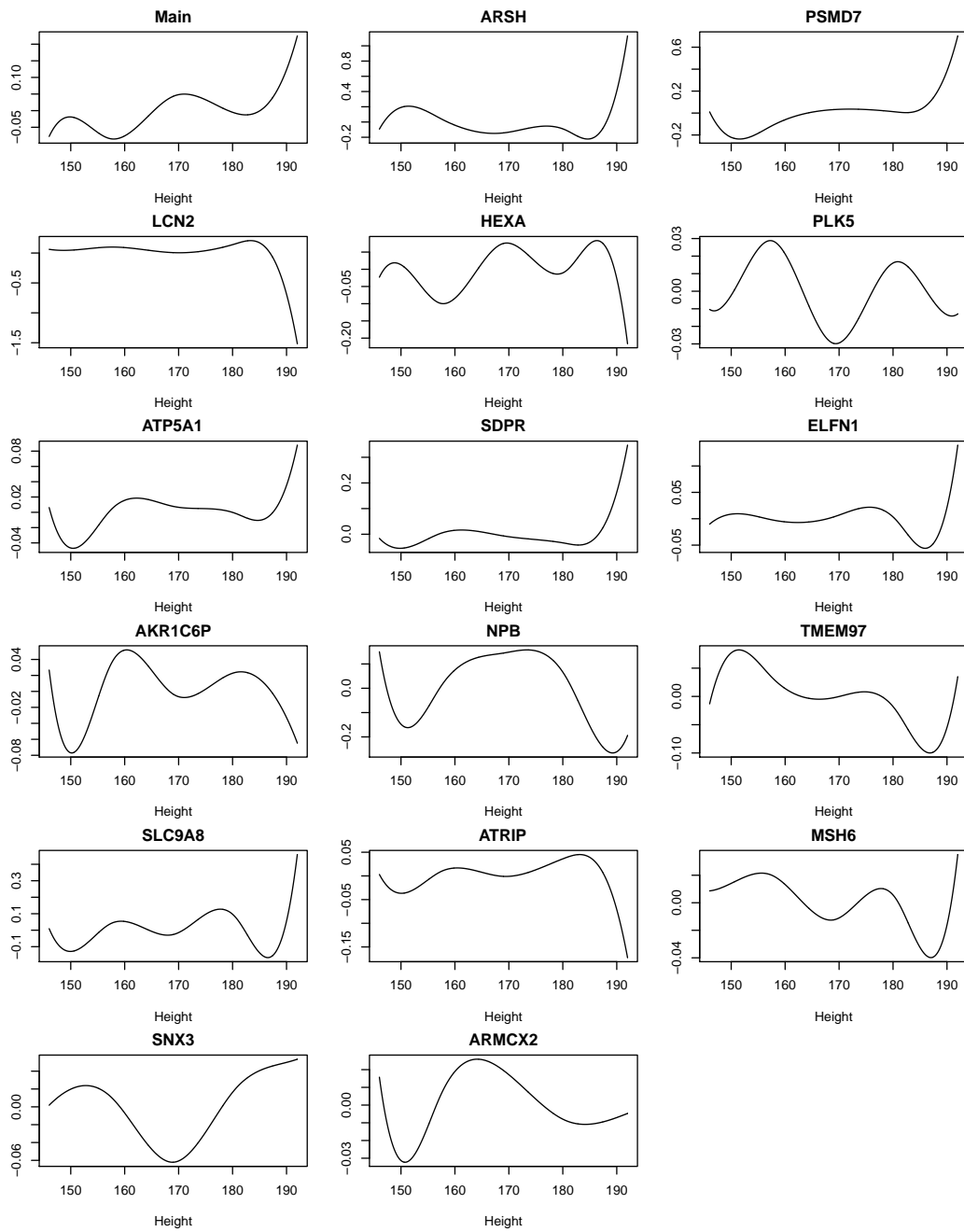


Figure S7: Analysis of SKCM data: estimated nonlinear effects of height using the proposed approach.

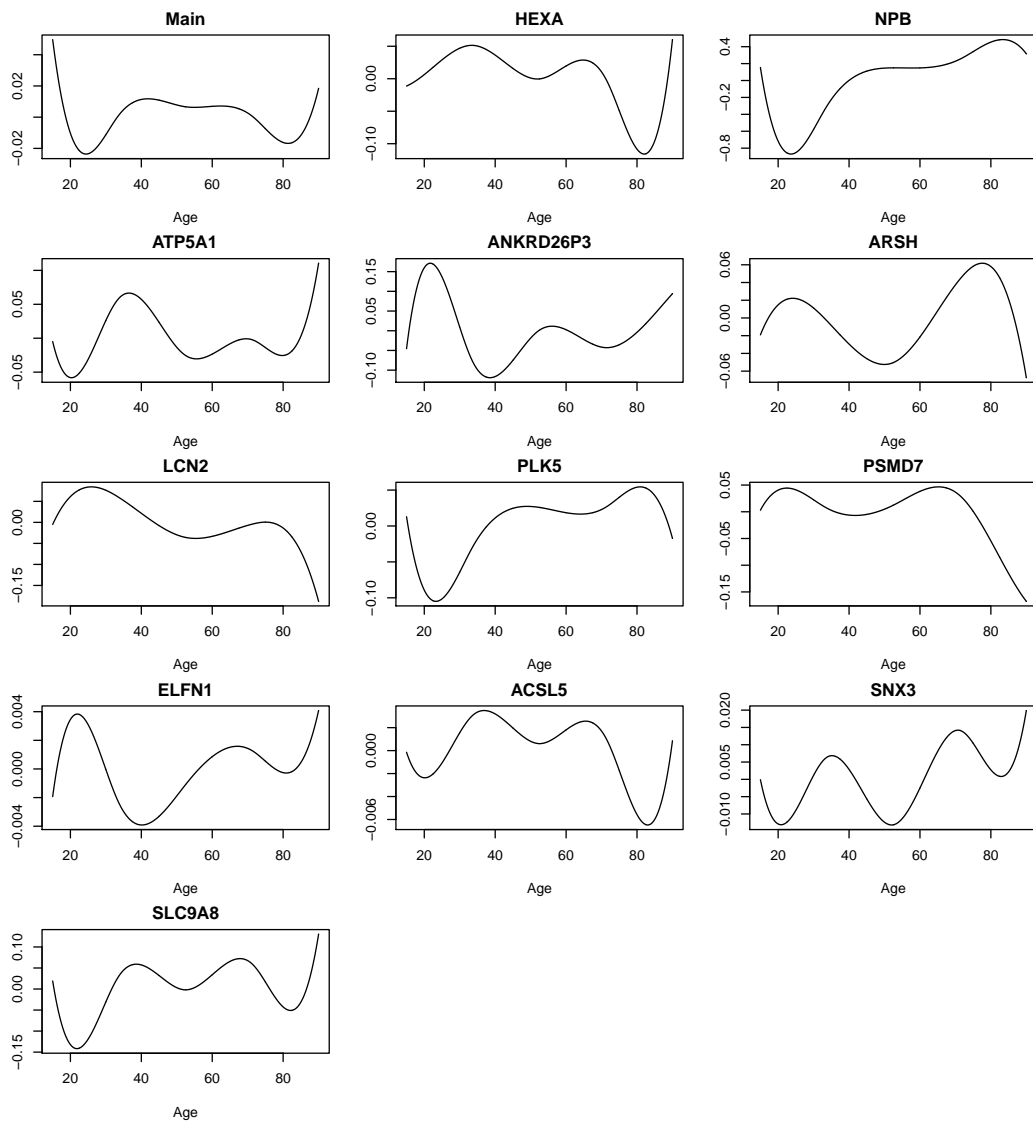


Figure S8: Analysis of SKCM data: estimated nonlinear effects of age using the proposed approach.

Table S20: Analysis of STAD data: number of overlapping interactions (RV-coefficient) identified by different approaches.

		A1	A2	A3	A4	A5
Main E	A1	3 (1.00)	1 (0.90)	2 (0.94)	0 (0.00)	0 (0.79)
	A2		1 (1.00)	1 (0.94)	0 (0.00)	0 (0.75)
	A3			3 (1.00)	0 (0.00)	0 (0.77)
	A4				0 (1.00)	0 (0.00)
	A5					1 (1.00)
Main G	A1	45 (1.00)	33 (0.83)	18 (0.54)	10 (0.52)	0 (0.06)
	A2		40 (1.00)	18 (0.54)	10 (0.53)	0 (0.07)
	A3			91 (1.00)	7 (0.37)	1 (0.13)
	A4				33 (1.00)	0 (0.03)
	A5					2 (1.00)
Interaction	A1	24 (1.00)	1 (0.22)	4 (0.47)	0 (0.05)	0 (0.19)
	A2		1 (1.00)	2 (0.04)	0 (0.00)	0 (0.03)
	A3			42 (1.00)	0 (0.05)	0 (0.22)
	A4				1 (1.00)	0 (0.01)
	A5					40 (1.00)

Table S21: Analysis of SKCM data: number of overlapping interactions (RV-coefficient) identified by different approaches.

		SBS-A1	CC-A1	ML-A2	SBP-A2	MRF-A1	SBS-A3	SBS-A4
Main E	SBS-A1	7 (1.00)	6 (1.00)	4 (0.81)	5 (0.97)	7 (1.00)	7 (1.00)	0 (0.00)
	CC-A1		6 (1.00)	3 (0.81)	4 (0.97)	6 (1.00)	6 (1.00)	0 (0.00)
	ML-A2			5 (1.00)	4 (0.82)	4 (0.81)	4 (0.81)	0 (0.00)
	SBP-A2				5 (1.00)	5 (0.97)	5 (0.97)	0 (0.00)
	MRF-A1					7 (1.00)	7 (1.00)	0 (0.00)
	SBS-A3						7 (1.00)	0 (0.00)
	SBS-A4							0 (1.00)
Main G	SBS-A1	35 (1.00)	8 (0.54)	18 (0.69)	22 (0.87)	18 (0.74)	13 (0.55)	0 (0.00)
	CC-A1		53 (1.00)	8 (0.63)	5 (0.56)	7 (0.44)	6 (0.54)	0 (0.00)
	ML-A2			31 (1.00)	19 (0.72)	17(0.53)	14 (0.48)	0 (0.00)
	SBP-A2				33 (1.00)	22 (0.83)	18 (0.69)	0 (0.00)
	MRF-A1					30 (1.00)	15 (0.65)	0 (0.00)
	SBS-A3						40 (1.00)	0 (0.00)
	SBS-A4							0 (1.00)
Interaction	SBS-A1	43 (1.00)	10 (0.79)	4 (0.51)	3 (0.46)	19 (0.76)	16 (0.69)	0 (0.54)
	CC-A1		109 (1.00)	2 (0.37)	2 (0.34)	3 (0.65)	7 (0.69)	1 (0.59)
	ML-A2			5 (1.00)	3 (0.71)	4 (0.56)	1 (0.35)	0 (0.21)
	SBP-A2				9 (1.00)	5 (0.48)	4 (0.38)	0 (0.22)
	MRF-A1					33 (1.00)	16 (0.69)	0 (0.38)
	SBS-A3						67 (1.00)	0 (0.38)
	SBS-A4							48 (1.00)